Current Status and Threats to Himalayan Birch and Its Socio-economic Impact on Local Community in Baltistan (Pakistan)

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Abstract

This study intends to evaluate the birch forest's current status and identify the main threats to the birch forest in District Skardu, Baltistan, Pakistan. This study aimed to investigate the connection between problems and anthropogenic activities, and threats, which had negatively affected the ratio of Birch trees in District Skardu, Gilgit Baltistan. The research has highlighted the importance of forest-based industry as its socioeconomic impact on the local community. A questionnaire was used to determine the socioeconomic importance and hazards facing the birch forest, highlighting issues like fuelwood gathered, deforestation, climate change, and catastrophic events. Additionally, Tehsil Roundu, District Skardu, used random fixed plot sampling to evaluate the forest. The studies stated 75% of people in rural areas including the urban area used Birch forest for, packing purposes, furniture making, and other anthropogenic activities due to mentioned factors it declared as threatened species. In the previous studies and records of 10 to 15 years, comparatively the Birch forest has declined 5 to 6%, which is a serious threat and environmental challenge. About 88% of people responded that deforestation is the primary driver in the reduction of Birch forest status, the studies also revealed that 75% of local communities used it for fuel wood and furniture making, 69% believed that it could be best used for multiple disease treatment.

Keywords: Deforestation, Roundu, Anthropogenic, Furniture, Deforestation.

Introduction

Forests are essential for maintaining biodiversity, controlling the climate, and maintaining ecosystems. The Food and Agriculture Organization (FAO, 2020) estimates that land-use changes

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and deforestation cause the globe to lose about 4.7 million hectares of forest annually. Only around 5.1% of Pakistan's geographical surface is covered by forests, which is a startlingly low percentage compared to the 25% that is advised by international standards. In vulnerable mountainous areas therefore, the objective of this study was to assess both the socioeconomic significance of the Himalayan birch forest for the local inhabitants in District Skardu as well as its current situation and threats. In light of these escalating requirements, the study also seeks to emphasize the necessity of sustainable forest management and conservation techniques. Gilgit-Baltistan, where people rely largely on trees for fuelwood, building materials, fodder, and medicinal plants, the situation is worse.

A keystone species of the sub-alpine and alpine forests in the Himalayan region, the Himalayan birch (Betula utilis) is essential to both ecological stability and local livelihoods. It can reach a height of 20 meters and offers vital ecosystem services such habitat creation, erosion management, and bio-shielding for other forest species. These woods in Pakistan are coming under more and more stress, especially in Gilgit-Baltistan. The Gilgit-Baltistan Forest Department (2022) reports that over the previous 20 years, the region's forest cover has shrunk by about 8%, with Betula utilis being one of the most impacted species.

According to the Pakistan Bureau of Statistics (2020), more than 70% of rural households in the area depend on fuelwood for their daily energy needs, which puts a lot of human pressure on native species that develop slowly, such as Himalayan birch. The strain on these high-altitude woods is also being exacerbated by changes in the climate. The ability of cold-adapted species like Betula utilis to regenerate has been severely affected by the average temperature increase of 1.2°C over the past 30 years, according to regional climate data (PMD, 2021). The species is still mostly overlooked in conservation policies, despite its ecological and therapeutic significance.

In District Skardu, Pakistan a native high-altitude tree species of special ecological and social importance is the Himalayan birch (Betula utilis). However, overgrazing, deforestation, overexploitation, and the effects of climate change have all become more serious threats to this species in recent decades. During 60% of the region's dense birch forest areas have decreased during the past 30 years, according to studies.

Therefore, the objective of this study was to assess both the socioeconomic significance of the Himalayan birch forest for the local inhabitants in District Skardu as well as its current situation and threats. In light of these escalating requirements, the study also seeks to emphasize the necessity of sustainable forest management and conservation techniques. The Himalayan medicinal plant *Betula utilis* is under threat from a number of factors right now, including deterioration, pollution, the introduction of alien species, overuse, and climate change. To ascertain a species' conservation status, factors including agriculture, grazing, and deforestation are taken into consideration. Plant species are essential to life on Earth, but by 2050, 60,000 of them are predicted to be extinct. The main causes of deforestation and overexploitation in the Himalayas are linked to population pressure and its consequences. The Betulaceae family plant *Betula utilis* has several advantages; however, preservation measures are required to preserve significant medical plants like it. (Safdar et al., 2017).

The study investigated the Astore, Gilgit, and Skardu districts in Gilgit-Baltistan, Pakistan ranging from 2616 to 3735 meters above sea level (a.s.l.), and 40 stands from 15 distinct locations. This study makes an effort to reveal the current state and potential developments in the arboreal vegetation and forest species in these regions. In several stands, size class distribution patterns differed. These forests are not in a stable condition since the majority of the divergence from an ideal distribution can be attributed to anthropogenic disturbances, such as grazing, cutting, sliding,

burning, and other human-induced events. It is concluded that these priceless woodlands would disappear in a few decades if quick action were not taken to curb existing harmful practices (Akber et al., 2013).

