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# Driving Forces Behind Depleting Forest Resources and Environmental Degradation in Northern Temperate of Pakistan

**Sultan Muhammad[1, 2], Moazzam Nizami[1]*, Muhammad Tayyab Khan[3], Nadim Arbab[3], Kaleem Mehmood[1, 4], Hina Jabeen[5], Uzair Khan[1], Islam Zada[6], Muhammad Haseen Ullah[1], Brekhna Gul[1], Shah Fahad[7,8]***

[1]Department of Forestry and Wildlife, Faculty of Physical & Applied Sciences, University of Haripur, Pakistan; sultanmuhammad@uswat.edu.pk (S.M) ; moazzam.nizami@uoh.edu.pk (M.N)
[2]Institute of Forest Sciences, University of Swat, Khyber-Pakhtunkhwa, Pakistan, brekhnagul20@gmail.com, kaleemmehmood@uswat.edu.pk (K.M)
[3]University of Padova, Department of Land, Environment, Agriculture and Forestry (TESAF), Via dell'Università 16, 35020 Legnaro, PD, Italy, nadim.arbab@studenti.unipd.it (N.A), muhammadtayyab.khan@studenti.unipd.it (M.T.K).
[4]College of Forestry, Beijing Forestry University, Beijing, 100083, PR, China,
[5]Department of Biotechnology, Women University Mardan, Pakistan, dr.hinajabeen@wumardan.edu.pk ( H.J)
[6]Sugar crops Research Institute(SCRI) Mardan Khyber Pakhtunkhwa. islamzada73@gmail.com (I.Z)
[7]Department of Agronomy, Abdul Wali Khan University Mardan, Khyber Pakhtunkhwa 23200, Pakistan; shah_fahad80@yahoo.com (S.F)
[8]Department of Natural Sciences, Lebanese American University, Byblos, Lebanon

***Corresponding Author:** Moazzam Nizami, Shah Fahad
*Email: moazzam.nizami@uoh.edu.pk, Email: shah_fahad80@yahoo.com (S.F)

**Abstract**
Depleting forest resources in coniferous forests of northern temperate region in Khyber Pakhtunkhwa present severe ecological challenges. This research investigates the factors contributing to the decline of forests, employing both a pretested survey and detailed interviews with 100 residents. The study identifies rapid hotel construction driven by tourism and new access roads as the primary cause of forest depletion, with illegal timber activities, unauthorized grazing, local resource dependence, and poor management also contributing to the degradation. To mitigate these issues, the study advocates for the promotion of controlled, ecotourism-driven development, along with the regulation of road expansion.

**Key words:** Deforestation, Ecotourism, Forest Degradation, Sustainable Management, Swat Khyber Pakhtunkhwa.

## 1. Introduction

The development of a nation depends heavily on its forests (Ali and Khan, 2015)[1]. However, In Pakistan forests cover is only 5.1% (excluding alpine pastures, farmland trees and linear plantations). The most economical forest occurs at an elevation range of 800 meters to 3350 meters in upper areas of Khyber Pakhtunkhwa and constitutes 1.4 %, 1.6% and 0.4% dry, moist and chir pine respectively (Bukhari et al., 2012)[2]. Deforestation being a global issue is encompassing Pakistan leading to depleting of its forest resources. The conifer forest declined at the rate of 1.27% per annum since 1992. From the year 1992 to 2001, the coniferous forests all over Pakistan saw an annual change rate of -2.3% but later examination of 10 years (2001-2010) found a loss rate of 0.28%, indicating significant forest area shrinkage emphasizing conservation measures (Ahmad et al., 2012)[3]. Qamer et al., (2016)[4] also reported that the woodlands of Pakistan have long been under danger from massive deforestation. In fact, during the past 20 years, 170,684 acres of forest have been destroyed, or 0.38% each year, due to clear cutting or severe deforestation. According to Shehzad et al., (2014)[5], twenty three per cent of forests in Chitral will be lost by 2030 with degradation of 8% if deforestation continues at the same rate. According to several studies, deforestation is the

