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Original article

# Assessment of risk, extinction, and threats to Himalayan yew in Pakistan

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ABSTRACT

Himalayan yew (*Taxus wallichiana*) is in high demand due to the presence of taxol in its bark, needles, and seeds. This metabolite is used for the treatment of breast and ovarian cancer. In addition, Himalayan yew wood is used to prepare slabs (Tabai), coffins (Taabut), for graveyards. Due to illegal cutting of plant parts and other anthropogenic pressures, Himalayan yew is endangered, and threatened with extinction, in Himalaya. This species grows slowly and regenerates poorly, primarily due to low production and delayed germination (1.5–2 years) of its seeds. The study being reported here was conducted to assess the factors (natural and anthropogenic) threatening this species. Nine valleys (Miandam, Kalam, Shinko, Beha, Lalku, Shahgram, Bishigram, Gurnai, and Daral) in the Swat district of Khyber Pakhtunkhwa (KP), Pakistan, have stands of Himalayan yew that were selected for the study. Before the survey was conducted, five informal discussions were carried out to identify people to be interviewed. A survey was conducted with 225 key informants in these valleys concerning the threats associated with this species. Nineteen percent of the respondents felt that the main problem was lack of awareness, while 17% indicated over-harvesting (peeling bark, lopping branches, etc.), and 13% thought it was slow growth. Other reasons for Himalayan yew decline included various anthropogenic pressures, such as: overgrazing, 15%; agriculture, 11%; roof construction, 9%; fuelwood, 7%; decoration, 5%; medicinal use, 3%; and other, 1% (e.g., utility poles, as blades in water turbine because of its hard nature). The results of this study suggest that there is an immediate need to protect *T. wallichiana* by increasing awareness of its importance and the threats from over-grazing; cuttings (peeling bark, lopping branches, etc.); and other damaging, anthropogenic activities. Biotechnological tools, such as vegetative propagation and in-vitro regeneration, could be practiced in nurseries and laboratories to produce large numbers of healthy, juvenile plants. In addition to in-situ and ex-situ conservation and management, there is a need for local community involvement in the large-scale reforestation efforts.


## 1. Introduction

Himalayan forests are among the globe's most depleted (Shaheen et al., 2011), and their degradation has resulted from nomadic activities, overgrazing, and tree harvesting (Ahmad et al., 1990, 2012). One component of these forests, Himalayan yew (*Taxus wallichiana*), which has medicinal value, has become endangered (Samant et al., 1998; Samant, 1999). This species is known as Banrya in Pushto, Barmi in Urdu and Hindi, and common yew or Himalayan yew in English (Mulliken and Crofton, 2008).

Species within the genus *Taxus* (family Taxaceae) are evergreen gymnosperms that are widely distributed throughout the temperate zone of the Northern Hemisphere (Clapham et al., 1962; Krüssmann, 1983; Rehder, 1971; Rudolf, 1974; Voliotis, 1986). The species has needle-shaped leaves and bright red fruit (Figure 1).In Pakistan, it is found in moist, temperate forests of the following regions: Swat, Murree, Galliat, Hazara, Kaghan, Kashmir, Kurram, and Chitral (Poudel et al., 2014). *Taxus* species are present at a wide range of elevations (Bhatt and Sachan, 2004), but typically found between 1800 and 3300 m (Farjon, 2001; Xu et al., 2009). They grow better in the understory of moist, cool forested habitats, temperate to subtropical climates (Price, 1990). Due to its shade-tolerant nature, *Taxus* species are often found growing under the canopy of other tree species, such as: *Abies pindrow*, *Betula utilizes*, *Pinus wallichiana*, *Acer cesium*,

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**Fig. 1.** Leaves and fruit (bright red berries) of Himalayan yew (*Taxus wallichiana*).

*Rhododendron arboretum*, and *Quercus semecarpifolia* (Rikhari et al., 1998; Samant et al., 2002; Joshi, 2002; Pant, 2005).

Himalayan yew flowers during March and April and its seeds ripen between September and November. Generally, regeneration of this species is best in shady and moist microsites that are undisturbed (Rikhari et al., 1998). It can tolerate strong winds, frost, and drought, and usually grows on soil derived from limestone (Clapham et al., 1962).

