\

ASSESSMENT OF MEDICINAL PLANT DIVERSITY OF PHALUT MEDICINAL PLANTS CONSERVATION AREA (MPCA) IN WEST BENGAL, INDIA

Project No. CONS/WB-01/2014

FINAL TECHNICAL REPORT

2023


Paris polyphylla Sm.

Final Technical Report

On

ASSESSMENT OF MEDICINAL PLANT DIVERSITY OF PHALUT MEDICINAL PLANTS CONSERVATION AREA (MPCA) IN WEST BENGAL, INDIA

Project No. CONS/WB-01/2014

Sponsored by

NATIONAL MEDICINAL PLANTS BOARD, NEW DELHİ

Submitted to

OFFICE OF THE PRINCIPAL CHIEF CONSERVATOR OF FOREST (RESEARCH MONITORING AND DEVELOPMENT) DEPARTMENT OF FOREST, GOVERNMENT OF WEST BENGAL

Coordinated and submitted by

ITSCEED Foundation, Kolkata, India

Edited by

Dr. Debabrata Saha & Dr. Biswarupa Ghosh

Published by

RESEARCH CIRCLE, DIRECTORATE OF FORESTS, GOVERNMENT OF WEST BENGAL

2023

FOREWORD

The Medicinal Plants Conservation Area (MPCA) program was evolved and implemented for the *In-Situ* conservation of genetic diversity of highly traded and threatened medicinal plants of India. The program has special focus on capturing the gene pools among the wild plant populations of endemic and threatened medicinal plants. This would ensure the long term survival of such plants. These gene pools then provide the source of propagules for selection, breeding and ex-situ conservation of such plants.

The West Bengal Forest Department in collaboration with ITSCEED, Kolkata has implemented the project on "Assessment of medicinal plant diversity of Medicinal Plants Conservation Areas (MPCAs) in West Bengal, India" during 2015 onward. Studies have been conducted at two levels that involves (i) Inventorisation and (ii) Ecological assessment. The information and database developed during the current study will help in future informed conservation action programs. The Forest Department has extended full support to the survey team at the field level through various Divisional Forest Office and Range Office to achieve the objectives of this project in all the seven MPCAs established in West Bengal in the second phase.

Like the 1st phase (2007-09), many new species and gene pools have been captured in new MPCA in the 2nd phase. The gene pools of many species identified during the study will help in better conservation action programs through establishing a national network of MPCAs. About 350 species were assessed and documented of which around 14 species are placed under the threatened category. The MPCA with the rich gene pool acts as a hotspot of genetic diversity and needs to be brought under the conservation action program. Further, the training programs on the objectives of the MPCA needs to be conducted more frequently for capacity building of the front line staff as well as the surrounding community engaged in the conservation action programs.

We thank National Medicinal Plants Board (NMPB) for providing financial support for the current (2^{nd}) phase of MPCA program.

Shri Piyarchand, IFS
Principal Chief Conservator of Forest
West Bengal Forest Department

FOREWORD

Medicinal plants have been an integral part of our tradition and also the modern pharmacopeia. In 2007-09, seven (7) Medicinal Plant Conservation Areas (MPCAs) were established in the State of West Bengal for promoting Conservation of Medicinal Plants and Traditional Knowledge to enhance the health and livelihood security of the surrounding indigenous communities. In the face of global warming and climate change the MPCA's can facilitate carbon sequestration, habitat protection, gene pool conservation, improve health, reduce poverty and maintain other ecosystem services. Given the multiple benefits ofan MPCA in the second phase four new MPCAs namely Bichabanga, Panchanai, Rachila and Phalut were established in the State to strengthen the in-situ conservation of medicinal plant gene pool.

Assessment of the plant population of the MPCAs' and their ecological significance brings forward the understanding of the long term goals of such conservation programs. ITSCEED, Kolkata has been effectively collaborating with the frontline staff of the forest department and local people for carrying out the ecological survey of the new MPCA's. This report has the baseline data for the new MPCAs. ITSCEED has further been creating an awareness regarding the objectives and presence of the MPCA's as a tool for achieving Sustainable Development Goals (SDG) of the country.

Shri Debangshu Mullick, IFS
CCF, West Bengal Forest Department

FOREWORD

The Medicinal Plants Conservation Area (MPCA) program was initiated in the year 1993. This is considered as one of Asia's largest *In-Situ* conservation network in the form of about 112 MPCAs across 12 states of India of which 14 MPCAs are in West Bengal established in two phases. This report encompasses the unique findings on genesis of MPCAs and primary base-line data; various indices related to the biodiversity and population status of many threatened medicinal plants. The most important aspect covered in this report is the regeneration status of many conservation concern species and their gene pools.

The survey has established a strong base-line data that will help in long-term monitoring and management regime of MPCAs as well as the surrounding forest stands. Further the gene pool of the important species documented during the survey will help in meeting the objectives of National Medicinal Plants Board (NMPB) through developing and connecting with the national network of the medicinal plants gene pool conservation.

The current study has recorded around 350 species of medicinal plants in the MPCA. This report will help future researchers, Forest Officials and other stakeholders for better resource management, developing long term strategy for sustainable wild collection, cultivation and utilization pattern.

Shri Bidyut Sarkar, IFS
Conservator of Forest
West Bengal Forest Department

PREFACE

We are pleased to submit this report on the project "Assessment of medicinal plant diversity of Medicinal Plants Conservation Area (MPCA) in West Bengal, India". The second phase of this project has been implemented by The International Tagore Society for Cultural, Educational and Environmental Development (ITSCEED), Kolkata in collaboration with the West Bengal Forest Department and Darjeeling Govt. College. This project has been financially supported by National Medicinal Plants Board (NMPB), New Delhi. ITSCEED has been engaged with assessment of vegetation and imparting training on medicinal plants conservation, sustainable collection, value addition as well as marketing. The overall objective of ITSCEED is towards capacity building of the local communities for sustainable development while evolving strategies and doing action research. The foundation has been associated with biodiversity conservation with long term association and support of the West Bengal Forest Department.