One of the six native tree species examined in this study is *Betula utilis*, also known as Himalayan birch. The study uses the Maximum Entropy (MaxEnt) model to forecast the distribution of Betula *utilis* in the present and the future under several scenarios of climate change. The main goal of the study is to use the MaxEnt model to forecast *Betula utilis* distribution under various climate change scenarios. It is determined that height, temperature, and precipitation are significant determinants for the species. With Receiver Operating Characteristic - Area under the Curve values over 0.9 and 0.84 for training and testing, the model performs well. The report proposes adopting cutting-edge technologies for future research and notes that some locations are tough to access. The findings offer crucial information for management plans and conservation strategies for *Betula utilis* and other tree species in Gilgit-Baltistan (Galani et al., 2020).

This study focuses on the Himalayan birch's (*Betula utilis*) vulnerability in the timberline ecotone of India's Western Himalayas' Nanda Devi Biosphere Reserve, a place of international significance. The study ranks the species according to several threat categories using rapid threat assessment and rapid vulnerability assessment. Additionally, phytosociological research is done to evaluate species variety, density, and capacity for regeneration. The study emphasizes the susceptibility and loss of adult Himalayan birch trees and the unsustainable use of the species. The study makes relevant recommendations for the management and protection of the species as well as the socioeconomic advancement of nearby populations (Maletha et al., 2020).

In the northern hemispheres' temperate and boreal climate zones, *Betula utilis* trees and shrubs can be found in a variety of environments. The therapeutic benefits of Betula bark and bark extracts have long been recognized in traditional medicine, particularly for inflammatory conditions like arthritis. This review attempts to present an in-depth analysis of the Betula species, covering their botany, conventional usage, Photochemistry, and pharmacological and toxicological research. This review's examination of *Betula utilis* therapeutic potential aims to highlight prospective areas for future investigation. (Pandey et al., 2018)

In the study, the bark of *Betula utilis* from Kashmir and Sikkim (BUK and BUS, respectively) was tested for fatty acid and antioxidant activities. 13 fatty acids were found by GCMS analysis, including some important ones as palmitic acid, linoleic acid, and oleic acid. BUK outperformed BUS in terms of radical scavenging capacity and phenolic and flavonoid concentration. The methanol and water extracts of BUK bark showed the lowest IC50 value for radical scavenging activities. Because BUK contains a lot of palmitic, linoleic, and oleic acids, it might have been used in the pharmaceutical and nutritional industries (Shukla et al., 2017).

A study was conducted to determine how the ethanolic extract of the Himalayan medicinal herb *Betula utilis* (BUE) affected Caenorhabditis elegans. The findings demonstrated that BUE improved C. elegance survival under stressful settings and increased its mean lifetime by 35.99%. BUE also delayed amyloid-induced paralyzes, reduced -syncline aggregation, and reduced intracellular reactive oxygen species (ROS). The study discovered that only certain genes—including sir-2.1-independent daf-16, hsf-1, and skin-1—were required for BUE-mediated lifespan extension. Additionally, BUE therapy increased the expression of genes that defend against stress, like sod-3 and gst-4. According to these results, BUE may lengthen life and slow the progression of neurodegenerative diseases (Pandey et al., 2020).

Materials and Methods

Study Area

The study was carried out at Baltistan District Skardu, Pakistan. The study region includes Tormik, Astak, Gunji, and Subsar Roundu; four specifics of the Himalayan Birch forest and chosen areas. The Himalayan Birch population is known to be numerous in these beats of the forest, and these areas are significant to the local people in terms of their socio-economic activities.

The study area District Skardu is Pakistan's most significant and fascinating area in terms of the birch forest its geography and natural beauty entitled the tourism capital hub in Pakistan. Massive numbers of tourists flow every year in the summer and winter seasons. Skardu is surrounded and confined by the Indus River and Shigar River, the Khaplu district, and the district Astore of Gilgit Baltistan.