Yew is a valuable medicinal plant, especially for its taxine alkaloids and 10-diacetyl baccatin III (DAB) content in its seeds, bark, and leaves (Miller, 1980). The latter is a precursor to paclitaxel, a drug sold under the tradename Taxol, which is used as chemotherapy to treat ovarian, breast, and lung cancer. At the start, the tree exploitation was for bark, but later its demand shifted to leaves, which are also a source of paclitaxel. Its anticancer properties were first reported in 1964 (Rowinsky et al., 1990; Appendino, 1993). Annually, the worldwide demand for the taxol is 800 to1000 kilograms. Approximately, 2–3 million kg of biomass is annually harvested whereas the sustainable rate of harvesting is estimated to be 0.6 million kg per year (Nimasow et al., 2015). In addition to Taxol, Himalayan yew is a source of Zarnab, an herbal drug used in the Unani medical system. The leaves and bark are also used to treat asthma, insect bites, and bronchitis and it is considered an aphrodisiac. In Himalaya high-altitude regions, local communities use the bark for the treatment of colds and cough by making a traditional tea (Purohit et al., 2001). The paste of the bark is applied externally for headaches cure and is included in plaster casts for fractured bones (Gaur, 1999). Yew wood is very durable and hard and, thus, desirable for manufacture carving, furniture, and as a fuel.

*Taxus* species have become threatened due to their small population size, slow germination from seed, slow propagation, narrow range, habitat specificity, destructive harvesting, overgrazing, high value, climate change, and habitat loss (Samant, 1999; Pant and Samant, 2008). The long-term impact of harsh climatic conditions with severe disturbances due to solar radiation, temperature extremes, cold winds that are related to both community and individual stands of yew are affecting the anatomy, physiology and behavioral individualities of yew; in particular the vegetative propagation of yew (Gegechkori 2018). Young plants require dense shade and shelter, they do not successively grow in the areas where forests have been cleared. Although trees of yew grow slowly they can become quite large because of their longevity. Some English yews that were planted in churchyards are over 1,000 years old (Lewington and Parker, 1999). Mostly the heights of yew species range from 6 to 12 m, but open-grown English yew trees can achieve heights of 12–25 m and trunk girths of up to 17 m (Lewington and Parker, 1999; Farr, 2008). It has been reported that the survival and growth of this species decline when the thickness of its bark is reduced to less than 0.43 cm (Purohit et al., 2001).

Currently, little information is available regarding the size and status of *Taxus* populations (Anon., 2004). The bark of 6 mature trees is required for getting one dose of paclitaxel. Trees are being damaged extensively by bark peeling, but also by lopping and grazing. The extent of canopy damage caused by the latter two is likely

to have serious consequences for biomass yield, natural regeneration, and survival of the plant. Collectively, these activities, along with poor regeneration, are responsible for the fast decline in yew population in the Himalaya (Rikhari et al., 1998). This species is now classified as 'endangered' in the Himalayan region (García et al., 2000; [ICIMOD], 2004; Wu and Raven, 1999; and IUCN, 2008).

## 2. Study area

This study was conducted in the district of Swat, which is in the north of KP, between 30° and 72° east longitude at 35° north latitude (Fig. 2). The Swat Valley altitude ranges from 975 to 2900 m. In this region, temperatures range from −2 °C to 34 °C and average annual precipitation is 1000–1200 mm. In Swat about 20% of the land area is forested. The government has designated areas concentrated north of Kalam and Madyan as "Protected Forest". Himalayan yew is found in the forests of Swat in the Kalam, Miandam, Beha, Lalku, Shahgram, Gurnai, Bhishigran, Daral and Shinko valleys. Information about these valleys including coordinates, human population, number of households, and forested area (ha) are mentioned in Table 1. In Miandam, small, medium, and large trees of *T. wallichiana* can be found, while dispersed, medium-sized trees can be found in the other valleys (Figure 3).

## 3. Material and methods

The study was conducted during 2017–2018 in nine valleys of the Swat district, namely: Miandam, Lalku, Kalam, Beha, Shinko, Bishigram, Shahgram, Gurnai, and Daral. An average of five informal discussions with the local people of these valleys was carried out to identify key informants. The key factors threatening Himalayan yew were identified through community consultation or in-depth discussions between the key informants and interviewers. Expert-reviewed questionnaires were used to collect data through these in-person interviews. Before the survey was conducted, five informal discussions were carried out to identify people to be interviewed. A total of 225 interviews were conducted, 25 in each of the selected valleys (Table 2). Field observations were based on a checklist on the morphological features and habitat of Himalayan yew.

