ANNUAL PROGRESS REPORT (2020-21)

PAKISTAN FOREST INSTITUTE PESHAWAR 2021

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Annual Progress Report (2020-21)

1. FORESTRY RESEARCH DIVISION

1.1 SILVICULTURE

1.1.1 Comparative study on growth performance of 17 poplar clones

Location: Pakistan Forest Institute, Peshawar
Year of commencement: 2018
Principal Investigator: Dr. Anwar Ali, DFRD
Co-Principal Investigator: Dr. Nowsherwan Zarif (Assistant Silviculturist)
Mr. Qayyum Khattak, FR (Silva)

Poplar is a fast growing tree species grown in agroforestry systems in Pakistan. It has the potneital to produce valuable industrial wood in short span of time and provides quick return for trees growers. Cuttings of poplar species and hybrids are easy to cultivate, and planting and subsequent care are typically not difficult. Their wood has been widely used for many years because of its light, white-hued colour, lack of odour or flavour, and ease of processing. The most common applications are veneer and saw wood manufacture, matches and match boxes, pulp and paper, and cellulose items.PFI is striving to identy best perforing clones of Poplar for further propagation in the field. The research was set up in February 2018 at the Silviculture Research Garden, PFI, to assess the growth performance of 17 poplar clones under irrigated conditions in Peshawar. In 2018, seventeen poplar clones (9" cuttings) were planted in a research trial as per the following parameters.

Design: Randomized Complete Block
Total area: 0.20 acres
Spacing: 2' x 1'
No. of clones: 17
No. of replications: 03

Data collected on growth variables of these clones is given in Table 1.

Table 1. Group Descriptive data of 17 clones

Species	/ Replications		Mean	SD	SE
Diameter(cm)	CHINA-I	3	3.04	0.5300	0.3060
	Y-511	3	3.46	0.1415	0.0817
	I-24/51	3	3.14	0.5599	0.3232
	DAVINA	3	3.67	0.2960	0.1709
	LUX	3	3.23	0.3750	0.2165
	ST-92	3	3.38	0.3342	0.1930
	EVERGREEN	3	3.95	0.2532	0.1462
	TRIPLO	3	4.47	0.4750	0.2742
	I-262	3	3.52	0.3995	0.2307
	I-24/64	3	4.23	0.6562	0.3788
	I-90/60	3	3.27	0.2524	0.1457
	I-69/234	3	3.37	0.3109	0.1795
	ONDA	3	3.17	0.0751	0.0433
	AY-48	3	2.94	0.5338	0.3082

Species	/ Replications		Mean	SD	SE
	I-18/62	3	3.69	0.5308	0.3064
	Y-13	3	3.17	0.4314	0.2491
	I-69/55	3	3.76	0.6374	0.3680
Height(m)	CHINA-I	3	5.54	0.8517	0.4917
	Y-511	3	6.15	0.3818	0.2204
	I-24/51	3	5.42	0.7240	0.4180
	DAVINA	3	6.46	0.8815	0.5090
	LUX	3	6.10	0.6872	0.3968
	ST-92	3	6.25	0.5121	0.2957
	EVERGREEN	3	7.44	0.4362	0.2518
	TRIPLO	3	7.30	1.1807	0.6817
	I-262	3	6.12	0.8329	0.4809
	I-24/64	3	6.78	0.5437	0.3139
	I-90/60	3	5.87	0.3943	0.2276
	I-69/234	3	6.21	0.8216	0.4744
	ONDA	3	5.40	0.3143	0.1815
	AY-48	3	5.19	0.7328	0.4231
	I-18/62	3	5.82	0.5838	0.3371
	Y-13	3	5.74	0.8184	0.4725
	I-69/55	3	6.16	0.5143	0.2969
Survival (%)	CHINA-I	3	31.64	0.7027	0.4057
	Y-511	3	31.13	1.2771	0.7374
	I-24/51	3	30.90	0.4061	0.2345
	DAVINA	3	30.09	0.7181	0.4146
	LUX	3	29.42	0.2406	0.1389
	ST-92	3	28.72	0.8699	0.5022
	EVERGREEN	3	28.05	0.4500	0.2598
	TRIPLO	3	26.78	0.6516	0.3762
	I-262	3	25.67	0.4034	0.2329
	I-24/64	3	25.34	0.7389	0.4266
	I-90/60	3	24.06	1.1086	0.6400
	I-69/234	3	23.02	0.8595	0.4962
	ONDA	3	22.88	1.2469	0.7199
	AY-48	3	21.98	0.8005	0.4622
	I-18/62	3	20.44	1.0010	0.5779
	Y-13	3	20.00	1.0411	0.6011
	I-69/55	3	18.79	2.1485	1.2404

Table 2. One-Way ANOVA (Fisher's) results and their interactions among diameter, height and survival of 17 poplar clones

SV	F	df1	df2	p
Diameter (cm)	2.88	16	34	0.005
Height (m)	2.41	16	34	0.015
Survival (%)	56.41	16	34	< .001

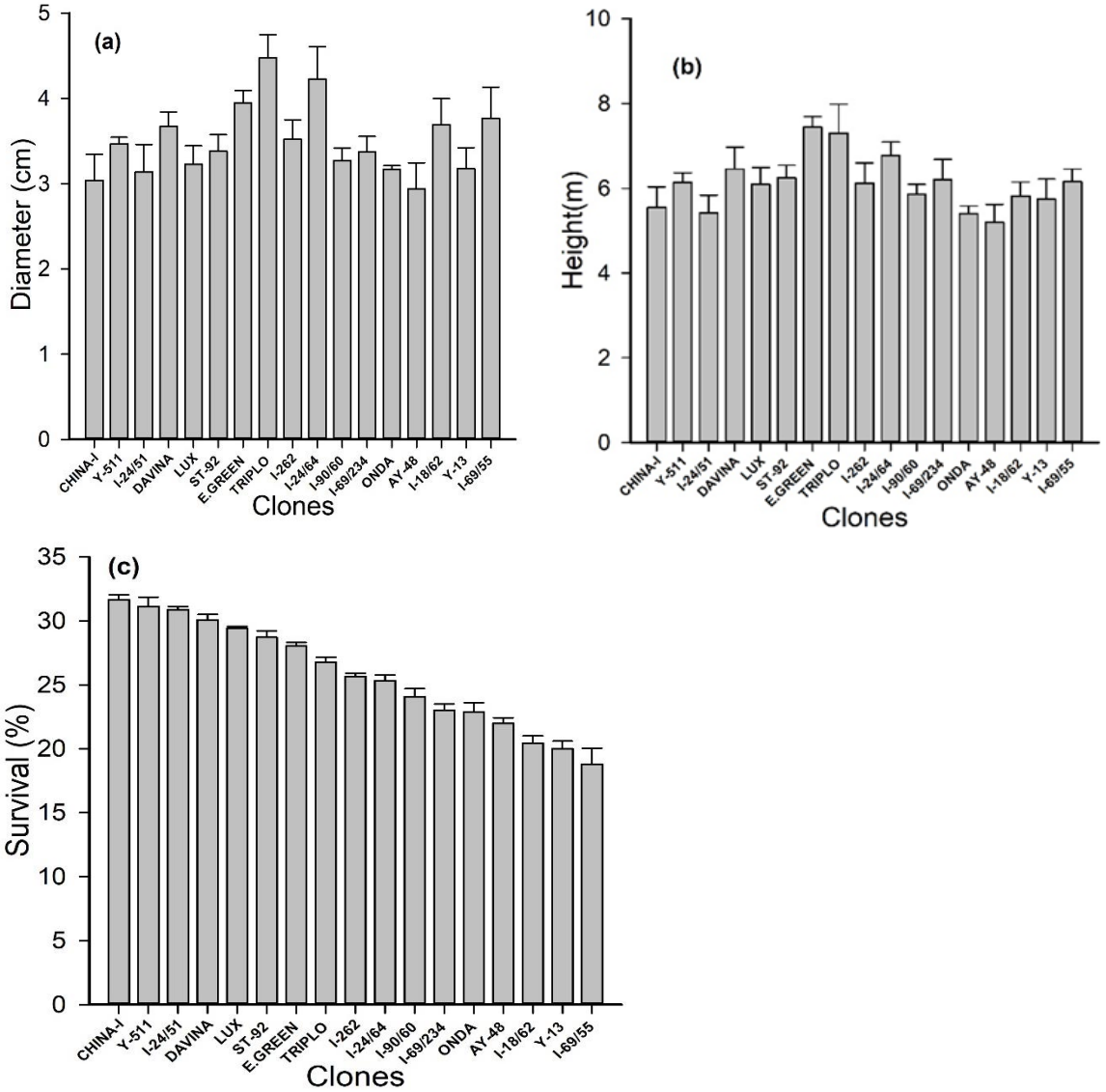


Figure 1. Diameter (cm) (a), Height (m) (b), and Survival (%) of 17 poplar clones.

The differences between species regarding height, diameter and survival were different (Table 1). However, significant differences were observed between clones in survival (%)(Table 2) China-I showed the highest % followed by Y-511,1-24/51, Davina, Lux, ST-92, Evergreen, Triplo, 1-262, 1-24/64,1-90/60, 1-69/234, Onda, Ay-48, I-18/62, Y-13 and I-69/55 respectively. While in terms of diameter and height, the Evergreen showed a significant increase (Figure 1a & b).

1.1.2 Comparative growth study of *Populous nigra* with other two clones of poplar

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2016
Principal Investigator:	Dr. Anwar Ali, DFRD
Co-Principal Investigator:	Dr. Nowsherwan Zarif (Assistant Silviculturist) Mr. Qayyum Khattak, FR (Silva)

Comparative studies of multiple species growing on the same soils help researchers better grasp how species vary under comparable nutritional circumstances. In this regard, a comparative growth study of Populous nigra with the clones of evergreen poplar and populous deltoids (i.e. AY-48 clone) was laid out.

Design:	Randomized Complete Block
Total area:	0.32 acres
Spacing:	3' x 2'
No. of clones:	3
No. of replications:	02

The descriptive data regarding height diameter and survival is given in table 3.

Table 3 Group Descriptive data of three poplar species

	Spp	Replications	Mean	SD	SE
Diameter (cm)	AY-48	2	8.13	1.945	1.375
E.Green		2	9.97	2.157	1.525
	P.Nigra	2	8.07	2.298	1.625
Height (m)	AY-48	2	10.37	1.973	1.395
	E.Green	2	12.13	2.588	1.830
	P.Nigra	2	10.22	2.355	1.665
Survival (%)	AY-48	2	73.65	0.919	0.650
	E.Green	2	53.90	1.273	0.900
	P.Nigra	2	65.50	0.707	0.500

Table 4. One-Way ANOVA (Welch's & Fisher's) results and their interactions among diameter, height and survival of poplar species.

		F	df1	df2	p
Diameter (cm)	Welch's	0.383	2	1.99	0.723
Fisher's		0.513	2	3	0.643
Height (m)	Welch's	0.278	2	1.97	0.783
Fisher's		0.419	2	3	0.691
Survival (%)	Welch's	118.546	2	1.90	0.010
Fisher's		199.341	2	3	< .001

Growth traits were quite variable, with the most significant differences among the three clones (Table 4). However, significant differences were observed between clones in survival (%) (Table 3) AY-48I (73.65%) showed the highest survival %, followed by *Populus nigra* (65.5%) and Evergreen (53.9%). However, in terms of diameter and height, Evergreen showed a significant increase (Table 3).

1.1.3 Comparative Growth study of Paulownia Species

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2016
Principal Investigator:	Dr. Anwar Ali, DFRD
Co-Principal Investigator:	Dr. Nowsherwan Zarif (Assistant Silviculturist) Mr. Qayyum Khattak, FR (Silva)

- Design: Randomized Complete Block
- Total area: 0.18 acres
- Spacing: 100 x 50 cm
- No. of species: 4
- No. of replications: 02

The benefits people obtain from ecosystems are an essential foundation for human well-being. Changes in land use have led to the significant degradation of many ecosystem services while enhancing others. Among the numerous drivers of land-use change is the increased demand for industrial forest products; in combination with the liberalization of trade, this has led to the rapid expansion of tree plantations around the globe. Despite the fact that the small area of industrial plantations in global terms (less than 3% of global forest cover) and their modest expansion compared to that of agricultural crops, plantations often form a significant part of land use at a local and regional level. The efficient and economic utilization of exotic fast-growing species like Paulownia is in view. A comparative growth study was conducted of four Paulownia species, i.e. *Paulownia fortunei, Paulownia catalpifolia, Paulownia elangata* and *Paulownia tomentosa*. The dia and height wise data is given in table 3.

Table 5 Group Descriptive data of Paulownia species

Species/Parameters	Replications	Mean	SD	SE
Diameter (cm)	2	9.18	0.601	0.425
P. catalpifolia				
P. tomentosa	2	9.85	0.990	0.700
P.elongata	2	9.05	0.283	0.200
P.fortunei	2	8.82	0.742	0.525
Height (m)	2	9.21	0.884	0.625
P. catalpifolia				
P. tomentosa	2	9.98	1.032	0.730
P.elongata	2	9.17	0.318	0.225
P.fortunei	2	9.20	1.195	0.845
Survival (%)	2	18.07	0.188	0.133
P. catalpifolia				
P. tomentosa	2	28.06	0.483	0.341
P.elongata	2	14.72	0.827	0.585
P.fortunei	2	15.93	0.240	0.170

Table 6. One-Way ANOVA (Welch's & Fisher's) results and their interactions among diameter, height and survival of Paulownia species.

Diameter	Welch's	0.302	3	1.99	0.826
	Fisher's	0.789	3	4	0.560
Height	Welch's	0.224	3	1.91	0.874
	Fisher's	0.366	3	4	0.782
Survival	Welch's	212.260	3	2.06	**0.004**
	Fisher's	292.032	3	4	**< .001**

As shown in the table above both the dia and hight of *Paulownia tomentosa* were found the highest.

1.1.4 Comparative growth study of different Poplar clones at nursery stage

Location: Pakistan Forest Institute, Peshawar
Year of commencement: 2021
Principal Investigator: Dr. Anwar Ali, DFRD
Co-Principal Investigator: Dr. Nowsherwan Zarif (Assistant Silviculturist)
Mr. Qayyum Khattak, FR (Silva)

Plantations are growing in size throughout the world. Many plantations are formed for a variety of objectives. Still, the majority are planted as monocultures and agroforestry to produce timber for goods like paper, solid wood, and fuel, among other things. In this regard, poplar is the preferable species with its rapid growth and early maturation; poplars could be a significant source of wood. Cuttings can propagate all poplar species and hybrids, and planting and subsequent treatment are generally not difficult. Because of its light, white colour, lack of odour or taste, and ease of processing, this wood has been widely used for a long time. Veneer and saw wood manufacturing, matches and matchboxes, pulp and paper, and cellulose products are the most common.

- Design: Randomized Complete Block
- Total area: 10 Kanals
- Spacing: 1.5’ x 1’
- No. of species: 19
- No. of replications: 02

Table 7. Group Descriptive data of Poplar Clones

	Species	N	Mean	SD	SE
Diameter	I-24/64	2	1.56	0.0354	0.0250
	I-262	2	1.31	0.0212	0.0150
	ST-92	2	1.65	0.0636	0.0450
	CHINA-I	2	1.44	0.0354	0.0250
	I-69/55	2	1.52	0.0283	0.0200
	I-69/234	2	1.94	0.0849	0.0600
	I-24/51	2	1.46	0.4313	0.3050
	AY-48	2	1.50	0.4243	0.3000
	GUARDI	2	2.00	0.1414	0.1000
	LENA	2	1.84	0.0849	0.0600
	LUX	2	1.40	0.1414	0.1000
	TRIPLO	2	1.84	0.0636	0.0450
	DAVINA	2	1.54	0.0919	0.0650
	Y-13	2	2.04	0.0212	0.0150
	I-18/62	2	1.85	0.0707	0.0500
	I-90/60	2	2.14	0.0566	0.0400
	ONDA	2	2.05	0.2121	0.1500
	Y-511	2	2.02	0.1131	0.0800
	EVERGREEN	2	2.13	0.2404	0.1700
Height	I-24/64	2	3.63	0.0636	0.0450
	I-262	2	3.19	0.0354	0.0250
	ST-92	2	3.46	0.0495	0.0350
	CHINA-I	2	3.45	0.0354	0.0250
	I-69/55	2	3.70	0.0212	0.0150
	I-69/234	2	3.82	0.0283	0.0200
	I-24/51	2	2.58	0.0354	0.0250
	AY-48	2	2.85	0.0495	0.0350
	GUARDI	2	3.67	0.0636	0.0450
	LENA	2	3.85	0.0424	0.0300
	LUX	2	3.58	0.0495	0.0350
	TRIPLO	2	3.92	0.0354	0.0250
	DAVINA	2	3.38	0.0566	0.0400
	Y-13	2	3.96	0.0283	0.0200
	I-18/62	2	3.91	0.0141	0.0100
	I-90/60	2	4.16	0.0849	0.0600
	ONDA	2	3.87	0.0636	0.0450
	Y-511	2	4.26	0.0636	0.0450
	EVERGREEN	2	4.47	0.0707	0.0500

Table 8. One-Way ANOVA (Welch's) results and their interactions among diameter, height and survival of Poplar Clones

	F	df1	df2	p
Diameter	32.9	18	6.99	**< .001**
Height	94.2	18	7.00	**< .001**

Table 7 illustrate the group descriptive data of mean annual growth of diameter in cm, and height in m. The analysis of variance for growth parameters i.e., diameter and height is shown in Table 8. Significant differences ($P < 0.05$) were found among clones and replications (blocks) for the diameter and as well as in height. Differences among clones are genetically related, but differences between blocks are possibly due to micro environmental soil and humidity conditions. Moreover, the evergreen clone showed a significant increase in height and also showed relatively better growth in terms of diameter.

1.1.5 Establishment of an arboretum of drought-resistant species

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2015
Principal Investigator:	Dr. Anwar Ali, DFRD
Co-Principal Investigator:	Dr. Nowsherwan Zarif (Assistant Silviculturist)
	Mr. Qayyum Khattak, FR (Silva)

In Pakistan, the per capita forest area is merely 0.033 ha compared with the world average of one hectare. The primary reason for the meagre forest area is that most of the land area (70-80%) of Pakistan falls in arid or semi-arid zones where precipitation is too low to support tree growth. Moreover, the ever-increasing demand for timber, fuelwood and other goods and services has degraded the existing forest resource. Afforestation of arid and semi-arid areas has become the need of the hour to meet the social, ecological and economic needs of the people dwelling in the rural areas. Due to har climatic conditions viz low and erratic rainfall and high temperature, the drought resistance species are amongst valuable options. PFI has tested and successfully demonstrated exotic Acacias in different parts of the country. The establishment of an arboretum of drought-resistant species aims to serve the purpose of demonstration and also provide a seed source for the future replenishment needs of the drought-resistant species.

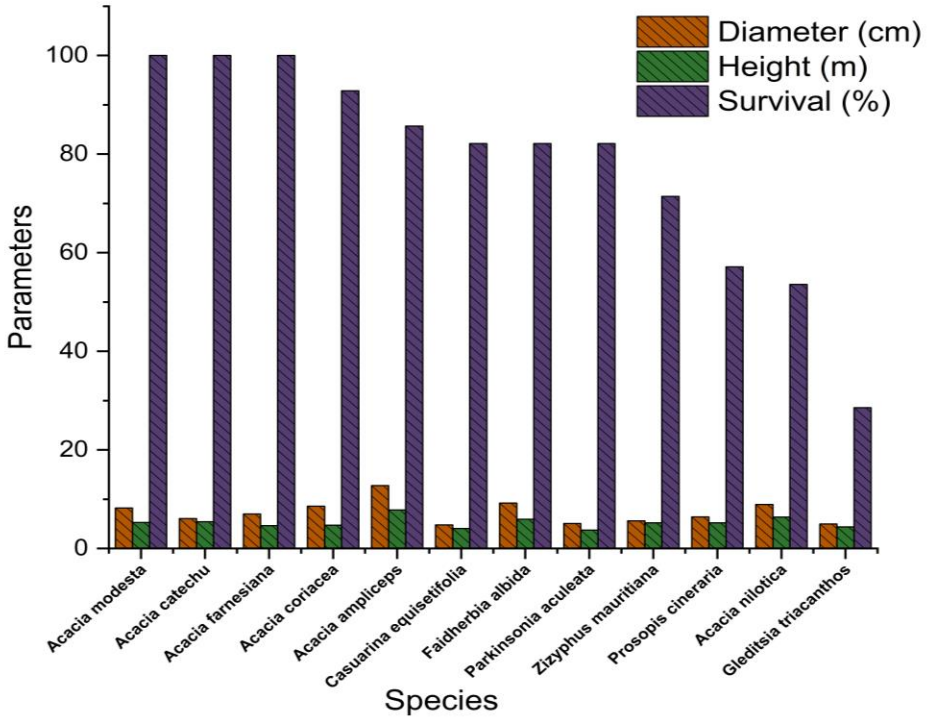


Figure 2 Survival (%), diameter (cm) and height (m).

Figure 2 illustrates the survival (%), diameter (cm) and height (m). Species like *Acacia modesta, Acacia catechu* and *Acacia fernesiana* showed a 100 % survival rate. As far as height and diameter are concerned *Acacia ampliceps* showed promising results in terms of height and diameter followed by *Faidherbia albida* and *Acacia nilotica* respectively.

1.2 FOREST MENSURATION

1.2.1 Study on Walnut Production in Kaghan

Location:	Kaghan
Year of commencement:	2020
Principal Investigator:	Dr. Anwar Ali, DFRD
Co-Principal Investigator:	Mr. Muhammad Tufail, Plant Operator

Walnut is an important tree species of Kaghan valley which produces edible nuts having high nutrition and taste. Kaghan valley is famous for walnut production in Pakistan. Walnut trees can be seen almost everywhere in the valley especially near habitation and along streams and river. A survey was conducted in Kaghan Valley under the Sustianble Forest Management (SFM) Project of MoCC and UNDP to identify major patches/stands of walnut trees, map these stands, quantify the nut production and study supply and marketing chain of walnut in the area.

Methodology

Primary data about production and marketing of fruit/nuts of walnut was collected through three different field surveys in Kaghan Valley under Sustainable Forest Management Project of MoCC and UNDP. Besides, secondary data on walnut was collected from different sources including office records of Forest Department, Technical Reports and Research Papers. The detail of methods employed for field surveys is given below.

Field Survey for Estimation of Number of Walnut Trees

Walnut trees are growing in Kaghan valley on the boundaries of farmlands, in the vicinity of villages and wastelands. These trees are either in the form of small patches or scattered. Some trees are also found along the streams in the forest area. Full enumeration was conducted in all the major areas of Kaghan Valley. Three separate field parties comprising forestry graduates and field assistants were constituted for the field work. These teams were assigned different subdivisions of Kaghan including Balakot, Jared and Kaghan forest subdivisions.

Main stands of walnut were identified with the help of local villagers and all trees in these patches were measured during the field survey. Diameter, height and age of these trees were measured. Diameter at breast height (1.37 m above ground level) was measured with the help of caliper and diameter tape, height was measured with the help of clinometer and haglof vertex hypsometer. Age was estimated with the help of local people knowledge. Data was recorded in inventory proformas prepared for the survey. Stand table showing number of trees in different diameter classes was prepared from this data. Besides, the trees not measured during the field survey were estimated through local people knowledge. Thus the total number of walnut in Kaghan valley was determined.

Determination of nuts production

In order to determine the average quantity of nuts production by the walnut trees, a total of 94 sample trees were selected comprising equal number of trees of small, medium and large size trees. All the nuts were removed from each of the selected sample trees at the time of maturity of the fruit in October 2020 and weighed on the spot. Barks were removed from the nuts and reweighed. Samples were brought to PFI and dried in open and weighed to determine moisture content and dry weight of the nuts. In this way dry weight of nuts produced by all sample trees was determined. Its average was used to estimate the total number of nuts production in the area.

Results

Stand Structure

About 56% of the walnut trees are grafted in the area whereas 44% are the natural trees growing from the seedlings. Different size trees of walnut are growing in Kaghan Valley ranging from 10 to 196 cm. The average diameter at breast height (DBH) of these trees was determined as 38.60 cm and the mean height was found to be 10.82 m (Table 1). The average age of the trees was estimated as 62 year. It was found that 33.85% trees fall in the diameter class less than 30 cm, 53.88% trees fall in diameter class 31-60 cm, 10.58% trees fall in the diameter class 61-90 cm and 1.69% trees have

diameter more than 90 cm (Figure 1). About 28 trees measured during the survey have diameter more than 100 cm. Out of the total 132 stands measured during the field survey, the average number of trees per stand was calculated as 43.

Table 1. Stand Structure of Walnut

Subdivision	Mean DBH (cm)	Mean Height (m)
Kaghan	37.03	11.09
Jared	40.00	10.15
Balakot	42.46	10.53
Total	38.60	10.82

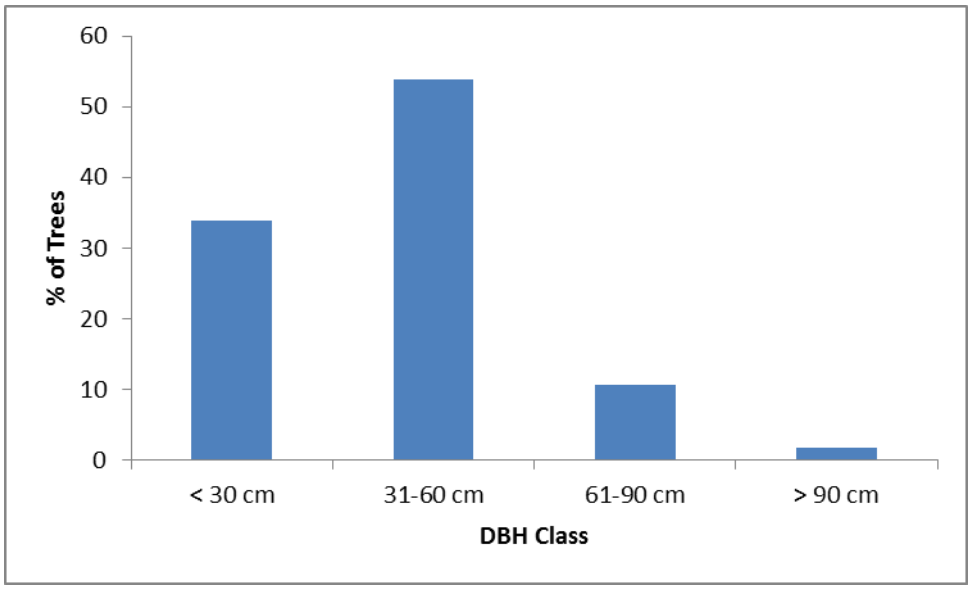


Figure 1: Diameter-class Distribution of Walnut

Diameter-Height Relationship

Diameter and height are important variables for measuring the volume of timber in a tree. As walnut is also a source of timber used for furniture, its wood is highly valuable. A strong relationship was found between diameter and height of walnut trees (R^2=0.3877) as shown in Figure 2. By using this model the height of a walnut tree can be determined from its DBH. Diameter and height are important variables for measuring the volume of timber in a tree.

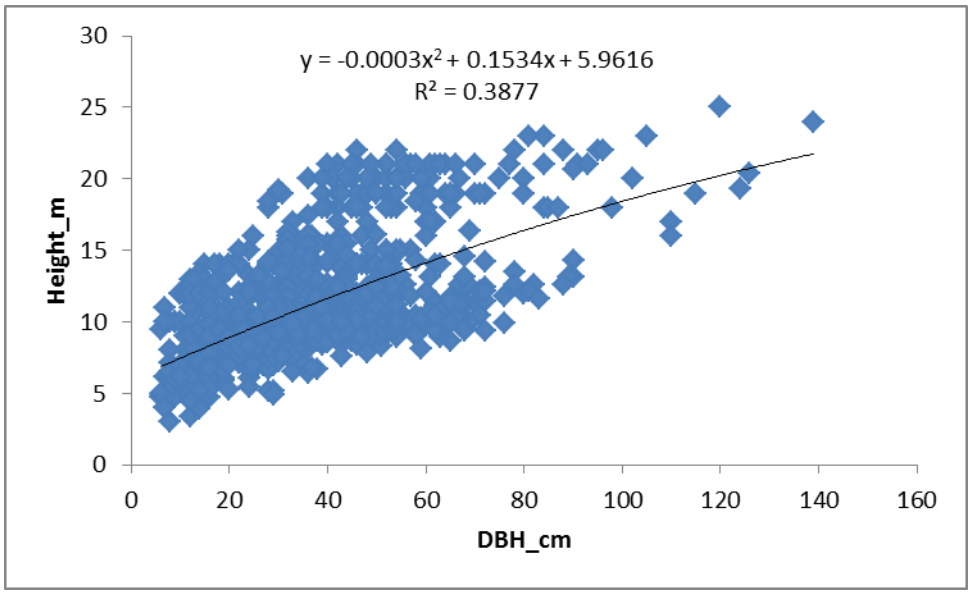


Figure 2: Diameter-Height Model of Walnut

Diameter-Age Relationship

It is often difficult to accurately determine the age of a broad-leaf tree unless its date of planting is known. During the field survey, local people were asked to estimate the age of the walnut trees growing in the vicinity of their village. Diameters of these trees were measured to derive a relationship between diameter and age of the walnut trees. A very strong relationship (R^2=0.81) was found between the DBH and age of walnut trees which is shown in Figure 3. This relationship can be used to estimate the age of the tree by measuring its DBH.

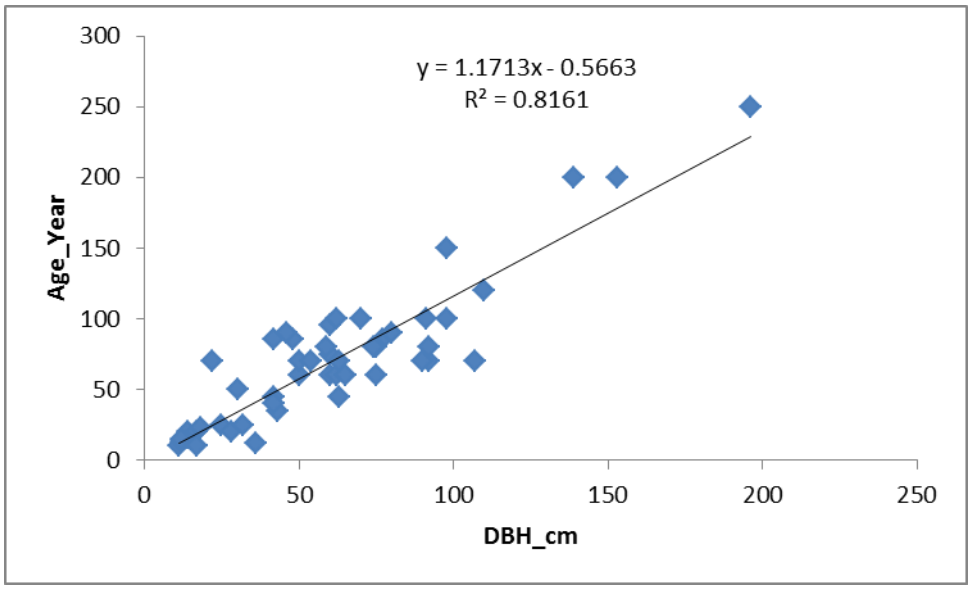


Figure 3: Diameter-Age Model of Walnut

Nut Production per Tree

Average dry weight of nut production was recorded as 23 kg per tree whereas the average fresh weight of nuts was determined as 34 kg per tree. It was also found that fresh nuts contain 30% moisture. The nuts are dried in the open air before sale to middle men or shopkeepers. Minimum air dry nut production was recorded as 2 kg for the tree having DBH of 20 cm and age of 15 years whereas maximum production was recorded as 57 kg for the tree with DBH 120 cm and age 120 year. It was found that the tree which produces 23 kg nuts (air-dry) has DBH of 50 cm, height of 17 m and age of 50 year. Nuts production for different size trees is given in Table 2. A strong relationship was found between DBH and nut production which is shown in Figure 4.

Table 2. Walnut Production per Tree

DBH Class	Mean Height (m)	Mean Age (Year)	Average Dry Nuts Production per Tree (Kg)
20-30 cm	13.81	19	17.38
31-60 cm	15.28	43	32.77
61-90 cm	16.30	57	44.94
>90 cm	19.60	122	60.92

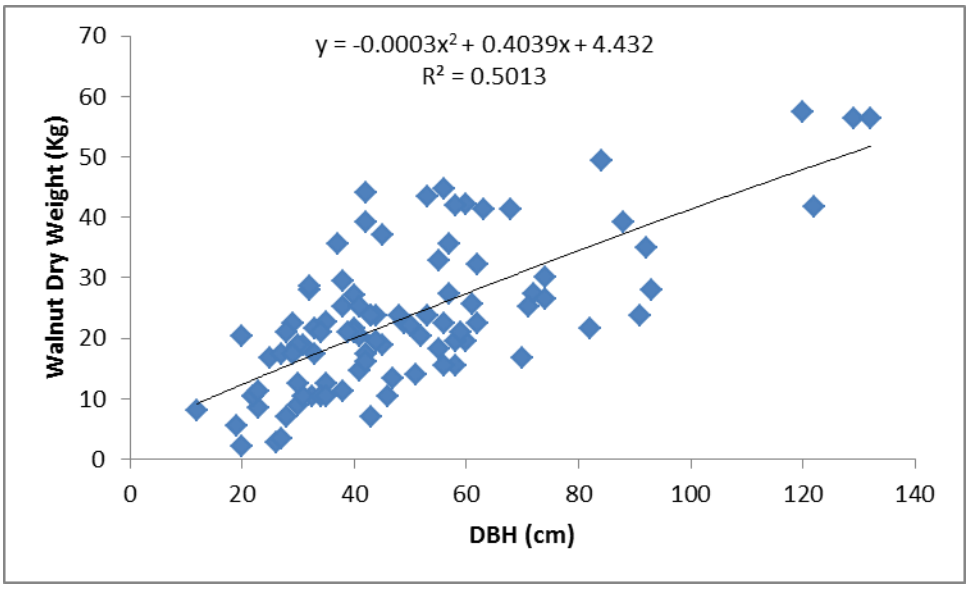


Figure 4: Diameter-Nuts Production Relationship

Total Walnut Production

During the survey a total of 16,929 walnut trees were physically measured in Kaghan valley. It is estimated that almost equal number would have been skipped during the physical measurement. The average production of walnut from each tree is estimated as 23 kg per season. The total production of walnut in the valley is estimated at 389,367 Kg (9,734 maund) per season. The average price of walnut fruit received by

the tree growers is Rs. 160 per kg. Thus, the total value of walnut is estimated as Rs. 62.298 million per year.

1.2.2 Study on Walnut Marketting in Kaghan

Location:	Kaghan
Year of commencement:	2020
Principal Investigator:	Dr. Anwar Ali, DFRD
Co-Principal Investigator:	Mr. Muhammad Tufail, Plant Operator

A field survey was conducted in Kaghan valley to study the marketing of walnut fruit in Kaghan Valley under Sustainable Forest Management Project of MoCC and UNDP. All shops dealing with walnut or dry fruits were cruised during this survey. The shopkeepers were interviewed using a structured questionnaire to estimate the total quantity of walnut traded per year, the sale and purchase prices, supply and demand and other aspect of marketing.

Results

It was found during field survey that 62% walnut farmers sell nuts in the form of standing trees and the remaining 38% sell nuts after collection from the trees. The average sale price of the standing tree is estimated at Rs. 5000 per tree whereas the average price of nuts is Rs. 160-180 per kg in the area. This is the price received by the local people from the sale of nuts to middlemen. About 70% walnut producers sell their produce to the middlemen whereas the remaining 30% directly sell the nuts in the local market.

The areas producing walnut are Paggal, Jared, Manur Bela, Noori and Kamalban. The walnuts are traded in the local markets of Balakot, Naran, Kaghan, Mahandri, Paghal, Kewai, Paras etc. There are 94 main shops in the valley which deal in walnut trading. On average each shopkeeper trade 43.75 maund or 2,188 kg per year. The average price paid by shopkeeper to nut producers is Rs.7,376 per maund whereas the wholesale price is estimated as Rs.9,047 per maund. Thus, the average profit earned by shop keepers is Rs.1,670 per maund. The retail price of walnut is Rs. 220-350 depending upon quality of the walnut. It is also worth mentioning that imported walnut (from China) is also traded in the area.

It was found during the survey that 51% shopkeepers purchase nuts directly from tree growers, 40% from middlemen and 9% purchase nuts from main dealers. It was further revealed that 93% shopkeepers sell walnuts to tourists and other purchasers whereas the remaining 7% sell walnuts to middlemen who take these nuts to other cities of the country. The main market of walnut is Balakot from where it is transported to the other parts of the country.

1.2.3 Estimation of Soil Erosion in Scrub Forests of Chakwal

Location:	Kaghan
Year of commencement:	2020
Principal Investigator:	Dr. Anwar Ali, DFRD
Co-Principal Investigator:	Mr. Khaled Javed, Field Assistant
	Mr. Muhammad Tufail, Plant Operator

Soil conservation and reduction of sediments load in streams and water bodies are key ecosystem services provided by forests. A study was designed to measure and compare runoff and sediment load in forestland, agricultural land and barren land in scrub forests of Chakwal, Punjab under Sustainable Forest Management Project of MoCC and UNDP. For this purpose erosion plots were established on the three land uses. A Rain Gauge was also installed in the area to measure the amount of rainfall. Runoff and sediments are collected in tanks placed at the bottom of the erosion plots.

Samples are taken after every event of rainfall and sediment loads are quantified in the Laboratory of PFI. This data provides valuable information required for the quantification of soil conservation made by scrub forests in the landscape.

Precipitation

The total annual rainfall received in the area was 708 mm during 2019 and 1017 mm during 2020 as per the record of Pakistan Meteorological Department. This rainfall is significantly higher compared to the past. The monthly rainfall data is given in the Table 3 and shown in Figure 5.

Table 3. Monthly Precipitation

Month	2019	2020
January	36.83	52.81
February	65.02	39.21
March	43.22	209.61
April	84.9	40.23
May	26.24	58.64
June	2.25	75.54
July	109.54	88.23
August	179.41	172.41
September	95.91	233.31
October	17.4	0
November	31.73	17.71
December	16	30
Total	708.45	1017.7

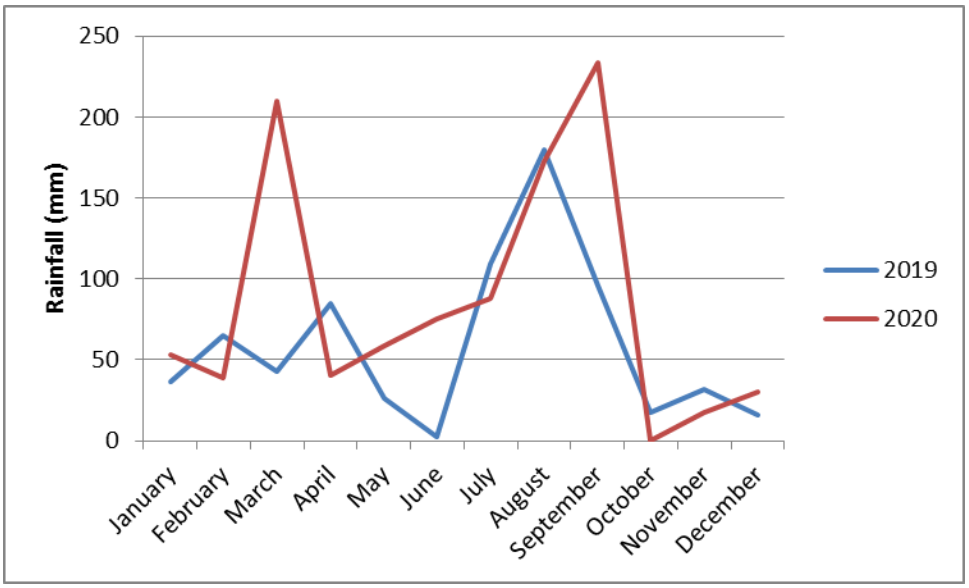


Figure 5: Monthly Rainfall

Temperature

The data on maximum and minimum temperature indicate that May, June and July are the hottest months whereas January and February are the coldest months in the area. Detail of monthly temperature is given in Table 4 and shown in Figure 6.

Table 4. Monthly Temperature

Month	2019		2020	
	Maximum	Minimum	Maximum	Minimum
January	14.8	3.6	17.1	3.3
February	16.2	5.5	14.0	3.0
March	21.6	9.5	20.8	10.3
April	30.7	16.0	28.2	14.7
May	34.6	18.8	33.9	19.3
June	39.2	23.1	35.7	22.3
July	35.3	24.2	36.9	24.1
August	33.6	23.5	33.8	24.3
September	32.9	23.1	33.4	21.4
October	29.2	16.3	31.7	15.7
November	21.3	10.3	22.2	9.3
December	20.4	6.4	-	-

Source: PMD,2020

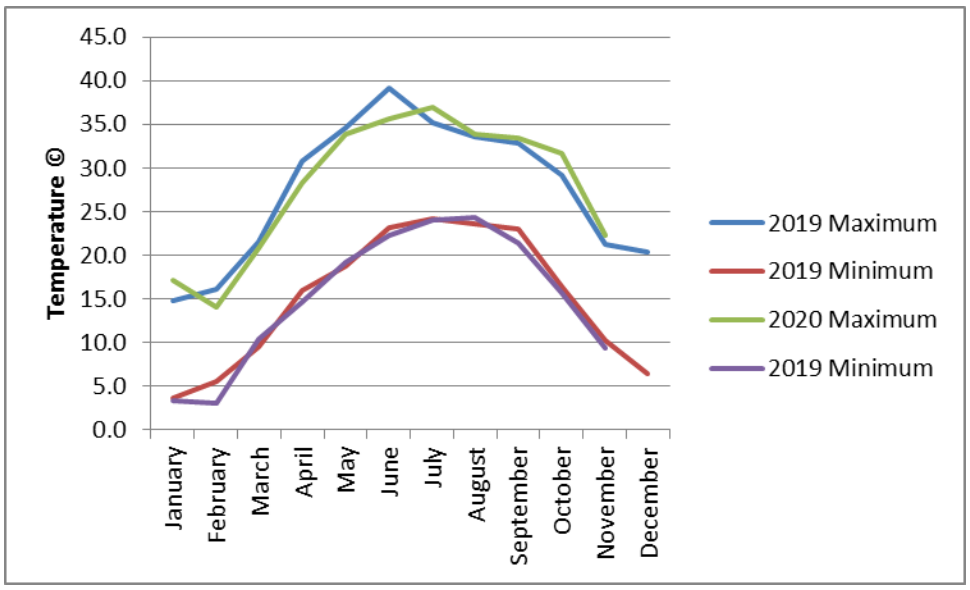


Figure 6: Monthly Minimum and Maximum Temperature

Runoff

The volume of runoff recorded from the erosion plots established on forest, agriculture and barren land is given in Table 5. The average slope of these plots was 10-150%. The highest runoff was recorded as 942 m^3/ha/year from barren land followed by 810 m^3/ha/year from agricultural land and the lowest runoff was recorded from forest as 734 m^3/ha/year.

Table 5: Runoff Volume (m^3/ha/year)

	Landuse		
Year	Barren	Agriculture	Forest
2019	754	634	468
2020	1130	987	1001
Average	942	810	734

Sediment Load

Sediment yield recorded from the erosion plots established on forest, agriculture and barren land is given in Table 6. The highest sediment yield was recorded as 2.29 t/ha/year from barren land followed by 1.32 t/ha/year from agricultural land and the lowest runoff was recorded from forest as 0.52 t/ha/year. This shows that sediment yield from forest is 4 times less than barren land and 2.5 times less than agricultural land.

Table 6. Sediment Yield (t/ha/year)

	Landuse		
Year	Barren	Agriculture	Forest
2019	2.77	1.13	0.40
2020	1.81	1.50	0.64
Average	**2.29**	**1.32**	**0.52**

A view of Erosion Plot Established on Barren Land in Samarkand (Chakwal)

A view of Erosion Plot Established in Scrub Forest in Samarkand

1.2.4 Assessment of Pasture Productivity in Kahuta and Kallar Syedan, Rawalpindi

Location:	Rawalpindi
Year of commencement:	2020
Principal Investigator:	Dr. Anwar Ali, DFRD
Co-Principal Investigator:	Mr. Khaled Javed, Field Assistant
	Mr. Muhammad Tufail, Plant Operator

Coniferous Forests of Kahuta and Kallar Syedan is one of the selected landscapes of SFM Project in Punjab. This landscape supports grazing of livestock and produces grasses which are one of the key provisioning ecosystem services. A study was conducted under SFM Project in the site during June-October 2020 to estimate status, forage production and carrying capacity of these grasslands.

Methodology

Data was collected from 25 sample plots of (one m^3); 15 sample plots were laid out in Kahuta Range and 10 sample plots were in Kallar Syedan Range. Initially data was collected in June which was repeated during July, August and September, 2020. All the vegetation in the sample plot was clipped. In each plot cover percentage, species composition and forage biomass were determined. The clipped vegetation was weighed with spring balance, put in bags and labeled. Then the material was put for seven (7) days in open air to determine its dry weight. Cover percentage, frequency percent and species composition percentage were determined.

