Population Census of Salix Species and Socio-Economic Impacts in Gilgit Baltistan

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Abstract

This study investigates the population census and socioeconomic impacts of Salix species in Gilgit-Baltistan, Pakistan. Comprehensive field surveys and structured interviews were carried out in Danyore, Hunza, and Nagar to measure species density and evaluate community dependence on these essential resources to measure species density and evaluate community dependence on these essential resources. Comprehensive field surveys and structured interviews were carried out in Danyore, Hunza, and Nagar to measure species density and evaluate community dependence on these essential resources. The findings show statistically significant ($p < 0.05$) variations in tree height and diameter among areas and an uneven distribution of Salix tetrasparma throughout the region, with Nagar showing the highest density. According to socioeconomic data, 42.2% of respondents know Salix's medicinal advantages, while 91.1% utilize it for fuelwood. The sustainability of these species is threatened by overexploitation and habitat degradation despite their vital significance in agroforestry, land restoration, and handicraft production. The study offers important baseline data to guide conservation plans, sustainable management techniques, and governmental efforts to protect Gilgit-Baltistan's Salix species' ecological and economic value.

Keywords: Salix Species, Socio-economic Impacts, Population Census, Gilgit-Baltistan.

Introduction

Salix, which belongs to the Salicaceae family, has over 450 species worldwide, most of which are found in the Northern Hemisphere. The overall number of willow species found in North America is estimated to be around 106 (Bagyanarayana, 2005). A small, deciduous tree up to 9 m tall with a diameter of 50 to 70 cm (Houston, Rigo & Caudullo, 2016). The family Salicaceae is a taxonomically recognized group comprising three genera and approximately 620 species, predominantly found in the Northern Hemisphere. Salix species are found on an estimated 10 million hectares of land worldwide, occupying various habitats, from arid regions to temperate

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forests (FAO, 2020). In Pakistan, this botanical family is represented by two genera, encompassing approximately 32 species and one subspecies (Ali & Qaiser, 2001). Populations of nearly 30% of Salix species worldwide are in danger due to habitat loss and overexploitation, with populations decreasing by 2% on average per year (IUCN, 2023).

In Pakistan, willows are primarily found in the Karakorum, Himalaya, and Sub-Himalayan regions, specifically in Azad Kashmir, the Salt Range, Murree Hills, Hazara, Swat, Chitral, the Northern Areas, district Kurram, and the mountains of Balochistan. They have been successfully cultivated in the plains, typically along watercourses (Mahmood, 2021). Willow species are extensively utilized for various purposes, including erosion control, reforestation, paper production, landscaping, cricket bats, fuel, basket making, matchsticks, and crates (Houston, Rigo & Caudullo, 2016). Short-rotation forestry offers a promising alternative for enhancing productivity and has been implemented in various forms. Among the species used in this practice, willows are recognized for being eco-friendly, multipurpose, and fast-growing, making them a popular choice for plantations worldwide. The Salix genus comprises approximately 350 to 500 species globally, with many cultivated for diverse applications, such as producing baskets, cricket bats, hurdles, furniture, plywood, paper and pulp, and rope. This genus is of significant economic importance due to its adaptability to various geographic and climatic conditions, extending from North America to China, except Australasia (Trybush et al., 2008). The global market for willow-based products, including furniture, baskets, and cricket bats, is projected to reach $500 million annually, highlighting the considerable economic impact of willow species on local communities (Global Willow Market Report, 2022). More than 70% of rural households in Gilgit-Baltistan depend on Salix species for traditional medicine, handicrafts, and fuelwood; these uses bring in an estimated $10 million annually for the local population (GB Forest Department, 2022).

In addition to their well-established roles, arborescent willow species have demonstrated remarkable adaptability, thriving in various soil types, including compacted, swampy, acidic, or alkaline soils, as long as their roots have access to sufficient moisture. Consequently, these species are exceptionally well-suited for a range of ecological functions, such as the biological control of soil erosion, mitigation of siltation, facilitation of nutrient recycling, phytoremediation efforts, carbon sequestration, and the purification of sewage-polluted water (Verwijst, 2001). Populations of approximately 30% of Salix species worldwide are in danger due to habitat degradation and overexploitation, with populations decreasing by 2% on average per year (IUCN, 2023). Salix populations in Gilgit-Baltistan have decreased by 40% in the last 20 years as a result of excessive willow harvesting for fuelwood and lumber (GB Forest Department, 2022).

Review of Literature

The study focused on Naltar Valley's diverse flora, which includes endangered endemic plants. Researchers documented ethnobotanical plants used by locals between 2009-2011. They gathered information from herbal healers, shepherds, and midwives using open-ended questionnaires. Using GPS, they pinpointed 46 locations and created a distribution map using ArcGIS 9.3. They found 141 plant species from 48 families and 107 genera used by locals. The ethnobotanical repertoire included 91 herbs and 23 shrubs. Main uses were medicinal (133 species), fodder (101), fuel/timber (37), ethnoveterinary (27), and others (10). Herbalists employed 133 plants to treat 48 diseases. Asteraceae had the highest Family Importance Value, followed by Fabaceae, Polygonaceae, and Rosacea. A comprehensive approach is crucial to protect local biodiversity due to threats like overharvesting and unsustainable management (Abbas, Qureshi, Naqvi, Khan & Hussain 2013)

Using a "augmented completely randomized design" with three control clones (SI-64-017, SI- 63-007, Kashmiri willow), the juvenile growth traits of recently introduced clones of Salix species from twelve countries, including Croatia, Sweden, Italy, Hungary, Turkey, Japan, Yugoslavia, UK, Belgium, New Zealand, Germany, and USA, were studied. Except for leaf length among test clones and volume index, leaf length, and petiole length among check vs test clones, there were significant differences in morphological features between test clones and test verses check clones. For the growth features of plant height, basal diameter, and volume index, the clones SI-63-016, J-799, PN-722, NZ-1002, PN-733, PN-731, SN-2, Sx61, 194, and 084/03 were shown to be superior to check clones. The highest levels of heritability were recorded for leaf breadth (91.08%) and volume index (75.24%), respectively. For basal diameter and volume index, the highest possible positive and significant correlation coefficient (0.959) was found. Through the use of a correlation matrix and principal component analysis, it was shown that three out of the eight components contributed 85.03 percent of the total variation, with the first principal component (l=3.086) accounting for 38.57 percent of the variance weighted at its highest level (0.937) by volume index. These potential clones chosen for the current study will be put through additional testing in other locations to explore the relationship between genotype and environment at various locales for investigation of clone suitability (Singh et al., 2012).

The effectiveness and economics of a willow (Salix alba L.)-based silvopastoral agroforestry system with intercropped sorghum (Sorghum vulgare L.) and maize (Zea mays L.) were assessed in a study conducted in the Kashmir valley. Two-year-old willows were interplanted using a randomized block pattern and planted at a spacing of 2.0 m x 2.0 m. Crop yield, biomass output, soil nutrient status (pH, organic carbon, nitrogen, phosphorous, and potassium), and Salix alba growth metrics (height, diameter, and girth) were all examined. Compared to farming willows alone, the silvopastoral system had a higher benefit-cost ratio (2.71 for maize and 2.68 for sorghum), according to economic study (2.66). According to the research, willow-based agroforestry offers a sustainable substitute for monoculture systems while improving financial returns, soil health, and production (Bhat et al., 2019).