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permanent loss of trees in a region that is replaced by other land uses. Since deforestation is a result of interactions between the environmental, social, economic, cultural, and political forces at play in any given nation or region, increasing attention is being paid to the detrimental socio-economic and environmental effects following forest degradation, particularly the shrinkage of the forest caused by deforestation (Zhu and Li, 2007)[6]. Deforestation is linked to population growth and the intensification of agriculture but in the long run, wood harvesting for export and use as fuel leads to deforestation (Allen and Barnes, 1985)[7]. Despite all the goods that forests provide for the forest, they are being destroyed at a startling rate (Bennett, 2017)[8]. According to Hosonuma et al., (2012)[9], deforestation is caused by Agriculture (commercial and local) alone is 73%. However, logging, and the extraction of timber around 52% and gathering of fuelwood and the manufacturing of charcoal (31%), uncontrolled fire (9%), and animal grazing (7%) are responsible for degradation of forest resources. According to a general definition, forest degradation refers to a decline in a forest's ability to provide ecosystem services like carbon storage and wood products, because of human and environmental changes (Thompson et al., 2013)[10]. Although there are different definitions of forest degradation, they all share the irreversible loss of forests, destroyed stand structure, diminished forest quality, and weakened forest services. One of the causes of forest degradation is forest decline, or tree decline, which includes overall declines in tree vigor, productivity growth at low levels, tree deaths, and even declines in soil fertility (Zhu and Li, 2007)[11]. Degradation, in general, is the outcome of a gradual deterioration in the structure, composition, and services that support a forest's vitality and strength. A degraded forest is one in which detrimental human activities have drastically altered or permanently destroyed its structure, function, species composition, or production (Vásquez-Grandón et al., 2018)[12]. As reported by Keenan et al., (2015)[13], forested regions increased in some regions of the world, but it decreased from the year 1990 to 2015 in South America, Central America, South and Southeast Asia and all three regions of Africa. Pakistan is one of the nations with a very excessive rate of deforestation (Ali et al., 2006)[14]. Over the recent times, Pakistan has seen a significant deterioration of its forest resources. Little has been done to identify the primary reasons for this severe level of deterioration (Yusuf, 2009)[15]. Therefore, the significance of this study was to investigate drivers of deforestation in the Northern temperate regions for the forest of Swat. These forests consist of economically important conifers forests and play a vital role in water shed management. However, these forests are subject to ruthless cutting for various purposes due to development and other activities. It is necessary to find the causes to prevent such degradation and deforestation.

## 2. Materials and Methods

### 2.1 Study area

The present study was conducted in the Swat region of Khyber located between 34.8065° N, 72.3548° E covering a total area of 5337 km2. It borders Dir to the west, Chitral to the north, and the Gilgit Agency to the northeast (Figure 1). The region is characterized by a moist temperate temperature zone and is situated at an elevation roughly 2600 meters above sea level. The forest within this geographical area has a diverse array of prevailing tree species, including as *Pinus wallichiana, Abies pindrow, Piecea smithiana*, horse chestnut, and walnut, among several others. It is of significance to acknowledge that the forest in question has been declared as a protected forest, operating under a shared agreement between the government and public. (Sohail et al., 2023)[16]. One of the main sources of revenue for the residents is tourism, which primarily occurs during the summertime whereas most people relocate to lower elevated places during the winter (Adnan et al., 2006)[17].

