

# Community based Tree Fern Conservation Strategy:

*With Special Reference to Panchase region*



October, 2017

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Production of this document was made possible by the generous support of The Rufford Foundation through a Rufford Small Research grant for a project entitled “Ecological exploration of endangered tree fern for community based conservation in Panchase mountain ecosystem, Nepal”.

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## DISCLAIMER

This Community based Tree Fern Conservation Strategy was prepared to guide communities and local stakeholders in various efforts for the conservation and better management of the tree ferns in the Panchase Area of Nepal. It was prepared using both the published and unpublished information on tree ferns from Nepal and other regions. This strategy does not represent a management decision by any authorized authority but rather offers best guidance expedited by the science for local stakeholders and decision makers.

Although the best scientific information available was used to the extent possible, it is expected that new information will arise. In the essence of continuous learning, knowledge generation and adaptive management, if you have new information that will assist in the conservation of tree fern species, please contact the authors through the contact information available in the document.

## ACKNOWLEDGEMENTS

First and foremost, we would like to express our deepest gratitude to the Rufford Grant Foundation for approving us a research grant for our research project - Ecological exploration of endangered tree fern for community based conservation in Panchase mountain ecosystem, Nepal.

We would also like to extend our gratitude to the communities of Panchase area for their hospitality, support and most importantly, their participation without which the project implementation would not have been possible. I would also like to thank different stakeholders - Machhapuchhre Development Organization, Panchase Protected Forest Council, local youth clubs and schools for their active participation and facilitation during the field survey and workshops and insights for developing the strategy.

Our sincere thanks to Dr. Dinesh Raj Bhujy and Prakash Chandra Aryal experts from the Tribhuvan University for their guidance and feedback in different stages of the project.

We thank all who have been working passionately for the biodiversity conservation and especially those who will use these strategy to help achieve more successful conservation of tree fern for the future.



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## STATUS REVIEW

**Ferns** and their allies are in a major division of the Plant Kingdom called Pteridophyta, and comprise much of the fossil records and occupies among the oldest species of the planet. Literatures reported evidences of fossil showing tree fern evolved some 350 million years ago, in Carboniferous period, the period also known as the age of ferns. Ferns existing today have been there for more than 300 million years, and their evolution through various forms has been phenomenal, while most of them have also been extinct (Fernandez, 2011).

Ferns had a vital role in establishing the early land flora as they were one of the first vascular plants to grow on the planet having spores as reproductive units and secondary growth (Kenrick & Crane, 1997). Ferns are regarded as 'Vascular cryptogams' - link between lower and higher group of plants as they show the evolution of vascular system and reflect the emergence of seed in the plant. Over 250 different genera of ferns (Chang et al., 2011) and about 12,000 species of ferns have been recorded in the world (Paul et al., 2015). Thus, they are placed between bryophytes and higher vascular plants i.e., gymnosperms and angiosperms in the hierarchical plant classification system.

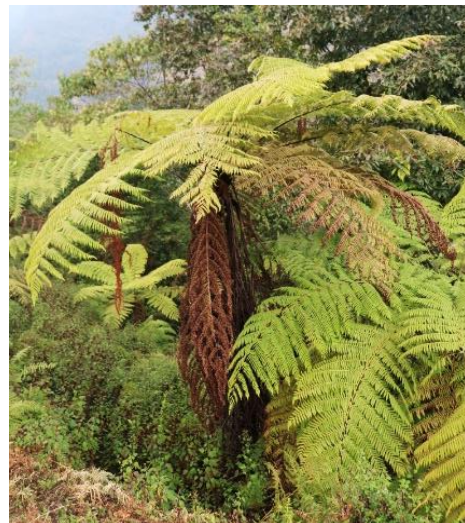
### CYATHEA SPINULOSA WALL EX.: AN OVERVIEW

**Scaly tree ferns, Cyatheaceae**, are group of mostly tree forming ferns with fossil evidences marking their origin in the Middle Jurassic age (Ho et al., 2016). Among Pteridophyta, Cyatheaceae stands as one of the interesting and second largest living fern group due to its striking morphology, its ability to escape extinction during the evolution of the earth and wide geographical

distribution along with local endemism (Tryon and Gastony, 1975).

The Genus, *Cyathea* belongs to the family Cyatheaceae which comprise the world's tallest tree ferns, some of them even reaching 20 m in height (Tryon and Tryon 1982) and includes ca.600 species (Korall et al., 2006). The distribution of genus have been reported from sea level to higher elevation up to 4200 m above sea level (Tryon, 1976).

Most of the species of Cyatheaceae are scaly, spore-bearing, caudex massive, erect, thick, unbranched and arborescent. They usually have huge leaves (to 5 m), bipinnate-tripinnatifid lamina, veins free to margin, mostly simple or forked. Sori indusiate or ex indusiate, apparently at the apex or the surface of the vein. Spores tetrahedral, trilete, non-perinate, exine smooth or granulose (Singh and Sahu 2015).



There are several genera mainly belonging two major families (Cyatheaceae and Dicksoniaceae) which comprise the majority of the tree fern species (Fernandes, 2003) and are commercialized ornamental plants, leading to overexploitation of natural populations (Forest Practices Authority 2011).

