ANNUAL PROGRESS REPORT
(2022-23)

PAKISTAN FOREST INSTITUTE
PESHAWAR
2023

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Annual Progress Report (2022-23)

FORESTRY RESEARCH DIVISION

1. SILVICULTURE

1.1 Study on the effect of bio-fertilizers on the growth performance of different poplar clones at nursery stage

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2022
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad Research Officer (Farm Forestry), Salman Ahmad Research Officer (Farm Forestry), Saif Ullah Khan Research Officer (Farm Forestry) Mr. Qayyum Khattak, FR (Silva).
Design:	Randomized Complete Block
Total area:	0.5 acres
Spacing:	2′ X 1′
No. of clones:	17
No. of replications:	02

Poplar trees are known for their rapid growth and early maturation, which enables them to produce significant amounts of wood. Poplar species and hybrids are relatively easy to propagate from cuttings, and their cultivation and maintenance tend to be straightforward. The wood of poplars has been widely utilized for many years. It is favored for its light color, white hue, and absence of flavor or odor, as well as its ease of processing. Common uses for poplar wood include the manufacture of veneer and sawn timber, matches and matchboxes, pulp and paper, and cellulose-based products. Biofertilizers, which are organic fertilizers composed of living microorganisms such as bacteria, algae, and fungi, either alone or in combination, play a crucial role in enhancing the availability of nutrients to plants. These biofertilizers, including farmyard manure and leaf manure, are particularly significant in the context of current concerns about climate change and rising fertilizer costs, as well as their potential to adversely affect soil health.

In 2022, an experiment was conducted at the Silviculture Research Garden of the PFI to evaluate the effects of different biofertilizers on the growth performance of 17 poplar clones. The treatments tested included:

1. Farmyard Manure (FYM)
2. Leaf Manure from others trees
3. A combination of Farmyard Manure and Leaf Manure from other trees
4. Eucalyptus Leaf Manure

This experiment aimed to assess the potential benefits and impacts of these biofertilizers on the growth of poplar clones. The plants raised in soil treated with farmyard manure with other tree leaves have attained the highest growth in the form of height and diameter. The soil treated with farmyard manure has the secondary growth while the soil treated with Eucalyptus tree leaves and other tree leaves has the weak and suppressed growth in the form of stunted plants. The reason for stunted growth is also attributed to the allelopathic effect of Eucalyptus trees, as given in below Figure 1.

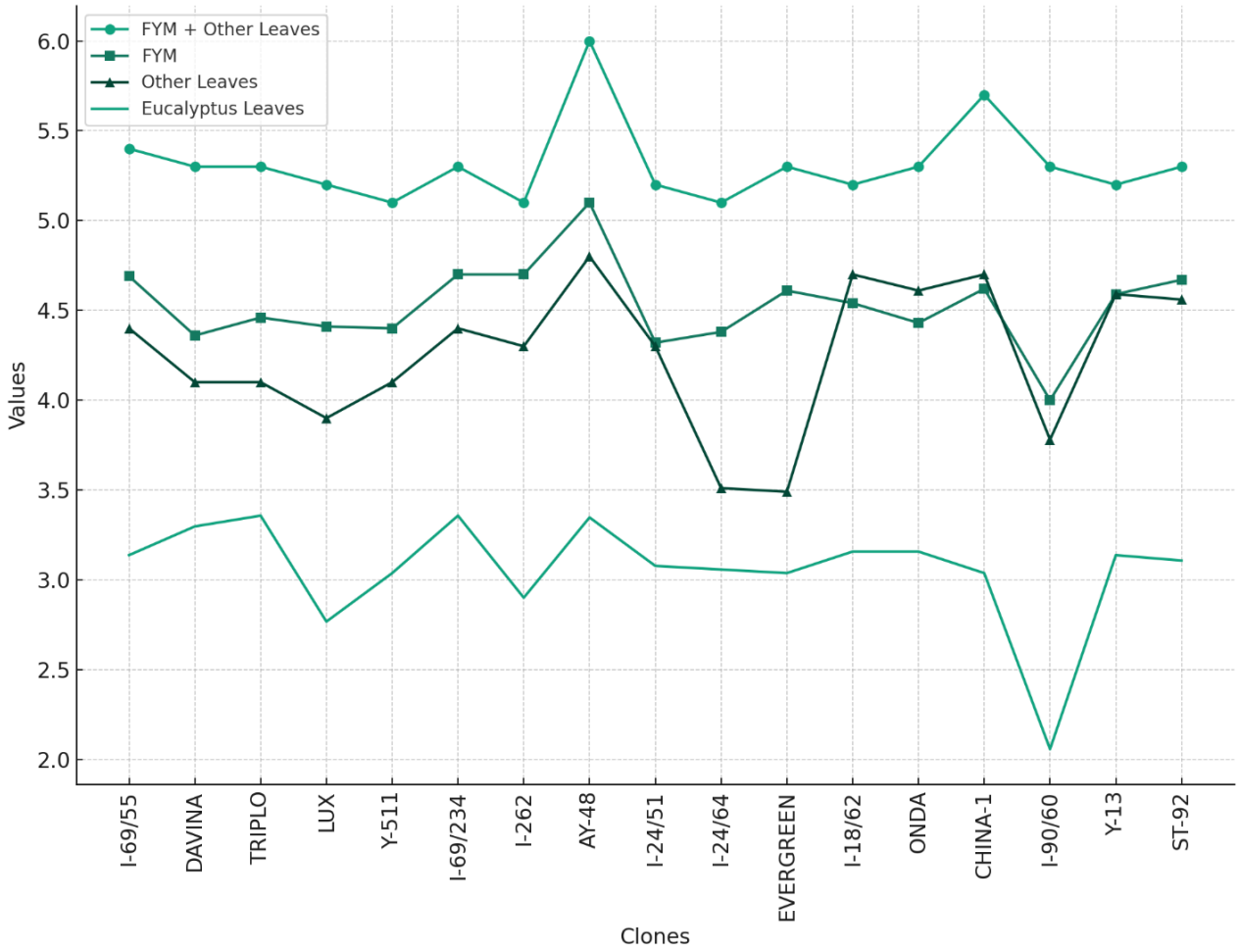


Figure.1 Displays the values for "FYM + Other Leaves," "FYM," "Other Leaves," and "Eucalyptus Leaves" across different clones. Each line represents a different category of leaves, and the values are plotted against the corresponding clones. The x-axis lists the names of the clones, while the y-axis shows the values for each category.

1.2 Study on the suitability of different species and soil treatments for raising Miyawaki Plantations

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2022
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad Research Officer (Farm Forestry), Salman Ahmad Research Officer (Farm Forestry), Saif Ullah Khan Research Officer (Farm Forestry) Mr. Qayyum Khattak, FR (Silva).
Design:	Randomized Complete Block
Total area:	10 kanals
Spacing:	2′x2′, 3′x3′, 3′x4′, 4′x4′
No. of replications:	02

The Miyawaki method, recognized for its effectiveness in rapidly establishing dense forests in urban environments, involves a unique approach to land preparation, the use of

native species, and close planting distances. This technique facilitates plant growth at a rate ten times faster than that of a conventional forest. In support of urban forestry initiatives, the government has established 53 Miyawaki plantations across the country. A detailed research study was conducted in the PFI Research Garden to examine the effects of various soil treatments and planting densities on plant growth. The experimental setup included different spacing configurations: 4x4, 3x4, 2x3, and 2x2 feet, with the land treated using leaf manure, farmyard manure, husk, and poultry waste. The trial involved twenty-one plant species, including various species of Bakain, Shisham, and Albizia. Students from PFI actively participated in the layout and planting processes, gaining practical experience in establishing Miyawaki forests.

After about one and a half year (1 ½ year) of planting, data was collected on survival rate, diameter at base and plant height to check the performance of different species and types of soil treatment as well as spacing. The data indicates that species requiring high levels of sunlight, predominantly Acacia species, experience suppression due to the shading caused by neighboring Eucalyptus and other trees. Conversely, species that receive ample sunlight exhibit better health and greater height. Spacing has no significant effect on the growth of plantation at this stage.

The growth of plants across all experimental replications was notably influenced by the soil treatments. Plants cultivated in soil amended with wheat husk exhibited suboptimal growth, as evidenced by smaller basal diameters and reduced plant heights. In contrast, plants in soil enriched with farmyard manure and leaf manure demonstrated significantly better growth. Furthermore, it was revealed that the shading from surrounding mature trees adversely affected plant development, leading to weaker and stunted growth in shaded plants. At this stage, the species that showed the most robust growth included *Melia azedarach (Irani)* and *Albizia lebbeck*, followed by *Leucaena leucocephala*, *Tecoma stans*, and *Acacia farnesiana*.

1.3 Comparative assessment of growth performance of different tree species in under storey i.e., partially or fully shaded areas.

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2022
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad Research Officer (Farm Forestry), Salman Ahmad Research Officer (Farm Forestry), Saif Ullah Khan Research Officer (Farm Forestry) Mr. Qayyum Khattak, FR (Silva).
Spacing:	10′ X 6′

A comprehensive evaluation was conducted to analyze the growth performance of various tree species in understory environments, characterized by partial or full shade. This study aimed to determine how different species adapt and thrive in conditions with reduced sunlight, a factor crucial for photosynthesis and overall plant health. The assessment focused on key growth indicators such as height, leaf density, and overall vitality under varying degrees of shade. The objective was to identify species that exhibit resilience and robust growth in shaded conditions, which is essential for effective forest management, especially in densely wooded areas or in urban settings where light availability is often limited. The findings from this study are expected to provide valuable insights for ecological conservation, landscaping, and urban forestry, where the selection of appropriate species for shaded areas is critical.

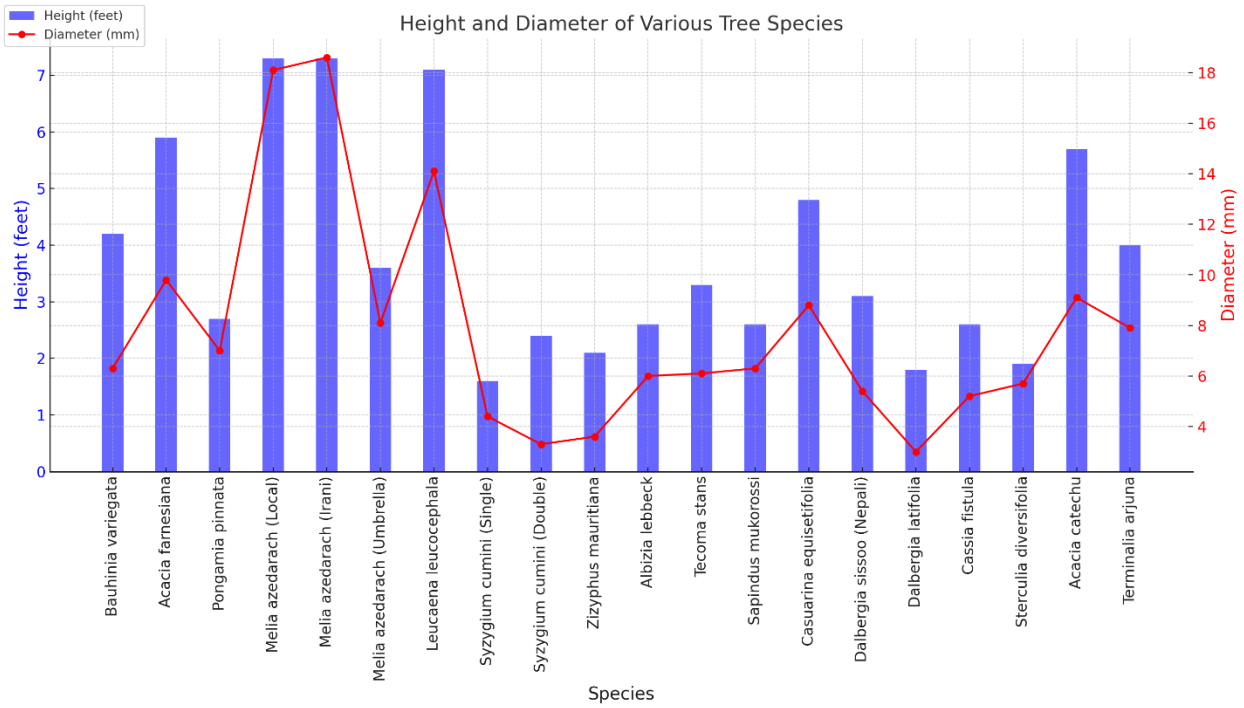


Figure 2 Illustrates the heights and diameters of various tree species. The blue bars represent the height of each species in feet, and the red line with markers represents the diameter in millimeters. Each species is labeled along the x-axis.

The data shows a general trend where species with greater height also tend to have larger diameters, with *Melia azedarach* (both Local and Irani) being the tallest and having the largest diameters. Some species like *Syzygium cumini* (Single) and *Dalbergia latifolia* are among the shortest with correspondingly smaller diameters.

1.4 Application of Nitrogen and Phosphorus Fertilizer during the nursery stage for Five Hybrid Poplar Clones.

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2023
Source of Funding:	Improving the efficiency of Forestry Management through the development of volume tables, yield tables and growth models for coniferous forest of Khyber Pakhtunkhwa.
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad Research Officer (Farm Forestry), Salman Ahmad Research Officer (Farm Forestry), Saif Ullah Khan Research Officer (Farm Forestry) Mr. Qayyum Khattak, FR (Silva).
Design:	Randomized Complete Block
Total area:	0.5 acres
Spacing:	2′ X 1′
No. of clones:	05
No. of replications:	02

Farmers have raised concerns regarding the suboptimal quality of hybrid poplar seedlings at the time of planting. In response to these observations, an experiment was conducted to explore the impact of artificial supplementation on these clones during the nursery stage. The experiment focused on enhancing the development and health of five distinct hybrid poplar clones by applying tailored nitrogen and phosphorus fertilizers. This approach aimed to address the specific nutritional deficiencies that might be contributing to the reported inadequacies in seedling quality. By adjusting the nutrient profile and application schedule, the study sought to improve root strength, foliage density, and overall plant vigor, thereby producing more robust and healthier seedlings that meet the expectations and requirements of the farmers for successful planting and growth.

In 2023, an experiment was conducted at the Silviculture Research Garden of the PFI to evaluate the effects of application of nitrogen and phosphorus fertilizers on the growth performance of 05 poplar clones. The treatments tested included in two replications:

1. Control
2. Nitrogen
3. Phosphorus

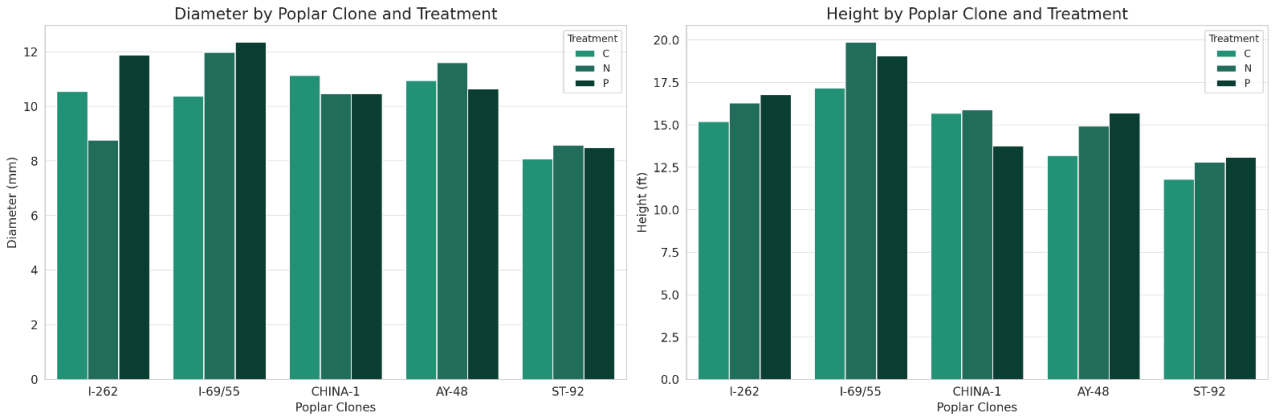


Figure 3 displays the diameter (in mm) of the poplar trees, broken down by clone and treatment type. Each poplar clone is represented on the x-axis, and the different colors within each bar denote the different treatments.

Table 1 ANOVA results of five different clones with application of fertilization

Source	DF	Sum of Squares	Mean Square	F Value	P Value
Poplar Clones	4	35.62037	8.905093	42.2413	<0.00001
Treatment	2	14.20941	1.776176	8.42529	0.000237
Poplar Clones*Treatment	2	1.79763	0.898815	4.263528	0.034192

The ANOVA results (Table 1) show that both the type of poplar clone and the treatment applied significantly affect the diameter of the trees. Furthermore, there's a significant interaction between clone type and treatment, indicating that different clones respond to treatments in varied ways. The clone factor had the most substantial effect on the diameter, followed by the interaction between clone and treatment.

1.5 Comparative assessment of growth performance of local and Nepali Shisham; local and Irani Bakain and other species.

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2023
Source of Funding :	Improving the efficiency of Forestry Management through the development of volume tables, yield tables and growth models for coniferous forest of Khyber Pakhtunkhwa
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad Research Officer (Farm Forestry), Salman Ahmad Research Officer (Farm Forestry), Saif Ullah Khan Research Officer (Farm Forestry) Mr. Qayyum Khattak, FR (Silva).
Design:	Randomized Complete Block
Total area:	1 acre
Spacing:	10′ X 6′
No. of replications:	02

In light of the increasing demand for trees suitable for medium density fiber production, a comparative study was undertaken to assess not only the growth performance of local and Nepali Shisham, local and Iranian Bakain, but also other species in terms of their potential biomass. This comprehensive evaluation focused on various growth parameters such as height, girth, and overall health, with a special emphasis on estimating the biomass yield of each species. The study aimed to determine which species can provide the most efficient and sustainable source of raw material for medium density fiber, considering the current market demands. By analyzing the biomass potential alongside the traditional growth metrics, this research seeks to inform forestry management and commercial planting decisions, ensuring that the selected species meet both ecological and industrial needs effectively.

This activity is under progress and the data collected in near future will be provided in the next progress report of Forestry Research Division.

1.6 Comparative Assessment of Biomass Yield in Different Hybrid Olive Varieties at Agroforestry models.

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2023
Source of Funding :	Improving the efficiency of Forestry Management through the development of volume tables, yield tables and growth models for coniferous forest of Khyber Pakhtunkwa
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad Research Officer (Farm Forestry), Salman Ahmad Research Officer (Farm Forestry), Saif Ullah Khan Research Officer (Farm Forestry) Mr. Qayyum Khattak, FR (Silva).
Design:	Randomized Complete Block
Total area:	0.79 acres
Spacing:	18′ X 18′
No. of replications:	02

The exploration into biomass yield of various hybrid olive varieties has unveiled groundbreaking insights into agricultural practices. This comprehensive analysis contrasts the productivity of different hybrids, taking into account factors such as growth rate, fruit yield, and overall biomass generation. Key findings suggest that genetic diversity among these hybrids significantly influences their performance. Factors like climate adaptability, disease resistance, and nutrient absorption efficiency play a pivotal role in determining the biomass output. Such research is pivotal for the agricultural sector, offering data-driven guidance for selecting the most efficient olive varieties. This not only aids in maximizing yield but also ensures sustainable and economically viable farming practices.

This activity is under progress and the data collected in near future will be provided in the next progress report of Forestry Research Division.

1.7 Assessment of different agroforestry models using different tree species and agricultural crops.

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2023
Source of Funding:	Improving the efficiency of Forestry Management through the development of volume tables, yield tables and growth models for coniferous forest of Khyber Pakhtunkwa
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Prinicpal Investigators:	Basheer Ahmad Research Officer (Farm Forestry), Salman Ahmad Research Officer (Farm Forestry), Saifullah Khan Research Offcier (Farm Forestry), Mr. Qayyum Khattak, FR(Silva)
Design:	Randomized Complete Block
Total area:	1.3 acres
Spacing:	18′ X 18′
No. of replications:	02

In the realm of applied forestry, a groundbreaking comparative assessment of biomass yield in different tree species within agroforestry models has garnered attention. This study delves into how varying tree species contribute to biomass production, a vital component in maximizing land use efficiency and environmental stewardship. Emphasizing the farmers' intention to utilize every inch of their land, the research explores the growth dynamics, leaf litter contribution, and overall biomass accumulation of these species in practical agroforestry settings. The results demonstrate that some trees, due to their rapid growth and substantial leaf fall, significantly enhance soil fertility and biomass yield. This knowledge is pivotal in applied forestry, guiding farmers in selecting tree species that not only optimize land use but also contribute to sustainable agricultural practices and ecological balance. This approach aligns with the dual objectives of environmental sustainability and maximizing agricultural output, crucial for farmers looking to make the most of their land resources.

This activity is under progress and the data collected in near future will be provided in the next progress report of Forestry Research Division.

1.8 Comparative assessment of growth performance of different species of Acacia, Ipil Ipil, Siris and Shisham using Super Absorbent Polymers (SAP)

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2023
Source of Funding:	Improving the efficiency of Forestry Management through the development of volume tables, yield tables and growth models for coniferous forest of Khyber Pakhtunkhwa.
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad Research Officer (Farm Forestry), Salman Ahmad Research Officer (Farm Forestry), Saif Ullah Khan Research Officer (Farm Forestry) Mr. Qayyum Khattak, FR (Silva).
Design:	Randomized Complete Block
Total area:	0.79 acres
Spacing:	10′ X 6′
No. of replications:	02

In a novel approach within the field of environmental sustainability, researchers have embarked on a comparative study examining the growth performance of distinct species such as Acacia, Ipil-Ipil, Siris, and Shisham, all in the presence of Super Absorbent Polymers (SAP). This investigation aims to understand how SAP, known for its water-retaining properties, impacts the growth dynamics of these diverse tree species. Each species, with its unique physiological characteristics and growth requirements, responds differently to the presence of SAP in their soil environment. The study meticulously tracks parameters such as growth rate, and overall health and vigor of the plants. This research is pivotal in identifying which tree species benefit most from SAP use, thereby providing valuable insights for forestry management and sustainable agricultural practices. The findings have the potential to revolutionize planting strategies in arid and semi-arid

regions, where water conservation is crucial, and could significantly impact the success of reforestation and afforestation efforts.

This activity is under progress and the data collected in near future will be provided in the next progress report of Forestry Research Division.

1.9 Establishment of an arboretum of drought-resistant species

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2015
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad Research Officer (Farm Forestry), Salman Ahmaf Research Officer (Farm Forestry), Saif Ullah Khan Research Officer (Farm Forestry) 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 harsh 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.

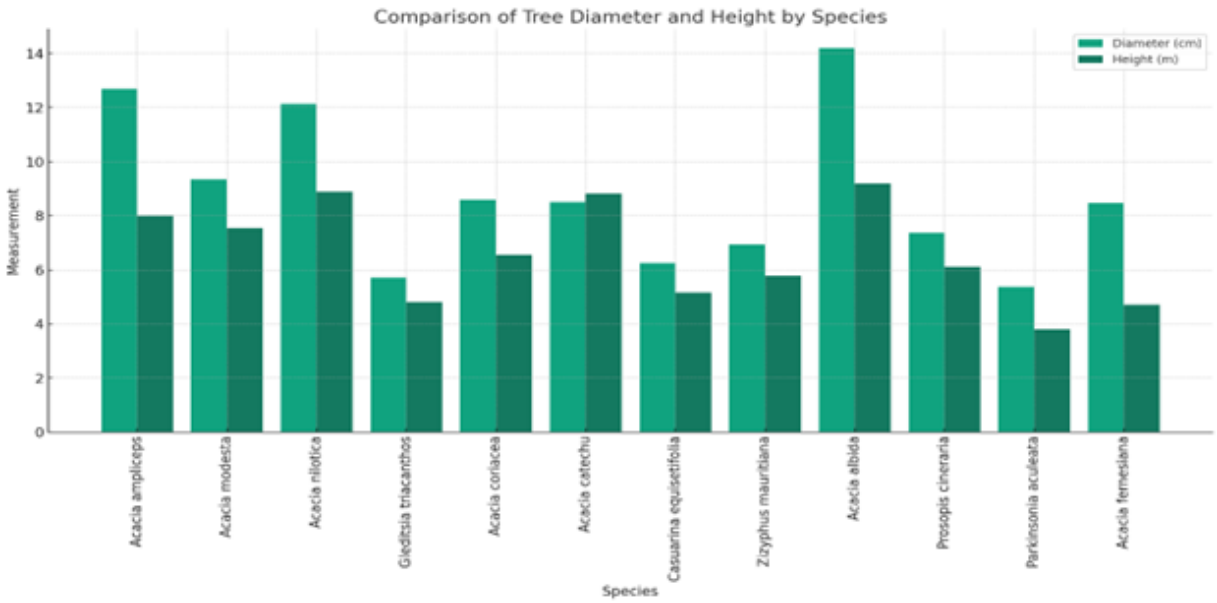


Figure 3 displays the diameters and heights of the different tree species. Each species has two bars; one represents the diameter in centimeters, and the other represents the height in meters.

The result illustrates the varying sizes of twelve tree species, with *Acacia albida* being the largest in both height and diameter, while *Gleditsia triacanthos* and *Parkinsonia aculeata* are among the smallest. Generally, there's a trend where species with larger diameters also have greater heights.

2.0. Maintenance of Nursery

Maintenance of a Bed and Tube Nursery is a regular activity of the Silviculture Branch where thousands of plants are raised from quality seed. These plants are used in different research trials of PFI and also provided to local farmers, educational institutions, NGOs and forest department on subsidized rates. The objective is to promote tree plantation culture in the society and propagate rare and endangered plant species of high quality in the country. The nursery also serves as a learning site for PFI students where they are practically involved in tube filling, punching, sowing, root pruning, shifting and other nursery activities.

50,000 tube plants and 15,000 Poplar cuttings were raised under the project titled" Improving the efficiency of forest management through the development of volume table, Yield tables and growth models for the coniferous forest of Khyber Pakhtunkhwa". Whereas, the target to be achieved is 100,000 tube plants. To overcome the whole target, 35,000 more plants will be raised in tube and through cuttings.

2. Mensuration Branch

Location:	Hazara and Malakand, Khyber Pakhtunkhwa
Year of commencement:	2023
Principal Investigator:	Dr. Anwar Ali (Director Forestry Research)
Co-Principal Investigators:	Sajid Ali (Assistant Silviculturist), Basheer Ahmad Research Officer (Farm Forestry), Salman Ahmad Research Officer (Farm Forestry), Saif Ullah Khan Research Officer (Farm Forestry) Mr. Faizan Ahmad (Research Officer).

The Forest Mensuration Branch's operational year unfolded with the following research-based activities under the project titled “Improving the Efficiency of Forest Management through Development of Volume Tables, Yield Tables, and Growth Models for Coniferous Forests of Khyber Pakhtunkhwa”.

2.1 Standardization of Forest Inventory Techniques

Different forest inventory techniques are being used by Forest Department for collection of data for preparation of management plans/working plans. These techniques include Relaskop sampling, prism sampling and fixed area sampling. A study was designed to compare the results of these techniques with data obtained from full enumeration in chirpine forests of Shinkiari. The details of this study are described below:

2.1.1 Full enumeration of Massar Compartment 8, Shinkiari

A field survey was conducted in Compartment No. 8 of Massar, Shinkiari, Siran Forest Division for the purpose of full enumeration. Data on diameters and heights of about 50,000 trees was collected. GIS maps of grid 300 mx 300 m, Map-marker and “Earth” digital applications were used for identification of compartment boundary and white colored spray was used for boundary demarcation. The whole area of the compartment was further divided into sub portions to avoid overlapping in measurements. Calipers and diameter tapes were used for taking trees diameter at breast height from uphill side, while Hypsometers were used for trees height, clinometers were used for slope gradients measurement and coordinates were taken by GPS.

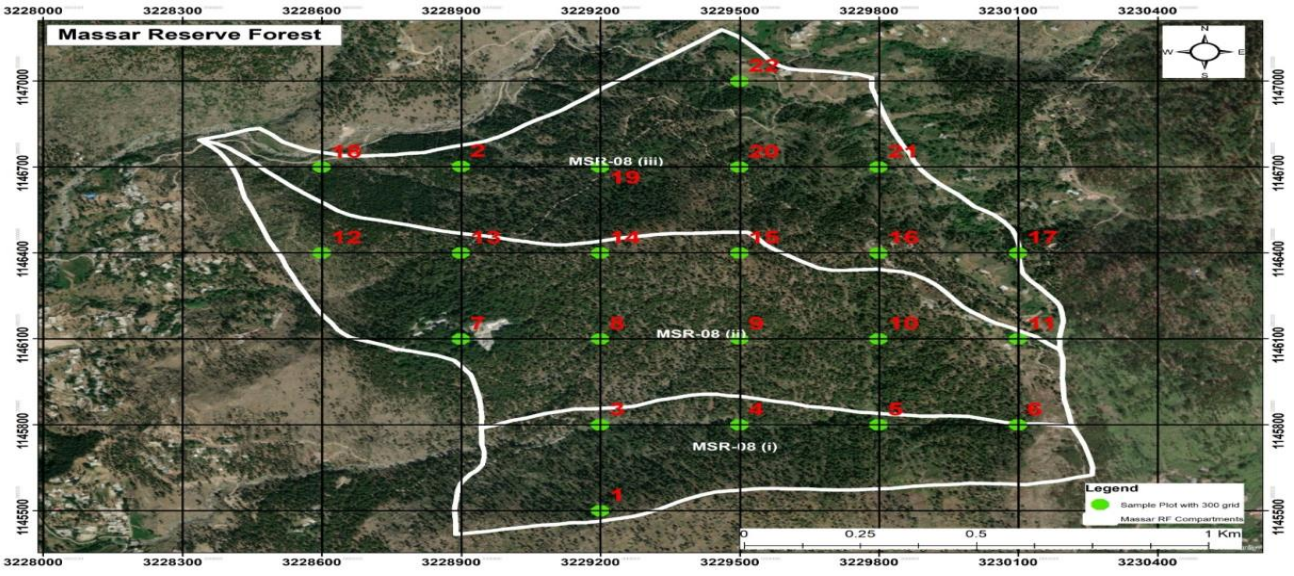


Fig 2: Map of Massar, Compartment 8



2.1.2 Relaskop Method

GPS was used for finding sample plot location on ground and data of “IN-trees” was collected using all four bands (Band-1, Band-2, Band-3, Band-4) of relaskope separately while trees height were taken by hypsometer.

2.1.3 Prism Method

Prisms of different basal area factors (M2, M4, M6, and M10) were used for data collection and comparison

2.1.4 Fixed Area Method

A fixed area plot of 17.84 m radius was used for data collection in the sample plots. Laser based vertex hypsometer was used for delineating boundaries of the sample plots. Data on DBH and height was recorded for all trees falling inside the sample plots.