## 4. Results and discussions

Table 3 lists the 10 factors (ranked in descending order of importance) that were identified as being most threatening to Himalayan yew and some examples of their uses in the Swat District. The percentage of respondents to these threatening factors is shown through the graph (Fig. 4). Table 4 shows the level of threatening factors and its destructive effects (1st to 6th level score is

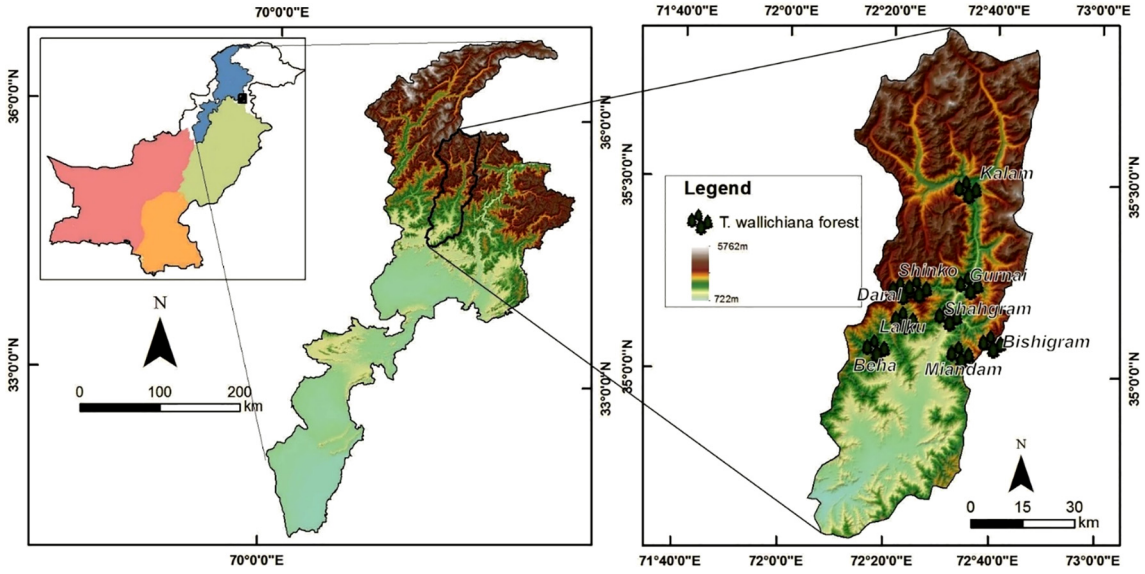


**Fig. 2.** GIS maps showing the distribution of *Taxus wallichiana* in the Swat District, Khyber Pakhtunkhwa, Pakistan.

**Table 1**
Information about the valleys in which *Taxus wallichiana* is found, including coordinates, human population, number of households, and forested area in Swat District, KP, Pakistan.

| Valley | Latitude | Longitude | Altitude | Population | Household | Forested area (ha) |
|---|---|---|---|---|---|---|
| Beha | 35.06546 | 72.29633 | 1596 | 5466 | 654 | 4120.43 |
| Bishigram | 35.08342 | 72.66615 | 3494 | 12,000 | 1204 | 3710.82 |
| Daral | 35.2171 | 72.37477 | 3212 | 5629 | 498 | 3350.46 |
| Gurnai | 35.23482 | 72.58968 | 1907 | 3796 | 479 | 1833.26 |
| Kalam | 35.48457 | 72.57664 | 2112 | 25,000 | 4543 | 38080.0 |
| Lalku | 35.14084 | 72.38587 | 1985 | 4800 | 684 | 5435.87 |
| Miandam | 35.05409 | 72.56485 | 1888 | 62,229 | 6223 | 14548.0 |
| Shahgram | 35.15104 | 72.52381 | 1497 | 4356 | 589 | 5678.43 |
| Shinko | 35.22271 | 72.42582 | 2993 | 7900 | 612 | 4567.65 |

**Fig. 3.** *Taxus wallichiana* tree growing in the Kalam Valley, KP, Pakistan. Bark was illicitly stripped from its stem and branches.

**Table 2**
Number of informal discussions and informant interviewers.

| Valley name | Informal discussions | Key informant interviews |
|---|---|---|
| Miandam | 6 | 25 |
| Lalku | 4 | 25 |
| Kalam | 4 | 25 |
| Beha | 6 | 25 |
| Shinko | 4 | 25 |
| Bishigram | 6 | 25 |
| Shahgram | 4 | 25 |
| Gurnai | 5 | 25 |
| Daral | 6 | 25 |

given, 6th level is the most and 1st level is the least destructive threat). Around 19% of the respondents felt that a lack of awareness of the indigenous people was the main threat to Himalayan yew, followed by its many uses and management strategies. Our results are consistent with those of Mesfin et al. (2013), who concluded that the main reason for the decline of this species is the lack of awareness. Similarly, Hizikias et al. (2011) reported that 90% of their respondents indicated that lack of awareness in nearby communities was the greatest threat to Himalayan yew, and that people paid little attention to its management. Knowledge of its importance as a medicinal plant is known by a few of the local healers.