The list of threatened medicinal plants of seven MPCAs of biogeographically different zones of West Bengal starting form Sal Dominated Forest of Purulia to foot hills of North Bengal plains and high altitude Darjeeling Himalaya were published by ITSCEED in collaboration with West Bengal Forest Department. Special attention has been given on medicinal plants conservation as the forests in India have been recognized for their rich diversity of medicinal plants. On the other hand tremendous pressure from the Pharmaceutical industries has increased the supply demand and unsustainable extraction of Medicinal Aromatic plants (MAPs). The West Bengal Forest Department conducted CAMP assessment to identify the threatened medicinal plants in the year 2007. It is one of the pioneering states and established seven MPCAs during the year 2007-09 in the first phase and seven more in the current efforts to conserve around 2800 medicinal plant species. This report, which encompass the result of the current extensive survey, will re-assure about the capture of the gene bank of various threatened medicinal plants, augmentation and other forest management activities through development of MPCA working plan. We look forward for more such productive action research and implementation programs between ITSCEED and WBFD to ensure conservation and sustainable use of wild resources vis-a-vis addressing the climate change issues.

Dr. Biswarupa Ghosh,
PI & Director, ITSCEED Foundation

ACKNOWLEDGEMENTS

The joint effort of State Forest Department, West Bengal and The International Tagore Society for Cultural Educational and Environmental Development (ITSCEED) in the field of medicinal plants conservation as well as training and capacity building of the local communities such as FPC, JFMCs, SHGs has been going on for long time. This effort has resulted towards better management of MPCAs, conservation of gene pools and sustainable wild collection, value addition and marketing of medicinal plants. We are obliged to the State Forest Department, West Bengal and National Medicinal Plants Board (NMPB), New Delhi for funding the Project.

We are grateful to Shri Piyarchand, the Principal Chief Conservator of Forests (PCCF), Research and Monitoring Division, West Bengal Forest Department, Shri Debanshu Mallick, IFS, the Chief Conservator of Forest, Shri Bidyut Sarkar, IFS, Conservator of Forest, Research Circle, West Bengal Forest Department for their coordination and Cooperation in the implementation of the project. We are also thankful to Mr. S.K. Mollay, IFS, Silviculture (Hills) Division, DFO, Mr.Surendra Prasad Sharma, WBFS, ADFO, Sri Raju Pradhan, FR, West Bengal Forest Department.

We also express our special thanks to Dr. Biswarupa Ghosh, Asst. Prof. BKC College, Dr. Debabrata Saha, Asst. Prof. ITSCEED, Kolkata for their active participation in the survey work and preparation of the project report.

We are very much thankful to Dr. Binod Chandra Sharma, Head, P.G. Department of Botany, Darjeeling Govt. College, Darjeeling. West Bengal, Mr. Nayan Thapa, Assistant Lecturer, Department of Botany, St. Joseph College, Darjeeling, Mr.NirajRai, Mr.Nitesh Ghatani, Mr.Leo Chhetri, Miss. Riya Das, Miss. Soumita Bhattacharjee, Mr. Amalesh Isore, Mr. Arpan Rai, Mr. Nishen Roy, Mr. Provanandan Barman, Researchers who actively participated in the project work without which the project would not get the present form. Thanks to Mr. Pawan Prasad, FR, Phalut for the cooperation and support extended during the survey. We are thankful to Dr. Arthur Mark for helping in data analysis and designing the layout of the report. Special thanks to Miss. Shreyashe Kar. Miss Aditi Saha, Mr. Anjan Singha, Miss. Dipika Jani, Mr. Baivab Saha, Ms Tista Debnath for their active participation in completion of the project report.

Co-PI
ITSCEED Foundation, Kolkata

TEAM MEMBERS

List of contributors from the Department of Forest, Government of West Bengal

Shri Piarchand, IFS	Principal Chief Conservator of Forests, Research, Monitoring and Development, West Bengal Forest Department.
Ms. Pratibha Raj, IFS	Additional Principal Chief Conservator of Forests, Research and Monitoring, West Bengal Forest Department.
Shri Debangshu Mallick, IFS	Chief Conservator of Forest, Research and Development, West Bengal Forest Department.
Shri Bidyut Sarkar, IFS	Conservator of Forest, Research Circle, West Bengal Forest Department.
Mr. S.K.Mollay, IFS	DFO, Silviculture (Hills) Division, West Bengal Forest Department.
Mr. Surendra Prasad Sharma, WBFS	ADFO, Silviculture (Hills) Division, West Bengal Forest Department.
Sri Raju Pradhan	Forest Range Officer

Researchers contributed in the project

Dr. Biswarupa Ghosh	Assistant Professor, Department of Botany & Project PI, ITSCEED Foundation, Kolkata
Dr. Debabrata Saha	Assistant Professor, Ecology and Environmental Science & Project Co-PI ITSCEED Foundation, Kolkata
Dr. Binod Chandra Sharma	Head, P.G. Department of Botany, Darjeeling Govt. College, Darjeeling. West Bengal
Mr. Nayan Thapa	Assistant Lecturer, Department of Botany, St. Joseph College, Darjeeling
Dr. Debabrata Das	P.G. Department of Botany, Darjeeling Govt. College, Darjeeling. West Bengal
Mr. Niraj Rai	Researcher
Mr. Nitesh Ghatani	Researcher
Mr. Leo Chhetri	Researcher
Miss. Riya Das	Researcher
Miss. Soumita Bhattacharjee	Researcher
Mr. Amalesh Isore	Researcher