Results

Surface features in Kahuta Grassland

Litter is the dominant surface cover in the grassland of Kahuta with 47.6% cover. Plant base comprise 29% of the surface, rock pavement is 2.33% and cryptogram is 0.27% whereas 20.80% is bare soil as shown in Figure 7.

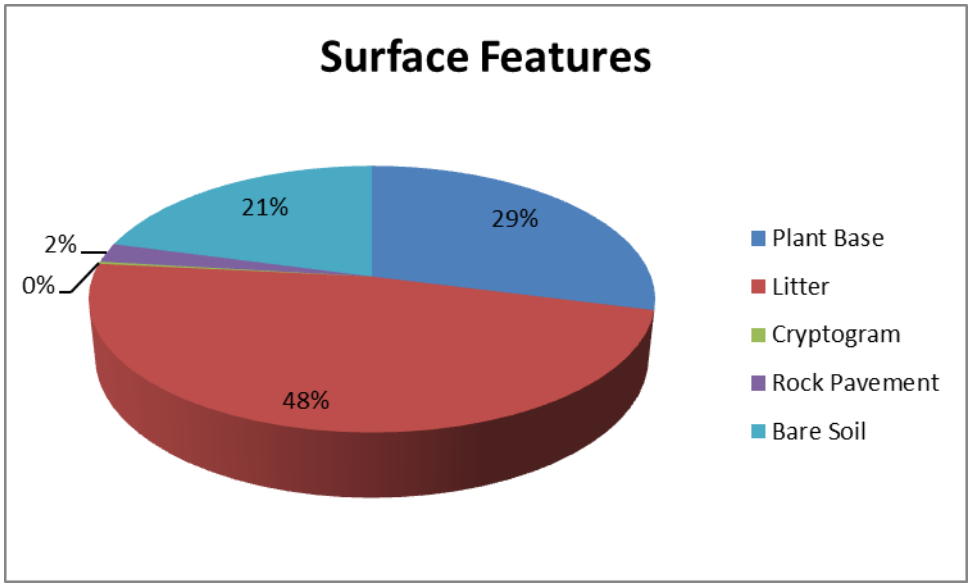


Figure 7: Surface Features of Grassland in Kahuta

Forage Production

Average forage production (air dry) was recorded as 2,953 kg per ha. The total carrying capacity of the grassland was estimated as 10.92 animal unit. This means that about 11 animals per ha can safely graze in these grasslands during the summer season. It was found that maximum forage production is achieved in June which can support grazing of 6.7 animal unit per ha. The detail is given in Table 7.

Table 7. Forage Production

Month	Fresh Weight (Kg Per Ha)	Air Day Weight (Kg Per Ha)	Carrying Capacity (AU per ha)
June	2964.50	1811.00	6.70
July	1000.00	556.25	2.06
August	807.15	277.15	1.02
September	700.00	308.70	1.14
Total	5471.65	2953.10	10.92

Surface features in Kallar Syedan Grassland

Litter is the dominant surface cover in the grassland of Kallar Syedan with 45.05% cover. Plant base comprises 17.06% of the surface, rock pavement is 12.09% whereas 24% is bare soil as shown in Figure 8.

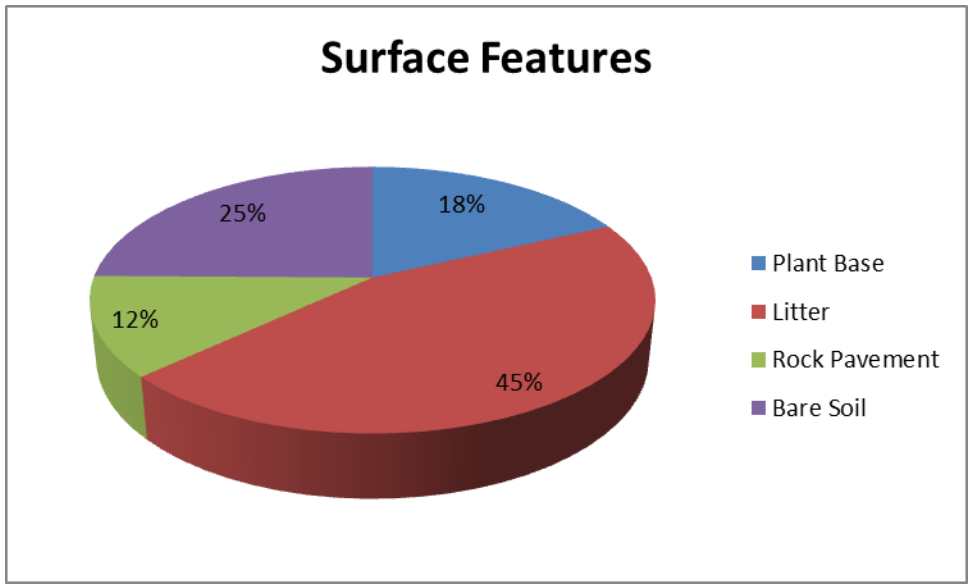


Figure 8: Surface Features of Grassland in Kallar Syedan

Forage Production

Average forage production (air dry) was recorded as 2,713 kg per ha in Kallar Syedan. The total carrying capacity of the grassland was estimated as 10.03 animal unit. Maximum forage production was recorded in June as 1616 kg per ha which can support grazing of 6 animal unit per ha. The detail is given in Table 8.

Table 8: Forage Production

Month	Fresh Weight (Kg Per Ha)	Air Dry Weight (Kg Per Ha)	Carrying Capacity (AU per Ha)
June	2172	1616	5.98
July	1095	504	1.86
August	1335	297	1.10
September	695	296	1.09
Total	5297	2713	10.03

Surface features in Grasslands in Scrub Forests of Chakwal

Rock pavement is the dominant surface cover in the grassland of Chakwal with 32.5% cover. Plant base comprises 30.2% of the surface, litter is 17% whereas 20.3% is bare soil as shown in Figure 9.

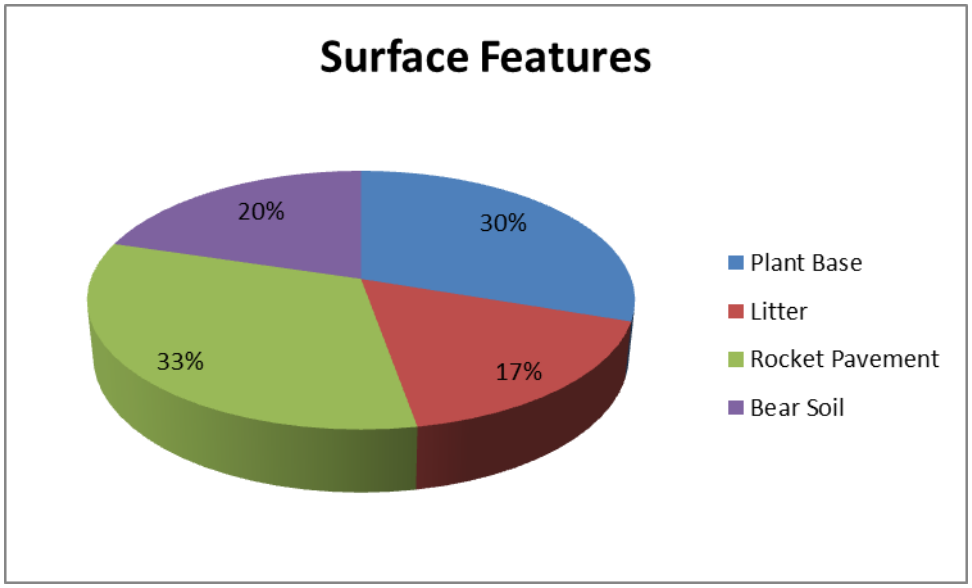


Figure 9: Surface Features of Grassland in Chakwal

Forage Production

Average forage production (air dry) was recorded as 5091 kg per ha in Chakwal. The total carrying capacity of the grassland was estimated as 18.85 animal unit. Maximum forage production was recorded in June as 3380 kg per ha which can support grazing of 12.52 animal unit per ha. The detail is given in Table 9.

Table 9: Forage Production

Month	Fresh Weight (Kg Per Ha)	Air Dry Weight (Kg Per Ha)	Carrying Capacity (AU per Ha)
June	4985	3380	12.52
July	1155	557	2.06
August	2130	704	2.60
September	960	450	1.67
Total	9230	5091	18.85

1.2.5 Assessment of Fuelwood Consumption in Siran Valley, Mansehra

Location: Kaghan
Year of commencement: 2020
Principal Investigator: Dr. Anwar Ali, DFRD
Co-Principal Investigator: Khaled Javed, Field Assistant
Mr. Muhammad Tufail, Plant Operator

Fuelwood collection is the major driver of deforestation and forest degradation in Khyber Pakhtunkhwa. A household survey was conducted in Siran Forest Division to quantify fuelwood consumption in the households and identify other sources of energy used at household level in the area.

Methodology

Data was collected from 797 households randomly selected from all four union councils of the Siran Valley through a semi-structured questionnaire. Data was compiled and analyzed with the help of MS Excel. The main findings are presented in the following section.

Results

Monthly Fuelwood Consumption

Fuelwood is the main source of household energy. It is used for cooking and heating. Average fuelwood consumption was estimated as 21.24 maund per household per month. Fuelwood consumption was 13.11 maund in summer and 29.36 maund in winter (Table 15). Devli has the highest fuelwood consumption in all union councils due to the reason that it lies at higher altitude and receives more snowfall in winter.

Table 15: Monthly Fuelwood Consumption

	Household Fuelwood Consumption (maund/month)		
UC	Summer	Winter	Total
Bhogarhmang	7.96	16.98	12.47
Devli	17.29	37.53	27.41
Jabori	13.52	29.84	21.68
Sachan	13.68	33.10	23.39
Total	13.11	29.36	21.24

1 maund = 40 kg

Total Fuelwood Consumption

Total fuelwood consumption was estimated as 218,261 maund or 8,730 tonnes per year. The highest fuelwood consumption was estimated for Devli as 67,017 maund followed by Jabori as 65,470 maund (Table 16).

Table 16. Total Fuelwood Consumption

UC	Households	Fuelwood Consumption (maund/HH/month)	Fuelwood Consumption (maund/year)
Bhogarhmang	2,625	12.47	32,734
Devli	2,445	27.41	67,017
Jabori	3,000	21.68	65,040
Sachan	2,286	23.39	53,470
Total	10,356	21.24	218,261

1 maund = 40 kg

Fuelwood Price

The average price of fuelwood was found as Rs. 531 per maund. There was no significant difference in fuelwood prices in all the union councils (Table 17).

Table 17: Fuelwood Prices

UC	Price (Rs. Per Maund)
Bhogarhmang	530
Devli	534
Jabori	531
Sachan	526
Average	531

1 Maund: 40 kg

Sources of Fuelwood

The survey results revealed that 65% of the fuelwood is collected from forests, 19% from wastelands and 16% from farmlands (Table 18). This indicates that forest resources are under tremendous pressure due to fuelwood collection.

Table 18: Sources of Fuelwood

UC	Forest	Wasteland	Farmland
Bhogarhmang	64.69	19.60	15.71
Devli	73.21	20.00	6.79
Jabori	64.71	13.15	22.14
Sachan	56.52	22.67	20.81
Average	64.78	18.85	16.37

Alternate Sources of Energy

Electricity and LPG are the alternate sources of energy. Crop residues and cow dung are also used as sources of fule but in very low quantity by small number of households. Electricity is mainly used for lighting whereas LPG is used for cooking. The average monthly consumption of LPG was estimated 14 kg per household. The average monthly bill of electricity was calculated Rs. 1160 per household (Table 19).

Table 19. Alternate Sources of Energy

UC	LPG Consumption (Kg/Month)	Price of LPG (Rs. Per Kg)	Electricity Bill (Rs. Per Month)
Bhogarhmang	14	139	1325
Devli	13	164	995
Jabori	14	143	1230
Sachan	14	181	1090
Average	14	157	1160

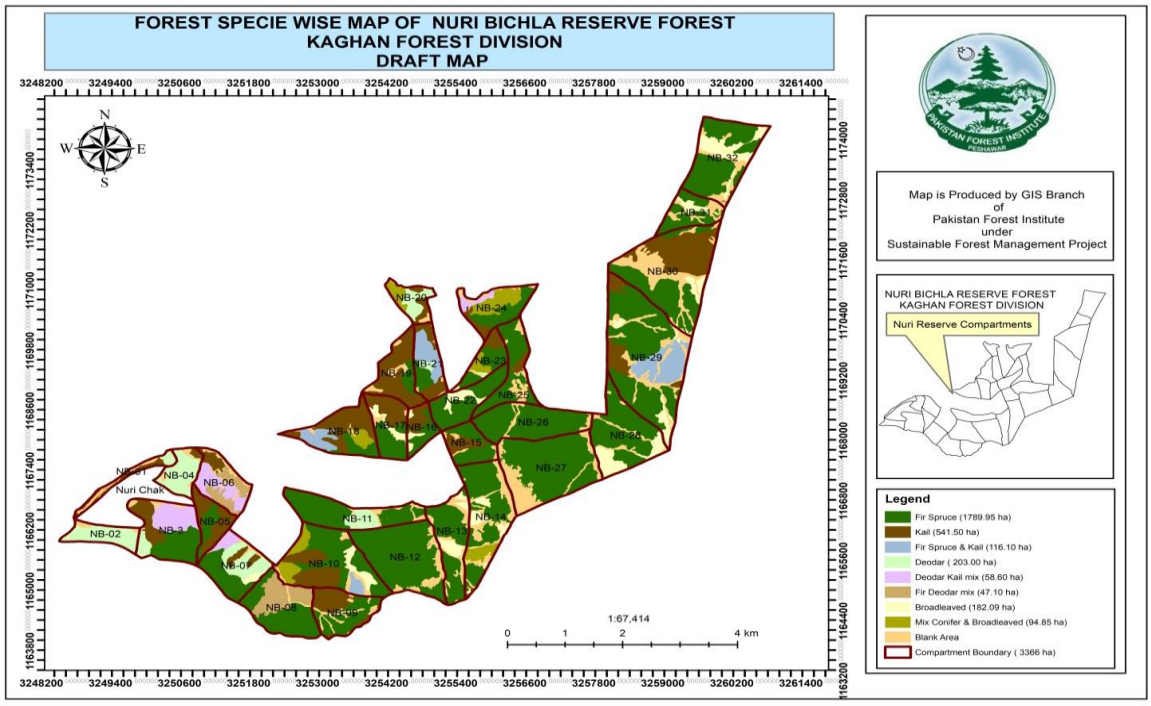
1.3 GIS

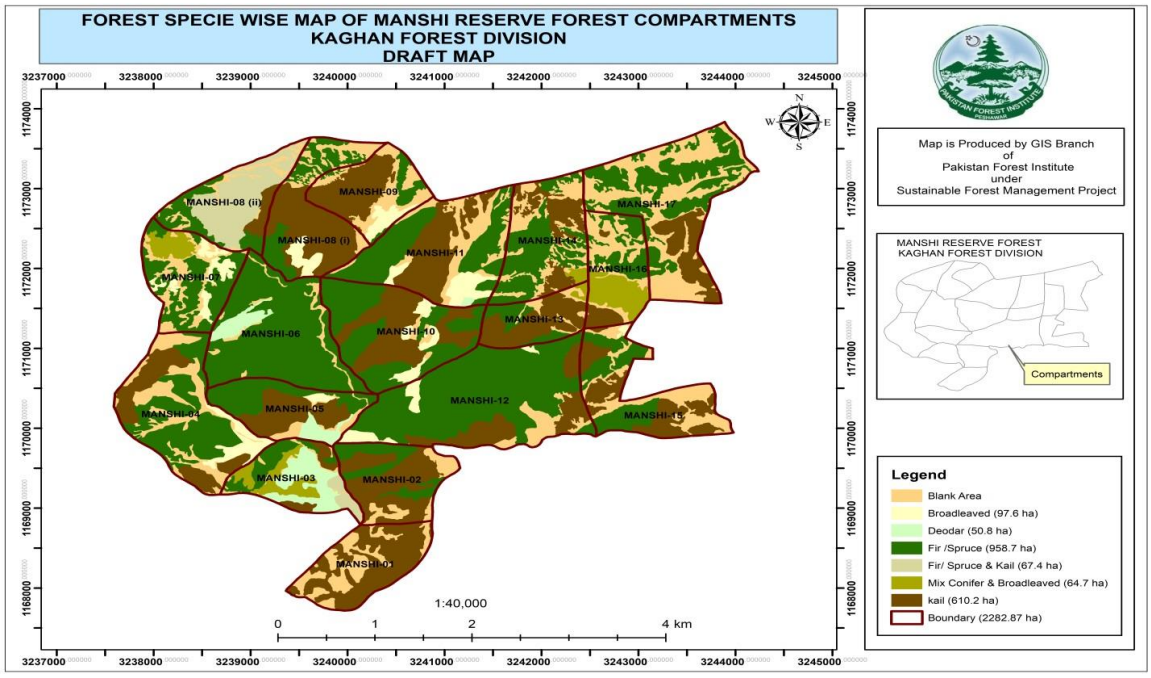
1.3.1 Specie wise Mapping of Kaghan Forests under SFM project

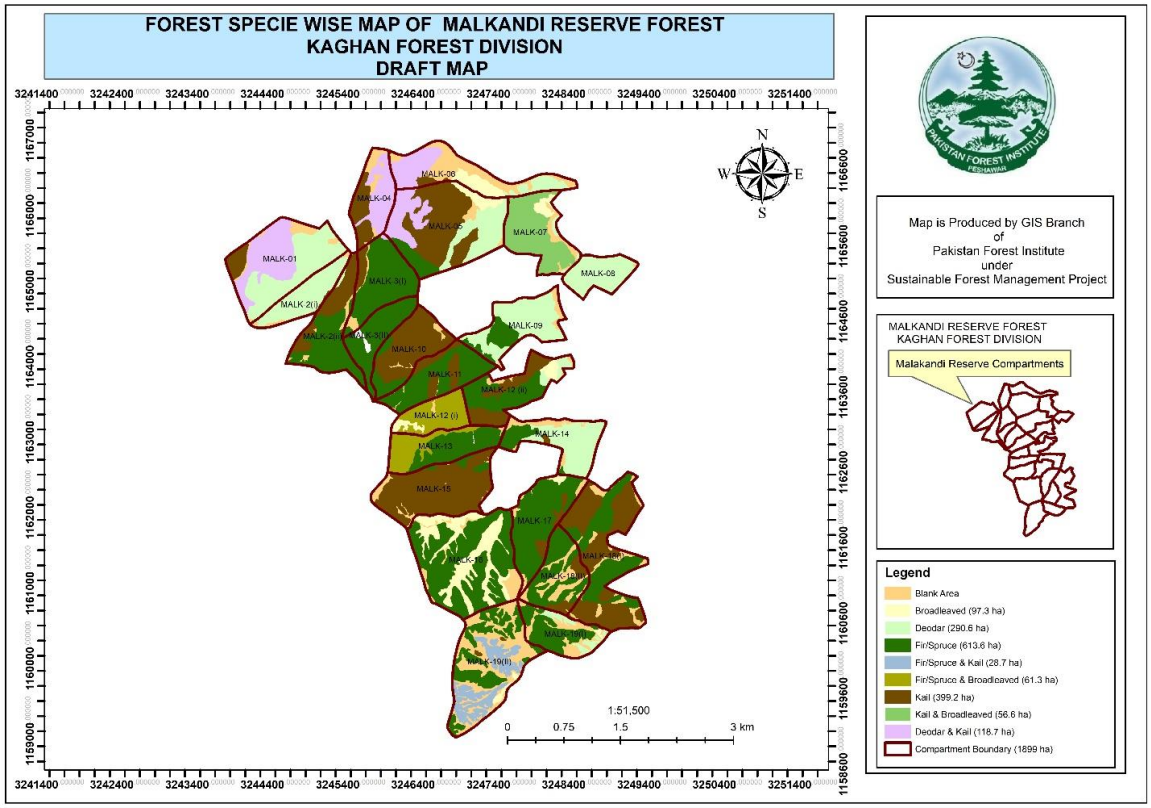
Location: Kaghan
Year of commencement: 2020
Principal Investigator: Mr. Aamir Shakeel, GIS Specialist
Co-Principal Investigator: Mr. Tahir Iqbal (Technical Assistant)
Mr. Ziad Raza (Technical Assistant)
Mr. Muhammad Ajmal (Technical Assistant)

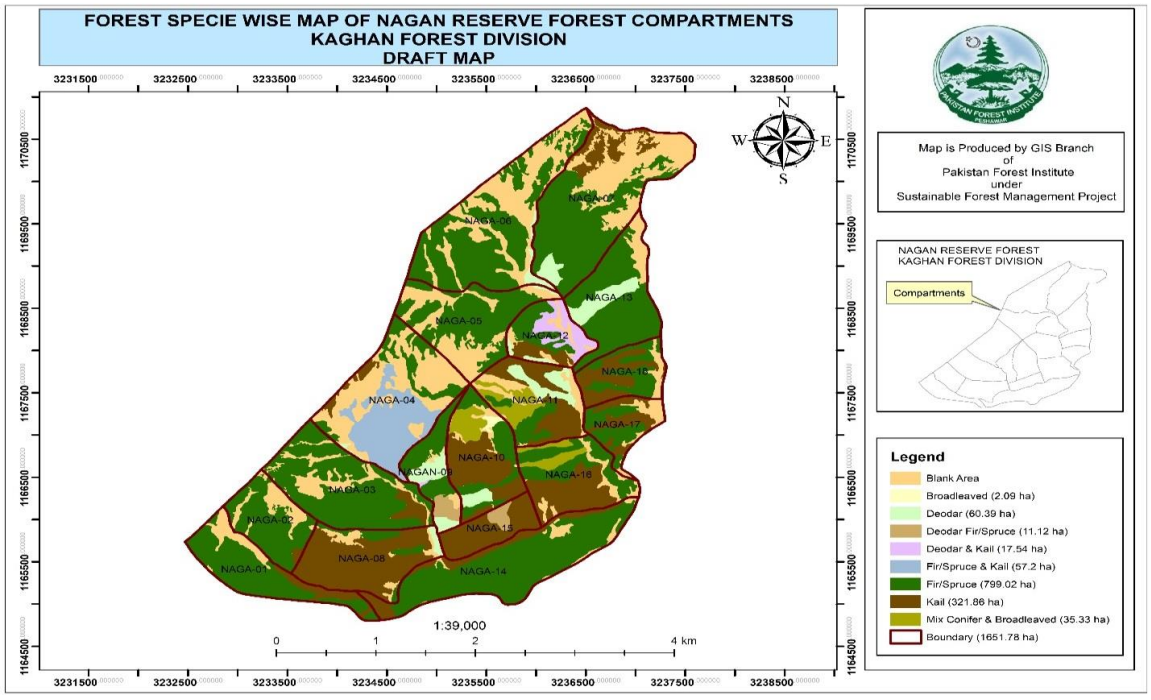
A field survey was carried out in Kaghan Forest division for specie wise mapping of reserve forest. Forest was classified into species in the presence of the concerned staff of forest department and draft maps were developed in the GIS Branch. The draft maps prepared were dispatched to the concerned divisions for further rectification.

Species maps were produced for each compartment with calculated covered area by forest species. Some of the output maps are given below.





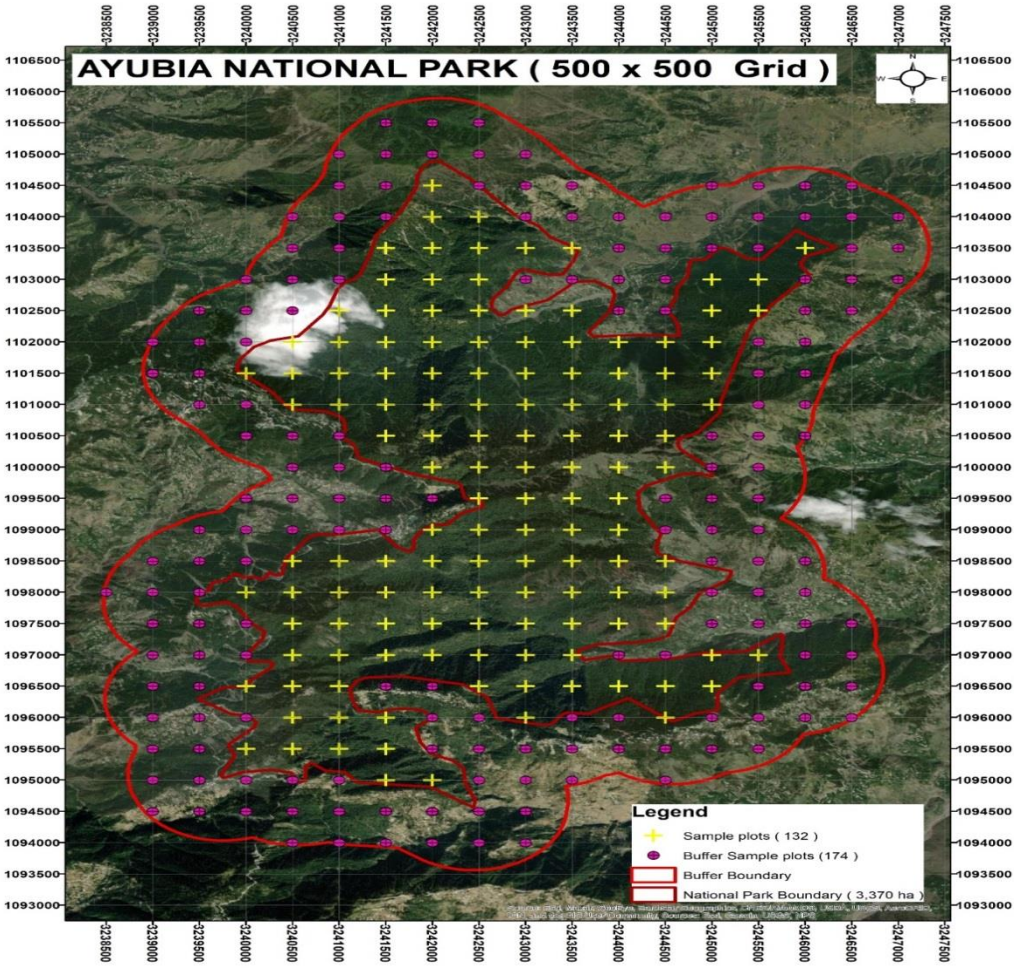

FOREST SPECIE WISE MAP OF MALKANDI RESERVE FOREST
KAGHAN FOREST DIVISION
DRAFT MAP
Map is Produced by GIS Branch
of
Pakistan Forest Institute
under
Sustainable Forest Management Project
MALKANDI RESERVE FOREST
KAGHAN FOREST DIVISION
Malakandi Reserve Compartments
Legend
Blank Area
Broadleaved (97.3 ha)
Deodar (290.6 ha)
Fir/Spruce (613.6 ha)
Fir/Spruce & Kail (28.7 ha)
Fir/Spruce & Broadleaved (61.3 ha)
Kail (399.2 ha)
Kail & Broadleaved (56.6 ha)
Deodar & Kail (118.7 ha)
Compartment Boundary (1899 ha)
1:51,500
0 0.75 1.5 3 km


FOREST SPECIE WISE MAP OF NAGAN RESERVE FOREST COMPARTMENTS
KAGHAN FOREST DIVISION
DRAFT MAP
Map is Produced by GIS Branch
of
Pakistan Forest Institute
under
Sustainable Forest Management Project
NAGAN RESERVE FOREST
KAGHAN FOREST DIVISION
Compartments
Legend
Blank Area
Broadleaved (2.09 ha)
Deodar (60.39 ha)
Deodar Fir/Spruce (11.12 ha)
Deodar & Kail (17.54 ha)
Fir/Spruce & Kail (57.2 ha)
Fir/Spruce (799.02 ha)
Kail (321.86 ha)
Mix Conifer & Broadleaved (35.33 ha)
Boundary (1651.78 ha)
1:39,000
0 1 2 4 km

1.3.2 Temporal Assessment of Fforest Cover Change in Ayubia National Park under SFM Project

Location:	Kaghan
Year of commencement:	2020
Principal Investigator:	Mr. Aamir Shakeel, GIS Specialist
Co-Principal Investigator:	Mr. Tahir Iqbal (Technical Assistant)
	Mr. Ziad Raza (Technical Assistant)
	Mr. Muhammad Ajmal (Technical Assistant)

The primary objective of the activity is to conduct “Temporal assessment of historic forest cover change in Ayubia National Park (ANP)”. Combination of GIS, GPS and RS technologies will be used to detect change in Forest Cover of ANP. In 1984, ANP was notified as National Park. 1990 was considered as baseline for the multi-temporal assessment. Following Maps were developed for the study.



Miscellaneous

- Taught courses of Silviculture, Forest Management, Forest menusration, Forest research methods, Forest statistics and GIS & RS to M.Sc, B.Sc. and BS Forestry classes.

- Supervised M.Sc. & BS Forestry students for their thesis.

1.4 WATERSHED MANAGEMENT

1.4.1 Compilation of Meteorological data recorded at Watershed Observatory Pakistan Forest Institute, Peshawar.

Location:	Pakistan Forest Institute
Data of commencement:	July 2020-June 2021
Principal Investigator:	Bilal Ahmed WMS
	Liaqat Ali, Forest Ranger

- Collection of meteorological data including maximum, minimum & daily temperatures, relative humidity, evaporation, sunshine duration, and rainfall at PFI, observatory on daily basis from July 2020 to June 2021.

- Compilation of meteorological data including maximum, minimum & daily temperatures, relative humidity, evaporation, sunshine duration and rainfall on daily basis during from July 2020 to June 2021. The compiled data is as Under:

Month	Maximum Temp	Minimum Temp.	Daily Temp.	Relative Humidity	Evaporation	Sunshine	Rainfall
	(C°)	(C°)	(C°)	(%)	(mm)	(hrs.)	(mm)
July	41.36	24.86	33.59	59.20	8.51	6.14	--
August	39.1	23.7	30.9	78.0	10.3	5.32	238
September	35.7	22.2	28.50	71.4	7.4	2.99	211
October	32.5	12.7	24	54.7	5.5	3.5	--
November	22.6	6.25	16.1	75	3.7	2.9	79
December	16.4	1.6	10.5	84.2	1.8	4.8	67
January	18.2	1.2	9.5	81.3	1.8	4.1	--
February	23.5	5.3	14.5	78.6	4.2	3.46	65.3
March	27.51	11.27	20.86	64.61	6.95	5.27	34.7
April	31.95	13.68	25.45	52.80	11.89	6.14	20.70
May	43.12	9.75	27	50.7	9.4	7.7	3.8
June	47	14.72	33.40	68.68	16.21	6.3	0.9
Average for the whole year	31.5	12.26	22.85	68.26	7.3	4.88	
Total Annual Rainfall							720.4

Education & Training

- Taught Forestry Extension & Forest Fire Management course to B.Sc. & M.Sc. Forestry Classes.
- Taught Sociology to B.Sc., M.Sc. and BS Forestry students.
- Conducted the Practical examination of M.Sc. Forestry students as an

Internal Examiner

- Supervised the research thesis of M.Sc. Forestry students.

2. FOREST PRODUCTS RESEARCH DIVISION

2.1 LOGGING

2.1.1 A Study on Dendroclimatic Potential of Deodar (*Cedrus deodara*) growing in Medani Forest Area, Kalam

Date of commencement: 2020-21
Principal Investigator: Tanvir Hussain, Logging Officer

Background

The science of studying tree rings to learn something about changes in the environment is called dendroclimatology, and it can be used to analyze patterns of processes and events in the natural, physical, and cultural sciences. Since the growth rate of a tree is sensitive to both natural and human-induced events, conditions during a given year will be either favorable or unfavorable for the tree growth resulting in a variation in ring width from year to year throughout the life of a tree. This pattern of wide and narrow growth rings can serve as an indicator to monitor environmental processes in most regions around the world. However, the responses of different species and sites to various climatic parameters are unusual. Studies have shown that conifers could be used in climatic investigations in the Himalayan region. The suitability of any tree species in tree ring studies depends upon its ring width characteristics i.e., sensitivity, cross match ability of narrow/wide rings and correlation among samples of a tree or between trees.

Cedrus deodara growing at Medani Forest area of Kalam valley has not yet been explored for dendroclimatological studies. Therefore, the present study has been designed with the objective to assess the potential of Deodar for this purpose, gather information about the climatic changes that have happened within 50 years and to find relationship between the climate and growth of Deodar (*Cedrus deodara*) grown in dry temperate climatic conditions of this areas.

Methodology

To conduct research work 20-30 cores were extracted from the trees of study site (table1). The core samples were air dried, mounted on wooden core holders and then sanded for smooth surfacing. Each core was examined under the variable power of microscope and their visual cross-matching among the cores were established. This procedure allows false or double and missing rings to be detected from ring-width series. A few cores were rejected at this stage. The cores showing good cross-matching were measured to the nearest 0.001mm using the most advance WinDendro System. The measurement series from each core was then cross-checked for possible dating errors using the software Cofecha. The cross dated series were then compiled into site chronology using the program dplR of R package. The age related growth effects were removed by single detrending using the Negative exponential Curve options in the program. For similar reason, the “Standard” chronologies from the output were selected for subsequent modeling. To strengthen the reliability of developed chronologies, pointer and even years of each study site chronology were determined using pointRes program of R packages.

To provide more insight into the relationship between the trees growth and climate, the Correlation function Analyses (CFA) were calculated by using computer based program "treeclim" of R package. The period of tree growth in the region is generally thought to commence around March and cease by the end of September, so the 12-month interval of October in the previous year to the end of current growing season (September) was selected. Included in the analysis was the investigation of the contribution for 4-years of prior growth.

Table 1. Site characteristics of Medani Forest Area, Kalam

Site Name	Latitude	Longitude	Aspect	Slop %	Elevation (ft)
Kalam	35.25	72.75	North-East	7-20	6000-7000

Results and Discussion

Climatic Data Analysis

Climatic data of Kalam collected from Climate Research Unit (CRU), having a grid size of 0.5 X 0.5 degree (50 km x 50 km) was used to study the impacts of climatic changes on the tree growth parameters of Deodar (*Cedrus deodara*) grown in this area. The Climate diagram for mean temperature and precipitation was constructed for the time scale of 1970-2020 as shown below in figure 1. The Climate diagram represented that July is the hottest month having mean temperature of 16.71°C with monthly mean precipitation 85.33 mm while January was recorded the coldest month with a precipitation of 62.74 mm. During the study period maximum and minimum mean annual temperature was recorded during the year 2020 (9.68^{o}C) and 1997 (6.14^{o}C) respectively. In case of rainfall, the minimum and maximum total annual precipitation was measured during the year 1971 (485.7 mm) and 2005 (1356.5 mm) correspondingly. A significant increase ($r=0.43$; $p<0.05$) of 0.90°C in mean annual temperature and a non-significant increase ($r=0.14$; $p>0.05$) 80.75 mm in total annual precipitation was calculated for the study period of 1970-2020.

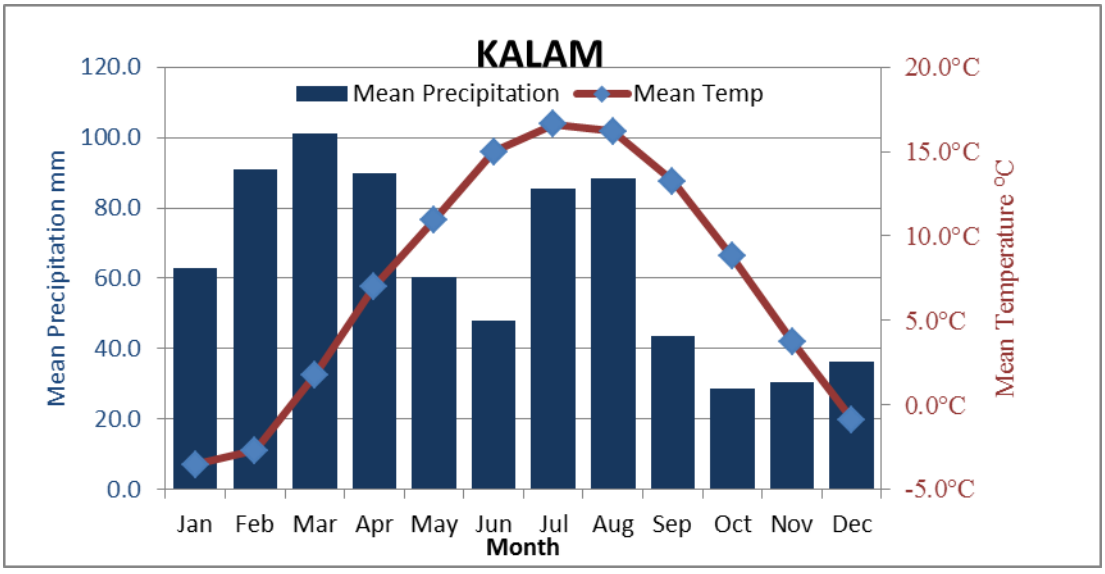


Figure1: Climatogram of Kalam Meteorological Data for the period (1970-2020)

Tree Ring Chronology Development

Summary of COFECHA analysis is presented in table 2 and figure 2. The chronology varies from 68 to 137 years. Correlation with master chronology ranges from 0.069 to 0.826 with an average of 0.484. The amount of auto correlation was dropped significantly from 0.84 to 0.015 after filtration. No absent or double rings were detected. It is also shown in figure 2 that out of 30 wood samples (cores), 20 were selected. Although the mean sensitivity showed a low value of 0.143 but it is acceptable internationally for dendro-climatic potential of a study for a particular study site. The parameter Rbar tells the signal strength of the chronology and explores the common signal strength of the series based upon the sample depth and the value detected 0.59 showed higher climatic signal in the chronology. Chronology confidence and strength of the common signal in the chronology is also determined by EPS and a value of 0.85 is considered reasonable but no minimum value is determined to ensure that a chronology is suitable for studying climate-growth relationships to reconstruct past climatic factors like temperature, precipitation etc. Therefore, the value of 0.995 showed suitability of tree ring chronology developed from the site of Medani Forest area, Kalam. SNR is an expression of the strength of the observed common signal among tree ring indices in the assemble and its high value indicated higher climatic signals in the chronology and the detected value (21.128) revealed a higher climatic signal suitable for the establishment of climate-growth relation for the study site.

Table 2: Descriptive Statistic using Cofecha and ARSTAN program.

Site	COFECHA						ARSTAN		
	Chrono. Span	[1]Corr with Master	[2]Mean msmt	[3]Std Dev	[4]Auto Corr	[5]Mean Sens	[6]Rbar	[7]EPS	[8]SNR
MFA	1884-2020	0.484	1.90	0.697	0.842	0.143	0.59	0.955	21.128

Note: 1= correlation with master chronology, 2= Mean ring width, 3= Standard deviation, 4= Autocorrelation, 6= Mean sensitivity, 7= mean inter- series correlation, 7= Expressed population signal, 8= Signal-to-noise ratio, KFD= Medani Forest Area of Kalam

Seq	Series	Interval	No. Years	No. Segmt	No. Flags	Corr with Master	//-------- Unfiltered --------\\ Mean msmt	Max msmt	Std dev	Auto corr	Mean sens	//---- Filtered -----\\ Max value	Std dev	Auto corr	AR ()
1	KLM19	1884 2020	137	5	0	.826	1.79	3.00	.508	.858	.117	2.58	.374	-.036	1
2	KLM11	1896 2020	125	5	0	.841	1.82	2.97	.517	.868	.113	2.62	.422	-.017	1
3	KLM12	1902 2020	119	4	0	.608	1.84	2.61	.442	.927	.066	2.71	.434	.011	1
4	KLM13	1906 2020	115	4	0	.659	1.87	2.64	.408	.897	.075	2.71	.539	.020	1
5	KLM15	1906 2020	115	4	0	.787	1.86	2.41	.375	.907	.068	2.52	.391	-.009	3
6	KLM17	1909 2020	112	4	0	.709	1.96	3.40	.563	.844	.121	2.64	.502	.000	1
7	KLM09	1916 2020	105	4	0	.453	2.21	4.33	.860	.865	.183	2.64	.447	-.009	2
8	KLM10	1919 2020	102	4	0	.419	1.84	3.73	.696	.856	.147	2.63	.445	-.047	1
9	KLM14	1921 2020	100	4	1	.479	1.99	4.63	.870	.764	.238	2.69	.507	-.001	1
10	KLM02	1922 2020	99	4	2	.423	1.75	4.10	.666	.893	.125	2.59	.444	.022	1
11	KLM01	1923 2020	98	4	0	.493	2.05	6.79	1.066	.880	.150	2.87	.526	-.058	1
12	KLM16	1924 2020	97	4	2	.335	2.20	7.01	1.208	.919	.135	2.55	.359	-.033	2
13	KLM03	1925 2020	96	3	0	.593	1.78	3.05	.506	.791	.137	2.52	.417	-.049	1
14	KLM18	1926 2020	95	3	1	.292	1.74	4.00	.776	.873	.171	2.64	.389	-.003	1
15	KLM08	1928 2020	93	3	2	.264	1.90	5.88	.956	.814	.175	2.46	.314	-.051	1
16	KLM07	1932 2020	89	3	1	.285	2.05	4.00	.706	.580	.246	2.69	.573	-.001	2
17	KLM20	1935 2020	86	3	3	.147	1.99	3.05	.450	.756	.127	2.57	.546	-.032	2
18	KLM04	1941 2020	80	3	2	.244	1.97	7.98	1.608	.925	.184	2.68	.511	-.061	1
19	KLM05	1942 2020	79	3	3	.102	1.54	3.24	.635	.792	.227	2.35	.317	.049	1
20	KLM06	1953 2020	68	2	2	.069	2.02	3.40	.491	.713	.149	2.57	.510	-.003	2
Total or mean:			2010	73	19	.484	1.90	7.98	.697	.842	.143	2.87	.446	-.015	

Figure 2: Cofecha statistics of tree ring chronology from Medani Forest, Kalam.

Figure 3 represents the results of *Cedrus deodara* tree ring width chronology developed after detrending and standardization procedure. The chronology covered span of 136 years from 1884 to 2020. The trend line showed an increase of ring width from 1920 to 1940, 1955 to 1980, and then from 1985 to 1998. From 1940 a decline happened upto 1945 and after 1998 a continuous decrease in growth was observed upto 2020. The negative pointer year detected for this study site may be considered the year 1984, where a decrease in ring width can be seen while 1894 and 1911were found positive pointer years. 1915 and 1944 were detected as negative event years whereas 1912,1928 and 1940 were detected as positive event years (Figure 4).

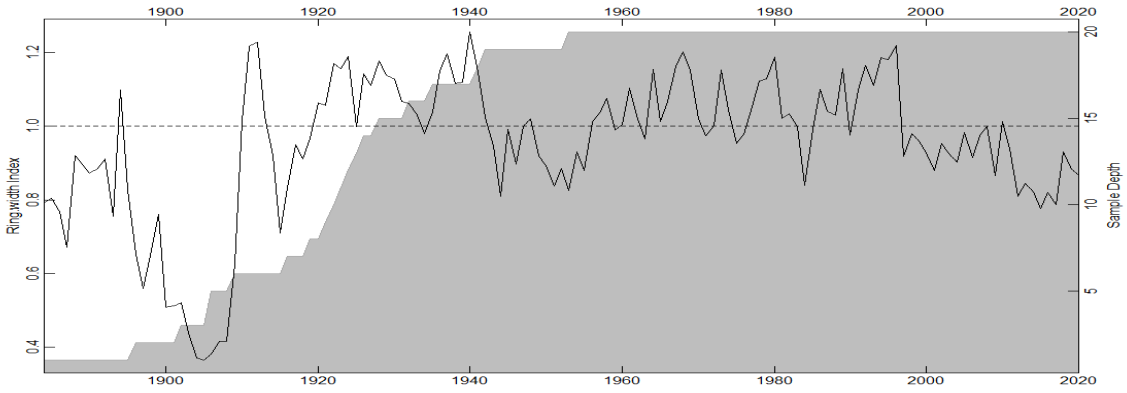


Figure 3. The regional tree ring width Chronology from 1884-2020 in Medani Forest Area, Kalam. The gray area represents the sample depth.

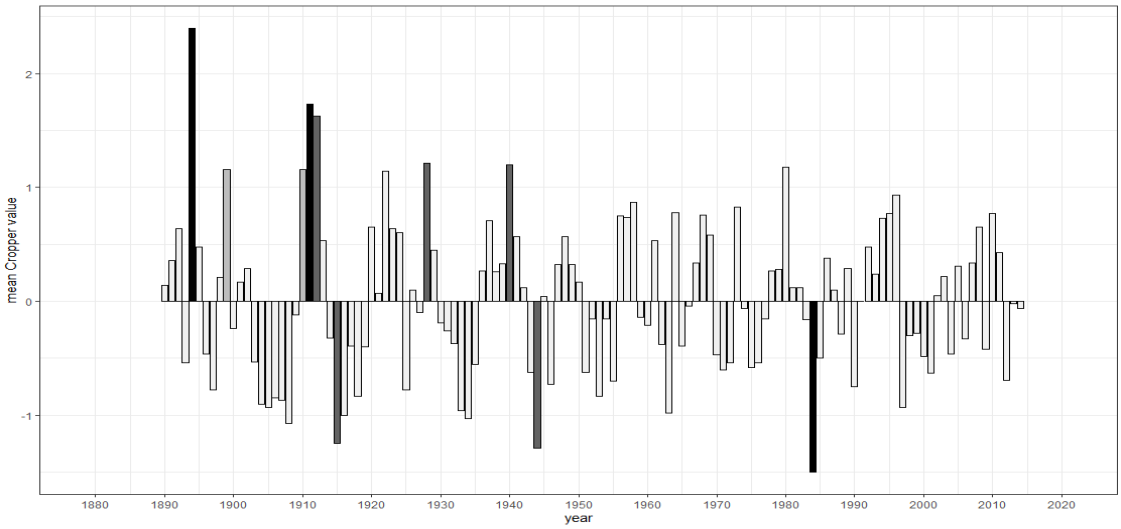


Figure 5. Positive and negative pointer and event years from 1888-2020 of Deodar growing in Medani Forest Area, Kalam.