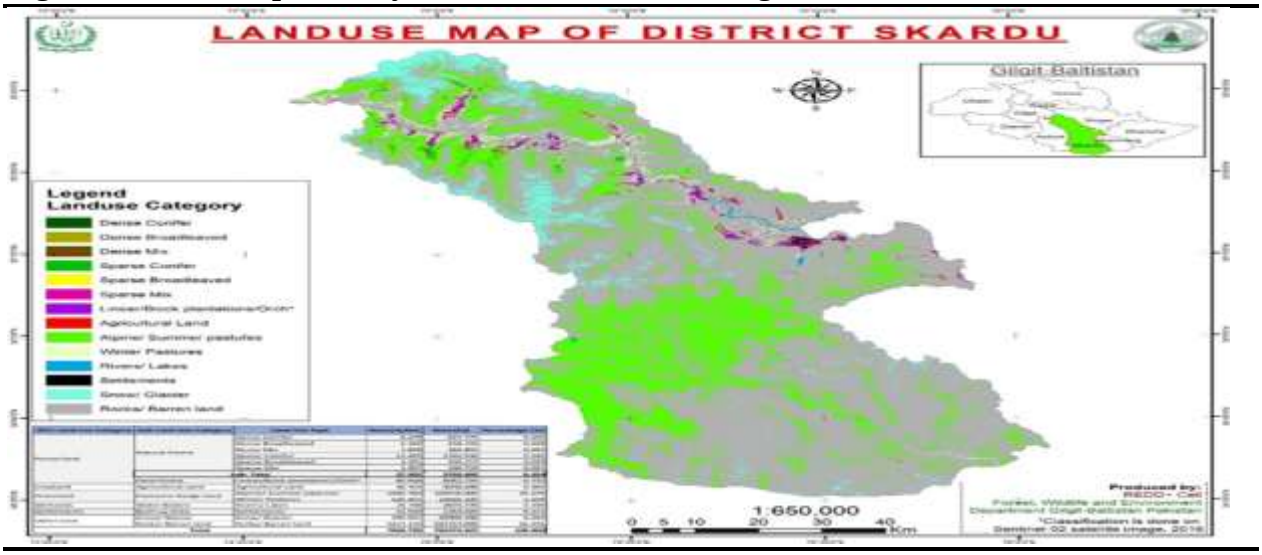
Skardu is situated at latitude 35.29787 and longitude 75.63372. Simple average. Nearly 2,500 m (8,202 feet). Skardu lies at 2500 meters (8202 feet) above sea level in the backdrop of the immense peak of "The Karakoram Mountain range". Summer rainfall is quite low because the mountains obstruct the summer monsoon. However, these mountains create severe winter weather, with the daytime temperatures from a maximum of 27 °C (81 °F) to a minimum of 8 °C (46 °F) in October. In the midwinter winter months of December to January, temperatures can drop as low as 10 °C (14 °F).

Study Design

Study Area and Sampling Intensity

Random fix plot sampling was used for the four selected areas, Tormik, Astak, Gunji, and Subsar of Sub-division Roundu, Skardu. Five plots were randomly selected from each area. The DBH (Diameter at Breast Height) and heights of the birch forest were measured within the selected plots, by tree caliper, and Abiney level and GPS (Global Positioning System) device were used for knowing the coordinates of the plots. Soil samples from every research site were also collected for the study of the nutrient status and its effect on crops and forest species especially the Birch forest of that area.

Figure 1: Detail map of study Area-District Skardu Gilgit Baltistan, Pakistan



Data Collection

With a standardized questionnaire, data was gathered. To make contact with the respondents easier, the questionnaire was initially written in English and then translated into the regional languages (Shina and Balti). Both closed-ended and open-ended questions were included in the survey. To ensure the validity and reliability of the questionnaire, a pre-test was conducted before the actual survey.

Data Analysis

Descriptive statistics including frequency distributions, percentages, and average and mean scores were used to analyze the acquired data. Additionally, the data was examined using inferential statistics, such as chi-square tests, to look for any appreciable variations in the replies between the four chosen areas. Data from the survey was examined using an Excel spreadsheet, Word, and SPSS 16.0.

SWOT Analysis

In order to increase the sustainability of the birch forest at study locations, management plans were identified based on an analysis of the strengths, weaknesses, opportunities, and threats (SWOT). Through it, the strengths and weaknesses of using birch forests to generate income and capital for the residents of the Skardu district in Baltistan, Pakistan, were also studied. We were also able to recognize the dangers to birch forests with the aid of field primary and secondary data. SWOT analysis aids in the summarization of collected data in order to generate overall conclusions and factors influencing the development and state of birch forests in study regions.

Ethical Considerations

The study was approved and authorized by the PMAS Arid Agriculture University's research ethics committee in Rawalpindi, Pakistan. Before the poll, informed consent was sought from each respondent. The responders received guarantees of secrecy, anonymity, and confidentiality.

Limitations

The study has several limitations that should be acknowledged. Firstly, the study was carried out in particular areas and sample size, due to the un-accessibility of roads and routes, threats of wildlife, and steep sloppy mountainous areas. The Birch forest was far-flung in remote areas, which was very hard for a common person to reach over there for that it may limit the generalizability of the findings. Secondly, the study was limited to only four selected areas, due to the dense availability of Birch forests in those selected areas, which may not be representative of the entire population in District Skardu, Baltistan. Finally, the study also relied on self-reported data, which may be subject and vulnerable to response bias.