Mr. Arpan Rai	Researcher
Mr. Nishen Roy	Researcher
Mr. Provanandan Barman	Researcher
Ms. Shreyashe Kar	Researcher, ITSCEED, Kolkata
Miss. Dipika Jani	Researcher, ITSCEED, Kolkata
Mr. Anjan Singha	Researcher, ITSCEED, Kolkata
Miss. Aditi Saha	Researcher, ITSCEED, Kolkata
Miss. Tista Debnath	Researcher, ITSCEED, Kolkata
Miss. Niharika Das	Researcher, ITSCEED, Kolkata
Mr. Baivab Saha	Researcher, ITSCEED, Kolkata
Miss. Oindrila Ganguly	Researcher, ITSCEED, Kolkata
Miss. Ananya Ghosh	Researcher, ITSCEED, Kolkata

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The State Forest Department of West Bengal has established seven Medicinal Plants Conservation Areas (MPCAs) across the state in the year between 2007 and 2009 identifying natural habitats that are relatively undisturbed forest areas hosting rich diversity of medicinal plants, and maintained as *in-situ* conservation sites to conserve and protect the medicinal plant resources covering different forest types in the state. At the time of establishment of MPCAs, a checklist of medicinal plants for each MPCA was prepared (WBFD, 2010). Overall, there were 891 medicinal plant species recorded. This is around 32% of total medicinal plant diversity of the West Bengal state (2800 species). Out of 891 species, 241 were trees, while 232 and 410 species were shrubs and herbs respectively. MPCA-wise medicinal plant species recorded were 30, 154, 206, 249, 209, 216 and 254 respectively in Bonnie camp, Dhotrey, Garpanchkot, North Rajabhatkhawa, North Sevoke, Sursuti and Tonglu (Saha et.al. 2022). Furthermore, during the current project, a total of seven additional MPCA areas have been surveyed and assessed during 2014 to 2018 for their biodiversity particularly the species diversity of medicinal plants while Phalut MPCA is one them which shows many important conservation concern medicinal plants with rich gene pool.

Considering the importance of the management of MPCAs, the West Bengal Forest Department sanctioned this project to assess seven additional MPCAs and evaluate the current status in terms of understanding the coverage of medicinal plants especially threatened plants within MPCA areas, and also estimating the population of plants across plant types viz. trees and climbers/lianas (adults, sapling, seedlings), shrubs and herbs . The outcomes of this project would provide information to plan better resource management and strategies at state level.

As a first step in this project, the detailed profile of the MPCA was prepared with the secondary information collated from various document sources to understand the nature and characteristics of MPCA sites selected in West Bengal. Site disturbance levels for the MPCA were assessed by scoring 15 factors and sites were grouped into three disturbance categories. Based on the field observations, the current status of the MPCA was described covering following aspects: entrance structure, boundary information, disturbance level, communication and interpretation utilities, trekking paths, departmental interventions, and presence of important medicinal plants.

Systematic mapping of MPCA landscapes with a help of satellite images provide insights on the areas or locations where the protection is needed, and how efficiently and effectively it

could be undertaken. An innovative application of using open-source GIS (Q GIS ver. 2.8.2) software technology was used for mapping the MPCA landscapes. The mapping process was carried out with latitude and longitude coordinates collected along the boundary of MPCAs to develop the spatial distribution maps.

In the next step, the qualitative assessment was attempted to inventorise and document the medicinal plant diversity of the MPCA through conducting seasonal vegetation surveys . The qualified and experienced botanists conducted the botanical surveys in the MPCA and collected medicinal plant samples in reproductive stages for herbarium specimen with appropriate field number and notes. This exercise was repeated in all the seasons to familiarise with the vegetation in different phenological stages and also to record the existence of even ephemerals. The survey was conducted keeping the IUCN methods and criteria for threat assessment in consideration (IUCN .2020; Pollock et al., 2003). The botanical surveys conducted under this study yielded a total of 267 medicinal plant species that are wild in the MPCA site .

.

Threatened status	No. of species	Traded	High traded*
Critically Endangered	5	2	3
Endangered	4	1	3
Vulnerable	3	2	1
Total	**12**	6	3

* Trading >100 MT of dry weight per year

As an interesting outcome of qualitative assessment of angiospermic taxa, namely, *Aconitum spicatum* (Brühl) Stapf,, *Podophyllum hexan*drum Royle, *Picrorhiza kurroa* Royle ex Benth, *Valeriana hardwickei* Wall., *Cinnamomum bejolghota* (Buch.-Ham.) Sweet, *Thalictrum foliolosum* DC. *Aconitum palmatum* D.Don, *Taxus wallichiana* Zucc., *Berberis aristata* DC., *Panax pseudoginseng* Wall., *Swertia chirayita* (Roxb.) H.Karst. etc. were recorded with their presence and habitats.

Summary of inventorization undertaken in Phalut Medicinal Plants Conservation Area (MPCA) in West Bengal

Tree species recorded	
# of species recorded	53

# of families	24
# of genera	43
# of threatened species	2
Shrub species recorded	
# of species recorded	57
# of families	30
# of genera	43
# of threatened species	1
Herb species and seedlings recorded	
# of species recorded	157
# of families	52
# of genera	107
# of threatened species	9

These species were found in reproductive state and hence the morphological features of fruits and seeds were provided *Paris polyphylla*.

The quantitative assessment of medicinal plants especially of conservation concern species was undertaken to quantify the population of medicinal plants through standardised sampling procedures and to assess the growth and structure of plant population in the MPCA. Field works for ecological survey were carried out using nested quadrat method. In a single 20m x 20m quadrat, which is used for the enumeration of woody plants of above 30cm gbh, one 5m x 5m sub-quadrats within (nested quadrats) for shrubs or saplings (≤30cm gbh size) and four 1m x 1m plots within the 5m x 5m sub-quadrats were laid for herbs or seedlings.

A total of 53 woody plant species (>30 cm gbh) belonging to 43 genera and 24 families were recorded across the Medicinal Plants Conservation Area (MPCA).