Climate-Growth Relationship

Correlation function analysis (CFA) of tree ring width of Deodar from Kalam Medani Forest and climatic factors is represented in figure 5. It is evident that precipitation of previous year December is significant predictor for tree growth of Deodar in this area which means that if more precipitation is available during the previous year, wider ring formation may happened in current growth year. On the other hand, temperature during the previous year September showed significant negative correlation coefficient value which represented that narrow ring width may happened during the current growth year. The other positive significant variables of precipitation were found during current year May and July indicating positive influence on the growth of Deodar in view of good availability of water for carrying out the process of photosynthesis. In case of temperature, again significant negative relationship were found in current year May, July, August and September which mean that high temperature in this area is not favoring the growth of this species and may be drought stress signal if suitable level of precipitation is not available. High temperature causing the melting of ice and ultimately providing plentiful supply of water during the growth period of this species. Further, very low temperature during the month of January also showed negative effect due to less availability of precipitation for the growth of trees.

Since precipitation showed significant positive and temperature presented significant negative correlation with tree growth, it revealed that precipitation is acting as limiting factor during the growth period of Deodar in this area.

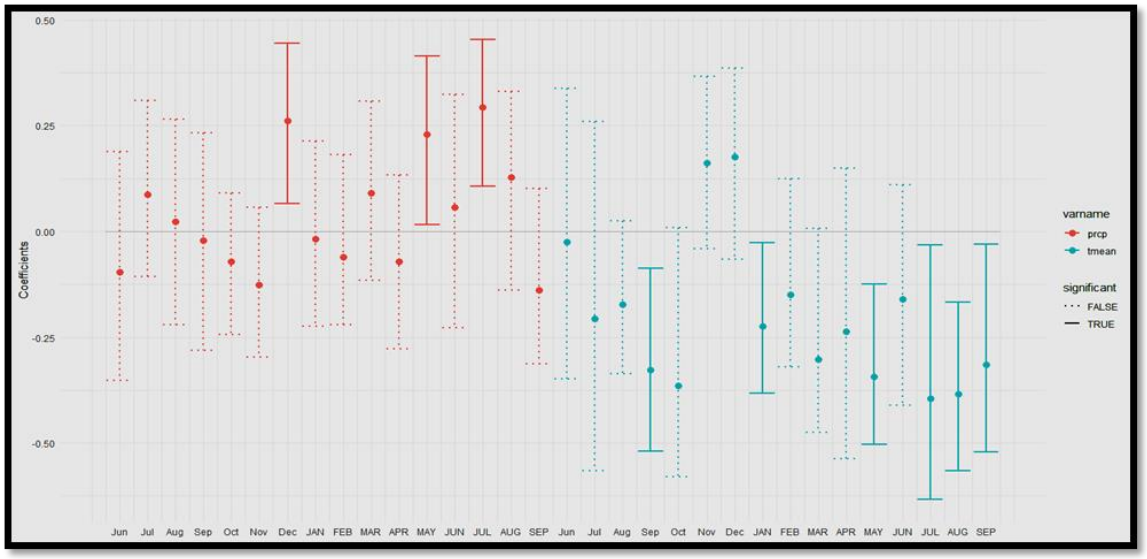


Figure 4. Correlation Function Analysis of Deodar tree ring width to mean annual temperature and precipitation. Solid Bars indicates 95% confidence limit of each element.

Conclusion

Based on the results it can be concluded that Deodar tree has good potential for dendroclimatic study and may be considered a sensitive species for the reconstruction of temperature or precipitation in Medani Forest of Kalam. A significant increase in mean annual temperature and a non-significant increase in total annual precipitation have happened in this area during the last 50 years which significantly influencing the growth of this species. Further, it was found that precipitation is acting as limiting factor during the growth period of Deodar in this area.

2.1.2 Assessment of dendrochronological potential of Siris *(Albizzia lebbeck)* grown in Peshawar

Location: Pakistan Forest Institute, Peshawar
Date of commencement: 2020-21
Principle Investigator: Khalid Hussain, Assistant Wood Technology Officer

Climate change is the endless variation in the characteristics of the global climate. However, this is a natural process, but in the recent past, systems have been altered by anthropogenic greenhouse gas emissions, resulting in elevated temperatures. The temperature rise is the main reason for extreme weather, i.e., famines, rainstorms, heat waves, variations in the flowering schedule of plants, and poleward range shifts of various genera and ecosystems. The continuity of these extreme weather happening may transform the system that may sustain life on earth. The earth's surface temperature is expected to rise up to 1.5–2.0°C by the end of the 21st century. According to climate change studies, almost 20-30% of plant and animal species may become extinct if the temperature reaches the expected level. Elevated temperature and changes in precipitation patterns are significant signs of climate change. Therefore, temperature and precipitation variations can be used to detect and quantify possible future changes in the climate.

Plants, being living entities, are sensitive and able to preserve variations in the climate because the climate frequently controls tree growth. These preserved variations are constant in time though due to the long life of trees; climate change variations can be traced back to the long past.

Pakistan is one of the most climate change-vulnerable countries in the world. Thus, it requires an understanding of the nature and impacts of this phenomenon for the sustainable planning and management of forests, water, and other natural resources. Hence, determining the response of the different plant species toward this changing environment scenario may help select the more adaptable and climate change-resistant species.

Siris *(Albizia lebbeck)* is a fast-growing, locally grown deciduous species. Widely distributed through tropical and subtropical regions and found almost all over Pakistan. The tree is moderately intolerant, grows on various moist sites, and requires a summer precipitation zone of 400 to 1000 mm/yr. It prefers a sub-humid, cold, warm, sub-tropical, and tropical climate with a temp: range of 4◦-40◦C and an elevation range of 0 to 1600 m. Growth rings are distinct but unremarkable, delimited by terminal parenchyma.

This study was initiated to check the adaptability, response, and survival capacity of the Siris *(Albizzia lebbeck)* in these changing phenomena of the environment. *Dendrochronology* is the field that may help well in the assessment of the species' potential for adaptability and sustainability in coping with climate change.

Samples of the species were collected from Peshawar; the collected samples were planned and sanded in the wood workshop at Pakistan Forest Institute. After planning and sanding, the annual rings were traced with a pencil to avoid measuring false and incomplete rings. Planned, sanded, and traced discs were scanned on a computer-attached scanner, and images of 1200 DPI were generated. The images were uploaded to the CooRecorder & CDendro, a computer program to measure rings and cross-date. COFECHA and ARSTAN, two computer Software, were used to check the cross-dating quality and generate the chronology, respectively.

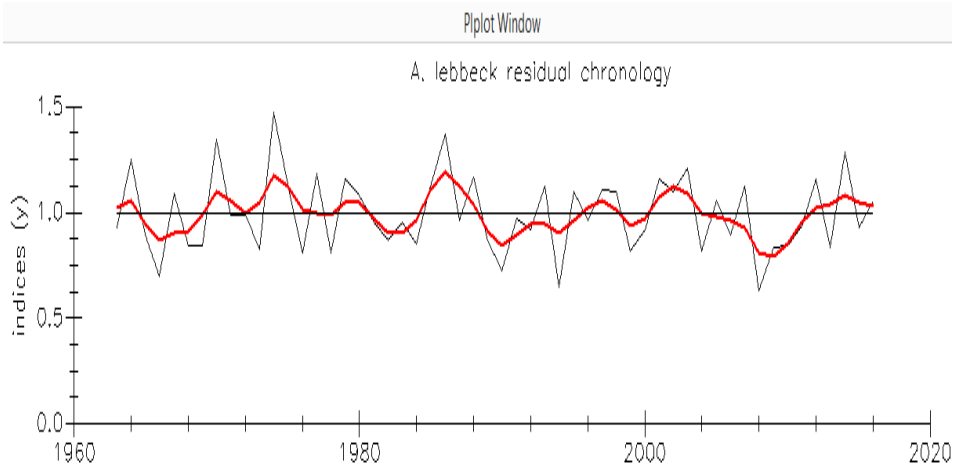


Fig 1. Master chronology (residuals) of *A. lebbeck* at Peshawar

Table 01. Statistical description of dendrochronological potential and TRW-CLIMATE relationship

Descriptive statistic				Dendrochronological Potential						Assessment of TRW-CLIMATE relationship						Vessel Description		
										TRW-PRECIPITATION			TRW-TEMP(◦C)			Vessel Diameter-Precipitation relationship		
Growth rings per inch	MV	SD	CV	CC	T	*Gleichläufigkeit*	SI	MS	AC	R	r^2	Sig	R	r^2	Sig	r	r^2	Sig
3-5	1.02	0.184	18.12 %	0.82	8.5	0.81	0.234	0.293	-0.002	-0.403	16.24 %	0.023	-0.007	0.5%	0.597	-.249	6.20%	0.160

The study showed moderate limitations of the climate on growth of the Siris grown in Peshawar. The species revealed moderate dendrochronological potential and an ability to receive climatic signals. The species is sensitive to the climate as relationship was found significant between the Tree Ring Width and precipitation. Thus, the precipitation is a significant limiting factor in growth of the species. Therefore, the specie may be used as proxy to study rainfall in Peshawar. Moreover, vessel dimeter and precipitation relationship were found not significant. The rainfall ratio was found high in last three decades thus, the assumption that high rainfall may result in production of small vessels to limit the sap conduction which cause slow growth was not established. Moreover, the sample was short thus the results are only an assumption and may be changed if sample is increased.

2.1.3 A morphology of fiber of some wood species grown in Lal Koo Swat, Khyber Pakhtunkhwa

Location: Pakistan Forest Institute, Peshawar
Date of commencement: 2020-21
Principle Investigator: Said Akhtar Khan, Assistant Wood Technologist
Co-Investigator: Khalid Hussain, Assistant Wood Technology Officer
Tanvir Hussain, Logging Officer, Pakistan Forest Institute, Peshawar.

The study was conducted to assess morphological and anatomical characteristics for determination of technological properties of wood fiber of different tree species. Assessment of morphological and anatomical characteristics is necessary for better utilization of the wood fiber. Wood fiber is the most important element of the pulp and paper manufacturing industry. Moreover, wood fiber determines the resilience and resistance of wood against the insect attack, weathering and seasoning.

Pakistan is one of the largest countries that import raw pulp and ready-made paper and use huge amount of foreign reserve on this important commodity. However, Pakistan is an agricultural country where fertile land, variety of tree species and water

resources are available to produce the best quality wood for pulp and paper and furniture industry. This activity may help in saving the chunk of foreign reserves. In this study nine hardwood species were selected for study from Lal-koo, Swat, KP (Khyber Pakhtunkhwa).

Black Locust *(Robinia pseudoacacia)* commonly known as Robinia. This is a medium to large size deciduous tree. The tree is native to the southeast and central United States. Because of its adaptability it is grown throughout temperate zones in the world. In Pakistan it has been successfully established in the plains and in the hills of the Punjab and KP.

Brown Oak *(Quercus semecarpifolia)* is a moderate to large size tree. Locally known as Banjar, Kru and Khassu, Kharya. Mostly found from Afghanistan to Bhuta in the inner Hiamalya. In Pakistan it is found in Punjab, Kurram and Kashmir.

Himalayan poplar *(Populus ciliate)* commonly known as Palach. This is a large, deciduous tree. The trunk is erect and the crown spreading. The species is distributed through the Subcontinent, North and Central Asia, and North America. In Pakistan it grows in Azad Kashmir, Northern Areas, Gilgit, Murree Hills, Hazara, Swat, Dir, Chitral and Tirah.

Himalyan yew *(Taxus wallichiana),* which may be deciduous and evergreen. Native to the Himalaya and parts of south-east Asia. The species has a variety of uses in traditional medicine. It is currently classified as endangered by the IUCN.

Indian Willow *(Salix tetrasperma)* commonly known as Bed-i-Laila. A small to medium sized, deciduous tree. The trunk is erect, with a large crown.

Mulberry *(Morus alba)* is a moderate sized deciduous tree. The tree is locally known as Tut. Mostly found in the lower Himalayan and Sub-Himalayan tracts. Indigenous to China but now planted in all over Pakistan mostly in Punjab and KP.

Pohu *(Parrotiopsis jacquemontiana)* is a species of deciduous shrub or small tree native to the western Himalayas, particularly Kashmir, Murree, Hazara, the Swat, and Kurram.

Tree of Heavan *(Ailanthus latissimus)* is a large polygamous tree. Native in China, cultivated in temperate and subtropical regions of the world and often naturalized. In Pakistan it is cultivated as a roadside tree on hills.

Walnut *(Juglans regia)* is locally known as Akrot, Akhor, Khor a deciduous tree. Found in most part of the world. In Pakistan grown in the northern areas including Dir, Swat, Hazara, Murree Hills and Azad Kashmir.

The suitable samples of the selected species were collected from the wood anatomy laboratory in the form of blocks of one (01) cubic inch. The blocks were converted into long thin sticks 02-03 mm in diameter for maceration. Out of these sticks more suitable and defect free sticks were selected and put into test tubes along with 20% Nitric Acid and small amount of Potassium Chlorate. The test tubes were put into the beaker full of water for boiling; this mixture along with sample sticks were boiled

down at the hot plate for 02-03 days till all of the lignin were dissolved from the wood sticks.

After boiling and dissolving of lignin from the wood fibers, the filtration process was started. During filtration the filter paper was used to filter the residues of potassium chlorate and nitric acid. The tap water was used to filter the fibers; after filtration small amount of safranin was used for the staining of fibers. Stained fibers were mounted on the slide for optical analysis.

Nikon i55 microscope was used for collecting data of length, diameter and wall thickness of the fibers. After collection and compilation of data the statistical analysis was conducted and mean value, standard deviation, coefficient of variations, minimum and maximum values were collected. Micro Soft Excel, spreadsheet computational computer program, was used for the collection of descriptive statistical data in the studied species the fibers were mostly found non-libriform, medium coarse, more or less rounded and aligned in radial rows, in extensive tracts between the vessels and the rays which contain metatracheal parenchyma. Fibers in the outer margins of the rings are observed as tabular and thicker-walled forming a narrow, sharply defined lines delimiting the growth ring, frequently contiguous to the vessels. The fibers were seen mostly non-septate, non-gelatinous; inter-fiber pits found comparatively abundant, largely confined to the radial walls, minute, bordered, oval and obliquely orientated, with slit-like orifice reaching to or beyond the pit cavity; fiber lumina were observed mostly empty.

Table 1. Descriptive statistics of fiber length of the selected species

S.No	SPP. NAME	FIBER LENGTH (µ)					FIBER DIAMETER (µ)					FIBER WALL THICKNESS (µ)					Runkle Ratio
		MV	SD	CV	MIN	MAX	MV	SD	CV	MIN	MAX	MV	SD	CV	MIN	MAX	
	Allianthus altisimia	639.75	188.14	29.40	59.38	950.20	9.33	2.05	22.06	6.07	14.51	3.83	0.90	23.57	2.21	5.71	0.22
	Juglans regia	1364.82	230.24	16.87	918.00	1897.00	15.71	4.17	26.53	5.43	26.82	6.79	1.54	22.69	4.37	10.30	0.86
	Morus alba	1097.00	257.67	23.48	137.26	1541.59	13.50	2.86	21.17	9.48	20.74	6.91	1.26	18.21	4.53	9.78	0.12
	Parotia jacouemontiana	1341.35	280.60	20.92	886.05	2187.77	17.80	4.44	24.96	11.45	29.36	10.06	2.39	23.76	6.07	15.21	0.96
	Populus ciliate	490.89	170.23	34.68	306.78	852.26	16.44	4.77	29.02	7.08	26.48	3.12	0.81	26.03	1.63	4.75	0.62
	quercus semicorpifolia	738.67	214.29	29.01	312.37	1202.22	9.56	1.73	18.16	7.07	14.17	4.54	0.58	12.83	3.37	5.67	0.94
	Robinia pseudoacacia	1074.83	314.38	29.25	119.45	1798.08	40.87	11.62	28.43	19.20	71.46	17.95	4.16	23.16	10.06	31.25	0.24
	Salix tetrosperma	835.65	152.06	18.19	531.21	1144.09	8.41	1.69	20.08	5.43	12.41	5.05	1.30	25.86	2.71	8.58	1
	Taxus wallichiana	1025.54	276.04	26.92	239.00	1770.00	20.79	5.28	25.42	10.90	29.19	3.46	1.05	30.39	1.33	5.70	0.50

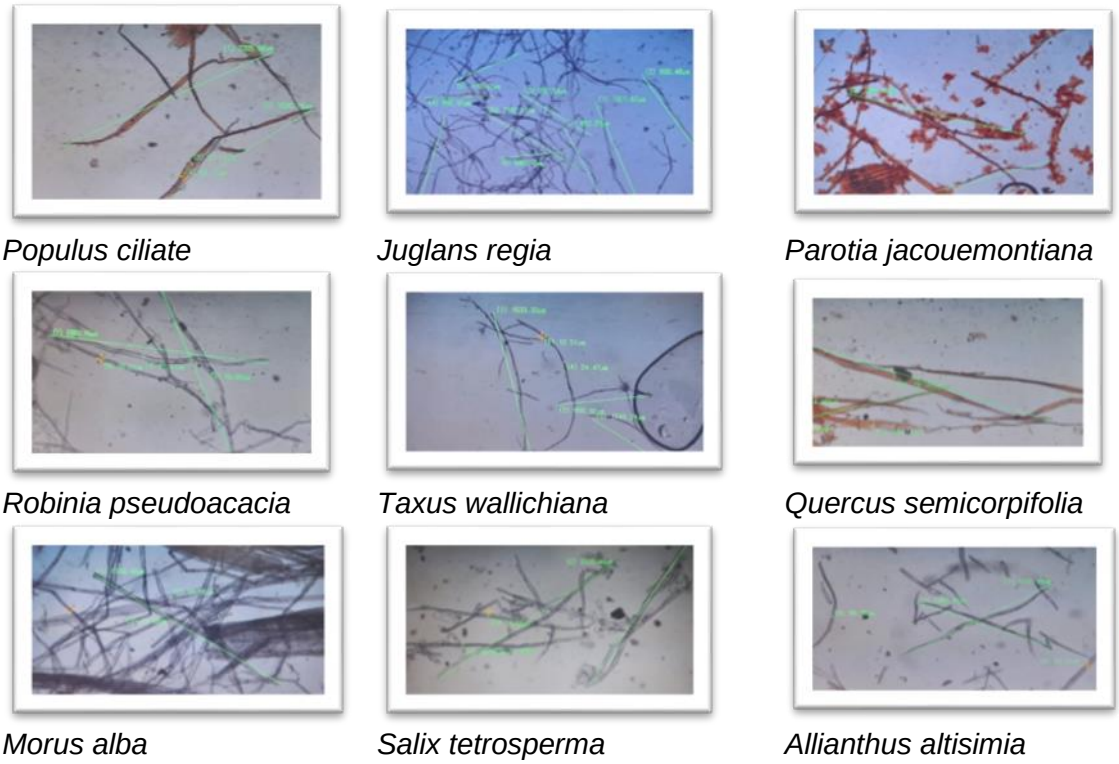


Fig. 1. Fibers of studied species

Walnut *(Juglans regia)* fibers were found comparatively very long i.e., mean value (mv) 1364.82±230.24 µ long (918-1897 µ) followed by Pohu *(Parotia jacouemontiana)* 1341.35±280.60 µ long (886.05-2187.77 µ), Mulberry *(Morus alba)* 1097±257.67 µ long (137.26-1541.59 µ), Black locust *(Robinia pseudoacacia)* 1074.83±314.38 µ long (119.45-1798.08 µ), Himalyan yew *(Taxus wallichiana)* 1025.54±276.04 µ (239.00-1770.00 µ), Indian willow *(Salix tetrosperma)* 835.65±152.06 µ long (531.21-1144.09 µ), Brown Oak *(Quercus semicorpifolia)* 738.67±214.29 µ long (312.37-1202.22 µ), Tree of Heavan *(Allianthus altisimia)* 639.75±188.14 µ long (59.38-950.20 µ) and Himalayan poplar *(Populus ciliate)* 490.89±170.23 µ long (306.78-852.26 µ).

Large fiber determines the quality of pulp and pulp, flexibility and resilience of the wood. Walnut fibers were found comparatively large in length which shows that walnut may produce better quality pulp and paper, wood articles with better flexibility and resilience followed by Pohu *(Parotia jacouemontiana),* Mulberry *(Morus alba)*, Black locust *(Robinia pseudoacacia)*, Himalyan yew *(Taxus wallichiana)*, Indian willow *(Salix tetrosperma)*, Brown Oak *(Quercus semicorpifolia)*, Tree of Heavan *(Allianthus altisimia)* and Himalayan poplar *(Populus ciliate)* wood.

Fibers of small diameter may produce a good quality of pulp and paper and its utilization may increase the quality of paper. Moreover, small diameter of fiber may increase the frequency of fibers in wood that may give a good strength and flexibility to the wood articles.

Fibers in *Salix tetrosperma* were found with small diameter i.e., mean value 8.41±1.69 µ long (5.43-12.41 µ) followed by *Ailanthus altisma* 9.33±2.05 µ long (6.07-14.51 µ), *Quercus semicorifolia* 9.56±1.73 µ long (7.07-14.17 µ), *Morus alba* 13.50±2.86 µ long (9.48-20.74 µ), *Juglans regia* 15.71±4.17 µ (5.43-26.82 µ),

Populus ciliate 16.44±4.77 µ long (7.08-26.48 µ), *Parotia jacouemontiana* 17.80±4.44 µ long (11.45-29.36 µ), *Taxus wallichiana* 20.79±5.28 µ long (10.90-29.19 µ) and *Robinia pseudoacacia* 40.87±11.62 µ long (19.20-71.46 µ).

Fiber wall thickness shows the strength, rigidity and a resistance against the fungal and insect attack of the wood. Fiber wall was found comparatively thin in *Populus ciliate* with mean value 3.12±0.81 *µ* long (1.63-4.75 *µ*) followed by *Taxus wallichiana* 3.46±1.05 *µ* long (1.33-5.70 *µ*), *Ailanthus altisma* 3.83±0.90 *µ* long (0.90-23.57 *µ*), *Quercus semicorifolia* 4.54±0.58 *µ* long (3.37-5.67 *µ*), *Salix tetrosperma* 5.05±1.54 *µ* long (2.71-8.58 *µ*), *Juglans regia* 6.79±1.54 *µ* long (4.37-10.30 *µ*), *Morus alba* 6.91±1.26 *µ* long (4.53+9.78 *µ*), *Parotia jacouemontiana* 10.06±2.39 *µ* long (6.07-15.21 *µ*) and *Robinia pseudoacacia* 17.95±4.16 *µ* long (10.06-31.25 *µ*).

Runkel ratio determines the quality of wood fiber for pulp and paper quality. The Runkel ratio less than 1.00 is considered better for pulp and paper making industry due to better beating capacity. Runkel ratio was found comparatively very low in *Morus alba* 0.12 followed by *Ailanthus altisma* 0.22, *Robinia pseudoacacia* 0.24, *Taxus wallichiana* 0.50, *Populus ciliate* 0.62, *Juglans regia* 0.86, *Quercus semicorpopifolia* 0.94, *Parotia jacouemontiana* 0.96 and *Salix tetrosperma* 1.00.

Juglans regia fibers were found comparatively large in length which shows that walnut may produce better quality pulp and paper, wood articles with better flexibility and resilience followed by *Parotia jacouemontiana*, *Morus alba*, *Robinia pseudoacacia*, *Taxus wallichiana*, *Salix tetrosperma*, *Quercus semicorpopifolia*, *Ailanthus altisma* and *Populus ciliate*.

Salix tetrasperma fibers were found with small diameter which reveals that the Salix tetrasperama wood may be used to produce good quality paper followed by *Ailanthus altisma*, *Quercus semicorpopifolia*, *Morus alba, Juglans regia*, *Populus ciliate*, *Parotia jacouemontiana*, *Taxus wallichiana* and *Robinia pseudoacacia*.

Moreover, thin fiber may be high in frequency in a wood; this high frequency may increase the resistance against the fungal and insect attack on wood article thus increasing the life of a wood article. Thus, the wood articles made of thin fiber wood may be longer in life. Wood articles from *Salix tetrasperma* may resist well against the fungal and insect attack on the basis of fiber diameter followed by *Ailanthus altisma*, *Quercus semicorpopifolia*, *Morus alba*, *Juglans regia*, *Populus ciliate*, *Parotia jacouemontiana*, *Taxus wallichiana* and *Robinia pseudoacacia*.

Fiber wall thickness shows that the strong, rigid and resistant wood articles may be produced from the *Populus ciliate* followed by *Taxus wallichiana*, *Ailanthus altisma*, *Quercus semicorifolia*, *Salix tetrosperma*, *Juglans regia*, *Morus alba*, *Parotia jacouemontiana* and *Robinia pseudoacacia*.

Runkel ratio reveals that better quality pulp and paper may be produced from the *Morus alba* followed by *Ailanthus altisma*, *Robinia pseudoacacia*, *Taxus wallichiana*, *Populus ciliate*, *Juglans regia*, *Quercus semicorpopifolia*, *Parotia jacouemontiana* and *Salix tetrosperma* wood.

2.2 WOOD MECHANICS

2.2.1 Equilibrium Moisture Content of Galliat and Peshawar

Location:	Pakistan Forest Institute, Peshawar
Date of commencement:	2020-21
Principle Investigator:	Zahid Rauf. Wood Seasoning and Preservation Officer

The dimensional changes accompanying the shrinking and swelling of wood are significant sources of furniture's visual and structural problems. Shrinking and swelling occur as the wood changes moisture content in response to daily and seasonal changes in the relative humidity of the atmosphere, i.e., when the air is humid, wood absorbs moisture and swells; when the air is dry, wood loses moisture and shrinks Various finishes and treatments May be used to slow this process, but, in general, they do not stop it. Likewise, air drying and kiln drying the wood do not prevent the wood from subsequently gaining or losing moisture. Thus, wood that is kiln dried to 6 percent moisture content and stored in a dry shed outdoors in a temperate climate like Indiana will retain moisture until it eventually reaches about 12 percent moisture content. Under the same conditions in a tropical environment, the wood will come to a moisture content of about 16 percent the moisture content of wood depends on the relative humidity and temperature of the air surrounding it. Suppose wood remains long enough in air where the relative humidity and temperature remain constant. In that case, the moisture content will also become constant at a value known as the equilibrium moisture content (EMC). Thus, relative humidity and temperature combination has an associated EMC value. The EMC increases with increasing relative humidity and decreasing temperature.

Accurate prediction of the equilibrium moisture content (EMC) of wood at given relative humidity and temperatures is essential in controlling wood products' quality. EMC values are helpful in engineering wood products. For example, the moisture content of wood during kiln-drying and manufacture should be matched to the expected EMC condition where the product will be used. This prevents shrinking and swelling defects.

To better understand the link between the equilibrium moisture content (EMC) and temperature, sorption isotherms of wood have been developed. Using this, we can better forecast how wood and composite panels will behave in different environmental conditions.

MATERIALS AND METHOD

Description of Study areas

Khyber Pakhtunkhwa province's Abbottabad District is located between 33°49' and 34°22' N. and 72°55' and 73°31' E. Abbottabad is the capital of Hazara Division, which have an area of 1,969 square miles. Mansehra, Muzaffarabad, Haripur, and Rawalpindi are all located in the immediate vicinity.

The population of Peshawar district in 1998 was 2,026,851. The city's annual growth rate is estimated at 3.29% per year, and the 2016 population of Peshawar district is estimated to be 3,405,414. With a population of 1,970,042 according to the 2017 census, Peshawar is the sixth-largest city of Pakistan and the largest city in

Khyber Pakhtunkhwa, with a population five times higher than the second-largest city in the province.

Climatic Data

Climatic data of Abbottabad and Galliat was taken from the metrological department Peshawar of three variables, i.e., temperature, precipitation and relative humidity of the past 20 years, i.e. 2000-2020. The summers are long, sweltering, and clear in Peshawar, and the winters are cold and mostly clear. Over the year, the temperature typically varies from 38°F to 106°F and is rarely below 32°F or above 112°F.

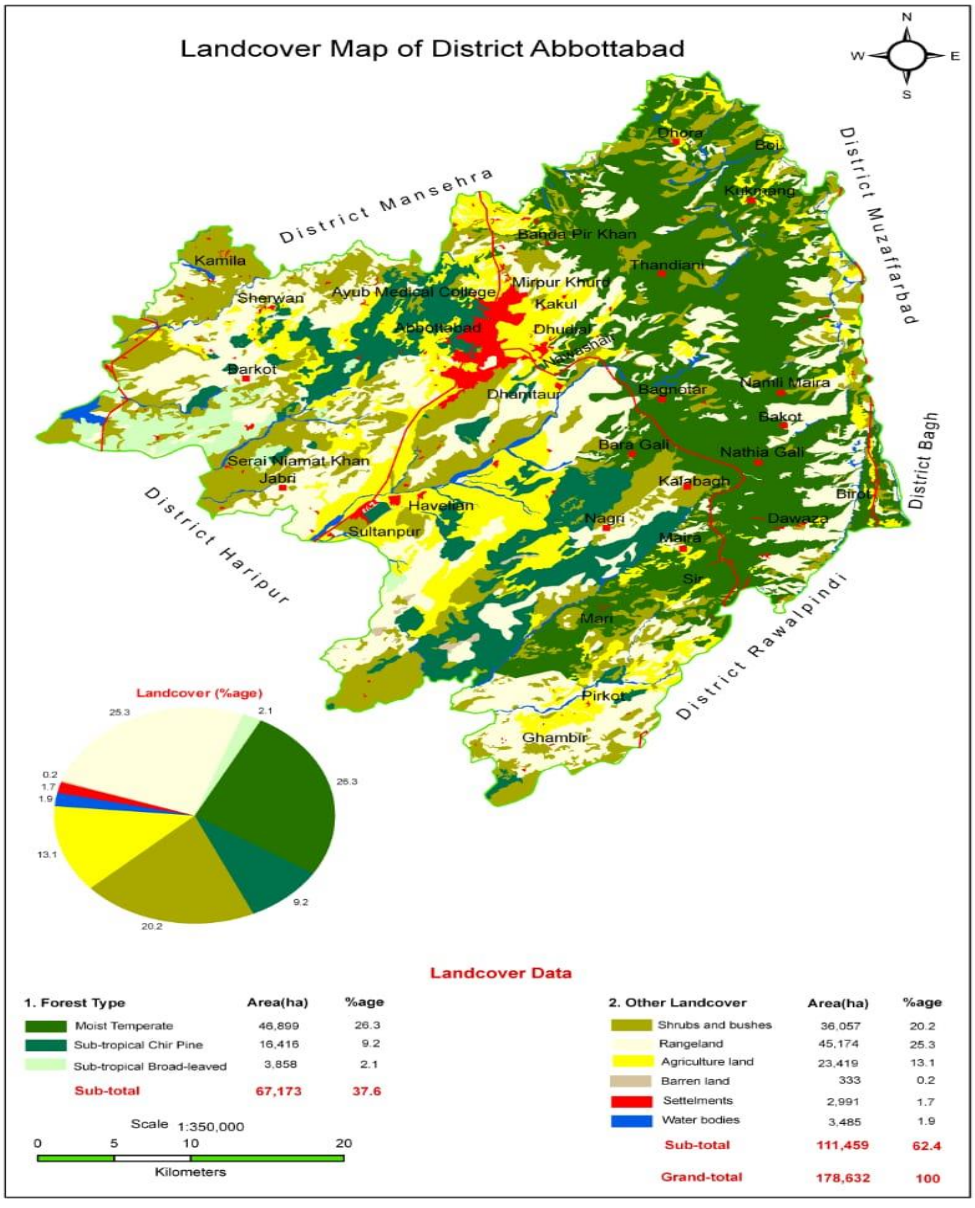


Figure shows Landcover map of Abbotabad and galiyat
(Source GIS Lab, PFI Peshawar)

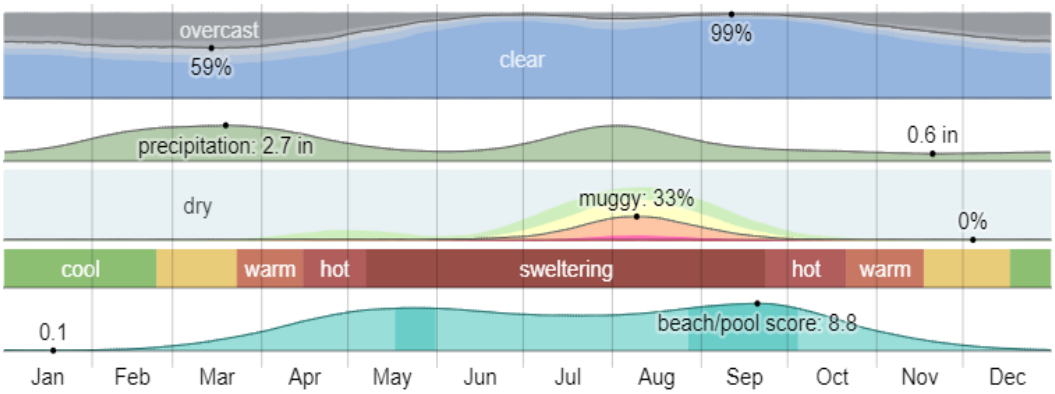


Figure illustrates Peshawar weather by month (source weather spark)

Calculation of EMC through Formula

Although the relationship between R.H. and moisture content is not linear, an increase in R.H.or a decrease in temperature will increase the predicted moisture content of wood after its equilibration with the air (EMC). The nonlinear nature of the RH-EMC relationship is a typical sorption isotherm and is described by sorption theory. An adsorption model employed by Simpson (1973) uses the approach developed by Hailwood and Horrobin (1946) to predict the EMC based on the combination of temperature and R.H. The form of the equation is as seen in Eq. 1.

$$EMC = \frac{1800}{W}\left(\frac{kh}{1-kh} + \frac{(k_1kh)+(2k_1k_2k^2h^2)}{1+(k_1kh)+(k_1k_2k^2h^2)}\right)$$

where EMC is the equilibrium moisture content (%), *h* is the relative humidity expressed in decimal form (%/100), and *W*, *K*, *K1*, and *K2* are coefficients defined by Eqs.2 through 5, respectively,

$W = 330+0.452T+0.00415T^2$ (2)

$K = 0.791+0.000463T-0.000000844T^2$ (3)

$K_1 = 6.34+ 0.000775T-0.0000935T^2$ (4)

$K_2 = 1.09 + 0.0284T-0.0000904T^2$ (5)

Where *T* is the dry-bulb temperature (°F)

Thus, given two pieces of information, dry-bulb (or ambient) temperature and the R.H., the EMC can be readily calculated.

Relative humidity May be measured directly with specific instruments. If the R.H. and temperature are given, then the Hailwood-Horrobin sorption equation (Eq. 1) can be used to calculate the EMC instantly. However, some instruments measure humidity in dew-point temperature or wet-bulb temperature. The following sections describe their use.

RESULTS AND DISCUSSION

Descriptive

The results of mean monthly EMC, standard deviation, Shapiro-p and Shapiro-w values are given in the table. These values are calculated based on the area's max & min temperature, precipitation, and relative humidity.

Table shows Mean monthly EMC, Standard deviation, Shapiro-p and Shapiro-w values of Galiyat and Abbotabad

Jan	Feb	March	April	May	June	July	August	Sep	Oct	Nov	Dec
N 21	21	21	21	21	21	21	21	21	21	21	21
Missing 0	0	0	0	0	0	0	0	0	0	0	0
Mean 10.4	11.1	10.5	9.38	8.20	8.57	12.2	14.1	11.9	9.87	10.1	9.42
Median 9.50	10.7	9.90	9.40	8.20	8.20	12.4	13.3	11.7	9.10	9.40	9.00
Standard 3.14	2.92	2.56	2.01	1.54	1.39	2.74	2.46	2.75	2.40	2.51	2.33
Minimum 7.10	6.90	7.00	6.10	6.40	6.10	6.10	11.7	8.00	6.90	7.60	6.30
Maximum 18.3	18.7	16.0	15.5	11.7	11.1	17.7	21.0	19.4	16.1	17.6	15.7
Shapiro-w 0.832	0.927	0.928	0.919	0.902	0.950	0.958	0.803	0.839	0.846	0.808	0.763
Shapiro-p 0.002	0.119	0.124	0.084	0.039	0.343	0.471	<.001	0.003	0.004	<.001	<.001

We collected climatic data from the metrological department of the following parameters temperature, rainfall, relative humidity of the past 20 years, i.e. (from 2000-2020). We calculated monthly and yearly equilibrium moisture content in wood for districts Abbottabad and Galiyat. The descriptive data of 20 years is present in table 4.1. Normality-tests were performed for statistical analysis.

Table shows Mean monthly EMC, Standard deviation, Shapiro-p and Shapiro-w values of Peshawar

	Jan	Feb	March	April	May	June	July	August	Sep	Oct	Nov	Dec
N	21	21	21	21	21	21	21	21	21	21	21	21
Missing	0	0	0	0	0	0	0	0	0	0	0	0
Mean	9.94	9.01	9.02	7.92	6.81	7.76	9.77	11.0	9.76	9.39	10.4	10.2
Median	10.0	8.90	8.80	8.00	6.60	7.30	10.0	10.8	9.90	9.30	10.3	9.90
Standard	1.21	1.55	1.73	1.27	1.22	2.47	1.18	0.974	0.770	0.965	1.21	0.896
Minimum	7.00	6.00	6.40	5.50	4.60	5.10	7.00	9.90	8.50	7.20	8.40	9.00
Maximum	12.3	11.4	12.1	9.70	8.50	17.3	11.7	13.6	11.9	11.5	12.8	12.0
Skewness	0.262	-0.173	0.314	-0.254	-0.0149	3.06	-0.641	1.24	0.751	-0.0430	0.346	0.347
Std. error	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501	0.501
Kurtosis	0.733	-0.452	-0.928	-0.867	-1.38	11.8	0.267	1.46	1.67	0.765	-0.682	-1.09
Std. error	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972
Shapiro-w	0.984	0.942	0.947	0.950	0.918	0.681	0.954	0.881	0.931	0.981	0.962	0.933
Shapiro-p	0.974	0.236	0.299	0.337	0.081	<.001	0.401	0.015	0.141	0.944	0.559	0.162

We collected climatic data from the metrological department of the following parameters temperature, rainfall, relative humidity of the past 20 years, i.e. (from 2000-2020). We calculated monthly and yearly equilibrium moisture content in wood for district Peshawar. The descriptive data of 20 years is present in table

Null Hypothesis:

H0: $\sigma^2_1 = \sigma^2_2$

The Alternative Hypothesis is a significant departure from normality; rejecting the null hypothesis in favour of the alternative indicates that the assumption of normality has not been met for the given sample.

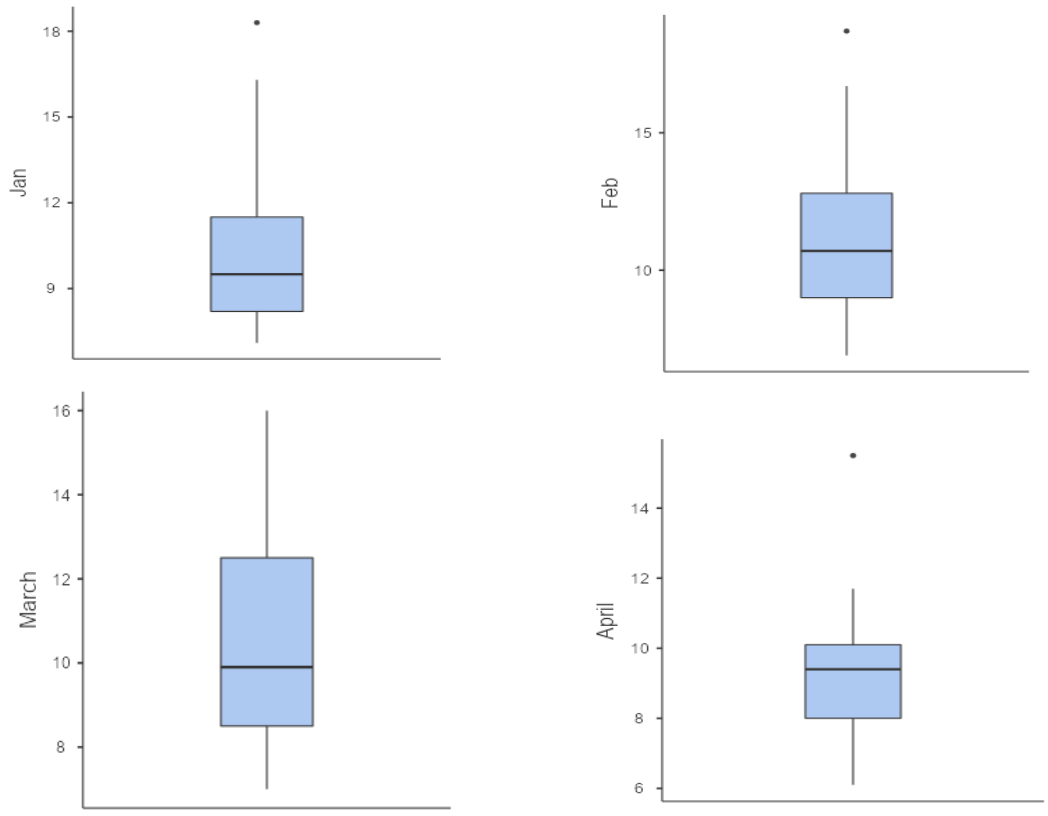
Alternative Hypothesis

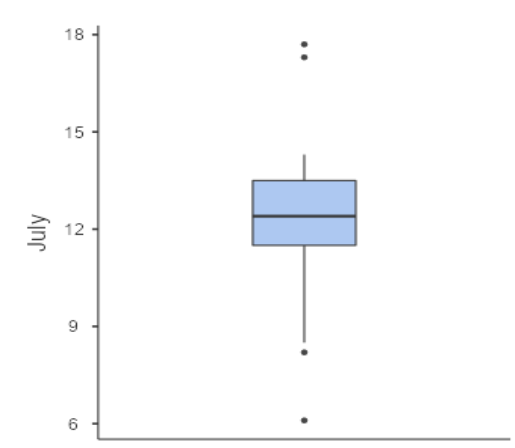
Ha: $\sigma^2_1 \neq \sigma^2_2$

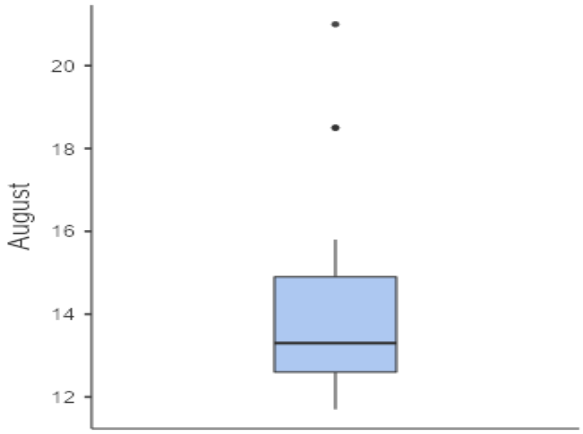
For Abbottabad and Galiyat, the results of January, February, March, April ,May, June, July, August, September, October, November and December, as shown in the descriptive table were subjected to normality test using Shapiro Wilktest. Table 4.2 shows that all the resulting p-value for February, March, April, June and July is more significant than 0.05(significance level or α) ($p > 0.05$); thus, we accept the null hypothesis, but the p-value for January, May, August, September, November and December is less than the significance level i.e.($p<0.05$) therefore we reject the null hypothesis.

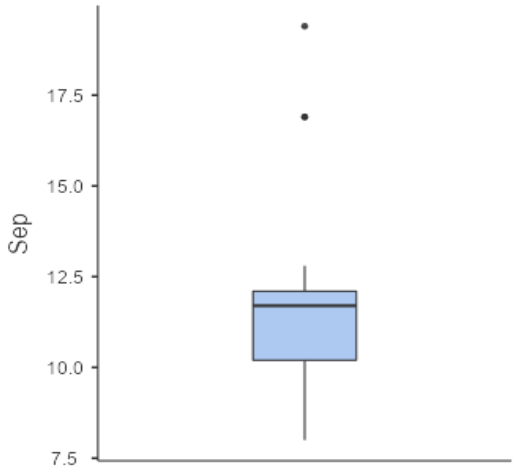
Similarly for Peshawar study area the results of January, February, March, April, May, June, July, August, September, October, November, December, as shown in the descriptive table, were subjected to a normality test using the Shapiro Wilk test. Table 4.2 shows that all the resulting p-value for January, February, March, April, May, July, September, October, November, December is more significant than 0.05(significance level or α) ($p > 0.05$); thus, we accept the null hypothesis, but the p-value for June and August is less than the significance level, i.e. ($p<0.05$) therefore we reject the null hypothesis.