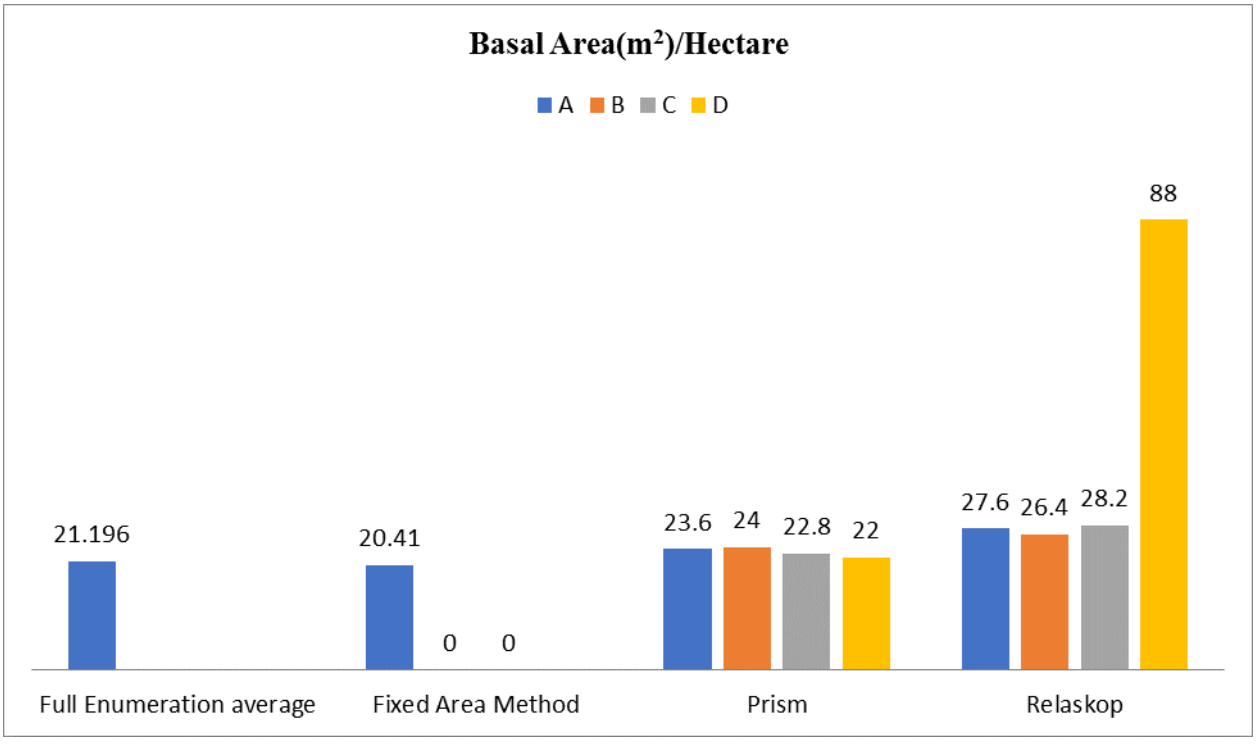

2.2 Data Analysis

When the data obtained through different inventory techniques were compared with the results of full enumeration, it was found that the fixed area method gives the most accurate result. The results obtained from prism sampling of different basal area factors are precisely significant with

each other, but slightly different than other methods. The results obtained from the first three bands of relaskop have no significant difference for the study area. The detail is given in Table 2.

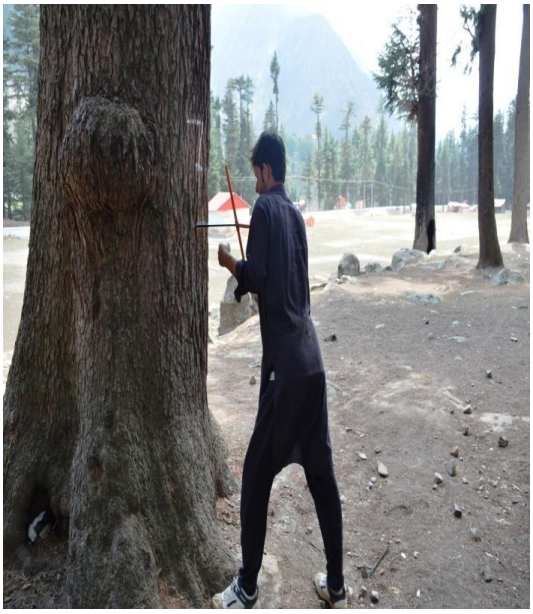
Method used		**Average Basal Area/Hectare**
Full enumeration		21.19 m^2
Partial enumeration		
Fixed area		20.41 m^2
Releskop	Band 1	27.6 m^2
	Band 2	26.4 m^2
	Band 3	28.2 m^2
	Band 4	88.0 m^2
Prism	M 2	23.6 m^2
	M 4	24.0 m^2
	M 6	22.8 m^2
	M 10	22.0 m^2
Chi-square test	$\chi 2 = 24.762$ **($\chi 2$, *df*=9)**	P = 0.001706

Table 2. Showing Average Basal area per hectare



2.3 Establishment of permanent sample plots for growth estimation in Kalam Forest Division

For development of Yield Tables and estimation of growth rates, 27 permanent sample plots were established in deodar, kail, fir, and spruce forests of Kalam. Data was collected on DBH, height, age, mean annual increment and current annual increment of trees in the sample plots.



2.4 Developed revised volume table of chirpine for Buner

It was reported by the KP Forest Department that the outturn of timber of chirpine trees is different from the estimates given in the volume tables of chirpine in Buner Forest Division. Therefore, field data was collected from sample trees in Buner Forest Divison and the Volume Table was revised. The revised volume table is given below:

Table 3: Revised Volume Table of Chirpine for Buner

Volume: Over bark

Dia (inch)	Height (ft)	Timber_cft	Small Wood_cft	Total Vol_cft
4	10	0	1	1
5	12	0	1	2
6	21	0	2	3
7	28	0	4	4
8	35	3	3	6
9	41	6	3	9
10	46	9	2	12
11	50	13	2	15
12	55	17	2	19
13	59	21	2	23
14	62	26	2	28
15	66	31	3	33
16	69	36	3	39

17	72	41	4	46
18	75	47	5	52
19	77	53	7	60
20	80	60	8	68
21	82	67	10	76
22	84	74	11	85
23	87	81	13	95
24	89	89	16	105
25	91	98	18	116
26	93	106	21	127
27	94	115	23	139
28	96	125	26	151
29	98	135	29	164
30	100	145	33	178
31	101	155	36	192
32	103	166	40	206
33	104	178	44	222
34	106	190	48	238
35	107	202	52	254
36	108	215	57	271
37	110	228	62	289
38	111	241	67	308
39	112	255	72	327
40	114	269	77	346

Derived from Equations

Height (m) = 14.945ln(D) - 34.174

Timber (m^3) = -0.42398+0.02162*D+0.000017*D^2*H

Total Volume (m^3) = EXP(-9.31377+0.63482*LN(H)+2.02949*LN(D))

Small Wood (m^3) = Total Volume – Timber

3. Watershed Management Branch

3.1 Compilation of Metrological Data Recorded at Watershed Observatery Pakistan Forest Institute, Peshawar.

Location	Pakistan Forest Institute
Date of commencement	July 2022-June 2023
Principal Investigator	Bilal Ahmed WMS
	Muhammad Iqbal, Field Assistant

- Collection of meteorological data including maximum, minimum & daily temperatures, relative humidity, evaporation, sunshine duration, and rainfall at PFI, observatory on daily basis from July 2022 to June 2023.
- Compilation of meteorological data including maximum, minimum & daily temperatures, relative humidity, evaporation, sunshine duration and rainfall on daily basis during from July 2022 to June 2023.

3.1 Technical Reports

- A technical report on “Rain water harvesting techniques” was written and submitted by the Watershed management specialist.
- A technical report on “Socio Economic and Environmental Impacts of Eucalyptus” was written and submitted by the Research officer (Watershed Sociology).

3.2 Research Papers/ Review Papers

- A review paper on Dry land afforestation in Pakistan was written and submitted by the Watershed management specialist.
- A review article on “Significance of cultivating genus Paulownia and its utilization in different sectors” was written and submitted by the Forest Ranger (Watershed).
- A review article on “Potential of Poplar (*Populus deltoides*) based agroforestry for economic benefits and climate change mitigation” was written and submitted by the Forest Ranger (watershed).

3.3 Concept Papers

- A project concept titled “Climate Change Mitigation in Different Region of Khyber Pakhtunkhwa, Pakistan” was prepared and submitted by the Research Officer (watershed Sociology).

Table 4. Summary of metrological data 2022-23

Month	Maximum Temperature (C°)	Minimum Temperature (C°)	Daily Temp. (C°)	Relative Humidity (%)	Evaporation (mm)	Sunshine (hrs.)	Rainfall (mm)
July	38.56	25.93	31.81	76.00	69.93	6.40	0.00
August	36.70	25.23	27.70	74.17	59.88	4.50	8.80
September	35.70	20.75	26.95	77.00	67.45	5.20	0.00
October	31.90	14.61	20.47	66.42	58.29	4.05	0.00
November	24.52	8.00	15.00	72.66	57.07	6.15	35.00
December	22.41	3.58	9.52	69.00	71.17	4.07	0.00
January	15.40	3.86	8.31	66.31	70.32	5.22	81.00
February	22.60	6.50	12.55	61.70	4.06	6.39	84.25
March	27.54	11.31	16.68	64.86	61.37	6.64	30.00
April	29.88	13.70	18.94	64.11	47.70	6.58	22.00
May	35.72	16.95	25.27	70.90	17.82	5.53	0.00
June	39.00	23.15	26.47	61.31	30.21	8.36	15.00
Average for the whole year	29.99	14.46	19.97	68.70	51.27	5.76	23.00

4.GIS & RS Branch

4.1. Mapping Digitization, Value Addition & Marketing of NTFP in Collaboration with NTFP Directorate Forest Department

Title of Project:	"Mapping Digitization, Value Addition & Marketing of NTFP in Collaboration with NTFP Directorate Forest Department"
Date of Commencement:	2019
Investigators / Co-Investigator	Aamir Shakeel (GIS Specialist), Naz Ul Amin (Technical Assistant GIS), Noman Khan (Assistant Computer Programmer)

Activity No.1

Field tour to district Kohat and Karak for monitoring and evaluation of NTFP sites under the project "Mapping, Digitization, Value Addition and Marketing of NTFP in collaboration with NTFP Directorate, Forest Department

From	17-09-2022 to 22-09-2022
Area Visited	District Karak, Kohat
Visiting Officer	Ziad Raza, Technical Assistant GIS, PFI Tahir Iqbal, Technical Assistant GIS, PFI

Visit to NTFP sites in District Kohat and Karak for monitoring and validation of NTFP sites previously visited by field staff.

Views of Field Verification & Monitoring of NTFP

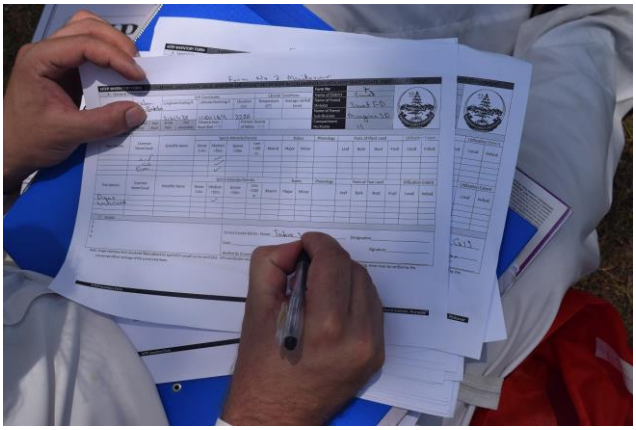
Activity No. 2:

Field tour to district Swat for monitoring and evaluation of NTFP sites

From 07-06-2022 to 15-06-2022

Area Visited	District Swat
Visiting Officer	Ziad Raza, Technical Assistant GIS, PFI
	Tahir Iqbal, Technical Assistant GIS, PFI

Visit to NTFP sites in District Swat for monitoring and validation of NTFP sites previously visited by field staff.




Views of Field Verification & Monitoring of NTFP

4.2 Development of National Action Plan for Forest & Landscape Restoration in Pakistan

Title of the Study/Project:	Development of National Action Plan for Forest and Landscape Restoration in Pakistan
Date of Commencement:	2023
Investigators / Co-Investigator:	Aamir Shakeel (GIS Specialist), Tahir Iqbal (Technical Assistant), Ziad Raza (Technical Assistant)

Activity No. 1

Field visit to the federating units of the country for the consultative meetings regarding the mapping of proposed sites for forest and landscape restoration. All provinces including

Area Visited	All Federating units of Pakistan

Visiting Officer	Aamir Shakeel GIS Specialist, PFI
	Ziad Raza, Technical Assistant GIS, PFI
	Tahir Iqbal, Technical Assistant GIS, PFI

Mapping of Potential Sites during Field Visit to Quetta, Balochistan

Mapping of Potential Sites during Field Visit to Uthal, Balochistan

Mapping of Potential Sites during Field Visit to Hyderabad , Sindh

Mapping of Potential Sites during Field Visit to Lahore , Punjab

Activity No.2:

Identification, demarcation and mapping of potential sites for forest and landscape restoration in all fedearating units of the country including Azad Jammu & Kashmir and Gilgit Baltistan

The following areas were identified and mapped for forest and landscape restoration during the field visit by the GIS team of PFI

Province/Region	**Potential Areas for FLR**	**Size (hectare)**	**Estimated Cost (million USD)**
Khyber Pakhtunkhwa	Dry Temperate: i) Drosh, Chitral ii) Arandu, Chitral iii) Kandia Valley Upper Indus Kohistan iv) Seo Valley, Kohistan v) Barawal Valley (Upper Dir)		230.27

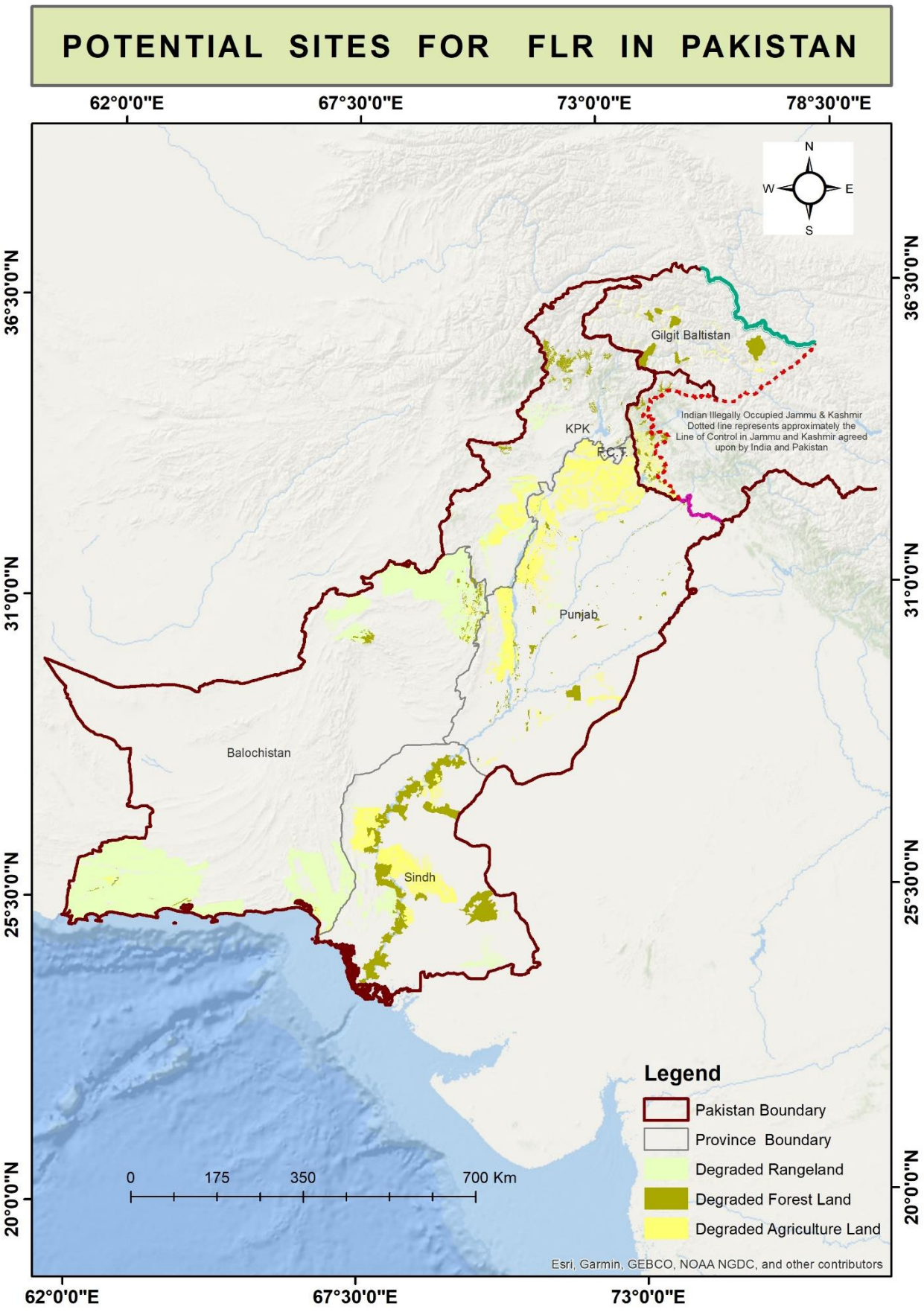
	vi) Dogdara, Dir Kohistan vii) Usho, Kalam viii) Utror, Kalam ix) Shawal Valley (North Waziristan) x) Para chamkani (Kurram Agency) Moist Temperate: i) Jabori Valley (Mansehra) ii) Karo Darra (Upper Dir) iii) Osorai Dara, Wari (Upper Dir) iv) Nehag Dara (Upper Dir) v) Jabori , Siran vi) Chail , Madyan Swat Sub-tropical Pine: i) Chagharzai Valley Buner ii) Jabri-satora (Sherwan, Mansehra) iii) Teerah Valley (Khyber) iv) Ghiljo Orakzai v) Shergarh , Mansehra vi) Paashto Valley,Allai,Batagram Sub-tropical Scrub: i) Gadoon Bir gali (Swabi) ii) Tank Kulachi (D.I. Khan) iii) Lawaghar Khwar (Karak)	1,076,102	
Balochistan	Mangrove: i) Kalmat, Pasni, Gawadar ii) Miani Hore, Lasbela iii) Gorchela, Pasni iv) Makola , Pasni v) Shadi kor, Turbat Musa Khel: i) Kingri, Barkhan ii) Drug iii) Wah Hassan Khel iv) Teri Sot v) Kingri vi) Musakhek Sad Chilghoza: i) Kapip, Sherani ii) Manikhwa, Sherani, iii) Danesar, Serani Juniper: i) Zandra, Ziarat	857,879	178.58

	ii) Kach, Ziarat iii) Kawas, Ziarat iv) Sadar Samalan, Sinjavi Ziarat v) Poi, Sinjavi Ziarat vi) Regorah, Sinjavi Ziarat		
Sindh	Riverine Forest: i)	3,246,232	818.63

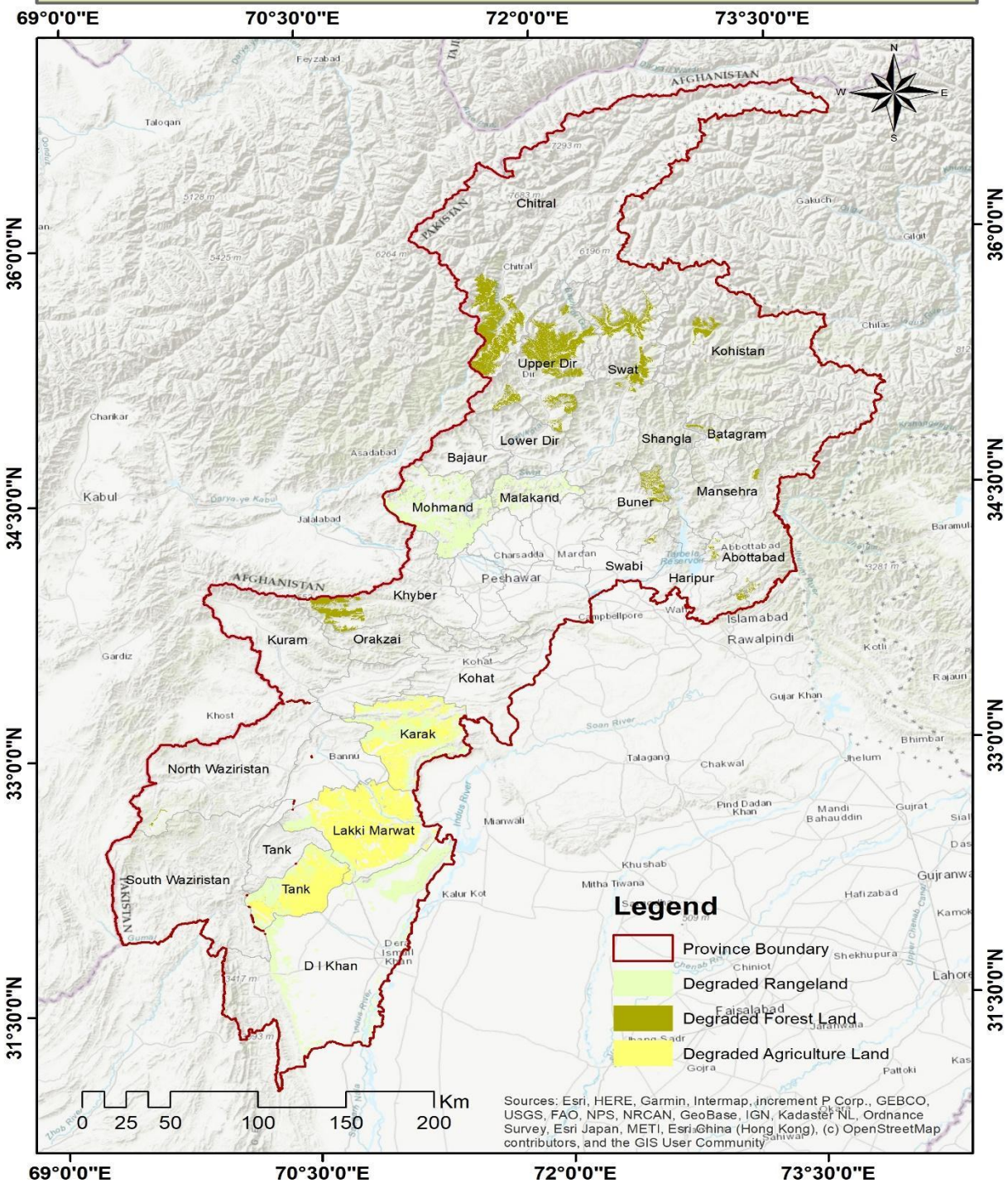
	ii) iii)		

	Range ecosystem: i) Karounjhar ii) Kohistan Region Khirthar		
Punjab	Desert: i) Cholistan ii) Thal Riverine Forest/ Belas: i) Irrigated Plantations ii) Potohar Plateau	3,168,063	618.07
Azad and Jammu Kashmir	i) Gureze Valley ii) Jagran Valley iii) Lachrat valley iv) Leepa valley v) Surgan valley vi) Kohala vii) Dhirkot viii) Banjosa ix) Tararkhel x) Goi kotli xi) Dudyal	385,806	90.49
Gilgit Baltistan	i) Samahni valley ii) Chaprot valley iii) Hudar valley iv) Hoshay valley v) Shagar Valley vi) Bagrot	504,225	140.79

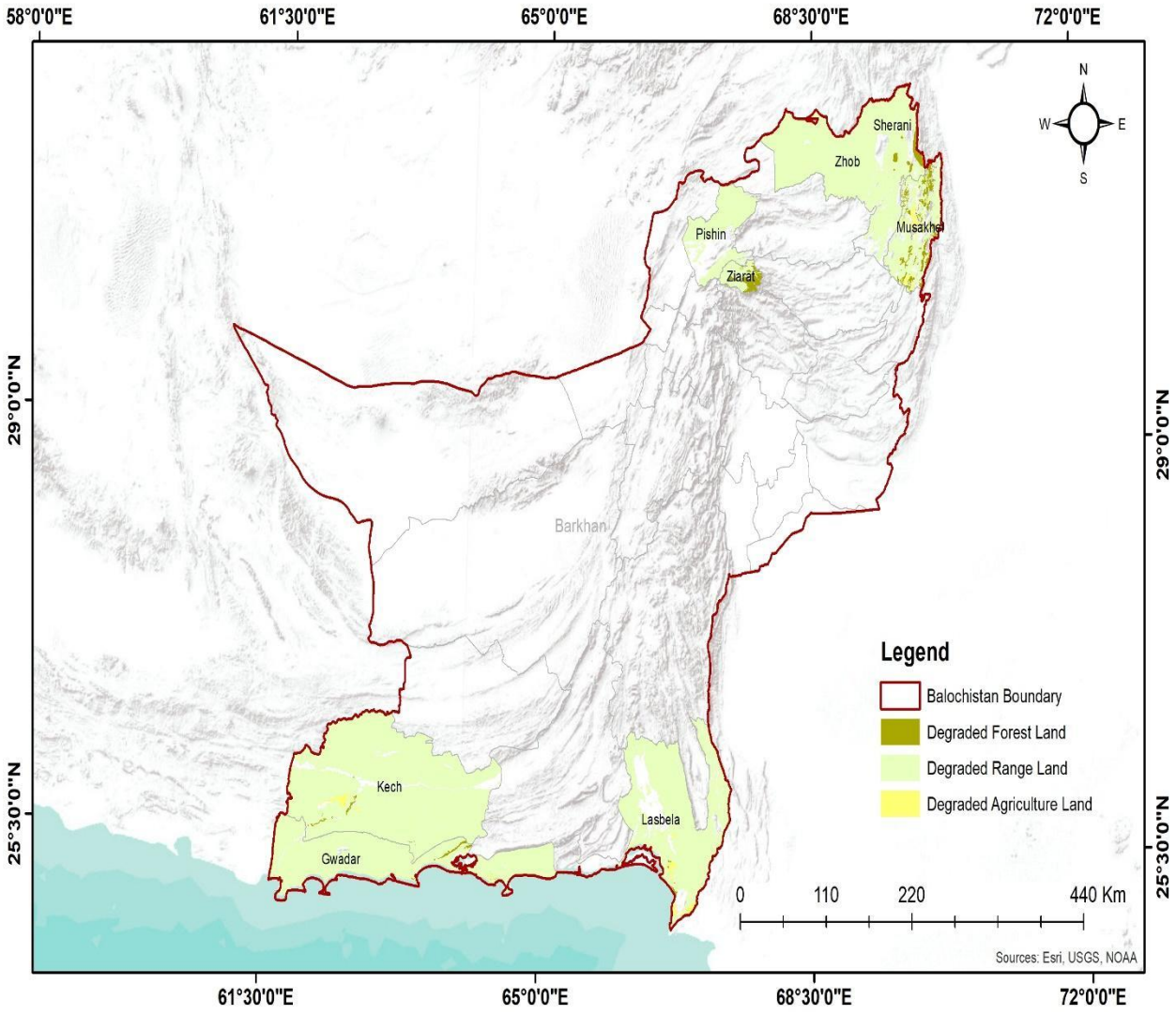
	vii) Fairy meadows viii) Rama ix) Sher Qila x) Thor		


POTENTIAL SITES FOR FLR IN PAKISTAN
62°0'0"E
67°30'0"E
73°0'0"E
78°30'0"E
36°30'0"N
31°0'0"N
25°30'0"N
20°0'0"N
N
W
E
S
Gilgit Baltistan
Indian Illegally Occupied Jammu & Kashmir
Dotted line represents approximately the
Line of Control in Jammu and Kashmir agreed
upon by India and Pakistan
KPK
F.C.T
Punjab
Balochistan
Sindh
0
175
350
700 Km
Legend
Pakistan Boundary
Province Boundary
Degraded Rangeland
Degraded Forest Land
Degraded Agriculture Land
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

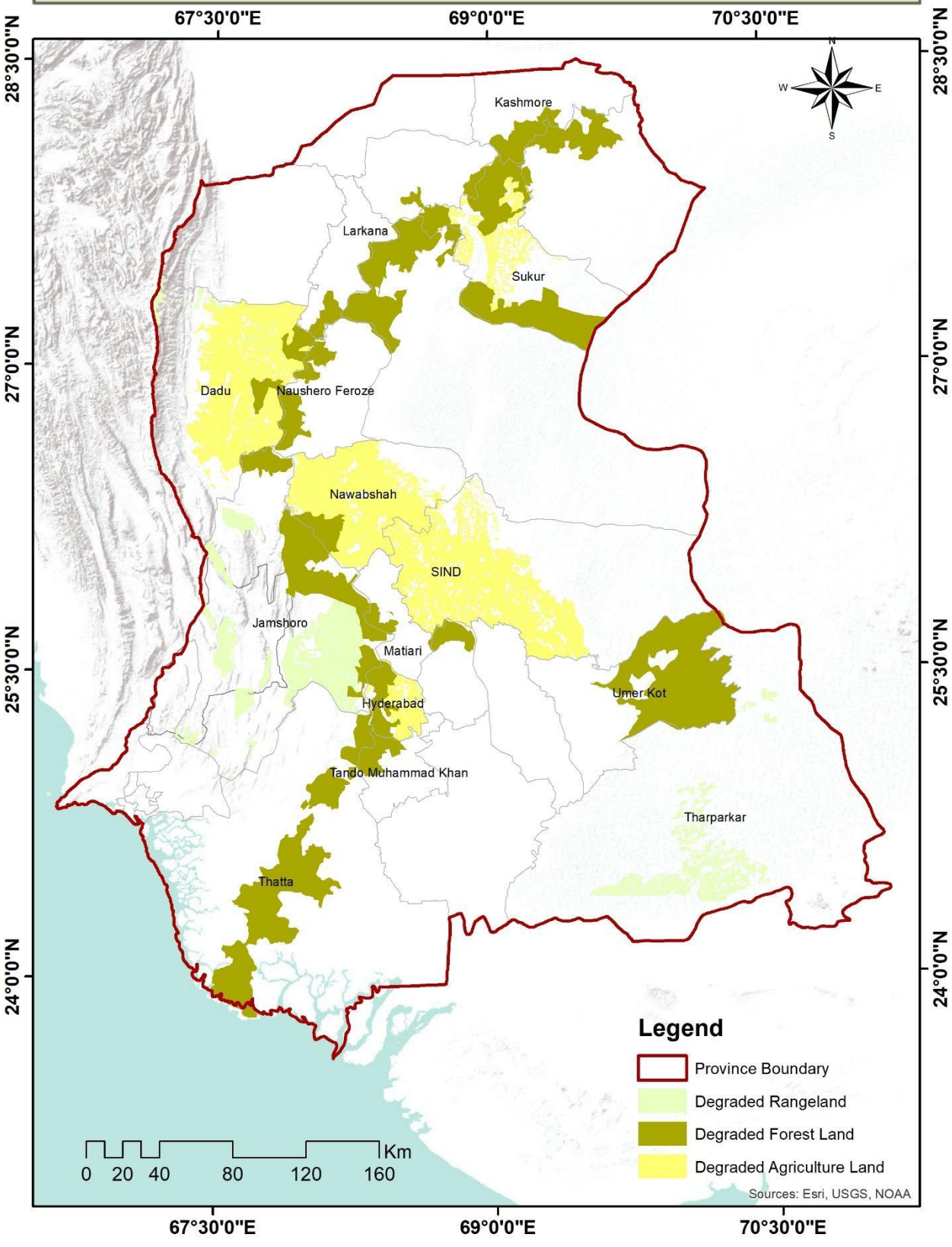
POTENTIAL SITES FOR FLR IN KHYBER PAKHTUNKHWA