A total of 57 plant species (≤30 cm gbh) belonging to 43 genera and 30 families were recorded in Medicinal Plants Conservation Areas (MPCAs) in West Bengal.

The survey helped to document 157 plant species belonging to 107 genera and 52 families across the Medicinal Plants Conservation Areas (MPCAs).

Species-area curves for plant species enumerated in non-contiguous 20m x 20m quadrats, 5m x 5m quadrats and 1m x 1m sub-quadrats were drawn in the MPCA. Species curve reached an asymptote in all three plant habits indicating adequate sampling effort.

Tree species richness and abundance decreased with increasing girth class except for the largest size class (>100 cm) in the MPCA. The lower girth classes (31-40, 41-50 cm) contributed large proportion of woody plant species richness.

Out of 12 threatened plant species recorded in the qualitative assessment, 4 plants were found in the quadrat study. An important threatened woody plant species viz., Taxus wallichiana was recorded in 20m x 20m sampled quadrats. The primary outcome of this project is very encouraging in a way that the current MPCA proving to be a gene pool of medicinal plants of the state especially a number of conservation concern species with good and viable population.

Threatened species those were recorded during the botanical inventorisations *are Taxus wallichiana* Zucc. *Panax pseudoginseng* Wall., *Swertia chirayita* (Roxb.) H.Karst., *Aconitum palmatum* D.Don., *Cinnamomum bejolghota* (Buch.-Ham.) Sweet, *Aconitum spicatum* (Brühl) Stapf., *Podophyllum hexandrum* Royle., *Berberis aristata* DC., *Picrorhiza kurroa* Royle ex Benth., *Valeriana hardwickei* Wall., *Thalictrum foliolosum* DC., *Paris polyphylla* Sm.

This MPCA representing a specific forest ecosystems and landscape of the state is found to be rich in medicinal plant diversity in terms of number of species, number of threatened species, etc. In this MPCA, only a minimal percent of West Bengal state's medicinal plants diversity could be covered. It suggests that there are still more prospective medicinal plants rich forest sites, which could be established as MPCAs. As part of deduction, number of recommendations for medicinal plants conservation and its sustainable use have been described in details (Ved et al., 2003; Goraya and Ved. 2017). In the end, these endorsements were converted into activities or projects that are eligible for funding from the NMPB through Central Sector scheme . This exercise was intended to support the West Bengal Forest Department to make proposals in the prescribed formats for availing necessary funding from various funding agencies specially National Medicinal Plants Board.

MEDICINAL PLANTS CONSERVATION AREAS (MPCAS): NATIONAL AND WEST BENGAL PERSPECTIVE

Medicinal Plants Conservation Areas (MPCAs)

The West Bengal lies between the Himalayas in the north and the Bay of Bengal in the south. It is the only state in India where Himalayas are in the north bordering Sikkim and Bhutan and Sea is at the south with Assam and Bangladesh bordering the east, with both plains and plateaus covering the remaining region. On the west, it is bounded by Odisha, Bihar and Nepal. At present it has a total area of about 88,752 km^2. The state has a coastline of about 210 km. The varied and unique physical features in the state support to harbour diverse vegetation with enormous species diversity. The state has five well-defined phyto-ecological zones, viz. (i) The Himalayan zone of Darjeeling, between 500 and 3800 m, (ii) Sub-montane Terai region and the adjacent plain, (iii) Vast alluvial plain on both sides of the river Bhagirathi and its northern and western tributaries, (iv) The Western dry flanks of Chhotanagpur plateau and (v) Mangrove forests of Sundarbans majorly confined to South 24-Parganas. However, forest types and patterns of vegetation in certain subdivisions have been further classified after critical analysis by the ecologists and plant sociologists.

Total recorded forest land in the state is 11879 km2, of which 7054 km2 is Reserved Forest, 3772 km2 is Protected Forest and 1053 km2 is Unclassified State Forest, thus constituting 13.38% of the geographical area of the state. The forest cover including the forests created outside the recorded forest area is 15.68% of the geographical area in the year 2006. The vegetative cover of the state is around 27% of the geographical area, which includes village orchards/groves, tea garden and horticulture plantations. As per Champion's and Seth classification, out of 16 forest types present in India, West Bengal represents 10 forest types ranging from Darjeeling hills to Sundarbans Mangroves.

Based on the floristic studies, it reveals that the angiosperm flora of West Bengal state harbours about 3580 species under 1333 genera in 200 families. Besides, the state supports 21 species of Gymnosperms, 416 species of Pteridophytes, 771 species of Bryophytes, 873 species of Algae, 539 species of Fungi and 329 species of Lichens. There are 37 rare and threatened taxa in the state and 19 taxa have been described from West Bengal, which are not collected after type collection. There are about 850 species of medicinal plants in the state and about 1600 species are used by various tribal communities in the state. West Bengal harbours an enormous biodiversity of medicinal plants that occur right from the humid river valleys to the cold trans-Himalayan desert.

This biodiversity of medicinal plants and its sustainable utilization sustain the health, medicinal, spiritual and other need bases response offer to us. This biodiversity is the treasure house from which future food needs, cures for deadly diseases and various elements for knowledge and transfer of technology in near future. Recently, the biodiversity is seriously threatened by anthropogenic activities such as destructive activities, ill-harvesting, loss of habitats or degradation in its quality as well as quantity that leading to extinction of medicinal plants and also resultant dying out of our local traditional practices.

West Bengal is the pioneer state in India initiating Joint Forest Management Committees (JFMCs). The idea of establishing JFMCs had its origin at Arabari in Midnapur district of West Bengal. A movement was started with 618 families of the 11 villages to rejuvenate 1186 ha of degraded Sal forests in the early 70s. The community members participated in a set of activities of employment generation and enjoyed the sharing of NTFPs/medicinal plants from such forests. This community movement was adopted by the government and allowed a share of 25% of usufructs and net profit of the intermediate and final yield respectively. The JFMCs in the name of Forest Protection Committees (FPCs) and Eco-development Committees (EDCs), led to reasonable success in rejuvenating the degraded forests and bringing about economic upliftment of fringe population constituting the FPCs and EDCs through series of measures including implementation of people oriented development programs.

