

**DISTRIBUTION PATTERN, MORPHOLOGY  
AND ANATOMY OF *Taxus mairei* (Lemée & Lév.)  
S.Y. Hu IN NEPAL**



**A Dissertation Submitted for the Partial Fulfillment of the  
Requirements of a Master's Degree in Botany**

BY

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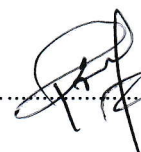
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July 2024

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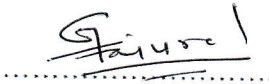
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**June, 2024**

## सारांश

नेपालमा अवस्थित अद्वितीय जैविक विविधताको कारण यहाँ फ्लोरिस्टिक क्षेत्रहरु धेरै रहेको तथा विभिन्न क्षेत्र क्रसरोडको रूपमा रहेकाले फूल फूलने प्रजातिहरुको विशेषता तथा बाहुल्यता रहेकोछ।वर्ल्ड प्लान्ट चेकलिस्टका अनुसार विश्वमा हालसम्म लौठसल्लाका १२ प्रजातिहरु फेला परेका छन्। पश्चिमी नेपालको दार्चुलादेखि मध्य नेपालको गोरखासम्म ट्याक्सस कन्टोर्टा, मध्य नेपालको मकवानपुर,ललितपुर,काठमाडौंको धादिङ, काभ्रेपलाञ्चोक र सिन्धुली जिल्लामा ट्याक्सस माइरेई र ट्याक्सस वालिचियाना बाग्लुङको पूर्व क्षेत्रदेखि पूर्वी नेपालको ताप्लेजुङसम्म पाइन्छ।नेपालमा रहेका जिम्नोस्पर्महरु मध्य एक प्रजाति ट्याक्सस माइरेई हो जुन आर्थिकरूपमा महत्त्वपूर्ण र ढिलो बढ्ने सदाबहार डायओसियस रूख हो जुन नेपालको मकवानपुर,धादिङ, सिन्धुली र काभ्रेपलाञ्चोक जिल्लामा कम उचाइमा विरलै फैलिएको छ।क्यान्सर निकोपार्ने उपयोगिताका कारण यो प्रजातिलाई बढी ध्यान दिइएको भए पनि नेपालमा अन्य दुई प्रजातिका ट्याक्ससको तुलनामा यो प्रजाति व्यापारमा ल्याइएको छैन। यस अध्ययनको उद्देश्य विभिन्न स्थानबाट सङ्कलन गरिएका प्रजातिहरुको morphology, distribution pattern तथा anatomy समावेश गरि सोध कार्यमा प्रस्तुत गर्नु हो। सोध कार्य तयार गर्ने क्रममा सन्दर्भ-सामग्रीको पुनरावलोकन गरी स्थलगत अध्ययनको चरणमा आवश्यक चेकलिस्टहरु तैयार पारी यस प्रजातिक नमुना सङ्कलन समेत गरिएको थियो।स्थलगत अध्ययनबाट विभिन्न स्थानहरूमा कुल २४ population को अध्ययन गरिएको छ। यस अध्ययनबाट यस प्रजातिहरुको taxonomic वितरण अन्य प्रजाति भाडा भन्दा फरक तर ट्याक्सस वालिचियाना नजिक रहेको पाईयो । यस प्रजातिको distribution मोडेलले यस प्रजातिको कम जनसंख्या घनत्वको बावजुद एक अपेक्षाकृत ठूलो क्षेत्रको distribution गरेको पाईयो, जुन अन्य प्रजातिहरूमा समान छतर wild population २००० मिटर तल सीमित पाईयो। यस अध्ययनबाट यस प्रजातिहरुको वितरण bioclim variables जस्तै वार्षिक तापक्रम र वर्षाले प्रभावित रहेको पाईयो।

मुख्यशब्द: जैविकविविधता, ट्याक्सस माइरेई, taxonomy, distribution, क्यान्सर, व्यापार

## ABSTRACT

Nepal lies in the central part of main Himalayan range harboring unique biological diversity and is floristically characterized as being crossroad of six floristic regions. One of the notable species of Nepal is *Taxus mairei* which is economically important and slow growing evergreen dioecious tree that is sparsely distributed in lower altitudes in Makawanpur, Dhading, Sindhuli, Kathmandu, Lalitpur and Kavrepalanchok districts of Nepal. This species has been paid more attention due to its usefulness to cure cancer, but this species has not been brought to the trade compared to other two species of *Taxus* in Nepal. The study aims to understand the taxonomy of the species collected from different location. This study is based on the distribution of the *Taxus mairei* (Lemée & Lév.) S.Y. Hu in Nepal. The field works were carried out to collect the flowering and fruiting of the species in Nepal from different literature, herbarium data and other documents. The field works were carried out from September 2023 to December 2023. Total of 24 populations were studied from different locations and collections were also done so as to perform the anatomical study as well as morphological study. The distribution of species was influenced by bioclim variables like annual temperature and precipitation. But the current model was not much different even from exclusion of the some of points of collection. The present model is correctly predicting the species in Bagmati Province (Central Nepal) while the future model predicted the possibility to find the suitable habitat in higher elevation. Study of morphological features suggested that *Taxus mairei* is distinguishable from other two species *Taxus wallichiana* and *Taxus contorta* while there were also marked features in anatomical study that helped in separating the species from other two species of the genus *Taxus* found in Nepal. *Taxus mairei* was found below 2000 m. Although the species population is less and most of the localities were determined to be cultivated land, the original natural field was not noted during the site visit. There is also concern on the conservation of this species which is closer to *T. wallichiana* but limited its distribution below 2000 m. This study is important in its kind where details morphological features from each population were studied to make the taxonomic treatment.

**Keywords:** Biological diversity, taxonomy, distribution, cancer, trade, morphology

## **ABBREVIATIONS AND ACRONYMS**

|          |   |
|----------|---|
| AIC      | : Akaike's Information Criterion                          |
| Alt      | : Altitude  |
| AUC      | : Area Under the Receiver Operating Characteristics Curve |
| CITES    | : Convention on International Trade in Endangered Species |
| GPS      | : Global Positioning System                               |
| ICIMOD   | : International Center of Integrated Mountain Development |
| IUCN     | : International Union for Conservation of Nature          |
| KATH     | : National Herbarium and Plant Laboratories               |
| ASCOL    | : Amrit Science Campus Herbarium                          |
| ASCOL    | : Amrit Science Campus                                    |
| km       | : Kilometer   |
| m a.s.l. | : Meters Above Sea Level                                  |
| MAPs     | : Medicinal And Aromatic Plants                           |
| NTFP     | : Non-Timber Forest Products                              |
| NTNC     | : Nepal Trust for Nature Conservation                     |
| TU       | : Tribhuvan University                                    |
| TUCH     | : Tribhuvan University Central Herbarium                  |
| UTM      | : Universal Transverse Mercator                           |

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# CHAPTER I: INTRODUCTION

## 1.1 Background

Nepal features a wide range of topographic and climatic variations across its elevation gradient, resulting in various ecosystems rich in floral diversity. Its complex biogeography is influenced by its geological history and its location at the intersection of the Palaeartic and Paleotropic bio-geographic realms (Udvardy 1975).

The country encompasses two major zoogeographical regions: the Palaeartic in the north and the Indo-Malayan in the south, as well as two primary phytogeographical regions: the Holarctic in the east, south, east north and the Paleotropic in the south. Additionally, Nepal is situated at the junction of six floristic regions: Central Asiatic in the north, Sino-Japanese in the east, Southeast Asia-Malaysia in the southeast, India in the south, Sudano-Zambian in the southwest, and Irano-Turanian in the west (Rajbhandari *et al.*, 2020).

Nepal is ranked 49th globally in terms of biodiversity, with over 22,000 species reported, accounting for 1.3% of the world's biodiversity. Among Asian countries, Nepal holds the 9th position for its rich floral diversity (Bhattarai *et al.*, 2013).

Despite occupying only 0.1% of the Earth's land area, Nepal boasts an exceptionally rich variety of flora and fauna. This diversity is attributed to its significant altitudinal range and monsoon climate, which create a wide range of habitats, from lowlands at 67 meters above sea level to coniferous forests, tree lines, rhododendron scrublands, and high alpine regions.

From the eastern to the western region of Nepal, there are 33 taxa belonging to the Gymnosperms (Rajbhandari and Baral 2010, Rajbandari *et al.*, 2015). Gymnosperm forests primarily dominate to temperate zones. However, certain gymnosperms such as *Abies*, *Tsuga*, and *Ephedra* are prevalent in the sub-alpine areas of Nepal (Chaudhary, 1998; Ministry of Forests and Soil Conservation, NBSAP 2014).

The family Taxaceae, commonly known as the yew family, consists of branched small trees and shrubs with evergreen leaves, often twisted to appear two-ranked (Simpson,

2010). Globally, there are 13 Taxa of the genus *Taxus*, including ten species and three infraspecific taxa (Farr, 2008). In Asia, there are five species of *Taxus* (Farr, 2008).

The genus *Taxus* comprises less than 2% of gymnosperm species and is widely grown in the northern hemisphere as an ornamental shrub (Price, R.A. 1990). *Taxus* is native to Nepal, China, Hainan, Taiwan, and Vietnam (Lingyu *et al.*, 2021).

In Nepal, naturally occurring *Taxus* is found across a broad elevation range of 1700-3450 meters, extending from east to west (Gajurel *et al.*, 2014; Rajbhandari *et al.*, 2015).

In Nepal, there are three species of *Taxus* that occur in natural forests: *Taxus contorta* Griffith, *Taxus wallichiana*, and *Taxus mairei* (Lemée & Lév.) S.Y. Hu (Rajbhandari and Baral, 2010; Rajbhandari *et al.*, 2015).

Out of the three species, *Taxus contorta* is distributed from West to Central, *Taxus wallichiana* in Central to East while *Taxus mairei* is confined to mid hills of the Central Nepal in three districts: Sindhuli, Kavrepalanchok and Makwanpur (Bashyal *et al.*, 2020, Bhatta *et al.*, 2017, Pandey *et al.*, 2019).

*Taxus mairei* is native to East Asia, primarily found in China, Taiwan, Vietnam, Laos, and the eastern Himalayas. In Nepal, it is only found in Bagmati Province. *Taxus mairei* is closely related to other species within the genus *Taxus*, and there has been some confusion and debate over its classification. Molecular studies and morphological assessments have helped to clarify its distinct status among East Asian yews. Its distribution is below 2000 m in Nepal.

*Taxus mairei* was treated as a variety of *T. chinensis* (Cheng and Fu 1978), but transferred to *T. wallichiana* later and so treated in Flora of China 4: 91 (1999). This appears to have been decided mostly on branching patterns, which in this case are not considered to provide separable character states, as these are even more prone to environmental influences during development than leaf shapes and sizes (Wu *et al.*, 2022), (LU *et al.*, 2008).

The reclassification is mainly depended on branching patterns. However, these patterns are not seen distinct character states because they are highly influenced by environmental factors during development, even more than leaf shapes and sizes (Wu *et al.*, 2022; Lu *et al.*, 2008).

Farjon (2010), treated *T. mairei* as a distinct species. The differences of *T. mairei* are minor and limited to leaf morphology (Spjut, 2007). According to the recent taxonomic treatment, the genus has further divided into a varietal rank, resulting in *T. mairei* var. *mairei*.

In Nepal, the wild populations of *Taxus mairei* are believed to consist of fewer than a few thousand individuals (Bashyal *et al.*, 2020).

The IUCN Red List classifies *T. mairei* as a Vulnerable species (IUCN, 2020; Zhou *et al.*, 2019). *T. mairei* is valued for its medicinal properties and high timber value, which are extensively exploited by local communities due to their efficacy in treating cancer.

Its leaves are specifically used in the production of taxol (Gangadevi and Muthumary, 2008; Wang, Lo, and Wang, 2008; Bashyal *et al.*, 2020). Taxol is extensively used to treat breast cancer, ovarian cancer, non-small cell lung cancer, bladder cancer, and leukemia (R. Croteau *et al.*, 2008; M. C. *et al.*, 2008).

Due to the high demand for paclitaxel, *Taxus mairei* has become a critical resource for pharmaceutical companies. The species is considered one of the most economically valuable yew species for the production of taxol. As a slow-growing, shade-tolerant tree, *Taxus mairei* plays an important role in forest ecology. It is a component of temperate and subtropical montane forests and provides habitat and food for various wildlife species.

The dense foliage of *Taxus mairei* offers shelter and breeding sites for birds and other forest fauna. Its seeds, encased in fleshy arils, are dispersed by birds and other animals, aiding in forest regeneration. Apart from its medicinal uses, *Taxus mairei* is also valuable for its wood. The wood of *Taxus mairei* is hard, fine-grained, and durable, making it suitable for high-quality woodworking, furniture making, and carving.

The importance of *Taxus mairei* spans ecological, medicinal, economic, and cultural domains. Its contribution to anti-cancer drug production highlights its global significance in medicine, while its ecological role underscores its value in maintaining biodiversity and forest health. Conservation efforts are vital to ensure the sustainable use and protection of this valuable species, balancing human needs with ecological preservation.

The habitats where *Taxus mairei* is found in Nepal do not fall under protected areas but are instead categorized as community forests or private forests (Mulliken and Crofton, 2008). Due to factors such as habitat destruction, medicinal uses, overharvesting, and climate change, the species is rapidly disappearing (Mulliken and Crofton, 2008; Gajurel *et al.*, 2014). In biodiversity conservation, a critical focus is on protecting endangered species and their habitats (Lindborg and Ehrlen, 2002; Larsen and Olsen, 2007; Zhang *et al.*, 2007). To restore the natural population of *Taxus mairei*, it is essential to enhance management practices and accurately map its distribution in specific areas where it occurs. This species is not found above 2000 meters, emphasizing the need for identification and distribution modeling to conserve this declining species in Nepal.

## **1.2 Rationale of the Study**

Research on *Taxus mairei* is limited globally, with scant specific population data available (Gajurel and Gautam, 2016). The Government of Nepal, National Herbarium and Plant Laboratories (Gajurel and Gautam, 2016) carried out a preliminary survey of yews (KATH). This survey underscored the importance of conducting detailed population assessment and raising awareness about conservation efforts (Bhatta *et al.*, 2017). However, the study focusing on its taxonomy, distribution along with anatomical study has not been done previously with collection of the specimens from all the localities where it was reported and other possible site.

## **1.3 Objectives**

The main objective of the study is to assess distribution pattern, morphology and anatomy of *Taxus mairei* in Nepal.

The specific objectives of the study are:

- To document morphological and anatomical features of *Taxus mairei* and compare those with closely related species .
- To find out the current and future distribution of *Taxus mairei* based on Maxent modeling.

## **1.4 Limitation of the Study**

The limitation of this study is that the species has been collected only from the known localities based on herbarium records from Bagmati province, Nepal.

## CHAPTER II: LITERATURE REVIEW

### 2.1 Morphology

Spjut and Richard (2007) discussed the taxonomy and naming of *Taxus*, noting that *T. mairei* was identified by its distinctive characteristics: two-ranked leaves that spread nearly at right angles, with the abaxial (lower) surface having a truncated but raised midrib and epidermal cells larger in diameter than those on the adaxial (upper) surface, giving it a mammillose appearance. The midrib is typically channeled, particularly in the middle section of the leaf.

Gajurel and Gautam (2016) conducted a study on the anatomy and morphology of *T. mairei* from Nepal. Morphologically, it was characterized by dark glossy green leaves on the upper side, non-straight leaves, twisted petioles on the dorsal surface, and persistent loss of bud scales. *T. mairei* was distinguished by having 12-16 rows of stomata.

### 2.2 Distribution

Li *et al.* (2000) examined the distribution and dynamics of *Taxus chinensis var. mairei* populations on Yunbaoshan mountain using methods like contiguous grid quadrat, t-tests for v/m ratio, negative binomial parameter, Green's index, Cassie's index, dispersion index, clumping index, mean crowding index, and patchiness index. Their findings indicated that the distribution pattern exhibited clustering. The degree of clustering decreased from saplings to mature trees, whereas large trees showed a random distribution pattern.

According to Qun *et al.* (2001), yews in China are primarily found in southwestern, central, southern, and eastern regions. Their distribution was analyzed using the Maxent model from the mid-Holocene to the 2070s. *Mairei* yew was favored in warm and humid environments.

Ru (2006) studied that *Taxus mairei* is found mainly in subtropical regions of China, covering 17 provinces, including Sichuan, Yunnan, Henan, and Shaanxi. It is distributed across areas with elevations ranging from 70 m to 2100 m, with a preference for humid,

subtropical climates. In these regions, it often grows in scattered populations and small clusters.

Lu *et al.* 2008 studied the effect of frugivorous birds on the establishment of a naturally regenerating population of Chinese yew in ex situ conservation in Nanjing Botanical Garden Memorial Sun Yat-Sen in Jiangsu province, China. In 2006, 236 individual yew seedling and sapling were found which were 10m away from mother tree. The spatial pattern occurred as clumped distribution. The regeneration of Yew is strongly dependent on bird, appropriate microhabitats of seed germination and seedling growth.

Wang *et al.* (2010) examined the spatial distribution of various age classes of *Taxus chinensis var. mairei* individuals. They found that at scales ranging from 2m to 25m, the distribution was random, but at scales less than 2m, the distribution was clumped.

Poudel *et al.* (2012) demonstrated that *T. mairei* was found at lower elevations with warmer temperatures, less seasonal variation, higher precipitation, and greater annual variability in rainfall compared to *T. contorta*. The study combined various morphological traits with climatic data and ecological niche modeling, revealing the three distinct *Taxus* species in the Hindu Kush Himalaya region.

Zhang (2012) documented that *T. mairei* was restricted to a specific region, making it an endemic and endangered tree species in China that was classified as first class protected due to its significant medicinal value. The study examined 95 samples of 10m x 10m plots in a temperate region, recording a total of 128 plant species. Floristic data and environmental data were analyzed using TWINSpan, DCA, and CCA methods. Measurements included height, basal area, cover, and number of individual trees, as well as cover, height, and abundance of shrubs and herbs in each quadrant.

Poudel *et al.* (2014) explored the low genetic diversity and notable inbreeding within the endangered yew population in central Himalayas. They conducted transect surveys to assess size class structures and predict future trends, noting a high likelihood of these issues occurring in the northern part of the Central Himalayas.

Run-mei *et al.* (2016) studied the natural distribution and community ecological traits of *Taxus chinensis var. mairei* in Shanxi Province, China. They identified its presence in four distinct communities, noting significant differences in species diversity index and

evenness index among these communities. The study also observed a scarcity of seedlings, with only four seedlings found.

Zaiyou *et al.* (2016) reported that *Taxus mairei* was broadly distributed in China, typically occurring between 750m to 1000m elevation. It is primarily found in Mohe town, Duohuo town, and Mgedang town. The species was severely endangered due to various biological and environmental factors. These biological factors include challenges in pollination, limited natural vegetation, growth and germination characteristics of seeds, and various environmental factors affecting distribution and community characteristics.

Zhang *et al.* (2017) examined the structural diversity of naturally regenerating Chinese yew using structural indices. A total of 170 individuals were observed across two samples, with Plot A containing 101 individuals and Plot B containing 69 individuals which was carried out in ex situ conservation into two forest type.

Bashyal *et al.* (2020) conducted a survey to identify potential yew habitats in Nepal, specifically in Kavrepalanchok with 545 individuals, Makwanpur with 553 individuals, and Sindhuli with 1133 individuals, totaling 2231 individuals. The survey employed transect methods for data collection.

Sharma *et al.* (2021) investigated the population status using various methodologies such as desk reviews, consultations, field planning, assessments, and predictive modeling across all districts. According to the study, *T. mairei* was found in six districts covering an area of 25,055 hectares. The population density is reported at 31 individuals per hectare, with the majority (>30 cm DBH) comprising 24 individuals per hectare.

Wu *et al.* (2022) chose two *Taxus* species, *T. chinensis* and *T. mairei*, utilized four environmental variables using the Maxent model. They evaluated these patterns under historical climate conditions as well as future climate scenarios.

Wu *et al.* (2022) demonstrated that *T. mairei* was found in Hunan province within the Sino-Japanese floristic region of China. The species' suitable elevation range had been influenced by climate change, with temperature and precipitation being the primary factors driving its distribution.

## 2.3 Conservation

Guo (2008) Studies emphasize the importance of understanding the spatial distribution of *Taxus mairei* for conservation, particularly due to its ecological and pharmacological significance.