To prevent anthropogenic pressure and export of important plant species worldwide, Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has included many species of the genus *Cyathea* in Appendix II (Thomas et al. 2006). International Union for Conservation of Nature (IUCN) has also included many species of the genus in Red List of Threatened Species category.

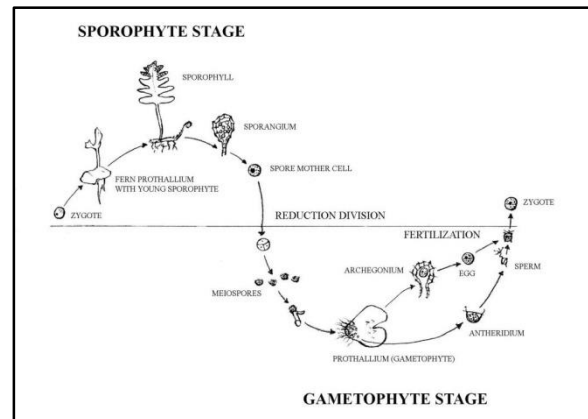
Scaly tree ferns have long fascinated scientists. Some species have socio-economic values owing to their diverse indigenous utilization around the world (Rybczyński and Mikula 2010). Tree ferns also have a rich ethnobotanical history which includes using the roots of *Cyathea delgadii* to make crafts, the trunk pith of *Cibotium glaucum* as a source of starch, and the hairs of *C. glaucum* to dress wounds and stuff pillows and mattresses (Hensley et al. 2003).

<b>Kingdom</b>	<i>Plantae</i>
<b>Phylum</b>	<i>Tracheophyta</i>
<b>Class</b>	<i>Polypodiopsida</i>
<b>Order</b>	<i>Cyatheales</i>
<b>Family</b>	<i>Cyatheaceae</i>
<b>Genus</b>	<i>Cyathea</i>

## LIFE CYCLE

Ferns differ from other plants in that they do not produce flowers or seed, instead they reproduce from spores. Spores are one-celled microscopic structures that cannot be seen with the naked eye. These spores are found most often on the underside or edges of the frond, and in some cases are borne on separate stalks. Ferns and their allies are clearly unique in the modern plant world and differ in many ways from the flowering plants.

The life cycle of the ferns has worked quite successfully for millions of years. Spores from the parent fall to the soil and with an enormous amount of luck (millions perish for every success) they will find suitable moisture and light.



The minuscule single-celled organism starts to grow by cell division, giving place to a little gametophyte or prothallia, whose morphological appearance passes through different stages: filamentous, spatulate and heart shaped. Although mostly are heart shaped, tuberous, strap-like, and ribbon-like gametophytes are also found in some specific families. This is an independent plant with its own simple “root” system (rhizoids) to provide it with nutrients and water. The prothallium then grows antheridia or male organs and archegonia or female organs on its underside. The antheridium produces antheridia, which will swim via a droplet of water to the egg produced by the archegonium. The fertilized egg then begins to grow the sporophyte, the plant that we know as fern.

Very reach references concerning fern biology bring various definitions of alternation between two independent generations: haploid gametophyte and diploid sporophyte. These two generations have the same genome but are fundamentally different organisms,

however, both are photosynthetically independent and are very strong autotrophs for the majority of their life.

Gametophyte life starts when spores uptake water, their coat breaks and unequal first cell division take place, and prothallial and rhizoidal initials are formed. This generation lacks the typical vascular character with limited number of active meristematic cells in notch, which are responsible for its somatic growth, produce tiny size with fast growth and with limited life span. The major function of this generation is to generate and to comfort next generation, it means, sporophyte.

Due to these facts, the formation of the sexual organs, both archegonia and antheridia, occurs on the bottom surface of the body. Such location of sexual organs helps to carry on the “water path” for sperms to the egg cells to make fertilization. In nature, gametophyte biological function is limited and completed when the first leaf of sporophyte starts photosynthetic activity. Until now, there is only limited information concerning perennial growth of gametophyte through vegetative proliferation, which increased its life span and formation of both sex organs, when met with favorable conditions for life (Khare et al., 2005).

## SERVICES AND VALUES

From the beginning of civilization, humans have been sustaining on a range of life-fulfilling services provided by the ecosystems. From the supply of food and clean water and regulation of climate to opportunities for cultural, spiritual and recreational experiences, ecosystems have been providing services for human in every dimension. These services provided by ecosystems include benefits from plants, animals and other organisms along with the nonliving

components of the environment (e.g. air, water, minerals etc.).

Tree fern provides all four ecosystem services: provisioning, regulating, supporting and cultural services. As for the provisioning services, which are the materials obtained from the tree fern for direct use by humans; its leaves and trunks are used. Young fronds of tree fern provide food, fodder and fiber. They are being used as food especially as pickles (*Achar*) while the matured ones as fodder for the livestock.



**Fiddle heads of tree fern used for food**

Occasionally, the trunk of tree fern is also being used as traditional gate (*Tagaro*) at the entrance of house. The preference compared to other wood is due to its slow resistant nature to decaying compared to other woods. The trunk of tree fern is also used as long in India.