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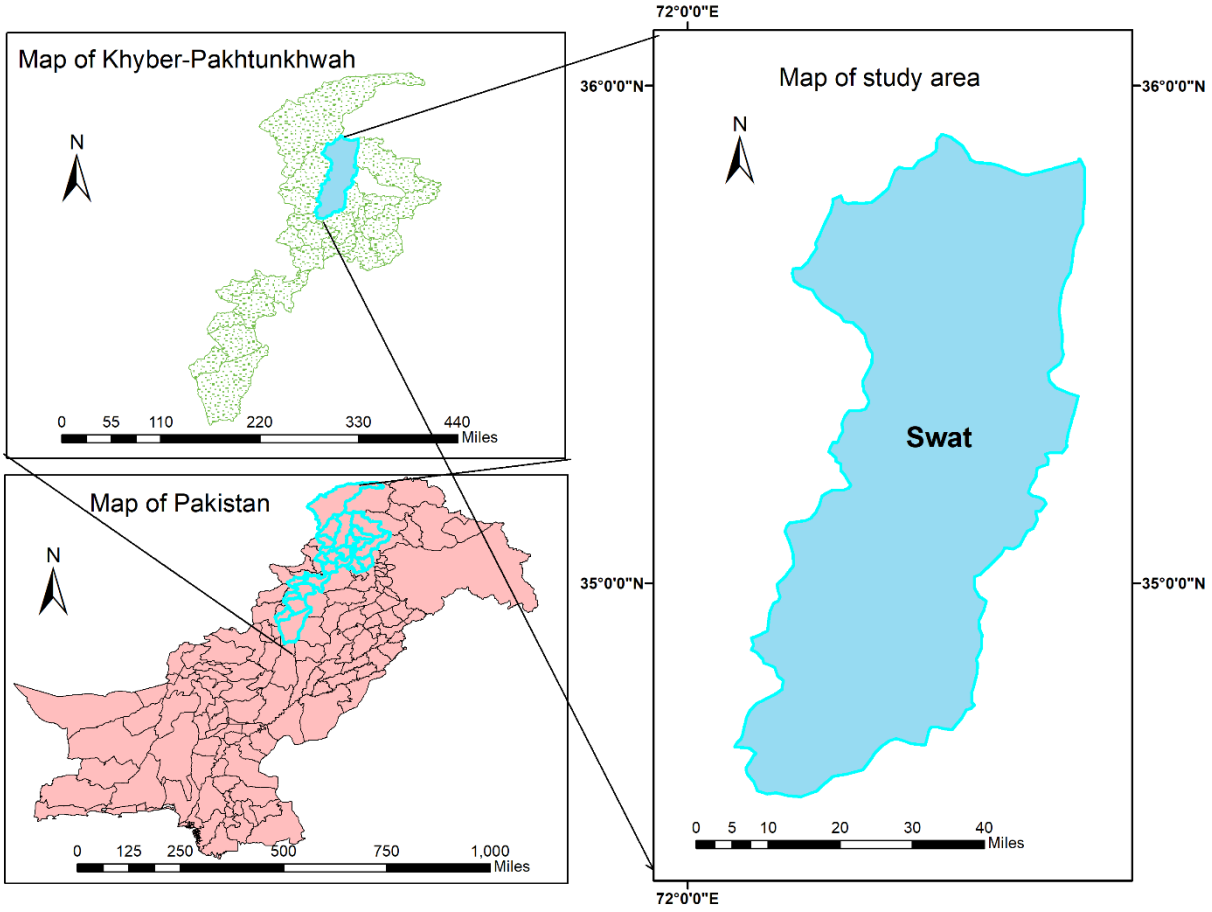


**Figure 1: Map of Swat valley**

### 2.2 Study design

A reconnaissance survey of the study area was conducted in September 2023 to identify potential causes of deforestation and degradation. The information was collected from local people, Provincial Forest departments staff through discussions. During the survey, tourism, hotel construction, road development, local utilization, grazing, timber mafia, Poor management and other minor factors were identified. A structural questionnaire was formulated and ranked from one to nine with nine as highest rank and vice versa. Inquiries were made to 100 local inhabitants through the structured questionnaires to ascertain the range and magnitude of these factors responsible for deforestation and degradation and the data was subjected to a prioritization process, yielding a hierarchy of factors on a scale of 1 to 7. The survey was conducted in various regions of Swat having economically important forest of conifers (Table 1). For ensuring gender participation, females participants were also interviewed (Kouassi et al., 2021)[18].