Wang *et al.* (2019) investigated five *Taxus* species threatened in China due to varying responses to climate and land use changes. *T. mairei*, found scattered throughout southern China, has a limited natural dispersion. This species was listed on the IUCN Red List of Threatened species and was under CITES protection due to deforestation. The study concluded that these threatened species are impacted not only by climate change and land use but also by specific ecological traits and distribution range attributes.

Zang and Wu (2010) conducted a study emphasizing the urgency of conserving *T. mairei*, a unique and endangered, tree species protected at the highest level in China. They investigated and analyzed the biological and ecological characteristics of its populations. The study suggested several conservation measures, such as creating nature reserves, improving population health through cultivation and relocation, establishing seed gardens and promoting plantation efforts among other conservation management strategies.

Bashyal *et al.* (2020) conducted a study on the population of Yew which involved local communities for the conservation across three districts. Conservation efforts included discussions at both local and policy levels. Protection measures were implemented for *T. mairei* trees over 300 years old. Information was gathered through semi-structured interviews, focusing on demographic details of harvesters and analysis of harvesting techniques using MS Excel.

Li *et al.* (2021) investigated the rewilding of Chinese yew in eastern China. *T. mairei*, recognized as a rare and endangered plant, will rely on frugivorous birds for seed dispersal as part of its conservation strategy.

## 2.4 Conservation status

The local name for this species is Lauth Salla. It is categorized as Vulnerable (VU) on the Global IUCN Red List (<https://www.iucnredlist.org/species/191659/1991533>).

However, this listing has not yet been updated to include Nepal as part of its range.

**Table 1 :** Common and Vernacular names of *Taxus mairei*.

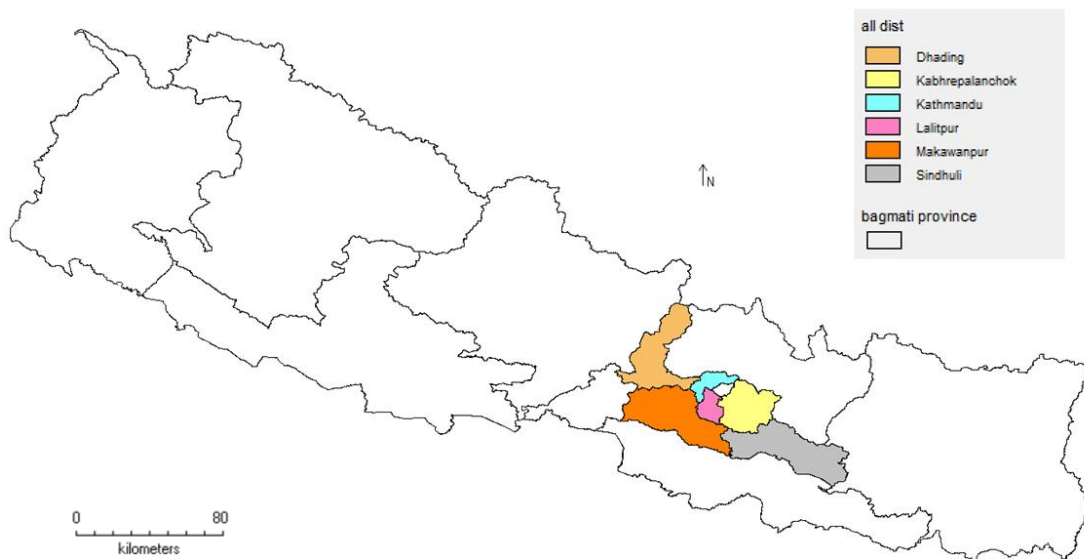
| English Name        | Maire's Yew, South China Yew                              |
|---------------------|---|
| Local name in Nepal | Dhengre, Lauth Salla, Barne Salla, Pate Salla, Talispatra |

Source: <https://www.iucnredlist.org/species/191659/1991533>

## CHAPTER III: MATERIALS AND METHODS

### 3.1 Study area

The study was carried out in all the localities where previously *Taxus mairei* was recorded. It included Dhading, Makwanpur, Sindhuli, Kathmandu, Kavrepalanchok and Lalitpur districts.(Figure 3.1 and 3.2.)

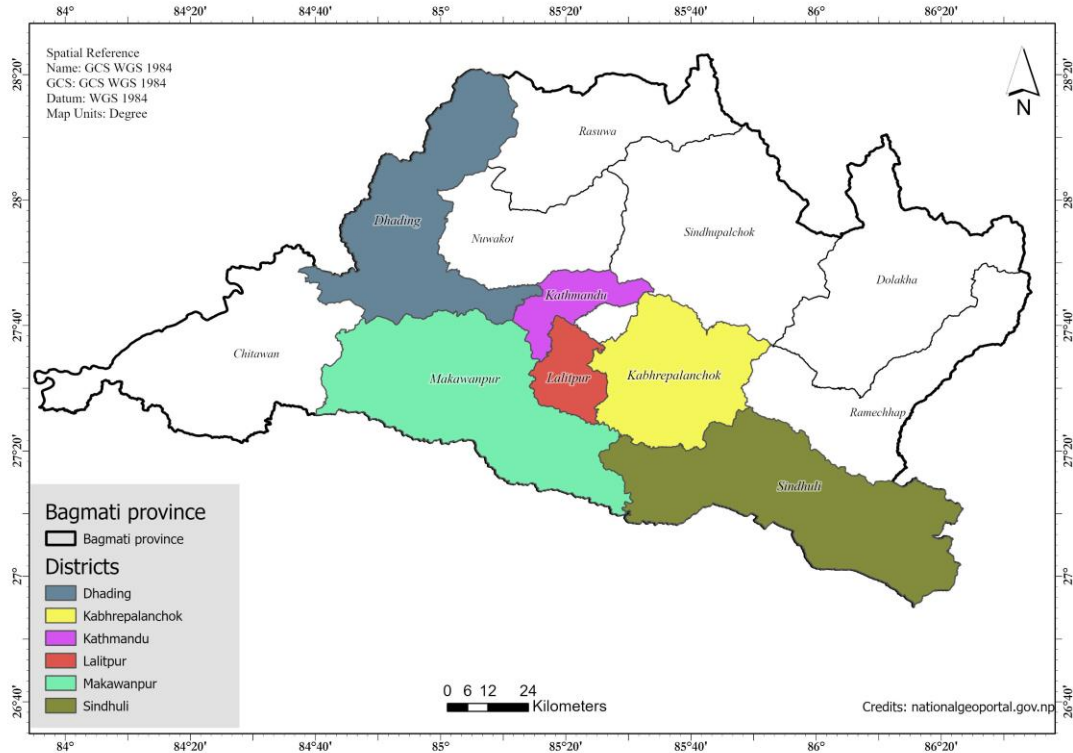


(map drawn based on DIVA GIS 2023)

**Figure 1:** Distribution of *Taxus mairei* in Bagmati province

*Taxus mairei* is cultivated in Nepal under specific climatic conditions conducive to its growth. It thrives in temperate to subtropical climates with moderate temperatures, typically preferring regions with mild winters and warm summers. Adequate rainfall is crucial, making areas with consistent or seasonal rainfall suitable for cultivation.

The yew species can adapt to various altitudes, ranging from 300 to 2500 meters above sea level, making it versatile for cultivation across Nepal's diverse topography, including mid-hills and subalpine zones. Well-drained soils that are slightly acidic to neutral are optimal for its growth. While *Taxus mairei* can tolerate partial shade, it generally benefits from ample sunlight, especially in cooler climates. These climatic conditions ensure successful cultivation of *Taxus mairei* in Nepal, supporting its growth and development for both ecological conservation and economic purposes.



(map drawn based on DIVA GIS 2023)

**Figure 2:** Distribution of *T.mairei* in different districts in Bagmati province

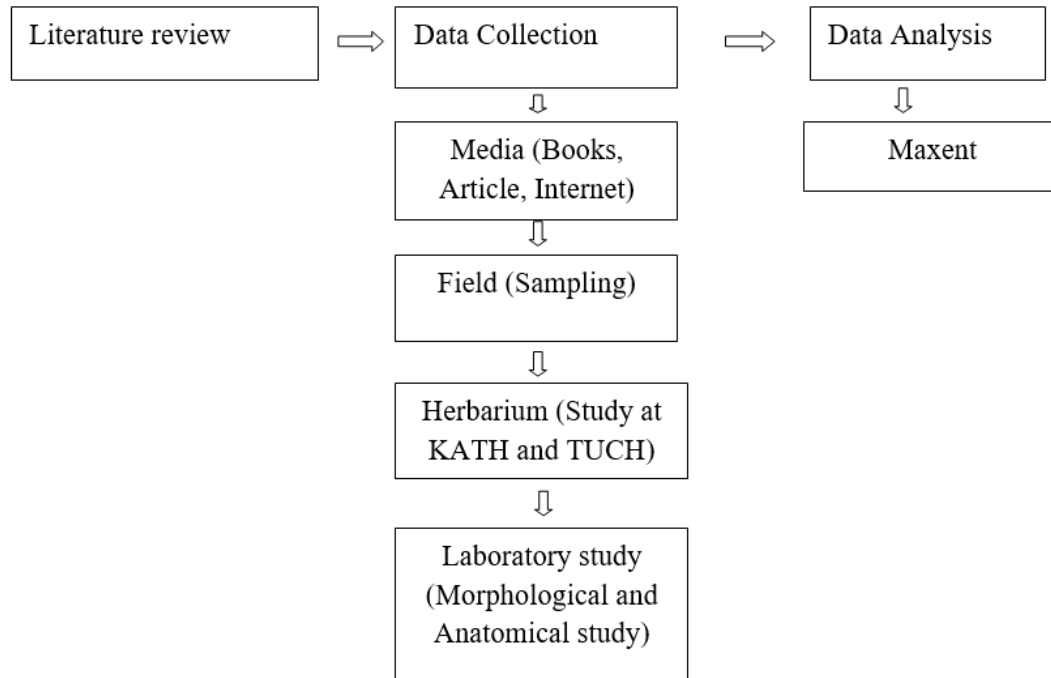
*Taxus mairei*, known as Maire's yew, grows in Nepal's Himalayan region. It thrives in moist, well-drained soil and can be found from 300 to 2500 meters above sea level. *Taxus mairei* prefers cool, moist conditions and is commonly associated with mixed broadleaf and coniferous forests. However, its populations are threatened due to over-exploitation for its wood and medicinal uses, requiring conservation efforts to protect this important species.

### 3.2 Methods

The research approach (Figure 3.3) was based on the collection and assessment of the study objectives. The quality control of the study was maintained through following the guidelines executed by the supervisor, carrying the entire study under the designed approach. The various proven protocols were followed for the assessment purpose, especially for anatomical study and climate data extraction and analysis.

The entire collection was based on the single time field visit (one season) in all the localities where the species was previously mentioned as present. Similarly, all the localities where the plant was reported and the adjoining districts with similar

physiography and climate were investigated. Meanwhile, the data for distribution modeling were obtained from secondary sources, due to short time period, no data loggers were used.



**Figure 3:** Research design framework

### 3.3 Collection and preparation of herbarium specimen

*Taxus mairei* individuals were gathered from selected locations across Dhading, Makwanpur, Sindhuli, Kathmandu, Kavrepalanchok, and Lalitpur districts. Specimens, including reproductive parts, were collected extensively, documented with field descriptions, tagged, and numbered. The plants were promptly pressed in the field, transferred to a herbarium press, and dried on newspaper. Due to the species fragmented and isolated populations, collections were conducted separately for each tree within a population. From each site three sample specimens were collected from each population. The flowering or fruiting branch was selected and herbarium specimen was prepared from those collections. The locations of the population was determined on the basis of the literatures and also from the information given by the local people. The morphological analysis of specimens (leaf, seed, flowers, etc) was conducted using stereomicroscopes and dissecting microscopes at the Laboratory of Golden Gate International College, which provided laboratory facilities. Relevant literature (Polunin &

Stainton, 1984; Möller *et al.*, 2007; Spujit, 2007; and Farjon, 2010) was consulted for the morphological study.

### 3.4 Species distribution modeling

Species distribution modeling using Maxent v3.3.3.k (Phillips *et al.*, 2006) was performed with default parameters given in the software. Different models were produced with help of specimen collection locations from Dhading, Makwanpur, Sindhuli, Kavrepalanchok, Lalitpur districts of Nepal, supplemented by 22 presence records. The input data for Model I included 19 Bioclim variables (current and future HadGEM2-ES), such as BIO1: Annual Mean Temperature, BIO2: Mean Diurnal Range, BIO3: Isothermality, BIO4: Temperature Seasonality, BIO5: Max Temperature of Warmest Month, BIO6: Min Temperature of Coldest Month, BIO7: Temperature Annual Range, BIO8: Mean Temperature of Wettest Quarter, BIO9: Mean Temperature of Driest Quarter, BIO10: Mean Temperature of Warmest Quarter, BIO11: Mean Temperature of Coldest Quarter, BIO12: Annual Precipitation, BIO13: Precipitation of Wettest Month, BIO14: Precipitation of Driest Month, BIO15: Precipitation Seasonality, BIO16: Precipitation of Wettest Quarter, BIO17: Precipitation of Driest Quarter, BIO18: Precipitation of Warmest Quarter and BIO19: Precipitation of Coldest Quarter were obtained from WorldClim (Hijmans *et al.*, 2005) at a spatial resolution of 30 arc.

For Model I, all bioclim variables were used while for Model II, only less correlated BIO4 = Temperature Seasonality, BIO5 = Max Temperature of Warmest Month, BIO6 = Min Temperature of Coldest Month, BIO12 = Annual Precipitation, BIO15 = Precipitation Seasonality, BIO17 = Precipitation of Driest Quarter were used.

The bioclimatic variables were correlated using Pearson's correlation testing (R version 4.4.1). Variables exhibiting high correlation were taken out from the analysis. The selected variables included bio 4 (temperature seasonality), bio 5 (maximum temperature of warmest month), bio 6 (minimum temperature of coldest month), bio 12 (annual precipitation), bio 15 (precipitation seasonality), and bio 17 (precipitation of driest quarter).

Future model was prepared where climate conditions from HadGEM2-ES. HadGEM2-ES was used that comprises a range of specific model configurations incorporating different levels of complexity but with a common physical framework coupled atmosphere-ocean configuration and an Earth-System configuration which includes

dynamic vegetation, ocean biology and atmospheric chemistry (Collins et al. 2008). These models used the data from 19 Bioclim variables, including altitude, obtained from WorldClim (Hijmans *et al.*, 2005), at a spatial resolution of 30 arc.

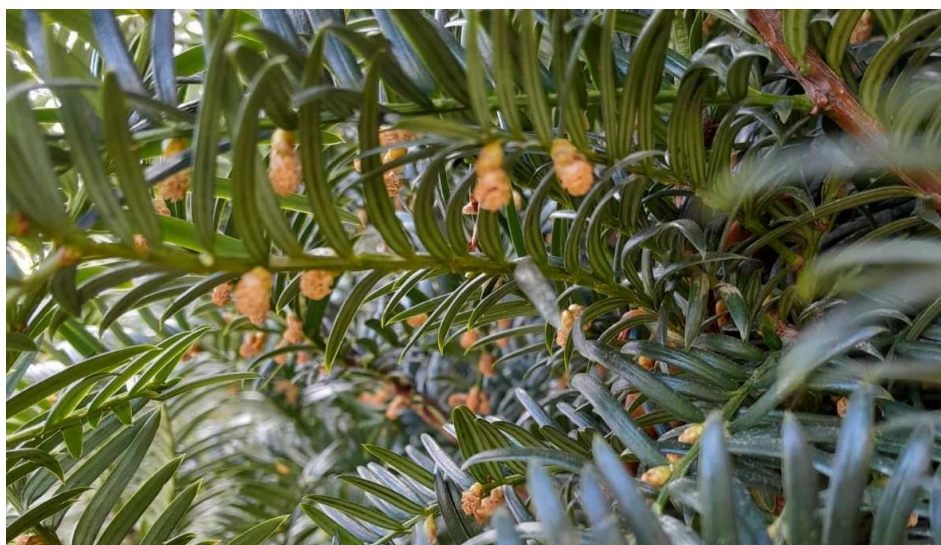
For the model validation, 50% of location sites were selected among the sampled data. Similarly, the remaining 50% of location sites were obtained from herbarium records and the research sites, which were used for optimal prediction. For the species distribution modeling Maxent v3.3.3.k (Phillips et al., 2006) was used with default parameters. Similarly, area under the receiver operating characteristics curve (AUC) were used to compare the present climatic models with similar studies.

## CHAPTER IV: RESULTS

### 4.1 Morphological study

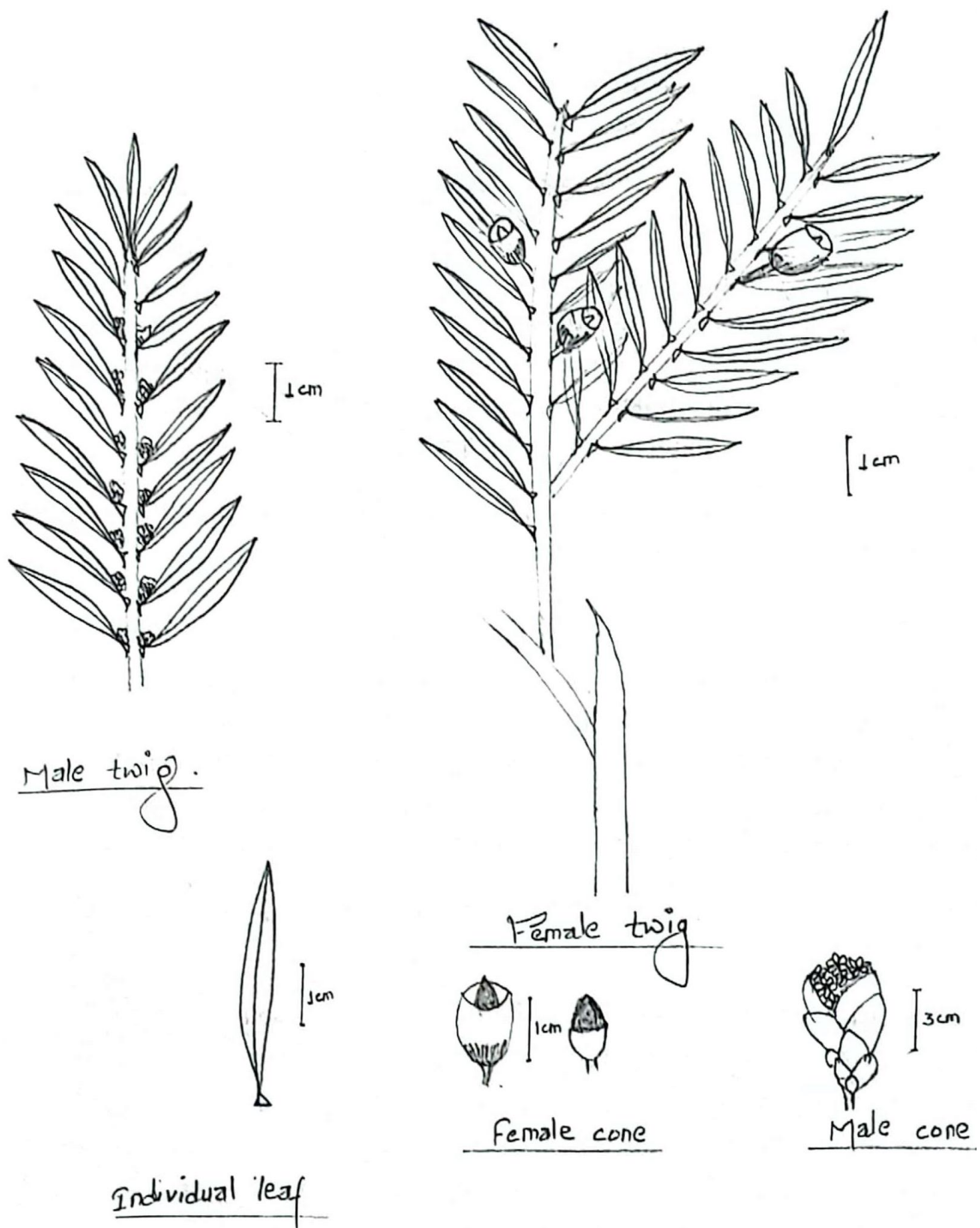
*Taxus mairei*, commonly known as Maire's yew or Chinese yew, is a small to medium-sized evergreen tree that typically grows between 10 to 20 meters in height, although it can occasionally reach up to 25 meters.