**Tree fern trunks used as "Tagaro" in Panchase**



This prehistoric tree fern plant is speculated for having certain role in the regulation of microclimate but research and knowledge of this services is unexplored. Ferns, as a key component of tropical and temperate vegetation, play significant roles in ecosystem functioning in the both canopy (Hietz, 1997) and forest floor (Hill and Silander, 2001) by moderating the light intensity reaching the understory, making it suitable for better growth of seedlings of other trees and epiphytes.



Locals in Panchase area receive more indirect services such as regulatory and socio-cultural services. It dominates the under-storey of these forests and help to create a sheltered and moist forest floor, making the ideal habitat for many bryophytes, invertebrate animals and a “nursery” for recruited seedlings of many species (Forest Practices Authority 2011).

Tree fern trunks are made up of persistent frond bases and layers of aerial roots which are excellent at holding moisture. They provide easy anchorage and offer a substrate for establishing epiphytes such as mosses and filmy ferns, and a nursery site for the germination of rainforest trees. Thus, Tree ferns may be a prominent component of some threatened forest communities and important for the survival of other species such as epiphytes, invertebrates, and even trees that

use the fern trunks as a seed-bed and nursery site.

Gurung (1992) mentioned the fascinating afforestation value of tree ferns with its rhizome holding in barren lands in waterlogged areas due to its well adaptability. He urged that the rhizome pushes into soil, binds it and prepare necessary conditions for growth of other herbs and shrubs which is further supported by shade of the fronds.

Physiological evidences have confirmed of the ability of tree ferns in carbon fixation at high rates at light intensities approximating 10% of full sunlight (Unwin and Hunt, 1997).

Some tree fern species have been utilized by indigenous groups since a long time and also holds economic values around the world (Rybczyński and Mikuła, 2010). In the tropical and subtropical region of South and Southeast Asia, tree ferns possess high economic value.

Tree ferns also have a rich ethno-botanical history which includes using the roots of *Cyathea delgadii* to make crafts, the trunk pith of *Cibotium glaucum* as a source of starch, and the hairs of *C. glaucum* to dress wounds and stuff pillows and mattresses (Hensley et al. 2003). In India, tree fern rhizoids are used as medicine combining with milk and black pepper to cure white discharge (Rout et al. 2009).

In northeast India, it has high value both culturally and economically. Tree fern makes good substrate for orchid growth therefore it is also used in orchid cultivation (Khan et al., 2002). Besides, it has been used as ornamental species due to its superfluous appearance. The trunks are also carved into statues and other handcrafted items as souvenirs for tourists (Sajem et al. 2008).

Tree ferns unique nature in the modern plant world makes it different in many ways from

other flowering plants (Chang et al., 2011). Despite their magnificent prehistoric appearance, tree ferns are yet remarkably little known for their ecological and socio-economic services they provide.

The most peculiar role played by the tree fern is in the regeneration dynamics thus is also considered as the key stone species (Bystriakova et al., 2011). Very recently, scientists have come up with another rationale to consider tree ferns as indicator species, which will help in developing suitable criteria for maintaining and monitoring ecologically sustainable forest management practices.

In the meanwhile, tree fern utilization by the indigenous people all around the world has also been reported. However, the present knowledge on the services provided by the tree fern and its valuation is still poorly understood.

### GLOBAL DISTRIBUTION

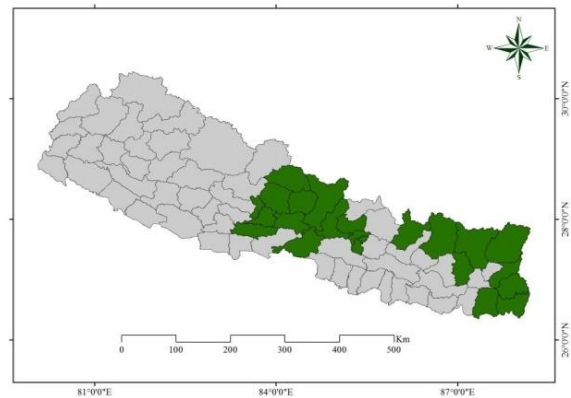
*Cyathea spinulosa* is observed as a Southeast Asian flora as its distribution is mostly found in tropical to temperate climatic regions. China, Taiwan, Hongkong, Southern Japan, Bangladesh, India, Nepal, Bhutan, Myanmar [Burma], N-Thailand, Laos, Vietnam and Philippines are nations where the presence of this species is recorded (Chandran 2008; Kholia et al, 2013; and Singh and Sahu 2015).