**Table 1: Detail of samples and sampling sites (n=100)**

| Region | Tehsil | Coordinates | Forest types | Participants |
|---|---|---|---|---|
| Gabin Jabba | Matta | 35.1706° N, 72.3711° E | Moist temperate | 20 |
| Marghuzar | Babuzai | 34.6678° N, 72.3431° E | chir pine forest | 20 |
| Malam Jabba | Charbagh | 34.7999° N, 72.5722° E | Moist temperate | 20 |
| Kalam | Bahrain | 35.4902° N, 72.5796° E | Dry temperate | 20 |
| Miandam | Khwaza Khela | 35.0541° N, 72.5648° E | Moist temperate | 20 |

### 2.3 Data analysis

Due to non-satisfaction of the normality assumption of the data, non-parametric independent Kruskal–Wallis test was applied to test significant variation among these factors (Fan et al., 2011)[19] to compare mean score of these factors for prioritization

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process. Following the initial assessment with the Kruskal-Wallis test, we applied for the post Hoc test, for multiple comparison among all pairs of these factors. This step was crucial for identifying specific pairs of treatments that showed significant differences in burn severity. In terms of quantifying the effect size, partial eta squared was used. Partial eta squared was calculated to measure the effect size of the Kruskal-Wallis test, providing insights into the proportion of variance explained by group differences. Post hoc test provided a more granular understanding of the pairwise differences that the Kruskal-Wallis test indicated.

## 3. Results

This study examined the equality of means scores across various treatments through independent Samples Kruskal-Wallis test. The null hypothesis suggested the same distribution of mean scores across all these treatments. However, the calculated p-value of 0.00 resulting in rejection of null hypothesis suggesting significant difference among distribution of mean score across treatment categories (Figure 2). This finding underscores the importance of further exploration and consideration of potential factors influencing the observed variations in mean scores.