The tree has a rounded to broadly conical crown with dense branches that are either spreading or ascending, creating a compact and somewhat layered appearance. The bark of *Taxus mairei* is thin, reddish-brown to grayish-brown, and becomes scaly or flaky with age; in younger trees, it appears smoother, while in older specimens, the bark peels off in thin scales or strips, revealing a reddish-brown inner layer beneath.



**Figure 4:** Flowering twig of *Taxus mairei* at natural habitat.

The leaves are one of its most distinctive features—linear, flat, and needle-like, measuring between 1.5 to 3.5 cm in length and 2-3 mm in width. They are arranged spirally around the stem but twisted at the base to appear in two flat ranks on either side of the shoot, giving the foliage as a distinctly flattened appearance. The upper surface of the leaves is dark green and glossy, contrasting with the paler green underside, which is marked by two distinct stomatal bands.



**Figure 5:** Line drawing of the *Taxus mairei*.

*Taxus mairei* is dioecious, meaning that male and female reproductive structures are found on separate trees. The male cones are small, globular, and about 3-4 mm in diameter, typically found singly or in small clusters on the underside of the leaves. These

cones produce pollen in early spring. The female cones are highly reduced and consist of a single seed enclosed within a fleshy, berry-like structure called an aril.



**Figure 6:** Flower and fruit of *Taxus mairei*.

The aril is bright red to reddish-brown, fleshy, and cup-shaped, measuring around 8-12 mm in diameter, partially enclosing a single ovoid seed that turns dark brown or black when mature.

The seeds, about 4-6 mm long, are partially exposed within the aril, which is not a true fruit but serves to attract birds and animals for seed dispersal.

The wood of *Taxus mairei* is hard, dense, and fine-grained, with reddish-brown heartwood and lighter-colored sapwood, prized for its durability and resistance to decay, making it valuable for fine woodworking, furniture, and carving.

On the basis of this study, a comparison table has been provided highlighting the distinct morphological characteristics of *Taxus mairei*. This comparison is based on the morphological study done for the *Taxus mairei* and rest of the species like *Taxus wallichiana* and *Taxus contorta*.

These three species of yew trees differ in leaf, bark, seed, and growth habits, which helps in their identification and differentiation. The morphology can distinctly separate it from *Taxus contorta* while many features are similar to *Taxus wallichiana* as in table 2.

**Table 2:** Comparative table showing morphological differences among Species of *Taxus* in Nepal.

| Character               | <i>Taxus mairei</i>  | <i>Taxus wallichiana</i>  | <i>Taxus contorta</i>   |
|-------------------------|--|---|---|
| <b>Common Name</b>      | Chinese Yew or Maire's Yew   | Himalayan Yew   | West Himalayan Yew  |
| <b>Bark</b>             | Reddish-brown to grayish-brown, thin, scaly                                  | Brown to dark reddish-brown, exfoliating in thin strips   | Reddish-brown, peeling in thin papery scales  |
| <b>Leaf Length</b>      | 1.5 to 3.5 cm  | 2 to 4 cm   | 1.5 to 2.5 cm   |
| <b>Leaf Width</b>       | 2-3 mm   | 2-3 mm  | 2-3 mm  |
| <b>Leaf Shape</b>       | Linear-lanceolate, slightly curved, dark green on top and lighter underneath | Linear-lanceolate, somewhat falcate, dark green   | Narrowly lanceolate to linear, dark green above and pale beneath  |
| <b>Leaf Arrangement</b> | Spirally arranged but twisted at base to lie in two flat ranks               | Spirally arranged, forming a flat plane due to twisting at the base   | Spirally arranged, less flattened than <i>Taxus wallichiana</i>   |
| <b>Leaf Apex</b>        | Acute to slightly rounded apex   | Acuminate (sharply pointed)   | Acute or slightly curved  |
| <b>Seed Cones</b>       | Solitary seeds with a fleshy red aril; aril more rounded                     | Solitary seeds with red aril; aril is more elongated and fleshy.<br><a href="https://bmcplantbiol.biomedcentral.com/articles/10.1186/s12870-024-05338-4">https://bmcplantbiol.biomedcentral.com/articles/10.1186/s12870-024-05338-4</a> ) | Similar to <i>T. wallichiana</i> but arils are more reddish and often slightly flattened. ( <a href="https://www.mdpi.com/1420-3049/21/10/1403">https://www.mdpi.com/1420-3049/21/10/1403</a> ) |

## 4.2 Anatomical study

The anatomy of *Taxus mairei* leaves and stems is characterized by unique structural features that adapt the tree to its evergreen nature and its growth in temperate and subtropical forest environments. Detailed knowledge of the leaf and stem anatomy of *Taxus mairei* provides insights into its physiological adaptations, such as drought resistance, photosynthetic efficiency, and defense mechanisms.

### Anatomy of *Taxus mairei* Leaves

The leaves of *Taxus mairei* are needle-like and possess a number of specialized anatomical features:

#### 1. Leaf Structure:

*Taxus mairei* leaves are linear, flattened, and needle-like, with a tough, leathery texture. They are typically 1.5 to 3.5 cm long and 2-3 mm wide. The leaves are dorsiventral, meaning they have distinct upper (adaxial) and lower (abaxial) surfaces that exhibit different anatomical characteristics.

#### 2. Epidermis:

The epidermis of the leaves is covered by a thick cuticle, which is a waxy layer that reduces water loss and protects against pathogens. The cuticle is thicker on the adaxial (upper) surface, giving it a glossy appearance. Both the adaxial and abaxial surfaces have a single layer of epidermal cells. The epidermal cells are compact and elongated, providing structural integrity and protection. Stomata are present on the abaxial surface, typically arranged in two parallel bands (stomatal bands) that are lighter in color.

#### 3. Mesophyll:

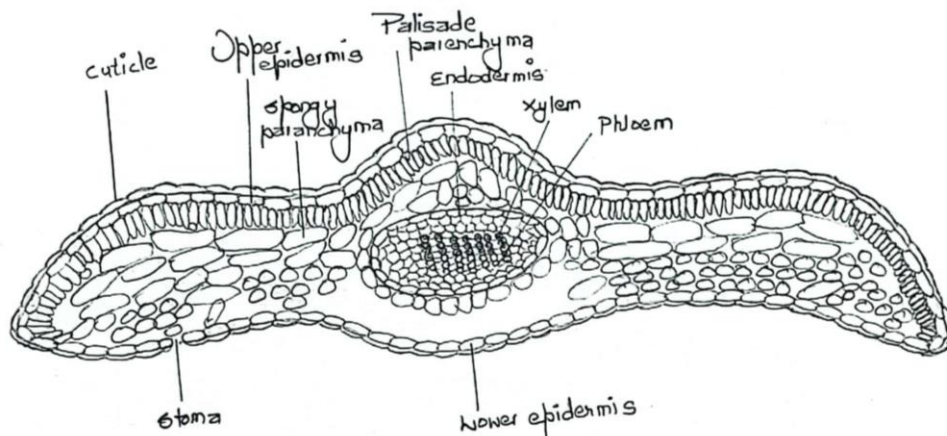
The mesophyll, the primary site of photosynthesis in the leaf, is differentiated into two regions: the palisade parenchyma and the spongy parenchyma. The palisade parenchyma consists of one or two layers of elongated cells rich in chloroplasts, located just beneath the upper epidermis. These cells are tightly packed, maximizing light absorption for photosynthesis. Below the palisade layer is the spongy parenchyma, which has loosely arranged cells with intercellular air spaces. This structure facilitates gas exchange (CO<sub>2</sub> and O<sub>2</sub>) within the leaf.

#### 4. Vascular Bundles:

The vascular bundles in *Taxus mairei* leaves are centrally located and are surrounded by a layer of endodermis cells. The xylem and phloem are arranged in a typical coniferous pattern, with xylem facing the upper epidermis and phloem facing the lower epidermis. Surrounding the vascular bundles is a bundle sheath composed of sclerenchyma cells, providing mechanical support to the leaf.

#### 5. Hypodermis and Resin Ducts:

Beneath the epidermis, there is a layer of hypodermis composed of thick-walled cells that provide additional support and protection. Unlike many conifers, *Taxus mairei* leaves generally lack prominent resin ducts. However, in some cases, small resin canals may be present, which can secrete compounds that protect against herbivory and pathogens.



**Figure 7:** Leaf showing upper and lower epidermis.

#### Anatomy of *Taxus mairei* (Stems)

The stems of *Taxus mairei* show typical features of gymnosperm anatomy, characterized by secondary growth and well-developed vascular tissues:

##### 1. Epidermis:

The stem is initially covered by a single-layered epidermis with a thin cuticle that provides protection against desiccation and external damage. In older stems, the epidermis is replaced by periderm (bark).

## **2. Cortex:**

Beneath the epidermis is the cortex, which consists of several layers of parenchyma cells. The cortex cells store starch and other nutrients. In addition, some regions of the cortex contain sclerenchyma cells that provide mechanical strength and support. The cortex also contains resin canals in some cases, though less prominent than in other gymnosperms.

## **3. Vascular Tissue:**

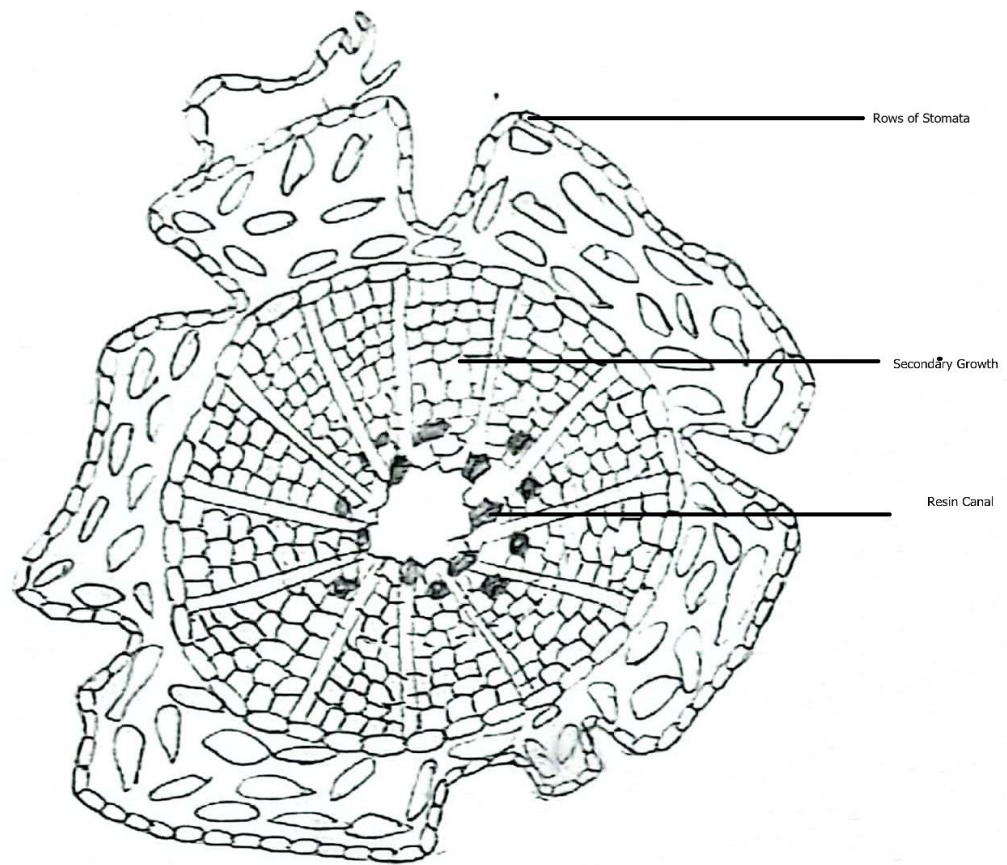
The vascular system of the stem consists of vascular bundles arranged in a ring around the central pith. The vascular bundles are composed of xylem (wood) and phloem tissues. The primary xylem is located towards the pith, while the secondary xylem is developed outward due to the activity of the vascular cambium. The xylem consists of tracheids with thick lignified walls, responsible for water conduction and support. Phloem is located on the outer side of the vascular cambium and is responsible for the transport of nutrients, primarily photosynthates (sugars) from the leaves to other parts of the plant.

## **4. Vascular Cambium and Secondary Growth:**

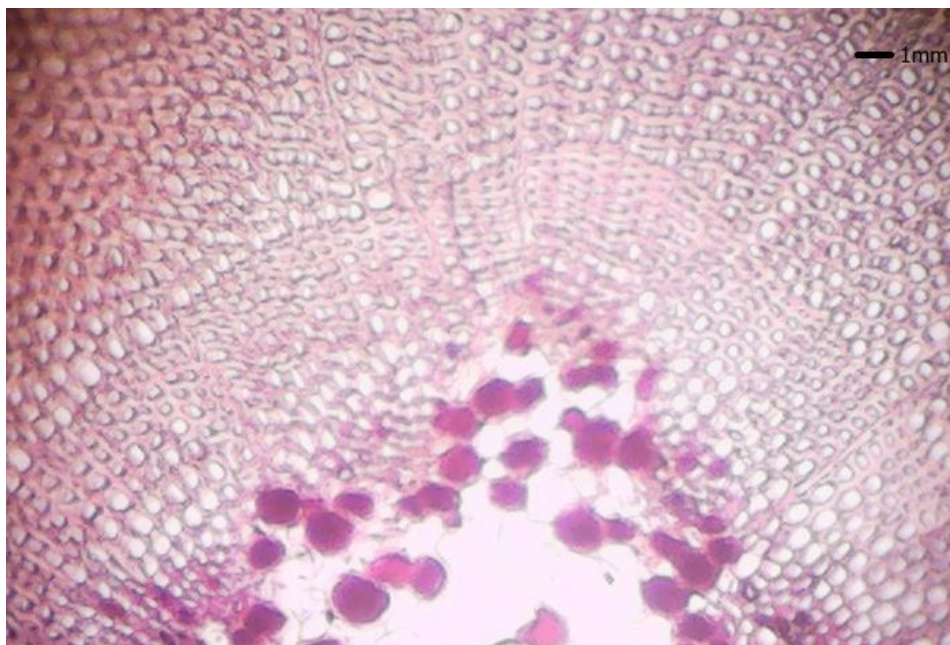
*Taxus mairei* exhibits significant secondary growth due to the activity of the vascular cambium, a lateral meristem that produces secondary xylem (wood) and secondary phloem. This growth contributes to the thickening of the stem and the formation of annual growth rings. The growth rings in the wood are less distinct in *Taxus mairei* compared to some other conifers, primarily due to the more uniform growth rate throughout the year in its subtropical and temperate environments.

## **5. Pith:**

At the center of the stem is the pith, which is composed of large, thin-walled parenchyma cells that may store starch and other nutrients. In older stems, the pith may become lignified or hollow due to secondary growth and tissue differentiation.



**Figure 8:** Section of Stem showing Secondary Tissues in line drawing



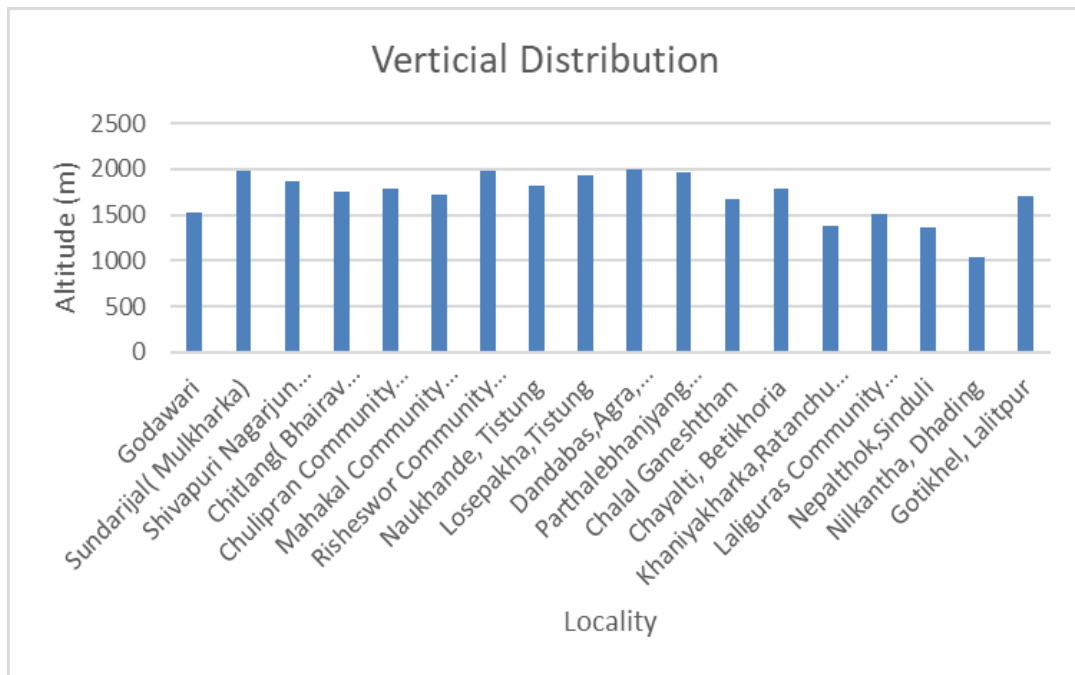
**Figure 9:** Section of Stem showing Secondary Tissues

**Table 3:** Comparative Table of Different Species of *Taxus* in Nepal on the basis of anatomy.

| Anatomical Feature | <i>Taxus mairei</i>                                  | <i>Taxus wallichiana</i>                  | <i>Taxus contorta</i>                     |
|--------------------|--|---|---|
| Epidermis          | Single-layered, thick cuticle                        | Single-layered, thick cuticle             | Single-layered, thinner cuticle           |
| Cuticle            | Thick, waxy layer                                    | Thick, waxy layer                         | Thin, waxy layer                          |
| Stomata            | Abaxial surface, two parallel bands (stomatal bands) | Abaxial surface, two white stomatal bands | Abaxial surface, two white stomatal bands |
| Mesophyll          | Palisade and spongy parenchyma                       | Palisade and spongy parenchyma            | Palisade and spongy parenchyma            |
| Resin Ducts        | Generally absent or very small                       | Absent                                    | Absent or very small                      |
| Growth Rings       | Less distinct, more uniform growth                   | Clear growth rings                        | Clear growth rings                        |

### 4.3 Elevation Distribution of *Taxus mairei*

The distribution of the species is presented in figure 4.6. It shows that the vertical distribution is up to 2000 masl as maximum height. Both wild as well as cultivated species are located below 2000 masl in different districts. The minimum elevation where it is found at 1000m asl.



**Figure 10:** Vertical Distribution of *Taxus mairei*.

**Table 4:** Comparative table showing different species of *Taxus* in Nepal based on distribution.

| Distribution              | <i>Taxus mairei</i>                                      | <i>Taxus wallichiana</i>   | <i>Taxus contorta</i>  |
|---------------------------|--|--|--|
| <b>Elevation</b>          | 1000-2500 m  | 2000-3500 m  | 2000-3500 m  |
| <b>Habitat</b>            | Mixed forests in montane areas                           | Drier colder climates with less moistures; more drought.             | Drier colder climates with less moistures; more drought.   |
| <b>Climate preference</b> | Subtropical to temperate climates with moderate rainfall | Cool temperate to sub alpine climates; higher moistures requirement. | Drier colder climates with less moistures; more drought.<br>( <a href="https://en.wikipedia.org/wiki/Taxus_contorta">https://en.wikipedia.org/wiki/Taxus contorta</a> )<br>( <a href="https://en.wikipedia.org/wiki/Taxus_wallichiana">https://en.wikipedia.org/wiki/Taxus_wallichiana</a> ) |

During the filed works, the species were located from different places whose details are presented in table 4.3, that shows the distribution of both wild and cultivated species.