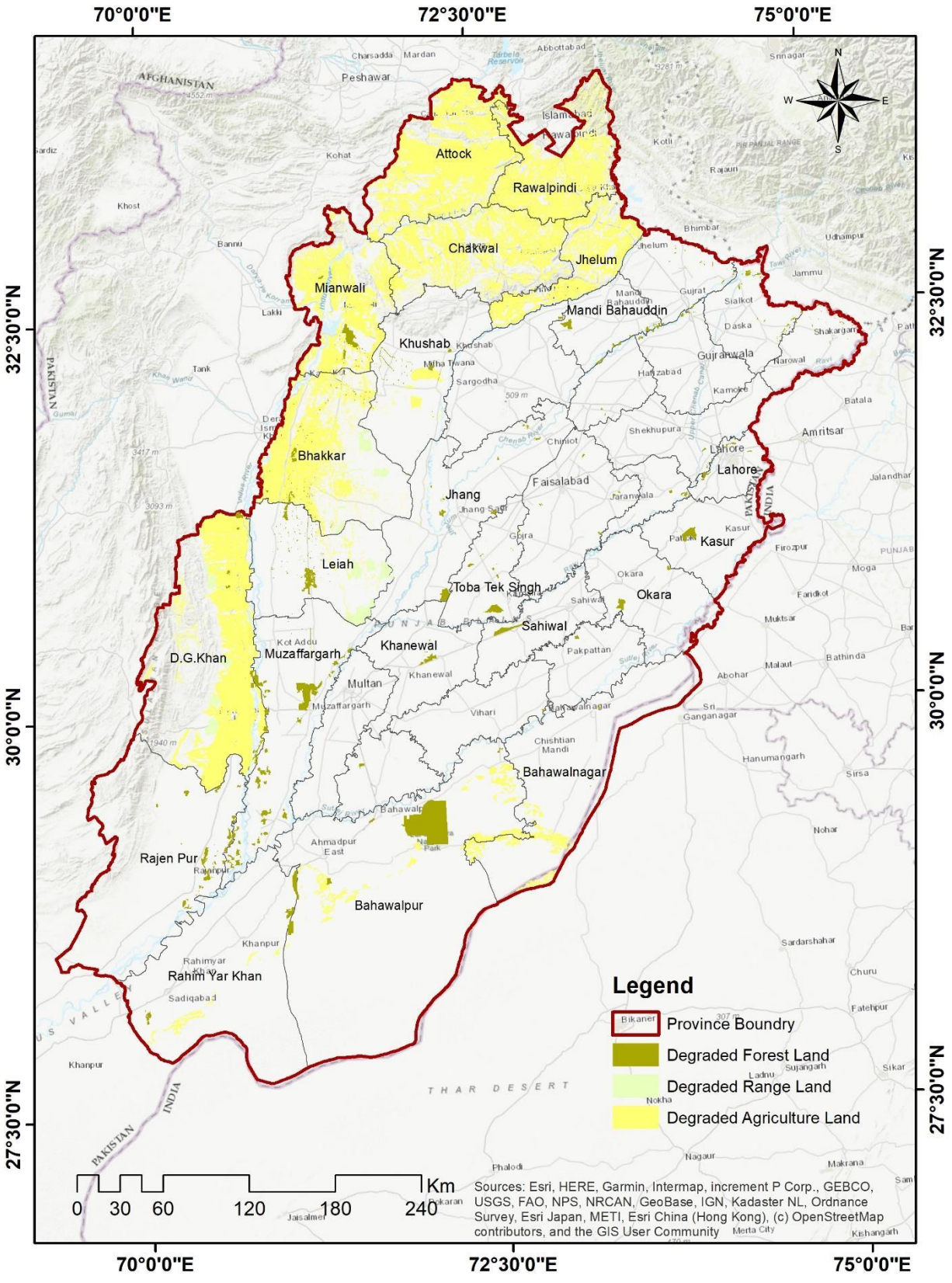
POTENTIAL SITES FOR FLR IN BALOCHISTAN



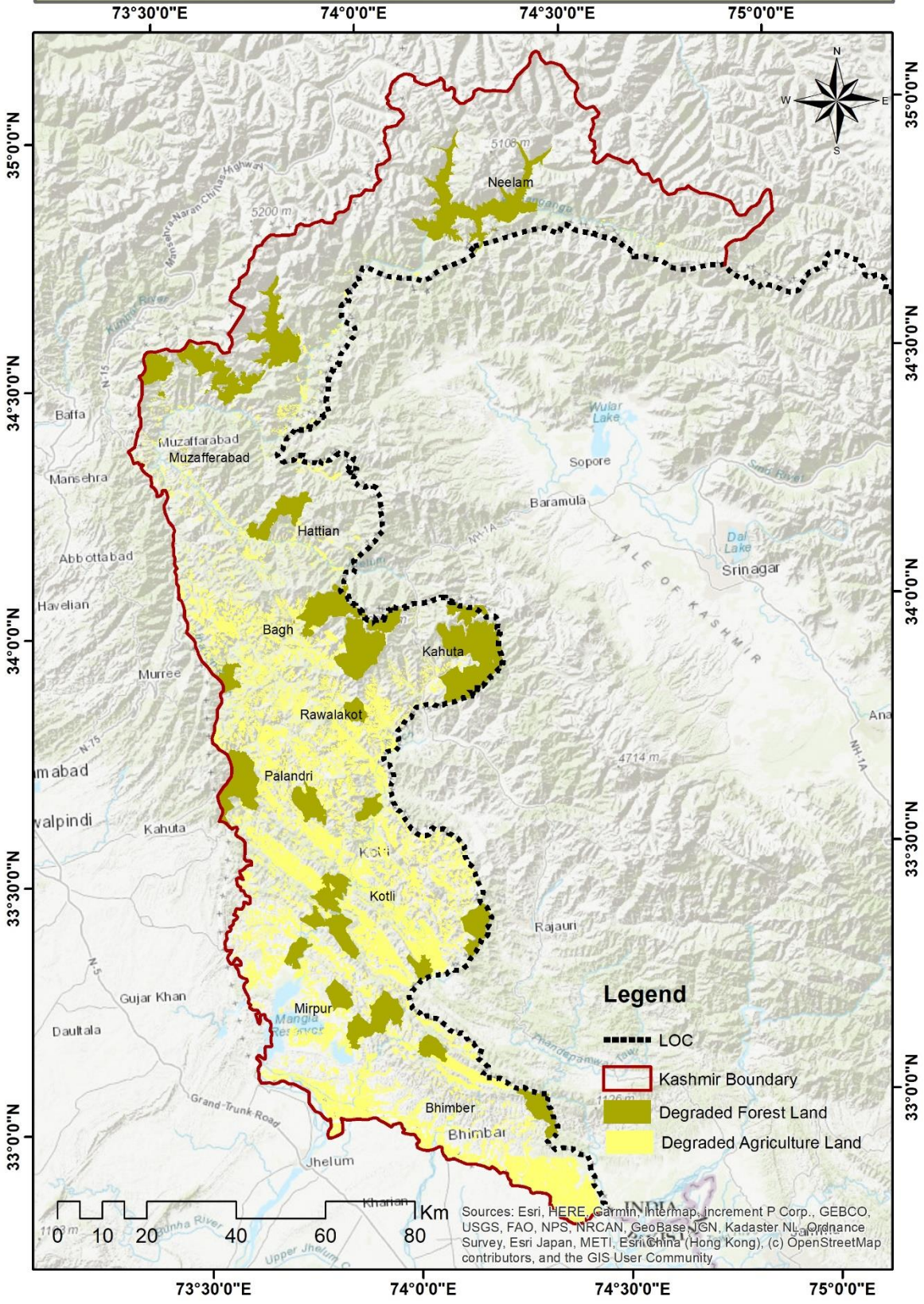
POTENTIAL SITES FOR FLR IN SINDH



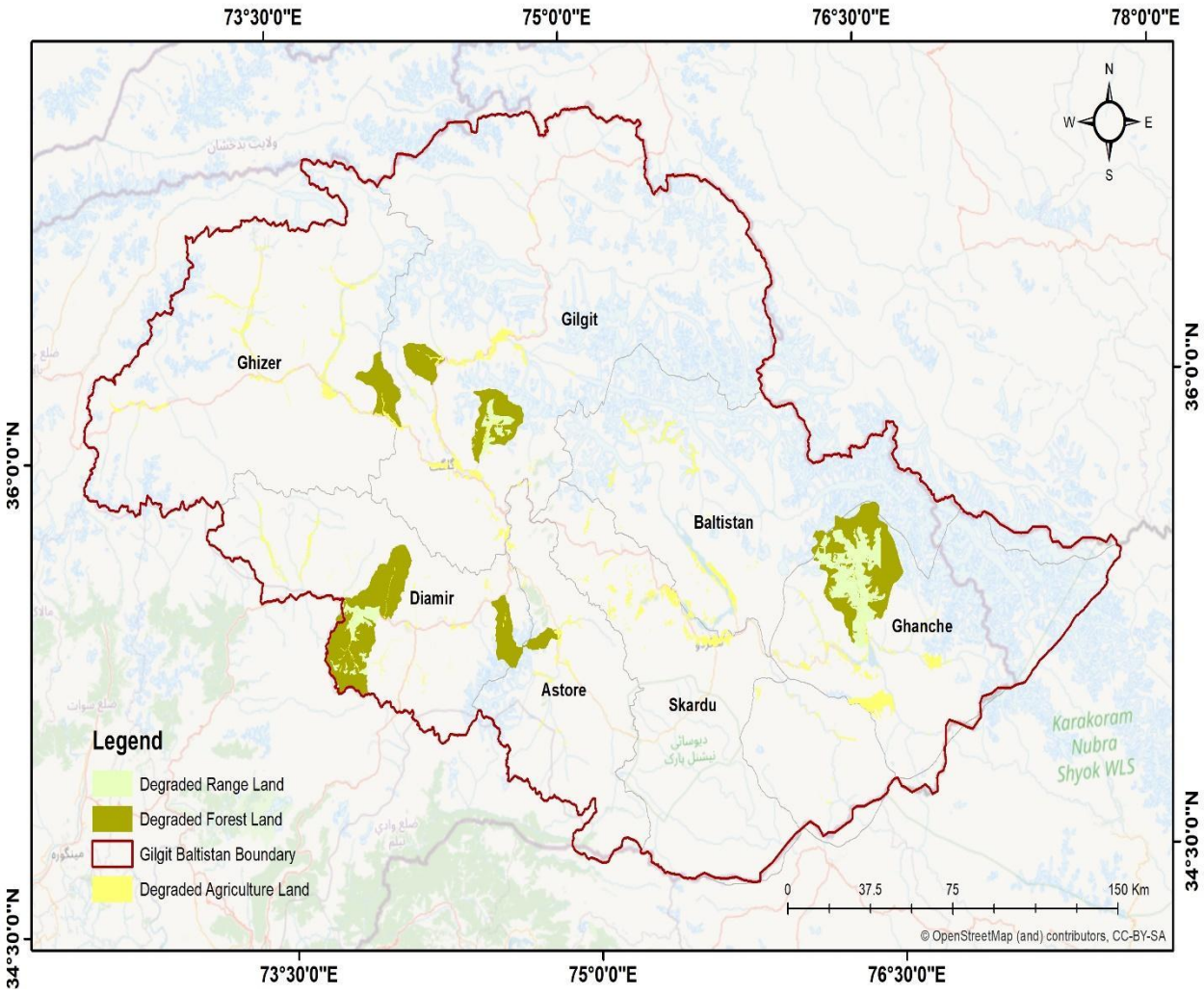
POTENTIAL SITES FOR FLR IN PUNJAB



Potential Sites for FLR in Azad Jammu & Kashmir



POTENTIAL SITES FOR FLR IN GILGIT BALTISTAN



Other tasks done in the GIS/RS branch during 2022-23

1. Audit and Inspection of Stocks and Stores in PFI
2. Commencement of classes for Specialization courses in GIS and remote sensing for 7th semester.
3. Taking regular classes in the subject of GIS/RS/GPS for the students of MSc, BSc and BS Forestry
4. Paper/Viva making and checking of the students of forestry
5. GPS data downloading received from the field teams of NTFP and other projects.
6. Technical assistance in the online meetings held in DG office and committee room
7. Procurement of different items required in the Institute.
8. Supervising student research work and related to GIS /RS and help them developing their maps.

Future Plans:

- Mapping, Digitizing, Geo-Spatial Data Base development of NTFPs under the project "Mapping Digitization, Value Addition and marketing of NTFP in Collaboration with NTFP Directorate Forest Department
- Providing technical support in the mapping activities of different projects in PFI
- Website maintenance and modification of website of NTFP.
- Supervising student research work related to GIS /RS and help them developing their maps.
- Raising the rest of 35,000 plants (Tube + Bare rooted) to achieve the target of 100,000 plants under the project Titled" Improving the efficiency of Forest Management through the development of Volume tables, Yield Tables and growth models for the coniferous forest of Khyber Pakhtunkhwa".
- Experiment of different Eucalyptus tree species in block plantation on 2 Acres of land in Silviculture Research Garden.
- Maintenance of current/under progress Research Trials and Nursery.

Miscellaneous

- Courses of Forest Management, Forest Mensuration, Energy Plantation and Bio fuels, Silviculture, Watershed Management, Forest research methods, Forest statistics, GIS & Remote Sensing taught to M.Sc, B.Sc. and BS Forestry classes.
- Supervising BS Forestry students in preparing their thesis.
- Co-supervised students and internees of The University of Peshawar and The University of Agriculture, Peshawar for their research works

2. FOREST PRODUCTS RESEARCH DIVISION

2.1 LOGGING BRANCH

2.1.1 Impact of Climate Change on Growth of Chilgoza Pine (*Pinus Gerardiana*) Growing in District Lower Chitral.

Year of commencement:	2022-23
Principal Investigator:	Dr. Tanvir Hussain, Logging Officer.
Co-Investigator:	Dr. Zahid Rauf, Director FPRD

Introduction

Chitral, nestled amidst the majestic Hindu Kush mountain range, boasts a diverse array of flora and fauna, with *Pinus gerardiana* being one of its iconic species. However, the region is not immune to the global phenomenon of climate change, which is altering the environmental conditions at an unprecedented rate. Rising temperatures, erratic precipitation patterns, and changing climatic extremes pose significant challenges to the ecological balance and sustainability of ecosystems. *Pinus gerardiana*, commonly known as the Chilgoza pine or the Gerard's pine, is a resilient and economically significant species native to the rugged terrains of the Chitral district in Pakistan. With its unique ecological niche and economic importance, understanding the impact of climate change on the growth patterns of *Pinus gerardiana* in this region is imperative. Understanding the vulnerabilities of *Pinus gerardiana* to climate change is crucial not only for the conservation of this iconic species but also for the livelihoods of local communities reliant on its economic value. The Chilgoza pine nuts harvested from *Pinus gerardiana* cones are a vital source of income and sustenance for many residents of Chitral, underscoring the socioeconomic significance intertwined with its ecological resilience.

This study aims to investigate the intricate relationship between climate change and the growth dynamics of Pinus gerardiana in Chitral. By examining historical climate data alongside comprehensive dendrochronological analyses of tree rings, we seek to elucidate how variations in temperature, precipitation, and other climatic factors influence the growth of this species growing under the dry temperate conditions of District lower Chitral.

Methodology

To conduct research work 20-30 cores were extracted from the healthy trees of study sites of District lower Chitral (table 1). 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. Ten 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 were 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 spline options in the program. For similar reason, the "Residual" chronologies from the output were selected for subsequent modeling.

Table 1: Sites characteristics of *Pinus gerardiana* at Chitral Gol National Park and Kalash valleys.

Site Name	**Latitude**	**Longitude**	**Aspect**	**Slope %**	**Elevation (m)**
Chitral Gol National Park	35.86	71.75	North	25-50	2316-2501
Rumbur Valley	35.78	71.63	North	35-65	2350-2666
Bumburet Valley	35.70	71.66	South	15-60	2402-2586

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.

Results and Discussion

a) Climate Change Scenario

It is evident from the climate diagram of Chitral Forest Division (Figure 1& table 2) that both the climatic parameters showed a significant increase for this regime (1921-2021). Regarding the annual mean temperature and precipitation, the month of July was found the hottest month with a maximum mean temperature of 17.80^{0}C along with mean rainfall of 38.50 mm while January was recorded as the coldest month with a minimum mean temperature of -6.38 ºC and mean monthly rainfall of 70.20 mm. The maximum total annual rainfall of 1101.70 mm was measured during 1965

with an annual mean temperature of 6.35 ºC. An increase of 0.97 ºC(r=0.49; p<0.001)and a significant increase of 91.14 mm in total annual precipitation were calculated for this studied period.

Table 2: Statistics of Climatic Factors in the Chitral Forest Division

Climatic Factors	p-Value	r-value	R^2-Value (%)	Significant (p<0.05)
Temperature	0.001	0.49	23.67	*
Precipitation	0.013	0.25	6.11	*

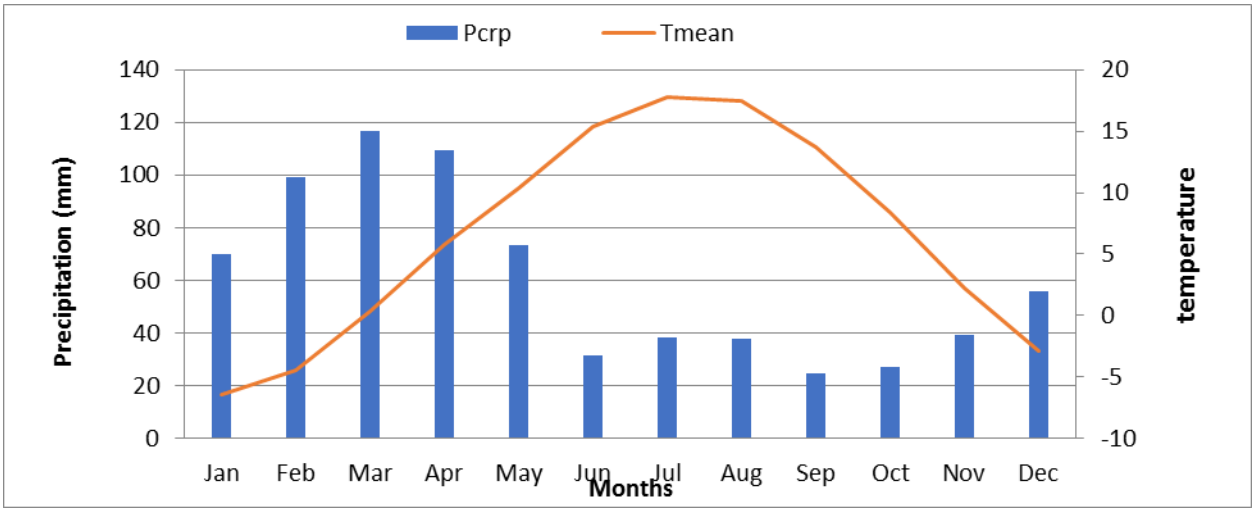
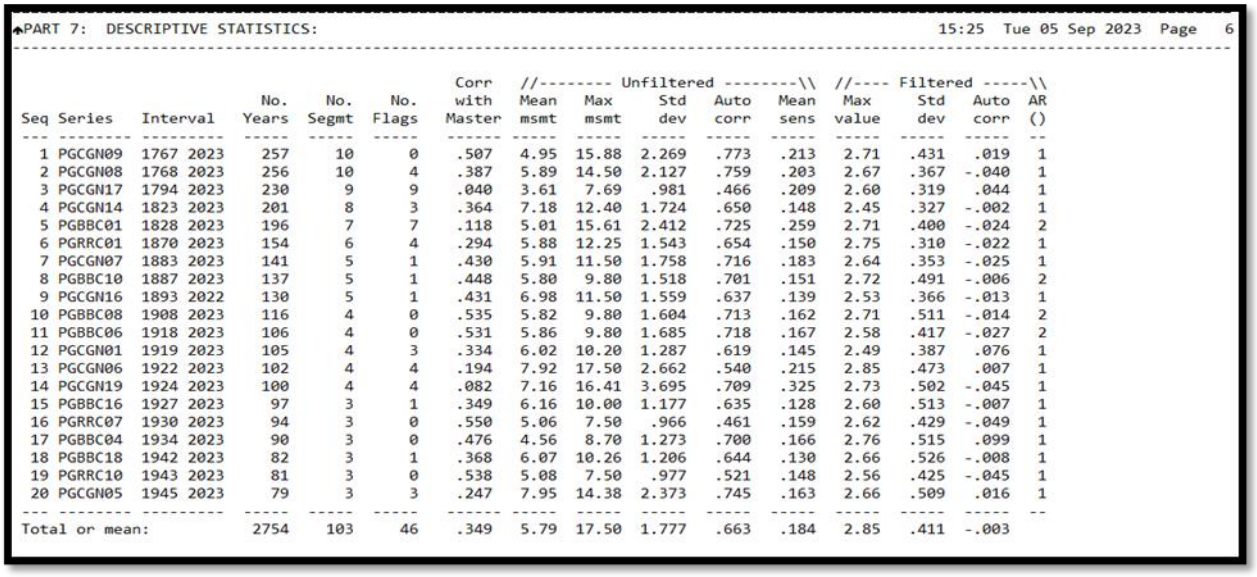


Figure 1: Monthly variation in mean annual Precipitation(Bar) and Tmean annual temperatute (line) in Chitral Forest Division, calculated for the period of 1921-2021.

b) Development of Tree Ring Chronology

Site tree ring width (TRW) of Chilghoza Pine was developed using Computer Based quality control Programs Cofecha and dplR of R package. The chronology spaned257 (1767-2023) years and was obtained up to an altitude of (2316-2666 meters) slopes (15-65 %) with northern facing of the Chitral Forest area of Bumburet , Rumbur and Chitral Gol National Park.

Table 3: Statistics of Quality control Program Cofecha for *Pinus gerardiana* from Chitral, Pakistan.



PART 7: DESCRIPTIVE STATISTICS: 15:25 Tue 05 Sep 2023 Page 6

Seq	Series	Interval	No. Years	No. Segmt	No. Flags	Corr with Master	Unfiltered Mean msmt	Unfiltered Max msmt	Unfiltered Std dev	Unfiltered Auto corr	Filtered Mean sens	Filtered Max value	Filtered Std dev	Filtered Auto corr	AR ()
1	PGCGN09	1767 2023	257	10	0	.507	4.95	15.88	2.269	.773	.213	2.71	.431	.019	1
2	PGCGN08	1768 2023	256	10	4	.387	5.89	14.50	2.127	.759	.203	2.67	.367	-.040	1
3	PGCGN17	1794 2023	230	9	9	.040	3.61	7.69	.981	.466	.209	2.60	.319	.044	1
4	PGCGN14	1823 2023	201	8	3	.364	7.18	12.40	1.724	.650	.148	2.45	.327	-.002	1
5	PGBBC01	1828 2023	196	7	7	.118	5.01	15.61	2.412	.725	.259	2.71	.400	-.024	2
6	PGRRC01	1870 2023	154	6	4	.294	5.88	12.25	1.543	.654	.150	2.75	.310	-.022	1
7	PGCGN07	1883 2023	141	5	1	.430	5.91	11.50	1.758	.716	.183	2.64	.353	-.025	1
8	PGBBC10	1887 2023	137	5	1	.448	5.80	9.80	1.518	.701	.151	2.72	.491	-.006	2
9	PGCGN16	1893 2022	130	5	1	.431	6.98	11.50	1.559	.637	.139	2.53	.366	-.013	1
10	PGBBC08	1908 2023	116	4	0	.535	5.82	9.80	1.604	.713	.162	2.71	.511	-.014	2
11	PGBBC06	1918 2023	106	4	0	.531	5.86	9.80	1.685	.718	.167	2.58	.417	-.027	2
12	PGCGN01	1919 2023	105	4	3	.334	6.02	10.20	1.287	.619	.145	2.49	.387	.076	1
13	PGCGN06	1922 2023	102	4	4	.194	7.92	17.50	2.662	.540	.215	2.85	.473	.007	1
14	PGCGN19	1924 2023	100	4	4	.082	7.16	16.41	3.695	.709	.325	2.73	.502	-.045	1
15	PGBBC16	1927 2023	97	3	1	.349	6.16	10.00	1.177	.635	.128	2.60	.513	-.007	1
16	PGRRC07	1930 2023	94	3	0	.550	5.06	7.50	.966	.461	.159	2.62	.429	-.049	1
17	PGBBC04	1934 2023	90	3	0	.476	4.56	8.70	1.273	.700	.166	2.76	.515	.099	1
18	PGBBC18	1942 2023	82	3	1	.368	6.07	10.26	1.206	.644	.130	2.66	.526	-.008	1
19	PGRRC10	1943 2023	81	3	0	.538	5.08	7.50	.977	.521	.148	2.56	.425	-.045	1
20	PGCGN05	1945 2023	79	3	3	.247	7.95	14.38	2.373	.745	.163	2.66	.509	.016	1
Total or mean:			2754	103	46	.349	5.79	17.50	1.777	.663	.184	2.85	.411	-.003	

According to statistical analysis of cofecha, the developed tree ring chronology of *Pinus gerardiana* showed a sophisticated value of all cores with master inter-series and the overall value of master chronology also fell in the acceptable range (showed a satisfactory correlation with master chronology. The mean measurement of all tree ring i.e 5.79. As for as the sensitivity of study site is concerned, the value of mean sensitivity (0.184) also satisfactory to study the climate-growth relationship. Regarding the previous effects of climatic factors on the growth of *Pinus gerardiana*, the value of auto-correlations showed no prominent range. The standard deviation value represented prominent variations in the growth pattern of this species.Figure 2 showed the standard chronology developed after detrending and standardization and spanned for the period 1967-2021 with sample depth and 99% confidential interval.

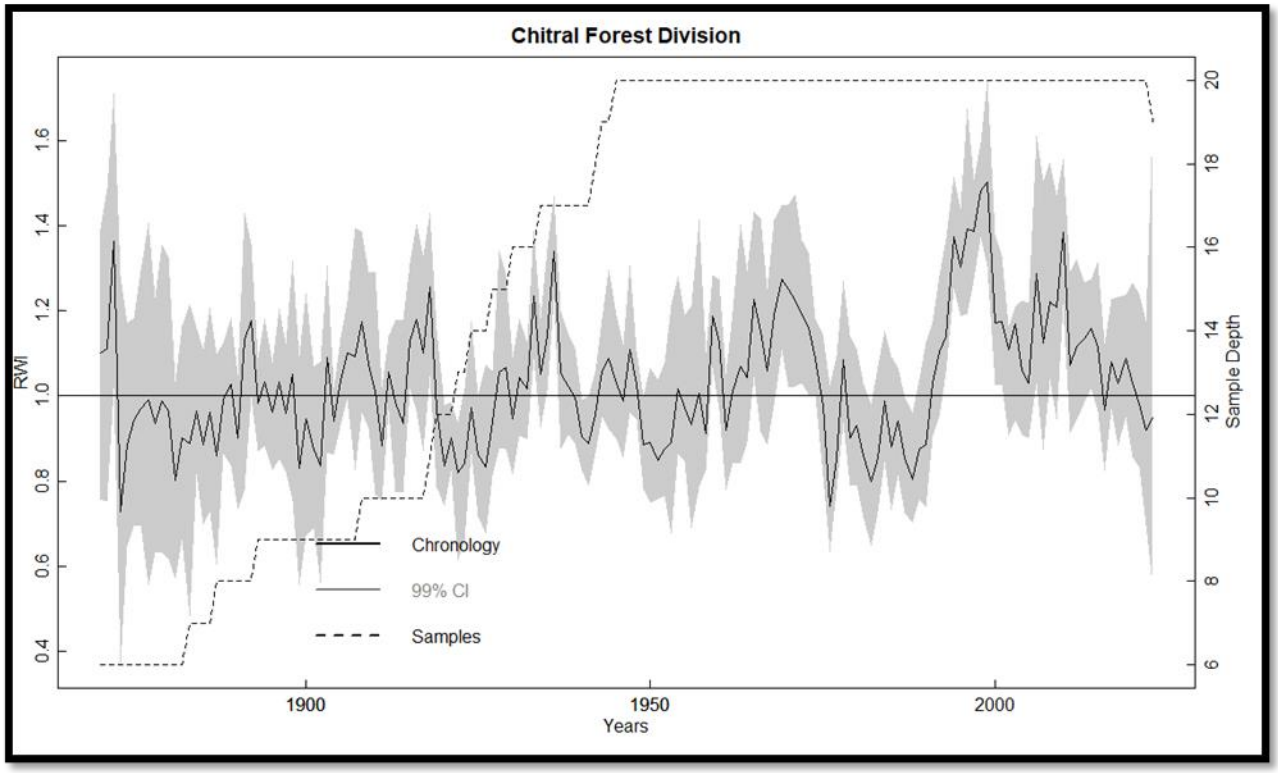


Figure 2: Tree Ring Width (TRW) chronology of *Pinus gerardiana* from Chitral Forest Division.

Climate-Growth Relationship

After detrending and standardization, TRW was converted to tree ring indices and as a result four chronologies were developed i.e. Raw, Residual, Standard and Arstan. To develop climate-growth model, residual chronology was used for climate-growth modelling. Growth response of *Pinus gerardiana* in the scenario of climate change during the period 1921-2021 was explored through Response Function Analysis (RFA).

Figure 4 represented the combine effect of annual mean temperature and the annual total precipitation prevailed during the period 1921-2021 on the growth of *Pinus gerardiana* growing in Chitral Forest area.It is evident from RF Analysis that precipitation during the month of July playing positive and significant role on the growth of this species. This explored that precipitation is acting as a limiting factor which mean that during the month of July, the high temperature help to melt the snow and the ultimate result is the availability of water. Under sufficient availability of soil water, tree species performed the process of photosynthesis in a very smooth way and the ultimate result is good growth. As for as the role of temperature is concerned, it was found that the higher temperature of June is negatively influencing the growth of this species under the prevailing climatic conditions of this study sites. Further, it was observed that itseffect throughout the current year as well as previous year was recorded as negative except during the months of August and October of the current year.

It is common observation that under dry temperate conditions, temperature acts as a limiting factor, but in this study, it was found that precipitation is acting as a limiting factor which is a clear-cut indication of effects of climate change in this area.

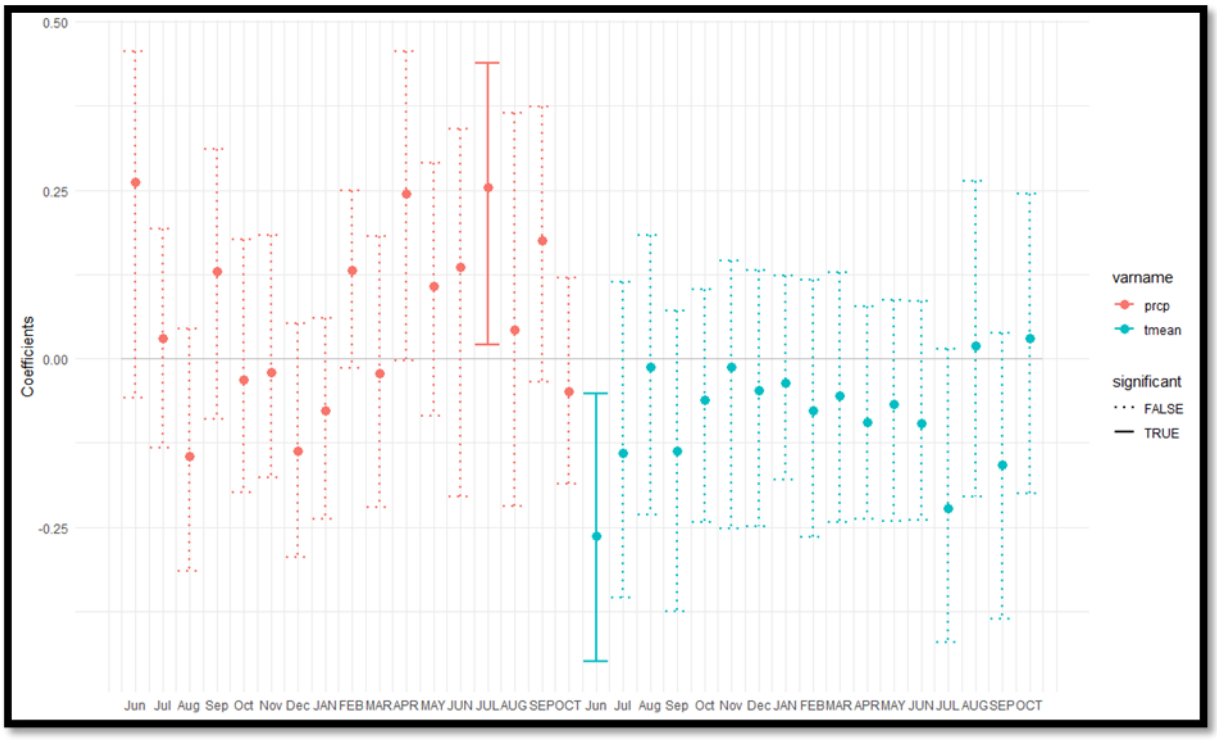


Figure 4: Bootstrapped Response Function analysis between TRW and Prcp and Tmeanfor the period 1921-2021. Responses were calculated from October of the previous year to October of the current growth year over the common period (1921-2021). Statistically significant relationships ($p<0.05$) are indicated by stick bar.

Growth Trend Analysis

To observe the increase or decrease in the growth of Chilgozapine for the studied period 1921-2021, Mann-Kendle Trend was conducted using minitab software-18. It was found that no prominent trend in growth happened under these prevailingclimatic conditions (Figure & Table).

Table 4: Growth Trend Analysis of Chilgoza pine at District Lower Chitral.