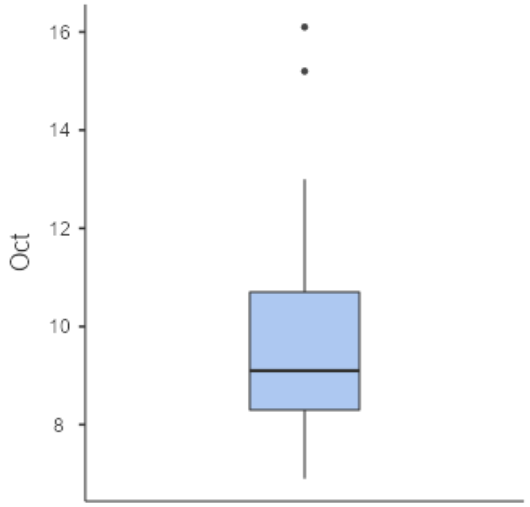
Box plots for Monthly equilibrium moisture content of Galiyat

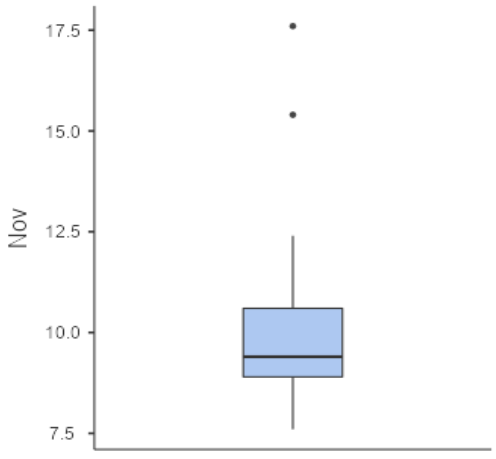


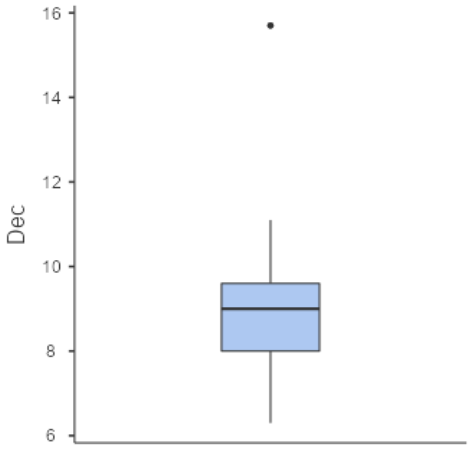

July
18
15
12
9
6


August
20
18
16
14
12


Sep
17.5
15.0
12.5
10.0
7.5


Oct
16
14
12
10
8


Nov
17.5
15.0
12.5
10.0
7.5


Dec
16
14
12
10
8
6

Conclusion

The results concluded that the mean monthly equilibrium moisture content of Abbottabad and Galiyat ranged from 14.1-8.20. The maximum value of equilibrium moisture content is recorded in August, and the lowest is recorded in May. The average value of equilibrium moisture content is 10.3. The equilibrium moisture content value of February, May, June, July, August and September differs significantly from the average value of equilibrium moisture content Based on conclusions, wood product manufacturers and consumers suggest that their wood products should be seasoned to 10.3 % for durability, strength, and longevity.

Similarly, it is concluded from the results that the mean monthly equilibrium moisture content of Peshawar ranged from 6.81-11.0. The maximum value of equilibrium moisture content is recorded in August, and the lowest is recorded in May. The average value of equilibrium moisture content is 9.17. The equilibrium moisture content value of February, March, April, May, June differs significantly from the average value of equilibrium moisture content. Based on conclusions, wood product manufacturers and consumers suggest that their wood products should be seasoned to 9.17 % for durability, strength, and longevity.

Miscellaneous

Various jobs/tasks related to Tree logging, woodworking, sawmilling, mechanical workshop, vehicle workshop were completed.

2.3 FOREST ECONOMICS

2.3.1 Compilation of Forestry Statistics

Location:	Pakistan Forest Institute
Year of Commencement:	2020-21
Principal Investigator:	Zahid Rauf, Director Forest Products Res. Div. Mir Azam, Asstt: Forest Economist.

Introduction

Development and conservation of Forests is of paramount importance in the world, as it is the only renewable natural resource, which is directly related with human existence, economically least expensive and environmentally most friendly. Forestry Statistics as hereby compiled to develop an efficient system of Data and Information on Forestry Statistics that could meet the growing demands of various Government Agencies, Environmentalists, and general public for Data on various aspects of Environment in Pakistan. The Forestry Statistics is a step in this direction.

In the regard, as per usual practice is to collect Data from office of Chief Conservator of Forests of respective Provinces in summary form. Letter and reminders were sent to the Chief Conservator of Forests for sending the Data for the year 2020-21, but the response is not encouraging. Report in hence finalized on basis of available Data, as per available Information some findings are given below:

Land Utilization

The geographical area of Pakistan including Azad Jammu & Kashmir and Gilgit-Baltistan is 87.98 million hectares. Of this, information on land use pattern is available for 59.49 million hectares (67% of total). The rest, 28.49 million hectares are unclassified. About 59% of unclassified area lies in the province of Baluchistan,

21% in Gilgit-Baltistan, 11% in Punjab, 6% in Khyber Pakhtunkhwa and 3% in Azad Jammu & Kashmir. At the time of independence, unclassified area constituted more than 50% of total land area. Against that, the percentage has now dropped to about 32.38%. This has happened due to extension in the coverage of area reported.

Pakistan is blessed with vast agricultural resources on account of its fertile land, well-irrigated plains, extremes of weather, and centuries old tradition of farming. It is because of its central importance in the economy that the Government has identified Agriculture as one of the four major drivers of growth. Cultivation of agricultural crops is the major use of land in Pakistan. The cultivable area amounts to 31.14 million hectares (35% of total area). The Punjab, Sindh, Baluchistan, Khyber Pakhtunkhwa, Gilgit Baltistan and Azad Jammu & Kashmir account for 45% 22% 20% 10% 2% and one percent of cultivable areas respectively. About 2/3rd of cultivable area is actually under cultivation and the rest 1/3rd is laying waste. The per capita availability of cultivable area is 0.150 hectare on the basis of 207.77 million populations.

Forest area under the control of Forest Department by type of Vegetation

Category	Punjab	Sindh	KPK	Baluchistan	Gilgit	Azad Kashmir
Coniferous	---	---	---	---	---	407519
Scrub	---	---	---	---	---	9307
Range Lands	---	---	---	---	---	149734
Total	**---**	**---**	**---**	**---**	**---**	**566560**

Area of Forest and Rangelands under the control of Forest Department

S. No	Legal category of Forest	Area (in hectares)
Compact areas		
1.	State Forest	1729187.62
2.	Reserved	--
3.	Protected	2681576.5
4.	Unclassed	--
5.	Resumed lands	--
6.	Guzara	--
7.	Communal	--
8.	Section 38	--
9.	Chose Act	--
10.	Miscellaneous	12803.38
	Total	4,423,567.5

Area regenerated during 2020-21 in different types of Forests
(Area in hectares)

S,NO	Vegetation Types	Mainly natural	Mainly coppice	Mainly Artificial		Total
				By Planting	By Sowing	
1.	Coniferous Forests	---	---	---	---	---
2.	Irrigated Plantations	---	---	---	---	---
3.	Riverine Forest	---	---	---	---	---
4.	Scrub Forests	---	---	---	---	---
5.	Coastal Forests	---	---	809	---	809
	Total	---	---	809	---	809

Liner Plantations (in Avenue Km)

1.	Road side	---	---	161	---	161
2.	Rail side	---	---	---	---	---
3.	Canal side	---	---	80	---	80
4.	Others	---	---	---	---	---
	Total			241		241

The precise and accurate estimate of rangeland area remained a technical issue since long to the range resource managers. Muhammad (1989) reported about 50.9% of the total area of the country under rangelands. FSMP Mission (1992) estimated 29 million ha. or 33% of total land area under rangelands. Land cover atlas of Pakistan (2012) estimated 40 million ha/or 45% of total land area under rangelands.

Rangelands on the dry plains of the Punjab, Sindh and Southern Khyber Pakhtunkhwa and on the plateau of Baluchistan sustain major livestock population in the country. People rear livestock to obtain milk, meat, wool and other products. Cattle also provide draught power for ploughing the fields and transportation of produce from farm to the markets. Livestock sector contributed approximately 58.3% of the agriculture value added and 11.4% to national GDP during 2016-17. Thus, they play an important role in the agricultural economy of the country. The population of total animals registered a significant increase of 14% in 2017 when compared with 2013. The population of livestock is as under.

Forest Area under the Control of Forest Departments by Type of Vegetation

Category	Punjab	Sindh	KPK	Baluchistan	Gilgit	Azad Kashmir	Total
2020-21	---	---	---	---	---	306.378	306.378
2021-22	---	---	---	---	---	408.643	408.643

Area Afforested during 2020-21

	Item	Unit	target	Achievement
1	Area afforested (Regular)			
	Compact	Acres	3055	3055
	Linear	Av.Km	241	241
2	Social Forestry			
	Block Plantations	(Hectares)	23	23
	Liner Plantations	(Hectares)	--	--
	Distribution of Plants	(Million No.)	96.62	96.62
3	Watershed Management			
	Area Planted	(Hectares)	--	
	Soil conservation	Cft	--	
	Number of plants distributed	(Million No.)	--	

Production of nursery plants during 2020-21

S.No		Area in hectares	Approximate number of Plants raise
01.	Bedded Nurseries	---	0.002
02.	Potted Nurseries	---	10.555
		Total	10.557

Revenue earned by the Forest Department during 2020-21

Source	Amount (in millions)
Transit fee on the Timber	0.183
Transit fee on Firewood	20.541
Sale of resin	0.201
Transit fee on Mazri	0.60875
Sale of Ephedra	0.02
Grazing, grass. cutting	0.1875
Other revenue (from minor forest produce) Compression Forest act	55.14
Miscellaneous(Wildlife)	32.368
Total	109.249

Expenditure incurred by the Forest Department during 2020-21

S.No		Non-Development	Development	Total
01.	Establishment pay, allowance etc,	1326.527	---	1326.527
02.	Sowing and Planting	41.969	---	41.969
03.	Conservancy and works except sowing and planting	---	499.711	499.711
04.	Others	71.698	---	71.698
05.	Total Expenditure	1540.194	287.599	1827.793
06.	Total Budget Allocation	1605.081	821.585	3767.698

The forests of Pakistan reflect great physiographic, climatic and edaphic contrasts. Pakistan is an oblong stretch of land between the Arabian Sea and Karakoram mountains, lying diagonally between 24° and 37° N latitudes and 61° and 75° E longitudes, and covering an area of 87.98 million hectares.

Topographically, the country has a continuous massive mountainous tract in the north, the west and south-west and a large fertile plain, the Indus plain. The northern mountain system, comprising the Karakoram, the great Himalayas, and the Hindu-Kush, has enormous mass of snow and glaciers and 100 peaks of over 5,400 m in elevation. K-2 (8,563 m) is the second highest peak in the world, the mountain system occupies one third of this part of the country. The western mountain ranges, not as high as in the north, comprise the Sufed Koh and the Suleiman, while the south-western ranges forming a high, dry and cold Baluchistan plateau. Characteristically, the mountain slopes are steep, even precipitous, making fragile watershed areas and associated forest vegetation which are extremely important from hydrological point of view. The mountains are continuously undergoing natural process of erosion. The nature of climate with high intensity rainfall in summer and of soil in the northern regions renders these mountains prone to landslides.

Linear Plantations

S.No	Legal category of Forests	Road side	Canal side	Rail side	Others	Total:
1	State	527	---	---	---	527
2	Reserved	---	---	---	---	---
3	Protected	699.17	860.3	---	72	1631.47
4	Un-classed	---	---	---	---	---
5	Others	220	---	---	---	220
	Total:	**1446.17**	**860.3**	**---**	**72**	**2378.47**

Political Forest area of Pakistan reported in different official documents has varied over the years with administrative and changes in country as well as with changes in methods of reporting data. The data extracted from the reports of provincial Forest Departments, the total forest area is 4.51 million hectares which corresponds to 5.1% of the total area of the country. The forest area of Khyber Pakhtunkhwa is 1.85 million hectares that makes 18.19% of the total land area of the province. The forests of Khyber Pakhtunkhwa including FATA comprised of coniferous, scrub and mazri lands. The forest area of Punjab is 0.67 million hectares that makes 3.25% of the total land area of the Province. The forests of Punjab are consist of coniferous, irrigated plantations, riverine, scrub and linear plantations. Similarly the Forests of Sindh extend over an area of 0.72 million hectares which is 5.11% of the total land area of the province.

The coniferous forests are the major vegetation type of Pakistan. These are sub tropical pine and temperate forests occurring at an elevation of 1000-3500 m above sea level and mainly consisting of species such as Chir pine, Blue pine, Deodar, Fir and Spruce together with broad-leaved associates viz, Maple, Walnut, Chestnut, Bird cherry, Oak, Poplar etc. The coniferous forests cover 1.66 million hectares and account for 37.0% of the total forest area. These are the main source of constructional timber in the country. However, their vital importance lies in their services towards conservation of soil and water resources of the country, control of floods, prevention of siltation of dams and water reservoirs, cleaning of air pollution and provision of recreational spots.

Area of Forests and rangelands under the control of Forest Department on 30/06/2021 by legal category

S.No.	Legal Category of Forest	Area (in acre)
01.	Reserved	226429
02.	Protected	1264867
03.	Resumed	90421.5
04.	Un-classed	3531512
05.	Section 38	349
06.	Communal	18774.57
07.	Guzara	590195
08.	Misc.	335284.2
09.	Private Plantation	---
	Total	**6057832.27**

Scrub forests are the broad-leaved evergreen type, occurring at an elevation of 500-1500 meters, mainly consisting of Olive and associates, and occupy about 1.00 million hectares (22.2%). Scrub forests supply fuel wood to the local population,

grazing to the animals and are rendering valuable services to control soil erosion for maintaining the productivity of agricultural lands in the plains.

The riverine forests occur between protective embankments and the banks of the Indus River and its tributaries. The pre-dominant species are: *Acacia nilotica, Tamarix dioica, Populus euphratica* and *Prosopis cineraria*. They cover about 0.35 million hectares area (7.8%) and occur mainly in Sindh and Punjab. Riverain forests are the source of mining timber and fuel wood. The area is entirely state owned and is mostly productive.

Another type is the state owned irrigated plantations in the plains. These are man-made forests raised on irrigation and mainly comprised of tree species like Shisham, Mulberry, Bakain and Poplar. Irrigated plantations are the main source of timber for furniture, sports goods, housing construction and plywood industries etc. Irrigated plantations occupy 0.28 million hectares (6%).

Mangrove forests in the Indus delta on the coast of Arabian Sea are categorized as coastal forests. They cover about 0.33 million hectares (7%) and are entirely owned by the state and provide a small quantity of fuel wood and fodder. Due to over felling and unrestricted grazing, these forests are shrinking at a fast pace facing a major ecological retrogression. The distribution of forest area by types is given in table 5.1.

Distribution of area of Forests and rangeland under the control of Forest Department on 30.06.2021 by vegetation type (Area in hectares)

S#	Vegetation type	State	Private	Total:
01.	Coniferous Forests	641955.1	489205	1131160.05
02.	Irrigated plantation	---	---	---
	Planted area	---	4349	4349
	Blank area	---	---	---
	Total:	---	---	---
03.	Riverine Forests	---	28023	28023
04.	Scrub Forests	6811	30502	37313
05.	Coastal Forests	---	---	---
06.	Mazri lands	---	---	---
07.	Range lands	76516.19	---	76516.19
08.	others	92850	13731	106581
	Total:	818132.3	565810	1383942.24

Forest area by vegetation types

Vegetation types	Total area	Area covered under working plant Compact area in hectares
Coniferous Forest	901596.9	895603.88
Irrigated plantations	713	---
Riverine Forests	---	---
Scrub Forests	16032	---
Coastal Forests	---	---
Mazri lands	60000	60000
Total:	978341.9	955603.88

Area of production and protection forests on 30/06/2021 by vegetation type

S.No.	Vegetation	Production Forests	Protection Forest	Total
Compact area (in hectares)				
01.	Coniferous Forests	562235.72	272080	834315.72
02.	Irrigated plantations	11	1150	1161
03.	Riverine Forests	168.07	---	168.07
04.	Scrub Forests	6811	---	6811
	Total:	569225.79	273230	842455.79

Linear Plantation

S.No.	Particulars	Total area	Area covered under working plan
1	Road side	744	162.5
2	Rail side	---	---
3	Canal side	410	---
4	Others	---	---
	Total:	1154	162.5

Area regenerated during 2020-21 in different types of Forests (Area in hectares)

S.No.	Vegetation type	Mainly natural	Mainly by coppice	Mainly artificial		Total:
				By planting	By sowing	
1	Coniferous Forests	28008	---	4499	1383	33890
2	Irrigated plantations	---	554	154	697	1405
3	Riverine Forests	---	---	168	---	168
4	Scrub Forests	---	---	---	---	---
5	Coastal Forests	---	---	---	---	---
	Total	28008	554	4821	2080	35463
Liner plantation (in Avenue Km)						
1	Road side	367	---	50	---	417
2	Rail side	---	---	---	---	---
3	Canal side	---	---	---	---	---
4	Others	334.885	---	---	---	334.885
	Total:	701.885	---	50	---	751.885

Area afforested during 2020-21

S.No.	Item	Unit	Target	Achievement
1	Area afforested (regular) Compact Liner	 (hectares) (AvKM)	 12142.96 296	 9061.40 334
2	Social Forestry Block plantations Liner plantations Distribution of plants	 (hectares) (hectares) Million No.)	 11539 97.212 37.664	 9890 110.525 28.834
3	Watershed Management Area planted Soil conservation works Number of plants distributed	 (hectares) (hectares) (Million No.)	 3818 450 0	 4863.51 1074 0

Out-turn of firewood and other minor Forest produce during 2020-21

Species Wise out turn of timber from the Forests under the control of Forest Department during 2020-21

Species	(Out turn in cubic meters)			
	Logs	Scantling	Others	Total:
Coniferous	0	101.59	0	101.59
Deodar	1731.242	13410.076	0	15141.318
Blue pine	15.607	9085.321	0	9100.928
Fir	13	3825.112	0	3838.112
Spruce	0	0	0	0
Chir pine	455.953	49.094	0	505.047
All others	0	0	0	0
Broad leaved	1957.27	8745.33	0	10702.6
Ailanthus	59	0	0	59
Parciman	206.8	0	0	206.8
Shisham	410.931	12.194	0	423.125
Mulberry	33.584	0	0	33.584
Babul	0	0	0	0
Chinar	132.86	0	0	132.86
Poplar (hybrid)	1914.757	608.8	0	2523.557
Bahn	0.53	0	0	0.53
Eucalyptus	2193.129	0	0	2193.129
Walnut	1347.741	6547.25	0	7894.991
Willow	23.55	0	0	23.55
Simal	2.311	0	0	2.311
Sherool	210.21	0	0	210.21
Kandi	0	0	0	0
Lai	0	0	0	0
All others	71.26	19885.95	8766.22	28723.43
Total:	10779.735	62270.717	8766.22	81816.672

Particulars	Unit	Quantity	Value (in rupees)
Firewood	Cubic meter stacked	1432776.026	1201135523
Resin	Metric tons	0	37000
Mazri	Metric tons	30170	719633
Ephedra	Metric tons	0	0
Other medicinal plants	Metric tons	506.79	147237500
Grazing and grass cutting etc	Kg	0	0
Other minor Forest produce	Kg	218789.08	20053346
Total		1682241.896	1369183002

Import of Wood and Wood Products

Forest resources of Pakistan are too meager to meet the demand for wood and Wood products, which is increasing rapidly with high rate of growth of population and living standard. The gap between demand and supply is accordingly met by imports, which places heavy burden on the balance of payment. The import of wood and wood products fall into these category viz, timber round and sawn, wood manufacture and pulp & paper items etc. A brief description of each category is given below:

Timber Round and Sawn

This category encompasses imports of veneer, saw logs, railway sleeper, sawn and planned timber, round timber and pit props. The imported timber is mainly used in the manufactures of plywood, high quality furniture, sports goods boat making and in the building construction.

Wood and Wood manufacture

They mainly comprise veneer, plywood, wood article, decoration pieces etc.

Pulp and Paper

The major constituent of import was Pulp paper, paperboard and articles made of paper and paperboard. With the spread of literacy in the country, the consumption of paper is rising and as a result the import is increasing.

Miscellaneous items

- Forestry Statistical information were supplied to different National and International Agencies
- Extended cooperation and provided advisory services to Provincial/Regional Forest Departments, NGOs, Forestry Projects and tree growing farmers in respect of forestry related activities.
- Taught Forestry Economics to the BS, B. Sc and M.Sc. Forestry Classes.
- Conducted the practical examination of B. Sc and M.Sc. Forestry 2nd term class as an Internal Examiner.
- Supervised three students of M. Sc Forestry in their thesis work.

3. BIOLOGICAL SCIENCES RESEARCH DIVISION

3.1 FOREST BOTANY

3.1.1 Maintenance and Improvement of Botanical Garden

Location: Pakistan Forest Institute, Peshawar
Data of commencement: 2020-21
Principle Investigator: Sohaib Ahmad, Forest Botanist/AP of Forestry

Cleanness

Weeds were uprooted from wild tress, paper mulberry, grasses etc. from all plots of botanical garden throughout the year.

Watering to all plots of Botanical garden throughout the year. De-siltation of irrigation channels and trenches inside and outside of Botanical Garden. Water supply to newly planted plants as well as to small plant with fountain and plastic pipe on alternate days. Pruning of different tree species and cut off the hedges from colony side and girls hostel.

Propagation

Seed collection and cuttings from different plants in botanical garden and sowing in polythene tubes and beds which are given bellow:

Myrtanuscomunis, Nariumindicum, Nyctanthasarbortristis, Ficus spp*., Gmelinaarborea, punicagranatum, Butea monosperma, Platanusorientalis, Chukrasiatabularis, Jatropha integerima, Rosa indica, Hibiscus rosa-sininses, Jasminiumhumile, Kydiacalycina, Olea europea, Tabernaemontanadivericata, Terminalia belerica, Terminalia arjuna, Tecomastans, Hiptagemadablota, Pongamiaglebra*etc.

Plantation

The following different plants species have been planted in different plots of Botanical Garden:

Murrayapaniculata, Murrayakoenigii, saphora japonica, China Palm, Julsimium spp*. Eriobotrya japonica, Justaciavera, Thevetianerifolia, Rhustyphina, Bauhinia veriegata, Oroxylemindicum, Plumeria obtuse, Nandinadomestica, Russeliajunia, Acacia modesta, Moringaoleifera* etc.

Seeds Provision

Seeds of different plants species were provided to Forest Genetics branch and Silviculture branch PFI, Peshawar which are listed below:

Moringaoleifera, Cassia fistula, Bambusa vulgaris, Acacia catechu, Sophora japonica etc.

Miscellaneous

- Lectures were delivered to students of department of botany, University of Peshawar and The University Agriculture Peshawar.

- Restore Huts roof at botanical garden.
- Maintaining Herbarium with proper preservative measures.
- Lectures delivered to Forestry students on herbarium and its importance in plant sciences.
- Relisting of all herbarium specimens is under process.

3.2 FOREST CHEMISTRY

3.2.1 Physico-Chemical Characteristics of Soil as Influenced by Different Elevations under Conifer Plantation in the Galyat of Khyber Pakhtunkhwa, Pakistan.

Location:	Pakistan Forest Institute, Peshawar
Data of commencement:	2020 - 21
Principal Investigator:	Dr. Bashir Ullah, Soil Chemist and Sanam Zarif Satti, Director Biological Sciences Research Division

Introduction

The soil is a compound structure consisting of different raw materials, gases, organic and inorganic molecules with different properties and characteristics. Soil testing serve as diagnostic tools, in addition to visual symptoms, for assessing any nutrient disorder. Altitude is the major factor affecting the properties of the soil ecosystem. The variation in altitude changes the climate which in turn influences the pedogenic processes and soil properties by affecting types and rates of chemical, physical, and biological processes. As we go up the rate of decrease of temperature is 6.5°C for each 1000 m altitude change. High altitude environment is characterized by high solar radiation, low temperature, rapid temperature changes, and low partial pressure of the air. Low altitude environment is characterized by higher temperature and different atmospheric humidity.

Impact of altitude on soil properties

It has been reported that the moisture content and water holding capacity of soil increase with increasing altitudes while the bulk density (BD) reduced with increasing altitude. The higher proportion of soil texture is contributed of sand > clay > silt with increase in altitude.

The chemical properties like pH, EC, organic carbon content, nutrient content also vary with altitude as shown in table 1.

Table 1. Properties of soil with increase in altitude

Physicochemical property	**Trend with altitude**
Soil texture	Sandy loam
Soil porosity	High
Water holding capacity	Low
pH	Decreases
EC	Remains constant
Soil organic and biomass Carbon	Decreases
Soil nutrients	Decreases
Microbial and enzyme activity	Decreases
Mineral nutrients(Ca, Co, Ni, B, Mg, Na, K, Fe and Cu)	Decreases

Impact on physical characteristics

Climate and parent material profoundly influence soil characteristics. The soil textural class shows clear difference with the differences in altitude. The high altitude soils are immature and are originated from weathered rocks and therefore have relative proportions of sand, gravel and stones. The presence of coarse grain soil particles indicates the slow process of soil formation. As the altitude decreases, there is an increase in the silt proportion and decrease in sand. The bulk density of soil decreases with increase in altitude. This is because of increase in organic matter content with increasing altitude. The bulk density of soil depends on soil structure and texture, organic matter, freezing and thawing process. The moisture content and water holding capacity also increased with increasing altitudes.

Impact on chemical characteristics

Higher silt but lower sand proportion at lower altitude indicates the presence of quartz, feldspars, micas, etc. in soil. Therefore, slow process of soil formation along the altitude results in very low content of clay particles which may cause low content of available nutrients in soil. With increasing altitude, soil pH is slightly decreases. The reduction in pH can be attributed due to accumulation and subsequent slow decomposition of organic matter, which releases acid. Another reason is because of increased precipitation levels at the higher altitudes. High amount of rainfall leaches out the base forming actions like Ca^{2+}, Mg^{2+}, K^{+} and increases the ions like Al^{3+} and H^{+}. The EC of the soils of low and high altitude does not have any significant variation proving that there is cumulative accumulation of salts along the altitude. The soil organic matter increases with the increase in altitude, this is due to decrease in temperature with increase in altitude. Low temperature decreases the microbial and enzymatic activity in high altitude soil; rendering the soil organic matter unaffected by microbial decomposition. The presence of phosphorus is dependent on soil pH, so with the increase in altitude the availability of P increases. Increased soil temperature is reported as a primary environmental factor that decrease the N mineralization processes thus influencing the bioavailability of soil nitrogen. Nitrogen associated with SOM is not readily mineralized, thus high total N content of the soil with increase in altitude could be the result of high SOM. The calcium, cobalt, nickel, boron, magnesium, molybdenum, sodium, potassium, iron and copper also decrease with increase in altitude.

The present study was carried out to study the soil physic chemical characteristics at various altitudinal gradients of Galiyat Khyber Pakhtunkhwa. Its aim is how an elevational gradient affects the physical and chemical characteristics of soil. The soil samples were collected at a depth of 0-30, with the help of auger or spade and mixed it thoroughly and took a composite of 1 kg from it. All the soil samples were properly packed, labeled and brought to the soil chemistry lab (Some samples were sent to the Agricultural Research Institute Tarnab, Peshawar for soil analysis due to lack of facilities at soil chemistry lab, PFI). Soil samples were grinded and sieved with 2mm sieve after air drying, these samples were analyzed for various soil properties viz. Soil texture, (Koehler et al. 1984), pH (McClean 1982), EC (Richards, 1954), Organic matter (Nelson and Sommers, 1982), total nitorogen (Bremner and Mulvancy 1992), AB-DTPA extractable phosphorous and potassium (Soltanpour and Schwab, 1977). The microelements were analysed by the procedure of Malathi and Stalin, 2018. The results of the analysis are shown in table 2.

Table 2. Physiochemical properties of soil as influenced by altitudinal gradients under conifer plantation

Altitude (m)	Organic matter (%)	Moisture Content (%)	pH	EC (μScm^{-1})	N (mg/kg)	P (mg/kg)	K (mg/kg)	Cu (mg/kg)	Co (mg/kg)	Fe (mg/kg)
1700	2.3	7.6	6.6	980	1400	61	16.58	14.50	0	150.05
1800	3.6	14.3	7.1	1190	800	52	19.18	8.00	0	156.48
1900	4.74	31.4	6.5	1329	200	17	33.43	12.00	0	82.15
2000	6.9	32	6.3	1322	700	70	33.60	5.50	0	103.53
2100	4.8	13.6	6.25	1218	1200	87	34.80	12.50	0	102.98
2200	4.46	27.2	6.75	973	500	56	24.18	8.00	4	116.55
2300	5.6	22.24	6.35	983	200	51	24.98	25.50	19.5	114.98
2400	5.06	16.69	6.65	1045	1600	65	31.80	0.00	0	137.38
2500	5.56	24.4	6.8	1369	200	51	20.18	25.50	19.5	138.80
2600	2.29	40.6	7.05	901	500	65	21.35	5.50	0	122.18
2700	3.3	37	7.2	1056	300	29	20.43	16.00	7.5	124.18
2800	10.36	33.6	6.4	1368	500	56	20.90	8.00	4	127.20
2900	4.9	31.6	6.45	1276	1200	74	24.33	18.50	1	161.98
2900	4.9	31.6	6.45	1276	1200	74	24.33	18.50	1	161.98
3000	9.09	32	6	1251	1000	65	21.43	14.50	5	157.10
3100	16.9	26.2	6.15	1276	600	10	20.53	14.00	9.5	185.83

Miscellaneous

- Lectures were delivered by soil chemist to the MSc students on the subject of soil science.

- About eight number of students were supervised by soil chemist in their final research.

3.3 FOREST PATHOLOGY

3.3.1 Survey and profiling of dieback resistant capacity in *Chinar (Platanusorientalis)* grown in Peshawar.

Location:	Pakistan Forest Institute, Peshawar
Data of commencement:	2020 - 21
Principal Investigator:	Khalid Hussain, AWTO/In-charge FPB

Introduction

Chinar *(Platanusorientalis)* a large deciduous tree, native to Southwestern Asia; Northern Areas, Khyber Pakhtunkhwa, Baluchistan, Peshawar and areas of Punjab. Pakistan is one of the countries which are highly vulnerable to the climatic disaster. Besides the climate threat the limited forest resources are another major problem that is worsening the climate and environment in the country. This fragile natural resource is under stress by the unmanageable growth in population and construction sector as well. Expanding population needs more food and residential areas and these two requirements are being fulfilled by cleaning forest land. Moreover, a major threat that may exhaust our forest cover and timber resources are plant diseases. Dieback disease that is caused by a group of fungi is a major threat to the mature tree species and forest as well. Unfortunately, due to lack of basic information, interest and commitment among the research communities to eliminate the disease, the disease is spreading rapidly and causing threat to valuable timber species.

This study was carried out to assess and develop a profile of the dieback resistant capacity in *Platanusorientalis* grown in Peshawar. The information would help in the selection of dieback resistant species for sustainable plantation and reforestation. To conduct study thirty (30) standing trees grown in premises of Pakistan Forest Institute (PFI) and PFI residential area were sampled randomly and scrutinized for dieback symptoms including exudation, cankers and wilting. Out of 30 observed samples only six (06) were found complete dead, two (02) half dead; whereas the rest of twenty-two (22) samples found healthy and green. Diagnosis of complete dead and half dead revealed no cankers and exudation traces. Ratio of healthy trees in selected samples was about 73.33% in comparison to the 26.66% dead in observed samples.

The survey revealed that the *Chinar (Platanusorientalis)* may resist efficiently against the dieback, wilting and other pathological attack as well. Survival capacity of the species is better in this environment and resist well against growing negative climatic impact and dieback attack as well.

Miscellaneous

- Lectures were delivered to the MSc, BS forestry classes.
- Students were got visited the Pathology Herbarium and pathological garden.
- Pathology Herbarium was sprayed with insecticide for the protection of specimen.
- In the cabinets of type specimens in the Pathology herbarium Neftalin balls were placed to preserve the specimens.
- Specimen bottles were refilled by the spirit for preservation of collected samples.
- Pathology garden was irrigated and maintained properly.
- Compilations and computerization of the herbarium of pathology is in progress.

4. NON-TIMBER FOREST PRODUCE DIVISION

Mapping, Digitization, Value Addition and Marketing of NTFP, in Collaboration with NTFP Directorate, Forest Department

Location	:	Pakistan Forest Institute, Peshawar
Commencement	:	2018-2019
Principal Investigator	:	Dr. Ghulam Ali Bajwa, Additional Director General (BS) / Director NTFP
Co-Principal Investigators		Mr. Iftikhar Ahmad, Director NTFP, KP Forest Department Mr. Aamir Shakil, GIS Specialist, PFI Mr. Naveed Ahmed, Director NTFP/ Forest Entomologist, PFI and Mr. Muhammad Muslim, Director Biodiversity / Muhammad Idrees

The title project is being executed under Khyber Pakhtunkhwa Annual Development Programme with primary objective of to document, store in a retrieval mode and disseminate information at large scale about NTFPs resources for conservation and eco-harvesting in Khyber Pakhtunkhwa. However the specific objectives of the project are:

1. Prepare baseline data through Reconnaissance surveys of NTFPs
2. Collect indigenous knowledge of communities about uses of NTFPs
3. Digitize and prepare maps of NTFPs using GPS coordinates
4. *Ex-situ* conservation of germplasm &develop propagation modules for medicinal plants, mulberry and silkworm
5. Survey of drug markets and marketing mechanisms
6. Preparing value added products based on NTFPs
7. Webhosting and Data uploading
8. Capacity building of different stakeholders of NTFPs

Under this project, reconnaissance surveys were conducted in Bannu, DI Khan, Hazara, Kohat, and Malakand Divisions as per following performa:

NTFP INVENTORY FORM	MAPPING, DIGITIZATION, VALUE ADDITION AND MARKETING OF NTFP IN COLLABORATION WITH NTFP DIRECTORATE, FOREST DEPARTMENT

A. General Information											Form No:
Name of Site			GPS Coordinates				Climatic Conditions				Name of District
			Longitude/Easting /X		Latitude/Northing/Y	Elevation(m)	Temperature (C°)		Rainfall (mm)		Nameof Forest Division
Season of Survey											Nameof Forest Sub-Division
Accessibility	Metalled Road	Jeep Road	Bridle Path	Not accessible	Distance from Road (Km)	6 km	Primary Source of Water		Spring		Compartment No/Name

B. NTFP Record

Plant Species	Common Name/ Local	Scientific Name	Specie Intensity/Density					Status		Phenology	Parts of Plant used				Utilization Extent	
			Dense 1-2m	Medium <10m	Sparse >10m	Low <100m	Absent	Major	Minor		Leaf	Bark	Root	Fruit	Local	Indusl.
Tree Species	Common Name /Local	Scientific Name	Specie Intensity/Density					Status		Phenology	Parts of Tree used				Utilization Extent	
			Dense 1-2m	Medium <10m	Sparse >10m	Low <100m	Absent	Major	Minor		Leaf	Bark	Root	Fruit	Local	Indusl.

C. Issues:

1. 2. 3.	SurveyConductedby:_____Designation_____ Date:____

1.2 NTFP species

More than 470 NTFP species are identified in five divisions are:

The detail of number of species is as follow:

- Bannu = 22
- DI Khan = 19
- Hazara = 210
- Kohat = 49
- Malakand = 170
- Mardan & Peshawar = Data entry in progress

More than 100 NTFP species belonging to 61 families are described with their ethnobotanical uses, plant parts used, along with scientific, vernacular & English name, and their habitats.

S. No	Scientific Name	Vernacular Name	English Name	Family	Parts used	Habitat
1	*Abiespindrow* (Royle ex D. Don) Royle	Achar/Pertal	West Himalayan fir	Pinaceae	Leaves are used as anti-inflammatory.	Temperate Himalaya
2	*Acacia Arabica* Willd	Babul	Acacia tree	Mimosoideae	Provides relief in pain and irritation, coughs and sore throats. Reduces body fat and restricts blood loss. Helps in wound healing and promotes oral health. Good source of fiber, dye and gum.	Sub-tropical &Tropical
3	*Acacia modesta*Wall	Phulai/ Palosa	Amritsar gum	Mimosoideae	Used to treat leprosy, wounds, dysentery, venereal diseases, cough, body weakness, bacterial infections and backache.	Sub-tropical & Tropical
4	*Acacia nilotica*(L.)	Kikar	Gum Arabic tree	Fabaceae	It has anti-microbial, anti-plasmodial and anti-oxidant activity and used for treatment of human immuno-deficiency virus, hepatitis C virus and cancer. It is useful for treatment of venereal diseases, nausea, burns and wounds, stomachache and diarrhea. Used for dye and provide gum.	Sub-tropical & Tropical
5	*Adiantumcapillus-veneris* Linn	Persoshah/ Sumbal	Maidenhair fern	Pteridaceae	The leaf tea provides relief in sore throats, asthma, cough, chest congestion. It is a good anthelmintic and snake bite antidote. Traditionally its infusion is used as antipyretic, expectorant and diurectic.	Moist rocky temperate Himalayas
6	*Adiantumvenustum* D. Don	Persoshah/ Sumbal	Maidenhair fern	Pteridaceae	Used for treating diabetes, asthma, convulsing, bacterial and fungal infections, obesity, hair loss, cholesterol and diarrhea. It is also used as analgesic, emetic, anti-inflammatory, anti-spasmodic, anti-oxidant and diuretic.	Moist rocks & soil with a good amount of humus & dead leaves in temperate Himalayas
7	*Aesculusindica* (Wall. ex Cambess.) Hook	Jawaz/ Bankhor	Indian horse-chestnut	Sapindaceae	Traditionally used for treating skin diseases, rheumatism, headache, as an astringent, acrid and narcotic. Its large leaves and flowers make it suitable for use as large-sized bonsai.	Grows wild in Himalaya region from 1200 to 3300 m masl
8	*Agaricusbisporus* J.E. Lange) Imbach	Khararay	Button Mushroom	Agaricaceae	Used for cancer, diabetes, high cholesterol, arteriosclerosis (hardening of the arteries), liver diseases, bloodstream disorders and digestive problems. Other uses include prevention of heart disease, osteoporosis (weakened bones) and stomach ulcer.	Sub-tropical to Temperate regions

9	*Ailanthus altissima* (Mill.) Swingle	AngreziBekaian	Tree of Heaven	Simaroubaceae	Used for diarrhea, asthma, cramps, epilepsy, palpitation, gonorrhea, genital infection and pain, malaria, and tapeworms. It is also used as a astringent tonic.	Temperate &subtropical regions; on wastelands & road sides
10	*Ajugabracteosa* Wall. ex. Benth.	Bootee	Bugleweed	Labiateae	The plant is aromatic, astringent and tonic. It is useful in the treatment of agues. The juice of the root is used in the treatment of diarrhea and dysentery.	Wildly distributed in Kashmir & sub-Himalayan regions
11	*Albizialebbeck*(L.) Benth.)	Black Siris	Lebbek tree, flea tree, and woman's tongue tree	Mimosaceae	Used by some cultures to treat boils, cough, eye, flu, gingivitis, lung problems, as a tonic, and is used to treat abdominal tumors. The bark is used to treat inflammation.	Cosmopolitan distribution Subtropical, Commonly planted on roadsides
12	*Arachishypogaea* Linn.	Moong-Phali	Peanut/ groundnut	Fabaceae	Nuts are edible and highly nutritive. The seeds are used in folk medicine as an anti-inflammatory, aphrodisiac and decoagulant. Peanut products including peanut oil, flour & protein are used in a variety of foods, such as desserts, cakes, confectionery, snacks, sauces, etc.	Cultivated in arid &semi-arid areas having sandy soils
13	*Arisaemaflavum* (Forsk.) Schott	Surganda/ Sanpbooti/ Marjarey	Indian Turnip	Araceae	Traditionally used to treat resolving phlegm, dampness, asthma, bronchitis, cold, cough, and laryngitis, etc. Juice of the fresh rhizome is applied to snake bite and scorpion sting some species are toxic.	Temperate W. Himalaya with fair distribution in open places from 1700-3000 masl.
14	*Artemisia maritima*Linn *Syn: A. brevifolia*Wall. ex DC.	Santonica/ Tarkha	Sea Wormwood	Asteraceae	It has digestive and carminative properties and mixed with meat dishes. It is known to be an anthelmintic, aphrodisiac, antiseptic, laxative, febrifuge, blood purifier, stomachic, tonic and antidote to scorpion stings. It is used as tonic for livestock.	25 species grow wildly in arid and semi-arid areas of Balochistan, Khyber Pakhtunkhwa northern Punjab, AJ&K &Gilgit-Baltistan
15	*Azadirachtaindica*A. Juss	Neem	Nim tree or Indian Lilac	Meliaceae	The plant is called village pharmacy. Bitter leaf and seed is used for leprosy, eye disorders, bloody nose, intestinal worms, stomach upset, loss of appetite, skin ulcers, diseases of the heart and blood vessels (cardiovascular disease), fever, diabetes, gingivitis, and liver problems. The leaf is also used for birth control, poultice for boils and to cause abortions. The bark is used for making gum. The fruit is edible and oil extracted from the seeds can be used as a purgative and anthelmintic. The plant has insecticidal properties.	Frost Free zone of Sindh, Punjab and Khyber Pakhtunkhwa

16	*Berberis vulgaris*Royle	Kashmal/ Khawney	Barberry	Berberidaceae	The roots and stem bark of *B. vulgaris* are used commonly in homeopathic medicine and used for various health problems. It is used to treat fever, cough, disorders of kidney, heart, liver. It is also used for depression, hyperlipidemia, hyperglycemia, bleeding, jaundice, diabetes, eye infections, internal wounds, diarrhea, rheumatism, stomachache, and its use as a general body tonic.	29 species belonging to genus *Berberis* grow wildly in Balochistan, Khyber Pakhtunkhwa, Punjab, AJ&K and Gilgit-Baltistan
17	*Bergeniaciliata*(Haw) Sternb Syn.: *B. himalaica*Boriss	Zakhm e hayat	Hairy Bergenia	Saxifragaceae	The Leaf, root and rhizome are used as powder or juice. The root decoction is used for asthma, stomachache, diabetes, kidney stones, hemorrhoids, antiulcer, anti-hepatotoxic, malaria, anti-HIV, anti-arrhythmic, neuroprotective, anti-fungal, anti-inflammatory, immunomodulatory and healing of burn wound.	Temperate Himalayas from 900 and 3,000 m masl
18	*Bistortaamplexicaulis* (D. Don) Greene Syn.: *Persicariaamplexicaulis*	Anjabar	Mountain fleece	Polygonaceae	Rhizome decoction is used as a tea and tonic, and is also useful in dysentery, rheumatism, backache, ulcer, bleeding gums, and diarrhea. The rhizome decoction about 10 ml is taken thrice a day for treatment of rheumatic pains, backache, fever and flu. It is also used for purifying blood. The leaf paste is applied to cure wounds. The decoction may cause abortion.	Temperate, sub-alpine &alpine zones.
19	*Caltha alba* Camb. Syn.: *C. palustris*	Makan path	White Marsh Marigold	Ranunculaceae	The leaf powder is used for wound healing,	Temperate regions of northern Pakistan and AJ&K

20	*Cannabis sativa* Linn.	Bhang	Hemp	Cannabaceae	An annual herb with cosmopolitan distribution. It has been used for medicinal purposes in many cultures since time immemorial. It is widely used for pain, spasms, asthma, insomnia, depression, and loss of appetite. A strong narcotic is derived from the resin of stem, leaves, flowers and even the fruits like (i) Ganja is obtained from the resinous exudation from the female flowering top and unfertilized female flowers, (ii) Charas is obtained by rubbing of the leaves, young twigs, flowers and young fruits, and (iii) Bhang from older leaves and mature fruits. Ganja and Charas are smoked and Bhang is either used in the preparation of green intoxicating beverage. Bhang is much weaker than Charas and Ganja. The seeds are occasionally eaten and much valued for feeding birds. The seed oil is used as luminant and in making of paints, varnishes and soap. It is also cultivated in some countries for making ropes and strings.	Sub-tropical plain areas to northern temperate hilly areas of Pakistan. Found abundantly along roads and waste lands up to about 3000 masl
21	*Cassia fistula* Linn.	Amaltas	Golden shower tree	Fabaceae	Bark of *C. fistula* is extensively used in traditional medicines for treating inflammation/ swellings and as a cleaning agent for ulcers and wounds. It is believed to decrease purulent discharge (pus) and act as a local antiseptic. The pulp of pods is used as a laxative. The bark is also used as tanning material and wood ash is used as caustic in dyeing.	Subtropical to temperate areas of Swat, Hazara & northern Punjab up to 2,000 m masl in deciduous forests.
22	*Cedrusdeodara* (Roxb.) G.Don	Deodar/ Nakhtar	Himalayan Cedar	Pinaceae	Essential oils obtained from Deodar is used in soap perfumes, household sprays, floor polishes, insecticides and in aromatherapy. Oil is also used as repellent against insect pest of livestock and cattle.	Temperate regions

23	*Citrussinensis* (Linn.) Osbeck	Malta/ Masemi	Sweet orange	Rutaceae	The fruit is a rich source of vitamin C. Traditionally fresh fruit or juice is used for boosting immunity. It is also used for cramps, constipation, colic, diarrhea, respiratory and menstrual disorders, tuberculosis, obesity, and kidney stones. The fruit contains large amount of potassium that provide an effective remedy against high blood pressure and strokes. The sweet fruit is also used for making squashes, jams and marmalades. The fruit peel is used in several medicines, and as flavor in soft drinks and food. The leaves are aromatic.	Sub-tropical regions and. Cultivated in canal irrigated areas.
24	*Citrus x paradisi*Macf.	Chakotra	Grapefruit	Rutacease	The fruit has nutritional and therapeutic activities. It contains vitamin C, essential oils and other antioxidants. It is used for diabetes and blood pressure, cholesterol, cardiovascular diseases (Ischemic stroke), obesity, constipation, cancer, skin health, boosting immune system, wound healing and aging effects. The fruit contains carbohydrates, protein, fibre and important minerals. The sections are commonly used in fruit cups or fruit salads, in gelatins or puddings and tarts. The grapefruit is commercially processed as marmalade, to make into jelly, while its juice is marketed as a beverage (fresh or canned) and dehydrated as powder. Grapefruit peel is an important source of pectin that can be used as preservative. It is also used as an ingredient of cosmetic, perfumes, soaps and detergents People taking medicines such as statins, calcium channel blockers, psychiatric drugs or have kidney disorders should not take grapefruit in large quantity or for longer time period.	Tropical & sub-tropical regions. Mostly cultivated in canal irrigated areas.
25	*Cordia myxa* Linn.	Lasura	Assyrian plum	Boraginaceae	The ripe pulpy drupe is edible, while immature drupe are used for pickles. Traditionally the bark, leaves, drupes are used to treat cough, chest complaints, stomachaches, and for wounds and ulcers. It has anti-inflammatory (demulcent), diuretic and analgesic properties.	Mostly planted but also found scattered trees in wild in plain tropical &subtropical areas.