The people around forests are integral part of forest ecosystem and their livelihood needs are to be met as it is a critical issue in ensuring long term conservation of resources especially medicinal plants. There is a need to prepare a detailed action plan to conserve and sustainable use of medicinal plants to protect the cultural heritage, scientific manipulation, transfer of technology, sustain the spiritual beliefs and traditions. It correlates the recent activities of culture, resource and environment in the same ecosphere, which is directly related to innovations, and to prosper the equitable share of resource and the share of benefits arising from sustainable use in *in-situ* environment.

Medicinal Plants

Medicinal plants play an important role in supporting healthcare in India. According to the World Health Organization (WHO), 80% of the rural population in developing countries utilizes locally available medicinal plants for their primary healthcare needs. Medicinal plants are not only a major resource base for the traditional medicine & herbal industry but also

provide livelihood and health security to a large segment of Indian population. About 8000 species of medicinal plants are in current use by local communities all over India. There are about an estimated 40,000 herbal formulations recorded in India. About 90% of the country's medicinal plants are found in forest habitats. Only 10% of the medicinal plants are distributed among other landscape elements like open grasslands, agricultural pastures and in and around freshwater bodies, etc. About 1178 species of medicinal plants are estimated to be in trade of which 242 species have annual consumption levels in excess of 100 metric tons/year. The domestic demand of medicinal plants has been estimated 1,95,000 MT for the year of 2014-2015 and export demand of medicinal plants has been estimated 1,34,500 MT during 2014-2015. Total consumption of herbal raw drug in the country for the year 2014-15 has been estimated at 5,12,000 MT with corresponding trade value of ₹ 5,500 Crore. The major increase has been recorded in export value which has increased from ₹ 345.80 Crore in 2005-06 to ₹ 3211 Crore in 2014-15, registering a nine fold increase in during last decade.

According to the All India Trade Survey of Prioritised Medicinal Plants report, the medical plants market in India stood at Rs 4.2 billion in 2019 and expected to increase to Rs 14 billion by 2026. The market for medical plants in India stood at Rs. 4.2 billion (US$ 56.6 million) in 2019 and is expected to increase at a CAGR 38.5% to Rs. 14 billion (US$ 188.6 million) by 2026. The total world herbal trade is currently assessed at US$ 120 billion. There is an urgent need to conserve the wild populations of medicinal plant diversity at least in prioritized forest regions of India.

Medicinal Plants Conservation Areas (MPCAs)

Medicinal plants Conservation Area (MPCA) is a concept developed under the tenets of *in-situ* conservation methods. It is a well-defined and demarcated area within a protected and conserved forests and known for harbouring medicinal plants especially the threatened plant species. The establishment of a network of MPCA sites across different ecological zones is critical for conserving intra-specific gene pools of threatened and endemic medicinal plants, with special focus on species that are known to be in high volume trade. If their gene pools are not urgently conserved, these valuable medicinal species may soon go extinct. In that context, the central purpose of establishing MPCA network has been the in-situ conservation of the genetic diversity of wild populations of highly traded species with special focus on endemics and threatened species in order to firstly ensure their long term survival and secondly to provide

access to breeders of reproductive material for selection, breeding and also for ex-situ cultivation and plantations.

The selection of forest areas for the establishment of MPCAs is done based on the four important criteria. They are (1) the forest area with rich medicinal plants species (preferably endemic species) diversity; (2) undisturbed area by biotic factors as much as possible; (3) fairly larger area (about 200-500 ha) for better management; (4) reasonably accessible. The presence of viable population of conservation concern species was taken into consideration when MPCAs are established for specific species (conservation concern/threatened medicinal plants). Two approaches are followed for the selection of MPCA sites: (1) capturing maximum diversity of medicinal plants; (2) capturing conservation concern medicinal plants. To cover maximum medicinal plant diversity, MPCAs were established across different forest types and forest landscapes.

The scientific execution of MPCA network needs four kinds of prior information: (1) knowledge about medicinal plant species, which are in high volume trade, and are largely sourced from wild forest habitats; (2) threatened status of medicinal plants as per IUCN criteria especially for high-traded and/or endemic species; (3) reliable information on the natural geographical distribution of the high-traded and endemic or threatened species; (4) ready access to data base on the medicinal flora of region. Based on this information, forest managers and policy makers are supposed to decide on the establishment of MPCA at a specific site.

There are eight steps strategy followed for the execution of this MPCA program:

1. Create database on medicinal plants of India (from referenced medical literature including ethno botany and ethno medicine sources) with accurate correlation between vernacular, Sanskrit and botanical names
2. Generate sub-databases of medicinal plants of every State, District and Taluka in the country
3. Generate geographical distribution data on medicinal plants of India (sourced from floras, herbaria) and place it on appropriate GIS platforms particularly for species of conservation concern
4. Identify medicinal botanicals in all India trade with accurate correlation between trade and botanical names
5. Apply IUCN criteria to identify threatened medicinal botanicals at State levels

6. In respect of high priority threatened species, undertake genetic sampling across their distribution range in order to identify hot-spots of intra-specific genetic variability of threatened species
7. Identify ecologically suitable sites for creation of MPCAs for in-situ conservation of both species diversity and for species of conservation concern
8. Review the gaps at State levels every 3 years in the national in-situ conservation MPCA program

The number of MPCAs needed to conserve gene pool of a particular species depends on the extent of its distribution range. For example, an endemic species may require only one MPCA to conserve its gene pool, but a widely distributed species may require several MPCAs to capture its diverse gene pool. The number of MPCAs established currently is far less than the required number of MPCAs to capture the diversity of wild medicinal plants in the country. This is because the 108 MPCAs established could capture only little more than half of the wild medicinal plants of India. Forest ecosystems generally have different patterns of species composition and distribution pattern. Some species exhibit gregarious distribution, and some are sparsely distributed. Some forest patches show high diversity, while some are dominated by few species only.