Map showing recorded global distribution of tree ferns

### CURRENT DISTRIBUTION AND ITS STATUS IN NEPAL

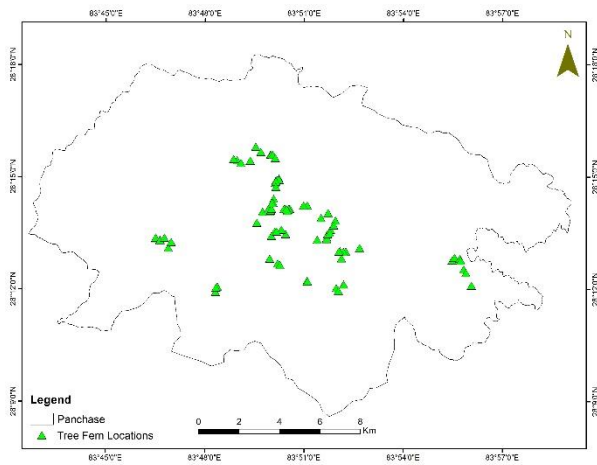
The presence of tree fern species had been recorded mainly from central and eastern Nepal. Bhuju and Joshi (2009) had recorded the species location from six areas of Ilam district in eastern Nepal. Similarly Fraser-Jenkins et al. (2015) had cited different locations of tree ferns from central and eastern Nepal.



Map showing recorded tree ferns in different areas of Nepal

The districts from where tree ferns were recorded are Manang, Palpa, Parbat, Kaski, Tansen, Gorkha, Dhading, Kathmandu, Bhaktapur, Dolakha, Solukhumbu, Sankhuwasabha, Bhojpur, Jhapa, Ilam, Panchthar, Taplejung, Morang, Nuwakot, Lalitpur, Lamjung, Syangja and Chitwan (Bhujju and Joshi, 2009; Bhagat and Shrestha, 2010; Fraser-Jenkins et al., 2015 and Bhattarai and Rajbhandary, 2017).

Our field visits in Kaski district of Central Nepal had also found presence of tree ferns in and around Panchase Protected Forest Area which is shown below in the map.



Map showing recorded tree fern sites in Panchase Protected Forest Area, Nepal

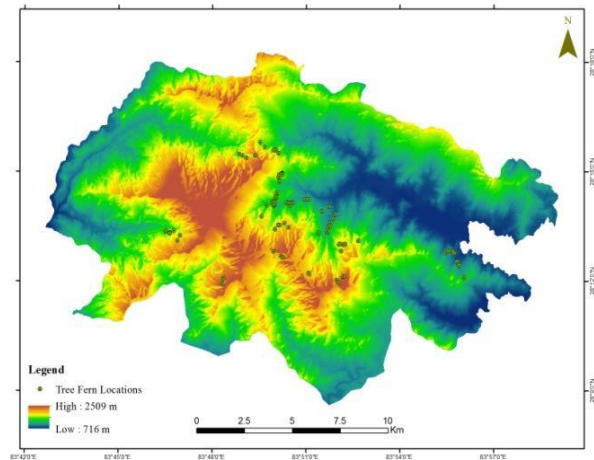
## PANCHASE PROTECTED FOREST

The project site was the Panchase Mountain Ecological Region, straddling across three districts- Kaski, Parbat and Syangja in Nepal's Western Development Region. The Panchase forest was designated as Panchase Protected Forest Area (PPFA) in 2011. The PPFA is bounded by 28°10'55" to 28°15'56" N latitude and 83°48'03" to 83°49'53" E longitude, covering a total area of 5775.73 ha with buffered fringe area covering 3740.60 ha (community managed) and core area (government managed) covering 2035.13 ha (MoFSC, 2013). The altitude of PPFA ranges from 855 m to 2517 m above mean sea level. Panchase Mountain as a sacred religious site also provides a multitude of cultural and aesthetic services. Forests form the sources of fuel wood, fodder, timber and many other forest products that support the local subsistence economy. Livelihood of the people is dependent dominantly on the provisioning services provided by the forest ecosystem.

## HABITAT

Tree ferns are noticeable plants of humid tropical and sub-tropical forests around the world. Majority of the tree ferns are recorded from shady and moist place to meet its moisture requirements needed for its rich growth along the streams side at 335 to 2000 m altitudes in East and Central Nepal (Gurung, 1991). Availability of moisture stands critical from early stages to different transition stage in its life cycle (Unwin and Hunt, 1997).

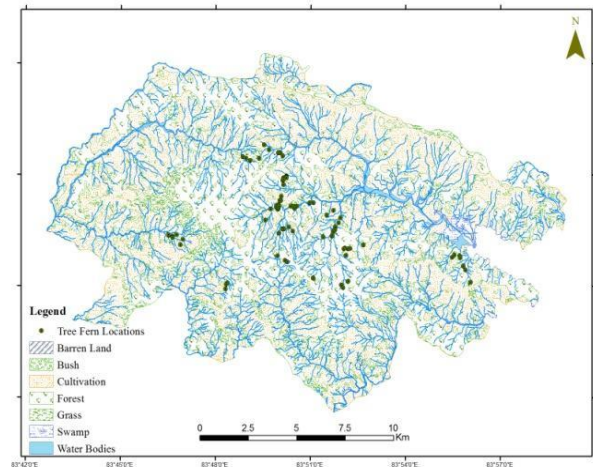
These are also reported in forested gully, wooded slope, edge of path, rocky banks of rivers, beneath dead trees, mountain ridge and from damp ravine (Chandran 2008; Bhujju & Joshi 2009; Dong 2009; Bhagat & Shrestha 2010; Kholia et al, 2013; Fraser-Jenkins et al. 2015; & Singh and Sahu 2015). While, the genus *Cyathea* prefers to grow in moist habitats (Paul et al., 2015).