According to our survey, 17% decline is due to the illicit harvesting (peeling bark, lopping branches, etc. Figure 3). This is done to satisfy the basic need of firewood for heating and cooking. Deforestation has been recognized by others as one of the reasons (Mesfin et al., 2013; Paul et al., 2013). This issue, which was also mentioned by Paul et al. (2013), leads many giant trees to die out in their natural habitat, which has negative effects on the growth and survival of the Himalayan yew as a species. Globally the main reasons for the decline of yew populations are widespread deforestation and selective felling (Jahn 1991; Tittensor 1980).

Leaves from Himalayan yew are a preferred source of forage by cattle, goats, sheep, and other livestock. Thus, 15% of the respondents thought that over-grazing (ranked 3rd, see Table 3) was an important contributor to its decline. Similar findings were reported in previous studies (Purohit et al., 2001; Mesfin et al., 2013; Bugala 1978).

Thirteen percent of the respondents to our survey indicated that a key cause of Himalayan yew depletion is its slow growth (ranked 4th) and its long period of seed dormancy (1.5 to 2 years). These results were consistent with those of Paul et al. (2013), who also concluded that the large numbers of the bright red berries were eaten by animals (e.g., birds, rats, monkeys, etc.), leading to a lack of regeneration.

Our work revealed that a key factor in the decline of Himalayan yew is agriculture (ranked 5th; Table 3), as people cultivate crops (e.g., potatoes, beans, etc.) in patches of the forests containing it, the slow-growing seeds were not able to survive naturally in areas that are cleared for agriculture. Its slow and low regeneration, and

**Table 3**
Reasons for threats and uses of *Taxus wallichiana* in the Swat District K.P, Pakistan.

| | Threats | Respondents | Rank | Reasons/Uses |
|---|---|---|---|---|
| 1 | Lack of awareness | 43 | 1st | Lack of knowledge about the importance of the species |
| 2 | Over-harvesting/ Deforestation | 38 | 2nd | Peeling bark, lopping branches, etc. Figure 3 Used in Slabs (tabai), coffin (taabut) in the graveyard |
| 3 | Over-grazing | 34 | 3rd | Its leaves are fodder for animals (goats and sheep) |
| 4 | Slow Growing | 29 | 4th | Due to its long seed dormancy period i.e. 1.5 to 2 years |
| 5 | Agriculture | 25 | 5th | Farming practices in the forest which removes the fresh germinating seeds |
| 6 | Construction | 20 | 6th | Furniture, roofs, and eaves |
| 7 | Firewood | 16 | 7th | Local people use the species for cooking purposes and by burning its wood for keeping themselves warm in cold weather |
| 8 | Decoration purpose | 11 | 8th | Wood carving because of its hard nature and beautiful red color |
| 9 | Medicinal use | 7 | 9th | Used for curing many diseases in the local areas by local Hakim |
| 10 | Other | 2 | 10th | Used as utility poles in the time of Wali-e-Swat (the leader of the princely Swat state, ruled therefrom 1926 to 1969) and as blades in water turbines to cut the water flow because of the hard nature of wood. |