Introduced to the trans-Himalayan cold desert region of Lahaul 150 years ago, the multipurpose willow (Salix fragilis L.) has made a substantial contribution to the ecology, ethnobotany, and economic well-being of the area, giving it the moniker "life line plant." Despite its success in agroforestry, mortality rates of 80% have been documented, owing to aphid infestations, fungal diseases, monoculture methods, old planting stocks, and changing environmental conditions. Repetitive vegetative propagation from the same genetic material is implicated in the reduction, according to scant study. In order to solve this and guarantee the survival of willow populations in the area, it is advised to introduce new and improved kinds (Sharma & Sharma, 2022).

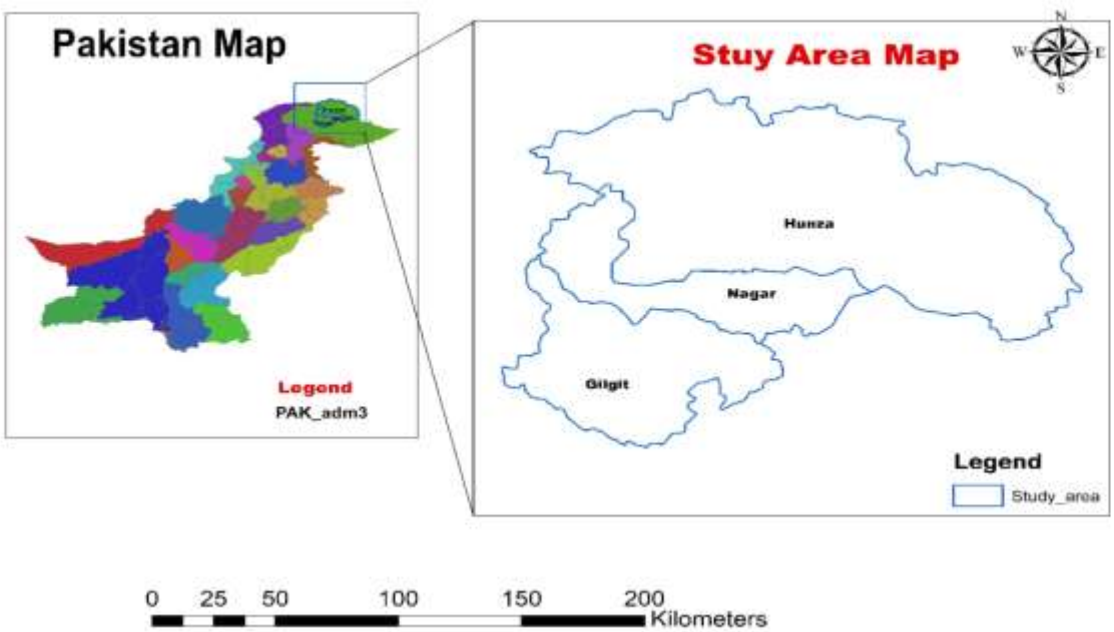
Materials and Methods

The study was conducted in Gilgit Baltistan including Danyore, Hunza, and Nagar. These areas are situated at an elevation ranging from 1500 to 2000 meters above sea level, with coordinates at approximately 35.29787° latitude and 75.63372° longitude. The region experiences an annual rainfall ranging from 120 to 240mm, with an average annual precipitation of 85.17mm. During the midwinter period, specifically in December to January, temperatures can drop significantly below -10°C. In contrast, summer temperatures exhibit an average variation between 10°C and 23°C (Bano *et al*., 2014). The flora of study area comprises of Willows (*Salix* spp) and other riparian vegetation various grasses, sedges, and rushes. Wetland plants such as reeds and cattails, coniferous trees such as Blue Pine (*Pinus wallichiana*) and Spruce (*Picea smithiana*) deciduous trees like various species of willows (*Salix* spp.) Juniper trees (*Juniperus* spp.) Birch trees (*Betula* spp.) Wild roses (*Rosa* spp.) various grasses and herbs.

Study Area Map

This map generated using GIS software (ArcGIS), which focuses on the Gilgit Baltistan region of northern Pakistan. The geographical scope of the study is represented by these districts, which are well defined by their blue borders. Because of its mountainous landscape and distinct ecological zones, Gilgit-Baltistan is an important site for research on biodiversity, natural resources, and socioeconomic effects. The map provides the precise and unambiguous representation required for field-based research by defining the spatial extent of the study area.

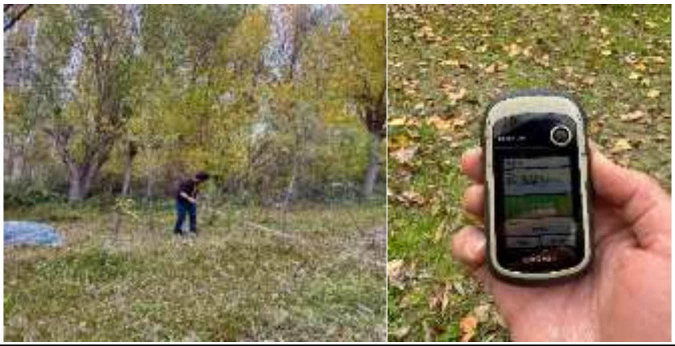
Figure 1: **Study area map**



Fixed Area Plot Method

The selected study areas were Tehsil Danyore, Nagar, and Hunza. The concerned forest department was visited, and compartment history files were obtained. The sampling intensity was 2.5% for scattered, mountainous terrain. The fixed-area plot method was used, in which 1/10th of a hectare (equal to 17.84 meters in radius) was taken. Within this radius, an inventory was conducted, including the total number of trees, diameter, age, and volume.

Figure 2: **Field images while taking the radius of fix area plot method using measuring tape and also finding the elevation of the area using a GPS**



Sampling Intensity

The precision of sampling is influenced by intensity of sampling. Usually in forest sampling the intensity is taken as 2.5% because of the forest trees density, market value of growing stock and inherent diversity (Walayat, 1998). Likewise same intensity will be taken in this study because of less heterogeneity in the growing stock and rather favorable terrain condition.

Plot size, 1/10' of hectare which is equal to 17.84 meters was taken as standard for all the plots.

Size of Sample Plot

The sample size of experimental plot was calculated according to the following formulae:

Area of circular plot = π r2

π1?=1/10 x 10000

Where 1ha= 10000 sq. meters and plot size is equal to $1/10^{th}$ of hectare.

π2=0.1 x 10000

7=1000/3.1416

(as π = 3.1416)

2=318 30

r = 17.84 meter

So, each circular plot of radius 17.84 meters will be taken.

Number of Plots in Each Compartment

Numbers of plots to be sampled in each compartment were calculated on the following basis:

Suppose the area of a particular compartment is 51.01 ha. In order to calculate the number of plots to be sampled to represent the sampling intensity of 2.5% for this compartment the following procedure will be adopted.

Area of a compartment = 51.01 ha

Sampling Intensity =2.5%

= .025 × 51.01

= 1.275 ha

Therefore 1.275 ha area of this compartment should be sampled

Area of one plot =1/10th ha

= 1.275/0.1

= 12.75 or 13 plots

Measurements
Following measurements were taken

Plant Height
A clinometer was used to measure the height of the trees by recording the top and base angles from a predetermined distance. To calculate heights, trigonometric formulas were used.