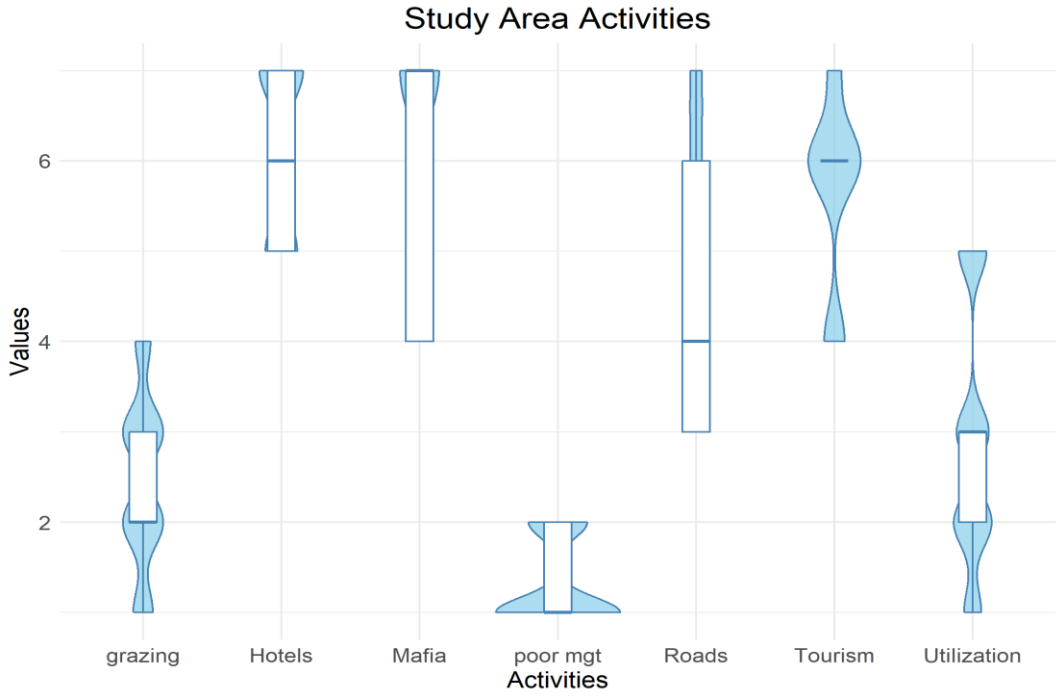


**Figure 2 Distribution of mean scores across various treatments**

For quantification of effect size and the association between mean scores and treatment in the study was assessed by eta squared. The results indicate a strong association, with an Eta value of 0.847 and an Eta Squared value of 0.717. These findings suggest that a substantial proportion (71.7%) of the variability in mean scores can be attributed to the treatment variable. This strong association stresses the importance of treatment in influencing the observed mean scores. The statistical analysis presents a comprehensive overview of different factors. The average values for each factor (hotel construction, tourism, access road, grazing, mafia, local utilization, poor management) are 6.12, 5.67, 4.55, 2.44, 5.96, 2.85 and 1.32 respectively. To assess the accuracy of these averages, the standard error of the mean was also calculated and ranges from .047 to .153, indicating variability within each group's sample. Additionally, confidence intervals along with error bars were computed at a confidence level of 95%, providing a range where the actual mean values for each factor are expected to fall. The lower limits range from 1.23 to 5.95 while the upper limits range 1.41 to 6.29 Table 2.

**Table 2: Statistical Summary of Mean Values Across Different Vegetation Strata.**

| Factors | Mean | Count | [1]SEM | [2]CI95 Low | [3]CI95 High |
|---|---|---|---|---|---|
| Hotel Construction | 6.12 | 100 | .087 | 5.95 | 6.29 |
| Tourism | 5.67 | 100 | .101 | 5.47 | 5.87 |
| Access road | 4.55 | 100 | .153 | 4.25 | 4.85 |
| Grazing | 2.44 | 100 | .092 | 2.26 | 2.62 |
| Mafia | 5.96 | 100 | .134 | 5.69 | 6.23 |
| Local Utilization | 2.85 | 100 | .137 | 2.58 | 3.12 |
| Poor management | 1.32 | 100 | .047 | 1.23 | 1.41 |
| **Total** | **4.13** | **100** | **.080** | **3.97** | **4.29** |

*[1]SEM standard error of the mean, [2]CI95 Low- lower bound of the 95% confidence interval, [3]CI95 -High-upper bound of the 95% confidence interval.*

Post hoc analysis resulted in the adjusted p- value to assess the significant differences between pairs. Results revealed significant differences (adjusted $p < 0.05$) in mean scores between Poor Management and each of Grazing, Local Utilization, Access Road, Tourism, Mafia, and Hotel Construction. However, no significant differences were observed in mean scores between Grazing and Local Utilization, Grazing and Tourism, Tourism and Mafia, as well as Tourism and Hotel Construction (adjusted $p > 0.05$). Additionally, Access Road showed significant differences in mean scores when compared to Tourism, Mafia, and Hotel Construction (Table 3). These findings provide insights into the nuanced variations in the impact of different factors on strata pairs, emphasizing the need for designed management strategies. The study investigated the distribution of impacts across various factors in a specified context. The highest frequency of mean score was recorded for hotels (612) followed by tourism (567) while the lowest was for poor management (132) (Figure 3). These findings provide an overview of the prevalence of different elements, indicating the relative significance of each factor within the studied context.

**Table 3 Detail of pair wise comparison among factors at (p = 0.05) and (n=100)**

| Pairs of strata | Adjusted p-value | Remarks |
|---|---|---|
| Poor Management vs Grazing | 0.002 | Significant |
| Poor Management vs Local Utilization | 0.000 | Significant |
| Poor Management vs Access Road | 0.000 | Significant |
| Poor Management vs Tourism | 0.000 | Significant |
| Poor management vs Mafia | 0.000 | Significant |
| Poor Management vs Hotel construction | 0.000 | Significant |
| Grazing vs local utilization | 1.000 | Non-Significant |
| Grazing vs Access Road | 0.000 | Significant |
| Grazing vs Tourism | 0.000 | Significant |
| Grazing vs Mafia | 0.000 | Significant |
| Grazing vs Hotel construction | 0.000 | Significant |
| Local Utilization vs Access Road | 0.000 | Significant |
| Local Utilization vs Tourism | 0.000 | Significant |
| Local utilization vs Mafia | 0.000 | Significant |
| Local utilization vs Hotel construction | 0.000 | Significant |
| Access road vs tourism | 0.011 | Significant |
| Access road vs Mafia | 0.000 | Significant |
| Access road vs Hotel construction | 0.000 | Significant |
| Tourism vs Mafia | 1.000 | Non-Significant |
| Tourism vs Hotel construction | 1.000 | Non-Significant |
| Mafia Hotel Construction | 1.000 | Non-Significant |