Name of Station	Tree ring Feature	Z-Value	p-Value (Upward)	p-Value (Downward)	Trend
DLC	Tree Ring width	0.715949	0.237011	0.762989	No Trend

DLC=District Lower Chitral

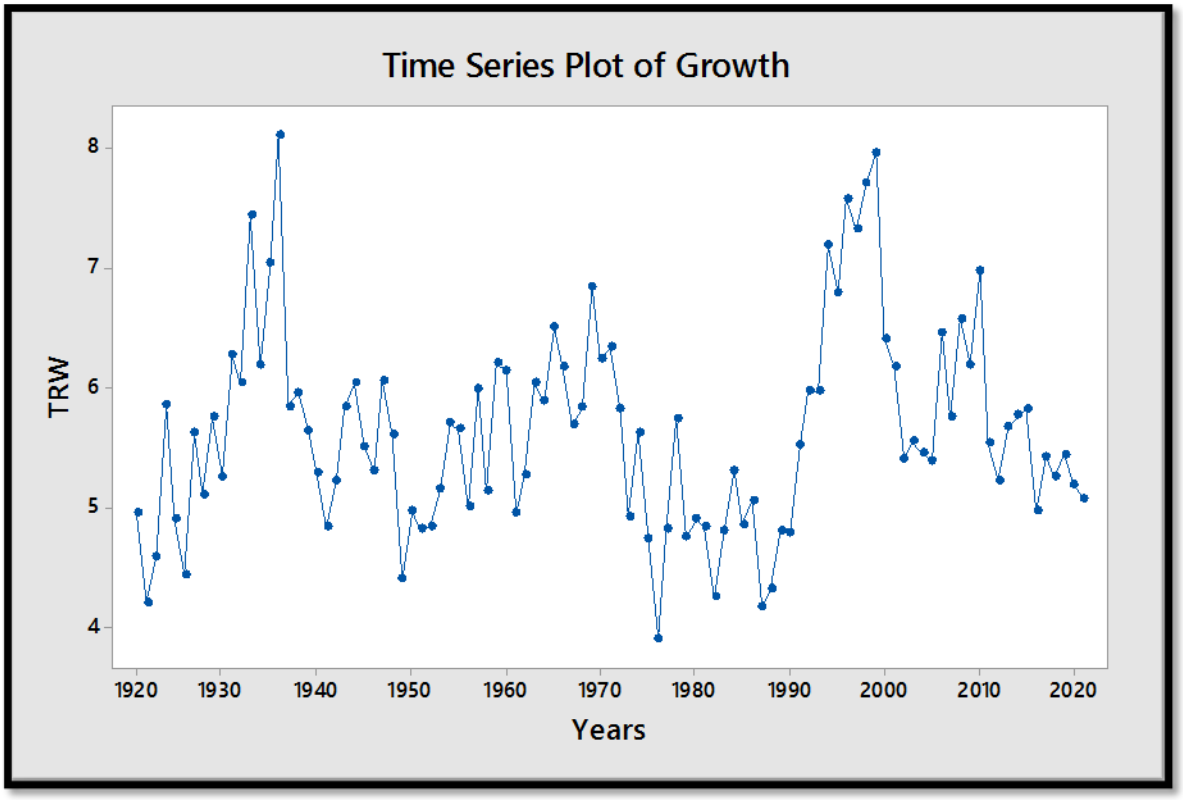


Figure 3: Growth Trend of *Pinus gerardiana* at Chitral Forest area during 1921-2021.

Conclusions

Based on the results it was concluded that *Pinus gerardiana* had great potential for studying the effect of climate change on the growth and may be used for reconstruction of long-term climatic factors for future planning with more study sites and number of samples.

2.1.2 A Study on Fiber Morphology of Some Hardwood Species Growing in Lalkoo, Swat for Assessment of Suitability for Pulp and Paper Manufacturing.

Year of commencement:	2022-23
Principal Investigator:	Dr. Tanvir Hussain, Logging Officer.
Co-Investigator:	Mr. Khalid Hussain Solangi, Assist. Wood Technology Officer, Mr. Said Akhtar Khan, Assist. Wood Technologist

Introduction

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. Paper industry has special significance in economic structure of Pakistan because of the two main reasons. First, Pakistan is predominantly an agrarian economy, offering suitable raw materials base. Second, Pakistan has a large and growing market size having a population of over 180 million. These factors are translating into consistent demand for paper industries output. Despite of current challenges faced by the country; it is a renowned fact that paper industry of Pakistan still has huge potential to develop. At Present Pakistan is highly independent on the import of a variety of paper products in general and raw material as pulp and wastepaper because wood is not being unutilized as raw material for paper manufacturing in industry. Therefore, it is imperative to determine the suitability of different locally grown wood species for their use in pulp and paper industries for manufacturing of various paper products. Fiber is the basic component material in paper making on which the paper properties depend. Fiber morphological characteristics play a key role to find out the suitability of a wood species for pulp and paper manufacturing.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.

Keeping in view of the above scenario, this study was conducted to assess morphological and anatomical characteristics for determination of technological properties of wood fiber of different tree species.

Materials and Methods

Research materials in the form of logs were collected/procured from local Deputes of Lalkoo, Swat. From each log of each species wood discs were cut down and samples in the form of Blocks were prepared. From each block of each species wood samples in the form of matchsticks were prepared and poured into test tubes and labeled properly. Then, 5 ml of 20% Nitric acid and 2mg of Potassium Chlorate were added and the test tubes were kept for maceration in beakers containing water. The beakers were put onto hot plate at 100 ^{0}C for 6-8 hours. After maceration, the pulpy material was repeatedly washed with water using filter paper until solution of chemicals completely removed. The mashie material of each wood samples was saved in test tubes for studying morphological parameter. Wood morphological characteristics were studied under microscope and statistical analysis was carried out with Microsoft Exell 2010.

Results and Discussion

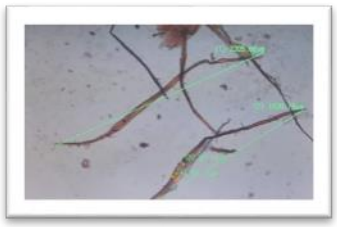
Walnut *(Juglans regia)* fibers were found comparatively very long i.e., mean value (mv) 1364.82±230.24µlong(918-1897µ)followed by Pohu *(Parotia jacouemontiana)* 1341.35±280.60µ long (886.05-2187.77 µ), Mulberry *(Morus alba)* 1097±257.67µ long (137.26-1541.59µ), Black locust

(Robinia pseudoacacia) 1074.83±314.38µ long (119.45-1798.08 µ), Himalyan yew *(Taxus wallichiana)* 1025.54±276.04µ (239.00-1770.00µ), Indian willow *(Salix tetrosperma)* 835.65±152.06 µ long (531.21-1144.09µ), Brown Oak *(Quercus semicorpifolia)* 738.67±214.29µ long (312.37-1202.22µ), Tree of Heavan *(Allianthus altisimia)* 639.75±188.14 µ long (59.38-950.20 µ) and Himalayan poplar *(Populus ciliate)* 490.89±170.23µ long (306.78-852.26µ). According to Wimmer *et.al*., 2002, the fiber with longer length, determines the quality of pulp and pulp, flexibility, and resilience of the wood. The wood fibers of Walnut were found comparatively longer 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.

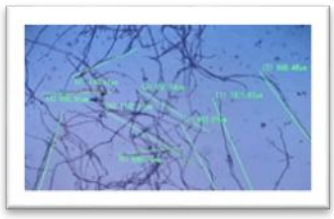
Ajala and Noah,2019 reported that fibers of small diameter may produce a good quality of pulp and paper and its utilization may increase the quality of paper. Moreover, small diameter of fiber may increase the frequency of fibers in wood that may give a good strength and flexibility to the wood articles. Keeping in view, it was found that fibers of*Salix tetrosperma* were found with small diameter i.e., mean value 8.41±1.69µ long (5.43-12.41µ) followed by *Ailanthus altisma* 9.33±2.05µ long (6.07-14.51µ), *Quercus semicorifolia* 9.56±1.73µ long (7.07-14.17µ), *Morus alba* 13.50±2.86 µ long (9.48-20.74µ), *Juglans regia* 15.71±4.17µ (5.43-26.82 µ), *Populus ciliate* 16.44±4.77µ long (7.08-26.48µ), *Parotia jacouemontiana* 17.80±4.44 µ long (11.45-29.36µ), *Taxus wallichiana* 20.79±5.28µ long (10.90-29.19µ) and *Robinia pseudoacacia* 40.87±11.62µ long (19.20-71.46µ).

Fiber wall thickness shows the strength, rigidity, and a resistance against the fungal and insect attack of the wood (Riki, 2019). 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*).

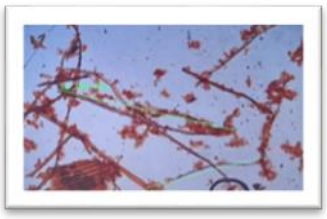
Runkel,1949 and Ademiluyi and Okeke,1977 described that Runkel ratio determines the quality of wood fiber for pulp and paper quality. The Runkel ratio less than 1.00 is considered better for pulp and paper making industry due to better beating capacity. Runkel ratio was found comparatively very low in *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.



Populus ciliate



Juglans regia



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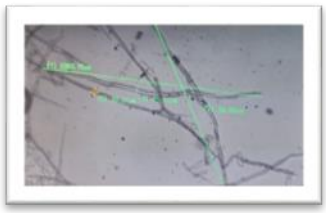
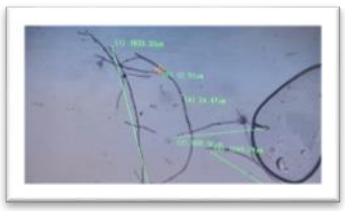
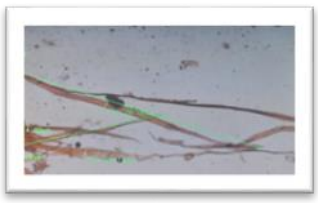


Robinia pseudoacacia

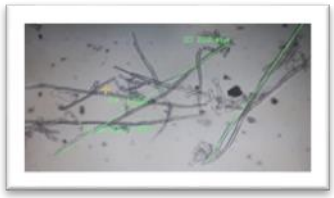


Taxus wallichiana



Quercus semicorpifolia

Morus alba



Salix tetrosperma

Allianthusaltisimia

Figure 1: Wood Fibers of Studied Species

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

MV= Mean Value; SD= Standard Deviation; CV= Commulative Variance; MIN= Minimum; MAX= Maximum.

S#	SPECIES 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	
1.	*Alliganthu saltisimia*	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
2.	*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
3.	*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
4.	*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
5.	*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
6.	*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
7.	*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
8.	*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	1.00
9.	*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

Conclusions

Based on the results of this study, it can be concluded that all wood species expect Red Willow (*Salix tetrosperma)* collected from Lalkoo, Swat have good potential for manufacturing of pulp and paper products. However, the quality of products may vary in view of the of fiber morphological characteristics.

2.2 PULP AND PAPER BRANCH

2.2.1 Comparative Study of Willow (*Salix Tetrasperma*) Wood & Lachi (*Eucalyptus Camaldulensis*) Hardwood Species for Pulp and Paper Manufacture Grown in Khyber Pakhtunkhwa.

Date of Commencement : 2023-24

Principal Investigator: Abdul Rehman, Pulp & Paper Officer

Background:

Around 3000 BC the modern paper we use today evolved from the ancient art of Egypt civilization that used papyrus tree as paper making material. These papers are not the same as we use today, the more expert way of making paper start from Chinese named T'sai Lun in 100 AD, who used bamboo and mulberry fiber. This paper making art is then started all over the world in beginning of 15th century.

As with time the global wealth increases, the paper demand will be doubled by 2050. With this global demand, it urges continuous research to ensure consistent and sustainable supply of raw material to keep the pulp and paper industries operative. The imbalances in the demand and supply of raw materials greatly affect the development of pulp and paper industry. To ensure sustainable supply of raw material for pulp and paper manufacturing, it is needed to find the plantation of renowned and used wood species.

The main source of Pulp & Paper manufacturing is Trees. Wood Pulp is a premium quality fiber which encompasses a high strength but with a high cost. The sources for the pulp and paper Industry would be broaden by investigating the pulping capacities of lesser used tropical Hardwoods. For example, for making wrapping papers and rigid cardboards, *Brachystegia spiciformis* Benth. and *Pericopsis angolensis* (Baker) Meeuwen were examined to have good pulping characteristics and suitable. *Ricinodendron heudelotii* (Baill.) Pierre ex Heckel fiber characteristics were analyzed by Ogunleye, Fuwape, Oluyege, Ajayi, and Fabiyi (2017) who concluded the suitability of specie for paper production. The fiber characteristics of *Ricinodendron heudelotii* (Baill.) Pierre ex Heckel were analyzed by Ogunleye, Fuwape, Oluyege, Ajayi, and Fabiyi (2017) who concluded their suitability for paper production. So, it is the need of the time to analyze the pulping characteristics of other plentiful and fewer used tropical Hardwood species to increase the raw material pool for Pulp and paper industry.

The alternative sources been developed, having low-cost production and new paper products, but having lower brightness, such as Packaging- the fattest growing sector of paper.

Willow (*Salix* spp.) belongs to family Salicaceae. *S. alpina* is a low-growing shale bush, 2–15cm tall. Young leaves are pubescent, adults are bare, only with cilia along the edge, re-versed, whole, brilliant, dark green from above, up to 2cm in length. Salix is classified into 3 sub categories, namely Salix, Vetrix and Chamaetia. The specie of the family Salicaceae, Salix, is the largest and prevalent genus with ca.320 species in all over the world.

The anatomical properties data of wood is needed for encouraging its use in the pulp and paper Industry, because such properties affect the pulpability of wood. The fiber characteristics, anatomical property, mainly influence the paper making potential of wood. The properties of paper that are to be affected by fibers are tearing resistance, bursting and tensile strengths, and stretch. Higher tear resistance paper is usually manufactured by long fibers. Other fiber derived indices, which give information to better conclude the papermaking potential of wood, are Runkle ratio, Slenderness Ratio, coefficient of Rigidity, Flexibility Coefficient, Luce's Shape Factor and solids Factor.

Methodology

The wood trees of two species, named Willow (*Salix tetrasperma*) wood and Lachi (*Eucalyptus camaldulensis*), were obtained from Range Forest Garden, Pakistan Forest Institute, Peshawar. The random selection of selected wood species was carried out and harvested at a stump height of 1.3 m. The harvested woods were debarked by (De-barker machine) and logs were obtained. Some samples were chipped into radial chips with the help of Staffi chipper Machine. Chips were prepared from each w In order to determine the fiber morphological characteristics, a small portion of wood of each specie radial chips were macerated in Schulze's method (30% Nitric Acid and a pinch of Potassium chlorate). Following this method, each sample of wood radial chips, having size of a half matchstick, was taken in different test tube. For getting fully separated fibers, the test tubes were placed in direct sunlight for two to three days. The separated fibers were carefully washed to remove the acid. The macerated fibers were stained in Safranin Stain and observe under the microscope (Nikkon 55 I Eclips) in wood anatomy Laboratory (Pakistan Forest Institute, Peshawar).

For this macerated fiber, measurements of fiber morphological properties were determined which are tabulated in Table.1. The International Association of Wood Anatomists IAWA, 1989 was followed for the terminologies that are written for the fiber microstructure description.

The Photomicrographs of the sections and macerated material were taken with the Nikkon Eclipse-55i compound light microscope (Anatomy Lab, Forest Product and Research Division, Pakistan Forest Institute) equipped with a Nikkon 4x0.1 camera.

Results

The basic density of both species is maximum at Freeness (SR^0) 64 which is **1.41±0.06** (g/cm^3) for willow and **1.2±0.073** (g/cm^3) for Eucalyptus. Among them, willow has the highest density [tab.3]. Pulp properties are strictly connected to wood density such as beating resistance, tensile strength, bursting strength, folding strength, sheet density and pulp yield. The paper sheet produced form low density wood have low pulp yield and tearing strength but high sheet density, folding, tensile and bursting strengths.

Table 3: Densities of two species at different Freeness

S.No	Specie	Density@ Freeness (SR^o) 25	Density@ Freeness (SR^o) 43	Density@ Freeness (SR^o) 64
1	Willow (Salix tetrasperma)	1.08±0.05	1.31±0.06	1.41±0.06
2	Lachi (Eucalyptus camaldulensis)	0.88±0.015	0.99±0.063	1.2±0.073

Hence, the mean density of willow is greater on all **Freeness (SR^o) i.e., 25, 43 & 64,** then the eucalyptus specie.

Wood Fiber properties related to pulp and paper quality:

As per results of Table 3 & 4, there is substantial variances can be found in fiber morphology (dimensions) i.e., Runkle ratio, slenderness ratio, coefficient of rigidity, Flexibility coefficient, Lune's Shape Factor, Solid Factor, wall coverage ratio, Fiber Coarseness and basic density, between the five authentic samples of each Willow (*Salix tetrasperma*) and Lachi (*Eucalyptus camaldulensis*) wood species used in this study.

Table 5. Fiber morphological characteristics of Willow (*Salix tetrasperma*) wood

Lachi (*Eucalyptus camaldulensis*)

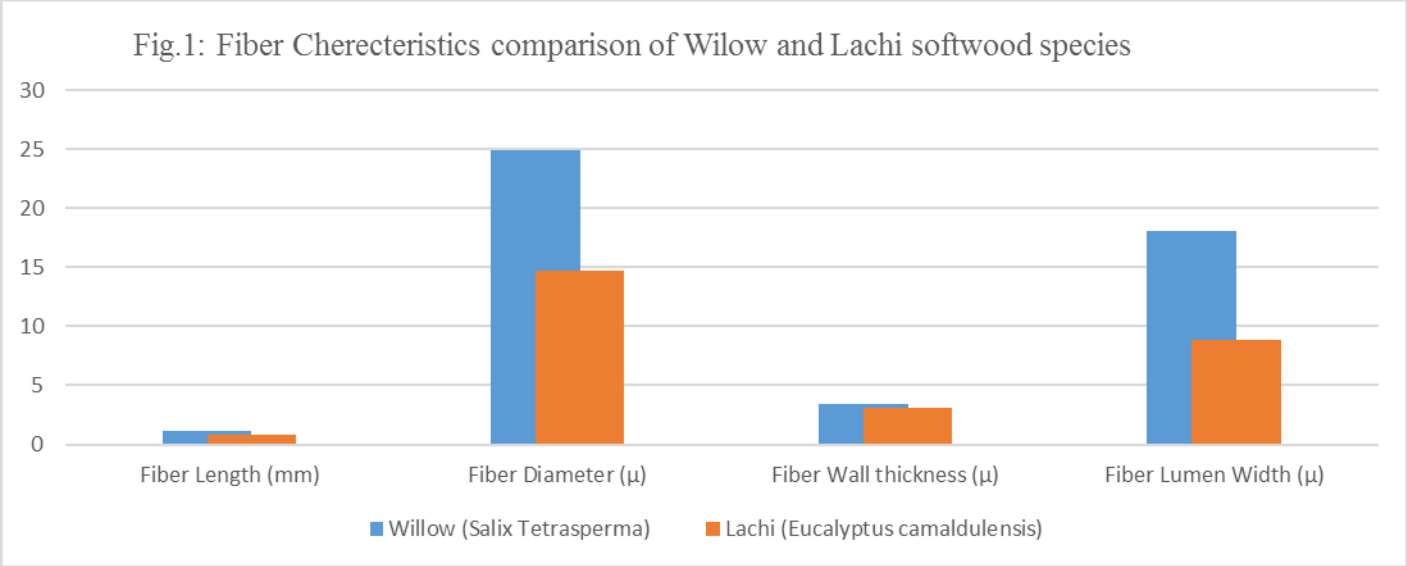
S.N	**Fiber**	**Average**	**Standard**	**Upper**	**Lower**	**Co-effient of**

o	characteristics	Value	Deviation (±)	Limit	Limit	Variation (%)
1	Fiber Length (mm)	0.81	0.12	0.93	0.69	19.81
2	Fiber Diameter (µ)	14.76	3.04	17.8	11.72	20.79
3	Fiber Wall thickness (µ)	3.05	0.53	3.58	2.52	21.49
4	Fiber Lumen Width (µ)	8.86				

Table 6. Fiber morphological characteristics of Willow (*Salix tetrasperma*) wood

Willow (*Salix tetrasperma*)

S.No	Fiber characteristics	Average Value	Standard Deviation (±)	Upper Limit	Lower Limit	Co-effient of Variation (%)
1	Fiber Length (mm)	1.11	0.22	1.33	0.89	19.81
2	Fiber Diameter (µ)	24.89	5.17	30.06	19.72	20.79
3	Fiber Wall thickness (µ)	3.42	0.73	4.15	2.69	21.49
4	Fiber Lumen Width (µ)	18.04				



Willow (*Salix tetrasperma*) has the longest fiber as compared to Lachi (*Eucalyptus camaldulensis*), clearly mentioned in the above give graph, Fig.1. But here is an anomaly in the wall thicknesses of their fibers. The fiber wall thickness of Willow (*Salix tetrasperma*) was also greater the that of (*Eucalyptus camaldulensis*), which can be seen in the given graph (Fig.1). Referring to Rydholm, 1967 for best quality paper, long fibers with thin walls are highly recommended for pulp and paper industries.

Species	Runkel Ratio	Slenderness Ratio	Coefficient of Rigidity	Flexibility Coefficient	Luce's Shape Factor	Solid Factor	wall coverage ratio	Fiber Coarseness
Willow (*Salix tetrasperma*)	0.38	44.6	0.14	0.72	0.31	0.33	0.27	294.07
Lachi (*Eucalyptus camaldulensis*)	0.69	54.87	0.34	0.6	0.217	0.112	0.41	139.36

In pulp and Paper manufacturing industry, for good quality pulp and paper, the Runkle Ratio of fiber provides useful pulp yield or digestibility. The Runkle Ratio of Lachi (*Eucalyptus camaldulensis*), with average value 0.69, is greater that of Willow (*Salix tetrasperma*), with a value of 0.38.

The Runkel ratios given in the table.4, gave high specific areas, which have required bonding ability. The Runkel Ratio less than one, produced paper which will be comprises of excellent folding endurance, bursting and tensile strength, and will be compact and have smooth surfaces. The tensile strength of the paper is directly related with the Runkle Ratio of the wood fibers.

The fiber strength increases with the increase of slenderness ratio and fiber length. The mean value of Lachi (*Eucalyptus camaldulensis*) (54.87) is greater than Willow (*Salix tetrasperma*) (44.6). Therefore, the paper produced from Lachi (*Eucalyptus camaldulensis*) is responsible for its higher bursting and tensile strength as compare to Willow (*Salix tetrasperma*).

Luce's shape factor contributes for resistance to beating and Flexibility coefficient for tearing and tensile strength of paper. Its value for Lachi (*Eucalyptus camaldulensis*) is 0.217 while for Willow (*Salix tetrasperma*) is 0.31. Referring to Moriya (1967), the paper strength produced was positively related to flexibility coefficient, burst and tear factors. Also, the flexibility coefficient value of Willow (*Salix tetrasperma*) is 0.72 and Lachi (*Eucalyptus camaldulensis*) is 0.6.

The solid factor was found directly related to the paper sheet density and the paper breaking length. But here in this study, solid factor value of Willow (*Salix tetrasperma*) is 0.33, higher than Lachi (*Eucalyptus camaldulensis*) which is 0.112.

CONCLUSION

Paper sheet density could be determined by the fiber diameter. Paper with good sheet density could be produced from small diameter fibers. The fiber with larger diameter increases pulp volume and their void spaces which subsequently produces a paper sheet with coarse-surface. Papers with good sheet density can be produce from fibers which have fiber diameter ranges from 20–40 µm. The fiber diameter recorded for Willow (*Salix tetrasperma*) is 24.89 ± 5.17 µm while that of Lachi (*Eucalyptus camaldulensis*) is 14.76 ± 3.04 µm.

The potential of wood in paper manufacturing is allegedly affected by its fiber thickness and lumen diameter or lumen width. The wood fibers with thick walled are reportedly undesirable in paper manufacturing because they occupied large void volume, bulky and coarse surface.

The present study was carried on the two hardwood species namely Willow (Salix tetrasperma) and Lachi (*Eucalyptus camaldulensis*). These species were grown locally in the Research Range Garden of Pakistan Forest institute, Peshawar. This study will help the pulp and paper industry as well as the local community to grow the best specie on Agro forestry basis. This study will help to reduce the pressure on traditional timber used in pulp and paper production and encourage good forest management and Agro-forestry in order to sustain nonstop forest resources to the pulp and paper industry.

The current study was carried out to compare the properties of two well know species grown in Khyber Pakhtunkhwa used in pulp and paper production.

Willow (*Salix tetrasperma*) fiber dimensions (i.e., length, diameter, lumen diameter and wall thickness) compared with those of Lachi (*Eucalyptus camaldulensis*), which are vastly used in pulp and paper manufacturing. Fiber of the first mentioned specie is most suitable for pulp and paper industry and to be recommended for KPK local community to be grown as an Agro-Forestry specie. It is because the former specie has low fiber length as compare to the preceding specie.

The base for the raw material to be used in the pulp and paper manufacturing industry can be increased by adding the both species i.e. Willow (*Salix tetrasperma*) and Lachi (*Eucalyptus camaldulensis*).

2.2.2 Relationship Between Fiber Characteristics and Pulping Properties of IPIL(Lecaena Leucocephala) Tree Grown in Khyber Pakhtunkwa

Date of commencement: 2022-23

Principle Investigator: Muhammad Umair Khan, Pulp and paper Officer (Chemistry), FPRD

BACKGROUND

The continuous development in Pakistan has led to a rapid increase in the country's demand for paper products. The majority of developing countries including Pakistan depends almost entirely on imports to meet its demand of pulp and paper even though the country is rich in various hardwood species that might serve as good source for pulp and paper production. The original properties of fiber and its outcomes from the processing variables determine successful transformation of pulp into a marketable product.

The original fiber properties and the fiber's response to processing variables are both important factors in the production of paper sheets and their physical characteristics. Since there is an enormous range of wood species, even though processing conditions may have been the same, the physical characteristics of a piece of paper from one species will frequently differ considerably from a similar piece from another species. The study analyzes and investigates the mutual relationship of pulping properties and fiber characteristics of *Leucaena leucocephala* grown in Khyber Pakhtunkhwa, Pakistan, in an effort to forecast pulp sheet performance depending on the fiber content and Kraft pulp quality.

MATERIAL AND METHODS

Wood material of Ipil ipil (*Leucaena leucocephala*) was purchased across the province of Khyber Pakhtunkhwa. The morphological characteristics of fiber, and testing and evaluation of its sample papers for various strengths were carried in Wood Anatomy and Pulp and Paper Lab of Forest Product Research Division, PFI.

1. Fiber Analysis

The mean fiber characteristics with their derived morphologies of Ipil ipil (*Leucaena leucocephala*) are shown in Table 1.

Table 1: Fiber morphological characteristics of Ipil ipil (Leucaena leucocephala) wood

S. No	Fiber Characteristics	Samples					Average value	Standard Deviation	Co-efficient of variation
		S1	S2	S3	S4	S5			
1	fiber length (mm)	0.92	0.88	1.1	1.41	1.42	1.15	0.27	23.47
2	Fiber diameter (microns)	18.42	17.81	23.1	29.51	28.99	23.66	5.85	24.75
3	fiber wall thickness (microns)	2.67	3.11	2.95	2.69	4.59	3.63	0.96	26.52
4	fiber lumen width (microns)	13.87	16.8	15.01	18.79	17.25	16.34	2.45	14.99

Based upon the fiber morphological characteristics of Ipil ipil (*Leucaena leucocephala*) in Table 1, the calculated wood properties of Ipil ipil (*Leucaena leucocephala*) wood are hereby calculated and shown in Table 2.

Table 2: Arithmetic ratios/ calculated wood properties of Ipil ipil (*Leucaena leucocephala*) wood

S. No	Property	Value
1	Runkel ratio (2 x fiber call wall thickness/lumen width)	0.44
2	Flexibility ratio	0.69

	(fiber lumen width/ fiber diameter)	
3	Felting power ratio (fiber length/ fiber diameter)	43.81
4	Rigidity coefficient (fiber wall thickness/fiber diameter)	0.15

2. Pulping Experiment

The debarked and disintegrated chips of collected wood species of Ipil ipil were subjected to Kraft Pulping Method. The digested pulp was disintegrated to get uniform pulp and percent yield was calculated and beaten for fiber freeness through SR (Schopper Regiler) beater. The cooking parameters are shown below.

Chips weight	1070 g
Na_2S	50 g
NaOH	150 g
Active alkali	15%
Sulphidity	25%
Cooking time	3 hours
Cooking temperature	170 ^{o}C
Wood : Liquid	1:5
Cooking yield	44.4%

3. Handsheet Preparation and Testing

Five handsheets were made from dried Ipil ipil pulp using a standard handsheet former as described in TAPPI test T205 sp-02 at each Freeness Level (^{o}SR). Each of the handsheet made at

three level of freeness was put to the tests of grammage, density, bulk, roughness, porosity and tear resistance as shown in Table 3.

Table 3: Pulp-sheet properties of Kraft pulp of Leucaena leucocephala wood at different freeness levels

S. No	**Pulping Property**	**Freeness (^{o}SR) 25**						**Standard deviation**	**Coefficient of variation**
		S1	S2	S3	S4	S5	Average value		
1	Grammage (g)	56.7	63	59.85	69.3	66.15	63	4.98	7.91
2	Density (g/cm3)	1.22	1.29	1.5	1.43	1.36	1.36	0.11	8.14
3	Bulk (cm3/g)	0.7	0.66	0.73	0.77	0.8	0.73	0.06	7.59
4	Roughness (ml/min)	564	595	659	627	690	627	49.96	7.97
5	Porosity (ml/min)	2846	3478	3004	3320	3162	3162	249.82	7.90
6	Tear Resistance (mN)	49	47	52	57	55	52	4.12	7.93
		Freeness (^{o}SR) 43						Standard deviation	Coefficient of variation
		S1	S2	S3	S4	S5	Average value		
1	Grammage (g)	61.75	65	58.5	68.25	71.5	65	5.14	7.91
2	Density (g/cm3)	1.38	1.46	1.61	1.68	1.53	1.53	0.12	7.75
3	Bulk (cm3/g)	0.7	0.6	0.5	0.6	0.65	0.65	0.05	7.30

		1	8	9	2				
4	Roughness (ml/min)	550	572	618	595	640	595	35.74	6.01
5	Porosity (ml/min)	2781	2642	2503	3059	2920	2781	219.78	7.90
6	Tear Resistance (mN)	45	47	55	53	50	50	4.12	8.25
		Freeness (^{o}SR) 67						Standard deviation	Coefficient of variation
		S1	S2	S3	S4	S5	Average value		
1	Grammage (g)	69.3	63	59.85	56.7	66.15	63	4.98	7.91
2	Density (g/cm3)	1.6	1.69	1.78	1.96	1.887	1.78	0.15	8.16
3	Bulk (cm3/g)	0.54	0.51	0.56	0.59	0.61	0.56	0.04	7.08
4	Roughness (ml/min)	409	431	454	499	477	454	35.74	7.87
5	Porosity (ml/min)	1908	1817	1635	1999	1726	1817	143.88	7.92
6	Tear Resistance (mN)	42.71	40.68	38.65	36.62	44.74	40.68	3.21	7.89

RESULTS

The relationship between paper and fiber must be interpreted with the indication whether softwood or hardwood is utilized for papermaking. Softwoods are more homogenous in their anatomical structure as compared to hardwoods. The heterogeneity of hardwoods make them

complicated to analyze the morphology of fiber and their impact on the characteristics of hardwood-based papers. The relationship that was found to arise from even the most significant hardwood fiber parameter to a particular paper property was generally found to be less certain than in the case of softwood fibers. However statistical study of correlation between paper and fiber can provide a wide understanding of suitability of hardwood as a potential raw material in the production of pulp and paper. Pearson Correlation coefficients between fiber morphological characteristics and paper properties were calculated and shown in Table 4:

Table 4: Relationship between Pulping Properties and Fiber Characteristics of *Leucaena leucocephala*

	Freeness level (^{o}SR) 25				Freeness level (^{o}SR) 43				Freeness level (^{o}SR) 67			
	FL	FD	FWT	FLW	FL	FD	FWT	FLW	FL	FD	FWT	FLW
Grammage	0.79	0.80	0.33	0.99	0.69	0.65	0.65	0.77	-0.40	-0.46	0.32	-0.62
Density	0.54	0.60	0.03	0.35	0.72	0.77	-0.03	0.65	0.94	0.96	0.35	0.84
Bulk	0.96	0.95	0.56	0.48	-0.54	-0.60	-0.03	-0.35	0.96	0.95	0.55	0.48
Roughness	0.74	0.75	0.73	0.40	0.93	0.95	0.31	0.84	0.93	0.95	0.31	0.84
Porosity	0.14	0.15	0.12	0.79	0.71	0.68	0.19	0.66	0.07	0.06	-0.48	0.34
Tear resistance	0.97	0.98	0.28	0.63	0.58	0.64	0.01	0.37	-0.10	-0.16	0.70	-0.35

Pearson Correlation coefficient: 1 shows Strong Positive Correlation, -1 shows Strong Negative Correlation | FL: Fiber Length, FD: Fiber diameter, FWT: Fiber wall thickness, FLW: Fiber Lumen width

CONCLUSION

It had been shown from the result of this work that the strength properties of the pulp sheet of *Leucaena leucocephala*were significantly influenced by the characteristics and morphologies of the fiber. It seems difficult to predict the quality and performance of pulp on the basis of a single morphological factor. However *Leucaena leucocephala* pulp had been influenced greatly by fiber length and fiber diameter. The investigation indicates that Ipil ipil wood has longer, larger in diameter and lumen width and somewhat thick-walled fibers. The wood has acceptable value of Runkel ratio value, higher value of flexibility ratio, medium value of felting power ratio and lower value of rigidity co-efficient ratio. The wood may be suitable to be used as raw material for pulp and paper manufacturing. It may produce high tearing resistance, flexible with better fording endurance and bursting strength and medium binding and mating of fibers in paper sheet.