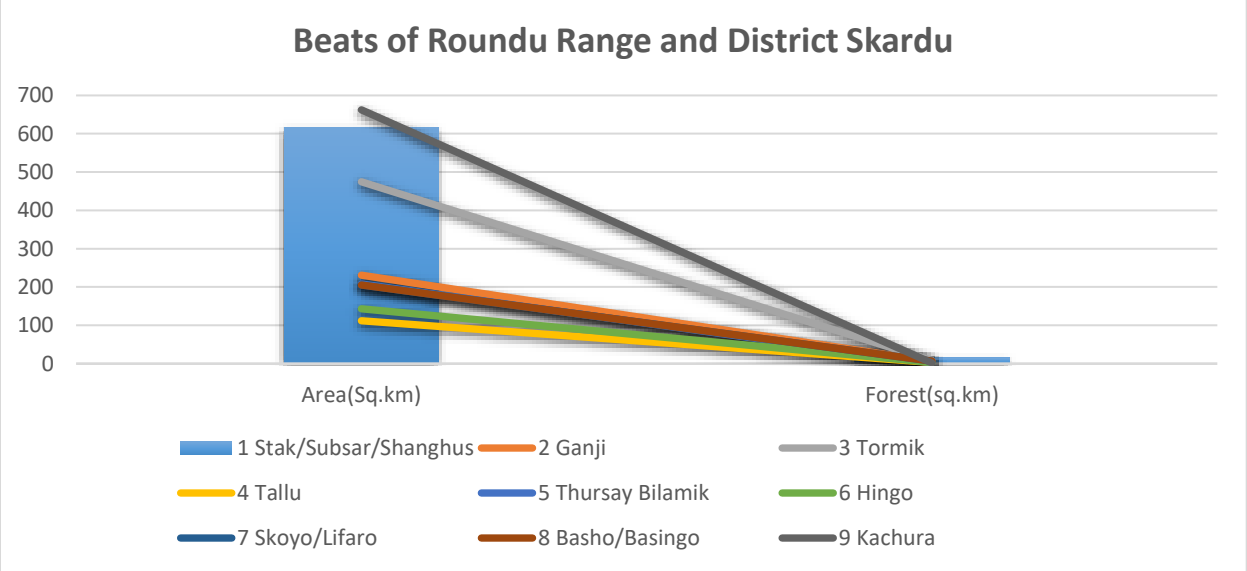
Results and Discussion

Random Fix Plot Sampling

Birch forest at Roundu, district Skardu was scattered and in random patches at high elevations(12000 feet), so we used random fix plot sampling to assess the DBM (diameter at breast height) and height of the trees for randomly selected plots for inventory. We took a maximum of five plots from the two blocks of tehsil Roundu, that were Block-1 and Block-2, the following table demonstrated Blocks and beats selected for the sampling of the diameter and height of Birch forest through random fixed plot sampling.

According to Forest Department sources, the Roundu Range of the Skardu-forest Division is divided into the following nine beats and two-Blocks.

Figure 2: Beats of Roundu range and District Skardu



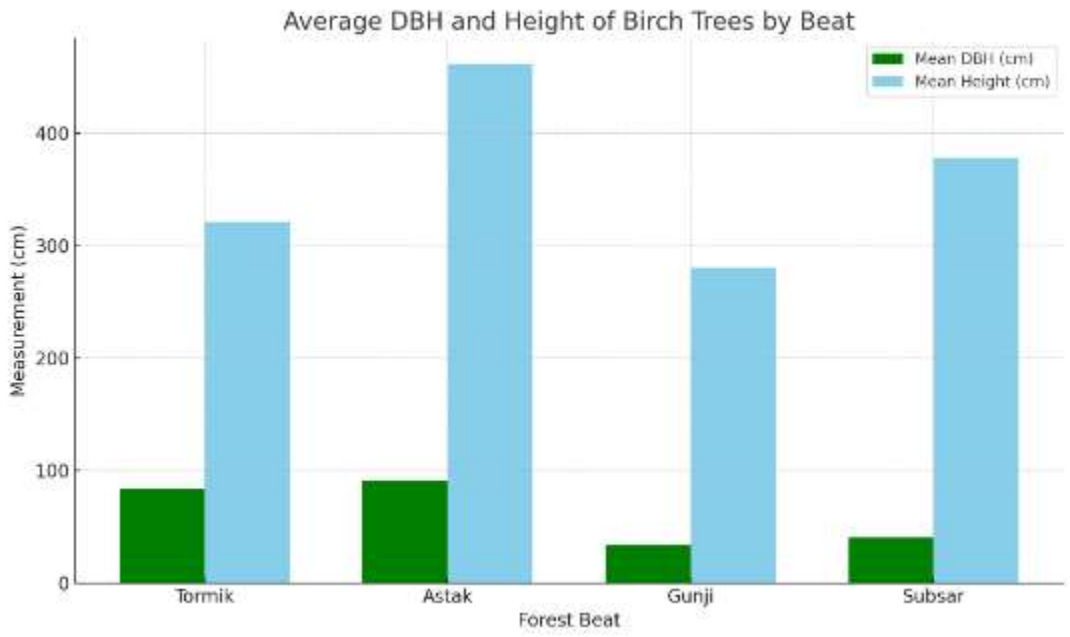
Five random plots were selected from this beats of Roundu range Skardu, as these selected field areas were considered density for the birch forest comparatively to the other forest beats of Skardu due to scattered and patchy birch forest, we took different locations and plots for random fix plot sampling. After collection and analysis of field data, the trend in mean values of DBH and mean height of the birch trees in those Beats and forest areas showed that it had declined due to anthropogenic activities, climate changes, and natural calamities/disasters.