Tree fern locations in different elevations in Panchase Protected Forest Area, Nepal

Species found at lower elevations are often widespread colonizers of disturbed or successional habitats. A large number of species are restricted to very small ranges on islands or at higher elevations, often in more-mature forests on isolated tropical mountain tops.

Also, tree ferns have moderate light requirements, which plays an important role in its life cycle. Adequate light enables the sporophyte and gametophyte to fully develop during its life cycle (Unwin and Hunt, 1997). That is intense light exposure or a dark environment will suppress sporophyte and gametophyte growth affecting seedling regeneration.



**Tree fern locations in different land uses in Panchase Protected Forest Area, Nepal**

## THREATS

Once abundant, tree ferns are now facing serious survival challenges due to increasing pressures resulting in loss of habitat by deforestation and development activities and also changing climate. Many tree fern species of ecological and economic significance are facing tremendous pressure and are at risk of endangerment and extinction. Tree ferns are declining rapidly in the wild (Dixit and Singh, 2004; Chandran, 2008). The poor regeneration stands as a critical threat because of the less populations of tree fern species in their natural habitats (Paul et al. 2015). Threats for tree fern include both natural and anthropogenic nature.

**Natural threats:** They are difficult to preserve in reserves or ex-situ plantations because of their large growth habit and cold-sensitivity.

Besides, if we consider the mode of reproduction and habitat preference of the species, it is important to protect its habitat that will guarantee the availability of micro climate requirements for its reproductive success and colonization. As the fertilization success depends on certain moisture and light conditions, even slight changes in these micro-climatic conditions will inhibit the fertilization and growth of tree fern.

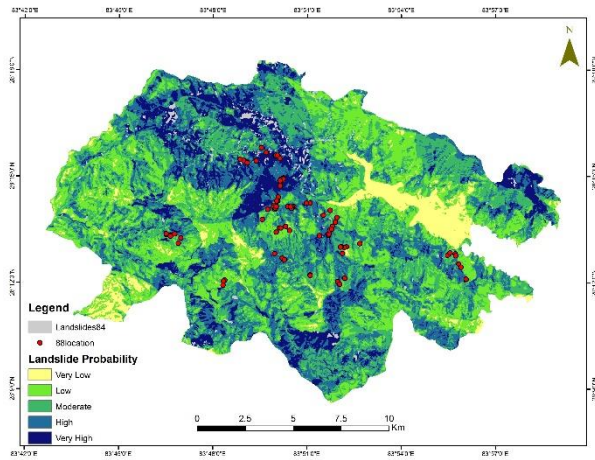
Tree ferns have a higher conservation value as it provides a good habitat for a number of epiphytic species and a base for regeneration of seedlings of other tree species. Any disturbance to tree fern or its surrounding not only affect the tree fern populations but also trigger the depletion of associated plant species (Paul et al. 2015).

In natural areas, the geological processes like landslides and floods are primarily posing threats to the species as well as its habitat. In Panchase area, about 500 landslides were mapped through Geographic Information System that measured 1.176 km<sup>2</sup> in area. It was observed, that some locations of tree ferns were near to those landslides. When the perimeter of landslides were extrapolated up to 500 m from all sides 33 locations having direct impacts. Four locations of tree ferns out of 33 lied within 100 m distance from landslide.

Additionally, 8 locations of tree fern presence occurred within the boundary of 200m. This implies that the increase in boundary of landslides or occurrence of new landslides



around pre-existing ones can pose threat to tree ferns and its habitat.



**Landslide mapping with tree fern locations in Panchase Area, Nepal**

While modelling habitat suitability for tree ferns our preliminary results showed area of 122.76 Km<sup>2</sup> and 49.24 Km<sup>2</sup> as more suitable and most suitable habitats respectively for tree fern viability in Panchase. Similarly when these suitable habitat classes were overlaid by existing 500 landslide boundaries we found certain areas are under threat. Total landslide area was 1.176Km<sup>2</sup> of which 0.609Km<sup>2</sup> and 0.342Km<sup>2</sup> occupied more suitable and most suitable classes of habitats respectively. Thus results showed that habitat types suitable for tree ferns are under more threat due to landslides.

**Anthropogenic threats:** Various anthropogenic activities like deforestation for agricultural land expansion, logging, urbanization and roads/trails building activities have resulted in tremendous pressure on the natural habitat of tree fern species.

Tree ferns are also not devoid of economic exploitation in some parts of the world, as it have high market demand due to its multiple

socio-economic uses viz. ornamental, horticulture, food and medicinal uses (Dixit & Singh, 2004; Rout et al, 2009; Chandra & Jenkins, 2008, Kholia, 2013; Singh & Singh, 2012; Singh et. al., 2013), resulting in the rapid decline of the wild population of tree ferns. This have resulted many species of tree ferns under threatened category in IUCN Red Data book and Appendix II of CITES.

At the local level, tree fern in Panchase area are being suffered from the unsustainable harvesting of tree fern fronds for food and fodder without being aware of the taking into consideration of its own natural viability challenges and its conservation status.



**Haphazard cutting of the fronds of tree fern saplings in Panchase Area, Nepal**

Lack of the knowledge on the importance of tree fern stands as one of the major factor for the declining tree fern populations in that area.