Figure 3: Field images while taking the height of willow species using a Clinometer

Table 1: Plant Height of District Gilgit

No. of Trees	Distance(m)	Top Angle	Base Angle	Radian top	Radian Base	Height(m)
T1	16	30	10	0.523333333	0.174444444	6.4
T2	12	31	8	0.540777778	0.139555556	5.5
T3	11	26	6	0.453555556	0.104666667	4.2
T4	19	34	15	0.593111111	0.261666667	7.7
T5	20	29	11	0.505888889	0.191888889	7.2
T6	14	28	10	0.488444444	0.174444444	5.0
T7	18	30	7	0.523333333	0.122111111	8.2
T8	13	27	9	0.471	0.157	4.6
T9	22	32	12	0.558222222	0.209333333	9.1
T10	16	31	5	0.540777778	0.087222222	8.2

Table 2: **Plant Height of District Hunza**

No. of trees	Distance(m)	Top Angle	Base Angle	Radian top	Radian Base	Height(m)
T1	15	28	8	0.488444444	0.139555556	5.9
T2	11	26	7	0.453555556	0.122111111	4.0
T3	17	31	10	0.540777778	0.174444444	7.2
T4	14	22	6	0.383777778	0.104666667	4.2
T5	13	24	7	0.418666667	0.122111111	4.2
T6	12	27	10	0.471	0.174444444	4.0
T7	20	34	12	0.593111111	0.209333333	9.2

T8	10	17	6	0.296555556	0.104666667	2.0
T9	19	29	10	0.505888889	0.174444444	7.2
T10	15	25	6	0.436111111	0.104666667	5.4
T11	9	18	4	0.314	0.069777778	2.3
T12	18	27	12	0.471	0.209333333	5.3

Table 3: Plant height of District Nagar

No. of Trees	Distance(m)	Top Angle	Base Angle	Radian top	Radian Base	Height(m)
T1	12	27	8	0.471	0.139555556	4.4
T2	16	32	11	0.558222222	0.191888889	6.9
T3	14	27	12	0.471	0.209333333	4.2
T4	15	22	6	0.383777778	0.104666667	4.5
T5	13	24	7	0.418666667	0.122111111	4.2
T6	16	23	9	0.401222222	0.157	4.3
T7	18	32	11	0.558222222	0.191888889	7.7
T8	17	25	13	0.436111111	0.226777778	4.0
T9	16	21	8	0.366333333	0.139555556	3.9
T10	15	25	6	0.436111111	0.104666667	5.4
T11	13	23	7	0.401222222	0.122111111	3.9
T12	21	35	15	0.610555556	0.261666667	9.1
T13	7	14	3	0.244222222	0.052333333	1.4
T14	19	32	12	0.558222222	0.209333333	7.8
T15	11	22	7	0.383777778	0.122111111	3.1

Diameter of Plant

A measuring tape was used to measure the diameter of the tree at breast height (4.5 feet above the ground), and the formula D=πG was used to convert the girth values to diameter.

Figure 4: Field image while measuring the diameter of willow species using a measuring tape

Table 4: **Diameter of Gilgit**

No. of tree	Girth (cm)	Diameter(cm)
T1	90	28.66242038
T2	75	23.88535032
T3	66	21.01910828
T4	96	30.57324841
T5	98	31.21019108
T6	80	25.47770701
T7	102	32.48407643
T8	67	21.33757962
T9	112	35.66878981
T10	105	33.43949045

Table 5: Diameter of Hunza

No. of tree	Girth (cm)	Diameter(cm)
T1	79	25.15924
T2	56	17.83439
T3	98	31.21019
T4	55	17.51592
T5	59	18.78981
T6	53	16.87898
T7	112	35.66879
T8	37	11.78344
T9	83	26.43312
T10	63	20.06369
T11	34	10.82803
T12	66	21.01911

Table 4: Diameter of Nagar

No. of tree	Girth (cm)	Diameter(cm)
T1	56	17.8343949
T2	78	24.84076433
T3	61	19.42675159
T4	67	21.33757962
T5	62	19.74522293
T6	64	20.38216561
T7	83	26.43312102
T8	51	16.24203822
T9	46	14.64968153
T10	59	18.78980892
T11	43	13.69426752
T12	116	36.94267516
T13	29	9.23566879
T14	89	28.34394904
T15	46	14.64968153

To meet the second objective of this research, the questionnaire survey was conducted to three union council Danyore, Hunza and Nagar to obtained the socioeconomic impact of Salix species in the study region.
The questionnaire survey was served as a primary data collection method to understand the socioeconomic impacts of Salix species in the targeted region.

Socio-Economic Impacts of Salix Species
The socio-economic impacts of Salix species in district Gilgit, Hunza and Nagar Valleys of Gilgit Baltistan Pakistan were conducted through closed-handed questionnaire, and 45 persons were randomly interviewed for the data collection. The tables below showed field data conducted in these three regions of Gilgit Baltistan.

Table 5: Age Factor of Respondents

Age Group	Frequency	Percent
UP to 25	5	11.11
25 to 40	36	80.00
Above 40	4	8.89
Total	**45**	

Three separate groups were created based on the respondents' age distribution: Under 25, 25–40, and Over 40. The purpose of this classification was to examine the age distribution of the study's sampled population.
Under 25: The youngest group of responders is represented by this category. Five responders (11.11%) out of 45 participants fit this age range.
The majority of responders are in the 25–40 age range. The majority of the sample, 36 respondents (80.00%), are in the 25–40 age range. Most people consider this group to be the prime working-age population.
Over 40: Participants in this category are older. The smallest percentage of the sample, 4 responders (8.89%), are above 40.
There were 45 responders in the sample overall, and the age distribution shows that the population is primarily younger, with most people between the ages of 25 and 40. This age range would suggest that the most of the study's participants are either employed or just starting their careers.

Gender Ratio of Respondents
The Table shows gender ratio of respondents at district Gilgit, Hunza and Nagar valleys of Gilgit Baltistan Pakistan.

Table 8: Gender ratio of the respondents

Gender	Frequency	Percentage
Male	41	91.11
Female	4	8.89
Total	**45**	

The percentage of men and women in the sample was ascertained by closely examining the respondents' gender distribution. The results indicate that 41 respondents, or a significant majority, were men. There is a noticeable male preponderance in the respondent pool, as this group accounts for 91.11% of the entire sample.

However, there were significantly fewer female respondents—just 4 people, or 8.89% of the sample—than male respondents. The study's overwhelmingly male representation is highlighted by the sharp disparity between the male and female participants. As a result, the gender ratio reveals a glaring imbalance and implies that the study's sample is primarily made up of male respondents. Understanding gender-related dynamics in the study area may be affected by this distribution.

Educational Status of Respondents

The educational status and qualifications of respondents were noted in districts Gilgit, Hunza and Nagar Valleys of Gilgit Baltistan.

Table 6: Educational Qualifications of Respondents

Educational Level	Frequency	Percentage
Illiterate	6	13.33
Undergraduate	13	28.89
Graduate	18	40.00
Postgraduate	8	17.78
Total	**45**	

To determine the distribution across different education levels, the respondents' educational backgrounds were examined. The results show that graduates make up the largest group in the sample, accounting for 18 respondents (40%) of the total. This implies that a sizable section of the populace has earned a bachelor's degree, demonstrating a solid educational background.