26	*Cotoneaster nummularius*Fisch. & C.A. Meyer	Nummular/ Kharawa/Mamanraha	Coinwort Cotoneaster	Rosaceae	A wild food plant. The fruit is used as food, as well as, its decoction is taken orally as an appetizer, stimulant, stomachic and expectorant. It is a good bee flora, as well as birds eat red ripe berries.	It grows wildly in foot hills at an altitudes of 1,400 m to 2,000 m
27	*Dalbergiasissoo*Roxb.	Shisham	Indian rosewood	Fabaceae	The roots, bark, wood, leaves and seeds are used as remedy in many diseases such as skin diseases, blood diseases, syphilis, stomach problems, gonorrhea dysentery, nausea, eye and nose disorders, aphrodisiac and expectorant. It contains basic dye (methylene blue).	Sub-tropical foothills up to 1,500 m masl Planted in irrigated & linear plantations along road sides and canal banks.
28	*Daphne oleoides*Schreb Syn.: *D. mucronata* Royle	Leghonay	Daphne	Thymelaeaceae	The leaves are poisonous applied for abscesses. The bark is used in diseases of bone and for washing hair. Gun powder charcoal is said to be made from the wood. The fruit can be eaten and is used as a dye for leather. It serves as food plant for goats.	Temperate rocky slopes at altitude of 1,700 to 3,000 m. Axerophytic shrub.
29	*Diosceriadeltoidea* Wall. ex Kunth,	Kaniaz	The Nepal yam	Dioscoreaceae	It is used as vermifuge and an anthelmintic for purging out intestinal worms, and treating digestive disorders, sore throat for struma, diarrhea, irritability, abdominal pain, wounds, burns and anemia. Dioscorea is an important source of steroidal saponins (diosgenin). Diosgenin is a basic material for hormone preparation. The rhizomes contain saponin, acrid resin, diosgenin, starch and calcium oxalate. It is used for washing shawls and woollen cloths.	Sub-tropical and temperate regions. It is fairly common at 900-3,000 m masl.
30	*Diospyros lotus* Linn.	Black Amlook	Date-plum	Ebenaceae	The fruit is edible and very nutritive. The ripe fruit is dried and eaten. The plant has pharmacological properties like a sedative, anti-septic, anti-diabetic, anti-tumor, laxative, and anti-pyretic. It contains a high contents of tannin.	Cosmopolitan distribution. Wildly grows in AJ&K, Chitral& Balochistan, cultivated in Hazara, Swat, Murree &Kurram at 1,500 m.
31	*Dodonaeaviscosa* (L.) Jacq.	Sanatha	Candlewood/ Hopbush	Sapindaceae	The leaves are used as plasters for wounds. It has anti-microbial, insecticidal, anti-oxidant and anti-diabetic activities. The wood is hard and has multiple uses.	Hilly tropical &sub-tropical regions in Scrub vegetation

32	*Dryopterisfilix-mas* (L.) Schott	Sarakh/ Kownjy	Male ferns	Dryopteridaceae	The rhizome is used in traditional medicine, especially for the treatment of inflammation, rheumatoid arthritis, wounds and ulcers. It is an effective treatments for tape worms.	Temperate regions of northern Pakistan
33	*Eriobotrya japonica* (Thunb.) Lindl.	Loquat	The loquat/ Japanese plum	Rosaceae	It is dible nutritive fruit. The leaf and flower extracts have been used for the treatment of cough, chronic bronchitis, inflammation, diabetes and cancer.	Sub-tropical regions. It cultivation started more than 2,000 years earlier, in China
34	*Eucalyptus* spp.	Sofeda/ Lachi	Gum	Myrtaceae	Dried leaf tea is a good source of anti-oxidants which are effective in cancer, heart diseases, dementia and oxidative stress. Leaf oil is used as antiseptic. It provide relief in headache, nasal congestion and colds. Used in some topical creams for arthritis and insect repellents. Leaf tea is toxic for children.	Wide habitat ranging from tropical to temperate regions
35	*Euphorbia helioscopia*L.	GandiBooti/Pupolak	Sun spurge	Euphorbiaceae	Used for skin diseases, warts, intestinal parasites, migraine and gonorrhea. Leaves and stems of the plants are traditionally used as vermifuge and seeds are used in cholera and constipation.	Cosmopolitan distribution; Common in sandy or sandy clay soils, rocky slopes, canal banks, 200 to 2,000 m a.s.l.
36	*Ficuscarica* L.	Injeer/ Inzer	Fig	Moraceae	Traditionally nutritive fresh and dried fruit is used for disorders of digestive, endocrine, reproductive, and respiratory systems. It is also used for infections of gastro-inestinal and urinary tracts.	Tropical and Sub-tropical regions; also cultivated
37	*Fragariaindica* Andrews Syn. *Duchesniaindica* Sm.	Jangli strawberry	Wild strawberry	Rosaceae	Fruit is tasteless and nutritive. Leaf tea is used for diarrhea, digestive disorders, gout, laryngitis, acute tonsillitis and as a gargle for sore throats. The fresh leaves and fruit is crushed and applied as a poultice to treat boils and abscesses, swellings, weeping eczema, ringworm, snake and insect bites and traumatic injuries.	Sub-tropical to temperate Himalaya regions; 2,500 m a.s.l.
38	*Geranium wallichianum* D. Don ex sweet	Ratanjot/ Srazeela/ Mamekh	Shepherd's needles/ Buxton's blue	Geraniaceae	The Rhizomes/ roots are used in backache, sexual debility, joint pain, colic, jaundice, and kidney and spleen disorder. Root is also used for astringent, ear & eye disorders and toothache. The juice of the plant is applied to fresh cuts to stem the bleeding. Used as tonic by women especially for physical fitness and other internal body complaints, passive hemorrhage, and leucorrhoea.	Sub-alpine & Temperate Himalaya regions, in moist damp places in forests and open slopes; 2,400-3,600 m masl.

39	*Grewiaoptiva*J.R.Drumm. ex Burret	Dhaman/Pastawanay	Bhimal	Malvaceae	The fruit is edible, while leaves and young shoots are fed to cattle, sheep and goats for increasing milk yield. The green bark is used by women for cleaning the hairs and the coarse bast fibers (also called phloem fiber, plant fiber that can be collected from the phloem or bast surrounding the stem) are used for making poor quality ropes for tying cattle and strings for cots.	Temperate Himalaya regions;2500 m masl.
40	*Gymnosporiaroyleana* Wall. ex Lawson Syn. *Maytenus*royleanus (Wall. ex Lawson)	Pataki/ SoorAzghai	Royle's Spike Thorn	Celastraceae	The leaves are used for digestive disorders, while it has also shown pharmacological properties as antimicrobial, antidiabetic, antioxidant, anticancer and haemagglutination. The fruit is kept in mouth to relieve toothache. The plant is a good bee flora.	Sub-tropical foot-hill
41	*Hederahelix*Linn.	Palool / Zeelai	English ivy	Araliaceae	The leaf used in homeopathy medicines. The aqueous leaf extract as well as dried leaf powder has antidiabetic properties. Also used for the cure of benign warts. Hederae folium preparation is used for the treatment of respiratory tract diseases with intense mucous formation, respiratory tract infections and in irritating cough due to common cold.	Temperate regions; wild and cultivated
42	*Indigoferaheterantha* Wall. ex Brandis Syn. *Indigoferagerardiana* Graham	Ghorija	Himalayan indigo/ Aniline	Fabaceae	The root, leaf and flowers are used both as dried powder form and decoction. Used for gastric disorders, muscular pain, headache, toothache, skin allergies, scabies, stomach pain, epilepsy, nervous disorders, asthma, bronchitis, cough, fever, liver diseases, hemorrhoids, gonorrhea, syphilis, and as diuretic and vermifuge and for snake bites.	Upper limits of sub-tropical & temperate pine regions of Himalaya; up to 3,000 m elevation
43	*Isodonregosus* (Wall. ex Benth.) Codd. Syn.: *Plectranthusrugosus*	BarosSperkai	Wrinkled leaf Isodon	Lamiaceae	Aromatic medicinal plant contains essential oil and has wide use in cosmetics. Fresh leaf extract is used for toothache, earache, hypertension, fever, gastric pain, rheumatism, dementia and abdominal pain. Bark extract is used for general body pain and dysentery.	Dry rocky slopes of western Himalaya regions; 1,900-3,000 m masl.
44	*Juglansregia*Linn.	Akhroot/Ghoz	English walnut or Persian walnut	Juglandaceae	It is valued for its edible fruit. The bark is antiseptic and used for teeth cleaning and gums protection. Dried bark is called *dandasa*. The bark is also used as a vermifuge and for staining. The seed oil used in cooking. *J. doucloxiana* (kaghzi akhrot) has high market value because of its thin shelled edible fruit.	Sub-tropical &temperate regions; 1,500-3,000 m masl.

45	*Justiciaadhatoda*L.	Baikar	Malabar Nut	Acanthaceae	Used for treating bronchitis, asthma, fever and jaundice on account of the antispasmodic properties of roots and leaves. The leaves contain an alkaloid vasicine and an essential oil.	Subtropical up to 1300 m masl
46	*Mallotusphilippensis* (Lam.) Muell. Arg. Syn.: *Aconceveibumtrinerve,Crotoncoccineus*	Kambila	kamala tree/ Red Kamala	Euphorbiaceae	The fruit is brick red covered with red powder that is used for dyeing silk and wool, and also as an antiseptic and anthelminthic. It is externally used to relieve excessive irritation, scabies and eczema.	Sub-tropical Himalaya regions; gregarious on stony slopes, rocky sandy hillsides in thorn scrub forests; up to 1,500 m masl.
47	*Mangiferaindica* Linn.	Aam	Mango	Anacardiaceae	Valued for its nutritive and delicious fruit. Used as a dentifrice (a paste or powder for cleaning the teeth), antiseptic, astringent, diaphoretic, stomachic, vermifuge, laxative and diuretic and to treat diarrhea, dysentery, anemia, asthma, bronchitis, cough, hypertension, insomnia, rheumatism and hemorrhage.	Planted in tropical and sub-tropical plain regions
48	*Matricariachamomilla* L. Syn.: *Matricariarecutita*	Gul-e-Babona	Chamomile/ Mayweed	Asteraceae	Chamomile has been used in herbal medicines for thousands of years. The Anglo-Saxons believed it as 1 of 9 sacred herbs given to humans by the lord. It is used widely for herbal tea, cosmetics, essential oil, and making herbal tinctures. The floral parts are primarily used as an anti-inflammatory, antiseptic, antispasmodic and as mildly sudorific (induces sweating). It is also used for cough, bronchitis, nervousness, insomnia, digestive disorders, colic hysteria and intermittent fever. The flowers contain the blue essential oil of high medicinal value. Cold decoction (1 table spoonful of the powdered flower in 1 L of cold water) is used for diarrhea, nausea, kidney stones, dysmenorrhea (painful menstrual periods due to contraction of uterine), swelling of mouth, throat, and eyes. The powder is topically applied for healing wounds, burns & skin eruptions (shingles & boils).	Introduced in plain areas of Pakistan from Europe about 300 years ago. It also grows naturally in highlands of Balochistan & temperate Himalaya regions.
49	*Melia azadarch* Linn.	Bakain/ Dhrek	Persian Lilac	Meliaceae	Leaf and seed pulp is used to treat 18 skin disorders and blood purifier. The plant has insecticidal and repellent properties. It is a healthy fodder for cows, goats and sheep.	Tropical plain and foot-hills up to 1,700 m masl.

50	*Menthaarvensis* L.	Pudiana	Corn mint/Field mint	Lamiaceae	Medicinal and aromatic plant. The plant has strong anti-inflammatory, antioxidant, anticancer, and antibacterial activities. The dried leaves are carminative, antispasmodic, stomachic, refrigerant and diuretic. The leaf tea with lemon grass is used as a febrifuge. Mint oil is used for hypertension, ischemic heart disease, indigestion, rheumatic pain, arthritis and to prevent vomiting. The plant is also used as spice and leafy vegetable.	Cosmopolitan distribution, tropical; sub-tropical &temperate regions. It is also cultivated.
51	*Menthalongifolia* (L.)	Wailany	Wild mint/ horsemint	Lamiaceae	Medicinal and aromatic plant. The leaf tea is taken for cough, cold, stomach cramps, asthma, flatulence, indigestion and headache. Externally, wild mint is used for healing wounds and treating swollen glands. Used as spice in salad and leafy vegetable. Rosmarinic acid or 'Labiatae tannin has potential to increase shelf life of food items. It is a good repellent against mosquitoes.	Cosmopolitan distribution; temperate damp or wet places.
52	*Monothecabuxifolia*	Goorgore	Gargole	Sapotaceae	The leaves and fruits are used in traditional medicines. The leaves are used as analgesic, hematinic, laxative, vermicide, antipyretic, and for the management of gastro-urinary disorders. The Fruits are purgative, vermifuge and refrigerant.	Tropical to temperate regions
53	*Morus alba* L.	Toot	White mulberry	Moraceae	The roots, leaves and fruit are used for the treatment of cough, sore throat, dizziness, insomnia, premature aging and for cholesterol. The fruit is edible and has provide relief against atherosclerosis, liver and kidney disorders, and inflammation. The fruit is used for making drinks, jams, marmalade and cakes. The leaves are used in cosmetics. The white mulberry is widely cultivated to feed the silkworms. A good source of fodder for livestock.	It has wide habitat ranging from tropical to temperate regions.
54	*Myrsineafricana* L.	Chapra/ Gugul/ Marowang	Cape myrtle	Myrsinaceae	The fruit is edible and also used as condiment. It is used as a powerful cathartic & vermifuge (anthelmintic). The plant gum is used for dysmenorrhea. The leaves are used soup and milk in Africa for reducing cholesterol levels. Sometimes the seed is an adulterant of powdered pepper.	Tropical to sub-tropical in Balochistan and Salt range in Punjab. Prefers shady places in the drier oak forests up to 2,700 m masl

55	*Myrtuscommunis* Linn.	HabbulAas/ VilayatiMehendi/ Hina/shamkai/ Manroo	Myrtle	Myrtaceae	Medicinal and aromatic plant. All plant parts are used for medicinal purposes. The leaf powder decoction is used for hypertension, eczema and other skin and respiratory disorders and hemorrhoids. It has been used in anti-inflammatory activities. The berries and essential oil are antibiotic, antiseptic, antiviral, astringent, carminative, decongestant and haemostatic. The berries are chewed as an appetite stimulant. They are useful in bronchitis, pharyngitis, spasmodic cough and in sinusitis.	Dry temperate; endangered species
56	*Nasturtium officinale*W.T. Aiton Syn.:Rorippa nasturtium-aquaticum (L)	Choo/ Tarmeera/ Hub-ul-Aas	Watercress	Brassicaceae	All plant parts are used. It provides relief in asthma, piles, skin disorders and thyroid gland disorders. A cup of fresh juice with a teaspoonful of lemon juice with common salt is useful in anemia and as a body tonic. Used also in combination with other herbs for urinary tract infections, cough, and bronchitis. Sometimes it is applied directly to the skin for muscular pain.	Aquatic herb, found in sub-tropical & temperate regions
57	*Nerium oleander* L. Syn.: *N. indica; N. odorum*	Kunair/ Ganira/Ghanderay	Oleander/ Rose bay	Apocynaceae	The plant is highly poisonous and used for suicide in some countries. The leaves are used in cutaneous eruption, while leaf decoction is used to destroy maggots infesting wounds. The leaves and seeds are used to prepare medicines for heart conditions, asthma, epilepsy, leprosy, cancer, dysmenorrhea, malaria, ringworm, indigestion, Gonorrhea and to cause abortion. Also used in homeopathic medicines	Cosmopolitan distribution; Naturalized or planted in tropical & sub-tropical regions
58	*OleaFerruginea*Royle Syn.: *Olea cuspidate* Wall. ex G. Don,	Kao/ Kahu	Indian Olive	Oleaceae	The fruits are directly consumed while the fresh leaves are used for making tea.	Tropical to sub-tropical regions associated with *A. modesta*; 500-2,000 m masl.
59	*Otostegialimbata* (Benth.) Boiss	Awan buti/ SpeenAghzai	Otostegia	Asteraceae	Traditionally used against several ailments. It possesses properties like antispasmodic, antiulcer, antidepressant, anti-inflammatory for eyes inflammation, antibacterial and antioxidant sedative and anxiolytic.	Sub-tropical to temperate, northern Pakistan and AJ&K

60	*Paeoniaemodi*Royle	Mamekh	Himalayan Peony	Paeoniaceae	The rhizomes are used for hysteria, convulsions, colic, uterine infections and obstruction of the bile duct. Also used as blood purifier. The seeds are cathartic and emetic. The dried flower infusion is useful in the treatment of diarrhea. The dried petals tea used as a cough remedy, and for treating hemorrhoids and varicose veins.	Temperate in semi-shady areas preferably on moist soils
61	*Parrotiapersica*	Bari ranj/ SarBanj	Persian ironwood	Hamamelidaceae	Excellent small lawn tree or street tree. Can be incorporated into foundation plantings, particularly in shrub form.	
62	*Phoenix dactylifera* Linn.	Khajur	Date/ date palm	Arecaceae	The fruit is delicious, edible and highly nutritive. Used for cold, fever, asthma, cystitis, edema, sore throat, bronchial catarrh, cough, liver cancer, low sperm count and gonorrhea. Fruit is also used as an aphrodisiac and for chest complaints. Fresh juice made of fruit has cooling and laxative activities, while gum is useful for diarrhea and gentio-urinary diseases.	Arid and Semi-arid areas
63	*Piceasmithiana*(Wall.) Boiss Syn. Piceamorinda	Mangazai	Spruce	Pinaceae	Immature females are roasted tastes sweet. Inner bark of immature female cone is dried, powdered and used as thickener in soups. A refreshing tea, rich in vitamin C, can be made from the young shoot tips.	Dry temperate regions; 2,100-3,600 m masl.
64	*Pinusroxburghii* Sargent Syn. *Pinuslongifolia* Roxb.	Chir	Chir pine	Pinaceae	The wood is aromatic and deodorant. The turpentine oil obtained from the resin is antiseptic, diuretic, rubefacient and vermifuge, Internally it provides relief against cough and respiratory disorders, while externally effective against skin complaints, wounds, sores, burns, boils, etc. Bark extract is analgesic and anti-inflammatory.	Sub-tropical to temperate regions associated with Chir pine; up to 2700 m masl.
65	*Pinuswallichiana*A. B. Jackson. Syn. *Pinusexcelsa* Wall. ex Lamb.	Kail	Blue pine	Pinaceae	The plant also contains turpentine oil and medicinal uses like other pine species.	Moist and dry temperate regions.
66	*Pistaceaintegrima* J. L. Stewart ex Brandis	Shanal / Kikarsongay	Crab's claw	Anacardiaceae	Blackish irregular shaped galls appear on the leaves and petioles and used in traditional medicines for treating cough, asthma, dysentery, liver disorders and for snake bite.	Semi-arid plains and exposed hilly slopes; 457 to 1,980 m masl. Cultivated in plains

67	*Platanusorientalis* Linn. Syn. *Platanuscuneata* Will d.	Chinar	Oriental sycamore/ Oriental plane	Platanaceae	The leaves are mildly astringent and leaf decoction is used dysentery. Fresh leaves are bruised and applied for ophthalmic diseases, while leaf cream is applied for healing wounds. The bark is boiled in vinegar and used for diarrhea, dysentery, hernias and toothache.	Cosmopolitan distribution, sub-tropical to temperate regions. Also planted in plain areas.
68	*Plectranthusrogusus* Syn: *Isodonrugosus* (Wall . ex Benth.) Codd	Sperky/ Khwangere	Spur-flower	Lamiaceae	The fresh leaf extract is applied topically to treat scabies, hypertension, fevers, rheumatism and toothache, while 1-2 drops of the extract are used to treat earache. A good honey bee flora.	Temperate regions especially on dry rocky slopes in association of conifer species
69	*Podophyllumemodi*	Bankakri/ Papra/Kakora	Indian podophyllum	Berberidaceae	The rhizome extract is used for leukemia (both Hodgkin and Non-Hodgkin lymphoma). Podophyllin resin is used for treating genital and anogenital warts, psoriasis (skin disease-causes red, itchy scaly patches, most commonly on the knees, elbows, trunk and scalp).	Alpine, Sub-Alpine & dry temperate; 2,300-3,900 m masl.
70	*Polygonatumbifloru m* (Walt.) Elliott.	Noor Alam	Smooth Solomon's seal	Convallariaceae/ Asparagaceae	It contains steroidal saponins and flavonoids. It is used in wound healing being antibacterial, also used as an expectorant. A tea made from root is used as laxative. Also used for indigestion, profuse menstruation, lung ailments, and general debility, piles, rheumatism and skin irritations. Tender leaves, young shoots and roots used as greens. They can be used as an asparagus substitute.	Temperate regions
71	*Polygonumvirginianum* Linn. Syn. *Persicariavirginiana*(Lin n.) Gaerth*; P. filiforme*Dougl.	Toor	Jumpseed	Polygonaceae	The plant is astringent, demulcent, diuretic and tonic. A hot infusion of the leaves combined with the Honey Locust Bark (*Gleditsiatriacanthos*) is used for treating whooping cough. The leaves and seeds are cooked or eaten raw.	Temperate Himalaya regions
72	*Primula denticulata*Wight	Phul Tara/Mamera	Drumstick primula	Primulaceae	The flower extract is used for ophthalmic diseases and as a hair tonic. The plant contains contact allergens, such as primin and other quinoid compounds.	Sub-alpine, Alpine & temperate regions; 1,300–4,300 m masl. in forest clearings or damp meadows.

73	*Prosopis cineraria* (L.) Druce Syn.: *P. spicigera* L. *Mimosa cineraria* L.	Jand	Spunge tree	Fabaceae/ Leguminosae	The plant is astringent and has anti-inflammatory activities. The bark is used for treating asthma, bronchitis, dysentery, leukoderma, leprosy, rheumatism, and piles. The flowers are mixed with sugar and used to prevent miscarriage. The pods are rich in protein and used as vegetables or dried powder used in cakes.	Warm arid &semi-arid regions
74	*Prunusarmeniaca* Linn.	Khobani	Apricot/ Armenian plum	Rosaceae	The fruit contains macro and micro nutrients, minerals and anti-oxidants. The fruit has antimicrobial, antidiabetic activities. It is also beneficial for metabolic disorder in dyslipidemia and cardiovascular and chest muscles. The decoction is used to soothe inflamed and irritated skin conditions. The seed is used for asthma, cough, acute or chronic bronchitis, constipation, and as analgesic, anthelmintic and expectorant.	Temperate regions, also cultivated in plain areas
75	*Punicagranatum* Linn.	Anar	Pomegranate	Lythraceae	The fruit is delicious and rich of major nutrients and minerals. It contains phenolic compounds and has antioxidant anti-inflammatory, antibacterial and anthelmintic activities. Used in natural and holistic medicine to treat sore throats, coughs, urinary infections, skin and digestive disorders, and arthritis. The fruit and bark are used against intestinal parasites, dysentery and diarrhea. The juice is considered a tonic for throat and heart. It is used to stop nose and gum bleeds and hemorrhoids. The seed oil has inhibitory effect on skin and breast cancer.	Cultivated in tropical and sub-tropical regions; wild in sub-temperate regions
76	*Pyruscommunis* Linn.	Toung/ Nashpati	European pear	Rosaceae	The fruit is edible and used in urinary therapeutics, as skin whitening agent, analgesic, spasmolytic antioxidant, anti-inflammatory and antibacterial. It is also used in diabetes because of low sucrose content.	Moist temperate regions and rarely in sub- tropical.
77	*Pytolaccaamerican* Linn.	Ghamar Salk	Pokeweed	Phytolaccaceae	Poisonous plant. Used in homeopathic medicines for chronic rheumatism, regular conjunctivitis, psoriasis (Chambal), and skin diseases. It reduces excess weight and increases fat metabolism. It provides relief in sore throat, cold and glandular swellings.	Tropical & sub-tropical regions

78	*Pytolaccalatbenia* (Moq.) Walter Syn. *Phytolaccaacinosa*Roxb.	Lubar/ Rinsag	Pokeweed	Phytolaccaceae	Plant is highly poisonous. The roots contain a resinoid substance (phytolaccin), which is used in medicine. They are also used to dilute belladonna. The paste of whole plant applied topically soothes arthritis, kills germs and leaves treats fungal infection. The leaves are cooked well and used as a vegetable. Uncooked leaves are poisonous.	Most moist temperate regions; 1,500-3,000 m masl.
79	*Quercusincana* Bartram	Ban / Shah baloot	Blue Jack Oak/ Oak	Fagaceae	The leaves and bark are used as astringent, diuretic, and antidiarrheal agent. It provides relief in asthma, diarrhea, hemorrhoids gastrointestinal disorder, and oral, genital and anal mucosa inflammations.	Sub-tropical to temperate southern slopes of the Himalayas from 1,000-2,700 m
80	*Ricinuscommunis* Linn.	Herhanda/Markhanda	Castor bean or castor oil plant	Euphorbiaceae	The leaf, root, and seed oil are used for treating inflammation, liver disorders, chronic backache and headache, sciatica, hypoglycemic, as a laxative and analgesic. The castor oil provides relief in abdominal disorders, arthritis and rheumatism, gallbladder pain, menstrual cramps and pain, sleeplessness and insomnia. It is also used for expulsion of placenta. Beans contain ricin and highly toxic to humans.	Tropical regions. Naturalized and cultivated in sub-tropical regions
81	*Robiniapseudoacacia* Linn. Syn. *Robiniapringlei*	Robinia	Black locust	Papilionaceae	The homeopathic medicine *Robiniapseudocacia.* Dilution prepared from the tree is used for treating hyperacidity and associated symptoms like nausea, indigestion and frontal headache. The leaf powder is helpful in treating wounds caused by burns. The flowers are aromatic, eaten raw or used for making jams, pancakes and drink. The root and bark is toxic and toxicity is removed by boiling.	Arid and semi-arid hilly areas; also planted as ornamental plant in plain areas.
82	*Rubusfruticosus* Linn.	Karwara/ Ach/ Baganrra	Blackberry	Rosaceae	All plant parts are edibles. The fruit, raw or cooked is used to make syrups, jams and other preserves. The young roots are boiled thoroughly and eaten. The dried leaves are used for making tea. The young shoots are peeled and used as salads. The root bark and leaves are astringent, diuretic and tonic and have wound healing activities. They are also used for diarrhea, asthma, cystitis and hemorrhoids. The leaf decoction is a good gargle for sore throats, mouth ulcers, gum inflammations and a mouthwash.	Moist and dry temperate and sub-tropical regions.

83	*Rumexdentatus* Linn. Syn. *R. klotzschianus; R. limosus*	Shalkhey	Toothed dock	Polygonaceae	Traditionally the plant is used as astringent, anti-inflammatory, antimicrobial and anthelmintic agent. The roots are used for treating ascariasis, eczema, diarrhea and constipation.	Weed found in agricultural crops from warm arid to temperate regions.
84	*Rumexhastatus* D. Don Syn. *Rumexdissectus*	Khatimal/Tarokay	Arrow leaf Dock	Polygonaceae	The whole plant is a rich source of carbohydrates, protein and fats. It is used as vegetable in northern Pakistan. The juice of the plant is astringent and is used for dysentery. The fresh tuber is chewed for relief in in throat pain. The plant has antidiabetic, anthelmintic, cytotoxic and antioxidant activities. Traditionally it is used for gastrointestinal diseases, jaundice, blood pressure, tonsillitis, sore throat and diuretic. It has potential of as an appetizer, snake bites antidote, flavoring and carminative agent.	Sub-tropical and temperate regions on dry slopes, rocks & walls; 700-2,500 m a.s.l.
85	*Salix babylonica* Linn. Syn. *S. pendula*	Majnun/ Wala	Weeping willow	Salicaceae	The bark is very bitter. Young shoots and flower buds cooked but very unpalatable. The leaves and bark are astringent and used as tonic and for rheumatism. The leaf decoction is used for treating abscesses, carbuncle, fever, skin diseases and ulcers. An infusion of the bark is used for diarrhea and fever.	Planted widely
86	*Salvia divinorum*Epling & J átiva	Tukhm-e-Balanga	Diviner's Sage	Lamiaceae	The seeds are used for treating cluster headaches, diarrhea, rheumatism, and anemia. The plant has transient psychoactive properties. The leaf smoke and tea produces hallucinations, and when chewed or extracts placed under the tongue.	
87	*Saussurealappa*(Falc.) Lipsch, Syn.: *S. costus*	Kuth/ Chob-e-kisht	Costus	Asteraceae	The root is traditionally used for chronic gastritis, rheumatoid arthritis, asthma and bronchitis, and in inflammation-related diseases.	Cosmopolitan distribution, temperate Himalaya regions; 2,100-3,500 m a.s.l
88	*Syzygiumcumini* (L.) Skeels; Syn. *Eugenia jambolana*Lamk	Jaman	Black Berry/ Java Plum	Myrtaceae	The fruit is edible and has pharmaceutical values. The bark is astringent and is used in the preparation of decoctions for gargles. The fresh juice is given to children with goat's milk for diarrhea. The fruit is useful astringent in bilious diarrhea. The flower juice is used in dysentery. The juice of ripe fruits is made into a vinegar and is used as a stomachic, carminative and diuretic. An aqueous extract of the seeds and fruit pulp is used as antihiatic remedy.	Tropical and sub-tropical regions; planted widely in plains & sub-mountainous areas.

89	*Taxusbaccata* Linn. Syn.: *T. wallichiana* Zucc.	Barmi/ Barria	English Yew	Taxaceae	The needles, bark and seed contains 'taxol' which is used for treating breast, ovarian and lung cancer. The plant is also used to prepare an herbal drug 'Zarnab'. Traditionally the bark and leaves are used for treating asthma, bronchitis and insect bites, and leaf tea is taken for cold, cough, fever and pain. It is also used as aphrodisiac.	Sub-tropical & Moist temperate regions; 1,800-3,300 m a.s.l.
90	*Trillium govanianum*Wallich ex Royle	Matarjari/ matarjarri	Himalayan Trilliu m	Melanthiaceae	The rhizome is used as an analgesic and to reduce inflammation. It is also used as antiseptic, for skin infection and wound healing, painful discharge of blood and mucous with bowel. It is provides relief in menstrual disorders. The rhizome is mixed with milk and used as sedative in children.	Temperate regions in humid areas; 2,400-3,200 m a.s.l.
91	*Urticadioica* Linn.	Bichchuboti/S eezonke	Common Nettle	Urticaceae	Traditionally it is used as remedy of cardiovascular disorders especially hypertension. The bark and leaf tea is used as antidiabetic. Nettle root prevents some of the effects of prostatic hyperplasia. It is also used as herbal remedy for arthritis pain and seasonal allergies.	Temperate regions
92	*Valerianajatamansi* J onesSyn.: *Valerianawallichii* D C.	Mushkbala/ Balchar/ Muskroot	Spikenard/ Jatamansi	Caprifoliaceae	The root/ rhizome is aromatic and used in traditional medicines as a bitter tonic, stimulant and antispasmodic. It is also used for treating hysteria, convulsions, fatigue, tension, anxiety, depression, epilepsy, insomnia and disorders of Nervous and Circulatory systems. The root contains an essential oil that is used as perfume and medicine since time immemorial. The oil is used in the preparation of tranquilizers and a remedy for the suppression of urine. It is also an important ingredient in perfumed powders.	Sub-alpine & temperate forests; 1,300-3,200 m a.s.l.
93	*Verbascumthapsus* Linn.	Janglitamak/ GidharTamba ku	Great mullein	Scrophulariace ae	The whole plant has medicinal values. The root has diuretic activities, while the flowers reduce eczema inflammation. Traditionally plant is used as expectorant for treating pulmonary problems, asthma, spasmodic coughs, diarrhea and migraine headaches. The liquid extract is used for remedy of earache.	Sub-tropical & temperate regions along road sides, meadows and pasture lands.

94	*Viburnum grandiflorum* Wall. ex DC. Syn. *V. foetens* Decne&*V. nervosum* D. Don	Guch/ Chamyaria/A moch	Cranberry bush	Adoxaceae	The fruit is sweetish and edible, while flowers are sweet scented. The leaves are mildly laxative and diuretic. The stem bark is used for treating wounds and malaria. Traditionally it is used to treat abdominal pain, wound, whooping cough, typhoid, respiratory diseases, dysmenorrhea and toothaches. The root decoction is used for treating uterine disease.	Temperate regions; 1,500-3,600 m masl.
95	*Viola serpens*Wall. exRoxb.)Syn. *Viola pilosa* Blume	Banafsha	Viola	Violaceae	It is antipyretic, diaphoretic, diuretic, mild laxative properties. It is also useful in respiratory track congestion, asthma, sore throat, cold, coryza (inflammation mucous membranes lining the nasal cavity), and throat cancer. It is beneficial in bleeding piles, headache, and skin diseases. The leaves contain an essential oil that has important use in preparation of drugs for infectious diseases.	Moist &dry temperate regions.
96	*Vitisjacquemontii* R. Parker Syn. *Vitislanata*Roxb.	GidarDakh/ JangliAngoor	Jackal grapes	Vitaceae	The watery stem sap is used to treat eye inflammation. Flowers are astringent, tonic and non-palatable. Fruit is laxative also used as carminative, antispasmodic, antipyretic, purgative, diaphoretic, anthelmintic and tonic. The fruit is edible, slightly sour and rich in carbohydrates and minerals. Eaten as fresh or dried. A yellow dye is obtained from the fresh or dried leaves.	Sub-tropical to temperate Himalayan hilly areas
97	*Zanthoxylamarmatum* DC. Syn. *Z. alatum* Roxb.	Timbar/ Dambara	Winged prickly ash	Rutaceae	It is an aromatic and medicinal plant. Whole plant has medicinal values. It is used for asthma, bronchitis, indigestion, varicose veins (swollen enlarged veins) and diarrhea. It is also used for toothache, chest infections, and scabies. It is carminative and antiseptic. The fruit, leaf and seed contain high valued essential oil called *Zanthoxylum* oil.	A xerophytic shrub found in the foothills up to 1,500 m masl.
98	*Ziziphusnummularia* (Burm. f.) Wight &Arn Syn. *Z. rotundifolia* Lam.*Rhamnusnummularia* Burm. f.	Malla, Jherberi	Lotebush/ Wild Jujube	Rhamnaceae	The fruit edible. It is used traditionally for cold, mental retardation, dysentery, diarrhea, fever, burns and colic. It is also used in ulcers, wound healing, pharyngitis, bronchitis, anemia, irritability, hysteria and as a nervine tonic. The leaves are applied in scabies and boils.	Arid and semi-arid areas (Thar desert)

99	*Ziziphusoxyphylla*Edgew Edgew. Syn. *Z. acuminata* Royle	Amlai/ Elania/ Tukbari	commonly called jujube	Rhamnaceae	Whole plant is used in traditional medicines, however, the use of fruit, leaf and root is overwhelming. The fruit used in the treatment of jaundice, diabetes, hypertension and liver disorders since long, while the root bark and leaves are for treating fever, inflammation and gastrointestinal complaints.	Tropical, sub-tropical and warm temperate regions.
100	*Zizyphusjujuba* Mill. Syn. *Z.sativa*Gaertn.	Ber	Red or Chinese date	Rhamnaceae	The plant is thought to be as old as the Bronze Age Shang Dynasty, and has been cultivated since 2000 BCE in the Indus Valley. The fruit is delicious and nutritive, very rich in carbohydrates. The fruit stimulate appetite and is beneficial for liver and also used for treating tuberculosis. The leaves provide relief in gastrointestinal disorders. The leaves are antipyretic and their paste is applied directly to the skin for wound healing, treating dry skin and sun burn, reducing wrinkles and aging signs. The seed is useful in leucorrhea, and as an astringent tonic to the heart and brain.	Arid and semi-arid sub-tropical regions. Planted in temperate regions.
101	*Zizyphusmauritiana* Lam.	Ber	Ber/ Indian jujube	Rhamnaceae	The fruit is small and delicious and used as food since antiquity. The root is used to treat coughs and headaches, whilst the bark is used on boils, and for dysentery. The leaves are antipyretic. The fruit improves muscular strength and weight. It is beneficial for liver diseases, tuberculosis and stress ulcers. The seed is useful in leucorrhea, and as an astringent tonic to the heart and brain.	Arid and semi-arid sub-tropical regions

1.3 Mapping and Digitization

A map of Khyber Pakhtunkhwa showing seven administrative Divisions was prepared as shown in Figure 1.

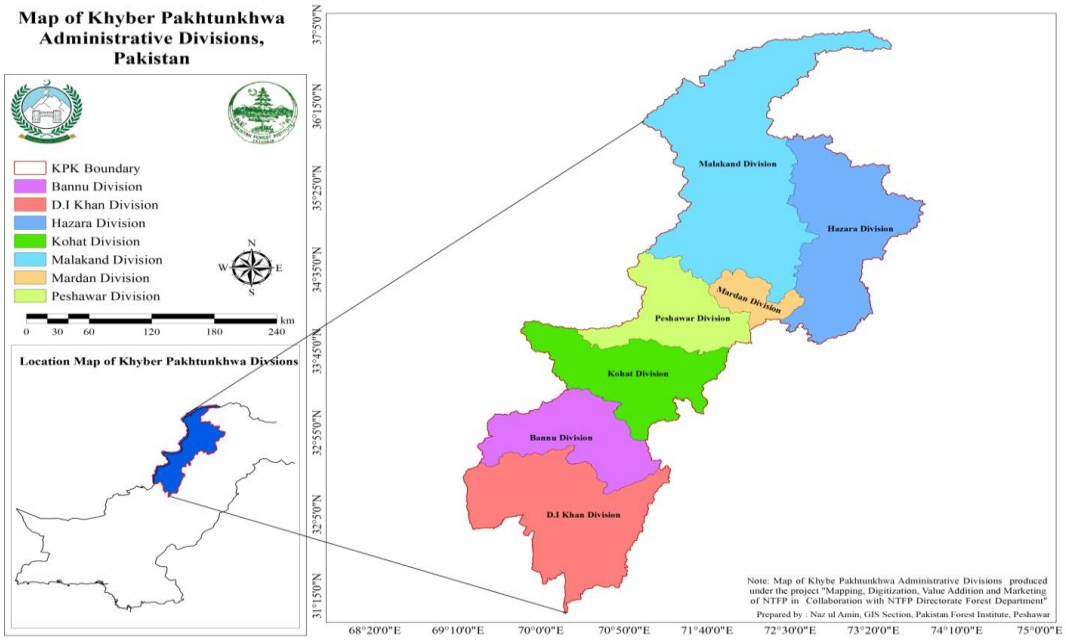


Figure 1: Administrative Divisions of Khyber Pakhtunkhwa

Survey data was fed to GIS database and for each individual species the database was created. The data was imported to ArcGIS and created shape files of NTFPs and finally the map was created**.** Non timber forest produces (NTFPs) maps of Hazara, Malakand, Kohat, Bannu and D.I Khan Divisions are respectively shown in Figure 2-6.