Currently construction of rural roads in Nepal and so in Panchase have aroused as a major threat to the habitat as well as species itself as

such construction practices are not well monitored.



**Tree fern individuals deforested due to the construction of trail affecting tree fern in Panchase Area, Nepal**

Keeping the aforesaid statements in view, the existing threats for tree fern expands across the social, economical and environmental dimensions both globally and locally due to which, they continue to be under great threat of extinction.

### **CONSERVATION AND MANAGEMENT PRACTICE IN PANCHASE**

The family Cyatheaceae is listed in Appendix II of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1975 in order to protect these epibiotic tree ferns from being sold randomly and overexploited. It is also listed in threatened category of IUCN Red Data Book in 1998. Despite the family being listed in CITES and IUCN Red Data Book, it has not been assessed for special protection in Nepal.

The five years long, pilot project - Ecosystem based Adaptation was implemented in Panchase Protected Forest Area in Nepal. The project identified and delineated natural habitat of tree fern in three different sites in Sidhane, Chitre and Arthar Danda-Kharka villages of Panchase area. However, this approach alone might not be effective as it lacks legal protection and conservation measures at the natural habitats.



**Tree fern demonstration plot near Sidhane village of Panchase Area, Nepal**

In addition, very limited researches have been conducted for the tree fern conservation in Nepal. Researches on reproductive biology of tree fern in Nepal is almost null due to which there's a huge gap in scope for effective conservation and management of this species. Beside the natural conditions to be considered for tree fern conservation, the actual threats from the human use in Nepal are still not known clearly. This is a huge knowledge gap to be addressed to identify the effective conservation measures for tree fern.

From our study, the awareness in communities on the importance and conservation of tree ferns in Panchase is very limited. Despite their dependency on tree fern dominantly for food and fodder purpose and few for medicinal values, people lack strong rationale for initiating some effective and





## VISION AND GOALS

Plant species (either Pteridophytes or other plants) are vital components of ecosystem. Over two third of world's plant species are facing danger of extinction with pressure from the human through habitat modification and deforestation, resource overexploitation, spread of invasive species, pollution and growing impacts of global climate change (CBD, 2008). Every organism in the planet has their own role in maintaining the planet's environmental balance and ecosystem stability.

*Cyathea* is one of the interesting genus among Pteridophytes due to its magnificent pre-historic existence and appearance and survival ability through evolutionary processes since millions of years ago. Like every living organisms, these threatened Pteridophytes provide a number of services to the humans and the ecosystem where it exists, yet very little is known about the ecology, social and economic values and potential threats that have been pushing these genus towards endangerment. . They have unique ecological niches and are highly sensitive to changes in microhabitat nearby its vicinity (Harper, 1977).

Despite its importance, the present execution of conservation efforts both by local communities and government authorities in Panchase have not been effective due to the absence of active community participation and awareness especially where subsistence livelihood system are highly dependent on forest resources. This has serious impact on tree fern species that have narrow niche. Apart from human influence, changing climatic conditions have also been a major factor inhibiting the proliferation of these species.

In order to achieve effective conservation of tree fern, collaborative actions from conservationists, local communities, civil societies and government authorities is very important.

Recognizing this importance, it becomes vital to bring together the different stakeholders for developing an effective and inclusive conservation strategy. To conserve the species, which are least concerned but threatened an effort should be done to strongly link conservation and community ownership through citizen scientist approach. And, this linkage needs support from the knowledge generated from the scientific researches on tree ferns and feeding the knowledge into the policies to have concrete achievements for the conservation and management of the tree ferns.

### Vision Statement:

*“To establish Panchase Protected Forest Area of Nepal as an excellent demonstration and research centre for tree fern and its associated species (such as Orchids) in their natural mountain habitats”*

The goal of this strategy is to contribute to the conservation of tree ferns, its associated species (such as Orchids) and their habitats by enhancing communities' knowledge on the importance of healthy ecosystems and the ecosystem services for the well-being of the environment and the community.



## OBJECTIVES

To achieve the goal in an effective and sustainable manner, following five objectives were identified.

1. Enhancing the scientific understanding and knowledge on tree fern for the development of database and research avenues related to tree fern
2. Conservation of tree fern and its associated species along with their habitats
3. Linking conservation of tree ferns with the livelihoods through wise use of tree ferns.
4. Promotion of knowledge and awareness on importance of tree fern and its conservation
5. Building capacity of the concerned stakeholders for the conservation of tree ferns, associated species and their habitats

### OBJECTIVE 1: ENHANCING SCIENTIFIC UNDERSTANDING AND KNOWLEDGE ON TREE FERN

This objective focuses on addressing the knowledge gap on tree fern through better understanding of tree fern dynamics with natural and anthropogenic factors. To achieve this objective, following actions will be undertaken.