**Table 5:** Location information of *Taxus mairei* based on field work.

| Date      | Place  | Elevation<br>(m) | Latitude             | Longitude                      |
|-----------|--|------------------|----------------------|--------------------------------|
|           |  |                  | 27.70847 /           |                                |
| 3/9/2080  | Tri- chandra Campus                                  | 1306             | 27°42' 30.93696' ' N | 85.31568 / 85°18' 56.7198' ' E |
|           |  |                  | 27.59431 /           | 85.37836 /                     |
| 4/9/2080  | Godawari   | 1523             | 27°35' 32.62236' ' N | 85°22' 52.599' ' E             |
|           |  |                  | 27.78019 /           | 85.43477 /                     |
| 5/9/2080  | Sundarijal(<br>Mulkharka)                            | 1976             | 27°46' 48.69048' ' N | 85°26' 5.06184' ' E            |
|           | Shivapuri Nagarjun<br>National<br>Park,Gokarneshwor, |                  | 27.7825 /            | 85.44354 /                     |
| 6/9/2080  | Nagmati Dam  | 1872             | 27°46' 57.14256' ' N | 85°26' 36.65292' ' E           |
|           |  |                  | 27.64384 /           | 85.16831 /                     |
| 8/9/2080  | Chitlang( Bhairav<br>Temple),Makwanpur               | 1746             | 27°38' 37.93884' ' N | 85°10' 5.86236' ' E            |
|           | Chulipran<br>Community                               |                  | 27.66211 /           | 85.13258 /                     |
| 8/9/2080  | Forest,Bajrabarahi                                   | 1786             | 27°39' 43.5576' ' N  | 85°7' 57.39672' ' E            |
|           |  |                  | 27.62252 /           | 85.0965 /                      |
| 9/9/2080  | Mahakal Community<br>Forest, Rupse                   | 1722             | 27°37' 21.17964' ' N | 85°5' 47.55948' ' E            |
|           | Risheswor<br>Community Forest,                       |                  | 27.61429 /           | 85.07677 /                     |
| 9/9/2080  | Palung   | 1976             | 27°36' 51.35544' ' N | 85°4' 35.55752' ' E            |
|           |  |                  | 27.67691 /           | 85.08064 /                     |
| 10/9/2080 | Naukhande, Tistung                                   | 1817             | 27°40' 36.98544' ' N | 85°4' 50.40588' ' E            |

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|           |                      |      | ' N                 | E                   |
|-----------|----------------------|------|---------------------|---------------------|
| 10/9/2080 | Losepakha,Tistung    | 1927 | 27°40' 145' N       | 85°08' 048' ' E     |
|           | Dandabas,Agra,       |      | 27.59431 /          | 85.31568 /          |
| 11/9/2080 | Makwanpur            | 1990 | 27°38' 32.68' ' N   | 85°0' 43.42' ' E    |
|           | Parthalebhanjyang    |      | 27.5324 /           | 85.49394 /          |
|           | Community Forest,    |      | 27°31' 57.13104'    | 85°29' 38.17428'    |
| 13/9/2080 | Bagane, Dhunkharka   | 1961 | ' N                 | ' E                 |
|           |                      |      | 27.54234 /          | 85.50103 /          |
|           |                      |      | 27°32' 32.50572'    | 85°30' 3.61152' ' ' |
| 14/9/2080 | Chalal Ganeshthan    | 1666 | ' N                 | E                   |
|           |                      |      | 27.59431 /          | 85.31568 /          |
| 14/9/2080 | Chayalti, Betikhoria | 1790 | 27°31' 3.19' ' N    | 85°30' 32.99' ' E   |
|           | Khaniyakharka,Ratan  |      | 27.25672 /          | 85.99236 /          |
|           | chura,Dhuradada,Sin  |      | 27°15' 24.1938' ' ' | 85°59' 32.36784'    |
| 16/9/2080 | duli                 | 1376 | N                   | ' E                 |
|           |                      |      | 27.24749 /          | 85.99574 /          |
|           | Laliguras Community  |      | 27°14' 51.29232'    | 85°59' 44.619' ' '  |
| 16/9/2080 | Forest,Ratanchura    | 1502 | ' N                 | E                   |
|           |                      |      | 27.28581 /          | 85.97791 /          |
|           |                      |      | 27°30' 39.16404'    | 85°42' 41.643' ' '  |
| 16/9/2080 | Nepalthok,Sinduli    | 1361 | ' N                 | E                   |
|           |                      |      | 27.911603 /         | 84.89856 /          |
|           |                      |      | 27°54' 41.85828'    | 84°53' 54.81852'    |
| 17/9/2080 | Nilkantha, Dhading   | 1030 | ' N                 | ' E                 |

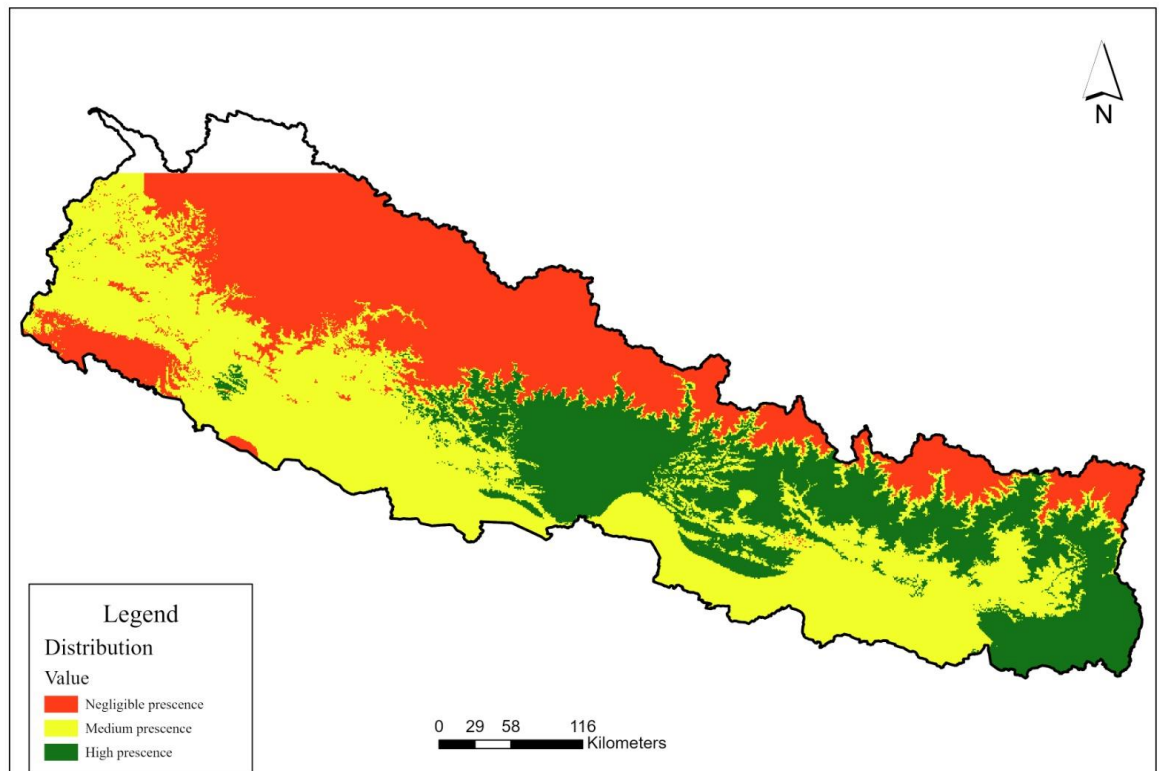
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#### 4.4 Species Distribution Model

The performance of present species distribution models I and II as well as future species distribution models were obtained. These current models of *Taxus mairei* in Nepal based on the data obtained in the field were compared and presented as Model I and Model II.

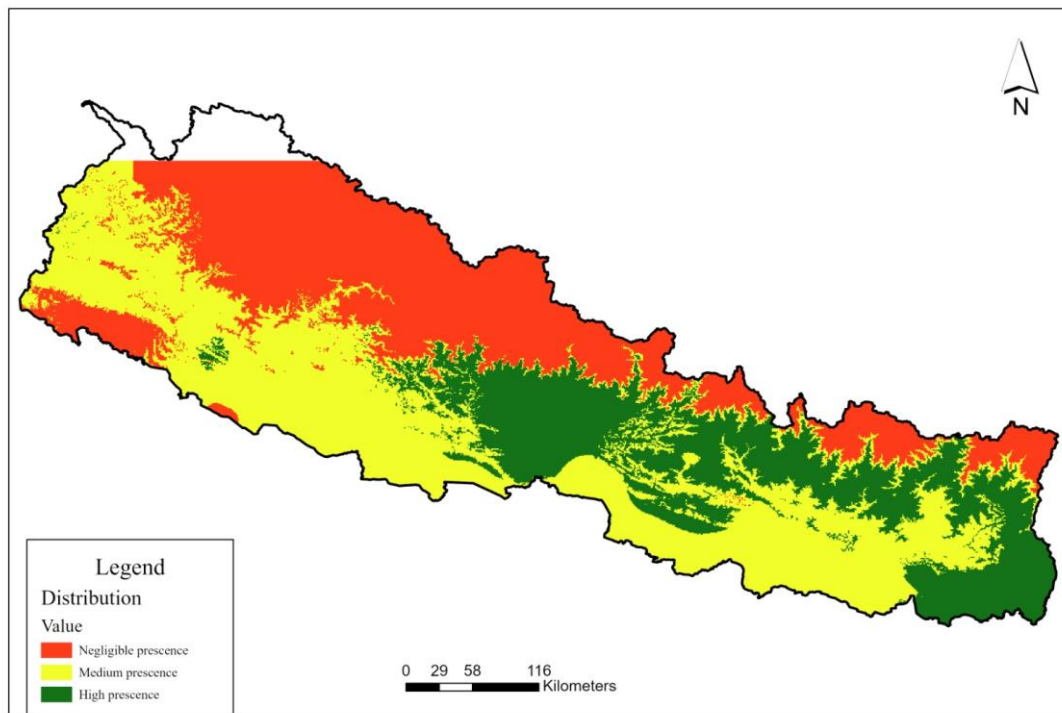
### Current Models:

During the modeling, the bioclimatic variables BIO1: Annual Mean Temperature, BIO2: Mean Diurnal Range, BIO3: Isothermality, BIO4: Temperature Seasonality, BIO5: Max Temperature of Warmest Month, BIO6: Min Temperature of Coldest Month, BIO7: Temperature Annual Range, BIO8: Mean Temperature of Wettest Quarter, BIO9: Mean Temperature of Driest Quarter, BIO10: Mean Temperature of Warmest Quarter, BIO11: Mean Temperature of Coldest Quarter, BIO12: Annual Precipitation, BIO13: Precipitation of Wettest Month, BIO14: Precipitation of Driest Month, BIO15: Precipitation Seasonality, BIO16: Precipitation of Wettest Quarter, BIO17: Precipitation of Driest Quarter, BIO18: Precipitation of Warmest Quarter and BIO19: Precipitation of Coldest Quarter were taken in first model. Similarly, in another model, only bio 4 (temperature seasonality), bio 5 (maximum temperature of warmest month), bio 6 (minimum temperature of coldest month), bio 12 (annual precipitation), bio 15 (precipitation seasonality) and bio 17 (precipitation of driest quarter) variables were taken as they were less correlated.



**Figure 11:** Present Distribution Model I

Both the current models were similar in predicting the current distribution pattern showing presence of the species in lower elevation unlike other species. The results showed that their presence distribution is in lower elevation but its requirements is similar to the other species. The area of coverage is more in lower elevation compared to higher elevation. This also showed possible sites for cultivation of this species. Both Model I and II showed total area of 878 square kilometer of occurrence. The distribution models also generated revealed higher AUC values (0.994 and 0.995 for Model I and II respectively).



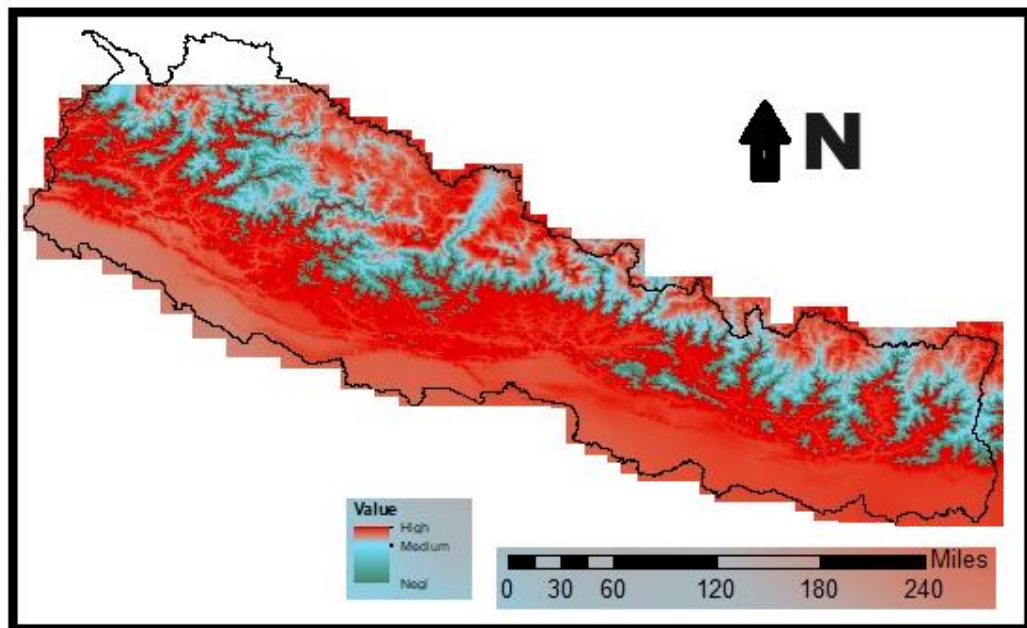
**Figure 12:** Present Distribution Model II

### Future Model

The Future model had climate conditions from HadGEM2-ES. HadGEM2-ES, which comprises a range of specific model configurations incorporating different levels of complexity but with a common physical framework coupled atmosphere-ocean configuration and an Earth-System configuration which includes dynamic vegetation, ocean biology and atmospheric chemistry. The input bioclimatic variables were BIO1: Annual Mean Temperature, BIO2: Mean Diurnal Range, BIO3: Isothermality, BIO4: Temperature Seasonality, BIO5: Max Temperature of Warmest Month, BIO6: Min Temperature of Coldest Month, BIO7: Temperature Annual Range, BIO8: Mean Temperature of Wettest Quarter, BIO9: Mean Temperature of Driest Quarter, BIO10:

Mean Temperature of Warmest Quarter, BIO11: Mean Temperature of Coldest Quarter, BIO12: Annual Precipitation, BIO13: Precipitation of Wettest Month, BIO14: Precipitation of Driest Month, BIO15: Precipitation Seasonality, BIO16: Precipitation of Wettest Quarter, BIO17: Precipitation of Driest Quarter, BIO18: Precipitation of Warmest Quarter and BIO19: Precipitation of Coldest Quarter.

The future model was also observed which shows more coverage in the lower altitude (785 square kilometer). The future distribution model revealed that the species can found in higher elevation as well (234 square kilometer).



**Figure 13:** Future Distribution Model III

All models highlighted the significance of temperature as a critical bioclimatic factor affecting the species' distribution. Additionally, precipitation was found to be notably influential in this study.

**Table 6:** Bioclimatic variables used for predicting the spatial distribution of *Taxus mairei* in Nepalese Himalaya and their contribution to the models (%) including Entropy, LPT and AUC

| Variables  | First Model | Second Model | Third Model |
|--|-------------|--------------|-------------|
| Bio3_Isothermality   |             | 2.3746       | 23.3897     |
| Bio4_Temperature Seasonality (standard deviation)          | 0.8375      |              | 18.9591     |
| Bio5_Max Temperature of Warmest Month                      | 64.9495     | 73.6786      | 11.8404     |
| Bio6_Min Temperature of Coldest Month                      | 14.2949     |              | 0.2094      |
| Bio12_Annual Precipitation                                 | 1.4009      |              |             |
| Bio14_Precipitation of Driest Month                        |             | 0.0711       |             |
| Bio15_Precipitation Seasonality (Coefficient of Variation) | 2.3607      | 2.5557       | 32.6707     |
| Bio17_Precipitation of Driest Quarter                      | 16.1565     | 19.1798      | 12.9305     |
| Bio19_Precipitation of Coldest Quarter                     |             | 2.1403       |             |
| <i>Entropy</i>   | 5.56        | 5.7          | 4.52        |
| <i>LPT</i>   | 0.24        | 0.22         | 0.31        |
| <i>AUC</i>   | 0.994       |              |             |
|  |             | 0.995        | 0.995       |

In all models examined, temperature was identified as a crucial bioclimatic factor influencing the species' distribution. Precipitation also played a significant role in this study.

## CHAPTER V: DISCUSSION

### 5.1 Morphological Study

The Nepalese species of *Taxus mairei*, commonly known as the Chinese Yew, exhibit several distinct morphological characteristics that distinguish them from other coniferous species.

These features are essential for the identification and classification of the species within its natural habitat. *Taxus mairei* is an evergreen tree or large shrub that can grow up to 2000 meters in height. *Taxus mairei* is native to East Asia, primarily found in China, Taiwan, Vietnam, Laos, and the eastern Himalayas. In Nepal, it is only found in Bagmati Province.

The glossy appearance on the underside of *Taxus mairei* leaves was absent in the specimens stored at the National Herbarium and TUCH. The dark green above and pale green below with two yellow-green stomatal bands is characteristics separating *Taxus mairei* with *T. wallichiana* and *T. contorta*.

The morphological features observed in the present work is similar to Spjut (2007) and Poudel *et al.*, (2012) for *Taxus mairei*. Poudel *et al.*, (2012) mentioned shininess as character separating *Taxus wallichiana* from *Taxus mairei*.

According to Zhang and Liu (2020), *Taxus mairei* has intermediate-sized leaves compared to *T. baccata* and *T. brevifolia*. Its aril is less vibrant than that of *T. baccata* but larger and more elongated than *T. cuspidata*. Based on morphological traits and molecular data, *T. mairei* is closely related to *T. chinensis* but can be differentiated by its habitat preferences and slightly narrower leaves.

Similarly, Chen and Wang (2019) found narrow leaves (2–3 mm) with moderate stomatal visibility, distinguishing it from broader-leafed species like *T. baccata*. *T. mairei* exhibits elongated arils, while *T. brevifolia* has rounder ones. *Taxus mairei* tends to have a conical to irregularly rounded crown compared to the uniform conical form of *T. cuspidata*.

## 5.2 Altitudinal distribution of the species

The altitudinal ranges reported here are similar to those given by Poudel *et al.*, (2012) but there is no mention in Hara *et al.* (1978) and Press *et al.* (2000). Most of the location of the species is based on the cultivation while the natural forests were observed in Chitlang, Chalal Ganesthan, Gotikhel, Mahakal Community Forest. The distribution mentioned earlier in other literatures does not match due to the cultivated species and not yet naturalized.

*Taxus mairei* is found mainly in subtropical regions of China, covering 17 provinces, including Sichuan, Yunnan, Henan, and Shaanxi. It is distributed across areas with elevations ranging from 70 m to 2100 m, with a preference for humid, subtropical climates. In these regions, it often grows in scattered populations and small clusters ( Ru (2006), Shi (2001), Zhang et al. (2011)).

*Taxus mairei* is found mainly in subtropical regions of China, covering 17 provinces, including Sichuan, Yunnan, Henan, and Shaanxi. It is distributed across areas with elevations ranging from 70 m to 2100 m, with a preference for humid, subtropical climates. In these regions, it often grows in scattered populations and small clusters ( Ru (2006), Shi (2001), Zhang et al. (2011)). Using the Maxent modeling approach, Li Hong-Qun, Xing Li-Gang, and Sun Xie-Ping analyzed the potential distribution of *Taxus mairei* under climate change scenarios. Their findings highlight that the species thrives in areas with specific climatic conditions: annual precipitation between 1,100 to 2,100 mm and minimum temperatures of -2 to 4°C The study also predicts that suitable habitats are likely to expand in regions like western Henan and southern Shaanxi. According to *Chen and Wang (2019)*, *Taxus mairei* is adapted to subtropical montane environments, whereas species like *T. baccata* are more common in temperate zones.

## 5.3 Anatomical study

The anatomical section of the stem shows single layered epidermal layer of the axial resin ducts and consists of 5-6 cells in all collections.

The epidermal layer is quite distinct with stomata when section of the leaf was considered. The secondary growth was visible with distinct annual rings in most of the matured stem. The distinct presence of axial tracheids and polygonal in T.S. section with rare intercellular spaces helps in distinguishing this species. There is also presence of the medullary rays with uniseriate features.

The internal structure of the stem and leaf of the species of *Taxus mairei* has not been presented before from Nepalese specimens with detailed figures.