2.3 WOOD SEASONING AND PRESERVATION BRANCH

The following wood species received from different organizations have been tested for average moisture contents and average density. The results have been shown here.

S. No	Wood Species	Organization Name	Average Moisture Contents%	Average Density g/cm^3
1	Deodar (Cedrus Deodara)	Rehman Construction Company	12.76	
2	Oak (Quercus)	Naval Headquarter Karachi	9.65	
3	Deodar (Cedrus Deodara)	SDEO Building No.1 Mardan	11.36	0.49
4	Shisham (Dulbergia Sisso)	KPESED	11.97	
5	Deodar (Cedrus Deodara)	MAK Engineering Services WADDAN	9.8	
6	Shisham (DulbergiaSisso)	CEO (DEA) Khushab	10.2	0.88
7	Ekki (Lophiraalata) Wood	Pakistan Railway Karachi Cantt	29.6	
8	Shisham (DulbergiaSisso)	DEO (M) Peshawar	10.9	
9	Deodar (Cedrus Deodara)	PPWD	9.7	
10	Ekki (Lophiraalata) Wood	Pakistan Railway Mughulpura	13.03	
11	Ash (Fraxinus excelsior) Wood	Project Management Team Islamabad	9.9	
12	Shisham (DulbergiaSisso)	KKKUK	11.6	

13	Keekar (Acacia n ilotica) wood	Project Management Team Islamabad	18.16	
14	Deodar (Cedrus Deodara)	NESPak	9.95	0.54
15	Chipboard sample (Keekar)	KKKUK	7.95	0.64

Moisture Meter

Submission of Research / Review Articles

The following research/review articles submitted to PJF.

1. Uses of Nanostructures in Innovative Composite Wood Products and their Applications.

2. Decoding the Nutritional Mystique: A Comparative Analysis of Guava and Peach Varieties from Diverse Climatic Regions.

3. Non Wood Fibbers as Raw Materials For Pulp And Paper Production In Pakistan: A Review

4. Relationship between Fiber Characterstics and pulping properties of IPIL IPIL (*Leucaena Leucocephela*) tree grown in Khyber Pakhtunkhwa.

Research Project / Proposal Submission

1. Development of Clean and Low Energy Wood Seasoning Technology at Pakistan Forest Institute for Wood Based Industries.
2. Testing and Evaluation of Some Imported Wood Species
3. Development of Improvised Solar Kiln Facility for Wood based Industries.
4. Increasing of Crops Production And Growing of Fruit Plants in the Rural Areas of District Karak Through Solar Tube Wells System And Using their Raw Products for Value Added Forest Product Research.

SUMMARY PLAN FOR 2024-25

The project aims to conduct a comprehensive examination of both local and imported wood species, focusing on their physical, mechanical, and environmental properties. This initiative is crucial for industries reliant on wood resources, as it seeks to provide valuable insights into the suitability, sustainability, and performance of various wood types. Representative samples of both local and imported wood species will be collected from diverse sources. Standardized testing methods for physical and mechanical properties, will be applied for ensuring accurate and comparable results. This project serves as a valuable resource for industries, policymakers, and environmental advocates, contributing to informed decision-making and sustainable practices in the utilization of both local and imported wood species. The findings will have a lasting impact on the woodworking and construction sectors, promoting responsible resource management and environmentalstewardship.

2.4 COMPOSITE WOOD BRANCH

2.4.1 Comparative Evalution of Particleboard Prepared from *Tamrix Aphylla* & *Morus Alba* Locally Grown in Khyber Pakhtunkhwa

Date of commencement: 2022-23

Principle Investigator: Abdur Rahman Khan, Assistant Composite Wood Officer, FPRD

Background

One of the ways to combat with deforestation is to reduce the consumption of wood. The wood finds its common application in home fixtures, furniture and fuel; therefore investigating the wood substitutes in these cases would be most advantageous. One of the most important wood-based composites is particleboard, which was made from wood or lignocellulose material particles glued with binder (adhesive) under pressure and temperature. Urea- formaldehyde is the most economic and useful adhesive because of its low cost and easy production. Historically, the products from the light wood technology were very expensive and exclusive. They were used in the aeronautic field or in the automotive field. Over the time, the light wood products could be produced cheap, but with a better quality through increased efficiency in production processes, research, and development. This trend is very strong in the furniture industry. Particleboard is cheaper, denser and more uniform than conventional wood and plywood and is substituted for them when appearance and strength are less important than cost. However, particleboard can be made more attractive by painting or the use of wood veneers that are glued onto surfaces that will be visible. There are over a hundred particleboard plants in operation today worldwide and particleboard is one of the strongest reconstituted panel products and is considered as an ideal substitute to wood and plywood.

Growing social demands for various wood-based panel products leads to the continuous efforts to find new wood resources as an alternative to solid wood from natural forests. The use of non-timber resources wood wastes and agricultural residues are a way of saving wood.

This research work therefore aims to evaluate locally grown non timber wood species Ghaz (*Tamrix aphylla*) and Toot (*Morus Alba)* for particle board manufacturing

Material

Tamrix aphylla and *Morus Alba* wood species, Urea Formaldehyde, chipper, Mixer, and compressor machine were used in this research work.

Methods

Collection of Wood Species

The *Tamrix aphylla* and *Morus Alba* were collected from local area of the Peshawar KPK, Pakistan. Total number of logs acquired is 4 of each species.

Processing of Wood Species

The *Tamrix aphylla* and *Morus Alba* logs are processed, debarked and then convert to chips of size with the help of chipper installed in the composite wood labs of Pakistan Forest Institute, Peshawar

Mixing with synthetic adhesive

The chips of were mixed with a fixed ratio to Urea Formaldehyde with the help of electrical mixer installed in composite wood plant so that equal distribution of the adhesive to each particle of the wood.

Hot pressing

After thoroughly mixing the mixture were transfer to the specific pot made for desired thickness of particle board sheet, and then put in Hot presser at temp about 150 c and time 10 min and pressure 200 kg per cm After that the sheet is cooled and dried.

Physical tests

Density Test

Density of the each board was determined to find the mean density of each board following the British code of standards BS EN 323 [18].

$$\sigma = \frac{m}{v}$$

σ Represents the density, m represents mass of each test piece in kg, and v is the volume of test piece.

Water Absorption test

Water absorption test was carried for the particle board that how much water absorbed by the particle board in a given time

$$WA = \frac{wf - wi}{Wi} \times 100$$

Wf Represents final weight, *Wi* represents initial weight and *WA* is the water absorbed by sample in %.

Thickness swelling test

The thickness swelling test is dimensional analysis test used for determination in the thickness of the board sample after being immersed in the water in a given time frame. This test is used to find the effect of water on the board sample. It was carried by following the British code of standards BS EN 317 [19].

$$Ts = \frac{T2 - T1}{T1} \times 100$$

t1 is initial thickness while t2 is final thickness and Ts is thickness swelling

Mechanical Tests

Static Bending tests

The Modulus of rupture (MOR) and Modulus of Elasticity (MOE) was determined using universal testing machine following the central concentration loading method. MOR and MOE are measured in N/mm^3. This was carried following British code of standards BS EN 310 [20].

$$\text{MOE} = \frac{(F2 - F1)l1^3}{4bt^3\,(a2 - a1)}$$

$$MOR = \frac{3Fmaxl1}{2bt^2}$$

- F_2-F_1 is is the gradual increase of load on the straight-line portion of the load deflection curve ad is measured in newton, N. F1 is approximately 10 % of the maximum load while F2 is approximately 40 %.
- Fmax is the maximum load measured in newtons.
- b is the breadth of the specimen, measured in millimeters, mm.
- t is the thickness of the specimen, measured in mm.
- l_1 is the distance between the centers of the support which is also measured in mm. a_2-a_1 is the deflection of the specimen at mid span, corresponding to F2 – F1 and is also measured in mm.

Results and Discussions

Ghaz *Tamrixaphylla*Data

PROPERTIES	x1	x2	x3	x4	Average value	standard deviation
Board density (kgm-3)	822	818	824	815	820	4.031128874
Water Absorption 2 hr	16.8	15.53	14.7	15.8	15.708	0.749779134
Water Absorption 24 hr	28.34	29	29.43	28.5	28.8175	0.429323596
Thickness Swelling 2 hr	5.6	4.9	6	6.5	5.75	0.585234996
Thickness Swelling 24 hr	17	14.3	15.5	17.5	16.075	1.261695288
Modulus of rupture (MOR) Kg/ cm^2	395	398.5	398	396	396.875	1.430690393
Modulus of Elacticity (MOE) Kg/ cm^2	38365	38370	38367	38369	38367.75	1.920286437

Face Nail with drawl Kg	114	112	128	123	119.25	6.533567173
Face Screw with drawl Kg	238	240	210	220	227	12.52996409

Toot *MORUS ALBA* Data

PROPERTIES	x1	x2	x3	x4	average value	standard deviation
Board density (kgm-3)	897	885	860	854	874	17.69746
Water Absorption 2 hr	17.59	19.78	13.93	14.78	16.52	2.187706
Water Absorption 24 hr	23.94	22.32	30.91	29.35	26.63	3.389623
Thickness Swelling 2 hr	8.21	7.93	2.81	3.33	5.57	2.416132
Thickness Swelling 24 hr	13.2	12.5	17.5	19.2	15.6	2.908883
Modulus of rupture (MOR) Kg/ cm^2	588	593	555	600	584	16.72603
Modulus of Elacticity (MOE) Kg/ cm^2	64228	62000	62500	63000	62932	740.7006
Face Nail with drawl Kg	154	141	185	200	170	24.25696
Face Screw with drawl Kg	180	280	200	300	240	51.53639

A representative trend showing the Density of Board samples shown in **Fig 1.**

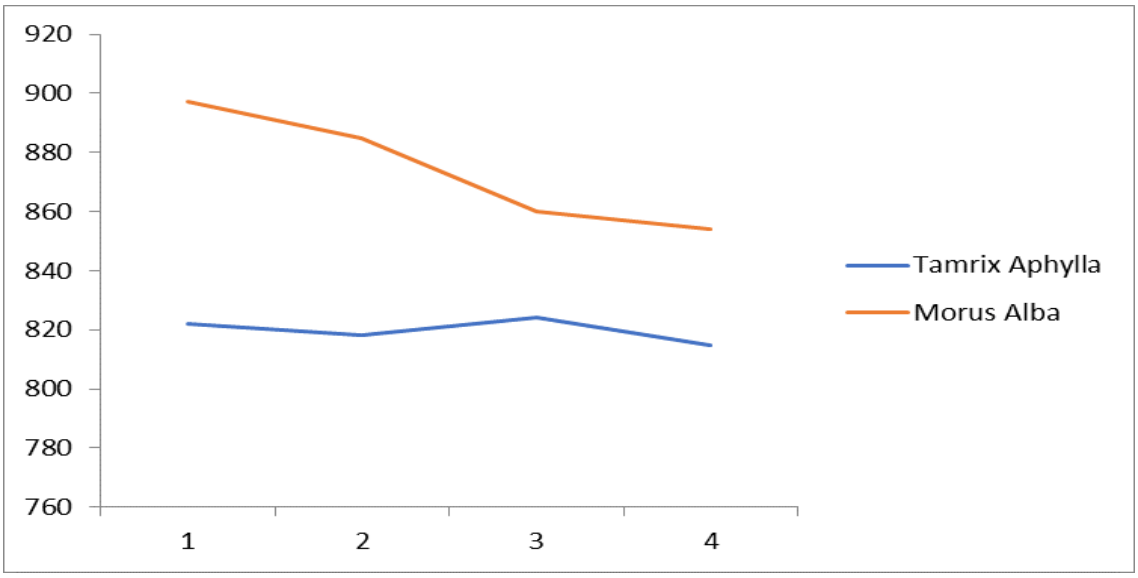


Figure 1: Variation in Density of Board Samples of *TamrixAphylla*and *Morus Alba*

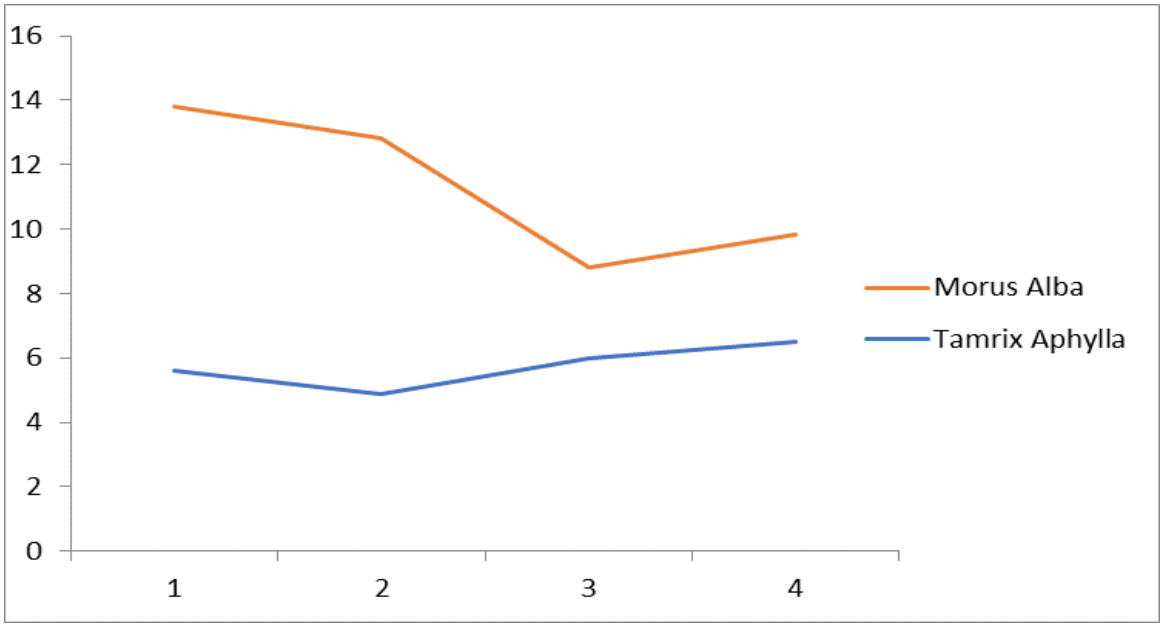


Figure2: Variation of thickness swelling after 2 hrs.

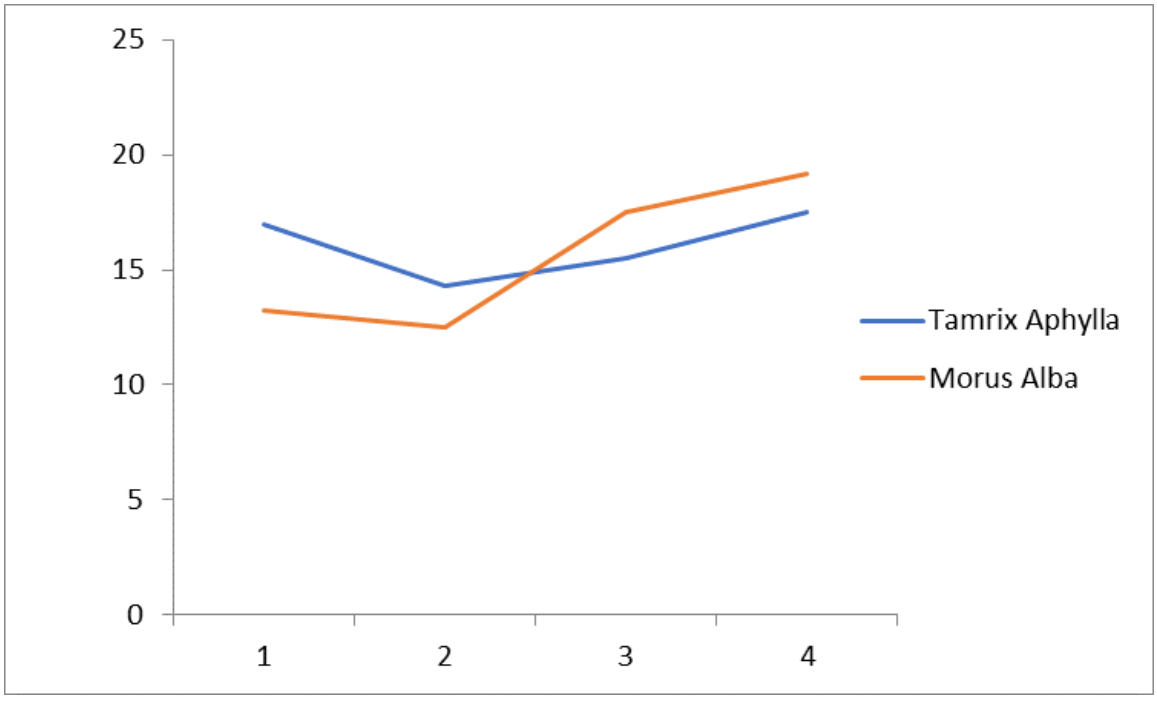


Figure3: Variation of thickness swelling after 24 hrs

The density value of composite wood material is an important property which determines its performance in service environment. As shown in **Fig 1** the density of different samples of *Tamrix Aphylla* and *Morus Alba* all of them are medium density particle boards. According to ANSI 280 [23] standards all these are medium density particle boards as above than 600 Kg/m^3.

The water absorption of particle boards at temperature (20℃) after 2hr and 24hr soaking in water. This is due to hydrophilic nature of wood which contains the organic polymers like cellulose and

lignin etc. which are rich in hydroxyl which readily interacts with water molecule. The similar trend is notice in thickness swelling test also.

Mechanical properties: The result of MOE and MOR value are presented in **figure 4** and **5**

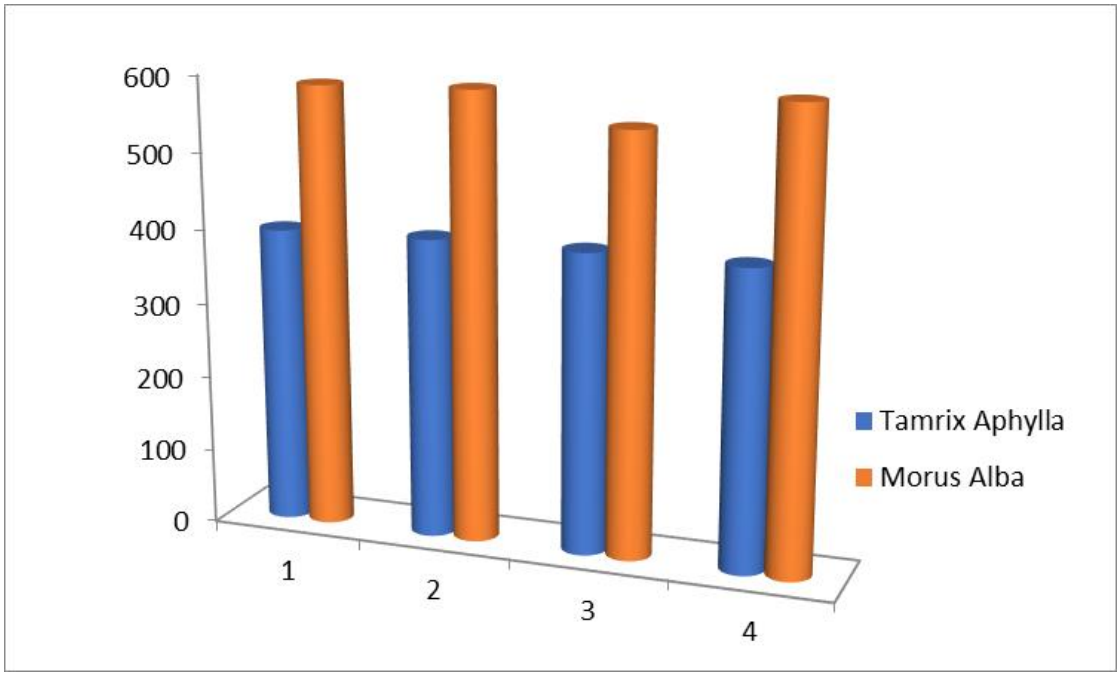


Figure4: Variation in Modulus of Rupture of Board Samples

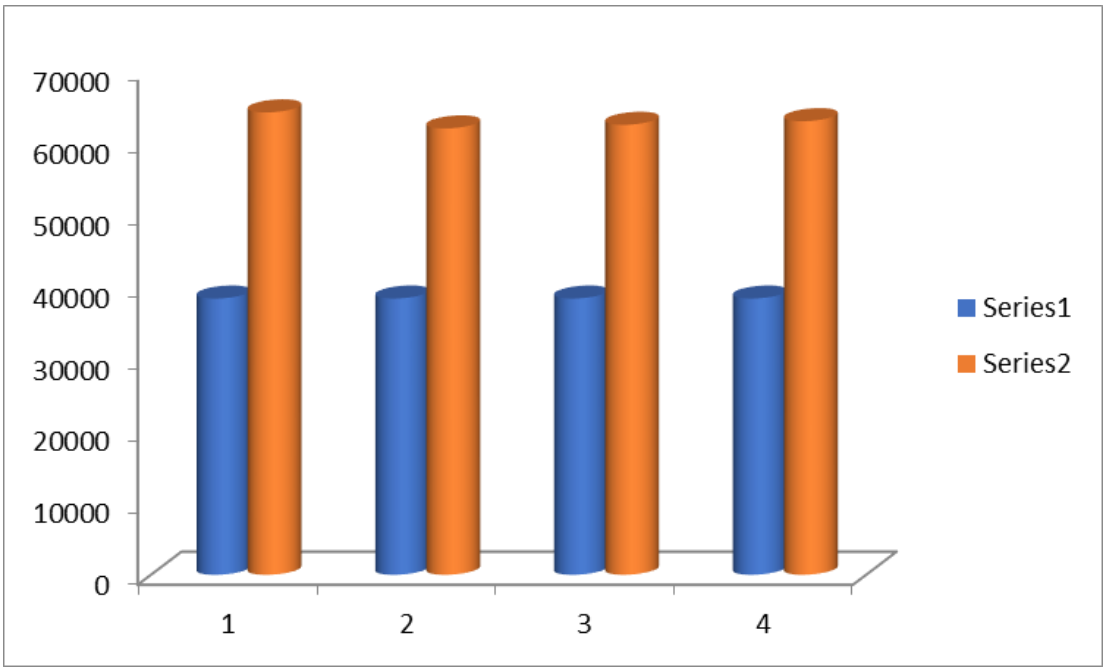


Figure5: Variation in Modulus of Elasticity of Board Samples

From the above two figures of MOR and MOE it shows that *Morus Alba* showed high mechanical strength than that of *Tamrix Aphylla.* This is because the hardness with in the species of *Morus Alba*

Conclusion

The particle board industry is flourishing very abruptly, so it is the need of the day to find new sources which is economic and easily available. From the above study we concluded that *Morus Alba* is better for the particle board production

3. BIOLOGICAL SCIENCES RESEARCH DIVISION

3.1 Forest Botany

3.1.1 Maintenance and Improvement of Botanical Garden

Location: Pakistan Forest Institute, Peshawar

Principle Investigator: Sohaib Ahmad, Assistant Professor of Forestry/Forest Botanist

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

Provided river water to all plots of Botanical garden weekly 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 and cuttings of the following plant species sown in small nursery of botanical garden.

Rosa indica (cutting), *Citrus* medica (seeds) *Quercus glauca* (cuttings) *Kydia calycina* (cuttings) *Gmelina arborea* (cuttings) *Duranta plumieri (cuttings) Ficus varigata* (cuttings) *Ficus infectoria* (cuttings) *Ficus elastica* (cuttings) *Punica granatum* (cuttings) *Cieba pindendra* (cuttings) *Pyracantha crenulata (*seeds/cuttings) *Cupaneupsis anacardeodes* (seeds) *Azaddercta indica* (seeds) *Cestrum nocturnum* (cuttings) *Rhus typhina*.

Plantations:

The following plant species are planted in different plots of Botanical garden.

Dodonea viscosa in hedge, *Ligustrum lucidum*, *Populus deltoids*, *Ziziphus jujube*, *Heptage benghalensis*, *Robinia psuduacacia*, *Erbotria japonica*, *Cedrus deodara*, *Eleagnus aungustifolia*, *Conocarpus lanceolatus*, *Plumaria obtuse, Tabernaemontana diversifolia*, *Nycanthes arbortristis*, *Acacia modesta*, *Thevitia nerufolia* and *Justitia vera*.

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

Moringa oleifera, Cassia fistula, Bambusa vulgaris, Acacia catechu, Sophora japonica etc.

Renovation: Restore Huts roof at Botanical garden

Lectures delivered: Lectures were delivered to students from IM Sciences Peshawar, PMAS Arid Agriculture University Rawalpindi. Agriculture University Peshawar on their visit to Botanical garden.

New Species Introduction: Following species have been introduced in Botanical garden.

Cedrus deodara, *Eleagnus aungustifolia* and *Conocarpus lanceolatus*.

MAINTENANCE OF HERBARIUM

Maintaining Herbarium with proper preservative measures

Lectures delivered to students from different universities on herbarium and its importance in plant sciences

Relisting of all herbarium specimens is under process

RESEARCH PAPERS SUBMITTED TO EXTENSION BRANCH FOR PJF

1. Floristic Composition and Ecological Evaluation of Plant Resources of Landikotal, District Khyber.
2. Dicot Flora of District Malakand, Khyber Pakhtunkhwa.
3. Invasive Species of Pakistan: Impacts, Challenges and Management Strategies.
4. Physiological, Biochemical and Morphological responses of Plants' to water deficit conditions: a review.

3.2 Forest Chemistry

3.2.1 Diversity of Bacterial and Fungal Genera in the Rhizosphere of *Taxus wallichiana* L. and Non-Rhizosphere of Mineral Soil at Various Altitudinal Gradients of Galiyat-Khyber Pakhtunkhwa, Pakistan

Principal Investigator: Sanam Zarif Satti, Director Biological Sciences Research Division
Year of commencement: 2022-23

Introduction:

Taxus wallichiana L. (Himalayan yew) is an evergreen coniferous tree (10 to 28 meters in height), native to the Himalayas grows on steep, moist mountain slopes at altitudes of about 2000 m to 3500 m above sea level. It has flat and dark green leaves, which are arranged spirally on the stem. The leaves and bark of Taxus species are the primary source of the chemotherapeutic drug Paclitaxel used in the treatment of breast and ovarian cancer, resulting in it receiving huge attention worldwide.

Soil is a major source of nutrients needed by plants for growth. The three main nutrients are nitrogen (N), phosphorus (P), and potassium (K). Together they make up the trio known as NPK. One of the important factors to determine the quality of soil and serves as a source of nutrients for improving the physical and biological properties of soils in addition to productivity is Organic matter. The soil chemical environment is dynamic and reactions that maintain dilute solutions of nutrient elements are indispensable for continual plant growth. The nutrient transformation and its availability in soils depend on pH, clay minerals, cation, and anion exchange capacity. The presence of dense vegetation affords the soil adequate cover, thereby reducing the loss of macro and micronutrients that are essential for plant growth and energy fluxes. Changes in the soil chemical properties in the form of P mineralization-immobilization of organic P are strongly influenced by seasonal variations in temperature, moisture, plant growth, and root activity, and by organic matter accumulation from litter fall.

Study Area and Soil Sampling:

The present study was carried out to assess the soil physicochemical characteristics at various seasonal and altitudinal gradients of the Himalayan region of Khyber Pakhtunkhwa. The soil samples were collected from the rhizosphere of *Taxus wallichiana* L. at various altitudes with four replications. About 1 kg of composite sample was collected at a depth of 0 – 30 cm from each site and then properly packed, labeled, and brought to the soil chemistry lab, Pakistan forest institute, Peshawar. Soil samples were air-dried, grinded, and sieved with a 2mm sieve and then analyzed for the following soil properties i.e. Soil texture, pH, EC, Soil organic matter, available nitrogen, AB-DTPA extractable phosphorous and potassium, and the microelements (Zn, Cu, Fe, Pb, and Cd).

RESULTS

Table 1: Soil Physico- Chemical Charactristics of Galiyat-Khyber Pakhtunkhwa, Pakistan.

S. No	Location	Specie	Textural Class	pH	EC (dSm^{-1})	$caCo_3$ (%)	OM (%)
1	Bara Gali-1	Taxus W.	Sandy loam	7.5	0.75	1.25	3.72
2	Bara Gali-2	Taxus W.	Sandy loam	7.4	0.73	1.25	3.25
3	Bara Gali	Pinus W.	Sandy loam	7.5	0.84	2.5	3.36
4	Dunga Gali-1a	Taxus W.	Sandy loam	6.7	0.73	10.25	4.85
5	Dunga Gali-1b	Taxus W.	Sandy loam	6.8	0.88	12.5	3.84
6	Dunga Gali-2a	Pinus W.	Sandy loam	7.0	0.86	1.25	2.17
7	Dunga Gali-2b	Taxus W.	Sandy loam	7.1	0.72	3.75	1.94
8	Ayubia (PTDC)-1a	Taxus W.	Sandy loam	7.2	0.72	12.5	1.82
9	Ayubia (PTDC)-1b	Pinus W.	Sandy loam	7.4	0.82	1.25	3.01
10	Ayubia (PTDC)-1c	Taxus W.	Sandy loam	7.3	0.83	12.5	3.01
11	Ayubia -2a	Pinus W.	Sandy loam	7.4	0.80	10.0	2.41
12	Ayubia-2b	Taxus W.	Sandy loam	7.7	0.86	2.50	2.53
13	Ayubia-2c	Pinus W.	Sandy loam	7.4	0.82	2.50	3.13
14	Kuldana-1a	Taxus W.	Sandy loam	7.2	0.82	3.75	3.01
15	Kuldana-1b	Pinus W.	Sandy loam	7.5	0.73	8.75	2.77
16	Kuldana-2	Taxus W.	Sandy loam	7.4	0.72	6.25	2.17
17	Kuldana-3	Grassland	Loam	7.5	0.65	1.0	1.46
18	Kuldana	Grassland	Sandy loam	7.5	0.81	1.25	3.25
19	Murree Express-1a	Taxus W.	Sandy loam	7.3	0.69	8.75	3.25
20	Murre Express-1b	Taxus W.	Sandy loam	7.1	0.81	1.25	2.29
21	Muree site-1	Taxus W.	Silty loam	7.4	0.75	8.75	2.29
22	Muree Site-2	Taxus W.	Sandy loam	7.3	0.71	5.0	2.17

Table 2: Soil Moisture Content and Macro nutrient analysis of Galiyat-Khyber Pakhtunkhwa, Pakistan.

S.No	Location	Specie	N (%)	P (mg kg^{-1})	K (mg kg^{-1})	MC (%)
1	Bara Gali-1	Taxus W.	0.069	6	168	10.72
2	Bara Gali-2	Taxus W.	0.074	6	184	19.14
3	Bara Gali	Pinus W.	0.081	47	52	30.69
4	Dunga Gali-1a	Taxus W.	0.063	4	134	8.67
5	Dunga Gali-1b	Taxus W.	0.081	9	108	9.70
6	Dunga Gali-2a	Pinus W.	0.089	9	38	13.05
7	Dunga Gali-2b	Taxus W.	0.074	13	166	10.45
8	Ayubia (PTDC)-1a	Taxus W.	0.074	6	80	93.54
9	Ayubia (PTDC)-1b	Pinus W.	0.081	4	48	28.28
10	Ayubia (PTDC)-1c	Taxus W.	0.063	9	60	55.88
11	Ayubia -2a	Pinus W.	0.081	26	112	62.24
12	Ayubia-2b	Taxus W.	0.074	46	148	46.91
13	Ayubia-2c	Pinus W.	0.081	15	40	5.20
14	Kuldana-1a	Taxus W.	0.063	11	64	30.77
15	Kuldana-1b	Pinus W.	0.063	4	70	32.42
16	Kuldana-2	Taxus W.	0.063	4	52	24.30
17	Kuldana-3	Grassland	0.045	16	64	33.33
18	Kuldana	Grassland	0.057	9	152	69.68
19	Murree Express-1a	Taxus W.	0.023	9	68	26.47
20	Murre Express-1b	Taxus W.	0.069	25	162	15.25
21	Muree site-1	Taxus W.	0.046	9	100	26.84
22	Muree Site-2	Taxus W.	0.057	6	66	40.84

Table 3: Soil Micro Nutrient Analysis of Galiyat-Khyber Pakhtunkhwa, Pakistan.