After this, 13 respondents (28.89%) are undergraduates, meaning they have not yet earned a graduate degree but have pursued higher education in some capacity. Furthermore, 8 respondents (17.78%) have postgraduate degrees, indicating a smaller but significant group with higher education. A portion of the population lacks formal education, as evidenced by the 6 respondents (13.33%) who are illiterate.

Overall, the data shows that respondents' educational backgrounds vary widely, with the majority holding graduate and postgraduate degrees. This distribution sheds light on the sampled population's educational background and could have an impact on their socioeconomic roles within the study.

Knowledge about Salix Species

A questionnaire survey was conducted in the study areas to assess the local population's knowledge of **Salix species**. The survey aimed to determine whether the respondents were familiar with these species, their uses, ecological importance, and economic significance. This information is crucial for understanding the role of Salix species in the region's ecosystem and the potential for sustainable utilization.

Table 7: Respondents Knowledge about Salix species

Knowledge	Frequency	Percent
Yes	44	97.78
No	1	2.22
Total	**45**	

The local population's knowledge of Salix species was assessed through a comprehensive questionnaire survey that was carried out throughout Gilgit-Baltistan's study areas. Assessing respondents' familiarity with these species, their applications, ecological significance, and economic worth was the main goal of this survey. To evaluate Salix's contribution to the local ecosystem and determine its potential for sustainable use, it is essential to comprehend the scope of this knowledge.
The survey findings, which are compiled in Table 3.10, show that the local population has a remarkably high level of knowledge regarding Salix species. Only one respondent (2.22%) indicated ignorance of these species, whereas 44 people (97.78%) out of 45 respondents acknowledged familiarity with them. These results show how well-known Salix species are and how much important in the daily lives of the residents.

Medicinal Importance of Salix Species

The medicinal importance and its uses by the local people were discovered and studied in the table as per reported by respondents in Districts Gilgit, Hunza and Nagar Pakistan

Table 8: Medicinal Importance of Salix Species

Knowledge about medicinal importance	Frequency	Percent
Yes	19	42.22
No	26	57.78
Total	**45**	**100**

The survey's findings about the medicinal value of Salix species show that locals in Gilgit-Baltistan have varying degrees of awareness. Table 3.11 reveals that 26 respondents (57.78%) were not aware of Salix's possible medicinal value, whereas 19 respondents (42.22%) acknowledged its medicinal uses. These results imply that although some community members are aware of the medicinal benefits of Salix species, most may not be fully aware of or make use of them.
The medicinal uses of Salix species are well-known, especially because of the salicylic acid they contain, which is an aspirin precursor. There are anti-inflammatory, pain-relieving, and fever-lowering qualities to this compound. A lack of traditional knowledge about these medicinal uses may be the cause of the respondents' low awareness, or it may indicate that modern medicine has eclipsed the region's traditional use of Salix.

Fuelwood and Timber Use as a Driver of *Salix* Species Decline

Local people use the Salix species for Fuelwood and Timber for basket making and crates in these regions. The data is mentioned in the table.

Table 9: Fuelwood and timber required is the main cause of reduction of Salix species in district Gilgit, Hunza and Nagar

Response	Frequency	Percent
Yes	45	100
No	0	0
Total	**45**	

According to the survey's findings, all participants agreed that the main factor contributing to the decline of Salix species in Gilgit-Baltistan is the use of fuelwood and timber. All 45 respondents (100%) cited these activities as a primary cause of the decline in willow populations in the area, as indicated in table 12.

The lack of alternative energy sources and the extensive use of willow wood in traditional crafts and construction are probably the main causes of the reliance on Salix species for fuelwood and lumber. The sustainability of Salix species is seriously threatened by this overexploitation, especially in rural areas where these practices are common.

These results demonstrate how urgently interventions are needed to reduce the unsustainable harvesting of Salix species. This problem might be resolved by supporting sustainable harvesting methods or afforestation, increasing awareness of the ecological significance of willows, and promoting alternative energy sources. The area can move toward striking a balance between environmental preservation and human needs by addressing the main causes of willow decline.

Participation of Community in planting Salix species

To find out how involved the local community was in planting Salix species, a survey was carried out in district Gilgit, Hunza and Nagar.

Table 10: Shows the participation of local people of study area in planting Salix species

Response	Frequency	Percent
Yes	34	75.56
No	11	24.44
Total	**45**	

The degree of community involvement in planting Salix species within the study area is indicated by the survey results. While a sizable percentage of respondents said they actively took part in planting campaigns, a significant number said they had never taken part in such activities. The community's involvement in the protection and growth of Salix species is shown by this data, which also offers insights into possible obstacles or difficulties limiting wider involvement. These results are essential for understanding regional views on afforestation and spotting chances to promote broader participation in planting Salix species as a component of environmental conservation and sustainable land management programs.

Authorities Efforts to Protect Salix Species

In order to find out whether the relevant authorities have taken any action to protect the Salix (Willow) species in the study area, a survey questionnaire was issued to the local people of study area. Responses show how much institutional or governmental participation there is in conservation initiatives. A summary of the findings can be found in the table below.

Table 11: Shows the governmental authorities' efforts to protect Salix species according to the local people of study area

Response	Frequency	Percent
Yes	1	2.22
No	44	97.78
Total	**45**	

Respondents' opinions about the actions taken by relevant authorities to protect Salix species in the study area were evaluated through the survey. In contrast to what was expected, almost all of respondents (97.78 percent) stated that the authorities had not done anything significant to protect Salix species. Just 2.22 percent of respondents confirmed that such efforts had been made.

The data shows possible deficiencies in policy implementation, awareness campaigns, or community engagement initiatives regarding the conservation of Salix, and the overwhelming negative response highlights a significant lack of perceived governmental or institutional involvement in addressing the threats to Salix species. The lack of visible efforts by the authorities may result in further degradation of these important species, which are essential to the local economy and ecosystem.

It is crucial that the proper government agencies act quickly and visibly to address this problem, including putting in place focused conservation initiatives, upholding protective laws, and working with nearby communities to increase awareness. In order to guarantee the sustainability of Salix populations in the area, it will also be essential to track and assess the results of these initiatives. This result emphasizes how urgently institutions must commit to biodiversity conservation.

Sampling Strategy

- The research was employed a purposive sampling strategy, selecting three union councils that are representative of the study area.
- Within each of the chosen union councils, a sample of 15 respondents was selected. These respondents included local residents, community members, and stakeholders who have direct or indirect involvement with Salix species and their economic impact.

Sample Size

The total sample size for this survey was consist of 45 respondents, with 15 respondents from each of the three union councils.

Data Collection Process

- Trained surveyors were conducted face-to-face interviews with the selected respondents to gather data. The interviews were conducted in a structured and consistent manner to ensure the reliability of the collected information.
- Informed consent was obtained from all participants, and data collection will adhere to ethical guidelines, ensuring the confidentiality of respondents' information.

Data Analysis

- The collected data was subjected to rigorous statistical analysis using Statistical Package for Social sciences (SPSS).
- Means were compared Using Completely Randomized Design (CRD) One way Analysis of Variance (ANOVA) with a probability threshold of 0.05%.