Figure 3: Field Data at random plot while taking DMH of Birch tree and coordinates of a plot through GPS

The Mean DBH and Average Height of Betula utilis across different plots in the Tormik, Astak, Gunji, and Subsar beats of the Roundu Range, Skardu, are shown in the subsequent bar charts.

Concerns over forest stress and fragmentation are reinforced by these, which clearly show variation in tree size and structural degradation, especially at Tormik (severe DBH variations) and Astak (inconsistent height patterns).

Figure 4: Average DBH and Height of Birch Trees of respective Beats of Roundu-Range



The data provided in this study includes measurements of the mean diameter at breast height (DBH) and mean height of trees in four different beats located in the Roundu Range: Tormik, Astak, Gunji, and Subsar. The measurements were taken in five different plots within each beat. The mean DBH and mean height values for each plot and beat showed that there is variation in the mean DBH and mean heights of the birch forest, the birch forest density has not been as encouraging and positive from the last 10 to 15 years records as per research data, comparatively to all the maximum mean DBH (Diameter at Breast Height) at Tormik-beat is 374.71cm

Tree height and diameter at breast height (DBH) varied considerably throughout the four forest beats, based on data from random fixed plot sampling. With extremes ranging from as low as 7.06 cm to over 374.71 cm, the DBH values in the Tormik beat were highly irregular, indicating that the forest structure was uneven and most likely the result of selective logging or infrequent regeneration. The Astak beat, on the other hand, had the tallest trees, with an average height of over 460 cm. Yet there were also significant variations in DBH, indicating that the forest patches were fragmented.

The DBH and height values of the beats of Gunji and Subsar were relatively moderate and consistent, with Subsar exhibiting the most balanced structural attributes, indicating relatively better forest health. These trends, which are backed by statistical averages and illustrated through bar charts, highlight the stress that environmental factors and anthropogenic pressures place on birch forests, which emphasizes the urgent need for protection and ecologically sound interventions.

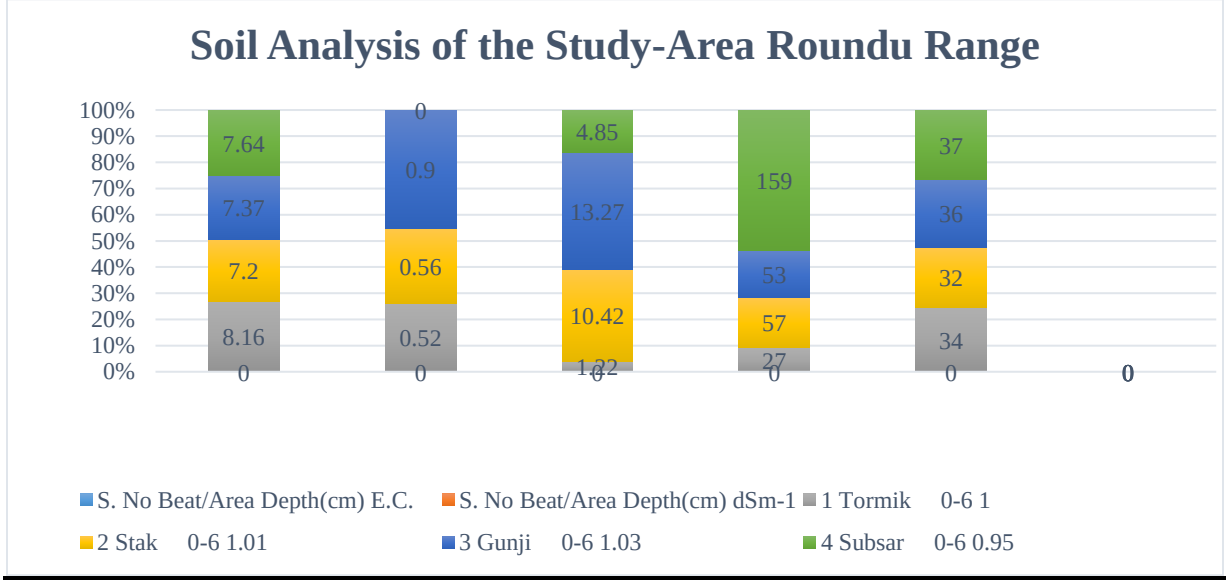
The overall trend in mean DBH and height of the beats showed that there is a decline in the status of birch forest, comparatively to the last 10 to 15 years' records as per analysis and random

sampling data there is a 5 to 6% decrease in birch forest at district Skardu, Gilgit Baltistan, Pakistan. (Safdar et al., 2017) found similar results and studies that *Betula utilis* had declined largely in the Himalayan range it had been considered a threatened species due to over-harvesting, deforestation, soil erosion, and global warming. The main root cause of the decline in birch forests is due to over-exploitation and illegal cutting by people in those areas. This species grows in the sub-alpine zone and up to 4500 meters and is distributed in regions of Waziristan, Kohistan, Swat, Azad Kashmir, and Gilgit Baltistan.