S.No	Location	Specie	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Cu (mg kg^{-1})	Cd (mg kg^{-1})	Pb (mg kg^{-1})
1	Bara Gali-1	Taxus W.	4.354	27.986	1.842	0.112	3.376
2	Bara Gali-2	Taxus W.	3.266	20.990	1.382	0.084	2.532
3	Bara Gali	Pinus W.	5.007	32.184	2.118	0.129	3.882
4	Dunga Gali-1a	Taxus W.	2.952	9.568	1.036	0.115	1.844
5	Dunga Gali-1b	Taxus W.	2.214	7.176	0.777	0.086	1.383
6	Dunga Gali-2a	Pinus W.	3.247	10.525	1.140	0.127	2.028
7	Dunga Gali-2b	Taxus W.	3.690	11.960	1.295	0.144	2.305
8	Ayubia (PTDC)-1a	Taxus W.	2.918	29.598	0.573	0.090	1.014
9	Ayubia (PTDC)-1b	Pinus W.	3.648	36.998	0.716	0.113	1.268
10	Ayubia (PTDC)-1c	Taxus W.	4.195	42.548	0.823	0.130	1.458
11	Ayubia -2a	Pinus W.	3.633	19.536	0.847	0.099	0.915
12	Ayubia-2b	Taxus W.	4.274	22.984	0.996	0.116	1.076
13	Ayubia-2c	Pinus W.	4.830	25.972	1.125	0.131	1.216
14	Kuldana-1a	Taxus W.	3.663	48.845	0.947	0.133	1.280
15	Kuldana-1b	Pinus W.	3.078	41.046	0.796	0.112	1.076
16	Kuldana-2	Taxus W.	2.678	35.710	0.693	0.097	0.936
17	Kuldana-3	Grassland	1.338	12.07	1.316	0.112	1.076
18	Kuldana	Grassland	1.525	13.760	1.500	0.128	1.227
19	Murree Express-1a	Taxus W.	2.742	23.568	0.716	0.111	1.652
20	Murre Express-1b	Taxus W.	2.961	25.453	0.773	0.120	1.784
21	Muree site-1	Taxus W.	6.924	28.4355	0.717	0.084	1.671
22	Muree Site-2	Taxus W.	9.232	37.914	0.956	0.112	2.228

Publication in 2023:

Published one research papers in the Pakistan Journal of Forestry (PJF) with the following titles:

i. Nutritive Value Analysis of Some Fodder Tree Species

3.3 Forest Pathology

3.3.1 Incidence of Kail mortality in Dir Kohistan Forest Division, Kumrat

Location: Kumrat Valley, Dir Kohistan Forest Division

Principle investigator: Mahnoor Baloch,

Designation: Research Officer (Pathology)

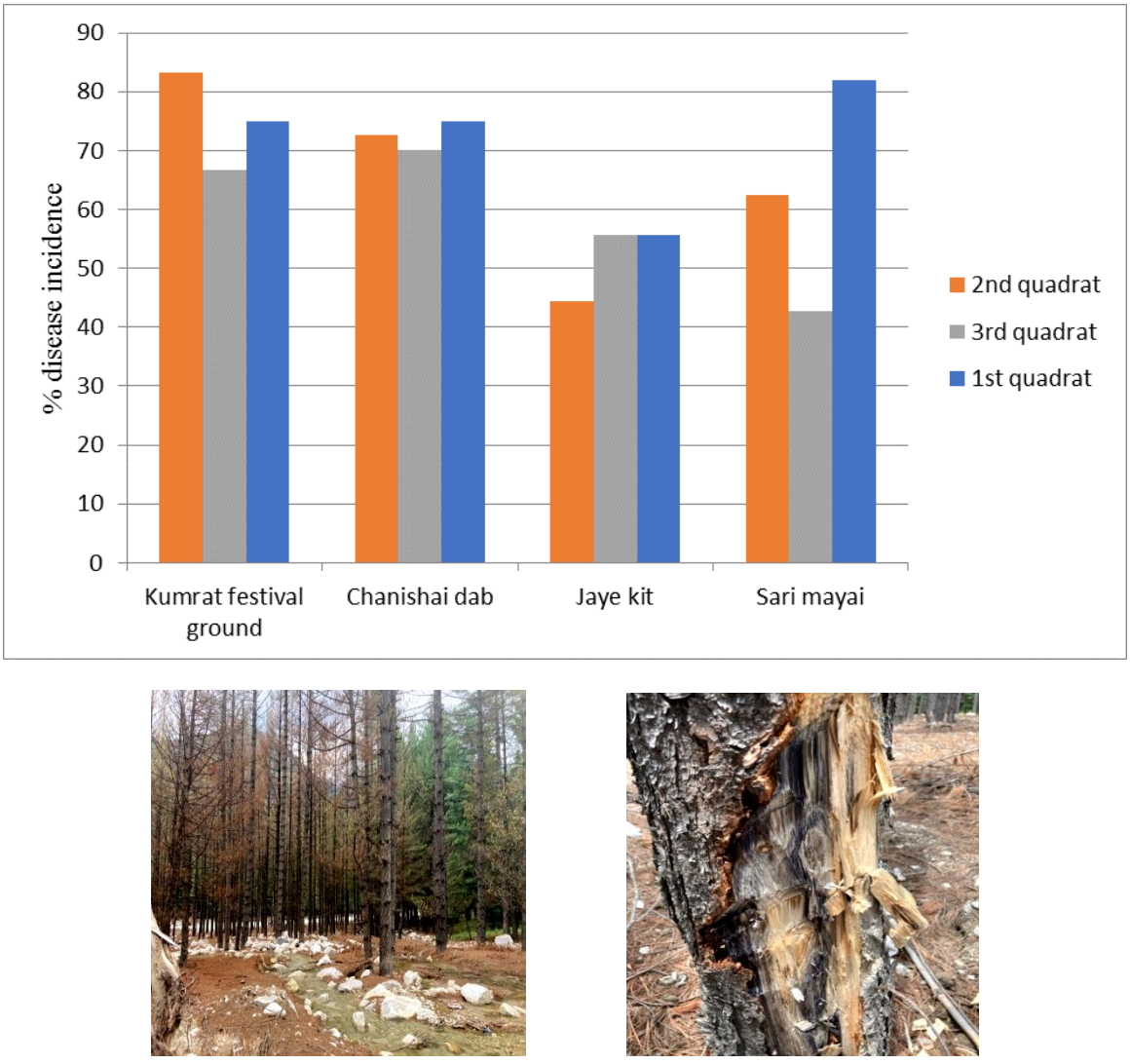
Year of commencement: 2023

Introduction:

Pinus wallichiana commonly known as Blue Pine (Kail) is an important coniferous tree specie in Pakistan. It grows in temperate areas of the country at altitude ranging from 1800 m to 4300 m, attaining height up to 50 m. Mortality of this specie in Dir Kohistan Forest Division, Kumrat valley was reported by DFO and approached Pakistan Forest Institute to investigate the cause of problem and suggest appropriate remedial measures. On this account, a team of PFI researchers visited Kumrat festival ground, Chanishai dab, Jaye kit and Sari mayai areas of Kumrat valley on 25/07/2023 to determine the cause of problem. To investigate the problem trees were observed to find out various factors responsible for deteriorating Kail forests in Kumrat valley. The problem started in early summer and progressed rigorously during the month of June and July, 2023. The problem was more severe in flood affected plain areas of the valley as compare to nearby elevated areas. Affected trees had dried and brown needles which remained hanging to the tree. The branches of trees were also drying. The bark of some trees under stress appeared red in color. Upon the removal of bark black colored fungal growths were observed invading the vascular tissues of the trees. The roots of infected trees were found water soaked and decayed. On severely affected trees white and green colored fungal mycelium were observed on the surface of branches and root. Overall, the diseased trees appeared brown and wilted. Signs of insect borers were also seen on infested branches. The disease was more severe on mature Kail trees and appeared randomly across the entire forest. From each locality three quadrates of 18×18 m were selected randomly. Number of trees per quadrat ranged from 40 to 60. Plants were visually observed for the presence of disease symptoms and percentage incidence was calculated from each quadrat using following formula:

$$\% \text{ disease incidence} = \frac{No\ of\ tress\ infected}{Total\ no\ of\ trees\ observed} \times 100$$

Disease incidence calculated from various quadrats is given in figure below. Almost all the quadrates were moderately or heavily infected. Needles, stem, bark and roots from symptomatic trees were collected and brought to laboratory for identification of causal pathogen.



(a) **(b)**

Fig 1: a. Intensive wilting of Kail trees in Kumrat valley, b. Fungal growth on affected tree trunk

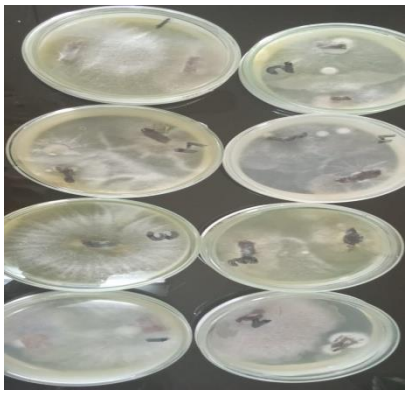
Isolation and identification of pathogen:

Samples were collected from trees which showed diseased symptoms; each sample consisted of needles, stem, bark and root. Samples were carefully placed in polythene bags, labeled and shifted to forest pathology laboratory for the identification of pathogens associated with Kail mortality. Tree needles, stem, bark and roots were cut into 1 to 2 cm long pieces, sterilized with 0.1% mercuric chloride and rinsed with distilled water. Samples were then placed on petri plates containing autoclaved Potato Dextrose Agar (PDA) media. Petri plates were incubated for 7 days at 25–30°C temperature. Fungal mycelium were visually observed and re-cultured repeatedly to isolate the causal fungi. Morphology of fungal cultures was examined under stereomicroscope. From each culture slides were prepared and observed under compound microscope to study fungal structures such as hyphae, spores etc.

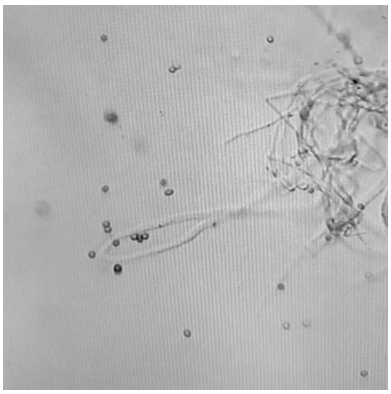
Table 1: Morphology and microscopic features of isolated fungi

S. No	Fungal Genus	Fungal mycelium	Microscopic features
1	*Fusarium spp.*	Fibrous or ropy white color mycelium with a tinge of orange	**Microspores:** one or two celled oval shaped asexual spores of fungi produced abundantly **Macrospores:** slightly larger than microspores, septate, fusiform and cylindrical in shape
2	*Phoma spp.*	White cottony	Pear shaped fruiting bodies (known as Pycnidia) bearing asexual spores

Fusarium is a soil inhabiting fungus which enters the plant through roots, penetrates root cortex and endodermis and move towards xylem. It attacks xylem tissues of stem and leaves, causing wilting and death of its host plant. *Phoma* is also plant pathogenic fungi; however some species in this genus are saprobic and often cause wood decay.

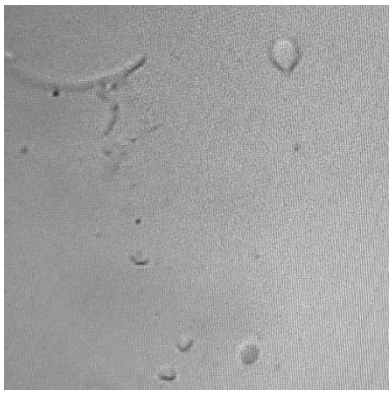


(a)



(b)

(c)



(d)

Fig 2: **a.** Fungal mycelium growth on PDA media containing affected Kail samples.

b. oval shaped microspores or micro-conidia of fungi.

c. Fusiform macrospores or macro-conidia of fungi.

d. Pyriform pycnidia of fungi.

Miscellaneous:

- Lectures were delivered to the BS forestry on forest pathology.
- Students from various universities visited pathology herbarium and were briefed about diseased plant/tree specimens.
- Specimens in Pathology herbarium were disinfected, labeled properly and placed in new paper bags.
- Spirit was refilled in preserved specimen bottles and fresh naphthalene balls were placed in cupboards.
- Compilations and computerization of the specimens of pathology herbarium is in progress.
- Pathology garden was maintained and irrigated, new plant species are also added to garden.

4. NON TIMBER FOREST PRODUCE DIVISION

4.1. SERICULTURE BRANCH

4.1.1 Effect of Feeding Mix Mulberry Varieties on Growth and Development of C-21 strain of Silkworm (*Bombyx Mori* L.) and on their Cocoon Characters

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2023
Principal Investigator:	Muhammad Salman, Research Officer (Silkworm Rearing)

The present study was carried out in the Sericulture laboratories of Pakistan Forest Institute, Peshawar during spring and autumn silkworm rearing seasons 2023 to observe and study the developmental stages and performance of silkworm (*Bombyx mori* L.) C-21 strain and their cocoon characters.

Introduction

The science of rearing silkworm for the commercial production of raw silk is termed as sericulture and it includes the operations which are required for the production of silk fiber. *Bombyx mori* L. (Lepidoptera, Bombycidae) is the common silkworm. *B. mori* undergoes complete metamorphosis i.e. its life cycle passes through four stages including egg, larva, pupa and adult. Besides silk used in manufacturing of cloth, it is also used in making of surgical sutures, artificial blood vessel, tire lining, parachute, electric insulating material, oil, protein and artificial vitamins; even its waste material (excreta) is used as artificial diet for animals and as green manure for crops. Due to their higher organic content, *B. mori* excreta can be used as manure and as poultry and fish feed.

Sericulture is practiced in all the four provinces of Pakistan and also in Azad and Jammu Kashmir; however, the main activity of natural silk production is practiced around the irrigated forest plantation of Changa Manga, Kamalia, Chichawatni and Multan in Punjab province (Anonymous, 1990). Pakistan's economy, largely depend on Agriculture and its raw products. The production of raw silk is inadequate to meet requirements of the textile industry. If the textile industry is provided with adequate raw silk, Pakistan can not only save its precious foreign exchange (i.e. reduce imports) but can also improve its economy by exporting the surplus commodity. Since the majority of population lives in rural areas and the villagers including men, women and children can increase their income through rearing of *B. mori* in their spare time. This process ends earlier than wheat crop harvest. Even they can easily get two generation of *B. mori* one after the other.

B. mori adults are creamy white in colour with several faint brownish lines. They do not feed, rarely fly and usually live only for a few days. Each female lays 300 to 500 eggs and the eggs hatch in about 12 days. When used for a commercial purpose, the pupae are killed before the adults emerge, otherwise the emergence of the moths break the fibers into pieces. Each cocoon is composed of single thread of about 914 meters long. About 3000 cocoons are required to make a pound of silk. *B. mori* classification may be based on native regions, the number of generation in a year, i.e. voltinism, or even the number of larval moults. *B. mori* are also classified according to the rearing period, body markings or pattern, body color of freshly hatched larva, body color of mature larva, color of cocoon or color of egg.

The *B. mori* is host specific insect and feeds only upon leaves of mulberry (*Morus* species) to make cocoon as its protective layer. Mulberry belongs to Genus *Morus* of Family Moraceae. At present there are more than 1000 variety of mulberry, which are being cultivated and classified into three types *M. bombycis* K., *M. alba* L., and *M. latifolia* L. Mulberry leaves are rich in protein and

amino acids. It is known that there is high correlation between leaf protein level and production efficiency of cocoon shell, which means cocoon shell weight to the total amount of mulberry leaves consumed by the *B. mori*. Therefore, increase in protein level may lead to improvement in productivity of cocoons and silk. Different species of mulberry may have compositional differences and might lead to varying effects on *B. mori* growth and silk productions. The growth rate of *B. mori* larvae and subsequent silk production depend mainly on the nutrient contents of mulberry leaves. The nutritive value of mulberry leaves varies due to species and leaf maturity of the plant. Keeping in view the above-mentioned importance of B. mori and sericulture, the experiment was conducted with the objective to observe and study different life stages of silkworm C-21 strain and their cocoon quality.

Methodology

The lab equipment/tools used during the experiment were Rearing trays, Rearing stands, Incubator, Nets, Sulphur and Formalin, Digital weight machine, Cocoon reeling machine, Thermometer, Humidifier, Hygrometer, Water bath, Pruning scissors, Leaf cutting board, Knife, Leaf collecting basket, Vernier caliper, Spinning material, Racks, Sickle, Fine brush etc.

The study consist of thirty number of larvae and cocoons of Chinese C-21 strain. The following procedures were adopted for conducting the research work.

Disinfection of rearing room

In order to avoid infection by micro-organisms, the rearing room was whitewashed and then fumigated with sulphur dioxide gas. Rearing trays, stands, incubator and all other tools were disinfected with Formaldehyde (2%) solution. Similarly floor of the rearing room was washed with phenyl. Two days after disinfection, the rearing room was opened to expel the excess of fumes from it and to let the fresh air circulate inside the rearing room. *B. mori* eggs were disinfected with 2% formalin placed in the incubator for hatching at 26±2°C and 75±5% relative humidity.

Incubation of the *B. mori* eggs

For incubation the eggs of C-21 strain, were kept in incubator under the following climatic conditions:

Table 1. Climatic conditions for incubation of silkworm eggs

Days	Humidity	Light (Lux)	Temperature (°C)
1-3	70-75%	30-50	20
4	76-80%	30-50	20
5-6	80-85%	30-50	23-25
Till Hatching	80-85%	30-50	25-26

Silk Reeling

It is the process by which several cocoons are boiled together and then reeling singly. This is accomplished by unwinding the filaments. The cocoons are cooked continuously in a hot water bath

at 90±5°C and winding the resulting yarn onto a fast-moving reel. The data were collected on the following parameters:

i. Cocoon weight with floss (g)

30 larvae were randomly collected from experimental unit and their weight have been recorded with floss with the assistance of digital weighing balance.

ii. Cocoon weight without floss (g)

Floss was removed from 30 randomly selected cocoons and their weight was determined in grams with the aid of digital weight machine.

iii. Diameter of cocoons (mm)

The diameter of all 30 cocoons of Chinese C-21 were taken with the help of Vernier caliper.

iv. Length of cocoons (mm)

30 randomly selected cocoons of Chinese C-21 strain and length was measured with the help of Vernier caliper.

v. Cocoon Filament length (m)

Cocoon filament length of randomly selected cocoons were determined by the digital counter attached with silk reeling machine.

vi. Cocoon Filament Size

The cocoon filament size in terms of denier was assesssed using following formula:

$$Filament\ size\ (Denier) = \frac{Filament\ weight\ (g)}{Filament\ length\ (m)}\ X\ 9000$$

vii. Boiling and processing loss

Boiling and processing loss of 30 cocoocs weight was determined which had been selected from experimental unit.

Results

To observe the silkworm rearing and developmental stages, business filament and cocoon characters of Chinese C-21 strain the following outcomes of different parameters are tested, evaluated and recorded.

Table 2. Developmental stages of *B. mori* under lab conditions during 2022

Egg	9 – 10 days					
Larva	20 – 30 days	1st instar	2nd instar	3rd instar	4th instar	5th instar
		4-5 days	3-4 days	3-4 days	3-4 days	4-5 days

Pupa	8 – 10 days
Adult	5 – 10 days

Larvae Weight (gm)

The result of the 30 randomly selected larval weight showed in Table 3 indicates that the mean larvae weight was 2.6 gm. The highest larvae weight recorded was 3.6 gm while the lowest larvae weight was 1.4 gm.

Larvae Length (mm)

The result of the larvae length showed in Table 3 shows that the mean larvae length was 57 mm. The longest larvae length recorded was 67 mm and the shortest was 49 mm.

Table 3. Larvae weight and length of Silkworm.

S. No.	Larvae Weight (gm)	Larvae Length (mm)
Mean	2.6	57
Min	1.4	49
Max	3.6	67

Weight without floss and weight with floss of cocoons in (gm)

The results of the cocoon weight with floss and without floss are reproduced in Table 4. The mean cocoon weight with floss was 1.20 gm. The highest cocoon weight with floss was recorded 2.3 gm while the lowest cocoon weight with floss was 0.34 gm. The results further indicated that the mean cocoon weight without floss was 1.17 gm. The cocoon weight without floss varied between 1.76 gm and 0.32 gm.

Shell weight of cocoons in (gm)

The results of the cocoon shell weight are reproduced in Table 4. The mean cocoon shell weight was 0.26 gm while the highest cocoon shell weight recorded was 0.83 gm and the shortest was 0.16 gm.

Diameter and length of cocoons in (mm)

The results of the cocoon dimensions showed in Table 4 indicates that the mean cocoon length was 31.1 mm. The longest cocoon length was recorded 34 mm while the shortest cocoon length was 27 mm. Similarly, the mean cocoon diameter was 16.6 mm. The highest cocoon diameter was recorded 22 mm while the lowest cocoon diameter was 14 mm.

Table 4. Mean Cocoon length and diameter, Cocoon weight with floss, cocoon weight without floss and shell weight of Silkworm under lab conditions during 2022.

CL= Cocoon length; **CD=** Cocoon diameter; **CWWF=**Cocoon weight with floss; **CWWOF=** Cocoon weight without floss; **CSW=** Cocoon shell weight.

S. No.	CWWF(g)	CWWOF(g)	CSW(g)	CD(mm)	CL(mm)
Mean	1.20	1.17	0.26	16.6	31.1
Min	0.34	0.32	0.16	14	27
Max	2.3	1.76	0.83	22	34

Cocoon weight

Four randomly selected cocoons were selected for the reeling process. The mean cocoon weight was recorded 0.697 gm. The cocoon weight varies between 0.512 gm and 1.184 gm as shown in Table 5.

Temperature

The mean boiling temperature was recorded 87°C. Temperature varies between 85°C and 90°C as shown in Table 5.

Filament length

The mean cocoon filament length was 936.75 m. The longest cocoon filament length was recorded 1123 m while the smallest cocoon filament length was 757 m as shown in Table 5.

Filament wet weight

The mean cocoon filament wet weight was 0.354 gm. The highest cocoon filament wet weight was recorded 0.806 gm while the smallest was 0.125 gm as shown in Table 5.

Filament dry weight

The results showed that the mean filament dry weight was 0.231 gm. The highest filament dry weight was recorded 0.288 gm while the smallest was 0.191 gm as shown in Table 5.

Table 5. Mean cocoon weight, temperature, filament length, filament dry weight and filament wet weight of silkworm under lab conditions during 2022.

S. No.	CW (g)	Temp°C	FL (m)	FWW (g)	FDW (g)
Mean	0.697	87.5	936.75	0.354	0.231
Min	0.512	85	757	0.125	0.191
Max	1.184	90	1123	0.806	0.288

CW= Cocoon weight, **FL =** Filament length, **FWW =** Filament wet weight, **FDW =** Filament dry weight.

Conclusion:

Silkworm rearing is a profitable cottage industry. The natural silk is the queen of textile. The eggs are chilled at 5°C at least for four months before incubation. The eggs hatch in about 10 days. Usually a larva passes through four molts during 25±3 day larval lifespan. Larval stage is the only feeding stage. Among larval instars more than 92% feed is taken by 5th instar. The ideal conditions for silkworm rearing are temperature: 26±2°C and 75±5% relative humidity. However, these conditions are adjusted with changing stages of developmental biology. Another important requirement of silkworm rearing is hygienic conditions. It is necessary to disinfect rearing rooms, rearing tools and fixture. A packet of silk seed (eggs) comprising 20,000 eggs with a weight of 12 gm can produce 32-35 kg cocoons. A farmer can earn Rs.35-40,000 approximately in one month by rearing one packet of silk seed. The productivity of silkworm depends on silkworm strains quality and quantity of mulberry leaves. In most of the silkworm rearing countries, hybrids strains are reared instead of pure lines. The hybrid strains are vigorous and resistant against microbial diseases. By carefully controlling the temperature and humidity levels and managing the feeding of silkworms, you can ensure optimal growth and development, resulting in healthy and productive silkworms.

4.1.2 Silk Seed Production

Location: Pakistan Forest Institute, Peshawar
Year of commencement: 2023
Principal Investigator: Muhammad Salman, Research Officer (Silkworm Rearing)

Silk seed is a useful product for commercial utilization and the raw material for silk industry. Disease free silk seed is essential for silkworm rearing. During both spring and autumn rearing seasons, 2022 male and female moths of Chinese variety, Chinese female × Chinese male were self-coupled for 3-6 hours and disease free eggs were produced from them. The duration of each coupling was 3 hours. The silk seed were processed thermally and disinfect with 2% formalin. The eggs laid were preserved at proper temperature 2.5°C in the refrigerator and would be studied for further investigation and rearing in the next rearing season.

Miscellaneous

- Published research paper titled “Current status of Apiculture and its impact on local livelihood in District Bannu” in the Pakistan Journal of Forestry.
- Published another research paper titled “Effect of feeding mix mulberry varieties on growth and development of C-21 strain of silkworm (*Bombyx mori* L.) and on their cocoon characters” in the Pakistan Journal of Forestry.
- Published research article in the Pakistan Journal of Forestry titled “Diversity of insect pollinators and their relative abundance associated with moringa (*Moringa oleifera*) in Peshawar”.
- Submitted one review paper titled “Management of Climatic factors for effective silkworm rearing (*Bombyx mori* L.) and higher quality silk yield: A Review” in the Pakistan Journal of Forestry. (under review)
- Delivered lectures on Forest Entomology and NTFP subject to BS Forestry classes at Forest Education Division of PFI.
- Delivered lectures to students and visitors on Mulberry Plantation & Sericulture at field and labs.
- Supervised three internee students of BS Zoology (last semester) of Government Frontier College for Women Peshawar and facilitated them in finalizing their thesis work.
- Submitted a newsletter on NTFP Division progress and activities to Extension Branch.
- Submitted two project proposals titled “Impact of different Mulberry Varieties on development of Silkworms” & “Promoting Quality Cocoon Production and Processing for Sustainable Livelihoods in Khyber Pakhtunkhwa, Pakistan”.

- Prepared a concept paper on titled “Assessing Impact of Environmental factors on development of different Mulberry Silkworm (*Bombyx mori* L.) varieties and Cocoon filament production”.

- Participated in:

  i. One day Training Workshop on “Health, Safety, Environment and Biodiversity” organized jointly by Centre of Plant Biodiversity University of Peshawar and Safety Standard Consultants, Islamabad on November 29, 2022.
  ii. One Week IT Training Course in “Online Platforms for Collaboration & Communication” organized by Staff Training Institute (STI) Establishment Department Government of Khyber Pakhtunkhwa on November 20-24, 2023.
  iii. Seminar on “GHAR: Green Housing, Affordable, Resilient Challenges and Opportunities” organized by UNOPS/Pakistan on 20th December, 2023 at Panning & Development Department, Civil Secretariat, Peshawar.
  iv. One day Workshop on “Mushroom Cultivation and Popularization as a Cottage Industry” organized by Pakistan Atomic Energy Commission (PAEC) and Nuclear Institute for Food & Agriculture (NIFA) on 21st December, 2023 at Tarnab, Peshawar.
  v. Two days Training in “Landscaping” conducted by Forestry Research Division (FRD), Pakistan Forest Institute (PFI) Peshawar under the project entitled “Improving the Efficiency of Forest Management through the Development of Volume Tables, Yield Tables and Growth Models for Coniferous Forests of Khyber Pakhtunkhwa” from December 26-27, 2023.

In addition to above studies/experiments, following activities were conducted:

- Disinfection and cleaning of rearing rooms, sheds and appliances was done at Sericulture Labs.
- Silk seed preservation was conducted at 2.5°C.
- Curative chemical control measures were carried out against termites, field rats and other pests at nurseries and office buildings at PFI, campus.
- Mulberry nursery, both tube plant and bed plantation was maintained in Sericulture Research Garden.
- Cleaning, hoeing and pruning were carried out in mulberry plantation at Pakistan Forest Institute, Peshawar during the rearing seasons of silkworm.

4.1.3 Exploring the Intricate Biochemistry of Silk Protein: From Structure to Function

Location:	Pakistan Forest Institute, Peshawar
Year of Commencement:	2023
Principal Investigator:	Mir Manzar Ud Din, Research Officer (Cocoon & Silk Technology).

Silk is a natural protein fiber produced by several species of insects, spiders, and silkworms. Silk fibers have been used for a wide range of applications, such as clothing, textiles, and medical devices, due to their unique mechanical properties, biocompatibility, and biodegradability. The mechanical properties of silk fibers are determined by their biochemical composition and structure, which includes different types of proteins, such as fibroin and sericin. This study focused on the biochemistry of silk fibroin, the primary protein component of silk fibers, which is responsible for its mechanical strength and elasticity.

Molecular Structure:

Silk fibroin is a large, complex protein with a molecular weight of approximately 350 kDa. It is composed of repeating units of amino acids, primarily glycine, alanine, and serine, which account for over 90% of the amino acid content. The amino acid sequence of silk fibroin is highly conserved across different species, indicating the importance of its structural and functional properties. The primary structure of silk fibroin consists of a repetitive sequence of amino acids, which forms a β-sheet secondary structure. The β-sheet structure is responsible for the mechanical strength of silk fibers, as it provides a rigid and stable framework that allows the fiber to resist deformation under stress.

Biosynthesis:

Silk fibroin is synthesized by specialized cells called silk glands, which are located in the abdomen of silkworms and spiders. The process of silk fibroin biosynthesis involves the synthesis of the fibroin protein in the silk gland cells and its subsequent secretion into the lumen of the gland. The fibroin protein is then extruded through a specialized spinneret, which is a tube-like structure that allows the protein to be processed into a fiber. During the extrusion process, the protein undergoes a series of physical and chemical changes, which contribute to the unique properties of silk fibers.

Properties:

Silk fibers possess several unique properties that make them an attractive material for various applications. The mechanical properties of silk fibers, such as their tensile strength and elasticity, are among the most notable. Silk fibers have a high tensile strength, meaning they can withstand significant tension without breaking. They also have a high elasticity, meaning they can stretch without breaking and return to their original shape when the tension is released. In addition to their mechanical properties, silk fibers are also biocompatible and biodegradable, making them suitable for use in medical applications, such as tissue engineering and drug delivery.

Applications:

Silk fibers have a wide range of applications in different industries, such as textiles, medicine, and electronics. In the textile industry, silk fibers are used to produce high-quality fabrics and garments due to their unique properties, such as their luster, softness, and durability. In the medical industry, silk fibers are used for tissue engineering, wound healing, and drug delivery due to their biocompatibility and biodegradability. In the electronics industry, silk fibers are used as a substrate for flexible and biodegradable electronic devices.

A. Silk Fibroin Characterization:

- **Molecular Weight Analysis:** The molecular weight of the extracted silk fibroin was determined by gel permeation chromatography (GPC). The analysis revealed a molecular weight of approximately 350 kDa, consistent with previous studies. This high molecular weight is indicative of the presence of intact silk fibroin, essential for its structural integrity and mechanical properties.
- **Amino Acid Composition:** Amino acid composition analysis demonstrated that silk fibroin primarily consists of glycine, alanine, and serine, accounting for over 90% of the total amino acid content. These amino acids play a crucial role in forming the β-sheet secondary structure of silk fibroin, contributing to its mechanical strength.
- **Secondary Structure:** Fourier Transform Infrared Spectroscopy (FTIR) analysis confirmed the presence of a predominant β-sheet secondary structure in silk fibroin. The β-sheet

structure is known to provide rigidity and stability to the fiber, allowing it to resist deformation under stress.

The characterization results indicate that the extracted silk fibroin possesses the key structural and biochemical properties necessary for its mechanical strength and elasticity.