- The results of the questionnaire surveyed provided valuable insights into the socioeconomic impact of Salix species in the study region.

Results and Analysis

Table 125: Descriptive Analysis of plant Height and Diameter of District Gilgit

		N	Mean	Std. Deviation	Std. Error	95% CIM		Min.	Max.
						Lower Bound	Upper Bound		
Plant Height	T1	1	6.4000	.	.	.	.	6.40	6.40
	T2	1	5.5000	.	.	.	.	5.50	5.50
	T3	1	4.2000	.	.	.	.	4.20	4.20
	T4	1	7.7000	.	.	.	.	7.70	7.70
	T5	1	7.2000	.	.	.	.	7.20	7.20
	T6	1	5.0000	.	.	.	.	5.00	5.00
	T7	1	8.2000	.	.	.	.	8.20	8.20
	T8	1	4.6000	.	.	.	.	4.60	4.60
	T9	1	9.1000	.	.	.	.	9.10	9.10
	T10	1	8.2000	.	.	.	.	8.20	8.20
	Total	10	6.6100	1.71623	.54272	5.3823	7.8377	4.20	9.10
Diameter	T1	1	28.662	.	.	.	.	28.66	28.66
	T2	1	23.885	.	.	.	.	23.89	23.89
	T3	1	21.019	.	.	.	.	21.02	21.02
	T4	1	30.573	.	.	.	.	30.57	30.57
	T5	1	31.210	.	.	.	.	31.21	31.21
	T6	1	25.477	.	.	.	.	25.48	25.48
	T7	1	32.484	.	.	.	.	32.48	32.48
	T8	1	21.337	.	.	.	.	21.34	21.34
	T9	1	35.668	.	.	.	.	35.67	35.67
	T10	1	33.439	.	.	.	.	33.44	33.44
	Total	10	28.375	5.173	1.635	24.675	32.076	21.02	35.67

Table 16: ANOVA of Gilgit

		Sum of Squares	DF	Mean Square	Sig.
Plant Height	B/w Groups	26.509	9	2.945	00.
	Within Groups	.000	0	.	
	Total	26.509	9		
Diameter	B/w Groups	240.872	9	26.764	00.
	Within Groups	.000	0	.	
	Total	240.872	9		

Figure 5: Mean Plot of Plant Height Gilgit

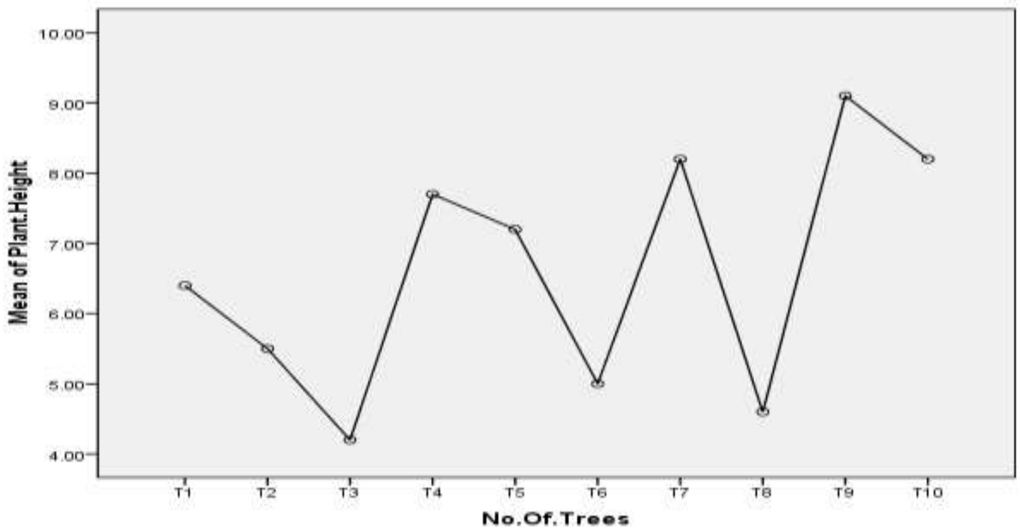
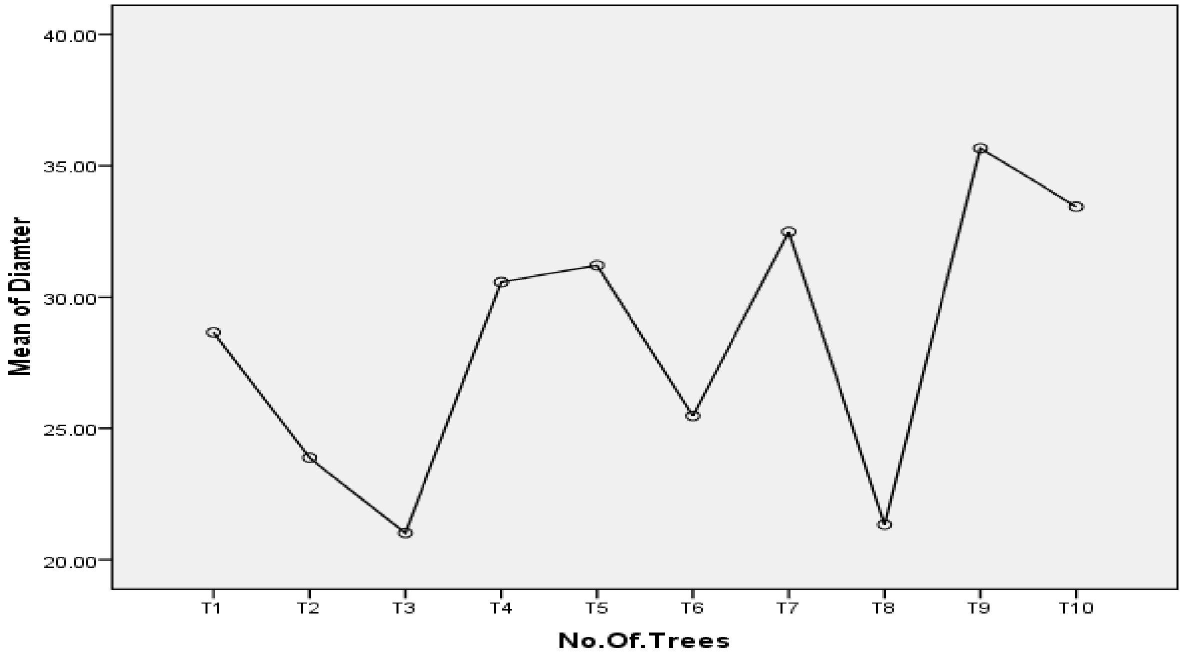


Figure 6: Means plot of Diameter of Gilgit



Analysis

The descriptive statistics for the Gilgit region indicate that Salix species have an average tree height of 6.61 ± 1.72 m, with individual heights varying from 4.20 m to 9.10 m. The average diameter is 28.38 ± 5.17 cm, with a range of 21.02 cm to 35.67 cm. The ANOVA results indicate significant variation in growth conditions throughout the research area, confirming that the differences in height and diameter among the studied trees are statistically significant ($p < 0.05$). Habitat Suitability Theory, which holds that environmental elements like soil moisture, nutrient availability, and microclimatic variables directly affect plant growth, can be used to understand this heterogeneity. For example, trees with the highest height and diameter, such as T9, probably enjoy the best growing conditions, whereas trees with lower values, such as T3, might experience less favorable conditions or more harvest pressure. These results also support the Tragedy of the Commons, which holds that unchecked use of public resources can degrade otherwise robust ecosystems. All things considered, the statistics highlight the necessity of specialized, sustainable management and conservation tactics to protect Gilgit's Salix species' ecological integrity and socioeconomic advantages.