Soil Sampling from Research Area

The four research sites and beats; Tormik, Astak, Gunji, and Subsar were selected for random fix plot sampling, from where soil samples were collected to study and analyze the soil nutrients level and its status of District Skardu, Gilgit Baltistan, Pakistan so the findings of the soil-reports are below:

Figure 5: Soil Analysis of the study Area Roundu Range Skardu, Pakistan



Various nutrient profiles and soil health were found in soil samples taken from four forest beats: Tormik, Stak, Gunji, and Subsar. With minimal organic matter (0.52%), a somewhat alkaline pH (8.16), and confined phosphorus (1.22 mg/kg) and potassium (27 mg/kg), Tormik revealed low fertility and the need for soil adaptation. With a slightly acidic pH of 7.2, increased organic content of 0.56%, and improved nutrient availability (P: 10.42 mg/kg; K: 57 mg/kg), Stak showed superior soil quality. Gunji soil contained strong phosphorus levels (13.27 mg/kg), a moderate acidity (pH 7.37), a greater salt content (E.C. 1.03 ds/m), and better organic matter (0.90%). Subsar beat revealed the healthiest soil profile, with the most organic matter (4.85%) and phosphorus (159 mg/kg), reflecting strong potential for plant and forest restoration.

SWOT Analysis of Birch Forest

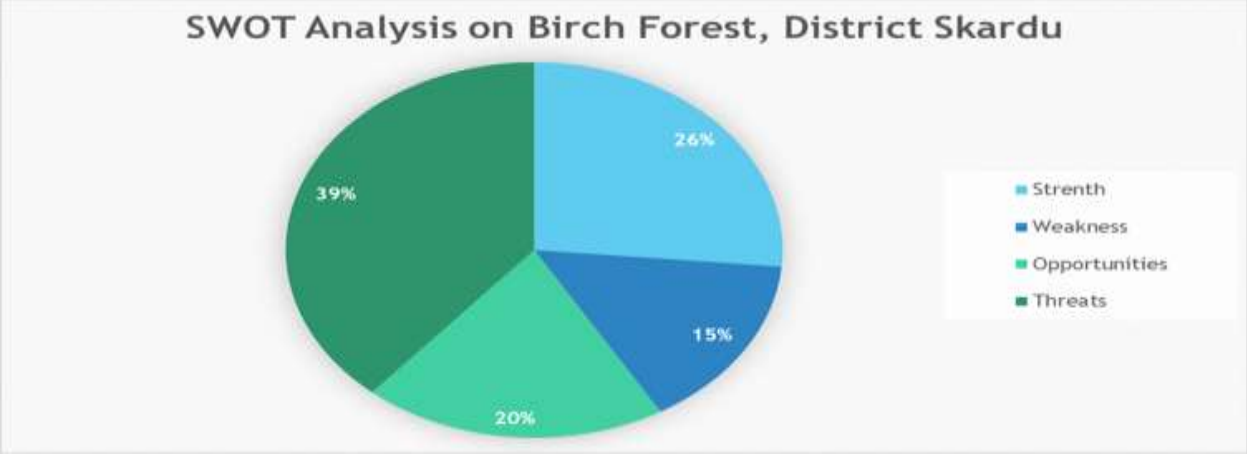
In accordance to the SWOT analysis, Skardu's birch forest faces a number of serious challenges, including threats (39%), opportunities (20%), weaknesses (15%), and strengths (26%). If immediate conservation measures are not carried out, the high threat level suggests a serious risk

of forest decline. This analysis additionally stressed the imminent risks plaguing birch ecosystems and the diminished capacity of forest-based industries.

Medicinal Importance of Birch Tree

According to a 2022 Skardu field survey, 69% of residents are aware of the birch tree's therapeutic benefits and frequently use its bark, sap, and leaves to cure conditions like infections, pain, inflammation, coughing, and skin problems. Betula utilis is well-known for its medicinal qualities around the world. Based to studies by Safdar et al. (2017) and Balakumbahan et al. (2019), components like betulin and betulic acid have the potential to treat many kinds of illnesses, including cancer, rheumatism, leprosy, and asthma. Because of the tree's socio-medical relevance, these findings lend support to its protection.

Figure 6: SWOT analysis and its four factors values in percentage of Birch forest of District Skardu



Dubois et al. (2020) In order to enhance forest policy and industrial decision-making, applied SWOT analysis to birch forests in Western Europe. They did this through assessing opportunities and threats based on socio-economic and ecological factors, as well as by identifying strengths and weaknesses from species attributes.