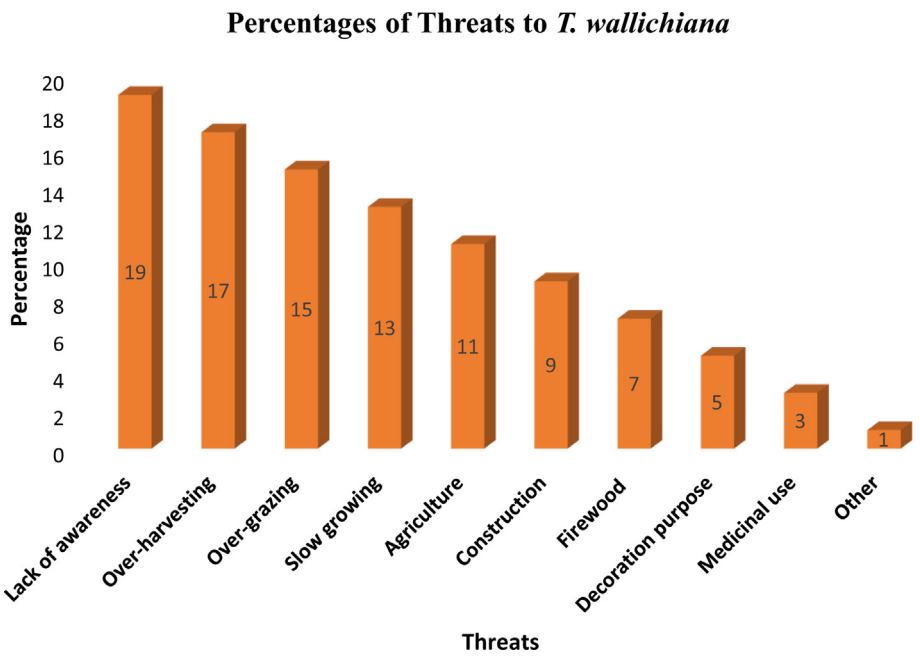


**Fig. 4.** Percentages of threats (natural and anthropogenic) to *Taxus wallichiana* in Swat district, KP, Pakistan.

**Table 4**
Level of threatening factors and its destructive effects (1st to 6th level score is given, 6th level is the most and 1st level is the least destructive threat).

| | Threatening factor | Level of threat | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | 3rd | 4th | 5th | 6th |
| 1 | Over-harvesting/Deforestation | | | | | | √√ |
| 2 | Over-grazing | | | | | √√ | |
| 3 | Slow Growing | | | | | √√ | |
| 4 | Agriculture | | | | √√ | | |
| 5 | Construction | | | √√ | | | |
| 6 | Firewood | | | √√ | | | |
| 7 | Decoration | | √√ | | | | |
| 8 | Medicinal use | | √√ | | | | |
| 9 | Lack of awareness | | | | | | √√ |
| 10 | Others | √√ | | | | | |

Key: 1st = Very Low, 2nd = Low, 3rd = Medium, 4th = Medium, 5th = High, 6th = Very High.

degradation of old populations in its natural habitat have been identified as key problems for this species (Nimasow et al., 2015). Other researchers have concluded that agriculture in the forests is one of the main reasons for the depletion of this species (Mesfine et al., 2009; 2013; Lulekal et al., 2008).

The wood from Himalayan yew is hard and has a beautiful color. As a result, it is widely used as a construction material for eaves, roofs, and furniture. Nine percent of people interviewed felt that this use was an important reason for the decline of this species (ranked 6th, see Table 3). Purohit et al. (2001) reported similar non-medicinal values for this species. They also mentioned the use of its wood for carving and beehive construction.

Paul et al. (2013) described how the use of branches as a source of fuelwood for cooking was a major contributor to the disappearance of Himalayan yew. In addition, Mesfin et al. (2013) concluded that firewood and construction were the key reasons for the depletion of this species. In our study, 7% of the respondents identified this as the primary factor (ranked 7th, see Table 3).

Finally, 5%, 3%, and 1% of the respondents attributed the decline in the numbers of Himalayan yew to the durability and decorative properties of its wood (ranked 8th), medicinal purposes by local people (ranked 9th), and utility poles and blades in water turbines (ranked 10th), respectively. As the bark of the species is used by the local people to cure many diseases, it was reported that when it is removed beyond a limit of 0.43 cm (average thickness of bark), its growth and survival declined significantly (Purohit et al., 2001).

Our findings suggest that immediate action is needed to save Himalayan yew from harvesting (peeling bark, lopping branches, etc.), over-grazing, and other destructive activities by making the local people aware of its importance by arranging workshops, seminars, etc. (Lanker et al., 2010).

## 5. Conclusion

The results of the present study indicate that both anthropogenic and natural factors are affecting the survival of Himalayan yew. Existing mismanagement of Himalayan yew, lack of awareness, over-harvesting, and over-grazing are the main anthropogenic factors leading to the decline of this species. However, natural factors, such as slow growth and long seed dormancy periods are also threating to this species. Other key factors identified by respondents include use for utility poles and as blades in water turbines. Lack of awareness was identified as the most threatening factor. Therefore, awareness-creation campaigns should be implemented so citizens are cognizant of the importance of the management of medicinal plants and may pass this knowledge down to future generations. It is advisable to develop management strategies and establish in-vitro (labs) and in-situ (nurseries) conservation programs to produce rooted plants from cuttings and seeds for reforestation efforts.

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## Author contributions

Bushra Khan conceived and designed the experiment, Javaid Iqbal conducted the survey from the key respondents, analyzed

the data and wrote the paper; Prof. Richard Meilan reviewed the Manuscript.

## Declaration of Competing Interest

The authors declare no conflict of interest. The funding sponsors (HEC) had no contribution to the Survey design; in the collection, analyses, or data interpretation; in the manuscript writing, and in the decision to publish the results.

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