However, the anatomical studies related to *Taxus mairei* has been done from other parts (Spjut 2007). Both morphological and anatomical description were similar to study carried out by Spjut (2007) and Gajurel and Gautam (2016). Key findings of the study include its distinct dark glossy leaves, twisted petioles, and fewer persistent bud scales. Anatomical observations reveal 12–16 rows of stomata and axial tracheids with polygonal sections. Morphological traits were compared to related species (*T. wallichiana* and *T. contorta*), highlighting differences in leaf width and curvature

Wang and Muang (2022) found significant anatomical adaptations for subtropical environments, including a thicker cuticle, sunken stomata, and denser wood. They also compared to *T. baccata* (European yew), it has narrower tracheids and less distinct growth rings, reflecting its need for efficient water transport in warmer climates. While, Wu and Chen (2020) found that anatomical features of *Taxus mairei* reflect its adaptation to subtropical montane forests, balancing water conservation with efficient photosynthesis and nutrient transport. Li and Zhao (2018) found that the wood anatomy of *Taxus mairei* reflects its adaptation to subtropical habitats, balancing efficient water transport with durability. However, there are no significant studies that mention on the detailed anatomy of this species.

#### **5.4 Distribution models**

The distribution models based on the collections of the species from Bagmati Province shows that eco physiologically important bioclimatic variables are the best predictor of the models. The various studies around the world show that distribution modeling can be used as a tool for finding additional localities of a known species (Bourg *et al.*, 2005; Guisan *et al.*, 2006, Rinnhofer *et al.*, 2012). Similar study was done by Gajurel *et al.*, 2016 for *Taxus wallichiana* while by Poudel *et al.*, (2012) for *Taxus mairei*.

Both the current models were similar in predicting the current distribution pattern showing presence of the species in lower elevation unlike other species. The current distribution in lower elevation showed its requirements is similar to the two species except elevation.

The area of coverage is more in lower elevation compared to higher elevation. This also showed possible sites for cultivation of this species in both lower and higher elevation from Eastern Nepal to Western Nepal but more on Central Nepal.

The future model has determined new sites. These new sites could help in conservation planning in Central Nepal. The predictions are the most accurate within the area that is covered by the collection sites of the Bagmati Province. The future model will also help in locating new populations of *Taxus mairei* in Nepal.

A species distribution model can be valuable to find sites for the reintroduction of a species (Pearce and Lindenmayer 1998). The distribution models generated in this study showed higher AUC values compared to previous species distribution models documented by Poudel et al. (2012), indicating enhanced model performance.

Although there were some differences between the model predictions and actual distributions, the initial model that integrated ecologically significant bioclimatic variables is expected to encompass most *Taxus mairei* sites in Nepal from west to east.

Some studies in other places outside also show that the distribution modeling can be used as a tool for finding additional localities of a known species (Bourg et al., 2005; Guisan et al., 2006, Rinnhofer et al., 2012). New site of population will help in conservation planning in remote areas even if the species is not expected to colonize all the suitable sites (Pearson 2007).

Using the Maxent modeling approach, Li Hong-Qun, Xing Li-Gang, and Sun Xie-Ping analyzed the potential distribution of *Taxus mairei* under climate change scenarios. Their findings highlight that the species thrives in areas with specific climatic conditions: annual precipitation between 1,100 to 2,100 mm and minimum temperatures of -2 to 4°C. The study also predicts that suitable habitats are likely to expand in regions like western Henan and southern Shaanxi.

Li Hong-Qun et al. explored the geographical distribution of *T. wallichiana* var. *mairei* from the Mid-Holocene to the 2070s. Key climatic variables included precipitation of the driest month and minimum temperature of the coldest month. The model predicted habitat expansion in areas such as southern Shaanxi and eastern Sichuan.

Xiaohuang Liu et al. also used MaxEnt modeling to simulate the suitable habitat for *T. chinensis* var. *mairei* in the Jiangnan region of China. Key environmental factors included precipitation during the warmest quarter and altitude. The study also assessed

the impact of different climate change scenarios (SSP1-2.6, SSP2-4.5, SSP5-8.5) on future habitat suitability.

## CHAPTER VI: CONCLUSION AND RECOMMENDATION

### 6.1 Conclusion

*Taxus*, is widely used for its potent anti-cancer properties and any other different type of dangerous diseases (Gangadevi & Muthumary, 2008) both globally and in the Hindu Kush Himalaya region ( Nimachow, Rawat, & Dai, 2010). Taxol, is a natural product derived from the *Taxus* tree, which is generally notable for its medicinal applications (Wang *et al.*, 2000; Wu *et al.*, 2016; Strobel & Daisy, 2003; Guo *et al.*, 2006; Isah, 2015).

*Taxus mairei* leaves are linear-lanceolate, dark green on the adaxial side, and yellow-green on the abaxial side, with a prominent midrib. This distinct leaf morphology aids in the identification of the species. The species has erect stems that can grow up to 20 meters, with young stems being green and mature stems turning reddish-brown and scaly. The bark of older trees peels off in flakes, which is a key identifying feature.

The area of coverage is more in lower elevation compared to higher elevations. The distribution is limited to Bagmati Province in Nepal and below 2000 m. The anatomical features related to the xylem and stomata is important for the identification of the species from other species.

The future distribution models generated exhibit higher AUC values compared to previous models, indicating enhanced accuracy and reliability in predicting the distribution of *Taxus mairei*. The current field observation showed less number of population and need conservation of this species.

### 6.2 Recommendation

Further studies should focus on refining these models, incorporating additional environmental variables along with data loggers, and continuously monitoring the populations to enhance conservation efforts. Future cultivation needs to be done in the areas of less impacts predicted by the model. The mixed plantation must be done to minimize the inbreeding of the species.

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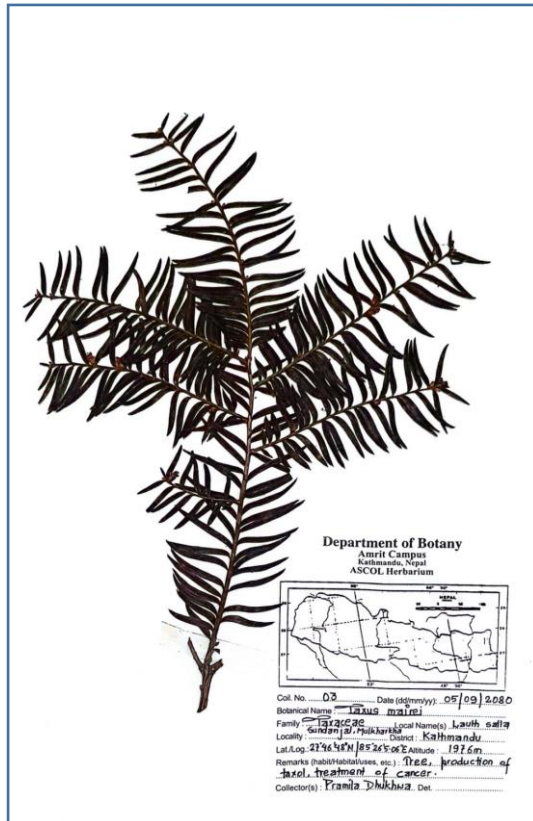
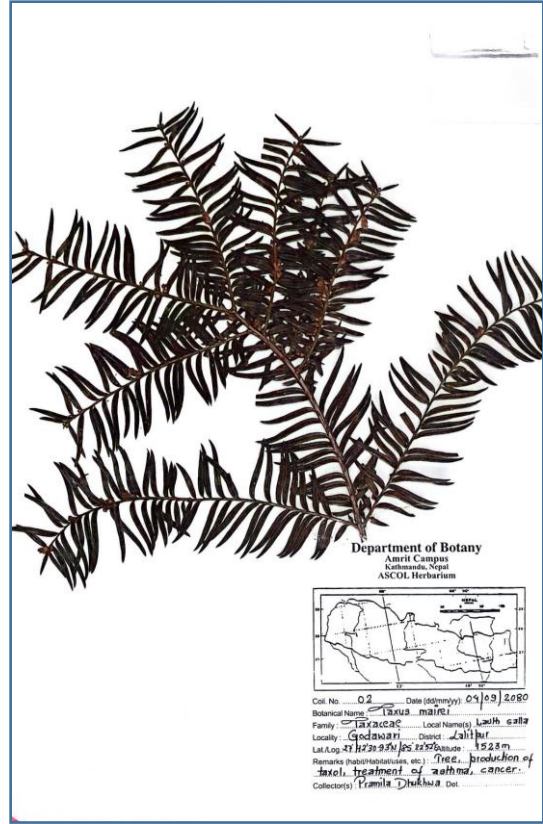
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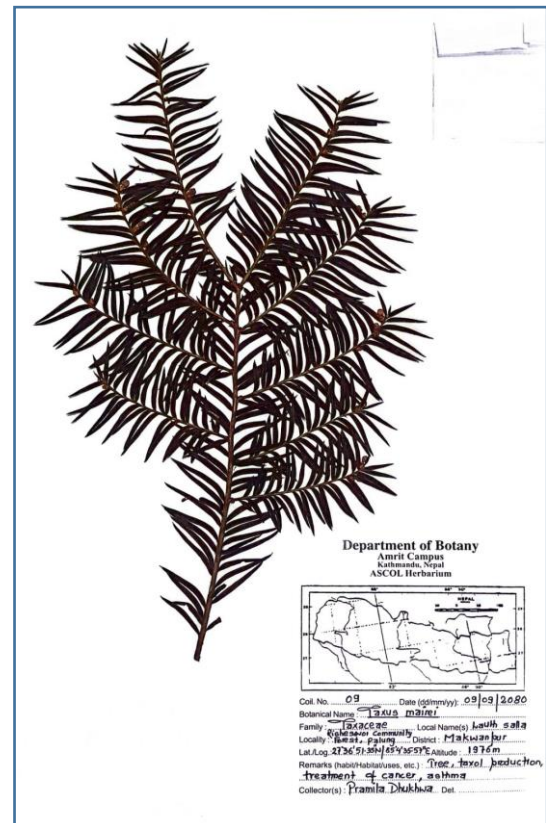
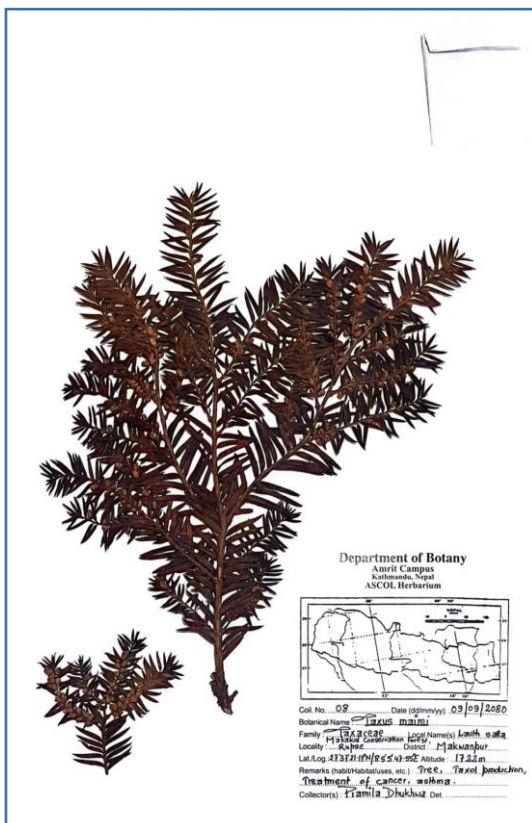
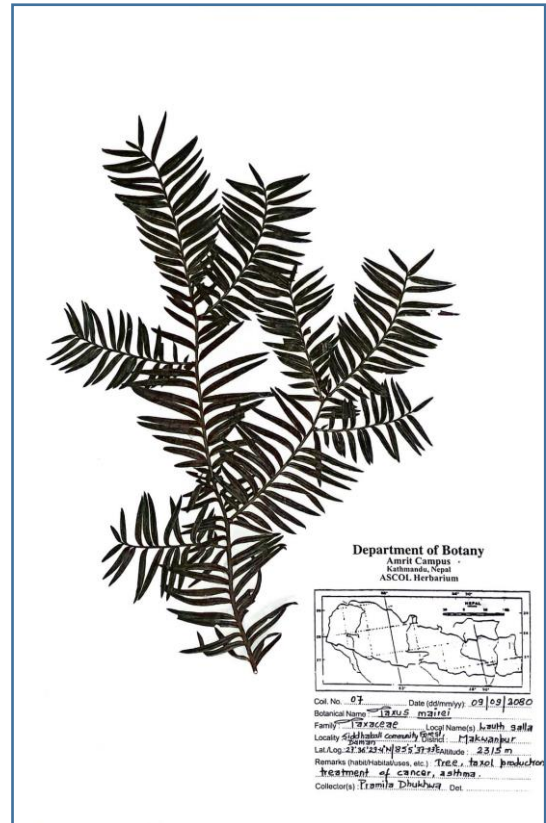
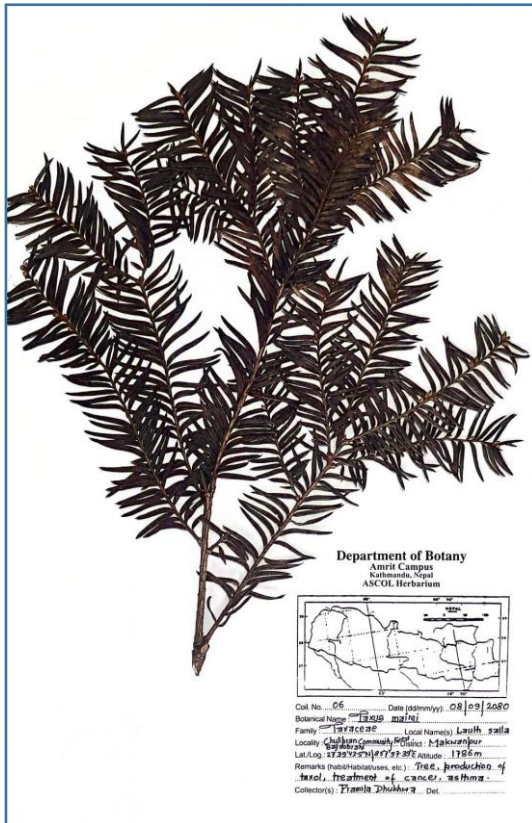
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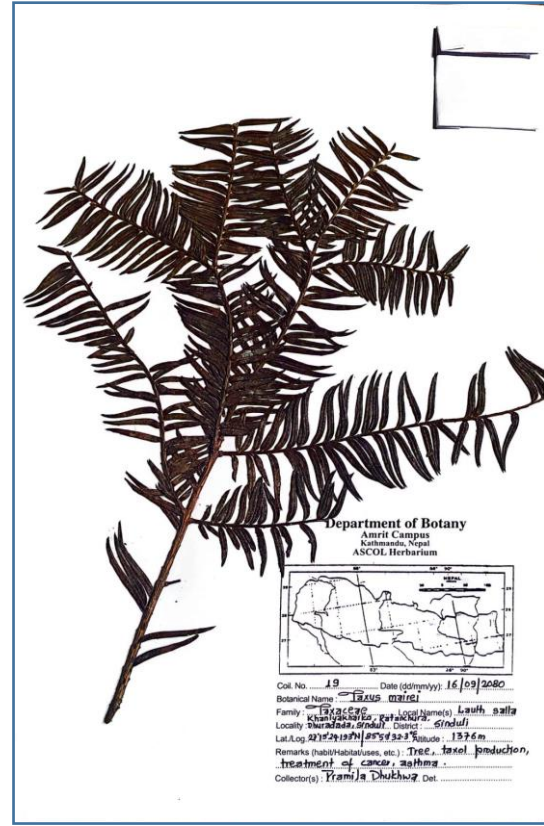
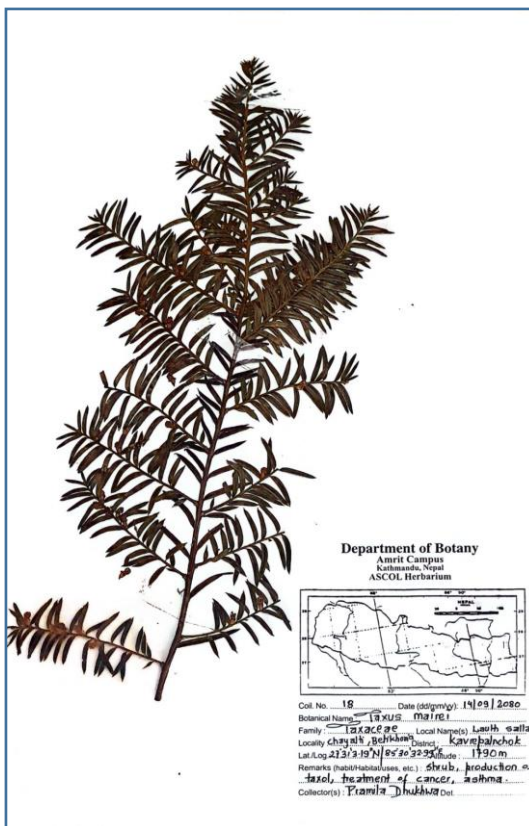
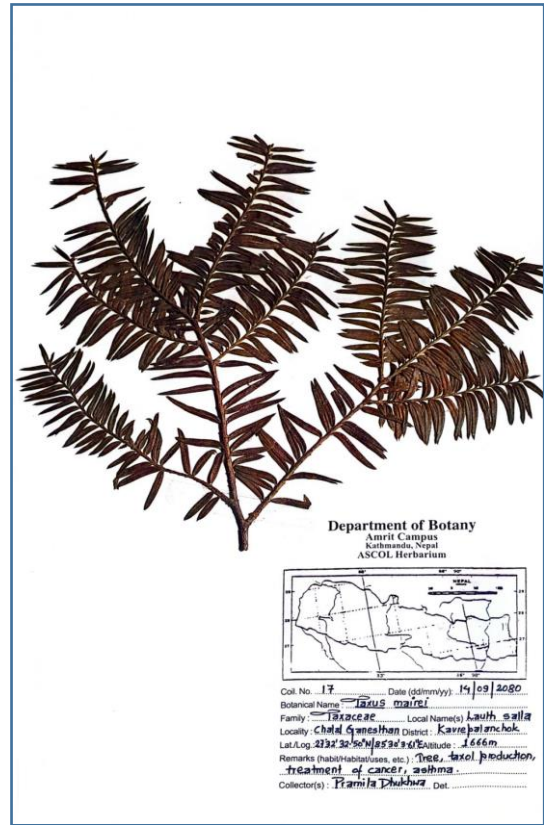
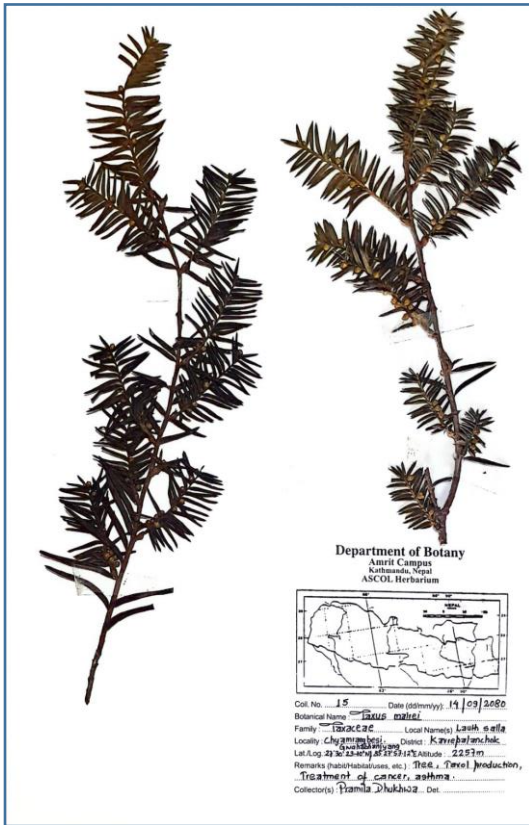
# ANNEXES