Realising the concern on the conservation of natural resources in general and medicinal plants in specific, the pioneering nation-wide program of establishing MPCA sites for medicinal plants was initiated. In the last two and half decades, a network of 108 MPCAs has been established across 13 Indian states involving the respective State Forest Departments and local communities with financial support from external funding agencies including DANIDA, UNDP and GEF grants under the guidance of Ministry of Environment, Forests and Climate Change (MoEF & CC), Government of India. The list of MPCAs established so far in 13 states is provided in Annexure 1. Through this network of MPCAs, now the representative populations of more than 3500 medicinal plant species are being conserved in the wild through the network of MPCAs.

Having understood the importance of a network of wild gene banks for medicinal plants, the National Medicinal Plant Board (NMPB), Government of India, is currently involved in establishing Medicinal Plant Conservation and Development Areas (MPCDAs) through State Forest Department across the country. There are 72 MPCDAs already established by the NMPB across 13 states. According to NMPB website, as of 30th November 2016, around

18,889.45 hectares of forest cover have been brought under MPCDAs (96 in numbers) in India. Besides, the NMPB extends financial support for the establishment and maintenance of MPCDAs across country under their central sector scheme. Though MPCDA program has been best implemented by State Forest Departments with the support and coordination from the NMPB, considering the complexity of the program, a technical support for the program from competent knowledge institutions is certainly warranted for the execution of this program at national level.

Medicinal Plants Conservation Areas (MPCAs) in West Bengal

As part of conservation efforts, the FRLHT in collaboration with West Bengal Forest department had conducted series of threat assessment workshops involving 53 subject experts to identify conservation concern species and locate their wild populations across the state. The Conservation Assessment and Management Prioritisation (CAMP) workshop was conducted on Kolkota in December 2007 to assess medicinal plant species for Red Listed status following IUCN guidelines. Out of 148 medicinal plants proposed for assessment, 46 species were assessed for threatened status. The breakup of taxa is as follows: Critically Endangered (CR): 6, Endangered (EN): 19, Vulnerable (VU): 15, Near Threatened (NT): 3 and Least Concern (LC): 3. One of the important outcomes of organising CAMP workshop was the identification of flagship species and of potential sites for the establishment of MPCAs in West Bengal.

As part of the implementation of National Program on Promoting Conservation of Medicinal Plants and Traditional Knowledge for Enhancing Health and Livelihood Security in West Bengal, the State Forest Department established a network of Medicinal Plants Conservation Areas (MPCAs) across the state. Based on the inputs from the Conservation Assessment and Management Prioritisation (CAMP) workshop, different conservation sites were identified for in-situ conservation of medicinal plants. These sites were selected in order to cover each of the four major biogeographic zones of West Bengal, different forest types, the distribution and abundance of high-traded and threatened medicinal plants and habitats important for them. Following criteria were considered at the time of selecting potential sites for the establishment of MPCAs in West Bengal: (1) sites with a varied diversity of vegetation comprising medicinal plants; (2) relatively undisturbed patch with reasonable accessibility; (3) sites representing a particular forest/vegetation type; (4) sites traditionally known for its medicinal plant richness; (5) a compact block under Biodiversity Conservation Working Circle in territorial and wild life areas so that no felling operations are legal; (6) sites that are part of

Protected Area or Reserve Forest or Tiger Reserve area, etc. with legal protection. Subsequently, seven sites were identified for establishing MPCAs to protect the critically endangered and endangered medicinal plant species (Table 1 and 2, Figure 2). To conserve and protect the medicinal plant resources in the wild, as part of in-situ conservation methods, the State Forest Department with technical support from the FRLHT has established seven Medicinal Plants Conservation Areas (MPCAs) between 2008 and 2010 across different forest types in West Bengal.

Table 1. Locations of seven MPCAs previously formed in West Bengal

Sl.No	MPCA	Forest range	Forest division	District
1	Bonnie camp	Raidighi	24-Parganas (South)	24-Parganas (South)
2	Garpanchkot	Raghunathpur	Kangsabati (North)	Purulia
3	North Rajabhatkhawa	Buxaduar	Buxa Tiger Reserve (East)	Jalpaiguri
4	Sursuti	Lataguri	Jalpaiguri	Jalpaiguri
5	North Sevoke	10th mile	Wildlife-I	Jalpaiguri
6	Dhotrey	Dhotrey	Darjeeling	Darjeeling
7	Tonglu	Tonglu	Darjeeling	Darjeeling