B. Mechanical Properties of Silk Fibers:

- **Tensile Strength:** Mechanical testing of silk fibers showed a high tensile strength, exceeding 1000 MPa, which is consistent with the exceptional strength reported in the literature. This remarkable tensile strength is attributed to the unique combination of molecular composition and β-sheet secondary structure.
- **Elasticity:** In addition to high tensile strength, the silk fibers also exhibited exceptional elasticity, 15-30%. They could stretch significantly without breaking and quickly return to their original shape when the tension was released. This property is vital for applications requiring flexibility and resilience.

C. Biosynthesis of Silk Fibroin:

- **Gene Expression Analysis:** The expression of fibroin-encoding genes in silk gland cells was analyzed using quantitative real-time polymerase chain reaction (qPCR). The results revealed a significant up regulation of fibroin mRNA during the silk synthesis process. This indicates active silk fibroin biosynthesis in silk gland cells.

The findings demonstrate the dynamic process of silk fibroin biosynthesis within the silk glands of silkworms, shedding light on the molecular mechanisms underlying silk production.

D. Potential Applications:

- **Fabrication of Silk-Based Scaffolds:** Three-dimensional porous scaffolds were successfully fabricated using silk fibroin via a freeze-drying technique. Scanning electron microscopy (SEM) analysis revealed well-defined pore structures with an average pore size of approximately 200 micrometers. These scaffolds hold promise for efficient cell infiltration, nutrient exchange, and potential applications in tissue engineering.
- **Biomedical Applications:** Cell culture experiments on silk-based scaffolds demonstrated excellent biocompatibility. Mammalian cells exhibited high viability, proliferation, and adhesion, suggesting that silk fibroin is a suitable substrate for tissue engineering and wound healing.
- **Textile and Electronic Applications:** The use of silk fibers in textiles resulted in high-quality fabrics with desirable properties, including luster, softness, and durability. In the electronics industry, silk fibers served as a biodegradable substrate for the development of flexible electronic devices, highlighting their potential for sustainable technology.

Effect of Temperature:

1. **Temperature Extremes:** Extreme temperatures can have detrimental effects on silk production. High temperatures exceeding 35°C can lead to the denaturation of silk proteins, resulting in reduced fiber quality. Conversely, exposure to low temperatures below 15°C can slow down the metabolic processes involved in silk protein synthesis, potentially delaying silk production.
2. **Optimal Temperature Range:** The optimum temperature recorded was 23°C to 30°C with a relative humidity between 70-80%. This range supports the activity of silk glands and efficient silk protein synthesis. Deviations from this range can significantly impact silk production efficiency.

Effect of pH:

1. **Acidic Environment:** The silk gland lumen maintains an acidic pH, which is essential for silk protein solubility and processing. The acidic environment aids in the proper extrusion and spinning of silk fibers. Variations in pH can disrupt silk protein solubility and spinning. The present study revealed that pH within the range of 5.5 to 6.5, is essential for silk protein solubility and processing. At pH values significantly higher than neutrality (pH > 8), silk proteins are highly susceptible to denaturation and degradation. This can result in the loss of the protein's structural integrity and mechanical properties. Alkaline conditions are generally detrimental to silk protein stability and fiber formation.
2. **pH Regulation:** Silk gland cells have mechanisms for pH regulation to ensure the acidic conditions necessary for silk protein processing are maintained. Disturbances in these regulatory mechanisms can affect silk protein synthesis and fiber formation.

Effect of Nutrients:

1. **Amino Acid Availability:** Silk fibroin is composed of specific amino acids, including glycine, alanine, and serine. The availability of these amino acids in the diet of silk-producing organisms is crucial for silk protein synthesis. Imbalances or deficiencies in essential amino acids can affect the composition and properties of silk fibroin.
2. **Nutrient Imbalances:** Inadequate or imbalanced nutrition can lead to variations in silk protein expression and properties. Proper nutrition, including a balanced supply of amino acids, is essential for robust silk protein synthesis.

The biochemistry of silk protein plays a critical role in determining its mechanical, physical, and chemical properties, which make it a versatile biomaterial with various applications in different industries. In conclusion, the comprehensive characterization of silk fibroin, coupled with the assessment of its mechanical properties and biosynthesis process, has provided valuable insights into the multifaceted potential of silk-based materials. The remarkable tensile strength, elasticity, and biocompatibility of silk fibers make them promising candidates for applications in biomedicine, textiles, and electronics. The findings of this study not only deepen our understanding of silk fibroin biochemistry but also highlight its significance across diverse domains, paving the way for innovative solutions in various industries. Future research on the biochemistry of silk protein may lead to the development of new and innovative applications for this remarkable biomaterial.

Publications:

The following papers have been published.

i. Diversity of insect pollinators and their relative abundance associated with moringa (*Moringa oleifera*) in Peshawar. (Pakistan journal of Forestry).

ii. Effect of feeding mulberry mix verities on growth and development of C-21 strain of silk worm (*Bombyx mori* L.) and on their cocoon characters. (Pakistan journal of Forestry).

iii. Efficacy of a parasitoid and synthetic insecticide against Woolly apple aphid, *Eriosoma lanigerum* (Hausmann) (Homoptera: Pemphigidae) on apple at Skardu-Baltistan. (Journal of Entomology and Zoology Studies).

iv. Study on synthetic and botanical insecticidal control of *Aulacophora foveicollis* (Lucas) (Chrysomelidae: Coleoptera) on three pumpkin varieties in Peshawar. (Journal of Entomology and Zoology Studies).

The following papers have been submitted to the ‘Pakistan Journal of Forestry’ for publication.

i. Exploring the Intricate Biochemistry of Silk Protein: From Structure to Function.

ii. Factors Affecting Cocoon Quality: A Review of the factors influencing cocoon quality, such as genetics, environmental conditions, and feeding habits of silkworms.

Internship:

Two BS-Zoology students of Govt. Frontier College for Women Peshawar were supervised for their BS internship. Details are as under:

i. Morphological diversity and adaptation, A comprehensive study on the order Blattodea.

ii. Exploring the species composition and morphology of butterflies in district Peshawar.

Miscellaneous:

i. Prepared and submitted a concept paper titled, Investigating the Prevalence and Control Measures of Diseases Affecting Silk Worms in Commercial Silk Production.

ii. Prepared and submitted project proposal titled, Promoting Quality Cocoon Production and Processing for Sustainable Livelihoods.

iii. Submitted a research note to the health department through secretary climate change, forestry, environment & wildlife department, government of Khyber Pakhtunkhwa under the subject of research report on combatting malaria and dengue fever: policy recommendations for effective vector control and prevention strategies.

4.2 FOREST ENTOMOLOGY BRANCH

4.2.1 Taxonomic Studies of the Genus *Megachile* from Coniferous Forests of Khyber Pakhtunkhwa, Pakistan

Location:	Coniferous Forests of Khyber Pakhtunkhwa
Year of commencement:	2022 to date
Principal investigator:	Naveed Ahmed, Director (NTFP)

Megachilidae being third largest and diverse family of bees, containing more than 4000 described species worldwide (Michener, 2007; Ascher & Pickering, 2013). This genus consists of leafcutter bees, mason bees and resin bees (Sardar *et al*. 2021). Currently more than 150 species of Genus *Megachile* in a several subgenera are recognized as valid Southeast Asian species (Ascher & Pickering, 2020). Taxonomic studies on Genus *Megachile* Latreille, 1802 bear a lot of significance, because of their role as main pollinators in Agro-landscape ecosystems. Taxonomic studies provide information on the identification, classification as well as their diversity and also provide floral association which will contribute to the better understanding of pollination biology in relation to important crop plants.

The present study is restricted to the species of the Genus *Megachile* Latreille, 1802 from Coniferous forests of Khyber Pakhtunkhwa Province. While bees were visiting on the flowers, they were collected. Then bees were killed with ethyl acetate. After collection, bees properly stretched and then followed for preservation. Keys known for eminent workers of Oriental region like Bingham (1897), Gupta (1997) and Michener (2007) were followed.

Genus *Megachile* Latreille, 1802

Megachile Latreille, 1802. Histoire naturelle de fourmis: 413.

Diagnosis: Body black and robust, covered with white, yellowish-grey or reddish-brown, short or long pubescence. Head rounded, female mandibles 3-5 teeth seldom with 6 teeth; mandibles with or without cutting edges, cutting edges if present than at the base of one or more interspace; in males mandibles narrower, 2-3 dentate, with a long triangular process ventrally, scutellum without prominent axillary spines. Arolia absent, in female scopa (pollen collecting hairs) present on Sternum S2-S5, sometimes on S6, entirely absent on hind tibia. In males tergum 6 with a narrow ventral tooth laterally or without it.

***1. Megachile (Creightonella) albifrons* (Smith, 1853)**

Female Description. Body length 14.25-17.82 mm; Clypeus convex, rounded anteriorily and hidden under thick pubescence, clypeus with median longitudinal impunctate line, mandible 6 dentate with incomplete cutting edge on 2nd and 3rd interspace; dense white pubescence on face, thorax covered with white pubescence on lateral sides, forewing is dark fuscous apically and subhyaline basally, anterior leg with fuscous pubescence mixed with few white hairs, intermediate and posterior

legs with few white hairs; tegulae black in colour; T6 disc clothed with black hairs; scopa S2-S5 with white hairs, S6 with erect black hairs.


2. *Megachile (Pseudomegachile) lanata* (Fabricius, 1775)

Female Description. Body length 12.17-16.58 mm; face with red fulvous pubescence, clypeus apical margin slightly emarginated medially, anteriorly transverse, mandibles quardidentate without cutting edges, mesosoma pubescence, first 2 terga is orange or with fulvous pubescence, 3rd to 5th terga have white apical bands and sparsely lined with erect black hairs, tegulae orange yellow; scutellum rounded; wings flavo-hyaline, legs black with fulvous pubescence; Scopa on S2-S5 pale white, S6 is dominated with short black hairs.


3. *Megachile (Eutricharaea) femoratella* (Cockerell, 1918)

Female Description. Body length 4.5-6.1mm; body black, head and thorax finely punctured, white pubescence on face, clypeus slightly convex with a median longitudinal line, clypeus anterior margin slightly arched, mandibles quaridentate with very small cutting edge in second interspace and complete cutting edges in third interspace mid and hind trochanter and femora entirely dull orange, posterior tibia and tarsi with pale whitish hair; white transverse bands on apical margins of abdominal segments T1-T5.


***4. Megachile (Callomegachile) lerma* (Cameron, 1908)**

Female Description. Body length 11.5-13.80 mm; Black pubescence on face and body, base of the clypeus and supra clypeal area strongly convex; mandible broad, quardidentate without cutting edges; head and thorax punctured and coarsely pitted; T3, T4 and T5 with white fasciae; white fasciae of T3 mixed with fulvous pubescence; lateral aspect of T3–T6 with erect black hairs; T6 disc covered with black pubescence, scopa pale white from S2-S5


***5. Megachile (Callomegachile) pseudodisjuncta* (Kumari, 2018)**

Female Description. Body length 13.15-14.83 mm; Clypeus convex, arched anteriorily, mandible tridentate without cutting edges, mandible with prominent carina at the base, face with black pubescence, lateral aspect of thorax with mixture of black and white hairs, scutum slightly convex, bare, scutellum with carinate on lateral side, swollen pronotal lobe, tegula black, wings hyaline. T1 with mixtures of white and fulvous hairs, T2-T6 long erect black hairs on lateral aspect, Scopa bright fulvous from S2-S5, S6 with black hairs.


***6. Megachile (Aethomegachile) laticeps* (Smith, 1853)**

Female Description. Head wider than the thorax, head and thorax strongly punctuate, clypeus slightly emarginate, mandible with 5 teeth, incomplete or rudimentary cutting edge in the 2nd interspace and conceal cutting edges in the 3rd interspace, white hair bands on lateral aspect of abdominal segments T2 to T4, but fulvous on T1, first four abdominal segments have entire fulvous hair-bands, scopa pale white from S2-S5, black on S6.


***7. Megachile (Amegachile) bicolor* (Fabricius, 1781)**

Female Description**.** Body length 14.16-16.56 mm; clypeus subtriangular, mandible 4 dentate with two cutting edges on 3rd and 4th interspace, supra clypeal area medially flattened and sloping at the sides, scutellum finely punctuate and rounded , slightly overhanging on metanotum; wings fusco-hyaline, abdomen above with rich fulvous red, T6 disc covered with suberect dark greyish pubescence, Intermediate and posterior tarsi fulvous red on the underside, Scopa white from S2 to S6, S6 sparsely covered with black hairs.


***8. Megachile (Callomegachile) cephalotes* Smith, 1853**

Female Description. 11.75 -13.82mm; Clypeus strongly convex, slightly emarginated, apical margin truncate, mandible tridentate long, narrow and curved, first and second teeth same in length and also same and equal in interspace distance, 2nd interspace distance long, incurved to 3rd tooth, wings flavohyaline, legs black, 1st ,2nd and 3rd abdominal segments with transverse white fascia, T2-T6 with suberect black hairs on lateral sides, Scopa without white apical fasciae, Scopa pale white from S2-S5.


4.2.2. Survey of Wild Bee Pollinators from Coniferous Forests of Khyber Pakhtunkhwa

Location:	Coniferous Forests of Khyber Pakhtunkhwa
Year of commencement:	2023 to date
Principal investigator:	Naveed Ahmed, Director (NTFP)

A pollinator is an animal that moves pollen from the male anther of a flower to the female stigma of a flower. This helps to bring about fertilization of the ovules in the flower by the male gametes from the pollen grains. Approximately, 80 percent of all flowering plants species are pollinated by animals, including vertebrates and mammals but the main pollinators are insects and

among insects, bees are most efficient pollinators. Pollinators are responsible for providing with a wide variety of orchard, agricultural crops, horticultural crops, forage production as well as forest trees. More than three quarters of the world's food crops rely at least on some parts on pollination by insects and other animals.

Surveys were conducted from different representative districts; Mansehra, Abbottabad, Malakand and Battagram. The bee specimens were collected with the help of Insect Net, Malaise Traps and Bowl Traps. Specimens were pinned by two methods. Small sized specimens will be mounted on a white card whereas large specimens were pinned directly between tegula and the middle of thorax towards right side. Every specimen was labeled with complete information. The preserved specimens were identified under microscope through different morphological characters. Identification was made with the help of available taxonomic keys, The Fauna of British India, by C. T. Bingham, (1897), The Bees of the World by C. D. Michener, (2007).

Table 1: List of Wild Bees collected during the Survey

S. No.	Family	No. of specimens	No. of species
1	Apidae	109	22
2	Megachilidae	88	15
3	Halictidae	35	08

Amegilla calceifera

Ceratina bryanti

Certina smaragdula

4.2.3.Diversity of insect pollinators and their relative abundance associated with moringa (*Moringa oleifera*) in Peshawar

Location: Medicinal Plant Garden, PFI Peshawar
Year of commencement: 2023
Principal investigator: Fazli Amin (Assistant Forest Entomologist)

This study aimed to explore the diversity and relative abundance of insects associated with the moringa tree. *Moringa oleifera* is a small, beautiful, deciduous tree with thin leaves belonging to Moringaceae family. It is a highly desirable plant found in many tropical and subtropical areas and is a multifunctional perennial crop. It is mainly a cross pollinated plant and needs insects for pollination. It provides food source to numerous pollinators and blossoms visitors from various groups of insect.

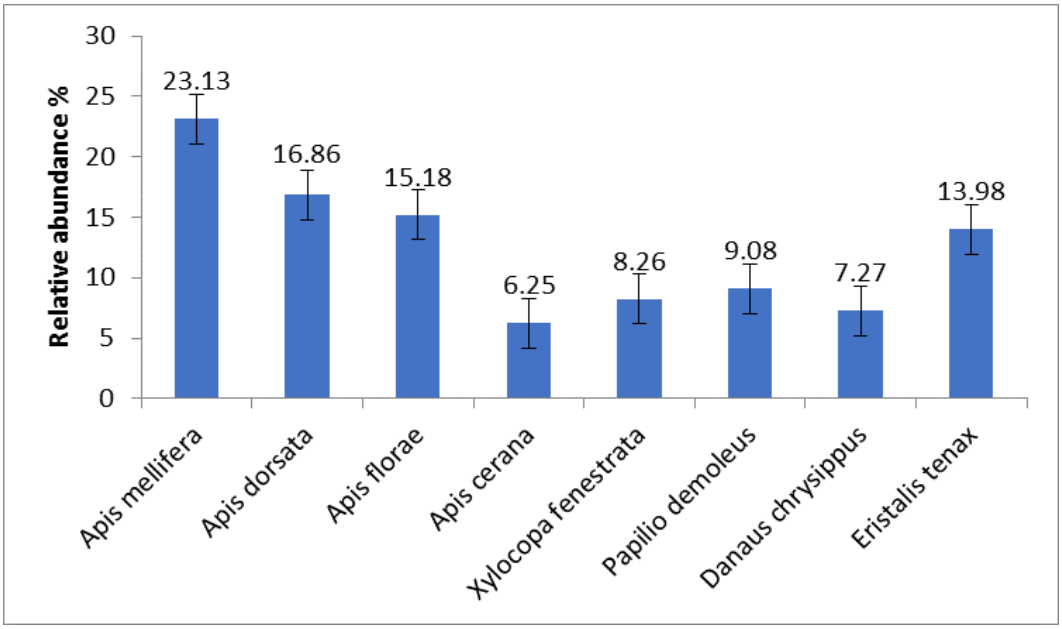
Various insect pollinators were recorded visiting Moringa flowers during the stud period (Table 1). Insects were captured through arial-net and then put into in a killing jar containing ethyl acetate as killing agent. The specimens were then counted and pinned for later species identification. All the collected specimens were identified with the help of taxonomist at Entomology Department, The University of Agriculture Peshawar. After identification, all the pollinator species were labeled, pinned and deposited in the Insect Museum of Pakistan Forest Institute, Peshawar. Data was recorded on daily basis from 9am to 6pm at two hours interval.

Species diversity:

Table 1. Insect pollinators visiting *Moringa oleifera*

S. No.	Insect species	Family	Order
1	*Apis mellifera*	Apidae	Hymenoptera
2	*Apis dorsata*	Apidae	Hymenoptera
3	*Apis florae*	Apidae	Hymenoptera
4	*Apis cerana*	Apidae	Hymenoptera
5	*Xylocopa fenestrata*	Apidae	Hymenoptera
6	*Papilio demoleus*	Papilionidae	Lepidoptera
7	*Danaus chrysippus*	Nymphalidae	Lepidoptera
8	*Eristalis tenax*	Syrphidae	Diptera

Fig 1. Relative abundance of insect pollinators (%)



4.2.4.Efficacy of different insecticides against shisham defoliator (*Plecoptera reflexa* Guen) in Peshawar

Location: Peshawar
Year of commencement: 2023
Principal investigator: Fazli Amin, Assistant Forest Entomologist

P. reflexa is a gregarious pioneering species and grows well in river beds, canal banks and irrigated plantations. It is a well-known and serious defoliator of *D. sissoo* in Pakistan. The caterpillar is a green semilooper, turning pinkish and measuring about 25 mm long when full-grown while the moth is greyish brown. The young caterpillar feeds on the lower surface of the leaf, but later instars consume the whole leaf including petiole and the green shoot.

Four synthetic insecticides were used for the control of *P. reflexa* in randomized complete block design with tree replications. The treatments include Novstar (bifenthrin+abamectin), Emamectin benzoate, Confidor (Imidacloprid), Match (Lufenuron) and untreated check (control). Each tree was taken as a replicate in each treatment. The infested shisham trees were sprayed with all the insecticides at recommended dose. Data was taken before spray and then after 24h, 48h, 72h and 7days of treatment.

Salient Findings

Results in Fig 2 showed % reduction in the population of caterpillars after the application of insecticides as compared to the control. Overall the test insecticides were significantly effective in reducing the infestation of *P. reflexa* on shisham.

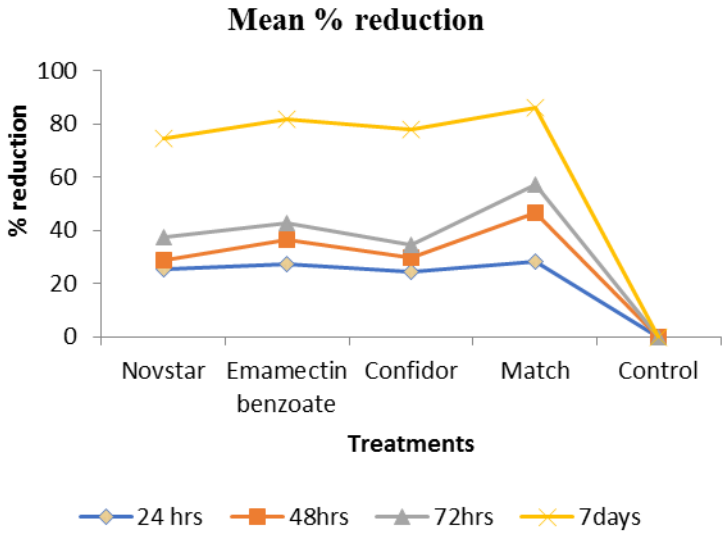


Fig 2. Percentage reduction in *Plecoptera reflexa* infestation with different insecticides

Miscellaneous information

Presented research studies before the Worthy Secretary Climate Change, Forestry, Environment & Wildlife Department on “Comparative studies of botanical extracts and synthetic insecticide against the shoot and fruit borer in brinjal crop”.

Publications

i. Diversity of insect pollinators and their relative abundance associated with moringa (*Moringa oleifera*) in Peshawar (The Pakistan Journal of Forestry)
ii. Effect of feeding mix mulberry varieties on growth and development of C-21 strain of silkworm (*Bombyx mori* L.) and on their cocoon characters (The Pakistan Journal of Forestry)
iii. Pollen and nectar collection preferences of the European honeybee (Apis mellifera Linnaeus) (Pure and Applied Biology)
iv. Response of two silkworm (*Bombyx mori* L.) Races against two different cultivars of mulberry at district Peshawar (Journal of Entomology and Zoology Studies)

Internship

One student of Entomology Department, The University of Agriculture Peshawar completed internship in my supervision. Details are as under:
1. Effect of different insecticides on the population of *Citrus psylla* (Liviidae:Hemiptera)

Teaching
Delivered lectures on NTFP, Forest Entomology courses to BS Forestry classes.

Extension services
1. Technical advisory services to the field forester, farmers, tree growers, researchers on various aspects of insect pest control.
2. Curative chemical control measures were carried out against termites, yellow wasps, field rats and other pests at the nurseries, ornamental plants, research gardens and other buildings at PFI, campus.

4.3 MEDICINAL PLANTS BRANCH

4.3.1. Cultivation and yield trials of *Matricaria chamomilla* to standardize its cultivation technology

Location: Medicinal Plant Garden, PFI Peshawar
Year of commencement: 2023
Principal investigator: Zia Ur Rahman, Assistant Economic Botanist

Matricaria chamomilla is well-known for its medicinal and domestic applications, possessing a remarkably calming, sedative, and completely harmless impact. It is utilized to alleviate nervousness, headaches, anxiety, and hysteria. The flowers emit a pleasant fragrance and exert a purifying and calming influence on the digestive system. Chamomile is among the safest herbs, beneficial for agitated children. Externally, it lightens light brown hair and imparts a golden reflection to blond hair; the tea can serve as a hair rinse. Inhalations with chamomile are recommended for asthma. The flower heads and essential oil are utilized as medicinal agents, harvested and carefully dried during the flowering period. It addresses various issues such as skin problems, minor wounds, perspiration, eczema, disturbed digestion, stomach and intestinal inflammation, bladder inflammation, and menstruation irregularities

Research and cultural studies were initiated to standardize its cultivation requirements and economic viability in Peshawar's climatic conditions. An experiment employing a randomized complete block design, replicated four times, was conducted to evaluate the impact of different row spacing (25, 35, 45 cm, and conventional broadcasting) on growth and flower yield. The plot size was maintained at 20 m². Before the trial, the experimental plots were meticulously prepared through plowing and leveling. Seeds were sown in October 2022 at varying row spacings, with the first irrigation provided immediately after sowing. Germination took 12 to 14 days. Thinning occurred in early February 2023, and weeding and hoeing were carried out twice (February-March 2023). Eight irrigations were administered at 12-day intervals. Flower harvesting took place in March, and the yield of fresh flowers was recorded in kilograms per plot.

Table 1. Effect of various row to row spacing on the flower yield in kg/plot (20 m^2).

Replication	**Broad-casting**	**Row spacing (cm)**		
--	**--**	**25**	**35**	**45**
1	2.20	3.95	5.50	2.42
2	2.36	3.67	5.30	2.25
3	1.90	4.72	4.85	4.65
4	1.65	4.20	5.65	3.85
Mean	2.027	4.135	5.325	3.292

A row to row spacing of 35 cm gave higher yield of fresh flower heads (2.35 tonnes/ha) as compared to broadcasting (1.60 tonnes/ha), 45 spacing cm (1.95 tonnes/ha) and 25 cm spacing (2.0 tonnes/ha) respectively.

4.3.2 Comparative studies on the performance of different species of *Ocimum* i.e*. O. americanum and O. basilicum* at Peshawar

Location: Medicinal Plant Garden, PFI Peshawar
Year of commencement: 2023
Principal investigator: Zia Ur Rahman, Assistant Economic Botanist

Ocimum species serve as significant sources of essential oils and aroma compounds with diverse applications in perfumery and cosmetic industries. Currently, various aroma chemicals like camphor, thymol, clove oil, geranial, etc., are imported to fulfill the needs of perfume, cosmetic, and pharmaceutical sectors. To evaluate the feasibility of cultivating these species in Peshawar's climatic conditions, seeds of two exotic species, namely O. *basilicum* and O. *americanum*, were obtained. Ongoing studies on introduction and performance continued through the second year of growth to examine the impact of different row spacing with irrigation intervals of 3 weeks versus 2 weeks on the leaf yield of these species. Two instances of weeding and hoeing were conducted in May and July 2023. Eight subsequent irrigations were administered at 3-week intervals until the end of October 2023. Leaf harvesting occurred twice in August and October 2023. The crop was harvested in December 2023, and the yield of leaves was measured in kilograms per plot. The fresh leaf yield of O. *basilicum* was influenced by various row spacing treatments, expressed in kilograms per plot (20m²).

Table 2. Mean fresh leaves yield of *Ocimum basilicum* in kg/plot.

Treatment row spacing (cm)	Leaves (kg)
35	2.70
45	3.45
55	4.82
65	4.60
Mean	3.89

A row to row spacing of 55 cm gave significantly higher leaves yield (2.45 tonne fresh leaves/ha) as compared to 45 cm row to row spacing (1.85 tonne leaves/ha). There was no significant difference in the mean yield of 55 and 66 cm row to row spacing. The fresh leaves were later dried in Solar Dryer for 6 days and dried yield was recorded.

4.3.3 Evaluation of screening Nurseries for identification and selection of best lines of medicinal herbs for Peshawar locality

Location: Medicinal Plant Garden, PFI Peshawar
Year of commencement: 2023
Principal investigator: Zia Ur Rahman, Assistant Economic Botanist

Seed Source: Indigenous lines (Plants Genetics Research Insitute, NARC Islamabad)/Extotic lines (Turkey)

Replications: 4
Layout: Single line Sowing
Date of sowing: 10th November 2022.

Crops:

Indigenous Lines		
S. No.	**Species**	**No. of Germplasm**
1	*Trigonella foenum*	20
2	*Lallemantia royleana*	17
3	*Plantago ovata*	15
4	*Linum usitatissimum*	25
5	*Foeniculum vulgare*	18
6	*Trachyspermum ammi*	15
7	*Hyoscyamus niger*	11
8	*Cuminum cyminum*	10
9	*Bunium persicum*	5
10	*Pimpinella anisum*	6

Exotic Species: *Nigella sativa, Nigella sativa* (Gameli variety), *Nigella damascena., Pimpinella anisum* (Denzil population), *Thumbra spicata, Origanum inites, salvia sclarea, Foeniculum* (va dul) *Foeniculum vulgare* (urfa population)

Publications

Diversity of insect pollinators and their relative abundance associated with moringa (*Moringa oleifera*) in Peshawar (The Pakistan Journal of Forestry)

Teaching

Delivered lectures on NTFP, Medicinal Plant courses to BS Forestry classes.

Linum usitatissimum at flowering stage

Nigella sativa at flowering stage

Nigella sativa

Foenicullum vulgare

5.BIODIVERSITY DIVISION

5.1 Forest Geneticist

Location: Pakistan Forest Institute (PFI), Peshawar and PFI Field Stations

Principal Investigator: Muhammad Bilal Zia, Forest Geneticist

Co- Principal Investigator: Mr. Hammad Ud Din Assistant Forest Geneticist

A) Adaptability of Paulownia 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 roots and shoot tips were taken out from the sand and planted in the field nursery. An area of 1.5 kanals in the field of nursery was tilled to about 30cm depth and 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 w.e.f 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:

Sr. 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) Paulownia Species Trials

Deciduous nature and fast-growing characteristics of Paulownia has led 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 Changa Manga to study their growth behaviour and adaptability under irrigated conditions.

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 % was collected in June, 2023 and is presented in table-1.

Table-1: DBH, height and survival % of Paulownia species at the age of twelve (12) years

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

It reveals that *P.elongata* showed maximum DBH of 28.0 cm*. P.catalpifolia* is ranked at top for DBH of 17.10 cm and survival of 60%.

iii) Maintenance of Gene Pool of Paulownina Species

Two Paulownia plantations, each comprising of four species i.e. *P. elongata, P. fortunei, P. catalpifolia P. tomentosa* were maintained on an area of 04 and 02 kanals respectively.

B) *Jatropha quercus* Provenance Plantation

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 of *Jatropha quercus* was maintained during this year. These provenances will serve as seed source for research activities in future. Detail is 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

Data regarding height of these provenances was collected in June, 2023 and is given in table-2.

Table 2: Height data of *Jatropha* quercus provenances

Sr. 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

C) Improvement of *Dalbergia sissoo*

Study 1. 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 PFI Research 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. Detail is given below:

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 at the age of first year of growth is given in table- 3.

Table-3: Average height and survival % of two sources of *D. sissoo*

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

Study-2. Comparative Growth Study of *Dalbergia sissoo* and *D. latifolia* at PFI Field Station Changa Manga

To compare the growth of three Dalbergia species, a study was conducted at Changa Manga irrigated plantation. Detail is as under:

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 was recorded for plant height and survival %, which is shown in table-4.

Table-4: DBH, height and survival % of two sources of *D. sissoo* and *D. latifolia* in June, 2023.

Sr. 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

Interim results reveal that *D. sissoo* (Nepali) exhibited maximum growth by attaining DBH of 20.8 cm and height 13.5 m followed by *D. sissoo* (local).

Study-3. Comparison of *Dalbergia sissoo w*ith Five Timber Wood Tree Species

Shisham dieback disease is widespread and complex in nature, involving caus-ative 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 the 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*. Detail is 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 June, 2023 is given in table-5.

Table-5: Diameter, height and survival % of six trees species in June, 2023

Sr. No.	Species	DBH (cm)	Height (m)	Survival %
1.	*Melia azedarach*	33.5	13.3	75
2.	*Bombacopsis*	29.4	10.5	75

	quinata			
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.

Study-4. Die Back Resistant (DBR) Shisham Progeny Trials

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

Data regarding survival% of progenies was collected in June, 2023 and is presented in table-6.

Table-6: Survival% and growth data of shisham progenies at the age of eleven years

Sr. 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 has shown the best performance regarding survival and Height i.e. 87.5 and 10.5 m respectively.

Study-5. 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 plantation. 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 has been maintained during this year.

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

D) Maintenance of 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, 2017 at PFI Field Station Ratta Kulachi, D.I.Khan on an area of 02 kanals. This block plantation showed the 83% survival and average height of 4.55 meters at the age of four years.

E) 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, 62.0 kg seed of various tree species was collected and stored.

Seed Quality Testing

Germination tests of collected and stored seed were carried out in the seed testing laboratory of PFI. Results are presented below in table-7.

Table-7: Seed germination percentage of various species

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

F) Maintenance of Nurseries

Forest Genetics Branch has maintained nurseries of different tree species at PFI, Research Garden and at PFI field station Ratta Kulachi (D.I. Khan). These include bare rooted as well as tube plants for 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.