*TARGET 1: DETAIL ASSESSMENT OF TREE FERN IN PANCHASE (PROTECTED FOREST, COMMUNITY FORESTS AND OTHER PLACES OF PANCHASE AREA)*

#### ACTIONS

- Comprehensive scientific inventory (presence point, different species, habit and habitat characteristics, disturbances, associated species) of tree fern using citizen scientist approach for the baseline database development
- Periodic scientific inventory on an annual basis in consideration of the baseline data and also updating the existing database from the periodic inventory
- Analyze regeneration trends and viability of tree fern populations and associated species
- Up-scaling the inventory of tree fern in a regional level and in other regions of Nepal
- Updating the database accordingly and developing a national level database for the long run monitoring to contribute the global database of tree ferns.

Data obtained from the inventory will also inform about the distribution pattern of tree fern in Panchase area and the different parts of Nepal. The database generated will then contribute in achieving the goal of Global Strategy of Plant Conservation.

*TARGET 2: ASSESSMENT OF CONSERVATION STATUS OF TREE FERN IN PANCHASE (BASIN, SUB-BASIN AND WATERSHED LEVEL)*

#### ACTIONS

- Assessment of information on the nature and level of uses, existing threats, conservation efforts being undertaken related to tree ferns using field observation and participatory rural appraisal tools (semi-structured questionnaire, key informant interviews, focus group discussion)
- Conservation status assessment of tree fern i.e. Red Listing assessment of IUCN
- Assessment of conservation status of tree fern in basin and sub-basin level (medium-term) and watershed level (long-term)

*TARGET 3: DEVELOP A MECHANISM (MODEL) FOR CONTINUOUS RESEARCH ON TREE FERN FOR ITS EFFECTIVE CONSERVATION IN PANCHASE AREA*

**ACTIONS**

- Identification of ecological (auto ecology, regeneration biology, tree fern as an ecosystem, niche, nomenclature, reproduction biology, ecological modeling, in-vitro cultivation etc.) and social (threats, valuation of ecological services, ethno botany, effectiveness of current conservation practices etc.) aspects of research on tree fern
- Establish a research fund in coordination with government, universities, conservation agencies for tree ferns for a long-term (at least five years)
- Encourage and explore opportunities with national and regional universities for tree fern research
- Collaboration with international universities to expand the tree fern research
- Engaging the local schools and colleges of Panchase area to include tree fern monitoring activities in their extra-curricular activities

**OBJECTIVE 2: CONSERVATION OF TREE FERN, ASSOCIATED SPECIES & ITS HABITAT**

This objective focuses on addressing the gaps in tree fern conservation based on the knowledge and understanding generated from the research. For instance, development of tree fern conservation and management plans and implementation to support in the conservation, restoration and sustainable management of tree fern in a sustainable way.

To achieve this objective following actions will be undertaken.

*TARGET 4: DELINEATE IMPORTANT TREE FERN AREAS*

**ACTIONS**

- Identification of important tree fern areas based on the inventory and scientific studies
- Identification of regenerative plots (plots with significant number of seedling and saplings of tree fern) and prioritizing them for strict conservation and monitoring continuously
- Conduct wider and concerned stakeholder consultations for delineation of the important tree fern areas for effective conservation activities such as developing rules and penalties inhibiting loss of tree fern populations and degradation of their habitats

*TARGET 5: CONSERVATION OF AT LEAST 75% IMPORTANT AREAS OF TREE FERN HABITAT IN COMMUNITY FOREST OF PANCHASE REGION.*

**ACTIONS**

- Identification of very important tree fern areas (high probability of regeneration) and prioritize 75% of the identified important areas for effective tree fern and its habitat conservation and management
- Integration of the monitoring, conservation and management of tree ferns into the community forestry operation and management plans

*TARGET 6: PROTECTION OF TREE FERN, AVAILABLE IN OR AROUND AGRICULTURAL LAND AND INTEGRATION OF TREE FERN IN AGRICULTURE ACTIVITIES IN PANCHASE REGION.*

**ACTIONS**

- Formulation of regulations restricting the activities of destruction and lopping of tree ferns in and around the agricultural lands or settlements
- Exploring opportunities in relation to commercial cultivation of tree ferns as per the developed habitat suitability maps and to integrate tree ferns with agricultural practices of intercropping and slope stability practices with maximum utilization of the presence of tree ferns (for e.g.; planting cardamom under the canopy of tree ferns; Sloping Agricultural Land Technology)

*TARGET 7: PREPARATION OF EFFECTIVE CONSERVATION AND MANAGEMENT PLAN FOR TREE FERNS*

**ACTIONS**

- Review of existing conservation practices and identifying important gaps that need immediate attention
- Formulation of tree fern, associated species and habitat conservation and management plan in close coordination and participation of the communities and concerned stakeholders
- Integration of the formulated conservation and management plan into the relevant local and national conservation strategies

*TARGET 8: EX-SITU CONSERVATION OF TREE FERNS*

**ACTIONS**

- Conduct studies in reproductive biology of the tree ferns
- Collection of the spores of tree fern and their preservation through the establishment of appropriate spore banks.
- Conduct in-vitro propagation of tree fern and establish nurseries and plantation of tree fern for its conservation
- Cultivation of tree fern as per the different economic values such as tree fern logs for orchid cultivation, provided by tree ferns in other parts of the world

*TARGET 9: PREPARATION OF MANAGEMENT PLAN FOR INVASIVE ALIEN SPECIES.*

Invasion of habitat by various species such as Eupatorium had degraded habitat of tree fern.