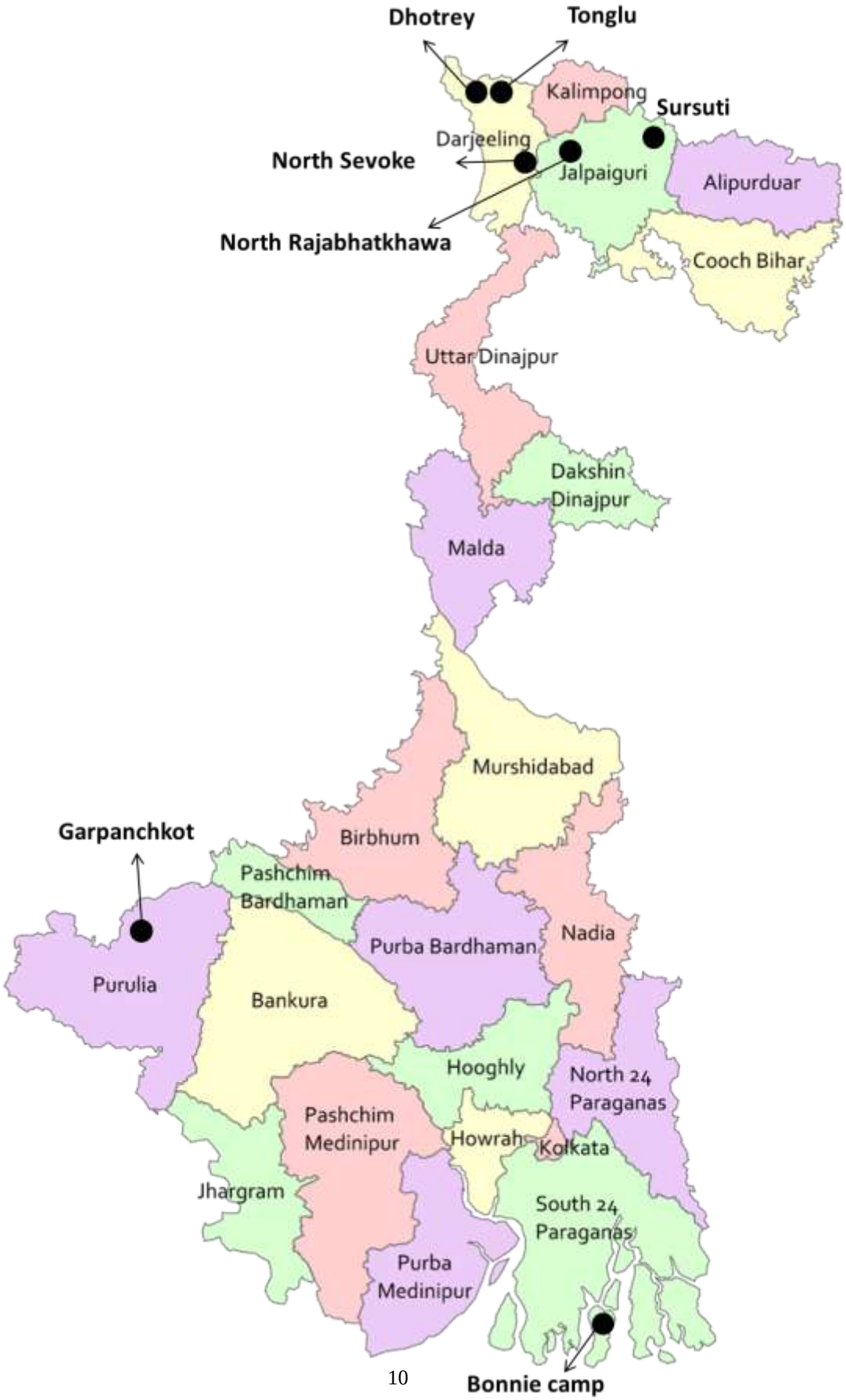
MPCA sites were carefully identified by the West Bengal Forest Department with inputs taken from the CAMP workshop and consultations with subject experts and local forest officers. They were established to capture the gene pools of the regenerating populations of high-traded endemics and threatened medicinal plants that were assessed during the CAMP workshop. Nevertheless, there is a lack or inadequacy of field data especially about the medicinal flora, traded and threatened species or their geographical distribution. It is important to generate relevant field data at least for the prioritised species and followed by the ground truthing and assessment to examine the changes in population of conservation concern medicinal plants. Better understanding and knowledge of different components in the MPCAs are expected to strengthen the MPCA program and ensure the protection of gene pools of medicinal plants in its natural landscapes.

Table 2. Details of seven MPCAs previously established in West Bengal

Name of MPCA	Year formed	Forest types	Area (ha)	Latitude	Longitude
Bonnie Camp	2008-09	Littoral and Swamp – Mangrove (4B)	300	21° 83’	88° 63’
Dhotrey	2008-09	Montane wet temperate (11B)	180	27° 05’	88° 07’
Garpanchkot	2008-09	Tropical dry deciduous (5B)	250	23° 63’	86° 77’
North Rajabhatkhawa	2008-09	Tropical moist deciduous (3C)	400	26° 68’	89° 55’
North Sevoke	2008-09	Tropical moist deciduous (3C)	100	26° 87’	88° 45’
Sursuti	2008-09	Tropical moist deciduous (3C)	100	26° 63’	86° 77’
Tonglu	2008-09	Montane wet temperate (11B)	230	27° 03’	88° 08’

Considering the importance of establishing MPCAs across West Bengal, the Office of the Conservator of Forests, Research Circle, West Bengal Forest Department has identified 4 more sites for MPCA program with the support of the National Medicinal Plants Board (NMPB) under the AYUSH ministry of Govt. of India. This project was proposed to evaluate the medicinal plants diversity of four MPCAs newly established in West Bengal. At the time of establishment, field data on plant diversity was mandated to prepare a checklist of medicinal plants of each MPCA. In the current survey, the presence of threatened plants needs to be noted, and the population of those plants need to be measured and assessed. This report is expected that there will be better understanding of medicinal plants diversity and their population status in newly established MPCAs.

Figure 1. Map locations of seven MPCAs previously established in West Bengal



PROJECT OBJECTIVES

Objectives

The overarching objective of this work was to survey the newly established Phalut MPCA in West Bengal to understand the status of MPCA in terms of medicinal plants diversity and population level through thorough botanical surveys and quadrat assessment. Following activities were planned to be undertaken in Phalut MPCA:

- inventorisation and documentation of medicinal plants diversity in the MPCA;
- conducting vegetation surveys in the MPCA;
- measuring the overall diversity of medicinal plants;
- measuring the species diversity and frequency of medicinal plants in MPCA;

Following are the tangible deliverables expected from the implementation of this project

- A checklist of medicinal plants recorded in Phalut MPCA
- Population assessment of medicinal plants especially conservation concern species through quadrat study
- Major threats identified in Phalut MPCA and recommendation for management of selected species

In the end, this work was expected to generate information and knowledge on medicinal plant species diversity and their status in newly established Phalut MPCA in West Bengal. So that better resource management and strategies can be planned at the state level. It would also provide the scope and opportunity available for the participation of local community members.