5.2 Wildlife Management

5.2.1 Survey of Ramsar Sites of Khyber Pakhtunkhwa

Location: Thanedar Wala

Year of commencement: 2022-2023

Principal Investigator: Manahil Wahab, Wildlife Management Specialist
Sajjad Ali, Field Assistant

Thanedar Wala is a game reserve and wetland Ramsar site, located 15 km east of Lakki Marwat District (formerly in Bannu District), Khyber Pakhtunkhwa, Pakistan. Most of the area consists of a complex of braided river channels and sandy or muddy places up to 4 km wide and famous for crane refugee and ducks. Thanedar Wala has been visited regularly for the last 8 to 10 year but ducks position is very critical and mostly found empty. In October & November during migration, thousands of migratory birds stay for different periods and then move to next destination.

Figure 3 A view of Thanedar Wala site

Thanedar Wala is a fresh water stream; water level fluctuates during the year and mainly depends on the rain. During migration in the rainy and cloudy day, ducks use to spend some time for a day or more in this reservoir in the water season.

During the survey, the whole area was observed very carefully but no duck was recorded. Only four species of birds were recorded. Moreover, three decoys were also seen. Data collected is presented in table-1 as under:

Table-1: List of birds recorded during survey

S#	Name	Scientific name	Status
1.	Kentish plover	*Charadrius alexandrines*	Common
2.	Pied Kingfisher	*Ceryle rudis*	Common
3.	Common sand piper	*Tringa grareola*	Few
4.	White wagtail	*Motacilla alba*	Common

5.2.2 SURVEY OF CRANES IN MERGED AREAS OF KHYBER PAKHTUNKHWA

Location: South & North Waziristan, FR D.I.Khan and FR Bannu:

Year of commencement: 2022-2023

Principal Investigator: Manahil Wahab, Wildlife Management Specialist
Sajjad Ali, Field Assistant

Cranes of Pakistan Out of 15 crane species found in the world, Pakistan was once a home of four species i.e. Common Crane (Grus grus), Demoiselle Crane (Grus virgo), Siberian Crane (Grus leucogeranus) and Sarus Crane (Grus antigone). For almost four decades, the Sarus crane and Siberian Crane has never been observed in Pakistan. Two of these species i.e Common crane and Demoiselle crane still provide hunting thrill to hunters. Consequently, these are decreasing with the increasing number of hunters, whereas Siberian crane is almost extinct in this area.

Figure 4: A pair of common cranes used for hunting

Cranes fly great distances to Southern hemisphere where winters are mild and plenty food is available. After spending peak winter months in the south, cranes fly back to their breeding grounds. During migration, the cranes come across heavy odds of physical barriers: Inclement weather, predators, food scarcity, lack staging areas and hunting pressures.

Study Area

Survey of Frontier Region (FR) D.I. Khan, North Waziristan, South Waziristan and FR Bannu was scheduled from 05-13 April, 2023 but due to security reasons, the permission to visit North and South Waziristan was not granted. Therefore, only FR D.I. Khan and FR Bannu districts were surveyed from 5-10 April, 2023. These areas represent a unique mosaic of desert and riverine ecosystem. The division lies in route and migratory pathway of waterfowls, bustards, quails, falcons, cranes and the migratory birds. On the Indus flyway, live catching of crane is practiced in D.I Khan, Bannu, Karak and Tribal Areas of Khyber Pakhtunkhwa. The climate of the area is dry and hot and the temperature is said to have increased considerably during the last 50 years. The annual rainfall of the district ranges between 125 to 200 mm. the socio-economic condition of the area is not satisfactory. The people are poor and mainly depended on agriculture for their livelihood. Government services and small businesses are other subsistence sources of their income. Only

Common and Demoiselle Cranes were found in the camps. Data collected is presented below in table-2.

Table-2: Number of Cranes Recorded

Study Area	**No. of camps**	**No. of calling birds(cranes)**	**No. of captured birds (cranes)**
FR D.I.Khan	3	65	3
FR Bannu	17	270	14
Total	20	335	17

1. Concept Papers

Following concept papers were submitted as demanded by Administrative Department:

Sr. No.	**Title of Concept Paper**
1.	Assessing the status and threats of Mongoose species in Khyber Pakhtunkhwa
2.	Conservation of Threatened Snake species in Peshawar.
3.	Saving the Asiatic Black Bear: Participatory Approach to Conservation in Northern Pakistan
4.	Executing Sustainable Development Goal Fifteen (Sdg-15) for Wildlife Conservation and its Role in other SDGs Achievement in Merged Areas (FATA)
5.	Conservation of Pangolin in Khyber Pakhtunkhwa. Pakistan.
6.	One Million Hectare Forest Land Restoration for Human & Ecological Well-being in Khyber Pakhtunkhwa, Pakistan.
7.	Developing and Implementing Community-based Adaptation strategies for Conserving Endangered Species Habitats in Pakistan

Miscellaneous:

1. Taught Wildlife Management to BS Forestry classes.
2. Attended different trainings on conservation of Wildlife species.

3. Wildlife Management Specialist attended KP Public Service Commission as Subject Specialist for the post of Sub-Divisional Wildlife Officer.
4. Wildlife Management Specialist took classes of training officers from Forest and Wildlife Departments.
5. Published research papers in Pakistan journal of Forestry.

5.3 RANGE MANAGEMENT BRANCH

5.3.1 Germplasm Multiplication of Different Forage and Fodder Species

Location	PFI, Peshawar
Period	2022-23
Principal Investigator	Assistant Silviculturist (Range)

The PFI Range Research Nursery is a crucial place for growing different types of forage plants in our country. These seeds are used for new research tests in various parts of the country by the Range Management Branch of PFI. Additionally, the seeds are sold or provided to Forest Departments, NGOs, and Farmers based on their needs.

Table-1: Seed Collection of forage grasses from Range Research Garden, PFI during 2022-23.

Sr. No.	Name of Species	Quantity (Kg)
1	*Panicum antidotale*	2.0
2	*Amorpha fruticosa*	1.0
3	*Cenchrus ciliaris*	0.8
4	*Setaria anceps*	1.0
5	*Pennisetum orientale*	2.5
Total		**7.3**

Table 2: Seed collection of fodder trees from Range Research Garden, PFI

Sr. No.	Name of Species	Quantity (Kg)
1.	*Grewia optiva*	2.0
2.	*Robinia pseudoacacia*	1.7
3.	*Sesbania sesban*	2.5
4.	Acacia spp.	1.0
Total		**7.2**

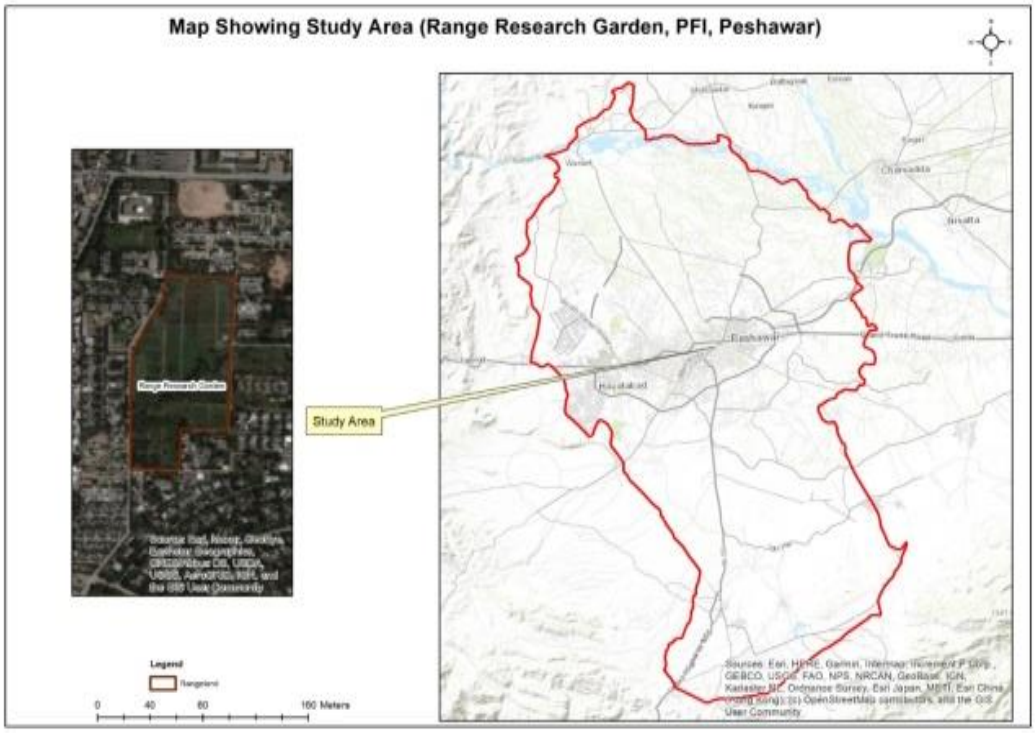
5.3.2 Performance of some tropical grasses under sub-tropical sub-humid conditions of Peshawar.

Location	PFI, Peshawar
Period	2022-23
Principal Investigator	Assistant Silviculturist (Range)

Exploring the performance of tropical grasses under sub-tropical sub-humid conditions of Peshawar is a good initiative for sustainable fodder production for livestock. Various forage grass species have been grown at Range Research Garden, PFI to assess their forage production. The present study was carried out at Range Research Garden, Pakistan Forest Institute, Peshawar to find out fresh forage yield and dry matter yield of palatable grasses namely Blue panic grass (*Panicum antidotale*), Buffel grass (*Cenchrus ciliaris*), Elephant grass (*Pennisetum purpureum*), Rhodes grass (*Chloris gayana*) and Setaria grass (*Setaria anceps*) at different stages of their phenological development. The grasses were clipped at three phenological stages viz. pre-flowering, full flowering and maturity. The samples were weighed freshly and then dried to find out dry matter yield. The data were subjected to Analysis of Variance followed by LSD test. It was observed that yield of grasses changed as they reached maturity. In Buffel, Rhodes and Setaria grasses, dry matter yield increased significantly at each growth stage until maturity stage. In Blue panic grass, dry matter yield increased significantly at full flowering stage while remained same at maturity stage. In Elephant grass, dry matter yield increased significantly at full flowering stage while decreased significantly at maturity stage. It can be inferred from the present study that full flowering stage is proper stage for harvesting optimum forage yield. Elephant grass, Rhodes grass, Buffel grass and *Setaria* grass are recommended for planting by the farmers for better fodder production in sub-tropical sub-humid areas.

Data collection from sample plots in Range Research Garden, PFI, Peshawar

The study was conducted in Range Research Garden, Pakistan Forest Institute Peshawar. It is located at 33.43°N 73.04°E. Its elevation is 507 meters (1663 ft). Features are a typical version of a sub-humid sub-tropical climate, with hot, humid summers accompanied by a monsoon season followed by cool winters.



Five grasses i.e., Blue panic grass (*Panicum antidotale*), Buffel grass (*Cenchrus ciliaris*), Elephant grass (*Pennisetum purpureum*), Rhodes grass (*Chloris gayana*) and Setaria grass (*Setaria anceps*) were selected for the research. The experiment was conducted in three replicates using Randomized Complete Block Design (RCBD). Three samples of each species were collected at three different stages of their phenological development i.e. vegetative, flowering and maturity. For this purpose, three quadrats from each plot were taken at random following standard procedure with the help of 1m^2 quadrat for fresh and dry matter determinations (Khan, 1966). Each sample at each growth stage was placed in a paper bag and dried at 70°C for 48 hours to obtain dry matter yield. The initial weight of the sample before drying and the final weight of the sample after drying were noted.

RESULTS

YIELD PERFORMANCE OF GRASSES AT DIFFERENT STAGES OF THEIR PHENOLOGICAL DEVELOPMENT

Changes in Fresh Yield of Grasses at different stages

In Rhodes and Setaria grasses, fresh yield increased significantly at full flowering stage and remained same at maturity stage while in Blue panic and Buffel grasses. In Elephant grass, fresh yield decreased significantly at full flowering stage while increased significantly at maturity stage.

Table-1: Fresh yield of grasses (t/ha) at three stages of their phenological development

Name of Grass	Pre- flowering stage	Full flowering stage	Maturity stage	LSD
Blue panic grass	4.46[a]	12.00[b]	6.78[a]	2.84
Buffel grass	3.80[a]	6.93[b]	4.92[a]	1.15
Elephant grass	11.70[b]	9.85[a]	11.71[b]	1.56
Rhodes grass	2.72[a]	6.00[b]	5.66[c]	1.14
Setaria grass	4.61[a]	8.00[b]	9.46[b]	3.21

Note. Values followed by the same letter(s) are statistically similar at P=0.05 level of significance.

Changes in Dry Matter Yield of grasses at different stages

In Buffel, Rhodes and Setaria grasses, dry matter yield increased significantly at each growth stage until the last harvest stage. In Blue panic, dry matter yield increased significantly at full flowering stage while remained same at maturity stage. In Elephant grass, dry matter yield increased significantly at full flowering stage while decreased significantly at maturity stage.

Table-2:Dry matter yield of grasses (t/ha) at three stages of their phenological development

Name of grass	Pre-flowering stage	Full flowering stage	Maturity stage	LSD

Blue panic grass	1.81[a]	4.85[b]	4.89[b]	1.04
Buffel grass	1.84[a]	3.30[b]	4.56[c]	1.09
Elephant grass	2.72[a]	5.90[b]	6.09[b]	1.14
Rhodes grass	0.76[a]	3.41[b]	3.90[c]	0.46
Setaria grass	1.00[a]	2.73[b]	5.13[c]	0.70

Note. Values followed by the same letter(s) are statistically similar at P=0.05 level of significance.

YIELD PERFORMANCE OF GRASSES AT PRE-FLOWERING STAGE OF GROWTH

Yield performance of grasses at pre flowering stage of growth

The highest fresh yield was shown by Elephant grass (11.70 t/ha) while the lowest fresh yield was shown by Rhodes grass (2.72 t/ha). The highest dry matter yield was shown by Elephant grass (2.79 t/ha) while the lowest dry matter yield was shown by Rhodes grass (0.76 t/ha) at first stage of growth.

Table-3: Yield performance of grasses (t/ha) at pre-flowering stage of growth

Name of Grass	Fresh yield	Dry matter yield
Blue panic grass	4.46[b]	1.81[b]
Buffel grass	3.80[a]	1.84[b]
Elephant grass	11.70[b]	2.79[c]
Rhodes grass	2.72[a]	0.76[a]
Setaria grass	4.61[a]	1.00[a]
LSD	4.28	0.51

Note. Values followed by the same letter(s) are statistically similar at P=0.05 level of significance.

Yield performance of grasses at full flowering stage of growth

At full flowering stage of growth, the highest fresh yield was shown by Blue panic grass (12.00 t/ha) while the lowest fresh was shown by Rhodes grass (6.00 t/ha). The highest dry matter yield was

shown by Elephant grass (5.90 t/ha) while the lowest dry matter yield was shown by Setaria grass (2.73 t/ha).

Table-4: Yield performance of grasses (t/ha) at Full flowering stage of growth

Name of Grass	Fresh yield	Dry matter yield
Blue panic grass	12.00[c]	4.85[b]
Buffel grass	6.93[ab]	3.30[a]
Elephant grass	9.85[bc]	5.90[c]
Rhodes grass	6.00[a]	3.41[a]
Setaria grass	8.00[ab]	2.73[a]
LSD	2.80	0.91

Note. Values followed by the same letter(s) are statistically similar at P=0.05 level of significance.

Yield performance of grasses at Maturity stage of growth

At maturity stage of development, the highest fresh yield was shown by Elephant grass (11.70 t/ha) while the lowest fresh yield was shown by Buffel grass (4.92 t/ha). The highest dry matter yield was shown by Setaria grass (5.13 t/ha) while the lowest dried yield was shown by Rhodes grass (3.90 t/ha).

Table-5: Yield performance of grasses (t/ha) at maturity stage of growth

Name of Grass	Fresh yield	Dry matter yield
Blue panic grass	6.78[a]	4.89[ab]
Buffel grass	4.92[a]	4.56[ab]
Elephant grass	11.70[c]	4.09[ab]
Rhodes grass	5.66[a]	3.90[a]
Setaria grass	9.46[b]	5.13[b]
LSD	2.18	1.20

Note. Values followed by the same letter(s) are statistically similar at P=0.05 level of significance.

As it is clear from the results that grasses exhibited significant differences in fresh and dry matter yield which ranged from 2.72 to 11.70 t/ha fresh matter yield in pre flowering stage, 6.00 to 12.00 t/ha in full flowering and 4.92 to 11.70 t/ha in maturity stage while 0.76 to 2.80 t/ah dry in full flowering and 4.92 to 11.70 t/ha in maturity stage while 0.76 to 2.80 t/ha dry matter yield in pre flowering stage, 2.73 to 5.90 t/ha in full flowering and 3.90 to 5.13 t/ha in maturity stage. This could be attributed to their genetic inheritance potential. Climatic and soil conditions also play a major role in determining yield and yield parameters. Significant differences were obtained among grasses in forage yield. The highest dry matter yield of 2.80 and 2.79 ton ha^{-1} was attained by elephant grass during pre-flowering stage respectively. The top dry matter yielding grasses during full flowering stage were elephant and blue panic grass that yielded 5.90 and 4.85 ton ha^{-1} respectively.

It was observed that yield and composition of grasses changed as they reached maturity. In Buffel, Rhodes, Setaria dry matter yield increased significantly at each growth stage until maturity stage. In Blue panic, dry matter yield increased significantly at full flowering stage while remained same at maturity stage. In Elephant grass, dry matter yield increased significantly at full flowering stage while decreased significantly at maturity stge.

CONCLUSION

It is concluded from the study that forage yield at pre flowering stage is low. Full flowering stage is the best stage for harvesting these grasses as we take into consideration forage yield. Maturity stage has adequate yield. Elephant and Blue panic grasses are high yielding grasses with 5.90 and 4.85 tons/ha dry matter yield respectively.

RECOMMENDATIONS

1. Taking into consideration forage yield and quality, Elephant and Blue panic grasses are recommended for large scale seeding/planting in Pothwar area.
2. Studies on mixing of low palatable grasses with fodder, tree leaves and palatable grasses may be done so that low palatable grasses may be included in the existing feedlot.
3. Value added of low palatable grass hay may also be studied to improve forage quality.

5.3.3 Study plans for the Annual Research Programme (2024-25)

a) Performance of *Sesbania sesban* (Perennial) as a fodder tree at Range Research

Garden PFI and PFI Field Station D.I Khan.

b) Comparative study on Agronomic Performance and Nutritive Value Analysis of Napier grass and Mott grass at Range Research Garden, PFI.

c) Forage productivity and Nutritive value analysis of perennial forage grasses at different stages of their phenological development at Range Research Garden, PFI.

5.3.4 Miscellaneous

1. Conducted ethno-botanical survey of North Waziristan and collected plant specimens for Range Herbarium under the project “Biodiversity research initiatives in merged area of Khyber Pakhtunkhwa”.
2. Submitted a research proposal to Pakistan Agricultural Research Council, Islamabad for the Agricultural Linkages Program (ALP) 10th Batch.
3. Taught Range Management to BS forestry class 6th Semester.
4. Published a research paper on “Dendrochronological Analysis of Historical forts located in Chitral and Gilgit Baltistan” in HEC recognized journal during March, 2023.
5. Attended one week training course on Natural Resource Management organized by Pakistan Academy for Rural Development, Peshawar.
6. Attended a training workshop at PFI on bamboo propagation.
7. Prepared and submitted a research article on “Decoding the Nutritional Mystique: A Comparative Analysis of Guava and Peach Varieties from Diverse Climatic Regions” to the Pakistan Journal of Forestry (PJF).
8. Conducted tour of Orakzai district for data collection on Assessment of Range condition, nutritive value analysis of range forage species, and to assess the grazing patterns under the project “Biodiversity research initiatives in merged area of Khyber Pakhtunkhwa”.

6.FOREST EDUCATION DIVISION

Admissions:

During the year 2022-23, 25 self-finance students were admitted from all the federating units of the country.

Passed Out:

During the year 2022-23 the following Classes of M. Sc & BS Forestry were passed out.

S. No	Classes	Strength
1.	M. Sc Forestry (2020-22)	38
2.	BS Forestry (2018-22)	26
Total Strength		64

Lectures Schedule

M.Sc. Forestry (2021-23), BS Forestry (2019-23), BS Forestry (2020-24), BS Forestry (2021-25) and BS Forestry (2022-26) courses were continued as per their study program & according to the lecture schedules.

Examinations & Results

All examinations of M. Sc and BS Forestry courses were conducted by the University of Peshawar according to schedule. The detail of results announced and examinations held during the year is tabulated below;

Annual Term/Semester Examinations

CLASSES	FROM	TO
BS Forestry (2021-25) 1st Semester	27-06-2022	06-07-2022
BS Forestry (2020-24) 3rd Semester	27-06-2022	06-07-2022
BS Forestry (2019-23) 5th Semester	27-06-2022	06-07-2022
BS Forestry (2018-22) 7th Semester	27-06-2022	06-07-2022
M. Sc Forestry (2021-23) 1st Term	27-06-2022	19-07-2022
M. Sc Forestry (2020-22) 3rd Term	27-06-2022	19-07-2022

Results

CLASSES	Results Declared On
BS Forestry (2021-25) 1st Semester	31-10-2022
BS Forestry (2020-24) 3rd Semester	31-10-2022
BS Forestry (2019-23) 5th Semester	31-10-2022
BS Forestry (2018-22) 7th Semester	31-10-2022
M. Sc Forestry (2021-23) 1st Term	24-10-2022
M. Sc Forestry (2020-22) 3rd Term	24-10-2022

Annual Terms/Semester Examinations

CLASSES	FROM	TO
BS Forestry (2021-25) 2nd Semester	06-12-2022	13-12-2022
BS Forestry (2020-24) 4th Semester	06-12-2022	13-12-2022
BS Forestry (2019-23) 6th Semester	06-12-2022	13-12-2022
BS Forestry (2018-22) 8th Semester	06-12-2022	13-12-2022
M. Sc Forestry (2021-23) 2nd Term	06-12-2022	16-12-2022
M. Sc Forestry (2020-22) 4th Term	06-12-2022	16-12-2022

Results

CLASSES	Results Declared On
BS Forestry (2021-25) 2nd Semester	13-02-2023
BS Forestry (2020-24) 4th Semester	13-02-2023
BS Forestry (2019-23) 6th Semester	13-02-2023
BS Forestry (2018-22) 8th Semester	31-01-2023
M.Sc Forestry (2021-23) 2nd Term	23-01-2023
M.Sc Forestry (2020-22) 4th Term	23-01-2023

Annual Term/Semester Examinations

CLASSES	FROM	TO
BS Forestry (2022-26) 1st Semester	17-05-2023	25-05-2023
BS Forestry (2021-25) 3rd Semester	17-05-2023	25-05-2023
BS Forestry (2020-24) 5th Semester	17-05-2023	25-05-2023
BS Forestry (2019-23) 7th Semester	17-05-2023	25-05-2023
M. Sc Forestry (2021-23) 3rd Term	17-05-2023	27-05-2023

Thesis:

Thesis of M.Sc. Forestry 2020-22 and BS Forestry (2018-22) were completed.

Tours:

1. Forest Survey Camp of M.Sc. Forestry (2021-23) and BS Forestry (2019-2023) were conducted from 08-07-2022 to 26-08-2022 at Field station Shinkiari.
2. Forest survey and leveling tour of BS Forestry (2020-2024) were conducted from 01-03-2023 to 11-03-2023at PFI Field Station Shinkiari.
3. Field work-III (Forest Management) tour of M. Sc Forestry (2020-22) & B.S Forestry (2018-22) was conducted from 07-02-2023 to 26-02-2023.
4. Study tour of Participatory Forestry, Climate change and Biodiversity and EIA for BS Forestry (2020-24) was conducted from 7-10-2022 to 10-10-2022.

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 Monsoon plantation day, world Environment Day, World Forest Day, World Mountain Day.

Orientation Tours:

Field Work-1 (Orientation) tour of BS Forestry (2022-26) was conducted from 21-12-2022 to 01-01-2023.

PFI Students Annual Sports Matches

Annual Sports Matches of Forestry Students were conducted during the 1st week of November 2022.

Marathon Race 2022 for Forestry Students

Forest Education Division Organized an event of Marathon Race 2022 for Forestry Students on 11 November, 2022.

Faculty Training for Professional Grooming

1. Mr. Raja Ghayyas Director Forest Education Division, attended the training on learning Management System organized by Khyber Pakhtunkhwa Information Technology Board at PFI.
2. Mr. Ahmad Zamir, Assistant Professor of Forestry, attended the training on Learning Management System organized by Khyber Pakhtunkhwa Information Technology Board at PFI.
3. Mr. Sohaib Ahmed, Assistant Professor of Forestry, attended the training on 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 2020-24		
S. No	**Province**	**Strength**
1.	Khyber Pakhtunkhwa	14
2.	Punjab	05
3.	Baluchistan Forest Department	03 (02 Departmental)
4.	Gilgit Baltistan	02
	Total	**24**
BS Forestry Session 2021-25		
S. No	**Province**	**Strength**
1.	Khyber Pakhtunkhwa	15
2.	Punjab	06
3.	Baluchistan	01
4.	AJK	01
5.	Gilgit Baltistan	01
	Total	**24**
BS Forestry Session 2022-26		
S. No	**Province**	**Strength**
1.	Khyber Pakhtunkhwa	17
2.	Punjab	04
3.	Gilgit Baltistan	01

4.	AJK	02
	Total	**24**
BS Forestry Session 2019-23		
S. No	**Province**	**Strength**
1.	Khyber Pakhtunkhwa	15 (01 Departmental)
2.	Punjab	04
3.	Gilgit Baltistan	01
4.	AJK	02
	Total	**22**
M. Sc Forestry Session 2021-23		
S. No	**Province**	**Strength**
1.	Khyber Pakhtunkhwa	17
2.	Punjab	04
3.	Baluchistan	01
4.	AJK	01
5.	Gilgit	01
	Total	**24**
	Grand Total	**118**

7. ANNUAL RESEARCH PROGRAMME OF PFI (2023-24)

S.No	Name of the project	Principal Investigator(s)	Location	Year of commencement	Sponsoring/ Collaborating agencies
1.	**FORESTRY RESEARCH DIVISION**				
1.1	**Silviculture**				
1.1.1	Raising nursery of rare and endangered species for conservation	Dr. Anwar Ali, DFRD & Dr. Nowsherwan Zarif (CS)	Silviculture Research Garden, PFI	2024	ADP Project
1.1.2	Research trail on assessment of growth performance of different Eucalyptus tree species	Dr. Anwar Ali, DFRD & Dr. Nowsherwan Zarif (CS)	Silviculture Research Garden, PFI	2024	ADP Project
1.1.3	Training of technical staff and maalis on vegetative propagation, compost preparation and landscaping	Dr. Anwar Ali, DFRD & Dr. Nowsherwan Zarif (CS)	Silviculture Research Garden, PFI	2024	ADP Project
1.2	**Forest Mensuration**				
1.2.1	Field survey for measurement of sampled trees in Malakand forest region for the development of volume tables	Dr. Anwar Ali, DFRD	Malakand Region	2022	ADP Project
1.2.2	Establishment of permanent sample plots in Deodar Forest	Dr. Anwar Ali, DFRD	Malakand and Hazara Region	2022	ADP Project
1.2.3	Establishment of permanent sample plots in Fir and Spruce forests	Dr. Anwar Ali, DFRD	Malakand and Hazara Region	2024	ADP Project
1.2.4	Standardization of inventory techniques for Chir pine forest	Dr. Anwar Ali, DFRD	Malakand and Hazara Region	2024	ADP Project
1.3	**Watershed Management**				
1.3.1	Collection of Meteorological Data	Mr. Bilal Ahmed Qazi & Mr. Muhammad Iqbal	PFI, Peshawar	2024	PFI
1.4	**GIS &RS**				
1.4.1	Maintenance and development of NTFP website www.pfintfp.gov.pk Development and deployment of NTFP android application in collaboration with KPITB	Mr. Aamir Shakeel (GIS Specialist)	All KP including merged area	2024	ADP Project
1.4.2	Deployment of Google workspace in collaboration with Tech valley Pakistan	Mr. Aamir Shakeel (GIS Specialist)	PFI & Tech Valley	2024	PFI
1.4.3	Deployment of PFI official website www.pfi.edu.pk	Mr. Aamir Shakeel (GIS Specialist)	PFI, Peshawar	2024	PFI
2.	**FOREST PRODUCTS RESEARCH DIVISION**				
3.	**BIOLOGICAL SCIENCES RESEARCH DIVISION**				
3.1	**Forest Botany**				
3.1.1	Bamboo resources in Pakistan	Muhammad Farooq , Assistant Forest Economist	PFI	2024-25	PFI
3.2	**Forest Chemistry**				

3.2.1	Physco-chemical characteristics of soil of PFI Research, Botanical and Medicinal Garden	Dr. Salim Saifullah, Assistant Forest Chemist **&**Muhammad Ilyas,Research Officer (Soil)	PFI	2024-25	PFI
3.3	**Forest Pathology**				
3.3.1	Anti-microbial potential of various plant extracts against shisham dieback causing pathogens	Mahnoor Blaoch Research Officer (Pathology)	PFI	2024-25	PFI
4.	**NON TIMBER FOREST PRODUCE DIVISION**				
4.1	**Sericulture**				
4.1.1	Assessment and Control of different diseases of silkworms	Mr. Muhammad Salman, R.O.	PFI	2023-24	PFI
4.1.2	Study on Morphology and Physiology of the Silkworms	Mr. Muhammad Salman, R.O.	PFI	2023-24	PFI
4.1.3	Reeling of silk and cocoons on different temperature levels to check its elasticity and strength	Mr. Mir Manzar Ud Din, R.O.	PFI	2023-24	PFI
4.1.4	Effects of Silkworm Rearing and Mounting Conditions on Cocoon Reelability	Mr. Mir Manzar Ud Din, R.O.	PFI	2023-24	PFI
4.2.	**Forest Entomology**				
4.2.1	Survey of wild bee pollinators from coniferous forests	Mr. Naveed Ahmed, Director NTFP	PFI	2023-24	PFI
4.2.2	Taxonomic studies of wild bee pollinators	Mr. Naveed Ahmed, Director NTFP	PFI	2023-24	PFI
4.3	**Medicinal Plants**				
4.3.1	Evaluation of screening nurseries of exotic lines (*Pimpinella anisum, Plantago ovata, Linum usitatissimum*) for identification and selection of best lines for Peshawar locality	Mr. Zia Ur Rahman, A.E.B.	PFI	2023-24	PFI
4.3.2	Promotion and conservation of *Moringa olifera* for the empowerment of local communities for Peshawar locality	Mr. Zia Ur Rahman, A.E.B.	PFI	2023-24	PFI
5.	**BIODIVERSITY DIVISION**				
5.1	**Forest Genetic**				
5.1.1	Screening of indigenous germplasm of Shisham against die back disease	Muhammad Bilal Zia Forest Geneticist & Hammad Ud Din Assistant Forest Geneticist	PFI/ D.I.Khan		Regular Budget
5.1.2	Establishment of Biotechnology Lab. at PFI. Peshawar.	Muhammad Bilal Zia Forest Geneticist & Hammad Ud Din Assistant Forest Geneticist	PFI Peshawar.		ADP 2022-23

5.1.3	Seed collection and seed quality studies of important forest tree species.	Muhammad Bilal Zia Forest Geneticist& Hammad Ud Din Assistant Forest Geneticist	PFI/KP		Regular Budget
5.1.4	Maintenance of research experiments at PFI and at PFI Field Stations	Muhammad Bilal Zia Forest Geneticist& Hammad Ud Din Assistant Forest Geneticist	PFI/KP/ Punjab		Regular Budget
5.2	**Wildlife Management**				
5.2.1	Survey of Waterfowls	WLMS	Merged Districts	2023	ADP Project
5.2.2	Survey of Falcons	WLMS	Merged Districts	2023	ADP Project
5.2.3	Survey of Cranes	WLMS	Merged Districts	2023	ADP Project
5.2.4	Survey of Common Birds	WLMS	Merged Districts	2023	ADP Project
5.3	Range Management				
5.3.1	Seed multiplication and forage yield determination of different forage species at Range Research Garden, PFI	Mr. Khalid Imran	PFI, Peshawar	On yearly basis	PFI
5.3.2	Comparative study on Agronomic Performance and Nutritive value analysis of Napier grass and Mott grass at Range Research Garden, PFI	Mr. Khalid Imran	PFI, Peshawar	March, 2023	PFI
5.3.2	Performance of *Sesbania sesban* (Perennial) as a fodder tree at Range Research Garden, PFI and PFI Field Station D.I.Khan	Mr. Khalid Imran	PFI, Peshawar & PFI, Field Station, D.I.Khan	March, 2023	PFI