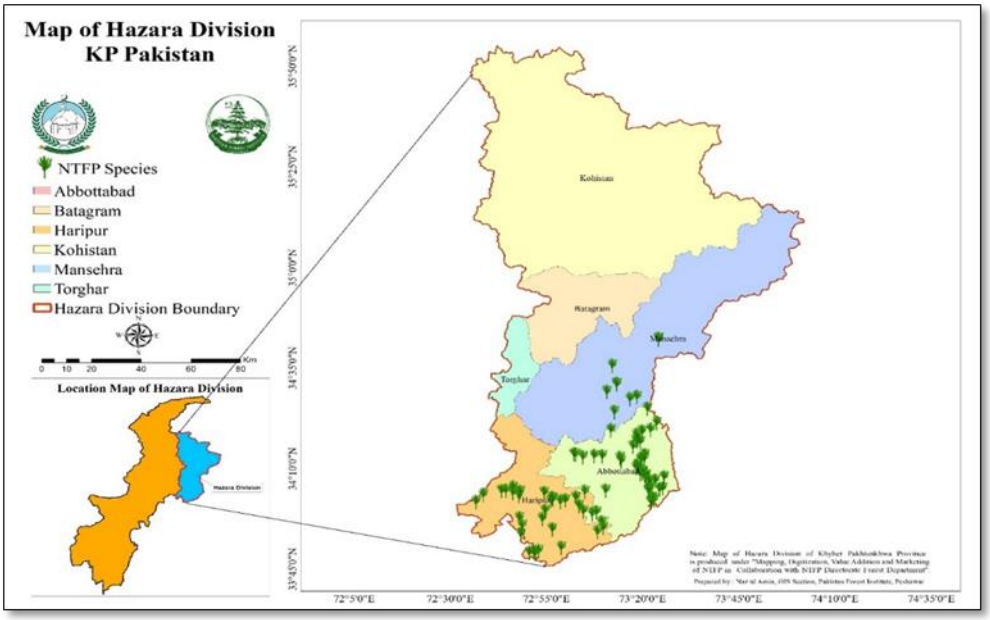


Figure 2: NTFPs species of Hazara Division of Khyber Pakhtunkhwa

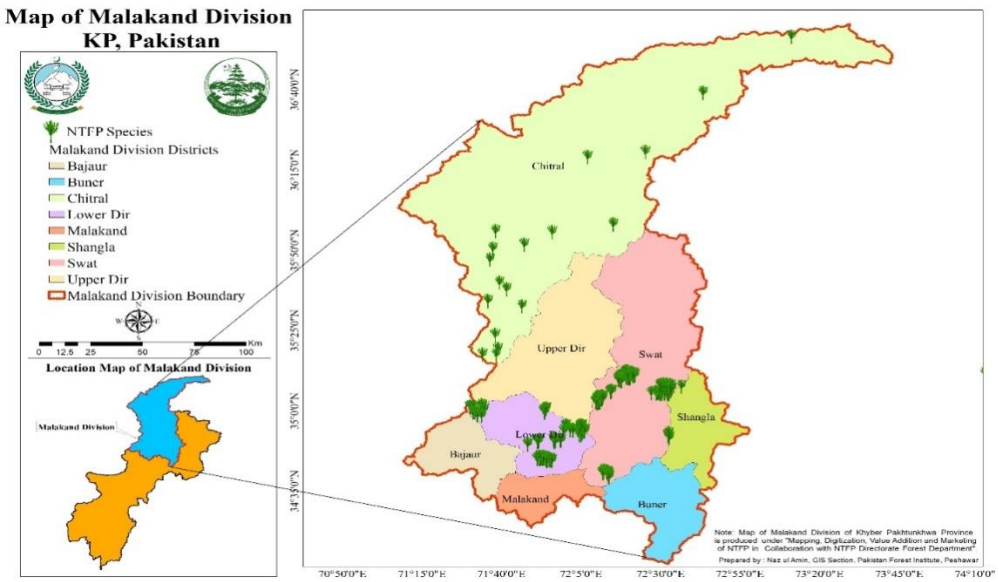


Figure 3: NTFPs species of Malakand Division of Khyber Pakhtunkhwa

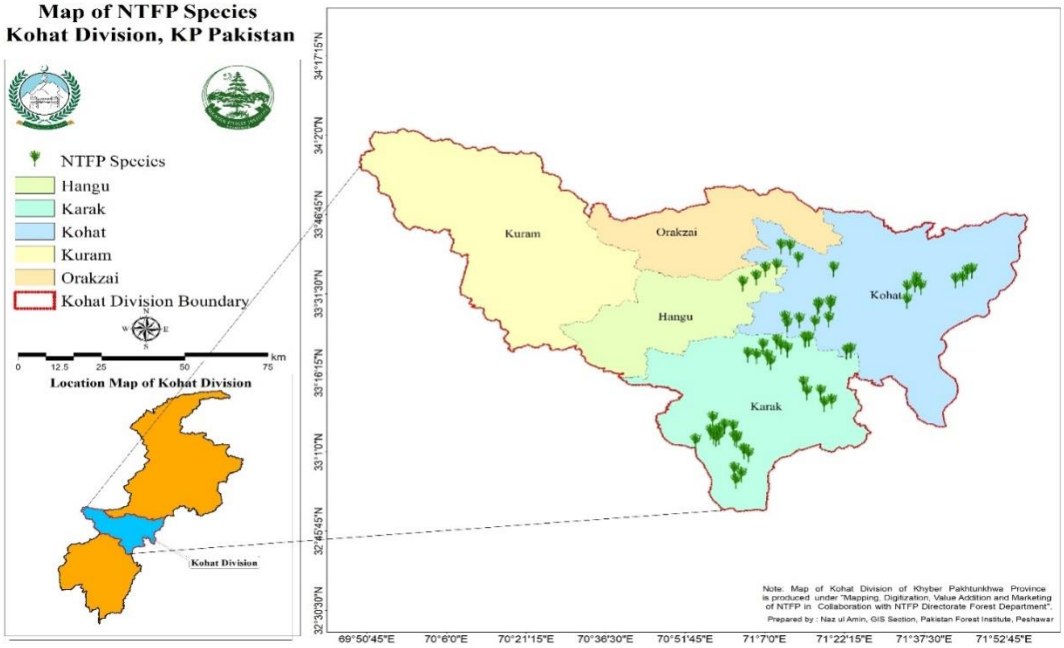


Figure 4: NTFPs species of Kohat Division of Khyber Pakhtunkhwa

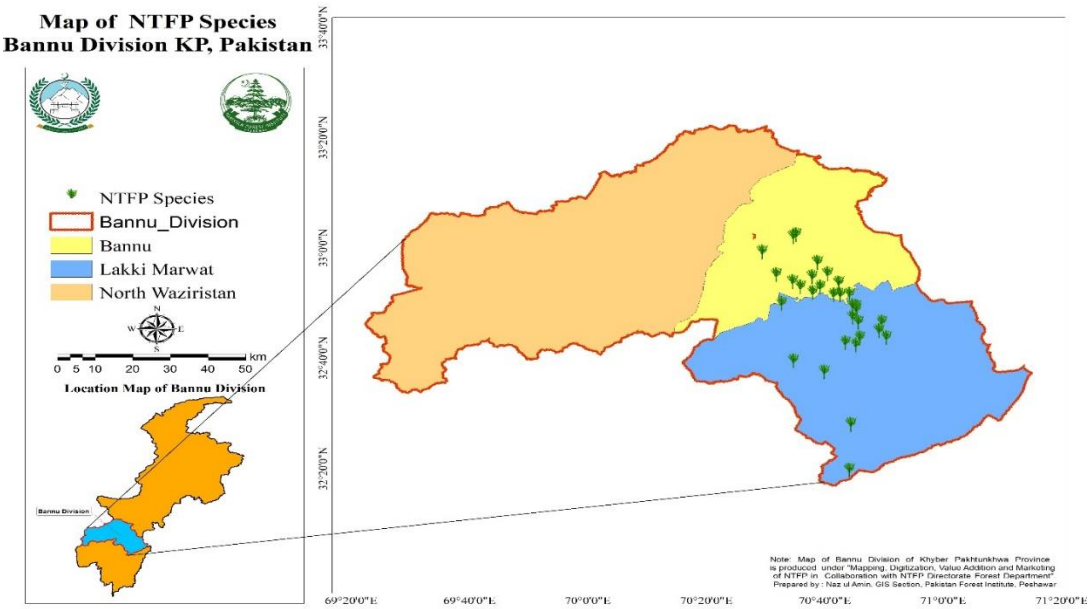


Figure 5: NTFPs species of Bannu Division of Khyber Pakhtunkhwa

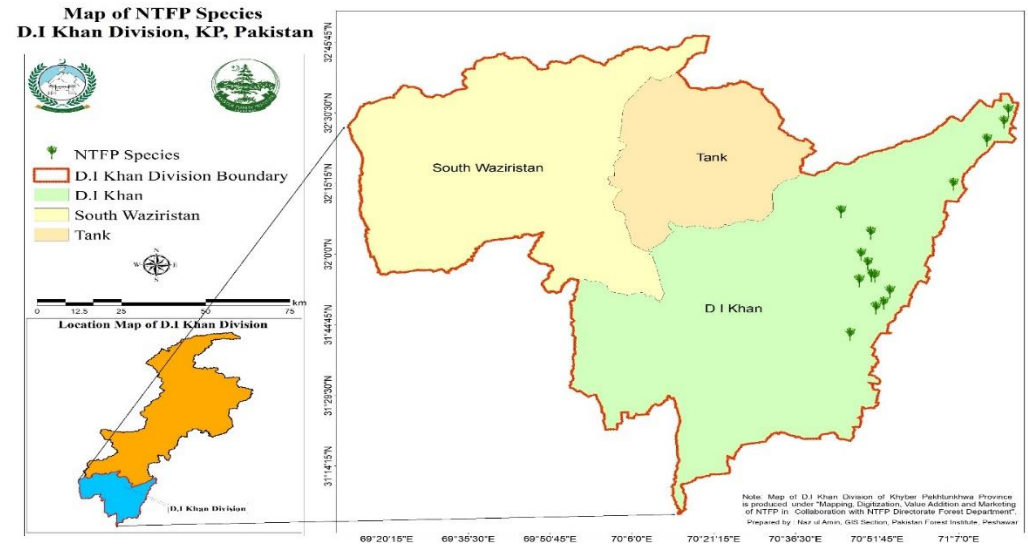


Figure 6: NTFPs species of DI Khan Division of Khyber Pakhtunkhwa

Following three step methodology was adopted to analyze and final layout of NTFP species in different areas of KHYBER Pakhtunkhwa.

Data Preparation

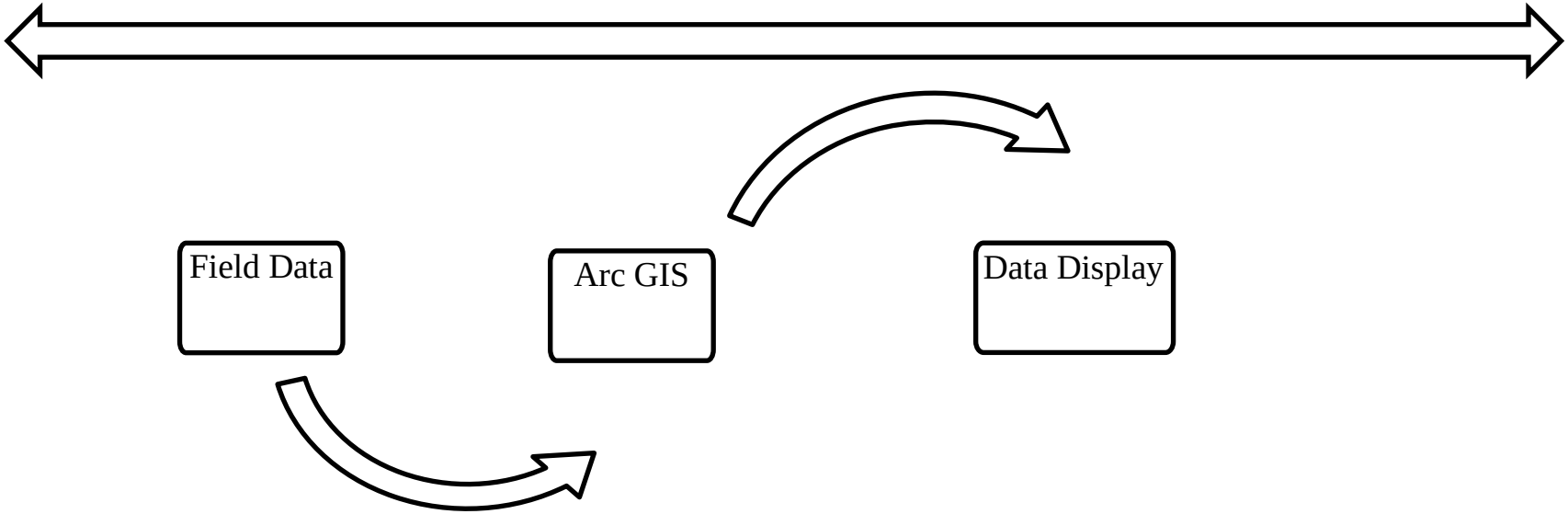
- Field data verification, cross checking of GPS coordinates through Google Earth, MapSource
- Data Feeding in Excel data base/Attribute data Preparation

ArcGIS

- Attribute data (excel) linking with ArcGIS for geo-ref (spatial) location through excel to table tool
- Verification of point and boundary data
- Adjustment of coordinate system

Final Layout

- Administrative Division/District wise mapping
- Finalization of layout with integration of data view in ArcGIS
- Shapefile to KML-KMZ conversion for Google Earth Database formation
- Layout Export and final printing



Spatial database was created for embedded maps of NTFPs species. For each specie separate CSV sheet was prepared. The data was imported to ArcGIS software and WGS 1984 coordinate system was assigned to species, and shape file of each species was created. The shape files were convert to KML layer, and subsequently embedded maps for each NTFPs species were created.

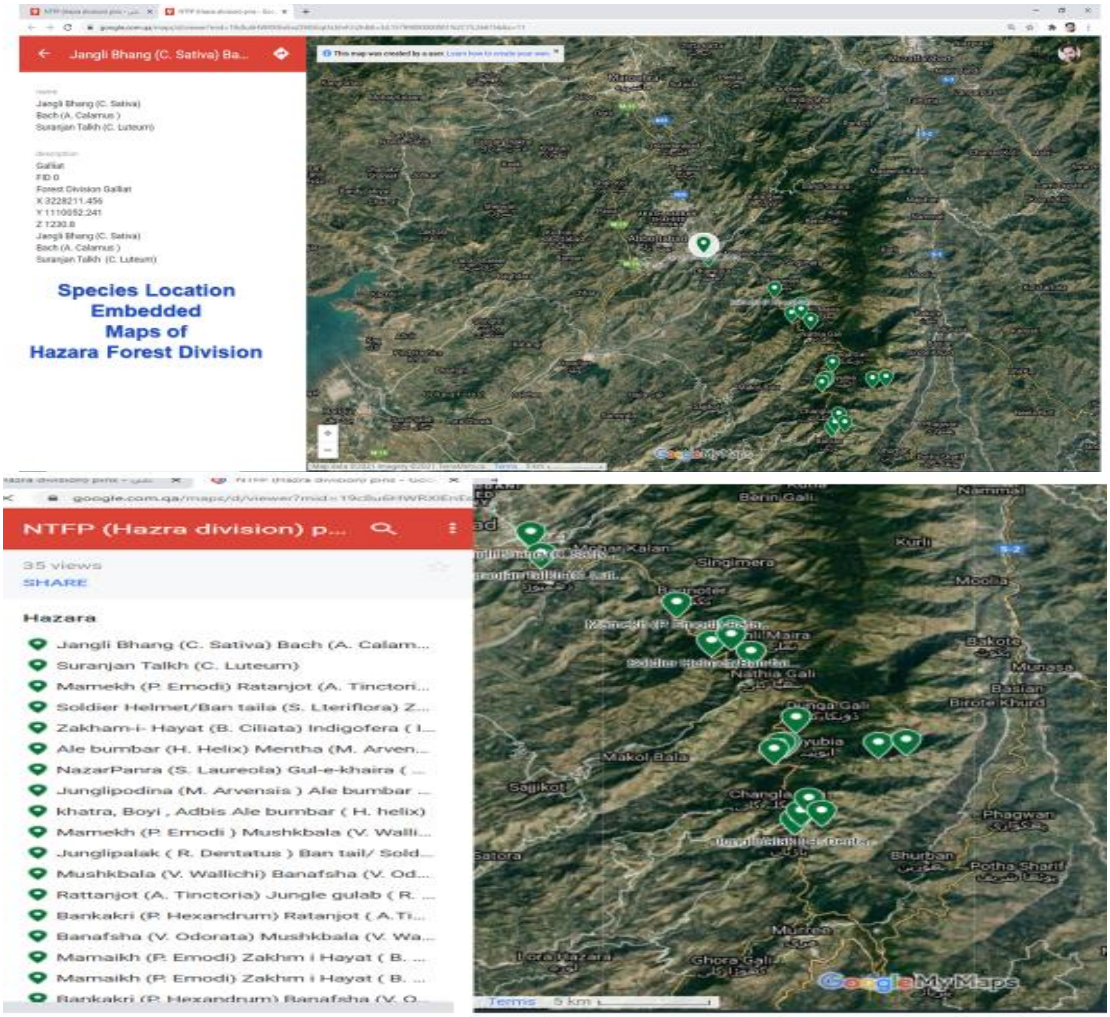


Figure 7: Embedded map of NTFP species of Hazara Division-Khyber Pakhtunkhwa

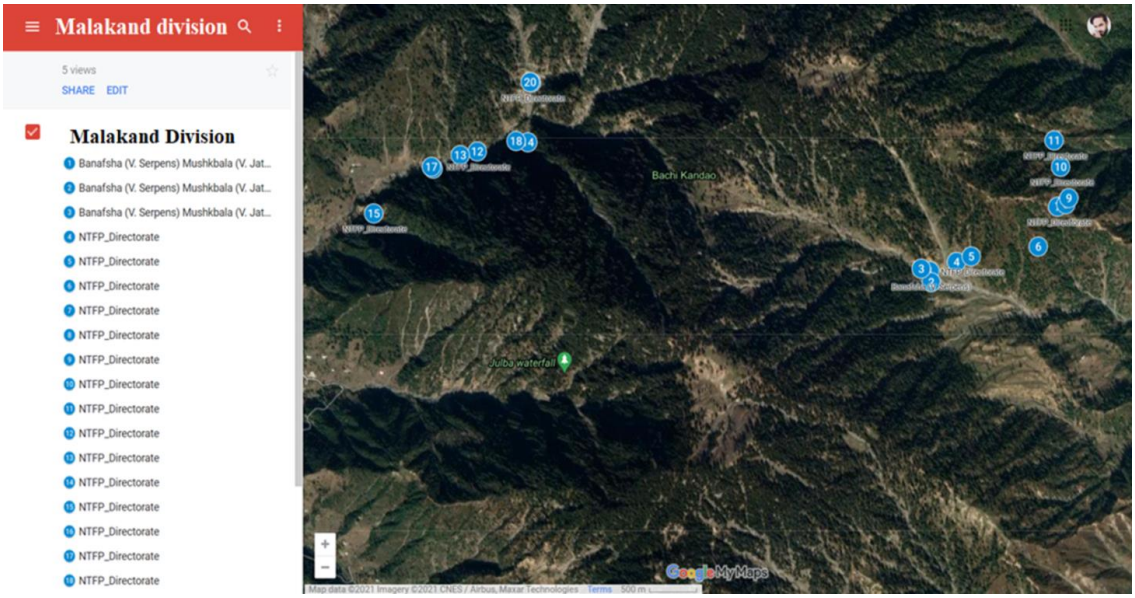


Figure 8: Embedded map of NTFP species of Malakand Division-Khyber Pakhtunkhwa

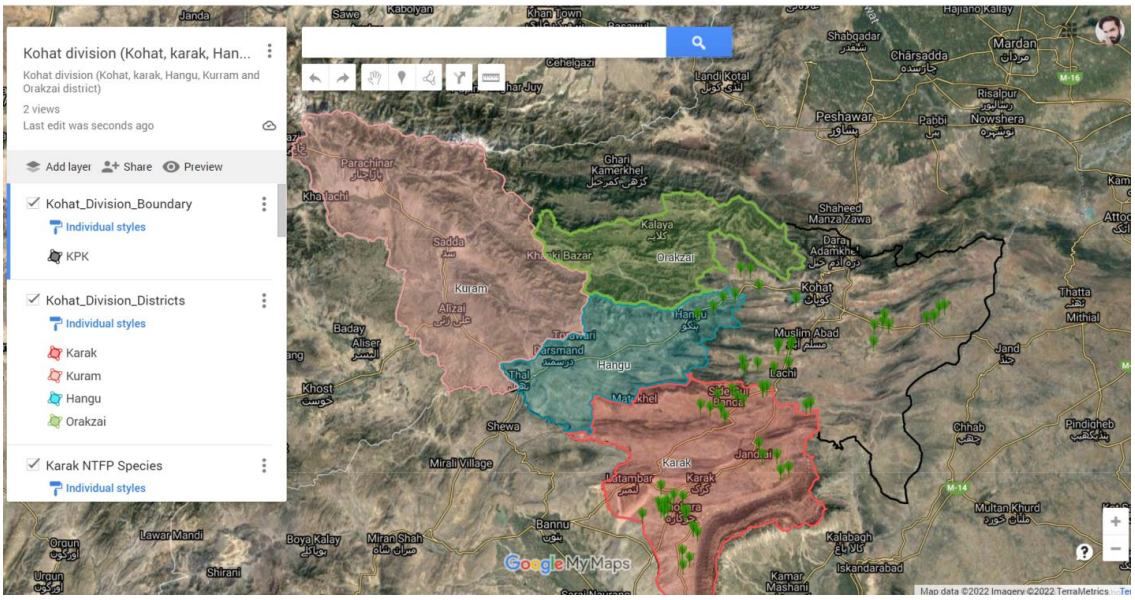


Figure 9: Embedded map of NTFP species of Kohat Division-Khyber Pakhtunkhwa

1.4 Website and Database Development

Domain Registration

Domain name acquired from PKNIC www.pfintfp.gov.pk. The domain name is purchased for seven years.Website Hosted in Khyber Pakhtunkhwa Data Center (KP data center)

Server and domain Configuration

Configuration of domain name and server.Creation of testing mode and maintenance mode.Cpanel Configuration and Official Email Configuration

Understanding Requirements

Functional Requirements

Features

- Login Functionality.
- Users (Super admin, manager and employee).
- Species Management System
- GIS Management System
- Publications Management System
- Proforma Management System
- Product Management System

Importance of MIS

- Access to information systems over the Web is necessary for full participation in
- Modern society
- Electronic access to Data
- To access the accurate information, available in a timely fashion
- Capability of decision making
- Accuracy and security of information contained in databases of different

Management Information System (MIS) for NTFP

- Integration of project components
- Inventory system for data entry of NTFP's surveys
- Centralized record of NTFP's species and their uses
- Track GIS-based location of NTFP's
- Organized the data for further analysis

Non-functional Requirements

- Security
- SSL (Secure socket login) certification.
- htaccess (hypertext access)
- Performance
- Routes URL configuration.
- MVC framework implementation.
- Fast database retrieval via Jquery implementation
- Usability
- Generation of Management system from scratch.
- Develop in a modular structure

Main Menu (links of web page):

- About us
- Gallery
- Publications
- GIS
- Login/register

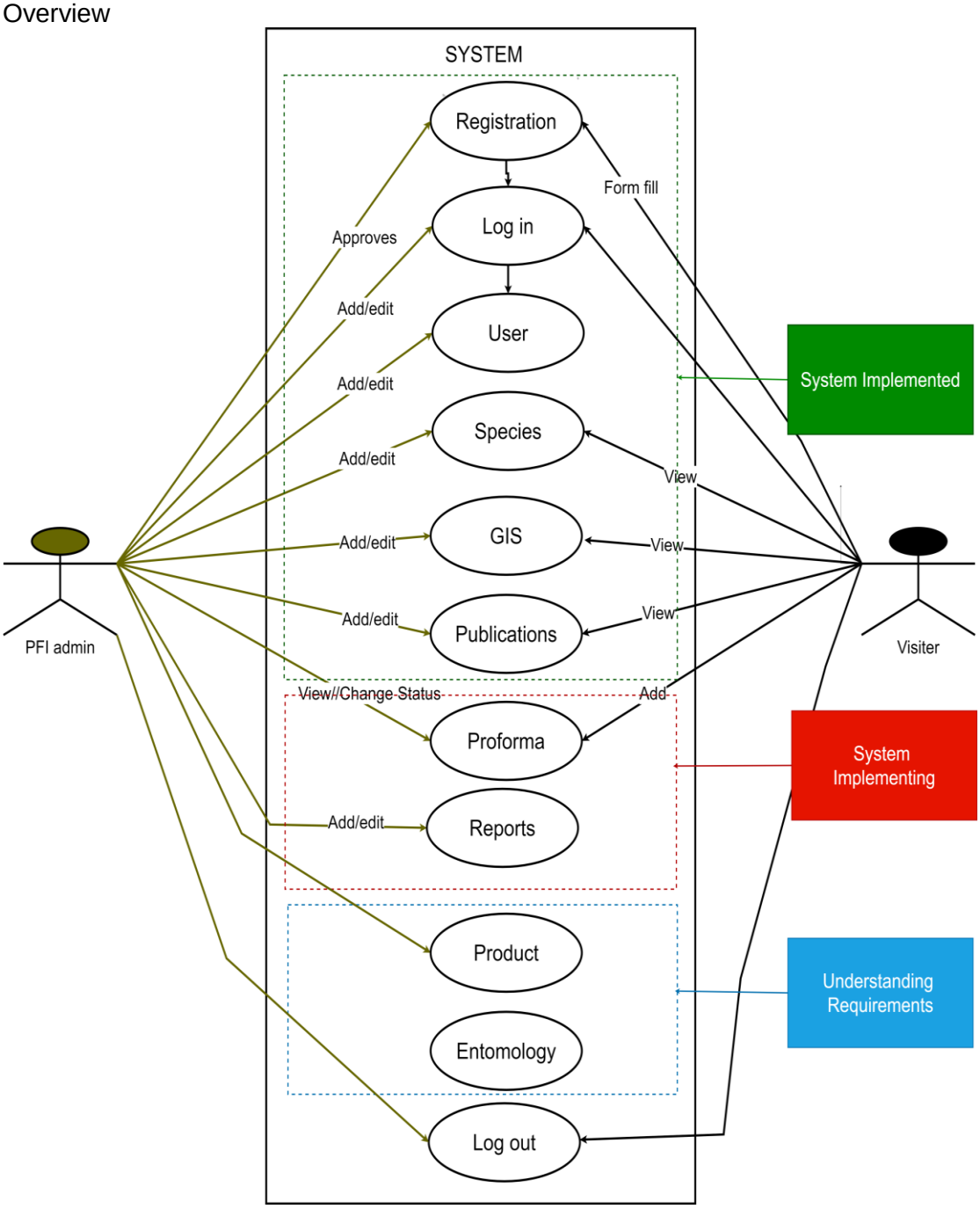
Home

- Slider: Images of Product with text and animation
- Introduction to NTFPs
- Other related Images and content

Species

Species Listing

System
Overview



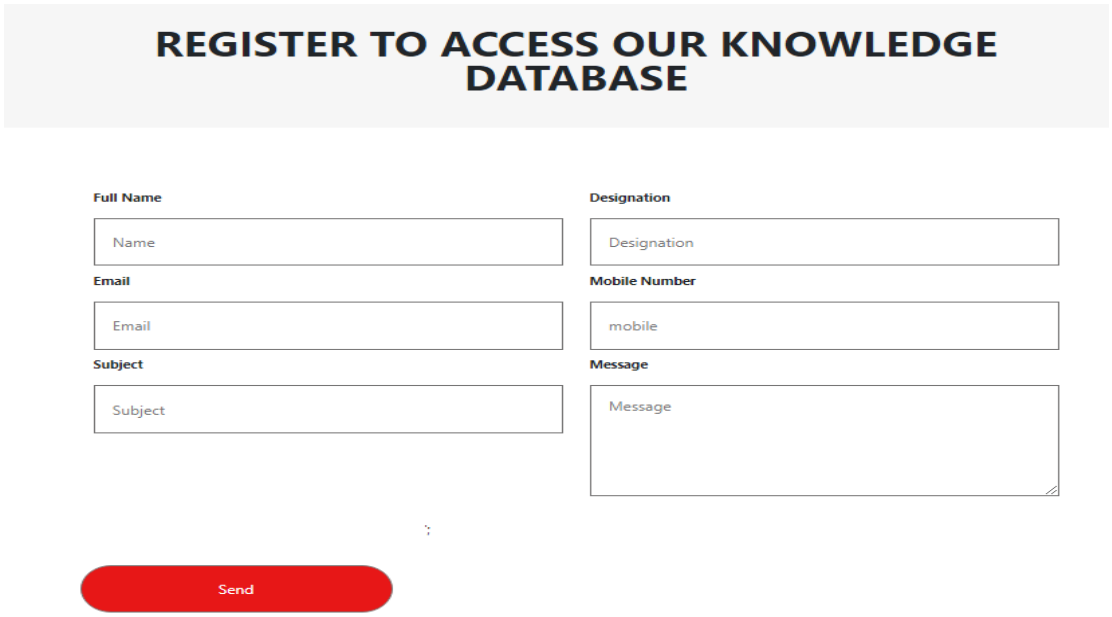
Implementation

FRONT-END

New design of the front-end and links to other pages/login. To access our knowledge database users can register themselves via login page.

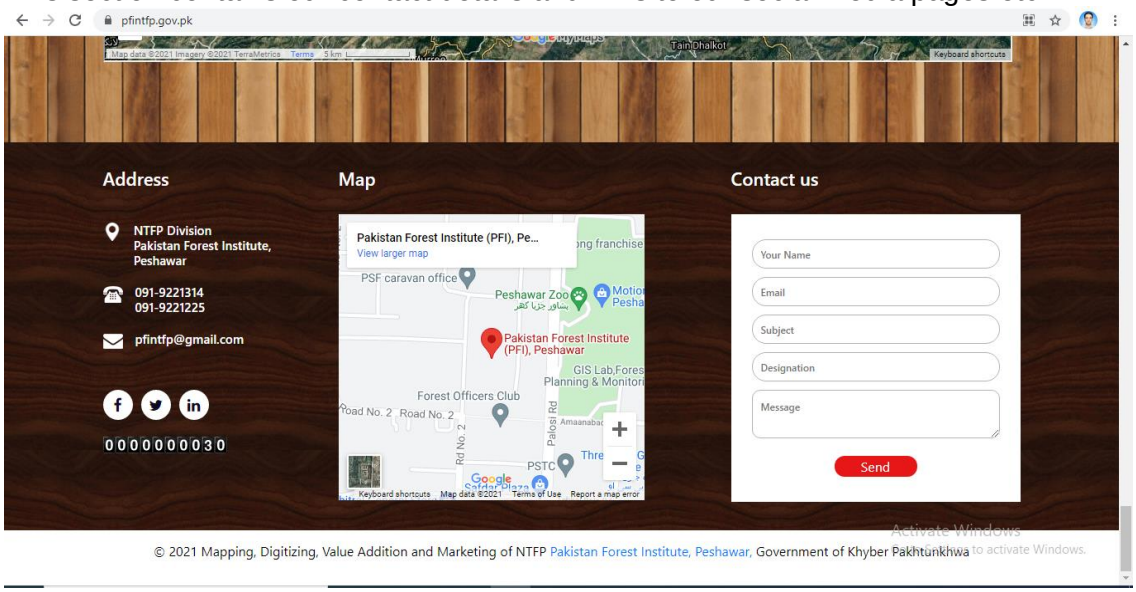
Registration page

After successful submission of this form the user will provided with username and password through which can login to our knowledge center.



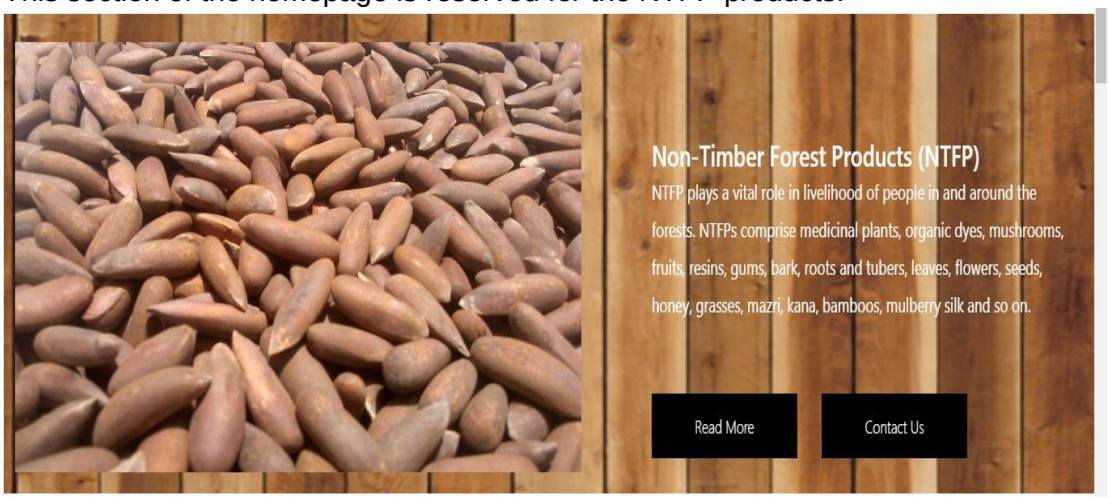
Footer

This section contains our contact details and links to our social media pages etc



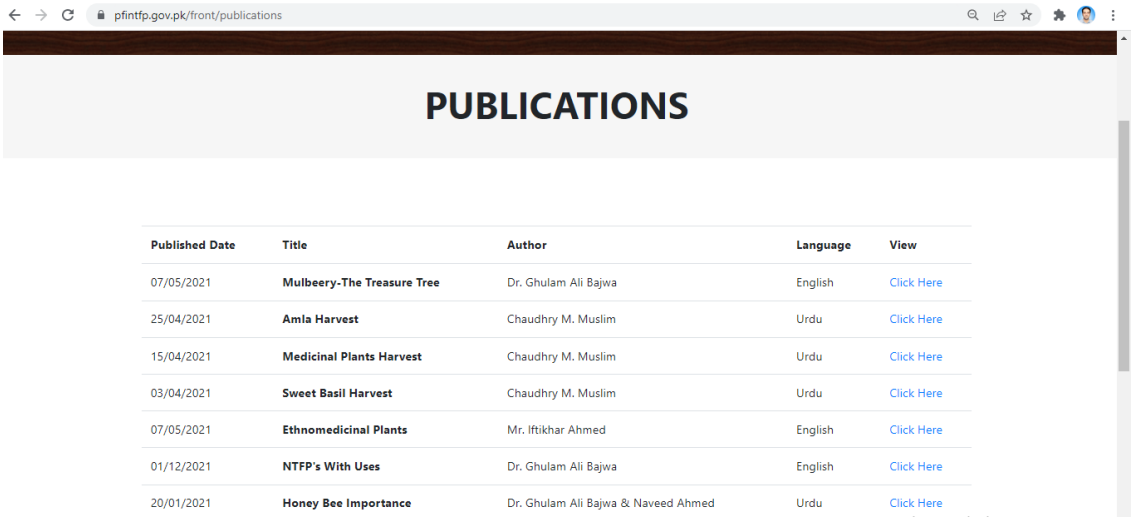
Product Display section (Homepage)

This section of the homepage is reserved for the NTFP products.



Publications

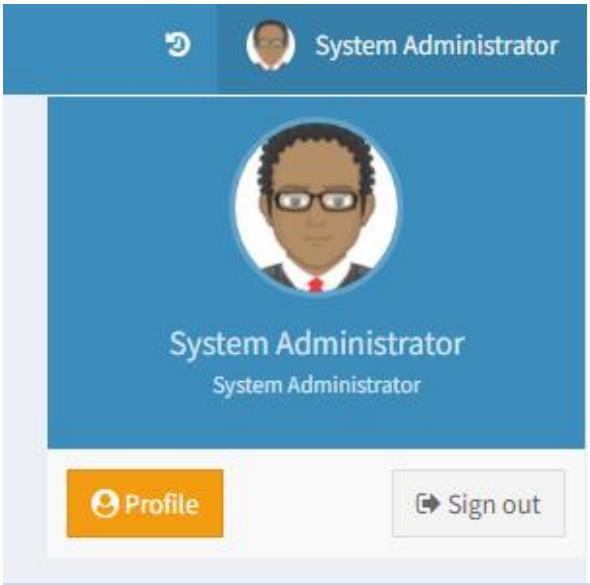
All the research work documents/publications can be downloaded from publications page.

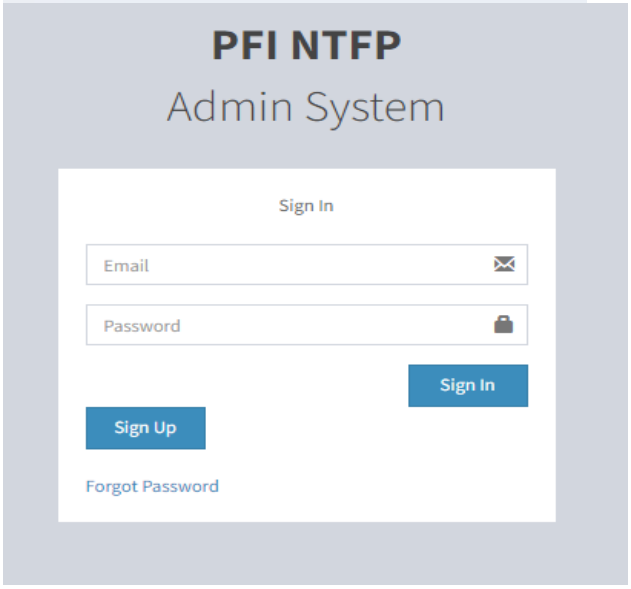


Published Date	Title	Author	Language	View
07/05/2021	**Mulbeery-The Treasure Tree**	Dr. Ghulam Ali Bajwa	English	Click Here
25/04/2021	**Amla Harvest**	Chaudhry M. Muslim	Urdu	Click Here
15/04/2021	**Medicinal Plants Harvest**	Chaudhry M. Muslim	Urdu	Click Here
03/04/2021	**Sweet Basil Harvest**	Chaudhry M. Muslim	Urdu	Click Here
07/05/2021	**Ethnomedicinal Plants**	Mr. Iftikhar Ahmed	English	Click Here
01/12/2021	**NTFP's With Uses**	Dr. Ghulam Ali Bajwa	English	Click Here
20/01/2021	**Honey Bee Importance**	Dr. Ghulam Ali Bajwa & Naveed Ahmed	Urdu	Click Here

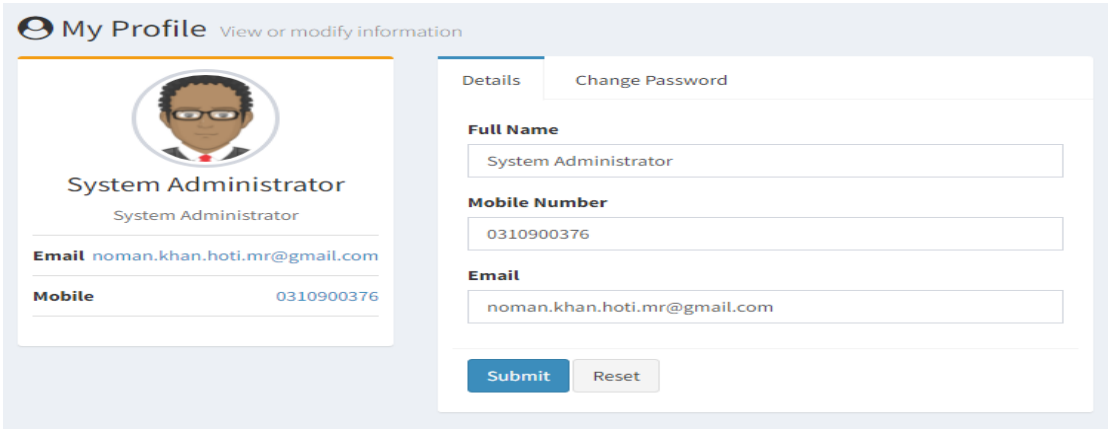
Login System

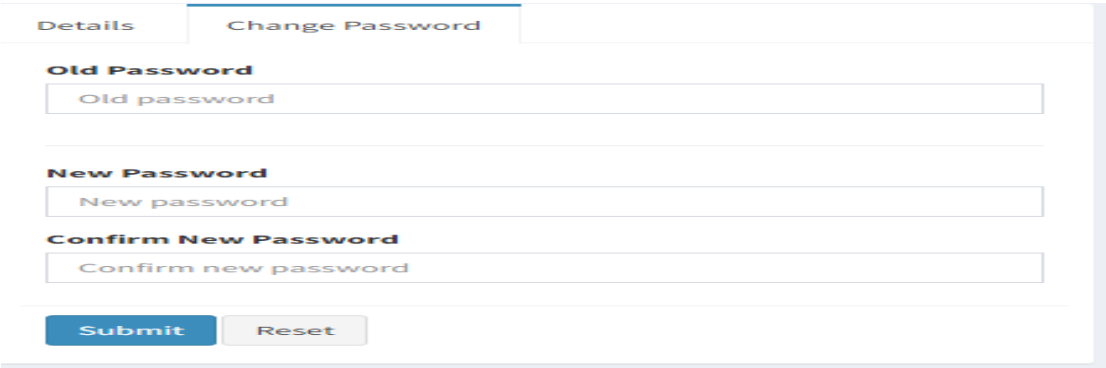
Access for different types of users roles





Users Profile





4. MORICULTURE

4.1.1 Characterization of Mulberry accessions using Random Amplified Polymorphic DNA (RAPD) Primers

Location	:	Pakistan Forest Institute, Peshawar
Commencement	:	2019-2020
Principal Investigator	:	Dr. Ghulam Ali Bajwa, Director Non-Timber Forest Produce

The leaves of eighteen mulberry (genus: *Morus*) accessions (BKP-18, CHKP-19, CMP-16, GTP-18, HAS-18, HSC-85, KMJ-85, KSK-85, LAP-18, MLJ-85, MQB-18, OKP-18, OMAK-18, PAS-18, PFI-1, QAB-18, QMK-85 and STP-18) were plucked from Mulberry Garden, Pakistan Forest Institute, Peshawar. The leaves were frozen in Lab at -4°C for DNA extraction.

Extraction of DNA

Genomic deoxyribonucleic acid was extracted using CTAB buffer (100 mMTris Base, 4.5 mMNaCl, 0.5 mMethylenedia- amine tetra acetic acid (EDTA), 2 g CTAB Powder and 2% mercaptoethanol). The samples were transferred into 2 ml Eppendorf tube and incubated at 65^{o}C for 30 minutes using hot water bath. The bath was vortexed constantly during incubation. In incubated samples, an equal amount of PCI solution (Phenol 25µl, Chloroform 24 µl, Isoamyl Alcohol 1 µl) was added and mixed using vortex mixer. The supernatant (upper aqueous phase containing DNA) was transferred into new Eppendorf tubes and added 28 µl Ammonium acetate, mixed gently by several inversions, and incubated at -20^{o}C for overnight. The overnight incubated samples were centrifuged at 13,000 rpm for 12 minutes to allow precipitation. The supernatant was discarded without disturbing the DNA pellets. The DNA pellets were washed with 70% cold ethanol (150-250 µl through centrifugation at 12,000 rpm for five minutes and dried by removing ethanol. Ribonucleic acid (RNA) was removed by adding 50-100 µl of 1x TE buffer and vortexing for 30 second. The quality of extracted DNA was verified by spectrophotometry (The DNA samples were stored at -20^{o}C for polymerase chain reaction (PCR).

RAPD Amplification

PCR were conducted using six RAPD primers in a thermal Cycler technique. The PCR Thermo profiling for amplification consisted of: 5 min initial denaturation at 94^{o}C and 45 sec denaturation at 94^{o}C, followed by 40 cycles each of 40 sec annealing at 74^{o}C, 1 min extension at 72^{o}C and 10 min final extension at 72^{o}C. DNA amplification fragments were separated by electrophoresis in a 1% Agarose with composition: 90% distilled water and 1 g Agarose in 10 ml 10x TE buffer (100

mMTris-borate, pH 8.0, 2 mM EDTA). The image of amplifications were visualized under Gel Documentation System (Unitec).

The results of DNA quality in terms of optical density and concentration are reproduced in table 1. The extracted DNA of mulberry accessions was of good quality as optical density ranged between 1.62 and 2.15 and concentration was ranged between 275.7 µg/mland 1411 µg/ml.

Table 1: Quality of extracted Deoxyribonucleic acid of different mulberry accessions

S. No.	Mulberry accession	Optical Density	Concentration (µg/ml)
1.	BKP-18	1.89	940.9
2.	CHKP-19	2.11	851.0
3.	CMP-16	1.90	565.0
4.	GTP-18	2.04	479.1
5.	HAS-18	2.12	1006.6
6.	HSC-84	1.96	531.0
7.	KMJ-84	2.08	758.2
8.	KSK-84	1.91	1411.4
9.	LAP-18	2.15	327.5
10.	MLJ-84	1.63	808.5
11.	MTB-18	2.09	487.5
12.	OKP-18	2.09	714.3
13.	OMK-18	2.14	275.7
14.	PAS-18	2.01	536.1
15.	PFI-1	1.62	628.6
16.	QAB-18	2.03	463.3
17.	QJK-84	1.81	719.4
18.	STP-18	2.08	817.2

The PCR products amplified by six RAPD decamer primers are reproduced in figures 1-6 as follow. The six primers resulted in a total of 112 distinctive and reproducible bands with 76 bands of polymorphic nature.The size of amplified PCR products ranged from 270 to 600 base pair. The primer OP-AP12 amplified larger sized fragments, while primer OP-G11 amplified smaller sized fragments.The primer OP-G19 amplified the highest number of monomorphic bands, Three primers (OP-B8, OP-G11 and OP-AP12) amplified 100% polymorphic bands.