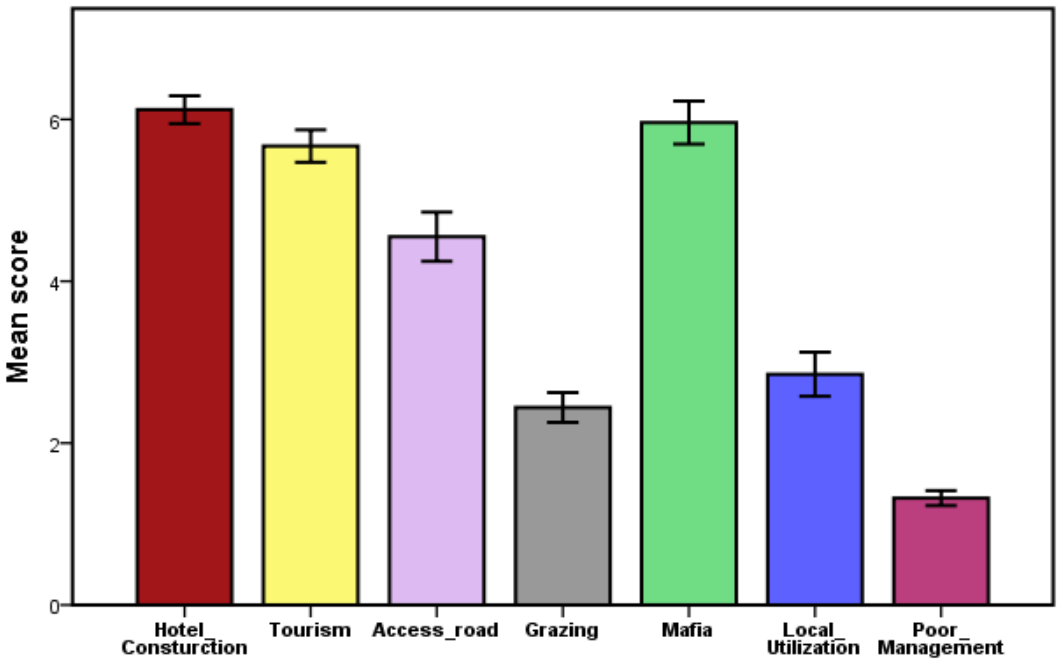


**Figure 3 Detail of mean score with standard error at 95% confidence interval**

## 4. Discussion

The aim of the study was to explore the driving forces behind deforestation and degradation in northern temperate region of Pakistan. This study examines the factors leading to forest decline by utilizing a validated survey alongside in-depth interviews with 100 residents. The rate and causes of deforestation have been the subject of several studies from different areas globally (Nagendra 2008 [20]; Phua et al., 2008 [21]; Htun et al., 2010 [22]; Lung and Schaab 2010[23]) and various elements have also been explored based on changes in forest cover. The current research was carried out to investigate the elements influencing deforestation and degradation in the Northern temperate regions forest of the Swat region. The Northern temperate forest in Pakistan, primarily characterized by coniferous trees along with broad-leaved species, plays a vital role in conserving watersheds within hilly areas. Nevertheless, these forests face indiscriminate logging for various purposes, resulting in deforestation and depletion of these valuable forest resources. Qasim et al., (2011)[24] reported that several research and statistics from throughout the world indicate that Pakistan has seen tremendous deforestation. The precious coniferous forest in Swat has drastically diminished, usually resulting in land degradation. Despite the environmental and other services, they provide, forest resources are destroyed at an alarming rate despite (Bennett, 2017)[25]. This study specifically investigated the causes behind deforestation and degradation, revealing that the primary driver is the construction of hotels driven by a surge in unplanned tourism. Several studies have reported agriculture and population growth as the main cause of deforestation (Alexander, 2018 [26]; Hosonuma et al., 2012 [27]; Casse et al., 2004 [28]; Allen and Barnes, 1985 [29]; Walker, 1987[30]). As Pakistan is harboring immense tourism potential due to a unique geographical setup, scenic landscapes, biological and cultural diversity, and hospitable people (Altaf et al., 2021)[31]. Therefore, in our situation, the main factor is the construction of hotels as a response to the rise in poorly planned tourism activities, coupled with the unsuitable hilly terrain of the study area for agriculture. Consequently, trees are systematically removed to initiate small-scale hotel construction, which later expands to cover larger areas. Ahmed et al., (1998)[32] have similarly noted that a significant portion of deforestation in Pakistan involves incremental loss, signifying the gradual removal of individual trees. The increase in tourism activities as pointed out by Sohail et al., (2023)[33] has been linked to negative impacts on the health of forest ecosystems, particularly due to practices such as girdling, and the expansion of hotels and other enterprises related to tourism. Due to dependency of local population as reported by Ali and khan, (2015)[34], rural people of the Swat district for jobs, wood, medicinal plants, grazing land for cattle and house construction are the main causes of deforestation in Swat valley. In our situation, although grazing and local utilization for fuel wood, medicinal and other purposes also contribute toward degradation and deforestation but is ranked after the hotel, tourism, and access road. The reason for this is the heavy dependency of the local population on these resources in the study area. As reported by Khan and Khan (2009) [35], the situation of deforestation further deteriorated after