**ACTIONS**

- Conduct studies on the different invasive species and its impact on tree fern, associated species and their habitats
- Develop specific actions to control or inhibit the growth and interaction of the biological invasion by the invasive species threatening tree fern and associated species and integrate in tree fern conservation and management plan

**OBJECTIVE 3: SUSTAINABLE AND WISE USE OF TREE FERN SPECIES**

This objective focuses on sustainable and wise use of tree ferns along with strengthening control measures of haphazard collection of tree fern. This will allow the sustainable supply of the services provided by tree fern.

Following actions will be taken to achieve this objective.

*TARGET 10: AWARENESS OF WISE USE CONCEPT TO COMMUNITIES*

**ACTIONS**

- Sensitization and training communities on sustainable harvest and wise use concept of tree fern resources
- Strict protection of the seedlings and saplings from any anthropogenic activities
- Control in open grazing of the livestock in areas with large number of tree fern seedlings and saplings

*TARGET 11: SUSTAINABLE MANAGEMENT OF TREE FERN DERIVED PRODUCT FOR BETTER LIVELIHOODS*

**ACTIONS**

- Identify potential markets for the tree fern derived products include food (Achar), timber, and plants for direct use as ornamental, medicinal or other purposes
- Cultivation of tree ferns as per the demands of the products as economic incentives for the better livelihoods of the communities
- Equitable sharing of benefits and the participation of indigenous and local communities for the conservation through sustainable management of tree fern and its products

**OBJECTIVE 4: PROMOTING EDUCATION AND CONSERVATION AWARENESS ABOUT TREE FERN.**

This objective intends to raise public awareness through communication and education about the importance of tree fern species and their conservation. Key target

audiences include local communities which are directly dependent on tree fern services, students, teachers, mothers groups, youth clubs, civil societies, conservationists, and government authorities and policy makers.

*TARGET 12: DEVELOPMENT OF INFORMATION SHARING MECHANISM RELATED TO TREE FERN FOR AWARENESS*

**ACTIONS**

- Preparation of appropriate IEC materials related to tree ferns
- Establishment of information centers on tree fern, their importance and need for conservation
- Utilization of mass media for dissemination of tree fern related information
- Development of online database portal of tree ferns
- Awareness campaigns and workshops, bringing together all the stakeholders for dialogues and policy advocacy

*TARGET 13: DISSEMINATION OF RESEARCH FINDINGS AND KNOWLEDGE GENERATED ABOUT TREE FERN*

**ACTIONS**

- Participations in Conference, Workshop, and Symposiums for wider dissemination of the knowledge on tree fern
- Publication of research findings in scientific journal articles
- Actions for informing policy for tree fern conservation through action research and consultations

*TARGET 14: INTEGRATION OF TREE FERN RELATED INFORMATION IN EDUCATIONAL ACTIVITIES OF PRIMARY, SECONDARY AND*



*HIGHER SECONDARY SCHOOLS IN PANCHASE AREA.*

**ACTIONS**

- Develop and integrate "conservation class" into the curriculum of local schools and include chapters on tree ferns
- Organizing field excursions and periodic monitoring of tree fern populations in tree ferns habitats around Panchase area to promote outdoor education and environmental stewardship for the students as a part of their extra-curricular activities

**OBJECTIVE 5: BUILDING CAPACITY FOR CONSERVATION OF TREE FERN DIVERSITY.**

The achievement of all the targets included in the Strategy will not be effective without the capacity building of the concerned stakeholders particularly to address the need for conservation practitioners. They need to be trained in a range of disciplines from scientific and social based assessments to the knowledge on tree fern life cycle, periodic monitoring and had access to adequate facilities. In addition to training programs, the achievement of this target will require establishing institutional arrangements for a long-term technical and financial commitment for tree fern conservation and sustainable management. Appropriate capacities include adequate technological, institutional and financial resources.

*TARGET 15: DEVELOPMENT OF TRAINING MODULES ON TREE FERN AND ITS HABITAT CONSERVATION.*

**ACTIONS**

- Develop necessary training modules on tree fern understanding, their life cycle, niche requirements, conservation status, nature and level of threats for tree ferns, continuous monitoring, and awareness for conservation and sustainable management including the cultivation potential of tree ferns.
- Integration of the training modules developed for tree ferns as a chapter into the training curriculum of the government

*TARGET 16: CONDUCT TRAININGS*

**ACTION**

- Conduct capacity building training programs focused on conservation and management of tree ferns for the concerned atkeholders (teachers, civil societies, community organizations, government) in the Panchase area and create "citizen scientists" with technical support from conservation practitioners

*TARGET 19: EQUIPMENT SUPPORT*

**ACTION**

- Support the provision of necessary field equipments for the field monitoring such as GPS, maps, measuring tape, camera for the monitoring groups

*TARGET 19: INSTITUTIONAL ARRANGEMENTS FOR THE SUSTAINABILITY*

**ACTION**

- Conduct wider stakeholder consultations at the local, regional and national level for institutionalizing the targets mentioned in the strategy for the sustainability of the efforts for the conservation of tree ferns

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