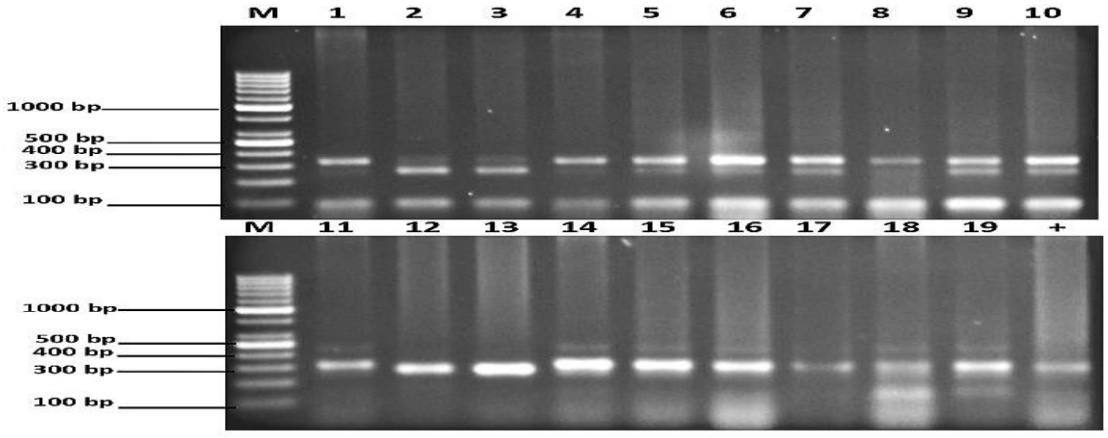


Figure 1: PCR amplification of mulberry genotypes with RAPD **primer- OP-B1**

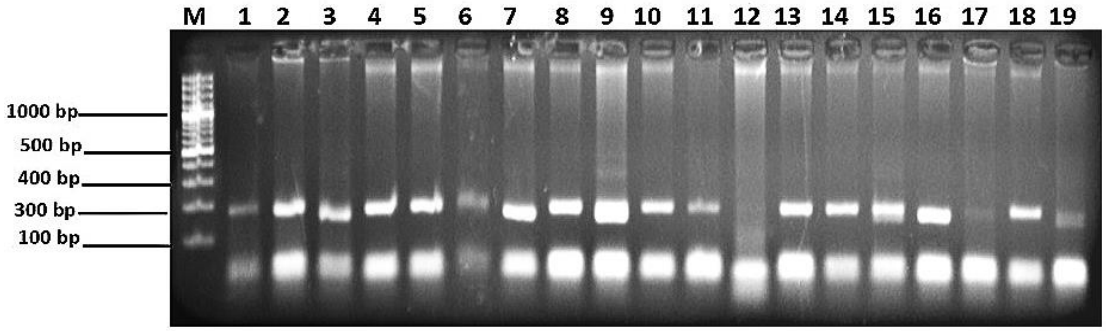


Figure 2: PCR amplification of mulberry genotypes with RAPD primer- OP-B8

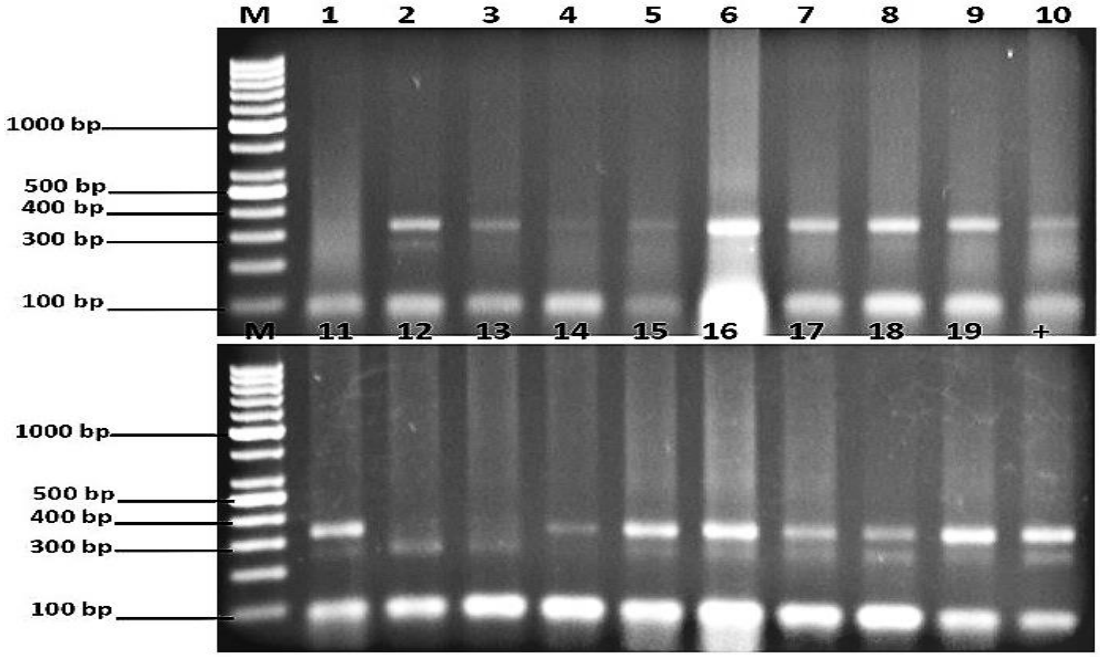


Figure 3: PCR amplification of mulberry genotypes with RAPD **primer- OP-G3**

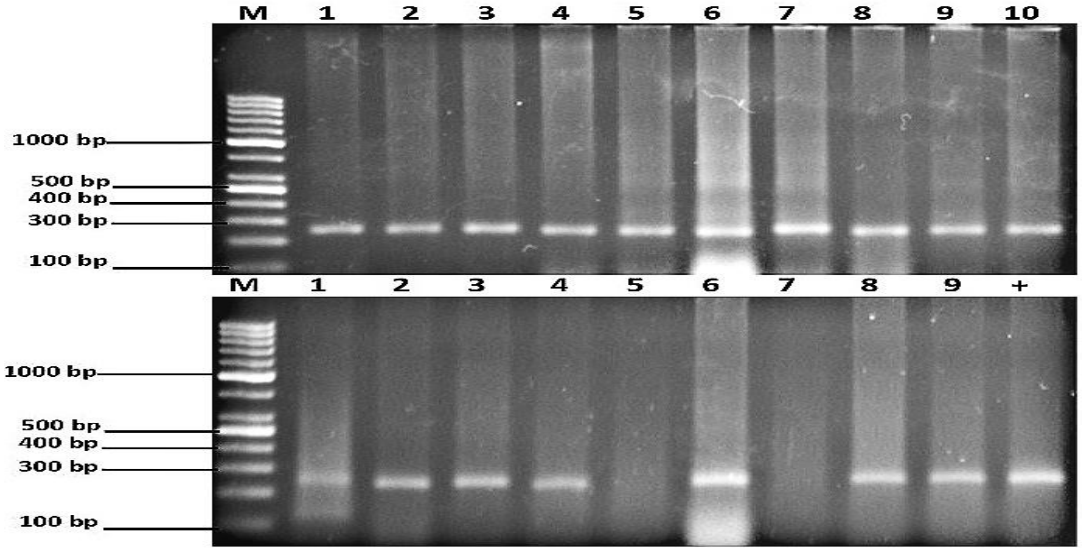


Figure 4: PCR amplification of mulberry genotypes with RAPD **primer- OP-G11**

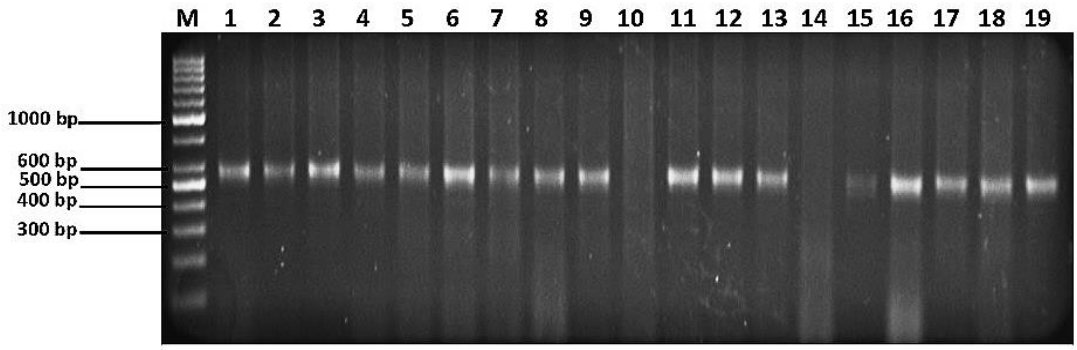


Figure 5: PCR amplification of mulberry genotypes with RAPD **primer- OP-AP12**

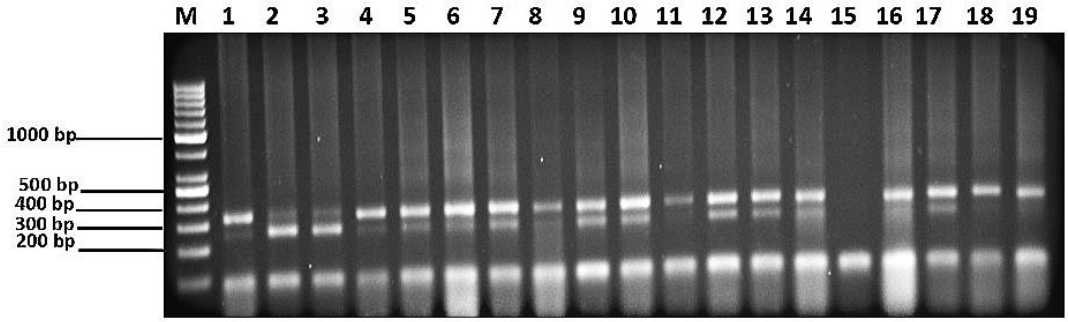
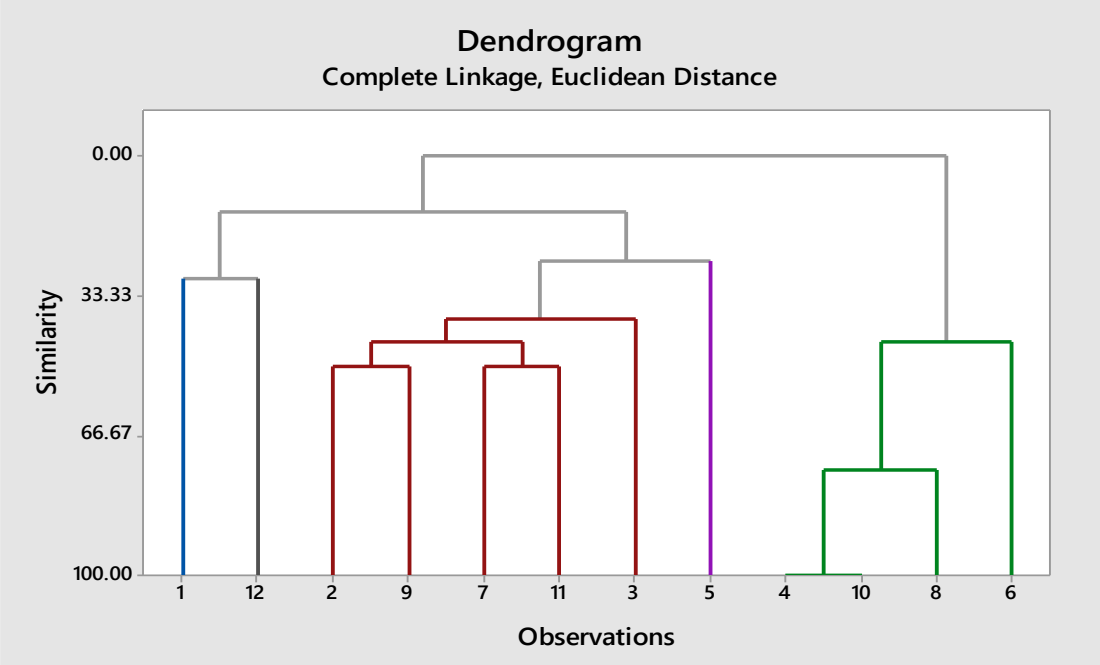


Figure 6. PCR amplification of mulberry genotypes with RAPD **primer- OP-G19**

The unweighted pair-group method of arithmetic mean (UPGMA) clustering analysis grouped 18 accessions in four principal clusters (Figure 7). Overall the analysis showed a great genetic diversity in the accessions. There was a mixed response of cultivated and wild accessions. Similarly, there was a large genetic variation in accessions within the same ecotype.



4.2 SERICULTURE

4.2.1 Synthesis of Bivoltine Hybrid Silkworm Strains

Location	:	Pakistan Forest Institute, Peshawar
Commencement	:	2018-19
Principal Investigator	:	Dr. Ghulam Ali Bajwa, Director Non-Timber Forest Produce

Six inbred bivoltine strains: C_{102}, PO_{205}, PO_{206}, J_{101}, MKD_{205}, MKD_{206} were used to synthesize ten hybrids: $MKD_{205}xPO_{205}$, $MKD_{205}xPO_{206}$, $MKD_{205}xC_{102}$, $MKD_{206}xC_{102}$, $PO_{206}xJ_{101}$, $C_{102}xMKD_{206}$, $C_{102}xJ_{101}$, $J_{101}xPO_{205}$, $MKD_{206}xPO_{205}$, and $PO_{205}xC_{102}$. The heterosis was assessed based on 11 quantitative characters giving equal weight. The quantitative traits estimated were the fecundity (number of eggs per female), egg hatchability, 5thinstar larval body weight (g), 5th instar larval period, pupation rate (%), cocoon yield/10,000 larvae (kg/10k larvae), single cocoon weight (g), shell weight (g), cocoon-shell ratio (%), filament length, and silk productivity. The Silkworm rearing conducted and heterosis values were estimated following methods as described by Bukhari et al., (2008), while Silk productivity was estimated applying following equation as described by Fouad (2020):

$$Silkproductivity\left(\frac{cg}{day}\right) = \frac{Cocoonshellweight(cg)}{5^{th}instarduration(day)}$$

The mean multiple evaluation index (MEI) values of pure and hybrid strains are summarized in table 2. All the pure line strains yielded MEI < 50, while hybrids MEI > 50. $PO_{206}\times J_{101}$resulted in MEI > 63, while eighty percent hybrids have MEI between 52.4 and 54.21. Seven percent hybrids resulted in evaluation index (EI) > 50 for egg hatchability, full grown 5th instar larval body weight and pupation rate, while six hybrids resulted in EI > 50 for fecundity and 5th instar larval period. The evaluation index value of silk productivity was > 50 in five hybrids, while EI of cocoon weight and cocoon shell weight was > 50 in six hybrids. Sevenhybrids had EI > 50 for cocoon shell ratio and cocoon yield by number.

Table 2. Multiple Evaluation Index (MEI) for bivoltine F_1 hybrids of *B. mori*

Silkworm Strains	Quantitative traits											Mean
	Fecun	Hatch	LBW	5th LS	PR	CW	CSW	CSR	FL	SP	CY	
C_{102}	44.6	49.3	39.3	36.2	51.7	45.2	43.7	42.4	43.5	47.3	41.7	44.1
PO_{205}	40.2	34.1	46.8	41.3	44.6	39.5	36.4	31.5	37.9	37.9	41.3	39.2
PO_{206}	59.8	46.9	39.7	41.3	34.4	45.3	46.6	49.6	44.2	49.0	41.7	45.3
J_{101}	27.7	36.1	36.2	31.0	39.3	39.9	38.9	37.7	37.7	43.4	37.2	36.8
MKD_{205}	46.3	34.0	36.2	41.3	40.4	46.5	46.7	48.0	40.8	49.1	45.1	43.1
MKD_{206}	39.9	40.3	46.4	56.9	35.5	35.3	36.5	37.9	31.7	34.6	37.5	39.3
$MKD_{205}\times PO_{205}$	47.2	60.5	63.2	62.1	58.2	54.0	54.7	55.9	55.2	51.3	54.2	56.0
$MKD_{205}\times PO_{206}$	63.9	51.4	51.8	51.7	44.9	48.4	49.7	52.3	52.6	49.2	49.2	51.4
$MKD_{205}\times C_{102}$	53.9	57.1	60.4	62.1	62.6	50.0	51.0	53.3	53.1	47.7	50.6	54.7
$MKD_{206}\times PO_{205}$	44.0	63.9	49.1	62.1	57.5	49.0	49.0	49.8	54.0	45.8	55.3	52.7
$MKD_{206}\times C_{102}$	56.1	48.2	45.2	49.1	49.9	50.9	56.5	64.9	55.9	57.0	51.4	53.2
$J_{101}\times PO_{205}$	44.3	62.9	43.9	56.9	61.3	46.8	49.0	53.2	53.3	47.1	47.8	51.5
$PO_{205}\times C_{102}$	56.0	52.3	65.4	62.1	63.0	65.9	63.6	58.8	62.9	60.0	64.8	61.4
$PO_{206}\times J_{101}$	52.0	47.3	64.1	43.9	41.5	75.2	76.0	70.6	70.2	79.4	74.5	63.2
$C_{102}\times MKD_{206}$	64.8	62.1	58.9	50.4	60.4	48.6	47.9	47.9	52.7	47.7	49.4	53.7
$C_{102}\times J_{101}$	59.3	53.5	53.3	51.7	54.8	59.6	53.8	46.4	54.4	53.4	58.1	54.4

Fecund = Fecundity (eggs female^{-1}); Hatch = Hatchability; LBW = Larval body weight; 5th LP = 5th stage larval period; PR = Pupation rate;CW = Cocoon weight; CSW =

Cocoon shell weight; CSW = Cocoon-shell ratio; FL = Filament length; SP = Silk productivity, CY = Cocoon yield by number (kg/10k larvae)

The results of mid parent heterosis effect are presented in table 3.The mean MPH was positive. The mean relative heterosis was ranged from 5.6 to 27.5. The highest and the lowest relative heterosis effect was found in $PO_{206}xJ_{101}$and $PO_{205}xC_{102}$, respectively. All synthesized hybrids showed positive MPH for the tested quantitative traits except one hybrids that showed negative MPH value for silk productivity.

Table 3. Mid Parent Heterosis effect (%) for bivoltine hybrids of *B. mori*

Hybrids	Quantitative traits											Mean
	Fecun	Hatch	LBW	5th LS	PR	CW	CSW	CSR	FL	SP	CY	
$MKD_{205}\times PO_{205}$	2.2	11.7	21.7	10.5	5.8	12.8	27.1	12.9	15.1	15.0	14.6	13.6
$MKD_{205}\times PO_{206}$	5.8	4.7	14.3	5.3	2.8	2.9	5.6	2.7	9.4	0.3	7.6	5.6
$MKD_{205}\times C_{102}$	4.7	6.6	23.5	12.0	6.1	4.6	11.1	6.2	10.2	-0.8	9.5	8.5
$MKD_{206}\times PO_{205}$	2.3	11.7	2.4	6.3	6.5	14.4	28.9	12.6	19.1	21.1	22.1	13.4
$MKD_{206}\times C_{102}$	7.9	1.4	2.3	1.3	2.4	12.8	34.9	19.8	17.7	32.3	16.4	13.6
$J_{101}\times PO_{205}$	6.1	12.3	2.5	10.8	7.2	8.6	25.5	15.6	14.9	13.1	11.9	11.7
$PO_{205}xC_{102}$	5.5	5.0	8.7	9.8	7.4	8.5	11.8	5.7	7.4	2.0	7.7	7.2
$PO_{206}\times J_{101}$	4.7	2.5	27.1	4.1	1.8	38.1	66.8	21.0	27.4	60.5	48.5	27.5
$C_{102}\times MKD_{206}$	12.7	7.3	15.8	1.9	6.2	10.0	16.6	6.1	14.5	13.7	13.5	10.8
$C_{102}\times J_{101}$	13.6	4.6	16.1	9.6	3.4	19.9	25.9	5.1	13.0	15.0	25.8	13.8
SE	1.23	1.24	2.91	1.23	0.67	3.16	5.46	2.06	1.81	5.78	3.90	1.90
CV	0.59	0.58	0.68	0.54	0.43	0.75	0.68	0.61	0.39	1.06	0.69	0.48

The results of Better Parent Heterosis (BPH) effect are summarized in table 4. The mean BPH effect was positive in all the hybrids. The BPH effect was found between 4.2 and 23.0. The highest and the lowest BPH effect was recorded in hybrids $PO_{206}xJ_{101}$ and $MKD_{205}xPO_{206}$, respectively. Character-wise negative BPH effect was also noted in three hybrids.

Table 4. Better-parent heterosis effect (%) for bivoltine hybrids of *B. mori*

Hybrid	Quantitative traits											Mean
	Fecun	Hatch	LBW	5th LS	PR	CW	CSW	CSR	FL	SP	CY	
$MKD_{205}\times PO_{205}$	0.5	11.7	15.6	10.5	5.0	8.4	14.8	6.0	13.5	3.9	11.8	9.2
$MKD_{205}\times PO_{206}$	2.1	1.9	12.3	5.3	1.7	2.1	5.5	2.0	7.7	0.2	5.3	4.2
$MKD_{205}\times C_{102}$	3.7	3.3	21.6	13.5	3.9	3.9	8.0	4.0	8.8	- 2.3	7.1	6.9
$MKD_{206}\times PO_{205}$	2.2	5.1	2.3	10.5	4.7	11.5	29.0	9.7	15.5	16.7	19.0	11.5
$MKD_{206}\times C_{102}$	6.5	- 0.5	- 1.2	6.8	- 0.6	6.4	25.3	17.7	11.4	17.3	16.1	9.6
$J_{101}\times PO_{205}$	2.3	11.8	- 2.7	13.9	6.1	8.3	22.1	12.7	14.8	7.2	8.9	9.6
$PO_{205}\times C_{102}$	6.4	1.3	17.7	13.5	4.1	23.4	39.3	12.9	17.8	22.7	31.1	17.3
$PO_{206}\times J_{101}$	- 4.0	0.2	24.8	6.9	0.8	33.9	54.8	15.6	23.7	52.8	44.0	23.0
$C_{102}\times MKD_{206}$	11.3	5.3	19.5	7.4	3.1	3.8	8.3	4.3	8.4	0.8	10.3	7.5
$C_{102}\times J_{101}$	8.2	1.8	14.3	11.1	1.1	16.3	19.9	3.1	10.0	11.0	22.1	10.8
SE	1.4	1.4	3.1	1.0	0.7	3.2	4.9	1.8	1.6	5.1	3.8	1.7
CV	1.1	1.1	0.8	0.3	0.7	0.9	0.7	0.6	0.4	1.2	0.7	0.5

Training of Mulberry Plantation

Bush type mulberry plants were pollarded at medium level cut-60 cm above ground level in January and December for having fresh, nutritious and tender leaves with for two silkworm rearing seasons including: (i) Spring Silkworm Rearing Season, and (ii) Autumn Silkworm Rearing Season, respectively. The plantation was weeded out and hoed twice, fertilized with Urea and Di-ammonium phosphate and irrigated at fortnightly interval.

Figure 8: Pollarding of mulberry for new sprouting

Conservation of Germplasm

During the reporting period, a total of 22 indigenous and six overseas mulberry accessions belonging genus *Morus*were propagated for conservation purposes. Similarly, six (06) inbred silkworm strains were reared in two seasons, i.e. Spring Silkworm Rearing Season and Autumn Silkworm Rearing Season, and conserved at 5.0°C.

Miscellaneous

- Published following two research papers in scientific Journals

i. Identifying hybrid genotypes of silkworm (*Bombyxmori*) using heterosis for biological and silk yielding traits Published in Pakistan Journal of Zoology.

ii. Analysis of Genetic Diversity among Cultivated and Wild Mulberry (*Morus* genus) Accessions Using Random Amplified Polymorphic DNA Primers submitted to Turkish Journal of Agriculture and Forestry

- Provided 0.2 million mulberry cuttings to different stakeholders
- Taught courses Climate Change to BS Forestry class.
- Supervised thesis research of MSc Agricultural-Entomology Student from the University of Agriculture, Peshawar.
- Supervised research of an internee student from the University of Agriculture, Peshawar.

4.3 FOREST ENTOMOLOGY

4.3.1 Diversity of Hawk Moths (Lepidoptera: Sphingidae) of Peshawar

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2020- to date
Principal Investigator:	Naveed Ahmed, Director (NTFP)/ Forest Entomologist

Lepidoptera are the second-most diverse order of insects after Coleoptera. The numerical strength of species in the order Lepidoptera comprises more than 100000 species (Richards & Davies, 1977). The family was split into two divisions, five subfamilies and seven tribes. Hampson (1892) recorded 121 species of hawkmoths from India and Ceylon and are classified them into six subfamilies. Bell & Scott (1937) recorded 183 species of sphingid moths from Indian sub region and classified them into five subfamilies and six tribes. Holloway (1987) reported 94 species of Sphingidae from Borneo and classified them into two subfamilies and four tribes. In the last decades much taxonomic information has been generated for the enormous number of sphingid species, genera and subgenera. Systematics and nomenclature have undergone many changes.

The adults of hawkmoths were collected on nightly basis by operating 125 watt mercury vapour light. The light was suspended in front of white cotton sheet affixed. The specimen which rested on the white sheet was subsequently scooped up with a killing bottle and quickly closing the lid. Numerous killing bottles were used for collecting the specimens. The killing bottles were prepared from wide mouth bottles and cotton wool placed in bottom and charged with ethyl acetate. A thick cardboard was kept above cotton wool so to reduce scales catches on cotton fibers

Taxonomy

Family SPHINGIDAE Latreille, (1802)
Subfamily: Sphinginae Latreille, (1802)
Tribe: Sphingini Latreille, (1802)
Genus: *Psilogramma* Rothschild & Jordan (1903)

1. *Psilogramma increta* Walker (1865) Fig: .

Distribution: South and East Asian distribution, ranging from north Pakistan and northwest India, east through Thailand, Vietnam, China, Taiwan, Korea to Japan, and south to southwest India and Sri Lanka, Sumatra and Borneo (Beck & Kitching, 2008).

2. *Psilogramma menephron* Cramer (1780)

Distribution: It is presently known from northern Pakistan, northwestern India, Nepal and northern Myanmar
Tribe: Acherontiini Boisduval (1875)
Genus: *Acherontia* Laspeyres (1809)

3. *Acherontia lachesis* Fabricius (1798) Fig: 2.

Distribution: This species is found from eastern Pakistan east through India, Sri Lanka, Nepal and China to southern Japan, then southeast through Myanmar,

Thailand, Laos, Vietnam, Malaysia, the Philippines and Indonesia to Papua New Guinea (Pittaway & Kitching, 2013).

4. *Acherontia styx* Westwood (1847), Fig: 1.

Distribution: This subspecies is found from north-central and western China, westward across northern Thailand, Myanmar, Bangladesh, India, Nepal, Pakistan and Iran to Saudi Arabia and Iraq (Pittaway & Kitching, 2013; Pittaway, 2013).
Genus: *Agrius* Hübner (1819)

5. *Agrius convolvuli* Linnaeus (1758) Fig: 2.

Distribution: This species has a wide distribution throughout the tropical and subtropical Old World, and regularly migrates into northern Europe and northern Asia (Pittaway & Kitching, 2013).
Genus: *Daphnis* Hübner, (1819)

6. *Daphnis nerii* Linnaeus (1758) Fig: 2.

Distribution: This species was recorded in Pakistan from Peshawar by Chaudhry et al. (1966) and from Faisalabad and Sialkot by Mehmood et al. (1996). The core distribution of D. nerii is Africa, the southern Mediterranean region and the Middle East, from where it extends east through South and South East Asia to southeast China, the Philippines, Borneo and Sumatra.
Genus: *Nephele* Hübner, (1819)

7. *Nephele hespera* (Fabricius, 1775) Fig: 2.

Distribution: It occurs from Afghanistan and Pakistan, east across Sri Lanka, India, Nepal, the Andaman Islands, Myanmar, Thailand, Laos and Vietnam, to southern China, Peninsular Malaysia, Sumatra and Java. It has also been recorded from southern Papua New Guinea and on the islands of Dauan and Warraber off the northern tip of Queensland, Australia (Pittaway & Kitching, 2013).
Genus: *Hippotion* Hübner, (1819)

8. *Hippotion boerhaviae* (Fabricius, 1775) Fig: 2.

Distribution: *Hippotion boerhaviae* has a broad range, from northeastern Pakistan, through India, Sri Lanka, Nepal, Thailand, southeastern China (Hong Kong and Guangdong), Vietnam, the Philippines, Indonesia and New Guinea, to eastern Australia, the Solomon Islands and New Caledonia (Pittaway & Kitching, 2013).

9. *Hippotion rosetta* (Swinhoe, 1892) Fig: 2.

Distribution: This species was recorded in Pakistan from Karachi by Younus & Kamaluddin (2010). Hippotion rosetta has a similar distribution to H. boerhaviae, but has reached more offshore and oceanic islands (e.g. the Maldives, Cocos Islands, the Ryukyu Archipelago and Palau)

Genus: *Hyles* Hübner (1819)

10. *Hippotion celerio*(Linnaeus, 1758) Fig: 6.

Distribution: This species is found from northeastern Iran, southern Turkmenistan, eastern Uzbekistan, southern Kazakhstan, Tajikistan and Kyrgyzstan to northern

Xinjiang Province, China, then southwest though eastern Afghanistan to southwestern Pakistan (Pittaway, 2013).

11. *Hippotion rosetta*(Esper, 1780) Fig: 14.

Distribution: *Hippotion rosetta* was recorded in Pakistan from Rawalpindi and Peshawar by Mohyuddin (1987), and from Sialkot and Faisalabad (as *H. lineata subsp. rosetta*) by Mehmood et al. (1996). It occurs as a breeding resident species in Africa (except rainforest areas) the Middle East, Central Asia, along the southern slopes of the Himalaya (at relatively low elevations) and western China, from where it regularly migrates north to Europe, Siberia and eastern China, and occasionally straying south to peninsular India, Thailand and Hainan Island, China (Pittaway & Kitching, 2013).

12. *Hippotion robertsi* (Butler, 1880) Fig: 2.

Distribution: The species was recorded (as *Celerio robertsi*) from Baluchistan—"Pakistan, S of Quetta, 1965"—by Daniel (1971); the ten specimens are in the Naturhistorisches Museum, Vienna, Austria.

Genus: *Theretra* Hübner, (1819)

13. *Theretra alecto* (Linnaeus, 1758) Fig: 3.

Distribution: This species was reported in Pakistan from Lala Musa, Jehlum and Faisalabad by Mehmood et al. (1996) and from Peshawar and Rawalpindi by Mohyuddin (1987). *Theretra alecto* occurs from the Balkans east across the Middle East and Central Asia, then south of the Himalaya through India and Sri Lanka and South East Asia, to southern China, Taiwan and southern Japan; then southeast through the Philippines and the Indonesian Archipelago as far as the Moluccas (Pittaway & Kitching, 2013).

4.3.2 Survey of Apiary Sites of Southern Districts of Khyber Pakhtunkhwa

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2020- to date
Principal Investigator:	Naveed Ahmed, Director (NTFP)/ Forest Entomologist

Honey, one of the major bee products, is made from the nectar of plants. It contains amino acids, minerals, vitamins, sugar, etc. Honey is widely used in food, sweetening, medicine, etc. Honey is produced in almost every country of the world and it is very important energy food.

Honey bees, important pollinators, have been demonstrated to be capable of increasing yield in 96% of animal-pollinated crops, creating a value of 212 billion dollars annually. An apiary is defined as the place where bees are kept in the hive to forage nectar and Pollen grains. Natural vegetation composed of forest trees, shrubs, herbs and climbers provide adequate nectar and pollen for the foraging bees. The locations of apiaries (yards where beehives are kept) are critically linked to the success of any beekeeping operation, Honeybees forage in a range that varies according to nectar availability. By placing hives in the right place at the right time, the beekeeper helps create the conditions whereby the colony collects nectar over and above its annual caloric requirements. It is this surplus that makes up the honey crop.

Survey of Karak District

District Karak is located between 70-40' - 71 '30' north and their longitudes 32'-48' to 33'-23' from east. These areas are mostly arid that acquires a huge land for bee parks during berry and Palosa flowering seasons which are the native plants of the mentioned district. The visitor beekeeping performs their activities are carried out from the month August – October. The land available for cultivation is only 3.32%. Banda Daud Shah and Takhte-e-Nasratti are the two main sub-divisions of Karak. District Karakhaving rich honey bee host plants particularly *Ziziphusjujuba* (Berry) and *Acacia modesta*(Palosa) are present in abundance. Questionnaire also contained the questions which were seasonal management, diseases management, breeding potential and the marketing problems etc.

Bee colonies collecting honey from Ber in district Karak

Survey of Dera Ismail Khan

Dera Ismail Khan (DIKhan) District is located in the south of Khyber PakhtunKhwa (KPK) of Pakistan. It is lying between 31° 15’ and 32° 32’ north latitude and 70° 11’ and 71° 20’ east longitude with an elevation of 173 meters from the sea level. Its total reported geographical land is 896,000 hectares out of which 300,000 hectares is cultivated. The climate is continental with marked temperature fluctuations both seasonal and diurnal, with significant aridity. January is the coldest month of the year and July the hottest. The mean maximum and minimum temperatures during winter are 20.3°C and 4.2°C respectively, compared to 42°C and 27°C during summer. Average annual rainfall is 259 mm. The area was

extensively surveyed to identify existing plant species visited by workers of honeybees for nectar and pollen collection. Bee keepers and professional honey collectors were also interviewed for documentation of information about honey, honeybee species present in the area.

It is always advisable to consider the carrying capacity of each site prior to placing the honeybee colonies. Over population of the colonies causes competition for food so that the expected honey yield will be low.

Phulai (*Acacia modesta*), Sarsoon (*Brassica campestris*), Kaghzinimboo (*Citrus aurantifolia*), Khatta (*C. medica*), Malta (*C. sinensis*), Shisham (*Dalbergia sissoo*), Date *(Phoenix dactylifera*), Barseen (*Trifolium alexandrianum*), Shaftal (*T. resupinatum*), Makai (*Zea mays*) and Ber (*Zizyphus mauritiana*) and Malla, Jherberi (*Z. numularia*) were found as major source for the production of surplus honey in D.I. Khan district.

Ideal apiary sites in DI Khan

4.4 MEDICINAL PLANTS

4.4.1 Introduction of *Linum usitatissimum* (Alsi)

Location	MPB Farm, PFI, Peshawar
Year of commencement	2020-21
Principal investigator	Muhammad Muslim, Medicinal Plant Botanist

Linum usitatissimum (Linn.), regularly known as flaxseed or linseed, has a place with the family Linaceae. The flax plant is certainly not another harvest and is local to West Asia and the Mediterranean waterfront lands, Asia Minor, Egypt, Algeria, Tunis, Spain, Italy, and Greece; in this large number of regionsjust fiber flax is developed. In south-west Asia, including Turkestan, Afghanistan, and India, just oil types are developed.

Economic Importance: Linseed (Alsi) is used throughout the world in a variety of different ways and forms. It contains 36-42% oil and 34-35% proteins, though the oil percentage depends upon the method of extraction. The cake, contain adequate amount of calcium and is rich in phosphorus, 7-8% crude fiber, it is deficient in amino acids such as methionine, cytine and lysine. It is a beneficial source of vitamins such as thiamine, riboflavin, nicotinamide, pantothenic acid and choline.

Cultural and fertilizer trials on *Linum usitatissimum* at PFI, Peshawar

Objectives

- To find out water requirement (6v3 irrigation) and application of different doses of nitrophos fertilizer on the seed yield.

Materials and methods

Seed source: PFI, Farm
Plot size: 30 m2
Row to row distance: 30 cm
Replications: 4
Layout: Split Plot Design
Date of sowing: 27th September 2020
Number of rows: 10
Irrigation interval: fortnightly vs. 3 weeks
Doses of nitrophos Fertilizer (Kg/ac): 0, 60, 100 and 140 kg

Doses of Nitrophos fertilizer (kg/plot)

Irrigation number	0	60	100	140
6	0.836	1.300	1.600	1.340
3	0.673	0.793	0.873	0.825
Pooled mean for fertilizer	0.754	1.046	1.236	1.082

Linum crop showed good response to the higher number of irrigations 6 (fortnightly) as compared to 3 irrigation (3 weeks). The application of split doses of nitrophos fertilizer @100 kg/ac gave higher seed yield (500.40 kg/ac) as compared to 60 kg nitrophos fertilizer/ ac (423.48 kg/ac) and control (305.26 kg/ac). There was no significant difference in the mean seed yield of 100 and 140 kg nitrophos/ac as both doses were mutually alike.

4.4.2 Introduction of *Matricaria chamomilla* (Gul-i-baboona)

Location: MPB Farm, PFI, Peshawar
Year of commencement: 2020-21
Principal investigator: Muhammad Muslim, Medicinal Plant Botanist

Chamomile (*Matricaria chamomilla* L.) is a well-known medicinal plant species from the Asteraceae family often referred to as the “star among medicinal species.” Nowadays it is a highly favored and much used medicinal plant in folk and traditional medicine. Its multitherapeutic, cosmetic, and nutritional values have been established through years of traditional and scientific use and research. Chamomile has an established domestic (Indian) and international market, which is increasing day by day. The plant available in the market many a times is adulterated and substituted by close relatives of chamomile.

Cultivation and yield trials of *Matricaria chamomilla* (Gul-i-baboona) to standardize its cultivation technology

Objectives

- To standardize its cultural requirement and economic feasibility under Peshawar climatic conditions

Material and methods:

Seed source:	MPB Farm, PFI
Plot size:	$20m^2$
Replications:	4
Layout:	RCBD
Plant to plant distance:	4cm
Date of sowing:	10^{th} October 2020.
Number of rows:	10
Treatment:	(25, 30, 35 cm and conventional broadcasting)

Effect of various row to row spacing on the flower yield in kg/plot ($20m^2$)

Row spacing (cm)				
Replication	**Broadcasting**	**25**	**30**	**35**
1	2.000	4.000	5.800	1.800
2	2.010	5.200	5.000	2.000
3	1.990	2.900	4.120	5.010
4	2.220	4.400	6.000	4.000
Mean	**2.055**	**4.125**	**5.230**	**3.202**

A row to row spacing of 30 cm gave higher yield of fresh flower heads (5.23) as compared to broadcasting (2.05), 35 spacing cm (3.20) and 25 cm spacing (4.12) kg/plot respectively.

4.4.3 Introduction of *Moringa oleifera* (Sohanjna)

Location	MPB Farm, PFI, Peshawar
Year of commencement	2020-21
Principal investigator	Muhammad Muslim, Medicinal Plant Botanist

Moringa oleifera (Sohanjna) is a species of genus moringa and household Moringacae. It is determined in many nations all over the world and native of subtropical areas like Pakistan. It is regarded due to the fact of its nutritious and its seed oil, additionally referred to as Ben oil. It is a tree having common top of eight m. In Pakistan, it is located regularly in southern Punjab and it is additionally viewed the foundation of Moringa plant. All components of plant can be used as therapy of many illnesses i.e., fever, headache, inflammation, asthma, anxious disorders, reproductive problems, pores and skin diseases, pores and skin infection, digestive disorders, create immunity, and the essential element that we are fixing these troubles naturally and transferring toward sustainability. Its seeds can be used as a herbal water purifier. In Ayurvedic standard medicine, *Moringa olefera* leaves are believed to have

an effect on blood stress and glucose levels. The leaves are the most nutritious phase of the plant, being a considerable supply of B vitamins, diet C, pro-vitamin A as beta-carotene, nutrition K, manganese, and protein, amongst different imperative nutrients. Moringa seeds have been procured from Multan and its nursery was once raised in Medicinal Plant Farm, PFI. Sand, silt and farm yard manure was once wholly combined and later it used to be crammed in polythane tubes. Seeds have been additionally sown in pots sized 12-18 inches in diameter with unfastened soil.

Common Name: Sohanjna, Drum-stick tree
Study Period: 2020-21
Location: PFI, Peshawar
Seed Source: PFI, Peshawar
Media: (i) Soil (ii) Sand+Silt (iii) Sand+FYM+Soil
3000 Polythene tubes
The study is under progress.

5. Survey of Medicinal Plants of Haripur District

Location PFI, Peshawar
Year of commencement 2020-21
Principal investigator Muhammad Idress, Incharge Medicinal Plant Garden

Survey was conducted under the project "Mapping, Digitization, Value Addition and Marketing of NTFP in collaboration with NTFP Directorate Forest Department". So far one hundred twelve trees, plant, herbs and shrubs were recorded from Haripur district. The detail is as under:

S. No.	Plant/Tree Species	Common name / Local	Scientific name
1	Herb	Bhaikar	*Adhatoda vasica*
2	Shrub to small tree	Gul tut	*Broussonetia papyrifera*
3	Medium size tree	Kao	*Olea ferruginea*
4	Shrub	Panch phool	*Lantana camara*
5	Medium tree	Bahishti darakht	*Ailanthus altissima*
6	Shrub	Granda	*Carissa opacastap f.*
7	Tree	Toot	*Morus alba*
8	Tree	Dhaman	*Grewia oppositifolia*
9	Tree	Batkarar	*Celtis australis*
10	Medium size tree	Kikar	*Acacia nilotica*
11	Shrub or small tree	Chanani	*Tabernaemontana coronaria*
12	Small tree	Ipil ipil	*Leucaenaleuco cephala*
13	Medium size tree	Phulai,Palosa	*Acacia modesta*
14	Herb	Bhang	*Cannabis sativa*
15	Tree	Shisham	*Dalbergia sissoo*
16	Shrub to small tree	Phagwar	*Ficu spalmata*
17	Herb	Poli	*Carthamus oxycantha*
18	Tree	Bkayan	*Melia azedarach*
19	Shrub	Aak	*Calotropis procera*
20	Shrub or Small tree	Malla, Jherberi, Karkanra	*Zizyphus numularia*
21	Shrub	Walaytiaak	*Ipomoea crassicaulis*
22	Grass	Darab grass	*Desmostachyabi pinnata*
23	Herb	Kandiari/Maraghuna	*Solanum surrattense*
24	Tree	Ber	*Zizyphus mauritiana*
25	Herb	Shamukay	*Plumbago auriculata*

26	Small tree	Unab	*Ziziphus jujaba*
27	Herb	Gajjarbutti	*Parthenium hysterophorus*
28	Herb	Sarkanda	*Saccharum bengalense*
29	Grass	Palwan grass	*Andropogoni schaemum*
30	Tree	Lachi	*Eucalyptus sp*
31	Medium to large tree	Robinia	*Robinia pseudoacacia*
32	Shrub	Sanatha	*Dodonaea viscosa*
33	Tree	Kamila	*Mallotusphilip pinensis*
34	Tree	Amaltas	*Cassia fistula*
35	Tree	Kangarphali	*Pistacia integerrima*
36	Herb	Chotagokhuro	*Xanthium strumarium*
37	Bush	Janglianar	*Punica granatum*
38	Shrub	Timar	*Zanthoxylum armatum*
39	Climbing plant	Kuchan	*Galium aparine*
40	Herb	Padar	*Mollugo cerviana*
41	Shrub	Arand	*Ricinus communis*
42	Shrub	Phitni	*Ziziphus oxyphylla*
43	Shruby herb	Kantala	*Agave americana*
44	Shrub	Marwan	*Vitex negundo*
45	Tree	Batangi	*Pyruspashia*
46	Shrub	Nagphini	*Opuntia dillenii*
47	Shrub	Kasmal/Sunbal	*Berberi slycium*
48	Tree	Daravi/Hill toon	*Cedrela serrata*
49	Herb	Strawberry	*Fragaria vesca*
50	Herb	Gul-e-laila	*Iris germanica*
51	Shrub	Pataki	*Gymnosporia royleana*
52	Grass	Bru grass	*Cymbopogon distans*
53	Climbing shrub	Jungligulab	*Rosa moschata*
54	Tree	Khubani	*Prunus armeniaca*
55	Shrub	Gangair	*Lycium depressum*
56	Grass	Khabbal	*Cynodon dactylon*
57	Herb	Khatmit	*Oxalis corniculata*
58	Tree	Chir	*Pinus roxburghii*
59	Herb	Ispaghol	*Plantago lanceolata*
60	Herb	Hind	*Sonchus asper*
61	Herb	Dodhal	*Taraxacum officinale*
62	Herb	Pakha	*Dryopteri sramosa*
63	Tree	Nashpati	*Pyrus communis*
64	Tree	Jangliamlook	*Diospyros lotus*
65	Tree	Akhroot	*Junglans regia*
66	Tree	Loquat	*Eriobotrya japonica*
67	Tree	Lychee	*Litchi chinensissonn*
68	Shrub or tree	Sarru	*Cupressus torulosa*
69	Tree	Sufaida	*Populus sp.*
70	Herb	Khat mat/ Khatitan	*Oxalis corniculata*
71	Tree	Alubukhara	*Prunus bokhariensis*
72	Small tree	Malta	*Citrus sinensis*
73	Creaper	Lay lie	*Convolvulus arvensis*
74	Medium size tree	Bies	*Salix alba*
75	Grass	Nar grass	*Phregmites karka*
76	Small tree	Khatta	*Citrus medica*
77	Tree	Chakotra	*Citrus grandis*
78	Herb	Mako	*Solanum nigrum*
79	Medium size tree	Kino	*Citrus reticulata*
80	Tree	Harrar	*Terminalia chebula*
81	Tree	Aaru	*Prunuspersica*
82	Tree	Amrood	*Pisidium guajava*
83	creeper	Angoor	*Vitis vinifera*

84	Tree	Anar	*Punica granatum*
85	Shrub	Kaghzinimboo	*Citrus aurantifolia*
86	Tree	Mitha	*Citrus limetta*
87	Tree	Alocha	*Prunus domestica*
88	Tree	Bahe	*Pyrus cydonia*
89	Tree	Ailanthus	*Ailanthus altissima*
90	Tree	Siris	*Albizia procera*
91	Herb	Behkar	*Adhato davasica*
92	Tree	Aam	*Mangifera indica*
93	Grass	Bans	*Bamboo spp.*
94	Shrub	Janglimirch	*Solanum pseudocapsicum*
95	Herb	Karela	*Momordicacharantia*
96	Creaper	Aakass bail	*Cuscutareflexa*
97	Tree	Jamun	*Eugenia jambolana*
98	Herb	Hansraj/persosha	*Adiantumcapillus-veneris*
99	Herb	Kana grass	*Saccharum bengalense*
100	Tree	Gullar	*Ficus glomerata*
101	Herb	Karko	*Ajuga bracteosa*
102	Shrub	Pirasoo	*Prosopis juliflora*
103	Herb	Chulai	*Amaranthus viridis*
104	Tree	Barh	*Ficus benghalensis*
105	Shrub	Sarphoka	*Indigofera oblongifolia*
106	Shrub or small tree	Lahura	*Tecomellaun dulata*
107	Herb	Marwanday	*Agnus castus*
108	Creaper	Giloe	*Tinospora cordifolia*
109	Shrub or small tree	Mazri	*Nannorrhops ritchiearia*
110	Climbimg plant	Kuchan	*Galium aparine*
111	Herb	It sit	*Trianthema pentandra*
112	Herb	Kandiara	*Astragalus candolleanus*

5. BIODIVERSITY RESEARCH DIVISION

5.1 FOREST GENETICS

5.1.1 Field Experiments

Paulownia Species Trials

Location: Pakistan Forest Institute (PFI), Peshawar and PFI, Field Stations
Principal Investigator: Muhammad Bilal Zia, Forest Geneticist

Deciduous nature and fast growing characteristics of Paulownia has lead its suitability in agro- forestry systems. Four species of Paulownia i.e. *Paulownia elongata, P. catalpifolia, P. fortunei* and *P. tomentosa* introduced from China, have been planted at Chhangamanga to study their growth behaviour and adaptability under irrigated conditions.

i) Paulownia Species Trial at PFI, Field Station Changa Manga

Treatments	=	04
Layout	=	RCBD
No. of replications	=	05
Spacing	=	3 x 3 m
Total no. of plants	=	1440
Total area	=	1.34 ha
Date of planting	=	April 2010

Data for growth and survival % were collected in June 2022 are given in following table.