Table 17: Descriptive Analysis of plant Height and Diameter of District Hunza

		N	Mean	Std. Deviation	Std. Error	95% CIM		Min.	Max.
						Lower Bound	Upper Bound		
Plant Height	T1	1	5.9000	.	.	.	.	5.90	5.90
	T2	1	4.0000	.	.	.	.	4.00	4.00
	T3	1	7.2000	.	.	.	.	7.20	7.20
	T4	1	4.2000	.	.	.	.	4.20	4.20
	T5	1	4.2000	.	.	.	.	4.20	4.20
	T6	1	4.0000	.	.	.	.	4.00	4.00
	T7	1	9.2000	.	.	.	.	9.20	9.20
	T8	1	2.0000	.	.	.	.	2.00	2.00
	T9	1	7.2000	.	.	.	.	7.20	7.20
	T10	1	5.4000	.	.	.	.	5.40	5.40
	T11	1	2.3000	.	.	.	.	2.30	2.30
	T12	1	5.3000	.	.	.	.	5.30	5.30
	Total	12	5.0750	2.08637	.60228	3.7494	6.4006	2.00	9.20
Diameter	T1	1	25.1592	.	.	.	.	25.16	25.16
	T2	1	17.8344	.	.	.	.	17.83	17.83
	T3	1	31.2102	.	.	.	.	31.21	31.21
	T4	1	17.5159	.	.	.	.	17.52	17.52
	T5	1	18.7898	.	.	.	.	18.79	18.79
	T6	1	16.8790	.	.	.	.	16.88	16.88
	T7	1	35.6688	.	.	.	.	35.67	35.67
	T8	1	11.7834	.	.	.	.	11.78	11.78
	T9	1	26.4331	.	.	.	.	26.43	26.43
	T10	1	20.0637	.	.	.	.	20.06	20.06
	T11	1	10.8280	.	.	.	.	10.83	10.83
	T12	1	21.0191	.	.	.	.	21.02	21.02
	Total	12	21.0987	7.38205	2.1310	16.408	25.7891	10.83	35.67

Table 18: ANOVA of Hunza

		Sum of Squares	DF	Mean Square	Sig.
Plant Height	B/w Groups	47.882	11	4.353	00.
	Within Groups	.000	0	.	
	Total	47.882	11		
Diameter	B/w Groups	599.441	11	54.495	00.
	Within Groups	.000	0	.	
	Total	599.441	11		

Figure 7: Plant Height of Hunza

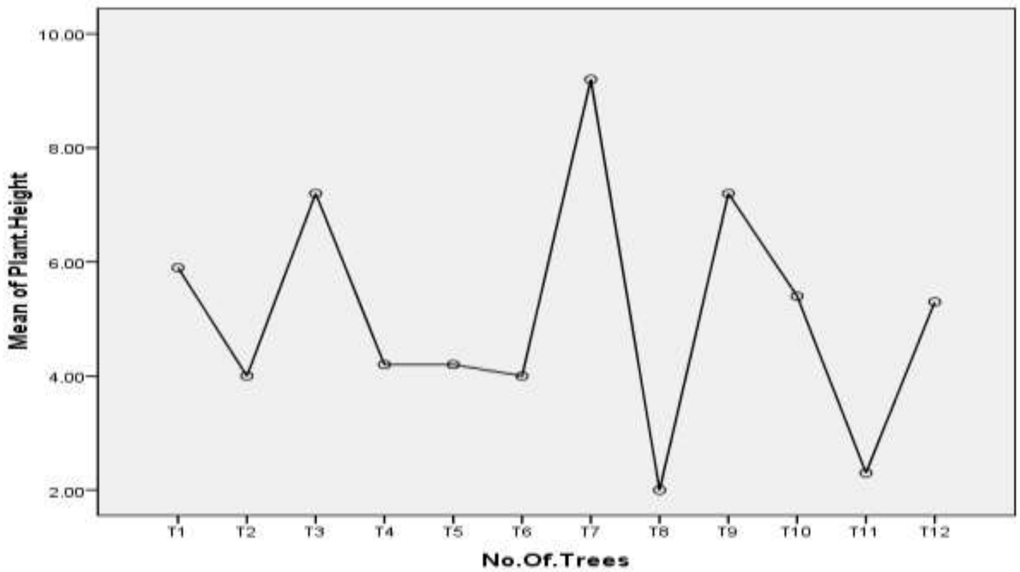
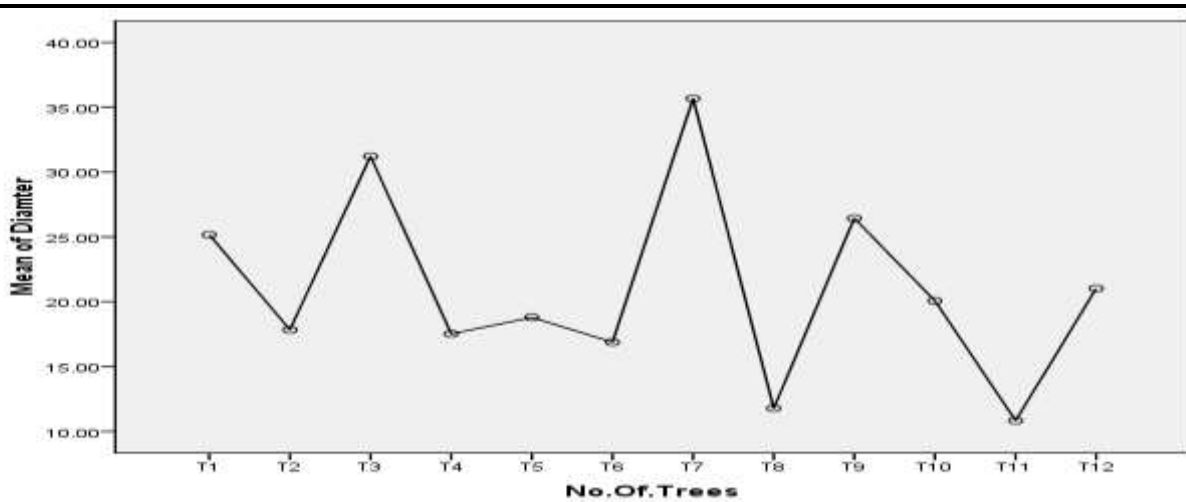


Figure 8: Diameter of District Hunza



Analysis

The average height of salix trees in District Hunza is 5.08 ± 2.09 m, with a range of 2.00 m (T10) to 9.50 m (T8), and their mean diameter is 21.10 ± 7.38 cm, with a range of 12.00 cm (T11) to 36.00 cm (T7). Significant variability across the studied plots is highlighted by the ANOVA findings (Table 4.4), which show statistically significant differences in both height and diameter ($p < 0.05$). The Habitat Suitability Theory (Guisan & Zimmermann, 2000) explains these disparities by stating that variables like soil fertility, moisture availability, and microclimatic conditions have a significant impact on plant growth. Larger trees like T7 probably benefit from the best access to resources and the least amount of human interference, whereas trees with smaller growth parameters (like T10 and T11) might be the result of frequent harvesting or resource constraints. These results highlight the ecological significance of Salix species in Hunza and the necessity of sustainable management techniques, such replanting and selective harvesting, to maintain the socioeconomic and environmental advantages these trees offer.