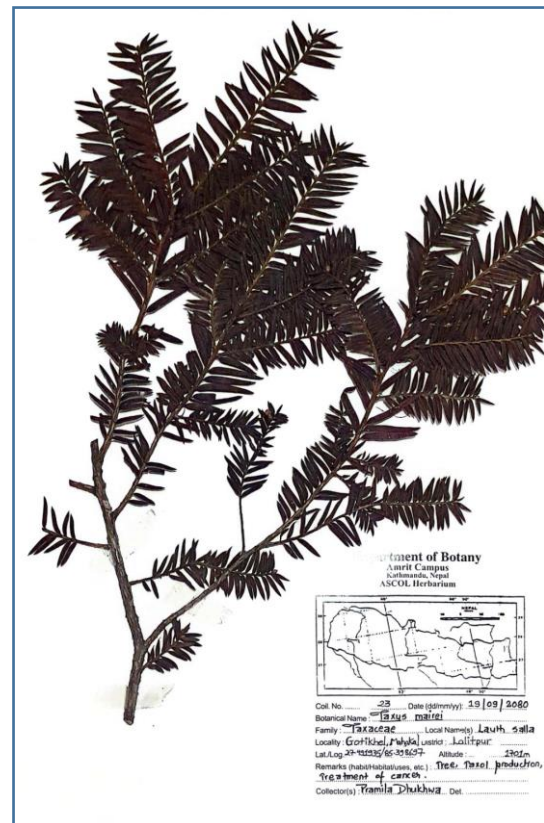
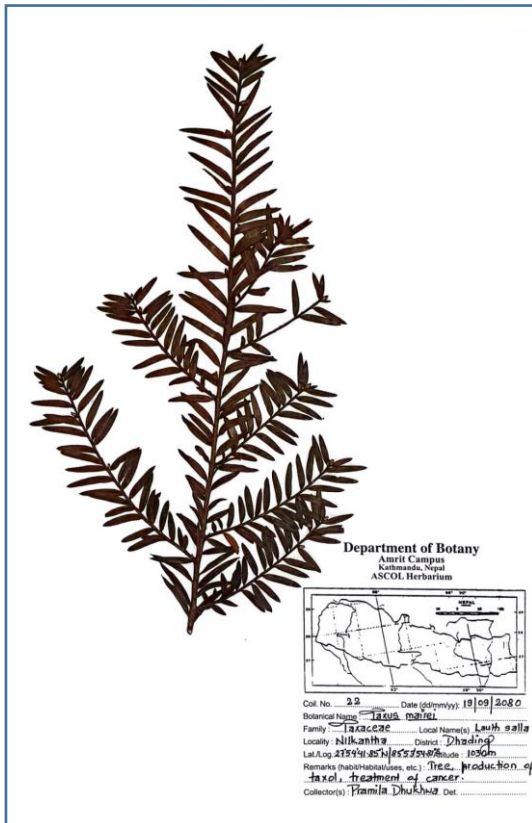
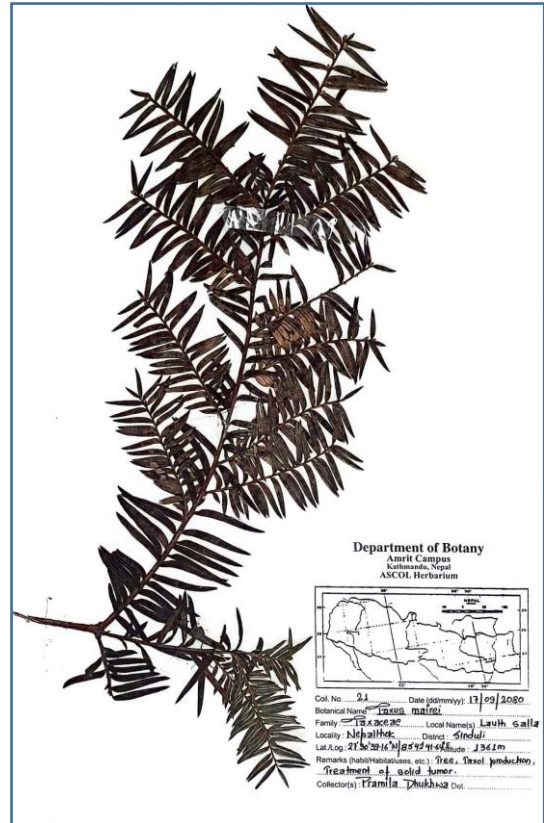
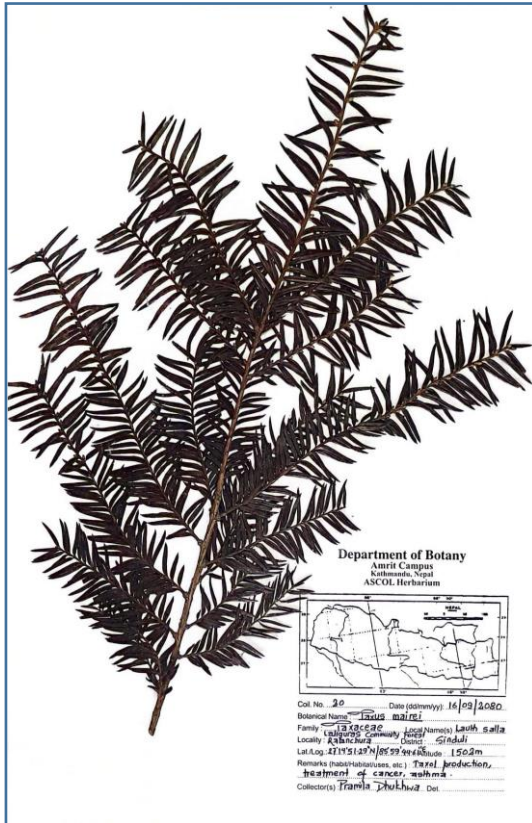
## ANNEX I: Herbarium Specimens







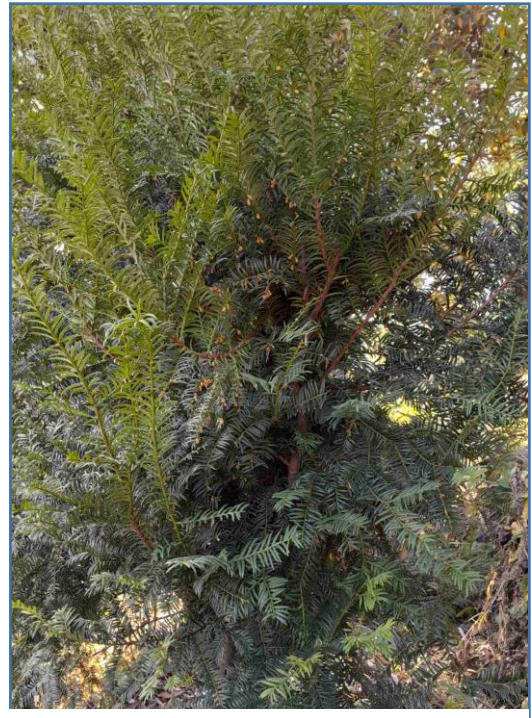




**ANNEX II: Field photos**



Mahakal Community Forest, Rupse



Chulipran Community Forest,  
Bajrabarahi



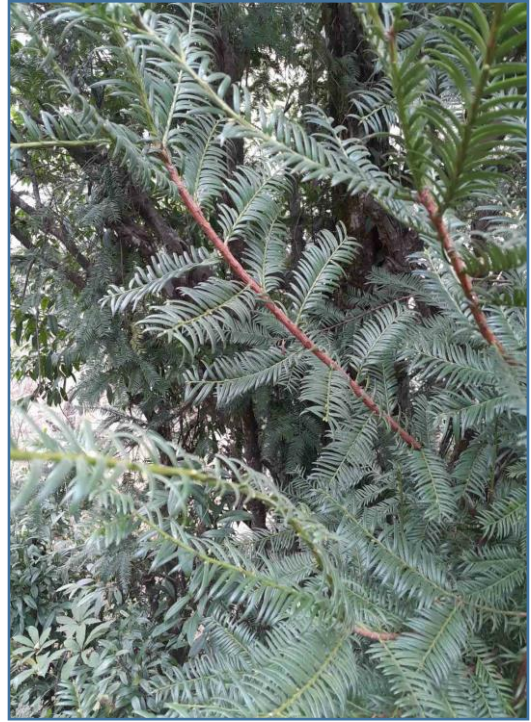
Naukhande, Tistung



Naukhande, Tistung



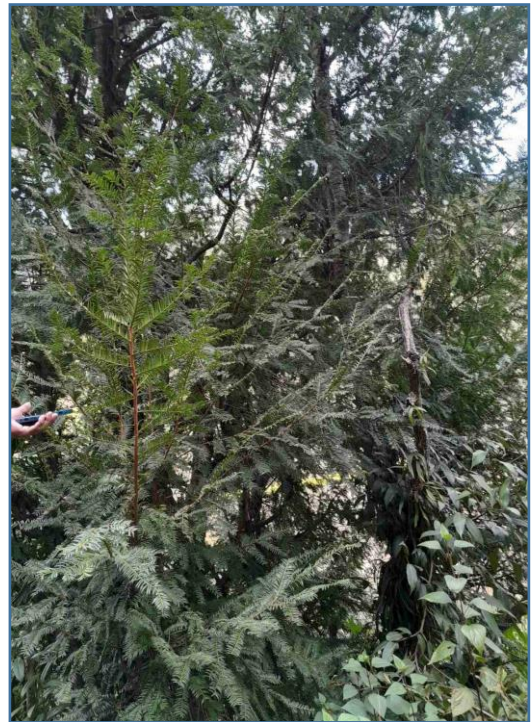
Chalal Ganesthan, Bhairav temple



Nilkantha, Dhading



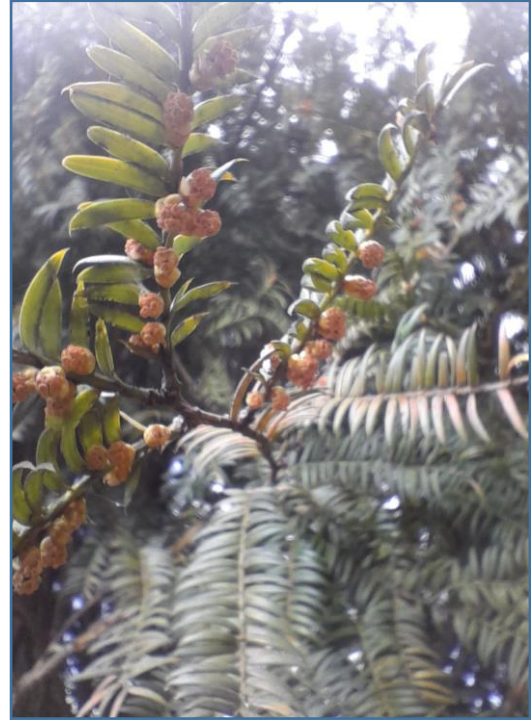
Deurali, Tistung



Godawari



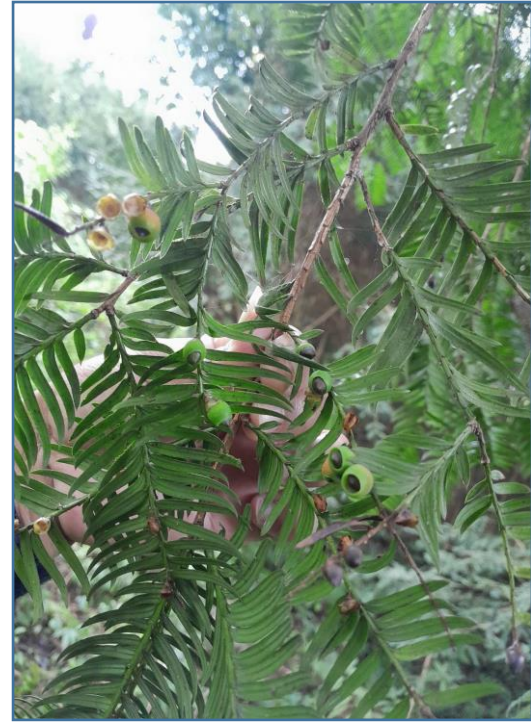
Risheswor Community Forest, Palung



Laliguras Community Forest,  
Ratanchura



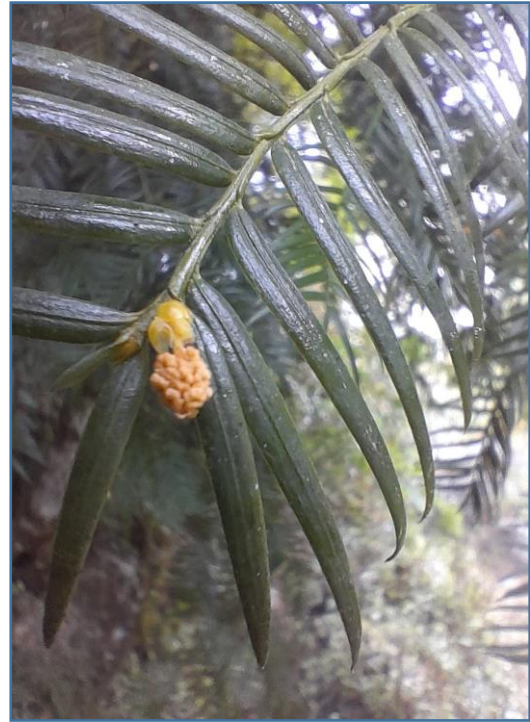
Shivapuri National Park,  
Gokarneshwor, Nagmati Dam



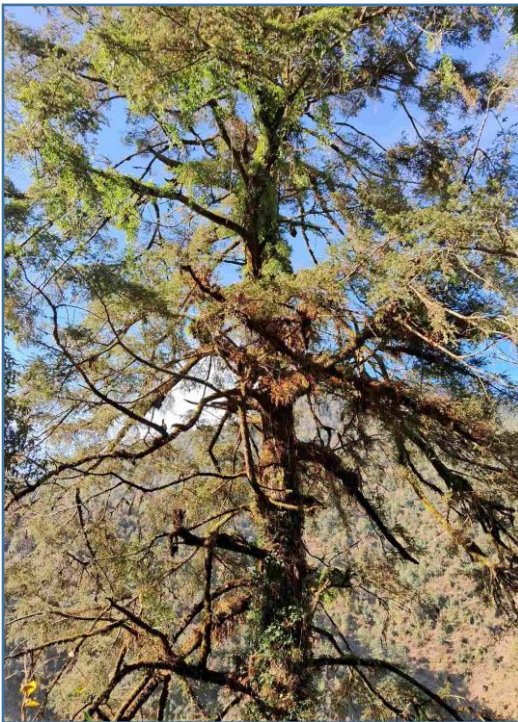
Khaniyakharka, Ratanchura,  
Dhuradada, Sinduli