Socio-economic Importance and Threats

Over 200 people were involved in structured interviews and surveys to evaluate the socioeconomic importance and hazards to birch woods in District Skardu. The local area has a significant youth presence, as evidenced by the data showing that 76% of respondents were under 25, 19% were between 25 and 50, and only 5% were above 50. Because younger respondents may see and interpret information differently than older ones, age is a critical factor in survey accuracy. Age is a crucial component in field-based socioeconomic studies since previous research (Cho et al., 2015; Groves et al., 2000) has confirmed that it affects data quality for both interviewees and respondents.

Uses, Threats, and Decline of Birch Forest in Skardu

According to a 2022 field study conducted in District Skardu, 85% of the population uses birch trees for furniture, paper, and fuelwood, demonstrating the great socioeconomic significance of the plant. These conclusions are supported by research by Arshad et al. (2018), Ali et al. (2019),

and Alam et al. (2017), which attests to the effectiveness of birch in Pakistani households as well as businesses. But according to 88% of respondents, deforestation and related risks—such as illicit logging, shifting land uses, and climate change—are also significant contributors to degraded forests. Those risks are consistent with studies from around the world (Houghton, 2018; FAO, 2021; Defries et al., 2019).

Table 1: Birch trees were used for fueling wood, papermaking, and furniture made by people at Skardu

	Frequency	Percent	Cumulative
Yes	85	85.0	85.0
No	15	15.0	15.0
Total	**100.0**	**100.0**	

Source: Field survey during 2022

Figure 7: 0uter barks of Birch tree at field area district Skardu, GB

Based on a field study done in 2022, it was discovered that 85% of the Skardu population used birch trees for fuelwood and agreed they could be used to make paper and furniture, while the remaining 15% did not, according to recorded data.

The utilization of birch trees for the production of furniture, paper, and fuelwood has been studied in detail. For instance, Birch trees were discovered to be often used as fuelwood in Pakistan according to a study by Arshad et al. (2018). Similarly, to this, a study by Ali et al. (2019) revealed that Birch trees were utilized to make paper in Skardu-area Kashmir. In addition, a study by Alam et al. (2017) revealed that Pakistan employed birch wood for furniture production.

It may be inferred that Birch trees are a vital resource for the locals in Skardu based on the high frequency with which they are used for these uses. However, to guarantee that birch trees will be around for a long time to come for future generations, sustainable harvesting techniques must be used. To lessen reliance on Birch trees and preserve this valuable resource, it is also necessary to look into alternate sources of fuelwood, paper, and furniture.

Furthermore, birch forest status has clearly declined in recent years, according to 67% of respondents. Landslides, glacier melt, soil erosion, and overharvesting are some of the contributing factors. According to studies by Ali et al. (2020), Han et al. (2017), and Sanguesabarreda et al.

(2019), birch ecosystems in Pakistan, China, and Spain are becoming smaller due to human pressures and climate change. Skardu's Hamyalan birch woodland is thought to have decreased by 5–6%, underscoring the pressing need for conservation and sustainable management measures.

Conclusion

The socioeconomic significance, risks, and condition of the Himalayan Birch forest in District Skardu were evaluated in this study. Deforestation, furniture manufacturing, overgrazing, climate change, and natural disasters including landslides and glacier melt are the primary triggers of the 5–6% decrease in birch forest cover, according to field data and SWOT analysis. According to surveys, the locals utilize birch for packing, fuel, and medicine. Anthropogenic activities and climatic variables have caused a 60% decrease in the last 30 years, according to sampling conducted in the Tormik, Astak, Gunji, and Subsar valleys. Even though it is endangered, birch has economic promise if it is managed responsibly, supporting sectors including sports products, furniture, and medicine. The study highlights the need for appropriate forest management and restricted use in order to preserve and reap the benefits of this essential resource.

Recommendations

An all-encompassing strategy is necessary to preserve Himalayan birch in Skardu. This entails encouraging sustainable forest management, reforestation through neighborhood collaborations, enforcing strong laws against unauthorized grazing and logging, and increasing public awareness. To lessen reliance on forests, other occupations like ecotourism and beekeeping should be established. For well-informed conservation plans, ongoing study and monitoring are essential. Emissions reduction strategies, the development of renewable energy, and sustainable land use are all necessary to mitigate the effects of climate change.

References

- Alam, M. A., Khan, M. N., Ahmad, R., Rashid, A., Khan, M. A., & Ghafoor, A. (2017). Suitability of different wood species for furniture making in Pakistan. *Pakistan Journal of Agricultural Sciences, 54*(2), 261-267.
- Ali, I., & Zaidi, A. H. 2019. Perception of students towards quality education in Baltistan region of Pakistan. *International Journal of Educational Management, 33*(1), 160-173.
- Ali, R. (2020). Climate change and its impact on forest resources: a case study of Skardu, Gilgit-Baltistan, Pakistan. *Journal of Forestry Research, 31*(3), 899-912.
- Ali, S., Yasin, T., & Tariq, S. 2019. Papermaking potential of some locally available tree species in Kashmir. *Pakistan Journal of Forestry, 69*(1), 53-62.
- Ahmad, M. 2021. Education and Development in Northern Areas of Pakistan: An Empirical Study. *Journal of Education and Educational Development, 8*(1), 43-57.
- Akbar, M., Ahmed, M., Shaukat, S. S., Hussain, A., Zafar, M. U., Sarangzai, A. M., & Hussain, F. 2013. Size class structure of some forests from the Himalayan range of Gilgit-Baltistan. *Science, Technology and Development Journal, 32*(1), 56-73.
- Arshad, M., Hussain, M., Iqbal, M. N., Anwar, M. N., & Khan, M. A. (2018). Fuelwood utilization patterns and their impacts on the forest resources in the Himalayan region of Pakistan. *Journal of Forestry Research, 29*(5), 1331-1341.
- Balakumbahan, R. (2019). Betulic Acid: A Review on its Antimicrobial Properties, Bioavailability, and Pharmacokinetics." *BioMed Research International,* vol. 2019, 2019, pp. 1-12.