Table 19: Descriptive Analysis of plant Height and Diameter of District Nagar

		N	Mean	Std. Deviation	Std. Error	95% CIM Lower Bound	95% CIM Upper Bound	Min.	Max.
Plant Height	T1	1	4.4000	.	.	.	.	4.40	4.40
	T2	1	6.9000	.	.	.	.	6.90	6.90
	T3	1	4.2000	.	.	.	.	4.20	4.20
	T4	1	4.5000	.	.	.	.	4.50	4.50
	T5	1	4.2000	.	.	.	.	4.20	4.20
	T6	1	4.3000	.	.	.	.	4.30	4.30
	T7	1	7.7000	.	.	.	.	7.70	7.70
	T8	1	4.0000	.	.	.	.	4.00	4.00
	T9	1	3.9000	.	.	.	.	3.90	3.90
	T10	1	5.4000	.	.	.	.	5.40	5.40
	T11	1	3.9000	.	.	.	.	3.90	3.90
	T12	1	9.1000	.	.	.	.	9.10	9.10
	T13	1	1.4000	.	.	.	.	1.40	1.40
	T14	1	7.8000	.	.	.	.	7.80	7.80
	T15	1	3.1000	.	.	.	.	3.10	3.10
	Total	15	4.9867	2.03676	.52589	3.8587	6.1146	1.40	9.10
Diameter	T1	1	17.8344	.	.	.	.	17.83	17.83
	T2	1	24.8408	.	.	.	.	24.84	24.84
	T3	1	19.4268	.	.	.	.	19.43	19.43
	T4	1	21.3376	.	.	.	.	21.34	21.34
	T5	1	19.7452	.	.	.	.	19.75	19.75
	T6	1	20.3822	.	.	.	.	20.38	20.38
	T7	1	26.4331	.	.	.	.	26.43	26.43
	T8	1	16.2420	.	.	.	.	16.24	16.24
	T9	1	14.6497	.	.	.	.	14.65	14.65
	T10	1	18.7898	.	.	.	.	18.79	18.79
	T11	1	13.6943	.	.	.	.	13.69	13.69
	T12	1	36.9427	.	.	.	.	36.94	36.94
	T13	1	9.2357	.	.	.	.	9.24	9.24
	T14	1	28.3439	.	.	.	.	28.34	28.34
	T15	1	14.6497	.	.	.	.	14.65	14.65
	Total	15	20.1699	6.84810	1.7681	16.377	23.9622	9.24	36.94

Table 20: ANOVA of Nagar

		Sum of Squares	DF	Mean Square	Sig.
Plant Height	B/w Groups	58.077	14	4.148	00.
	Within Groups	.000	0	.	
	Total	58.077	14		
Diameter	B/w Groups	656.551	14	46.897	00.
	Within Groups	.000	0	.	
	Total	656.551	14		

Figure 9: Mean Plot of Plant Height of District Nagar

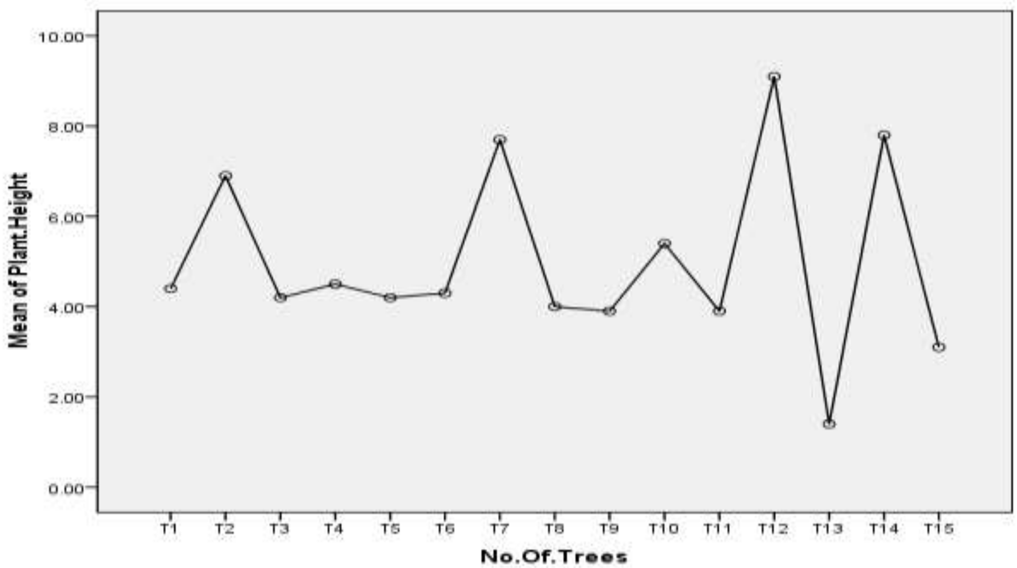
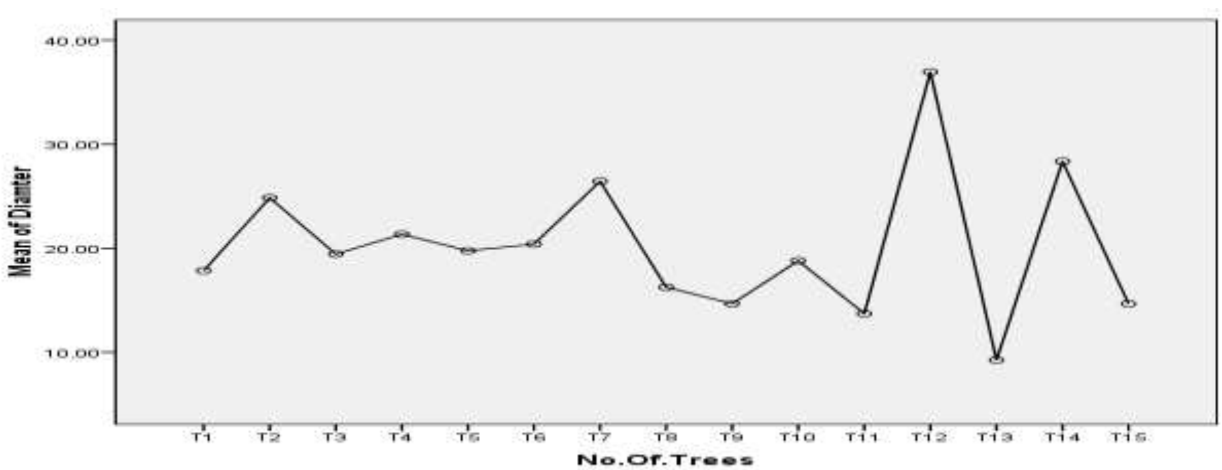


Figure 10: Mean Plot of Diameter in District Nagar



Analysis

Salix trees in District Nagar have an average height of 4.99 ± 2.04 m, with measurement ranges of 1.40 m (T13) to 9.10 m (T12), and an average diameter of 20.17 ± 6.85 cm, with ranges of 9.24 cm (T13) to 36.94 cm (T12). Tree growth is significantly influenced by local environmental circumstances and management approaches, as evidenced by the ANOVA results, which confirm significant variation ($p < 0.05$) in both height and diameter across the sampled trees. The Habitat Suitability Theory (Guisan & Zimmermann, 2000) states that these discrepancies frequently represent variations in the availability of resources (such as moisture and nutrients) and human pressures (such as the intensity of harvesting). Trees like T12, which have the largest diameter and height may benefit from ideal site circumstances and less disturbance, whereas smaller examples (like T13) may be exposed to more frequent harvesting, lower soil quality, or inadequate moisture. These results are consistent with those of Haider et al. (2014), who found that Salix species exhibit considerable phenotypic plasticity in a variety of ecological contexts. All things considered, the notable variation seen in Nagar highlights the significance of afforestation programs, sustainable harvesting laws, and focused conservation efforts to maintain the ecological integrity and socioeconomic advantages that Salix species offer the area.