Losepakha, Tistung



Nepalthok, Sinduli



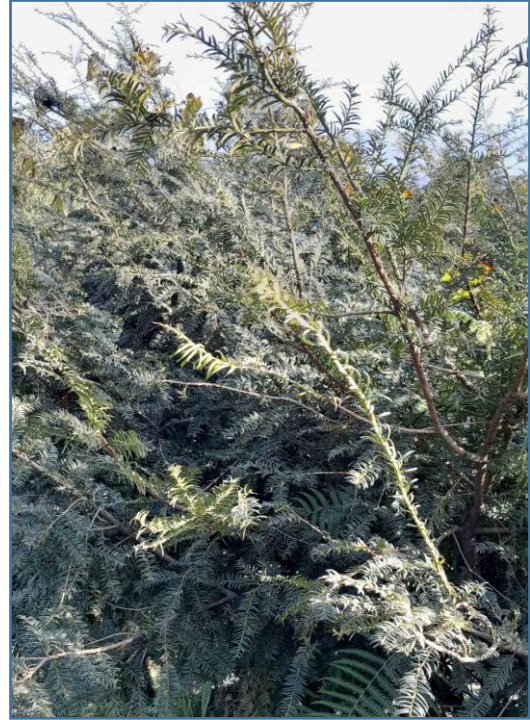
Dandabas, Agra, Makwanpur



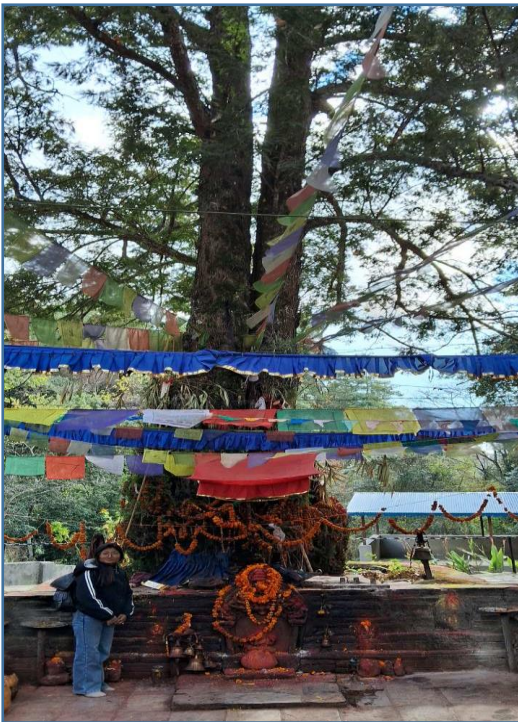
Sundarijal, Mulkharka



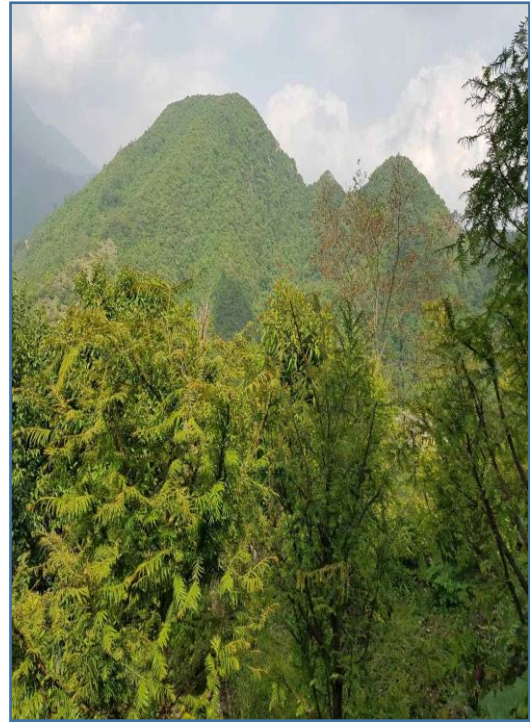
Tri Chandra Campus



Parthalebhanjyang Community Forest,  
Bagane, Dhunikharka



Chitlang , Bhairav Temple,  
Makwanpur



Gotikhel, Lalitpur

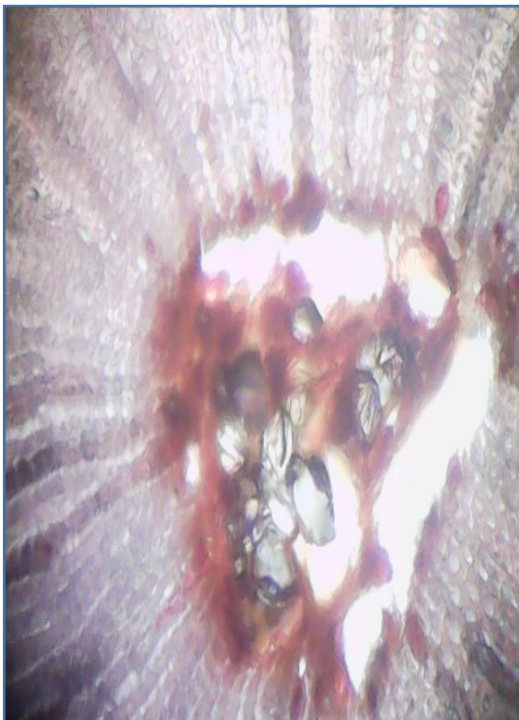
**ANNEX III: Anatomical Slides**



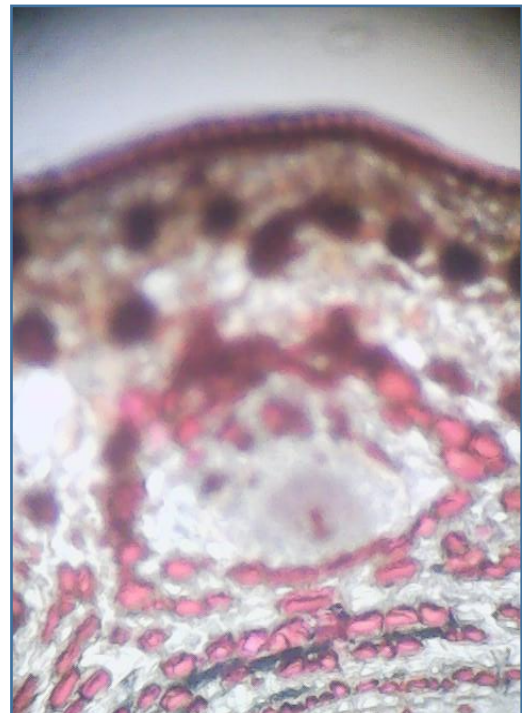
T.S of Stem of Godawari



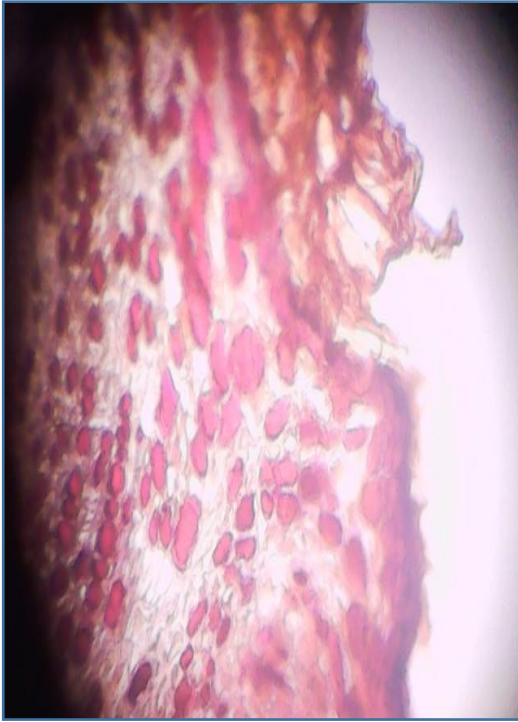
T.S of Leaf of Godawari



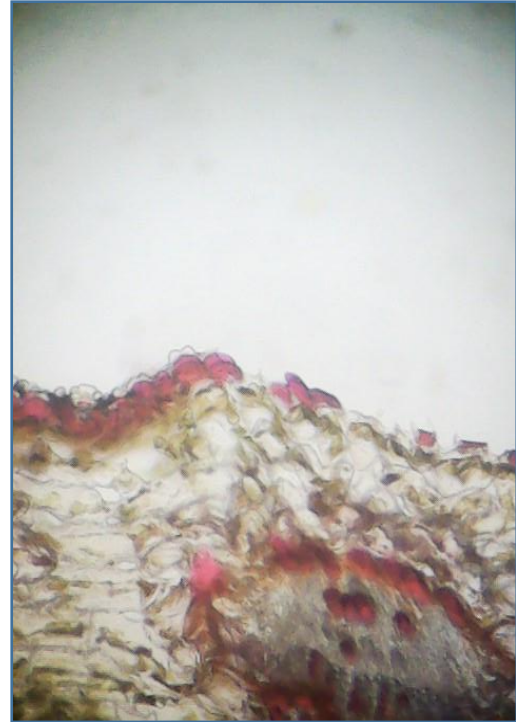
T.S of Stem of Tri chandra



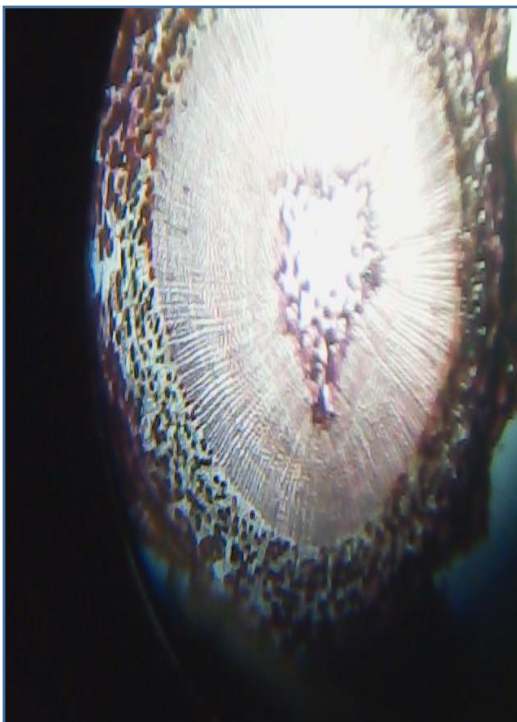
T.S of Leaf Tri chandra



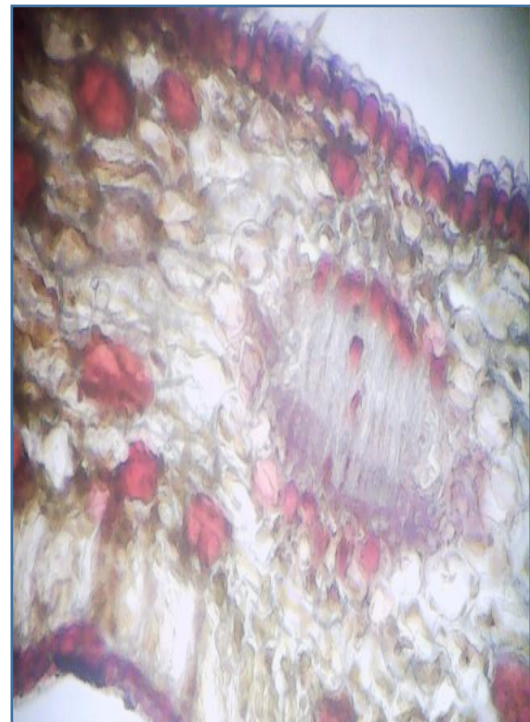
T.S of Stem of Sundarijal



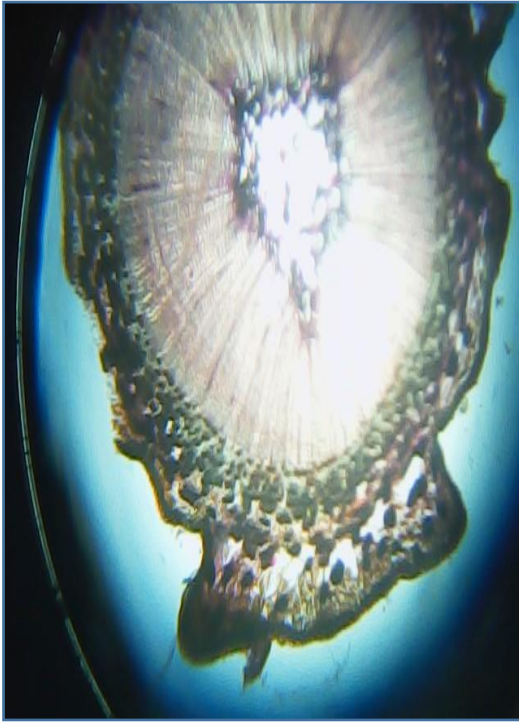
T.S of Leaf of Sundarijal



T.S of Stem of Chitlang



T.S of Leaf of Chitlang



T.S of Stem of Chulipran Community  
Forest



T.S of Leaf of Chulipran Community  
Forest



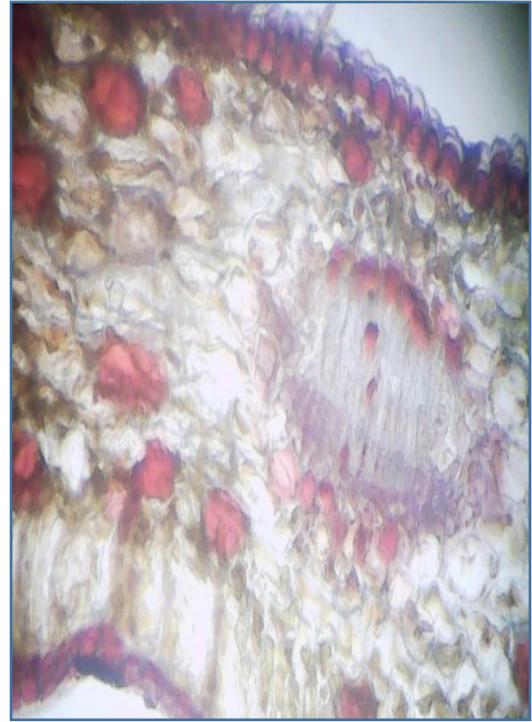
T.S of Stem of Rishewsor Community  
Forest



T.S of Leaf of Rishewsor Community  
Forest



T.S of Stem of Mahakal Community  
Forest



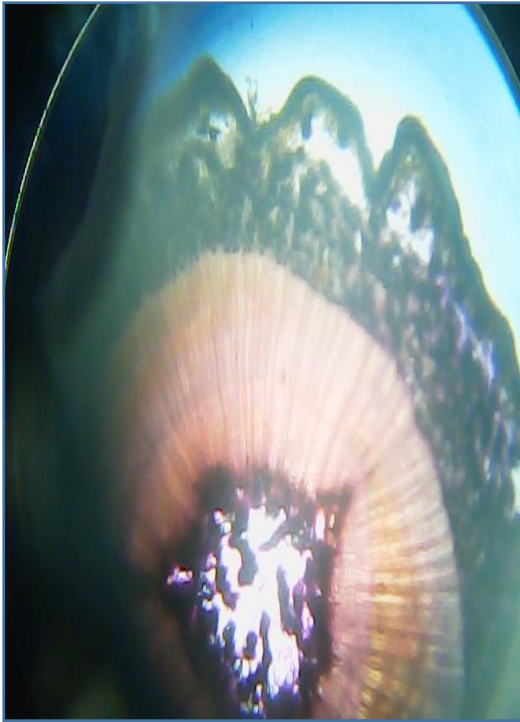
T.S of Leaf of Mahakal Community  
Forest



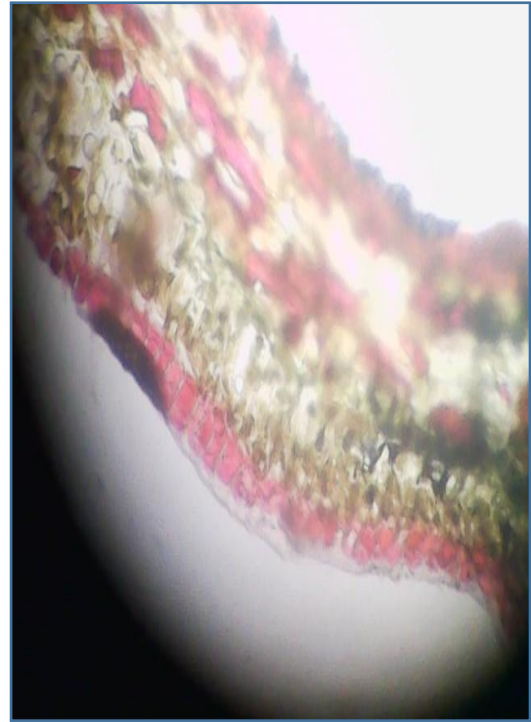
T.S of Stem of Naukhande, Tistung



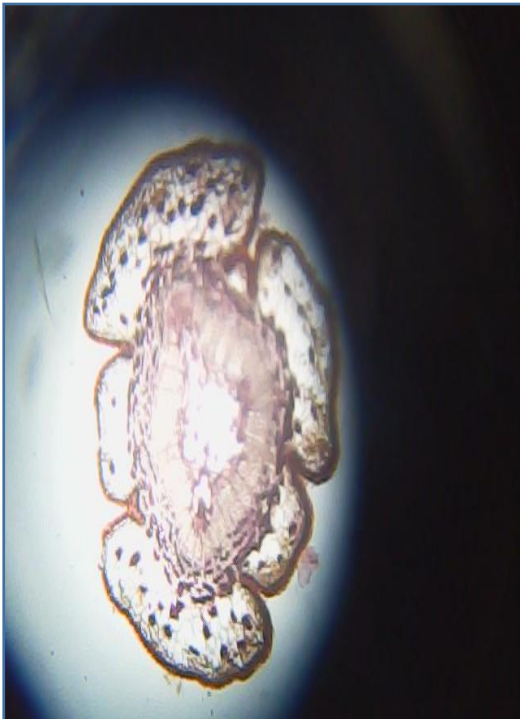
T.S of Leaf of Naukhande, Tistung



T.S of Stem of Losepakha, Tistung



T.S of Leaf of Losepakha, Tistung



T.S of Stem of Dandabas, Agra



T.S of Leaf of Dandabas, Agra



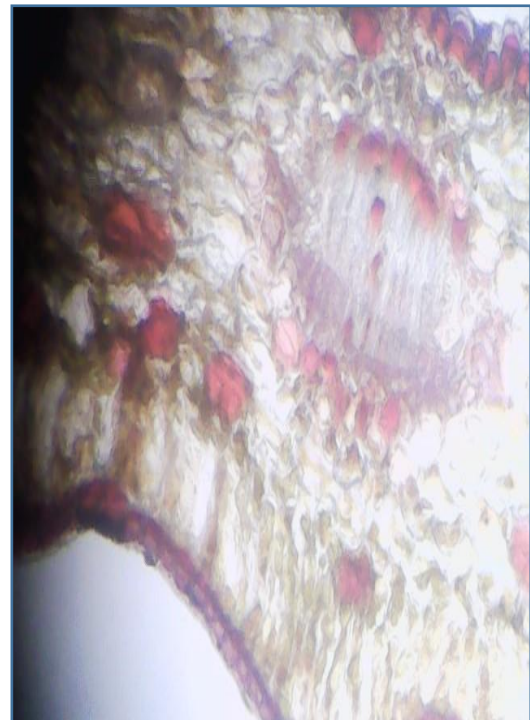
T.S of Stem of Parthalebhanjyang  
Community Forest



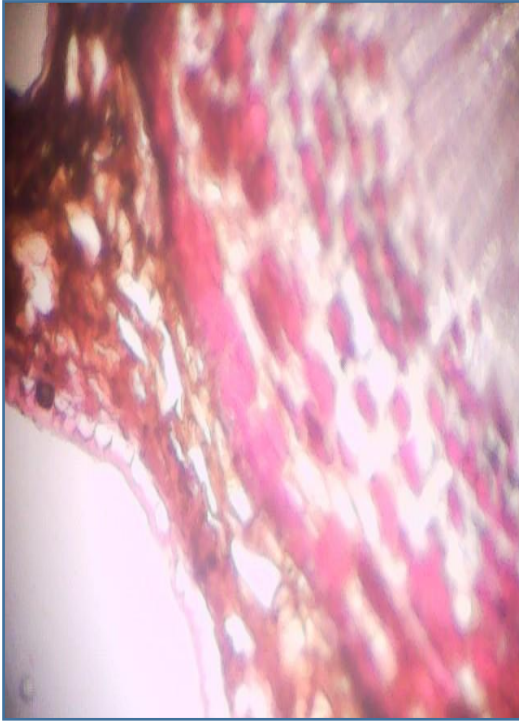
T.S of Leaf of Parthalebhanjyang  
Community Forest



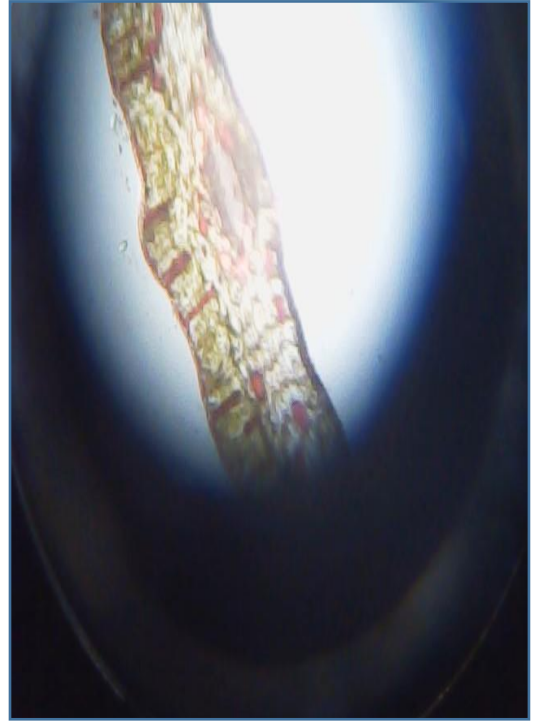
T.S of Stem of Chalal Ganesthan



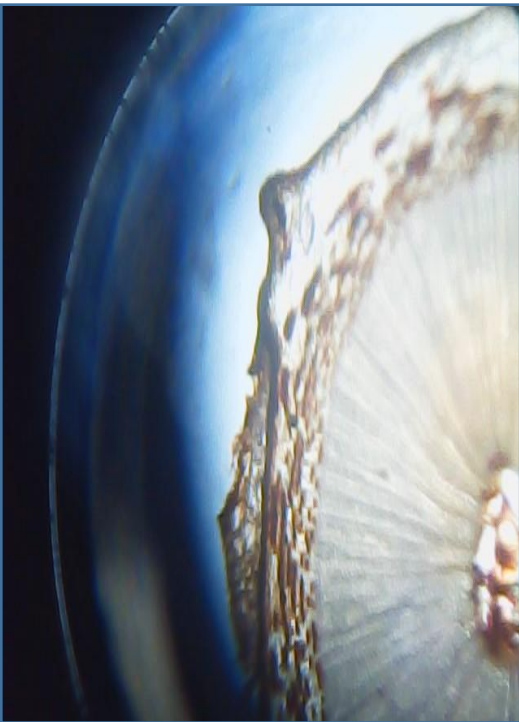
T.S of Leaf of Chalal Ganesthan



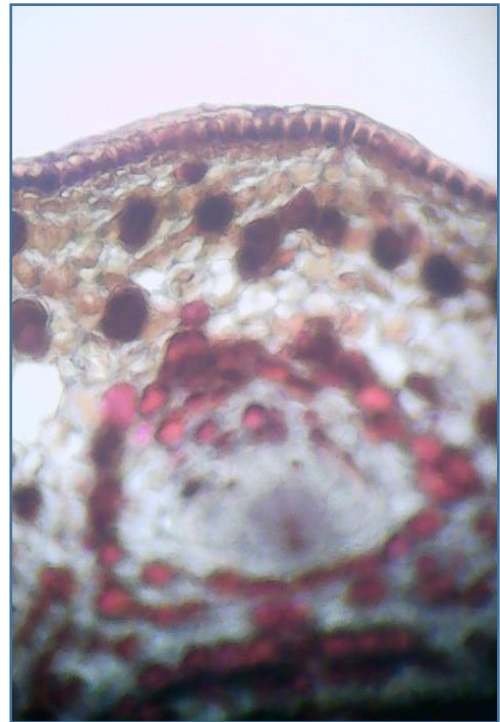
T.S of Stem of Chyalti Betikhorja



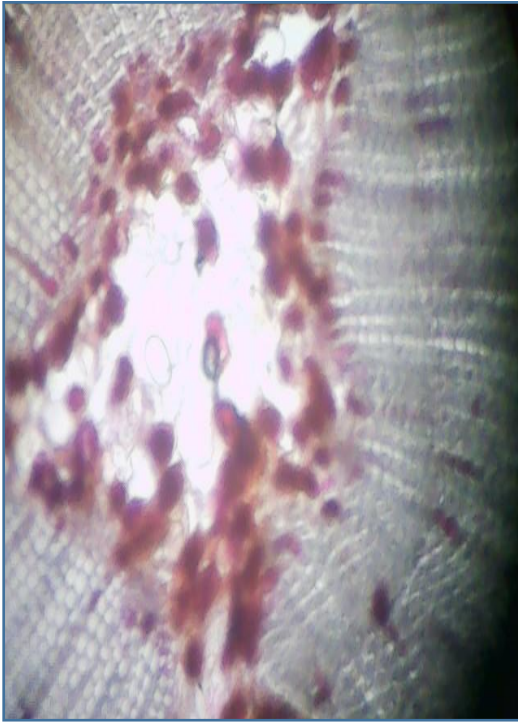
T.S of Leaf of Chyalti Betikhorja



T.S of Stem of Khanyakharkha



T.S of Leaf of Khanyakharkha



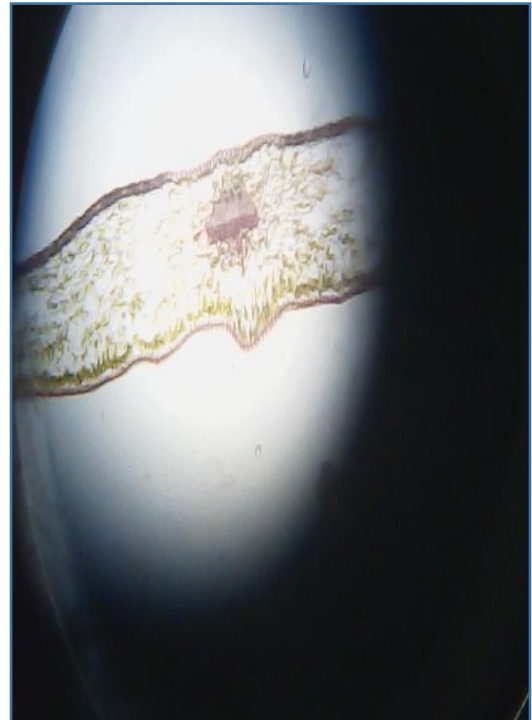
T.S of Stem of Lalliguras Community  
Forest