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proclamation for forest land as protected land which led to conflicts between statutory law and customary law due to their dependency on these resources. Although Ali and Benjaminsen, (2004)[36] reported that root drivers of the estimated 30% deforestation over the last thirty years are commercial extraction of timber and weak governmental administration. However, in our situation this factor has been ranked lowest indicating least or almost no contribution toward degradation corresponding to best management. As outlined in the research conducted by Tariq and Aziz, (2015)[37], substantial deforestation occurred in Khyber Pakhtunkhwa to fulfill household needs like cooking, furniture, heating, and income generation. Another notable factor influencing these forests is the influence of black markets and stakeholders. This aligns with our study, where the timber mafia and local utilization have been identified and ranked as significant contributors to forest degradation. The construction of linkages and access roads is typically viewed as beneficial for the optimal management of forest resources. However, in our specific scenario, this factor was ranked third in terms of contributing to degradation. This result aligns with findings from Ali et al., (2005)[38], supporting the idea that the expansion of forests due to access road development may not be universally applicable. In conclusion, the results highlight hotel construction and tourism as the primary drivers of forest degradation, while poor forest management has the least impact.

## 5. Conclusion

This study establishes that the primary drivers of forest degradation in Swat's Northern temperate forests are hotel construction and the associated surge in tourism. The development of new access roads exacerbates this impact. These factors are identified as the most significant in harming the local forest ecosystem. Secondary contributors include mafia activities, grazing, local resource use, and inadequate management, each playing a moderate role in degradation. The findings highlight the urgent need for comprehensive management and sustainable tourism practices to mitigate these adverse effects. While poor forest management is noted, it ranks lower in impact compared to other factors. These insights offer critical guidance for policymakers and conservationists in developing effective strategies for the forest's preservation and sustainable management.

**Authors contribution:**

Conceptualization, Sultan Muhammad; Moazzam Nizami; Formal analysis, Kaleem Mehmood; Hina Jabeen, Uzair Khan: Investigation, Anwar Ali; Nadim Arbab, Hina Jabeen, Uzair Khan: Methodology, Moazzam Nizami; Software, Kaleem Mehmood; Muhammad Tayyab Khan, Visualization, Sultan Muhammad; Moazzam Nizami; Data Curation, Sultan Muhammad: Brekhna: Haseen Ullah, Islam Zada, Hina Jabeen: Validation, Supervision, Moazzam Nizami; Writing – original draft, Writing – review & editing; Shah Fahad

**Declaration of competing interest**

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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**Data availability**

Data will be made available on request.

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