- Cho, Y. I., Johnson, T. P., & Fendrich, M. (2015). Survey response rate and completeness among older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 70*(1), 29-39.
- Ceci, S. J., & Williams, W. M. (2011). Understanding current causes of women's underrepresentation in science. *Proceedings of the National Academy of Sciences*, 108(8): 3157-3162.
- Dubois, H., Verkasalo, E., & Claessens, H. (2020). Potential of birch (*Betula pendula Roth and B. pubescens)* for forestry and forest-based industry sector within the changing climatic and socio-economic context of Western Europe. *Forests, 11*(3), 336.
- Defries, R., Pekin, B., & Foley, J. A. (2019). Deforestation driven by urban population growth and agricultural trade in the twenty-first century. *Nature Sustainability, 2*(10), 927-934.
- Eagly, A. H., & Karau, S. J. (2002). Role congruity theory of prejudice toward female leaders. *Psychological Review, 109*(3), 573-598.
- FAO. (2021). *Global Forest Resources Assessment 2020: Key findings*. Food and Agriculture Organization of the United Nations.
- Gilani, H., Goheer, M. A., Ahmad, H., & Hussain, K. (2020). Under predicted climate change: Distribution and ecological niche modeling of six native tree species in Gilgit-Baltistan, Pakistan. *Ecological Indicators, 111*, 106049.
- Groves, R. M., Presser, S., & Dipko, S. (2000). The role of topic interest in survey participation decisions. *Public Opinion Quarterly, 64*(2), 255-266.
- Han, Y. (2017). Decline and regeneration of birch forests in northeastern China. *Forest Ecology and Management, 383*, 45-53.
- Hunt, V., Prince, S., Dixon-Fyle, S., & Yee, L. (2018). *Delivering through diversity*. McKinsey & Company.
- Kala, C. P. (2018). Uses, Population status, and management of *Betula utilis*. *Science and Education, 6*(3), 79-83.
- Maletha, A., Maikhuri, R. K., & Bargali, S. S. (2020). Criteria and indicator for assessing threat on Himalayan birch (*Betula utilis*) at timberline ecotone of Nanda Devi Biosphere Reserve: A world heritage site, Western Himalaya, India. *Environmental and Sustainability Indicators, 8*, 100086.
- Moss-Racusin, C. A., Dovidio, J. F., Brescoll, V. L., Graham, M. J., & Handelsman, J. (2012). Science faculty's subtle gender biases favor male students. *Proceedings of the National Academy of Sciences, 109*(41), 16474-16479.
- Pandey, S., Carrer, M., Castagneri, D., & Petit, G. (2018). Xylem anatomical responses to climate variability in Himalayan birch trees at one of the world's highest forest limit. *Perspectives in Plant Ecology, Evolution and Systematics, 33*, 34-41.
- Pandey, S., Phulara, S. C., Mishra, S. K., Bajpai, R., Kumar, A., Niranjan, A., & Chauhan, P. S. (2020). *Betula utilis* extract prolongs life expectancy, protects against amyloid-β toxicity and reduces Alpha Synuclien in Caenorhabditis elegans via DAF-16 and SKN-1. *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology, 228*, 108647.
- Rastogi, S., Pandey, M. M., & Rawat, A. K. S. (2015). Medicinal plants of the genus Betula Traditional uses and a phytochemical–pharmacological review. *Journal of Ethnopharmacology, 159*, 62-83.
- Safdar, I., Bibi Y., Hussain, M., Iqbal, M., Saira, H., Shaheen, S. & Mehboob. H. 2017. Review on current status of *Betula utilis*: An important medicinal plant from Himalaya. *Journal of Botanical Sciences, 6*, 1.
- Sanguesa-Barreda, G., (2019). Changes in forest cover and species composition in the Spanish Pyrenees: the case of birch forests. *Mountain Research and Development, 39*(3), R28-R37.
- Shukla, S., Mishra, T., Pal, M., Meena, B., Rana, T. S., & Upreti, D. K. (2017). Comparative analysis of fatty acids and antioxidant activity of *Betula utilis* bark collected from different geographical regions of India. *Free Radicals and Antioxidants, 7*(1), 80-85.