Table 1. Diameter, height and survival % of Paulownia species at the age of twelve years

S.No.	Species	DBH (cm)	Height (m)	Survival (%)
1.	*P. tomentosa*	29.25	12.00	45
2.	*P. elongata*	28.00	11.97	56
3.	*P. catalpifolia*	26.00	17.10	60
4.	*P. fortunei*	25.16	16.23	60

The above mentioned table reveals that *P.elongata* showed maximum DBH of 28.00 cm*. P.catalpifolia* is ranked at top for DBH of 17.10 cm and survival of 60%.

ii) Screening of *Dalbergia sissoo* germplasm against Dieback Disease at PFI

Dalbergia sissoo is a large fast growing deciduous tree species and its wood has international recognition due to its multi-dimensional use. Unluckily its survival is confronted with gigantive problems in the form of discriminate or indiscriminate felling and die-back of trees. These problems necessitate that superior and disease resistant phenotypes be selected and multiplied to recover the previous status and for further increase the area under shisham plantation, so that tangible gains can be achieved in afforestation programmes.

Forest Genetics Branch, PFI collected the seed and raised a nursery from Die-back resistant *D.sissoo* mother trees on the basis of visual observations and local knowledge from Basham (Distt. Shangla). However its resistance status shall be tested scientifically by following standard procedures such as pathogen isolation, identification and inoculation. The stock thus collected deemed to be tested in the field heavily infested with the dieback, which is termed here as "HOT SPOT". The selected site (die-back hot spot) at garden-II already contained the Shisham trial for transplanting the selected materials. The genotypes which will prove to be resistant will further be characterized at molecular level. The plot was established at Garden-II, PFI, Peshawar which is detailed as:

Entries	=	02
Layout	=	Block plantation
Spacing	=	2x4.5 m
Total no. of plants	=	240
Total area	=	0.53 ha
Date of planting	=	April 2019

The performance of shisham species after three months of growth is given in table 2.

Table 2. Average height and survival % of two sources of *D. sissoo*

Species	**Survival (%)**
D. sissoo (Local)	84
D. sissoo (Basham)	90

iii) Comparative Growth Study of *Dalbergia sissoo* and *D. latifolia* at PFI Field Station Chhangamanga

To compare the growth of three Dalbergia species, a study was conducted at irrigated plantation of Changamanga, its details are given as:

Treatments	=	3
Layout	=	RCBD
No. of replications	=	5
Spacing	=	3X1.5 m
Total no. of plants	=	900
Total area	=	0.41 ha
Date of planting	=	April 2011

Data were recorded for plant height and survival %, which are shown in table 3.

Table 3.DBH, height and survival % of two sources of *D. sissoo* and *D. latifolia* in December 2021

S. No.	Sources	DBH(cm)	Height(m)	Survival (%)
1.	*D. sissoo* (Local)	20.5	10.7	40
2.	*D. sissoo* (Nepali)	20.8	13.5	43
3.	*D. latifolia*	12.25	9.5	26

In the above table *D.sissoo* (Nepali) exhibited maximum growth by attaining DBH of 20.8 cm and height 13.5 m while *D.sissoo* (local) reflected good survival of 40%.

iv) Comparison of *Dalbergia sissoo, w*ith Five Timber Wood Tree Species

Shisham dieback disease is widespread and complex in nature, involving causative factors that are poorly understood. So far its remedial measures look very distant. It is therefore, argued and opined by professional foresters and researchers to find out best substitute of shisham. For this purpose an experiment was laid out at Changa manga for comparing the performance of five different tree species namely; *Dalbergia latifolia, Melia azedarach, Terminalia arjuna, Paulownia fortunei, Bombacopsis quinata* with *Dalbergia sissoo*. The methodology of experiment is briefed as under:

Treatments	=	6
Layout	=	RCBS
No. of replications	=	4
Total no. of plants	=	648
Total area	=	0.90 ha
Date of planting	=	March 2010

Performance of these six species observed in December 2021 is given in table 4.

Table 4.Diameter, height and survival % of six trees species in December 2021

S.No.	Species	DBH (cm)	Height (m)	Survival %
1.	*Melia azedarach*	33.5	13.3	75
2.	*Bombacopsis quinata*	29.4	10.5	75
3.	*D. sissoo*	27.0	10.0	68
4.	*Paulownia fortunei*	27.8	9.3	35
5.	*D. latifolia*	15.7	8.5	40
6.	*Terminalia arjuna*	20.8	9.2	68

The above table exhibits that *Melia azedarach* has attained good DBH of 33.5 cm and height 13.3 m. It is followed by *Bombacopsis quinata* having DBH 29.4 cm. On the basis of survival % *Bombacopsis quinata* and *Melia azedarach* were ranked on top with 75% survival.

v) Die Back Resistant (DBR) Shisham Progenies Trial

A nursery of Die Back Resistant (DBR) shisham progenies was raised at PFI during 2005. To evaluate these progenies a study was established at PFI field station D.I.Khan as detailed below:

Treatments	=	08
Layout	=	RCBD
No. of Reps	=	03
Spacing	=	2 x 3 m
Total no. of plants	=	96
Total area	=	0.075 ha
Date of planting	=	March 2012

The data regarding survival% of progenies were collected in December 2021 and are given in following table.

Table 5. Survival % and growth data of shisham progenies at the age of eleven years

S.No.	Progenies	DBH (cm)	Height (m)	Survival (%)
1.	M-131	23.1	10.00	87.5
2.	M-143	21.7	10.85	25.0
3.	M-144	22.5	9.90	50.0
4.	B-145	26.8	10.5	87.5
5.	B-146	26.5	9.3	87.5
6.	B-147	25.1	8.5	50.0
7.	B-148	20.8	8.45	62.5
8.	L-149	18.6	10.4	87.5

The above table reveals that the progeny B-145 showed best performance regarding survival and Height i.e. 87.5 and 10.5 m respectively.

vi) Shisham Progenies Test-cum Seed Orchard

An experiment comprising of 108 progenies having 92 progenies of plus trees and that of 16 die-back resistant (DBR) trees of local shisham was planted at Changa manga. The objective is to establish seed orchard of superior quality stand after evaluation and selection for growth and disease resistance. After thinning out of weak progenies, the blocks will be converted into seed orchard. This study was maintained during this year.

The methodology is shown as:

Treatments	=	108
Layout	=	Block planting
No. of blocks	=	04
Spacing	=	3 x 1.8 m
Total no. of plants	=	5616
Total area	=	3.30ha
Date of planting	=	March 2007

5.1.2 Maintenance of Block Plantations as Seed Sources

i) Straight-boled Nepali Shisham Plots

Three plots of Nepali shisham were planted at PFI research garden during March 2010 on an area of 0.70 acre. The objective is to use the superior plants as a seed source for further research studies and field plantations. These plots were maintained through eradication of weeds and irrigation.

Under the Establishment of High Mountains Biodiversity Research and Training Station at Kalam project a seed source plot of Neepali Shisham was established in March 2017at PFI Field Station Ratta Kulachi D.I.Khan on an area of 2kanals. This block plantation showed the 83% survival and average height of 4.55 meters at the age of four years.

ii) Block Plantations of Paulownina

Two Paulownia planations, each comprising of four species i.e. *P. elongata, P. fortunei, P. catalpifolia P. tomentosa* were maintained on an area of 4 and 2 kanals respectively.

iii) Block Plantation of Jatropha Provenances

The global demand for fuel is raising day by day and after the next twenty years the demand for energy is expected to be raised by about 50 – 60 %. Due to spiraling prices of crude oil, world is looking for its alternatives. While exploring the energy alternatives, bio-diesel obtained by conversion of non edible oils of plant sources can be used as a substitute of fossil fuel. Presently the base source of producing bio-diesel is considered to be Jatropha, a plant that grows mainly in tropical climate. The oil contents in Jatropha vary from 30 – 60% depending upon the species.

A block plantation of seven provenances *Jatropha quercus* was maintained during this year. These provenances will serve as seed source for research activities in future. Its details are as under

Treatments	=	07 provenances
Layout	=	Block plantation
Spacing	=	3 x 3 m
Total no. of plants	=	70
Total area	=	0.14 ha.
Date of planting	=	September 2012

The data regarding height of these provenances were collected in June 2022 and are given in following table.

Table 6.

S.No.	Provenance	Av.Height (m)
1	Raigarh	4.25
2	Uttar anchal	3.90
3	Rai pur	3.32
4	Australia	3.80
5	Andhra pardesh	2.89
6	Ambika pur	2.70
7	Udhia pur	2.43

5.1.3 Seed Collection

A regular activity of Forest Genetics Branch is to collect the seed from phenotypically superior (plus) trees of various species to be used in various research experiments and nursery raising at PFI Peshawar as well as its distribution to various forestry based organizations. During this year 45.0 kg seed of various tree species were collected and stored. All demand of seed of Silviculture Branch of Forestry Research Div. was fulfilled for nursery raising.

Seed Quality Testing

Germination tests of collected and stored seed were in the seed testing laboratory that ranged from 65-78%.

S.No.	Species	Germination %
1.	*A. coriacea*	73
2.	*A. modesta*	78
3.	*A. nilotica* (Local) *A. nilotica* (cupressiformis type)	65 71
4.	*tortilis*	77
5.	*Albizia lebbeck*	65
6.	*Cassia fistula*	65
7.	*Dalbergia sissoo* (local) *Dalbergia sissoo* (Nepali)	65 75
8.	*Eucalyptus citreodora*	71
9.	*Eucalyptus Camaldulances*	78
10.	*Melia azedarach* (Irani) *Melia azedarach* (U-type)	73 69
11.	*Pinus roxburghii*	77
12.	*Ziziphus murritiana*	68

5.1.4 Maintenance of Nurseries

Genetics Branch maintained nurseries of different tree species at PFI, Research Garden and at field station Ratta Kulachi (D.I. Khan). These include bare rooted as well tube plants for its own research experiments as well as for supplying superior stock to various Govt. agencies, NGOs, farmers and individual tree growers. The emphasis was to grow drought tolerant species.

i) Paulownia Nursery

Vegetative propagation from root or stem cuttings is important for producing genetically uniform planting stock. Paulownia stem cuttings are however, difficult to propagate as compared to root cuttings.

A number of roots of standing selected Paulownia trees growing in research garden at PFI were collected. All roots of 1-4 cm diameter were trimmed to the base and converted into 4-6 cm long segments. The cuttings were air dried for 3-5 days depending upon the weather conditions. In order to accelerate the formation of root and shoot primordia, the cuttings were placed in moist sand for two weeks and covered with polythene sheet to raise the temperature. The cuttings which showed callus formation or cracks and few root and shoot tips were taken out from the sand and planted in the field nursery. The area of 1.5 kanals in the field of nursery was tilled to about 30cm depth, leveled. Well shaped 0.5m wide beds were prepared for planting the cuttings on both sides. About 1800 root cuttings were planted on these beds at 0.5 m spacing on 20-22 March, 2020. Restocking of cuttings was done after 15 days of planting. Maintenance practices i.e. irrigation, hoeing and eradication of weeds were carried out regularly.

The survival rate of sprouted cuttings was 79% and the height of saplings ranged from 3.25 to 4.50 m after 15 months. Species wise details are as under:

S.No.	Species	No. of Cuttings planted
1.	*P. fortunei*	200
2.	*P. elongata*	200
3.	*P. tomentosa*	200
4.	*P. catalpifolia*	200
	Total:	800

ii) Potted Nurseries

All necessary operations including, tube filling, sowing, hand watering pruning and bed shifting of plants depending upon weather and general maintenance of nurseries were carried out.

Sowing of seed of *Pinus roxburghii, D.sissoo*, was done in 2200 tubes to raise tube plants at PFI research garden and sowing of seed of different Acacia species was conducted in 2000 tubes at PFI field station D.I.Khan.

Old Nursery stock of 5500 plants of important species was maintained at PFI, while same was done for stock of 3800 plants of different species at D.I.Khan.

Miscellaneous

- Under the capacity building component of SFE project Forest Geneticist was also engaged in long term training Ph.D in Forestry at University of Agriculture, Faisalabad and successfully completed comprehensive exams Part 1 (written) and Part 2 (Oral defense) at University of Agriculture Faisalabad.

- Forest Genetics subject was taught to B.Sc and M.Sc Forestry classes at

- Guided the forestry students for their term papers and research work.

5.2 WILDLIFE MANAGEMENT

5.2.1 Survey of Ramsar sites of Khyber Pakhtunkhwa Migration of Migratory Birds in Pakistan

Migratory birds take various routes to come Pakistan. Migration of ducks and other birds starts in end of September. Some birds arrive at the end of November and leave in February. Some arrive from Siberia, over the Karakoram, Hindu Kush and Suleiman Ranges along the Indus River, and move down to the delta through the Indus Flyway No 4. Birds from China and Russia cover a distance of 4,500 km by using the Indus Flyway to reach Pakistan. Thanedar Wala is a fresh water stream; water level fluctuates during the year and mainly depends on the rain water. During migration in the rainy and cloudy day, ducks use to spend some time for a day or more in this reservoir in the winter season. The birds use a combination of several different types of innate biological senses and experience for this purpose.

A view of ducks

Birds watching

Many birds have special chemicals or compounds in their bodies and have a strong navigation that help them sense the Earth's magnetic field, which helps them find the right direction for long journeys. In other words, they have some internal compass to guide them. They also have a built-in mechanism to gauge the position of the stars and the sun above the horizon, which help them navigate their routes. Birds usually go from the cold northern hemisphere, where they nest during the milder season, to more temperate southern areas when winter becomes harsh. The migration is both ways, not just north to south (fall migration) but also from south to north (Spring migration). Pakistan is among the 30 countries of North, Central and South Asia, and Trans-Caucasus that are covered by the Central Asian Flyway, one of the seven flyways around the globe used by migratory birds. Migratory birds takes various routes to come to Pakistan through Indus flyway which is also known as central Asian Flyway or Green route flyway which covers huge Eurasian Continental areas between the Indian ocean, Artic ocean and Island linked with these oceans and comprises several important migrations for migratory birds. Mostly ruddy shelduck, common teal, mallard, shoveller, gadwall, common pochard, pintail, garganey, red crested pochard, Wigeon, tufted duck, pintail, white eyed duck and other water birds such as coots, grebes, moorhen, stints, egrets, geese, flamingos, swans, gulls, plovers, snipes, cormorant, spoon bills, snipe, pelican, darter, storks, ibis etc. Beside these cranes and falcons, Houbara bustard, raptors, and passerines such as warblers, pipits and buntings are also visited these areas.

Survey of Thanedar Wala Ramsar Site

Location:	Thanedar Wala:
Year of commencement:	2020-2021
Compiled & Check by:	Manahil Wahab, Wildlife Management Specialist.
Survey conducted by:	Muhammad Idrees, Forest Ranger and Sajjad Ali, Field Assistant

Thanedar Wala situated in District Lakki Marwat, and declared as a Ramsar site on 23 July 1976. On both side of the river small villages are present, and people come to contact each other by passing through the river by foot. Agriculture and grazing livestock is the common practice in the area. Local inhabitant considered typha as a crop and they sell it in the market.

It is famous for crane refugee and ducks and other migratory birds e.g. ruddy shelduck, common teal, mallard, shoveller, common pochard, red crested pochard, wigeon and Pintail were mostly observed in migratory season. During the survey the whole area was observed very carefully but few species of ducks has been sighted. Moreover three decoys were also seen in the area of Survey. Birds species sighted with their number during the survey are listed below in table -1.

Table 1. Birds species sighted

S#	Birds Name	Number of Birds
1.	Kentish plover	34
2.	Pied Kingfisher	14
3.	Common sand piper	18
4.	White wagtail	13
5	Gadwall	20
6	Wigeon	17
7	Mallard	26
8	Common teal	33
9	Common pochard	15
10	Pintail	07
11	Little egret	27

Survey of Tanda Dam Ramsar site

Location:	Tanda Dam
Year of commencement:	2020-2021
Compiled & Check by:	Manahil Wahab, Wildlife Management Specialist.
Survey conducted by:	Muhammad Idrees, Forest Ranger and Sajjad Ali, Field Assistant

A close view of duck

A group of ducks

Pied kingfisher

A group of egrets

Tanda dam is situated in Kohat District of Khyber Pakhtunkhwa Province of Pakistan. The dam supplies water for irrigation to Jurma, Shahpur and many villages by means of canals from Tanda Lake. Tanda Dam is a Ramsar site under the Ramsar Convention, an international treaty for the conservation and sustainable utilization of wetlands. It was included as a Ramsar site on July 23, 1976. The lake is home to migratory birds from Siberia and the Caspian during winter. It is a Wildlife Park and the area is covered by Sub-tropical scrub forest which consists of *Acacia modesta* and *Olea ferruginea, Dodonaea viscosa* as the dominant species and also serves as a resting habitat/stopover and feeding site of migratory waterfowls.

The arrival of geese, swans, cranes, waterfowls and waders from Siberia start arriving in early November. Birds species sighted with their number during the survey are listed below in table 2.

Birds watching at Tanda Dam Ramsar Site

View of Shoveller, common teal and mallard

S#.	Birds Name	Number of Birds
1	Mallard	137
2	Great crested grebe	33
3	Little egret	23
4	Common Teal	170
5	Little Cormorant	12
6	Grey heron	04
7	Common Pochard	19
8	Tufted duck	16
9	Little grebe	09
10	Wigeon	27
. 11	Pintail	44
. 12	Gadwall	38
. 13	Unidentified ducks	35

Ducks in Tanda Dam

Common Teals

5.3 RANGE MANAGEMENT

5.3.1 Germplasm Multiplication of different Forage and Fodder Species

Location : PFI, Peshawar
Period : 2020-21
Principal Investigator : Ashar Farooq, Range Management Officer

Different forage and fodder grasses have been grown at Range Research Garden, PFI Peshawar to serve as a purpose of seed collection. The seed collected is used for new range research trials in experimental sites and is also sold /supplied to Forest Departments, NGOs and Farmers on demand basis.

Detail of seed collected during the year 2020-21 is given below:

Table 1. Seed Collection of forage and fodder grasses from Range Research Garden, PFI during the year 2020-21

Sr.No.	Name of species	Quantity (Kg)
1.	*Cenchrus ciliaris*	0.6
2.	*Chloris gayana*	0.3
3.	*Panicum antidotale*	0.5
4.	*Panicum coloratum*	0.2
5.	*Panicum maximum*	0.3
6.	*Pennisetum orientale*	0.3
7.	*Setaria anceps*	0.4
8.	*Sorghum almum*	2.4
	Total:	5.0

5.3.2 Determination of forage yield of forage grasses grown at Range Research Garden, PFI, Peshawar

Location : PFI, Peshawar
Period : 2020-21
Principal Investigator : Ashar Farooq, Range Management Officer

Forage and fodder species/varieties have been grown to assess their forage production at PFI Range Research Garden. Yield of the following grass species was determined from each plot by single clipping in 3 quadrats. Fresh and air dried weights were recorded. The forage production of different species is as under:

Table 2. Air-dried forage production (Kg/ha) during November, 2020

Sr.No.	Name of species	Forage Production (kg/ha)
01.	*Cenchrus ciliaris*	4170
02.	*Chloris gayana*	4210
03.	*Hybrid Napier bajra*	12940
04.	*Panicum antidotale*	8230
05.	*Panicum coloratum*	5870
06.	*Panicum maximum*	6190
07.	*Pennisetum orientale*	5450
08.	*Pennisetum purpureum* (mott grass)	19450
09.	*Setaria anceps*	10760
10.	*Sorghum almum*	8640

Results reveal that the highest air dried forage yield (19450 Kg/ha) was obtained from Pennisetum purpureum followed by Hybrid Napier Bajra with total forage yield of 12940 Kg/ha and Setaria anceps with forage yield of 10760 Kg/ha. All the 3 species are recommended for enhancing fodder production in irrigated areas. *Chloris gayana, Panicum maximum, Panicum coloratum* and *Sorghum almum* are also promising species for fodder purposes.

5.3.3 Nutritive Value Analysis of Fodder Tree Species grown at Range Research Garden, PFI, Peshawar

Location	:	PFI, Peshawar
Period	:	2020-21
Principal Investigator	:	Ashar Farooq, Range Management Officer

Fodder trees play an important role for providing fodder to the range animals during the winter season and under drought conditions when grasses are not available. Fodder trees are a valuable resource and contribute to food security by providing fodder for maintaining livestock in a pastoral system. Trees and shrubs are increasingly recognized as important components of animal feeding, especially as suppliers of protein. In difficult environmental conditions, where the available grazing is not sufficient to meet the maintenance requirements of animals for part of the year, the contribution from trees and shrubs is significant. Tree fodders contain high levels of crude protein and minerals and many show high levels of digestibility. They are readily accepted by livestock and presumably because of their deep-root systems, they continue to produce well into the dry season. However, anti nutritive factors can be a problem in some species. The objective of this study was to evaluate the nutritive value of fodder trees with the change of seasons

Leaves and twig growth of tree species namely *Acacia nilotica, Acacia modesta, Albezzia lebbek, Morus alba* and *Zizyphus mauritiana* were collected in two seasons from March 2020 to Dec 2020 from Range Research Garden.

The experiment was conducted in three replicates in RCB design. Three samples of each species were collected at two different seasons of growth i.e. Summer, winter and weighed. For this purpose, three samples from each plot were harvested at random following standard method for fresh and dry matter determinations. Each sample was placed in a paper bag and dried at 70°C for 48 hours to obtain dried samples with minimum chemical changes and was weighed again. The initial weight of the sample before drying and the final weight of the sample after drying were noted. After that, the samples were grinded by the grinder and then the samples were forwarded to the analysis step in which the following parameters were analyzed.

Dry Matter (DM), Crude Protein (CP), Crude Fiber (CF), Ether Extract (EE) and Total Ash (TA) were determined in Forage Nutrition Lab of Pakistan Forest Institute, Peshawar according to the standard rules. (AOAC, 1980 Van Soest, 1994).

Dry Matter (DM)

A known weight (W1) of the sample was taken in a tarred, previously weighed Petri dish. The dish was placed in an oven at 80°C and the sample was dried to a constant temperature to get dried weight (W2). The dry matter of the sample was calculated according to the following formula:

$$\text{Dry Matter \%} = W2/ (W1) \times 100$$

Crude Protein (CP)

Total nitrogen in the samples was determined by Kjeldahl's method. A know amount of the oven dried sample (W1) was taken in the flask. 5 g of catalyst mixture containing CuSO4 (9:1) and 25 ml of concentrated H2SO4 were also added to the flask. The sample was boiling in a digestion rack, initially at low temperature and then with vigorous boiling till the content became clear. After cooling, the contents of the flask were diluted with distilled water in a 250 ml volumetric flask. A 10 ml aliquot of this solution was transferred to the distillation apparatus and distilled in the presence of 10 ml of 40% NaOH solution. The ammonia so liberated was collected in a flask containing 10 ml of 2% boric acid solution having two drops of methyl red as an indicator. The distillate was titrated against standard 0.1 N H2SO4 to light pink which is the end point. The nitrogen and crude protein (CP) percentage were calculated with the help of the following formula:

Nitrogen (%) = ml 0.1 N H2SO4 x 0.001 x 250 ml/ (W1) x 10

CP (%) = N% x 6.25

Ether Extract (EE)

A known weight (W1) of the oven dried sample was taken in an extraction thimble. It was plugged with fat free cotton. The sample was extracted with petroleum ether (40-60oC) in Soxhlet's apparatus by fixing the condensation rate at 80 drops per minute. The process was continued for about 6 h. The contents of the receiving flask were transferred to a tarred previously weighed Petri dish. Ether was evaporated by placing it in an oven at 60°C till the extract attained a constant weight (W1-W2). Percentage of EE was calculated with the help of the following formula.

E.E (%) = W2/W1 x 100

Ash Content (AC)

Ash content was determined by ignited the known amount of plant material in muffle furnace to 650Cfor at least 8 hours. Ash was cooled in desiccator at room temperature and weighed. Ash content of the samples was determined by AOAC, (1990).

Crude Fiber (CF)

Fibers are the organic residue that remains after being digested. Weight 2gm moisture free and ether extracted sample place in a beaker, and add 200ml boiling dilute H_2SO_4.Digested the sample for exactly 30 minutes on crude fiber extraction apparatus. Filtered through glass funnel with the aid of suction air pump. Washed with hot water until it is acid free. Collect 15ml filtrate; added one ml of NaOH and one ml of phenolphthalein indicator. (A pink color indicates that it is acid free).Then transferred it in to beaker again. Then again added 200ml boiling dilute NaOH. Again digested for exactly 30 minutes, filtered through glass funnel with the aid of suction air pump. Washed this H2SO4, and then with hot water until it is acid free and first with 10ml hot dilute transferred it into crucible dry it in oven at 135 Co for 2 hour. The whole sample was cooled in desiccator for 30 minutes and weighed. As a last step it was ignited in muffle furnace at 600 Co for 30 minutes and cooled in desiccator for 1hour and weight.

$$\%\,\text{Crude fiber (DM)} = \frac{\%\,\text{crude fiber (as fed)}}{\%\,\text{dry matter of sample}} \text{x} 100$$

Results

Results of nutritive value analysis of fodder trees are summarized as under:

Phulai (*Acacia modesta*)

Table 3. Showing Average value of all measured properties of *Acacia modesta*

Season	DM %	CP %	EE %	AC %	CF %
Summer	30.72	19.38	3.49	28.31	35.5
Winter	47.48	17.37	3.99	35.91	39.95

Kikar (*Acacia nilotica*)

Table 4. Showing Average value of all measured properties of *Acacia nilotica*

Season	DM %	CP %	EE %	AC %	CF %
Summer	32.86	15.29	2.88	5.18	22.36
Winter	40.72	11.18	3.62	10.02	30.78

Siris (Albizzia lebbek)

Table 5. Showing Average value of all measured properties of *Albizzia lebbek*

Season	DM %	CP %	EE %	AC %
Summer	17.75	2.15	6.7	29.9
Winter	16.5	3.5	8	33

Toot (*Morus alba*)

Table 6. Showing Average value of all measured properties of *Morus alba*

Season	DM %	CP %	EE %	AC %	CF %
Summer	26.4	13.6	4.8	14.7	28.8
Winter	30.1	18.3	5.3	17.5	26.2

Ber (*Zizyphus mauritiana*)

Table 7. Showing Average value of all measured properties of *Zizyphus mauritiana*

Season	DM %	CP %	EE %	AC %	CF %
Summer	31.3	17.04	3.01	10.5	18.4
Winter	38.4	19.70	2.05	8.25	17.01

Conclusion

The results show a great variation and have a significant difference in seasons i.e. winter and summer. DM % evaluation shows that there was a significant difference in season. DM% value was less in summer than that of DM% value in winter. In all observed tree species, the same trend was followed. CP % evaluation

shows that there was a significant difference in season. CP% value was less in winter than that of CP% value in summer. In all observed tree species, the same trend was followed. CF% evaluation shows that there was a significant difference in season. CF% value was less in winter than that of CF% value in summer. In all observed tree species, the same trend was followed. EE% evaluation shows that there was a significant difference in season and as well as in species. EE% evaluation shows that in *Albizzia lebbek* and *Morus alba*, the EE% value was less in summer than that of winter. EE% evaluation shows that in *Acacia nilotica, Acacia modesta* and *Zizyphus mauritiana*, the value was less in winter than that of summer.

AC% evaluation shows that there was a significant difference in season and as well as in species. AC% evaluation shows that in *Albizzia lebbek, Acacia nilotica* and *Acacia modesta*, value was less in summer than that of winter. In *Morus alba* and *Zizyphus mauritiana*, the AC% value was less in winter than that of summer.

Miscellaneous

Prepared and got published a research article in Pakistan Journal of Forestry Vol.70(1):17-30, 2020.

Taught Range Management to B.S. and M.Sc. Forestry classes.

Supervised two (02 Nos.) students of M.Sc. forestry (2018-20) in their thesis work.

Supervised four (04 Nos.) students of BS Forestry in their thesis work.

Conducted the Practical examination of B.Sc. Forestry 3rd term class and M.Sc. Forestry 3rd term class as an Internal Examiner

6. FOREST EDUCATION DIVISION

The Forest Education Division of Pakistan Forest Institute is striving hard to come up to the expectations of the countryeven after its devolution to the Province of Khyber Pakhtunkhwa. During the year 2020-21, the Departmental Nominees as well as self-finance students were admitted from all the federating units of the country.

Forest Education Division of PFI is fully aware of the Forestry Educational needs of the country. Hence as per instructions and guidelines of Higher Education Commission the 4-Year BS Forestry program was started and the first batch of 25 students were passed out in 2017. Similarly, 4-Year BS Forestry second batch of 17 were passed out in 2020. On the contrary, 2-Year B.Sc Forestry and the 2-Year M.Sc Forestry students were also passed out in 2020. However, consequent to the guidelines of the Higher Education Commission, 2-Year B.Sc Forestry program has been phase-out, and the2-Year M.Sc Forestry will be abolished from December 2022 onward.

Teaching Activities

Lecture Schedule

M.Sc Forestry (2020-22 & 2019-21), B.Sc Forestry (2019-21) & BS Forestry (2018-22, 2019-23 & 2020-24) courses were continued as per their study program & according to the lecture schedule.

Examinations

All examinations of M.Sc, B.Sc and BS Forestry courses were conducted by the University of Peshawar according to the schedule.In the month of August the University of Peshawar has started examinations from 04-08-2021 and will be finish on 18-08-21.

Thesis & Term Paper

Thesis of M.Sc Forestry 2019-21 and Term Paper of B.Sc Forestry 2019-21 are in progress.

Tours

1. Forest Management Field Work-III tour of M.Sc&B.Sc Forestry (2018-20) was conducted from 16-11-2020 to 03-12-2020.

2. Field Work-1 (Orientation) tour of M.Sc& B.,Sc Forestry (2020-22) and BS Forestry (2020-24) were conducted from 31-05-2021 to 07-06-2021.

3. Forest Survey Camp of M.Sc & B.Sc Forestry (2019-21) and BS Forestry (2018-22) were conducted from 04-02-2021 to 18-02-2021.

4. Forest Survey Camp of Forest survey and leveling of BS Forestry (2018-2022) at PFI Field Station Shinkiari, were conducted from 29-05-2021 to 15-06-2021.

5. Field Work-1 (Orientation) of BS Forestry (2019-23) and M.Sc Forestry (2019-21) were conducted from 26-12-2019 to 03-01-2020.

6. Field Work-III (Forest Management) tour of M.Sc & B.Sc Forestry (2019-21) and BS Forestry (2019-21) were conducted from 27-03-2021 to 08-04-2021.

7. Study tour programme of Forest Ecology BS Forestry (2019-23)were conducted from 01-03-2020 to 10-03-2020.

8. Participatory Forestry tour of BS Forestry (2016-20) and (2018-22) were conducted from 01-12-2021 to 01-15-2021.

9. Field Work-II (Forest Types) tours of M.Sc & B.Sc Forestry (2019-21) were conducted from 25-06-2021 to 30-06-2021.

10. Field Work-II (Forest Types) tours of BS Forestry (2018-22) is scheduled from 24-08-2021 to 06-09-2021.

PT and Games

Regular P.T. and Games were conducted throughout the year.

Co-curricular Activities

All the National and International Days related to Environment and Bio-diversity were celebrated at PFI in collaboration with line departments. Students took part in these programmes by participating in speech contests etc.

Faculty Training for Professional Grooming

1. Dr. Mamoona Wali Muhammad, Assistant Professor of Forestry, attended the learning Management System organized by Khyber Pakhtunkhwa Information Technology Board at PFI.

2. Mr. Ahmad Zamir, Assistant Professor of Forestry, attended the Learning Management System organized by Khyber Pakhtunkhwa Information Technology Board at PFI.

3. Mr. Sohaib Ahmed, Assistant Professor of Forestry, attended the learning Management System organized by Khyber Pakhtunkhwa Information Technology Board at PFI.

4. Mr, Ahmad Zamir, Assistant Professor of Forestry, has successfully completed M.Phil. in Geo Environmental Science from NCEG, University of Peshawar.

5. All Faculty members participated in intensive training course of Sustainable Forest Management at Pakistan Forest Institute, Peshawar.

STUDENTS ENROLLMENT

BS Forestry Session 2018-22		
S.No	**Province**	**Strength**
1.	Khyber Pakhtunkhwa	19
2.	Punjab	04
3.	PFI	02 (Department)
4.	Gilgit Baltistan	01
Total		**26**
BS Forestry Session 2019-23		
S.No	**Province**	**Strength**
1.	Khyber Pakhtunkhwa	15 (01 Department)
2.	Punjab	04
3.	AJK	02
4.	Gilgit Baltistan	01
Total		**22**
M.Sc Forestry Session 2019-21		
S.No	**Province**	**Strength**
1.	Khyber Pakhtunkhwa	29
2.	Punjab	02
3.	Gilgit Baltistan	02 (01 Department
4.	Balochistan	01
5.	AJK	01
Total		**35**
B.Sc Forestry Session 2019-21		
S.No	**Province**	**Strength**
1.	Khyber Pakhtunkhwa	16
2.	Punjab	04
3.	Gilgit Baltistan	02 (01 Department)
4.	Balochistan	01
5.	AJK	01
Total		**24**
M.Sc Forestry Session 2020-22		
S.No	**Province**	**Strength**
1.	Khyber Pakhtunkhwa	22 (03 Department)
2.	Punjab	05
3.	Sindh	05 (Department)
4.	Balochistan	10 (Department)
5.	AJK	01
Total		**43**
BS Forestry Session 2019-23		
S.No	**Province**	**Strength**
1.	Khyber Pakhtunkhwa	14
2.	Punjab	05
3.	Balochistan	04 (03 Department)
4.	Gilgit Baltistan	02 (01 Department)
Total		**25**
Grand Total		**175/-**

7. ANNUAL RESEARCH PROGRAMME OF PFI (2021-22)

S.No	Name of the project	Principal Investigator(s)	Location	Year of commencement	Sponsoring/ Collaborating agencies
1.	**FORESTRY RESEARCH DIVISION**				
1.1	**Forest Mensuration**				
1.1.1	Temporal assessment of historic forest cover changes and the associated carbon dynamics in Ayubia National Park	Dr. Anwar Ali, DFRD	Ayubia National Park	2021	SFM, Project
1.4.2	Carbon accounting of all activities of SFM Project in Khyber Pakhtunkhwa, Punjab and Sindh	Dr. Anwar Ali, DFRD	Khyber Pakhtunkhwa, Punjab and Sindh	2021	SFM, Project
1.4.3	Intensive Training Course on Sustainabe Forest Management	Dr. Anwar Ali, DFRD	Peshawar, Ayubia, Shinkiari	2021	SFM, Project
1.2	**GIS**				
1.2.1	Temporal Assessment of Forest Cover Change in Ayubia National Park under SFM Project	Mr. Aamir Shakeel (GIS Specialist)	Ayubia National Park	2020	SFM Project
1.2.2	Tree Species Mapping of Ayubia National Park under SFM Project	Mr. Aamir Shakeel (GIS Specialist)	Ayubia National Park	2021	SFM Project
1.2.3	Aboveground Biomass Mapping of Ayubia National Park under SFM Project	Mr. Aamir Shakeel (GIS Specialist)	Ayubia National Park	2021	SFM Project
1.3	**Silviculture**				
1.3.1	Study on the effect of bio-fertilizers on the growth performance of different poplar clones at nursery stage	Dr. Anwar Ali, DFRD & Dr. Nowsherwan Zarif (CS)	Silviculture Research garden, PFI	2022	PFI, Peshawar (Normal Budget)
1.3.2	Study on the suitability of different species and soil treatments for raising Miyawaki Plantations	Dr. Anwar Ali, DFRD & Dr. Nowsherwan Zarif (CS)	Silviculture Research garden, PFI	2022	PFI, Peshawar (Normal Budget)
1.4	**Watershed Management**				
1.4.1	Collection of Meteorological Data	Mr. Bilal Ahmed Qazi & Mr. Muhammad Iqbal	PFI, Peshawar	2022	PFI
2.	**FOREST PRODUCTS RESEARCH DIVISION**				
2.1	**Wood Mechanics, Seasoning and Preservation**				
2.1.1	Radial growth, present status and future prospects of west Himalayan fir (*Abies pindrow* Royle) growing in the moist temperate forest of Himalayan mountains of Pakistan.	Mr. Zahid Rauf, DFPRD	PFI Peshawar	2022	PFI

S.No	Name of the project	Principal Investigator(s)	Location	Year of commencement	Sponsoring/ Collaborating agencies
2.2	**Logging**				
2.2.1	A Study on Dendroclimatic Potential of Kail (*Pinus wallichiana*) growing in Shangla, Swat.	Mr. Tanvir Hussain, LO	PFI, Peshawar	2022	PFI
2.2.2	Xylotomy and identification of Shisham *(Dalbergia sissoo)* and Kikar *(Acacia nilotica)* wood: a manual for layman.	Mr. Khalid Hussain, AWTO	PFI, Peshawar	2022	PFI
2.2.3	Climate change and plant anatomy: assessment of adaptability potential of Walnut *(Juglans regia)* grown in Swat, Khyber Pakhtunkhwa.	Mr. Khalid Hussain, AWTO	PFI, Peshawar	2022	PFI
2.2.4	Assessment of wood figure and defect minimization in Chinar *(Platanus orientalus)* wood by using different methods of sawing.	Mr. Khalid Hussain, AWTO	PFI, Peshawar	2022	PFI
2.2.5	A Study on Fiber Morphology of some Hardwood Species Grown in Peshawar, Khyber Pakhtunkhwa.	Mr. Said Akhtar, AWT	PFI, Peshawar	2022	PFI
2.3	**Forest Economics**				
2.3.1	Study on "State of Forestry in Pakistan" for the years 2015-16 and 2016-17 (in progress)	Mir Azam, Asstt. Forest Economist	Pakistan	2020-21	Khyber Pakhtunkhwa.
2.3.2	Study on "Development of Data base for Utilization of Wood Resource in Wood Based Industries of Pakistan"	Mr. Zahid Rauf, DFPRD, and Mir Azam ,AFE	KPK & Punjab	2020-21	Khyber Pakhtunkhwa.
3.	**BIOLOGICAL SCIENCES RESEARCH DIVISION**				
3.1	**Forest Botany**				
3.1.1	Maintenance and improvement of Botanical Garden	Sohaib Ahmad, FB	PFI	2022	PFI
3.2	**Forest Chemistry**				
3.2.1	Assessment of Forest Residue addition effect on decomposition rate, soil phosphorus dynamics and plant phosphorus uptake	Dr. Bashir Ullah, SC, and Sanam Zarif Satti, DBSRD	PFI	2020-21	PFI
3.3	**Forest Pathology**				
3.3.1	Survey of die-back resistant Shisham plantation produced through induced mutation in Peshawar	Khalid Hussain, AWTO / Forest Pathologist	PFI	2021-22	PFI

S.No	Name of the project	Principal Investigator(s)	Location	Year of commencement	Sponsoring/ Collaborating agencies
4.	**NON-TIMBER FOREST PRODUCE DIVISION**				
4.1	**Sericulture & Moriculture**				
4.1.1	Synthesis of Bivoltine Hybrid Mulbery Silkworm Strains	Dr. Ghulam Ali Bajwa, Add. Director General (Bio.Sciences)	PFI	2019	PFI
4.1.2	In-vitro Conservation of Silkworm Germplasm	Dr. Ghulam Ali Bajwa, Add. Director General (Bio.Sciences)	PFI	2018	PFI
4.1.3	In-situ Conservation of Mulberry Germplasm	Dr. Ghulam Ali Bajwa, Add. Director General (Bio.Sciences)	PFI	2018	PFI
4.1.4	Silk Seed Production	Dr. Ghulam Ali Bajwa, Add. Director General (Bio.Sciences)	PFI	2020	PFI
4.2	**Forest Entomology**				
4.2.1	Assessment of wild bee diversity from coniferous forests of KPK	Naveed Ahmed Director Non-Timber Forest Produce/ Forest Entomologist	PFI	2022	PFI
4.2.2	Development of IPM techniques against forest insect pests	Naveed Ahmed Director Non-Timber Forest Produce/ Forest Entomologist	PFI	2019	PFI
4.2.3	Introduction of innovative crop production modules of important medicinal plant herbs	Muhammad Idress Incharge Medicinal Plant Garden	PFI	2022	PFI
5.	**BIODIVERSITY DIVISION**				
5.1	**Forest Genetics**				
5.1.1	Screening of indigenous germplasm of Shisham against die back disease.	Muhammad Bilal Zia Forest Geneticist	PFI/ D.I.Khan	2014	PFI
5.1.2	Establishment of Biotechnology Lab. at PFI, Peshawar	Muhammad Bilal Zia Forest Geneticist	PFI, Peshawar	2022	ADP 2022-23
5.1.3	Seed collection and seed quality studies of important forest tree species.	Muhammad Bilal Zia Forest Geneticist	PFI/KP	2019	PFI
5.1.4	Maintenance of Field studies at PFI and at Field Stations	Muhammad Bilal Zia Forest Geneticist	PFI/KP/ Punjab	2020	PFI
5.2	**Wildlife Management**				
5.2.1	Survey of waterfowls at Uchalli complex	Ashar Farooq, DBRD	District Khushab, Punjab	2021-22	PFI
5.2.2	Survey of Birds at Bajaur District	Ashar Farooq, DBRD	District Bajaur, KP	2021-22	PFI

S.No	Name of the project	Principal Investigator(s)	Location	Year of commencement	Sponsoring/ Collaborating agencies
5.3	**Range Management**				
5.3.1	Seed multiplication and forage yield determination of different forage species	Ashar Farooq RMO	PFI, Peshawar	On yearly basis	PFI
5.3.2	Comparative study on the performance of three perennial grass species of Panicum	Ashar Farooq RMO	PFI, Peshawar	2020	PFI
5.3.3	Seasonal variation in nutritional value of Fodder Tree grown	Ashar Farooq RMO	PFI, Peshawar	2020	PFI
5.3.4	Nutritive value of perennial forage grasses at different stages of their phonological development	Ashar Farooq RMO	PFI, Peshawar	2020	PFI

APPENDIX – I

LIST OF TECHNICAL STAFF
PAKISTAN FOREST INSTITUTE, PESHAWAR

S.No.	Name & Designation	Qualification
1.	Mr. Javed Anwar Director General	
2.	Mr. Ali Gauher Khan Director, Forestry Research Division	B.Sc. (University of Peshawar) M.Sc. (Forestry) Pakistan Forest Institute
3.	Dr. Ghulam Ali Bajwa Senior Research Officer (Silkworm Pathology)	Ph.D. (Forestry) Malaysia M.Sc. (Hon) Agriculture, Entomology
4.	Mr. Tanvir Ahmad Qureshi Director, Biological Sciences Research Division/FC	M.Sc. (Chemistry)
5.	Mr. Ghulam Mustafa Nasir Director, Forest Products Research Division/LO	M.Sc. (Botany)
6.	Dr. Mamoona Wali Muhammad Director, Forest Education Division/APoF	Ph.D. (Forest Management) Malaysia M.Sc. (Forestry)
7.	Mr. Muhammad Muslim, Director, Biodiversity	M.Sc. (Forestry)
8.	Mr. Ghayyas Ahmad Assistant Professor of Forestry	M.Sc. (Forestry)
9.	Dr. Ainual Hussain Medical Officer	M.B.B.S.
10.	Mr. Ayaz Khan Marwat Senior Research Officer	M.Sc. (Forestry) M.A. (Economics)
11.	Mr. Muhammad Muslim Wildlife Management Specialist	M.Sc. (Forestry) M.Sc. (Hon) Agriculture
12.	Mr. Ashar Farooq Range Management Officer	M.Sc. (Forestry)
13.	Mr. Muhammad Atif Majeed Deputy Director (Technical)	M.Sc. (Forestry)
14.	Mr. Muhammad Bilal Zia Forest Geneticist	M.Sc. (Hons) PB&G
15.	Mr. Anwar Ali Forest Mansuration Officer	M.Sc. (Forestry)
16.	Mr. Saz Muhammad Assistant Forest Economist	M.A. Economics
17.	Mst. Sanam Zarif Bio Chemist	M.Sc. Chemistry
18.	Mst. Qudsia Khanum Lady Medical Officer	M.B.B.S.
19.	Mr. Nowsherwan Zarif Assistant Silviculturist	M.Sc. (Forestry)
20.	Mr. Zahid Mehmood Executive Officer	M.Sc. (Forestry)
21.	Mr. Tanveer Hussain Assistant Wood Technologist	M.Sc (Botany), M.Phil
22.	Mr. Naveed Ahmad Assistant Forest Entomologist	M.Sc. (Hons) Agriculture, Entomology
23.	Mr. Zahid Rauf Assistant Wood Seasoning Officer	M.Sc. (Chemistry)
24.	Mr. Khalid Hussain	Master of Science, B.Sc. (Hons)

S.No.	Name & Designation	Qualification
	Assistant Wood Technology Officer	
25.	Mr. Ahmad Zamir Lecturer in Forestry	M.Sc. (Forestry)
26.	Mr. Sohaib Ahmad Lecturer in Forestry	M.Sc. (Forestry) M.Phil (Forestry & Range Management)
27.	Mr. Ejaz Ahmad Technical Assistant	Three Years Diploma (Civil Tech) , B.A
28.	Mr. Said Akhtar Khan Assistant Wood Working Officer	Diploma of Association Engineering
29.	Syed Tehseen Akhtar Hussain Assistant Librarian	M.L.S.
30.	Mr. Bilal Ahmad Technical Assistnat	M.Sc. (Forestry)