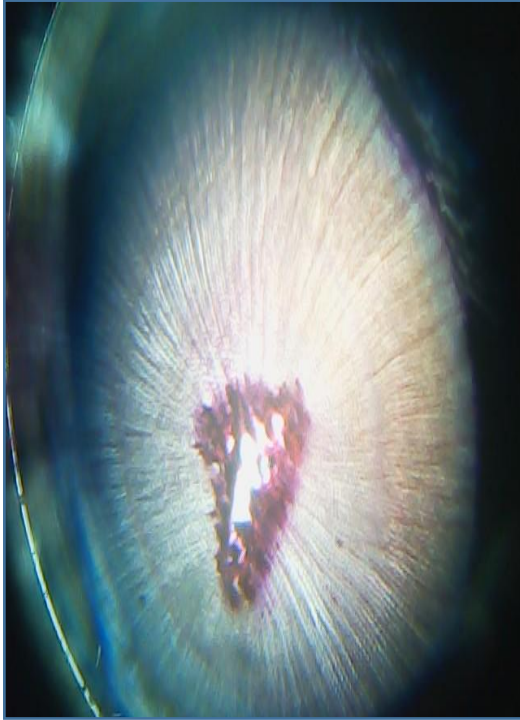
T.S of Leaf of Lalliguras Community  
Forest



T.S of Stem of Tistung Deurali



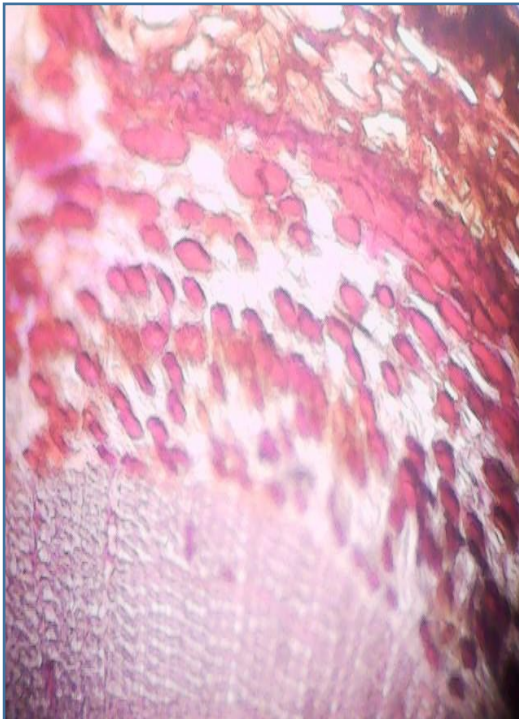
T.S of Leaf of Tistung Deurali



T.S of Stem of Nepalthok



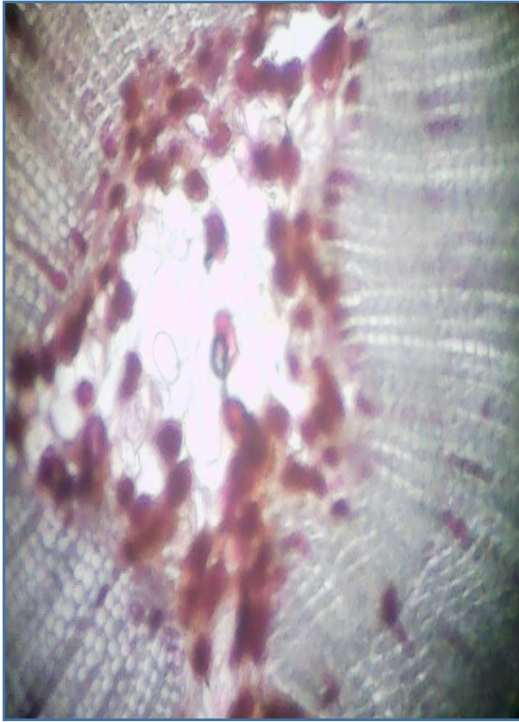
T.S of Leaf f Nepalthok



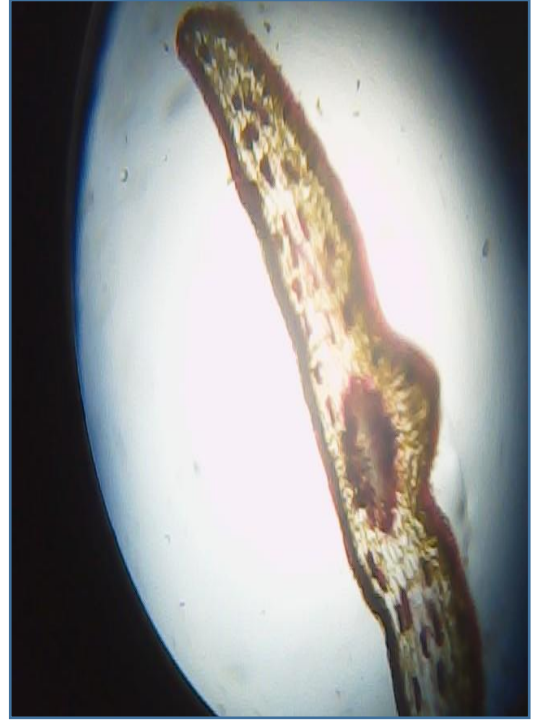
T.S of Stem of Nilkantha



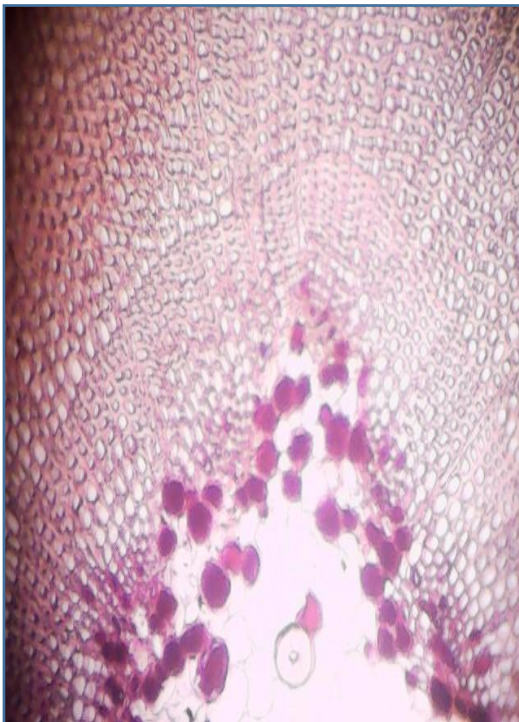
T.S of Leaf of Nilkantha



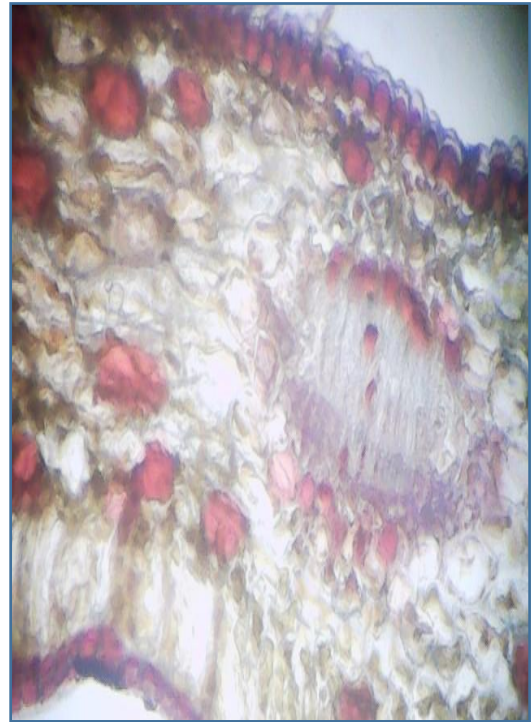
T.S of Stem of Gotikhel



T.S of Leaf of Gotikhel



T.S of Stem of Shivapuri National  
Park



T.S of Leaf of Shivapuri National Park



नेपाल सरकार  
वन तथा वातावरण मन्त्रालय

फोन नं. { ४-२२७५७४  
४-२२०३०३  
फ्याक्स: ४-२२७३७४



## वन तथा भू-संरक्षण विभाग

प्राप्त पत्र संख्या र मिति:-

पत्र संख्या:- ०८०१८९

च. नं.:- ६२५

विषय: अनुसन्धान अनुमति सम्बन्धमा ।

श्री प्रमिला धुखवा,  
भक्तपुर, नेपाल ।

(कृपया पत्रोत्तरमा प्राप्त पत्र संख्या  
र मिति उल्लेख गर्नुहोला ।  
बबरमहल, काठमाडौं, नेपाल

मिति: २०८०/०९/०३

प्रस्तुत विषयमा Tribhuvan University, Amrit Campus, Kathmandu मा M. Sc. in Botany 4<sup>th</sup> semester मा अध्ययनरत तपाईंले "Taxonomy and Species Distribution Modeling of *Taxus mairie* (Lemee and Lev.) S.Y.Hu ex T.S. Liu (Maire's Yew) in Nepal Himalaya" को विषयमा अध्ययन अनुसन्धानका लागि अध्ययन अनुमति उपलब्ध गराइदिनु हुन भनि मिति २०८०/०८/१८ गते यस विभागमा दिनु भएको निवेदन साथ प्रपोजल प्राप्त भयो । सो सम्बन्धमा कारवाही हुँदा उक्त प्रपोजलमा उल्लेखित Methodology (Plant collection and preparation of herbarium specimen, Purposive sampling and Maxent Modelling) अनुसार तपसिलको शर्तहरूको अधिनमा रही डिभिजन वन कार्यालयसँग समन्वय गरि सन् २०२३, December 19<sup>th</sup> देखि सन् २०२४, June 18<sup>th</sup> सम्मका लागि अनुसन्धान गर्नु हुन निर्देशानुसार अनुरोध छ ।

### शर्तहरू

१. अनुसन्धानकर्ताले वन ऐन २०७६ तथा वन नियमावली २०७९, राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण ऐन, २०२९ र नियमावली २०३० तथा यस मातहतका नियमावलीहरूको पूर्ण पालना गर्नुपर्नेछ ।
२. अनुसन्धान कार्य डिभिजन वन कार्यालयसँगको समन्वयमा गर्नुपर्नेछ ।
३. संकलित नमुनाहरूको परिक्षण कार्य Golden Gate International College, Kathmandu को प्रयोगशालामा गर्नुपर्नेछ ।
४. अनुसन्धानको क्रममा प्राप्त भएको जैविक विविधता संरक्षणसँग सम्बन्धित संवेदनशिल सूचनाहरू गोप्य राख्नु पर्नेछ । अनाधिकृत रूपमा त्यस्ता सूचनाहरू कसैलाई पनि उपलब्ध गराउन पाइने छैन ।
५. अनुसन्धान कार्य समाप्त भए पश्चात एक प्रति रिपोर्ट/प्रतिवेदन (कागजी तथा विद्युतीय) यस विभागमा अनिवार्य रूपमा बुझाउनु पर्नेछ ।
६. तोकिएका शर्तहरूको पालना नगरिएमा विभागले कुनै पनि समयमा अनुसन्धान अनुमति रद्द गर्न सक्नेछ ।

(सवनम पाठक)  
वन अधिकृत

### बोधार्थ

श्री डिभिजन वन कार्यालय, धादिङ्ग, मकवानपुर, काभ्रेपलाञ्चोक, सिन्धुपाल्चोक, सिन्धुली, काठमाण्डौं, दोलखा ।  
: जानकारी तथा आवश्यक सहयोगका लागि अनुरोध छ ।



नेपाल सरकार  
वन तथा वातावरण मन्त्रालय  
राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण विभाग  
शिवपुरी नागार्जुन राष्ट्रिय निकुञ्ज कार्यालय



मिति: २०८०/०९/०५

पत्र संख्या: ०८०/८१

चलानी नं.: ९९६

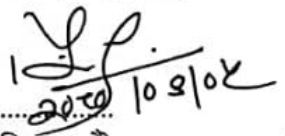
विषय: अध्ययन अनुसन्धान अनुमति सम्बन्धमा ।

श्री प्रमिला घुस्वा  
कोलाछे, भक्तपुर ।

प्रस्तुत विषयमा श्री राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण विभागको प.सं. २०८०/०८१, इको-१३१ च.नं. १२२७, मिति २०८०/८/२१ गतेको अध्ययन-अनुसन्धान अनुमति पत्रानुसार "Taxonomy and species distribution modelling of Taxus Mairei in Nepal Himalaya" विषयमा यस निकुञ्ज तथा मध्यवर्ती क्षेत्रमा २१ डिसेम्बर २०२३ देखि १० जनवरी २०२४ सम्म तपशिलमा उल्लेख गरिएका शर्तहरू पालना गर्ने गरी र प्रचलित ऐन नियमको परिधि भित्र रही अध्ययन अनुसन्धान कार्य गर्नका लागि अनुमति प्रदान गरेको व्यहोरा आदेशानुसार अनुरोध छ ।

तपसिल

- १) अनुसन्धानकर्ताले राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण ऐन २०२९, र अन्तर्गतका नियमावलीहरूको पूर्ण पालना गर्नु पर्नेछ ।
- २) अनुसन्धानकर्ताले यस कार्यालयको सम्बन्धित सेक्टर, पोष्ट र प्रवेशद्वारसँग समन्वय गरी कार्य गर्नु पर्नेछ ।
- ३) नमुना संकलन गर्दा यस निकुञ्जको सम्बन्धित सेक्टर/पोष्ट/ प्रवेशद्वारमा चेकजाँच गराई मात्र लाग्नु पर्नेछ ।
- ४) अनुसन्धानकर्ताले अनुसन्धान समाप्त भएपछि एक/एक प्रति कागजी र विद्युतीय प्रतिवेदन यस कार्यालयमा (snnp.gov@gmail.com) अनिवार्य बुझाउनु पर्नेछ ।
- ५) अध्ययन सहयोगीको रूपमा बढिमा २ जना व्यक्तिलाई मात्र नि:शुल्क प्रवेश दिईनेछ र निजहरूको विवरण प्रवेश गर्ने समयमा सम्बन्धित प्रवेशद्वारमा बुझाउनु पर्नेछ ।
- ६) राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण विभागको प.सं. २०८०/०८१, इको-१३१ च.नं. १२२७, मिति २०८०/८/२१ गतेको पत्रमा उल्लेखित सबै शर्तहरू पालना गर्नु पर्नेछ ।

  
शिवलाल गैर  
(संरक्षण अधिकृत)

बोधार्थ:

- श्री भवानीदल गण, लिपिकोट व्यारेक, काठमाण्डौ: जानकारीको लागि ।  
श्री कालीध्वज गण, नागार्जुन व्यारेक, फुलबारी गेट काठमाण्डौ: जानकारीको लागि ।  
श्री नागार्जुन सेक्टर, फुलबारी गेट, काठमाण्डौ: जानकारीको लागि ।  
श्री सुन्दरीजल सेक्टर, सुन्दरीजल, काठमाण्डौ: जानकारीको लागि ।  
श्री ढकालचौर सेक्टर, जगात, काठमाण्डौ: जानकारीको लागि ।  
श्री पानीमुहान रेञ्जपोष्ट, पानीमुहान, काठमाण्डौ: जानकारी तथा अनुगमन गर्नु गराउनुहुन ।



नेपाल सरकार

वन तथा वातावरण मन्त्रालय

राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण विभाग

फोन नं. : ४२२०८६०  
: ४२२०९१२  
: ४२२७९२९  
फ्याक्स नं. : ४२२७९७५पत्र संख्या २०८०/८९,६९३९/.....  
चलानी नं. : -९२२६

शाखा)


पो.ब. नं. - ८६०  
बबरमहन, काठमाडौं  
Email : info@dnppwc.gov.np  
http://www.dnppwc.gov.np  
मिति: २०८०/०८/२९

विषय: अध्ययन-अनुसन्धान अनुमति सम्बन्धमा ।

श्री शिवपुरी नागार्जुन राष्ट्रिय निकुञ्ज कार्यालय,  
पानीमुहान, काठमाडौं ।

प्रस्तुत विषयमा तहाँ निकुञ्ज क्षेत्रमा निम्नानुसारको अध्ययन अनुसन्धानको अनुमति प्रदान गरिएको व्यहोरा आदेशानुसार अनुरोध छ ।

|                      |  |                                 |                                   |
|----------------------|--|---------------------------------|-----------------------------------|
| अनुसन्धानकर्ताको नाम | प्रमिला धुब्बा   |                                 |                                   |
| ठेगाना               | कोलाछे   | इमेल : woobinapramila@gmail.com | फोन नं: ९८६६२९७५९७                |
| सम्बद्ध संस्था       | Ascol Campus   |                                 |                                   |
| अनुसन्धानको प्रकृति  | Personal   |                                 |                                   |
| पद                   | Student  |                                 |                                   |
| अनुसन्धानको तह       | Master's Degree  |                                 |                                   |
| अनुसन्धानको शीर्षक   | Taxonomy and species distribution modelling of Taxus Mairei in Nepal Himalaya  |                                 |                                   |
| अनुसन्धान विधि       | Field visit, plant sample collection, lab test   | नमूना संकलन गर्ने               | नमूना परिक्षण कहाँ गर्ने<br>नेपाल |
| अनुसन्धानको अवधि     | ०७ डिसेम्बर, २०२३ देखि १० जेनेवरी, २०२४ सम्म   |                                 |                                   |
| शर्त:                | <ol style="list-style-type: none"> <li>अनुसन्धानकर्ताले राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण ऐन, २०२९ र नियमावली, २०३० तथा मातहतका सबै नियमावली, निर्देशिका एवं कार्यविधिहरूको पूर्ण रूपमा पालना गर्नु पर्नेछ ।</li> <li>अध्ययन अनुसन्धान गर्दा अनुसन्धानकर्ताले राष्ट्रिय निकुञ्ज विभाग र सम्बन्धित निकुञ्ज कार्यालयसँग आवश्यक समन्वय गरी गर्नु पर्नेछ ।</li> <li>अनुसन्धानकर्ताले आफ्नो अनुसन्धानको प्रस्ताव सम्बन्धित निकुञ्ज कार्यालयमा समेत पेश गर्नु पर्नेछ ।</li> <li>अनुसन्धानकर्ताले अनुसन्धान समाप्त भएपछि एक प्रति कागजी प्रतिवेदन र एक प्रति इलेक्ट्रोनिक प्रतिवेदन यस विभाग र सम्बन्धित निकुञ्ज कार्यालयमा अनिवार्य रूपमा बुझाउनु पर्नेछ ।</li> <li>अनुसन्धानकर्ताले नतिजाहरू प्रकाशित गर्दा अनुसन्धानमा संलग्न यस विभाग र अन्तर्गतका कर्मचारीको योगदानको आधारमा सहलेखकको रूपमा समावेश गराउनु पर्नेछ ।</li> <li>नमूना संकलन गर्दा हर्बेरियम प्रयोगशालामा अभिलेखिकरण तथा ल्याब परिक्षण प्रयोजनका लागि जम्मा २ वटा मात्र नमूना संकलन गर्नु पर्नेछ ।</li> <li>कुनै पनि संकलित नमूना विदेश लैजान पाइने छैन ।</li> <li>तोकिएका शर्तहरूको पालना नगरेमा विभागले कुनै पनि समयमा अनुमति पत्र रद्द गर्न सक्नेछ ।</li> <li>तोकिएको शर्तहरूको हकमा सोही बमोजिम र अन्य बाँकीको हकमा प्रचलित कानून बमोजिम हुनेछ ।</li> </ol> |                                 |                                   |

  
 (श्री प्रमिला धुब्बा)  
 इकोलोजिष्ट

बोधार्थ:

श्री प्रमिला धुब्बा: सम्बन्धित निकुञ्ज कार्यालयसँग समन्वय गरी अध्ययन अनुसन्धान गर्नु हुन ।



# GoldenGate International College

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Date: Mangsir 19, 2080

## TO WHOM IT MAY CONCERN

This is to inform that **Ms. PRAMILA DHUKHWA (TU Reg. 5-2-20-583-2014)**, M.Sc. Student in Department of Botany, Amrit Campus (ASCOL) is a regular student who is doing thesis under my supervision. Her proposed title of the Thesis is Taxonomy and Distribution Modelling of *Taxus mairei* (Lemée&Lév.) S.Y. Hu ex T.S.Liu in Nepal Himalaya". During her thesis, she is using my research lab at GoldenGate International College for Anatomical Study of the leaves under my supervision. I therefore, request for granting permission for her to have study permission for collection of sample specimens.

If there is anything, please do not hesitate to contact us at our college.

*Signature!*

-----  
Dr. Jyoti Prasad Gajurel,

Director, B.Sc. Program,

Email: [j.gajurel@goldengate.edu.np](mailto:j.gajurel@goldengate.edu.np), [jpgajurel2010@gmail.com](mailto:jpgajurel2010@gmail.com)

Contact: 9771-9851243732