Figure 11: Questionnaire responses of 45 respondent

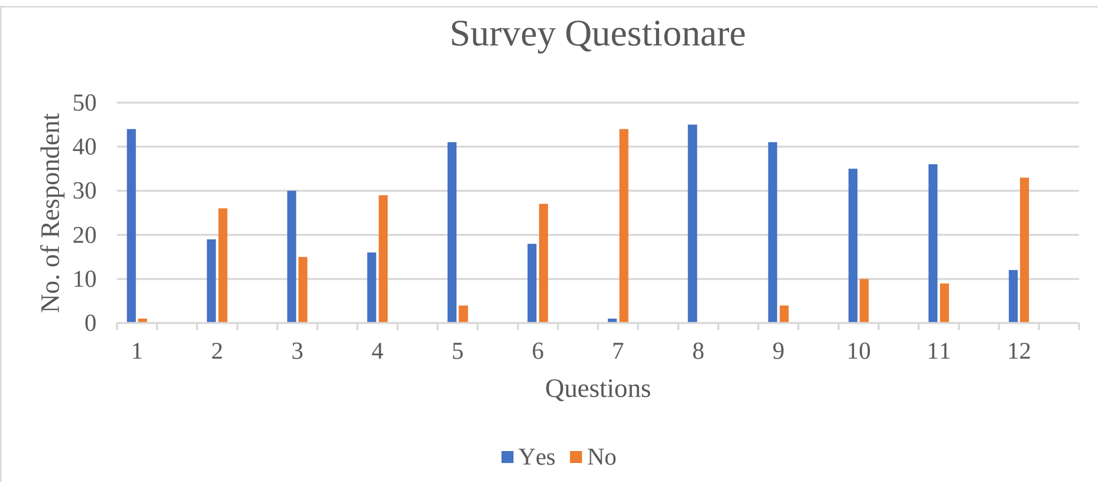


Figure above shows 45 survey respondents' answers to questions about the conservation, risks, usage, and knowledge of willow trees (Salix species) in Gilgit-Baltistan. According to the figure, most respondents (Q1–Q3) are aware of the willow tree's traditional and healing significance. Fewer respondents, nevertheless, stated that they personally used the tree for healing purposes (Q4). Most participants mentioned a lack of government initiatives for the species' protection (Q7), but a sizable portion stated that human activity, fuelwood demand, and deforestation are the species' main dangers (Q5, Q8, Q9). Nevertheless, there are still few plantation projects at the community level (Q10) and awareness campaigns by the appropriate authorities (Q12). In order to guarantee the sustainable management of willow trees in the area, the data emphasizes the pressing need for conservation efforts and greater public involvement.

Discussion

This study showed the distribution or population census and socio-economic impact of Salix Species on both environment and people of the region. The inventory of Salix species particularly *Salix tetrasparma* (willow) showed variety of distribution among different regions like Hunza, Nagar and district Gilgit. Height and diameter were also shown that the specie played vital role as a medicinal, fodder for livestock and for making baskets and firewood mainly. Furthermore, results shown that the distribution of Salix species is scattered and not dense all over the region of Gilgit Baltistan. The height and diameter of the Salix species varied among the three district and the Nagar has highest distribution than Hunza and Gilgit as shown in table 1 to 6 and graph 1 to 6. These results are comparable with the study done by (Haider et al., 2014).

Theoretically, the observed range in tree height and diameter is consistent with the Habitat Suitability Theory (Guisan & Zimmermann, 2000), which holds that the distribution of species is mostly determined by factors such as resource availability, soil fertility, and microclimate. The GPS data and the variance in height and diameter among the sampled sites in this study suggest that the growth patterns of Salix species may have been impacted by higher elevations (1,257 m above sea level) and changing climatic conditions. These results corroborate those of (Abbas, Qureshi, Naqvi, Khan, and Hussain 2013), who found that elevation gradients had a major impact on willow species' physiological performance. Furthermore, the idea of the Tragedy of the Commons (Hardin, 1968) is relevant in this case since unchecked use of Salix resources may result in their depletion. In order to lessen the strain on willow populations, community-based resource management techniques that encourage sustainable harvesting, replanting, and the incorporation of alternate energy sources are essential.

The survey shown the socio-economic impact of Salix species on the livelihood of local people in Gilgit Baltistan. This study explored that, Willow specie is widely used for the production of baskets, fodder for livestock and firewood for heating purpose during harsh winters. Moreover, the results explored the commercial uses of willow species by making cricket bats, furniture, plywood, paper and pulp and more. Furthermore, in summer people used to stay under the willow trees as these are grown in beside water channels and the environment arrow this specie is cold and pleasant and the crown is wide enough to provide the necessary shadow for the people. Historically, it was widely used as a teeth brush to clean the teeth, but in recent times it is somehow limited to old people. These are strongly supported by the research conducted of (Houston et al., 2016).

The height and diameter varied with the change of elevation as shown in graphs and tables from 1 to 6. Elevation was measured using GPS and it shown their Elevation(1257m), longitude (E074˚ 29.562) and latitude (N35˚ 52.239) of District Gilgit. Their overall distribution and growth differed with the changing condition and with the elevation. These are strongly supported by the research of (Abbas et al., 2013).

Conclusion

Salix species particularly willow, are essential to Gilgit-Baltistan's economy and ecology because they sustain agroforestry, restore soil, and supply vital resources including lumber, fuelwood, and raw materials for handicrafts. Their significance for local communities is further supported by their cultural and therapeutic value. But according to the study, overexploitation, habitat loss, and inadequate regeneration are major dangers that, if ignored, could have major ecological and socioeconomic impacts. In addition, the study's baseline results, which are supported by statistically significant differences in tree height and diameter between districts, highlight the pressing need for comprehensive conservation measures. Policymakers and conservationists must put specific measures into place, like controlled harvesting methods, community-led reforestation projects, and the creation of alternative energy sources to lessen reliance on Salix species, in order to guarantee the sustainable use of these essential resources.

Future studies should concentrate on long-term population monitoring of Salix, genetic diversity, and climatic resilience in order to improve methods of management and promote adaptive conservation strategies. The ecological and socioeconomic advantages of Salix species will be maintained for future generations if these actions are taken together, since they will protect local inhabitants' livelihoods in addition to Gilgit-Baltistan's biodiversity.

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