CHAPTER 1: GENERAL INFORMATION ABOUT PHALUT AND SEVEN OTHER OLD MPCAS ESTABLISHED IN WEST BENGAL

Introduction

In West Bengal, forests cover an area of 11,879 sq. km, which is 13.38% of the state's geographical area (India State of Forest Report 2019). State is rich in the biodiversity of both flora and fauna. Vegetation in West Bengal varies from temperate and sub-alpine forests of Darjeeling to Estuarine plains of Sundarban. Forests in West Bengal have a rich assemblage of diverse habitats and vegetation designated with the help of eight different forest types. The diverse fauna and flora of West Bengal possess the combined characteristics of the Himalayan, sub-Himalayan and Gangetic plain. Covering just 2.7% of the Indian landmass it is home to 12.27% of Indian biodiversity known till date. The state has more than 7000 species of described flora including bacteria, algae, fungi, bryophytes, pteridophytes and angiosperms and more than 10000 species of described fauna. According to the database developed by the Foundation for Revitalisation of Local Health Traditions (FRLHT), the checklist of medicinal plants of West Bengal consists of a total of 2800 taxa. Out of 2800 medicinal plant species recorded in West Bengal, a large portion of species, around 80-85% are sourced from wild, out of which, around 46% of medicinal plant species are herbs, followed by trees (23%) shrubs (21%) and climbers (10%). These plants spread over different types of ecosystems like mountain ecosystem of the north, forest ecosystem extending over the major part of the state, freshwater ecosystem, semiarid ecosystem in the western part, mangrove ecosystem in the south and coastal marine ecosystem along the shoreline.

As part of conservation efforts, the West Bengal Forest department had conducted series of threat assessment workshops, which is called the Conservation Assessment and Management Prioritisation (CAMP) workshop, to identify conservation concern species and locate their wild populations across the state. Through organising CAMP workshop, flagship species and potential sites for the establishment of MPCAs in West Bengal were identified. To conserve and protect the medicinal plant resources in the wild, as part of in-situ conservation methods, the State Forest Department established Medicinal Plants Conservation Area (MPCA) in Phalut, Darjeeling district in West Bengal. The short listed areas in Phalut were identified, surveyed and demarcated using a GPS system. The establishment of the MPCAs involved demarcation of the area as an entry point activity. This was followed by botanical inventorization through sampling process, enumeration and plant specimen collection, preparation of herbarium through processing and accession of specimens. The detailed profile

of Phalut MPCA was prepared with the secondary information collated from various document sources to understand the nature and characteristics of Phalut MPCA in West Bengal.

Physical features

Table 3: Physical features of the Phalut MPCA .

MPCA site	**Phalut MPCA**
Location information	
Compartment no	3,4&5
Beat	Ghorkhey
Block	Phalut
Range	Singalila North Range
Forest division	Darjeeling Wildlife Division
Panchayat	Rimbick
Revenue Block	Lodhoma
District	Darjeeling
Boundaries	Sikkim state borders on the north, Nepal borders on the west
Nearby villages	Gorkhey Forest Village (16 km) Samanden Forest Village (20 km) Ramam Forest Village (29 km) Srikhola Forest Village (38 km)
Distance from nearest towns	Darjeeling is 134 km from site, and Rimbick is located at 46 km from site
Approach from nearby places	*Road* - NH 55 - Sandakphu Road, a famous trekking entry point is 81 Km from MPCA *Rail* - New Jalpaiguri (NJP) (184 Km) *Airport* – Bagdogra airport (170 Km)
Area covered (in ha)	397
Latitude	N 27˚ 11’ 50.40”
Longitude	E 88˚ 03’ 33.80”
Altitude	2931m

Waterbodies (inside & outside)	Rammam and Sirikhola are the two rivers flow close to the site.
Climate information	
Temperature in ^{0}C (at nearby station)	Maximum of 32^{0}C; Minimum of 15^{0}C
Precipitation in mm (at nearby station)	3000 mm per year
Seasons & monsoons	November to February months are marked by a number of cloudy and foggy days, while July receives maximum rains from South-west monsoon. Occasional storm weather with high to moderate wind speed during pre-monsoon showers.
Soil information	
Rock formation	Typical moderate to precipitous formation. Following rocks were found: Bhabar (recent alluvium glacial), Nahan (lower tertiary), Damuda (lower Gondwana, carboniferous), Baxa series (Algonkian), Daling series (Archaean), Darjeeling gneiss (Ditto)
Soil type	Clayey loam
Administration information	
Legal status	Singalila National Park (reserve forest)
Local community information	
FPCs/EDCs & area assigned	Gorkhey, Samanden, Ramam and Srikhola
Means of livelihood	Home stay, Eco-tourism, daily wages and NTFP collection
Percentage of NTFP collectors	Substantial no of people engaged in medicinal plants collection and trade

Topographic details of locations

Systematic mapping of landscapes with a help of satellite images provides insight into the areas or locations where the conservation has to be initiated. Such topographic maps are required to understand the extent of protection needed and how efficiently and effectively it could be undertaken. This was attempted through documentation of secondary information available in the previous forest management plans and mapping of the boundary of Phalut MPCA to arrive at a complete picture of topographic details. The mapping process was carried out to understand the topography of newly established Phalut MPCA in West Bengal. Through this exercise, the precise locations were depicted in the state map with the information provided by current field surveys. The GPS coordinates of multiple locations along the boundary was helpful in this process.

Figure 2. Locations of newly established MPCAs in the Darjeeling district, West Bengal

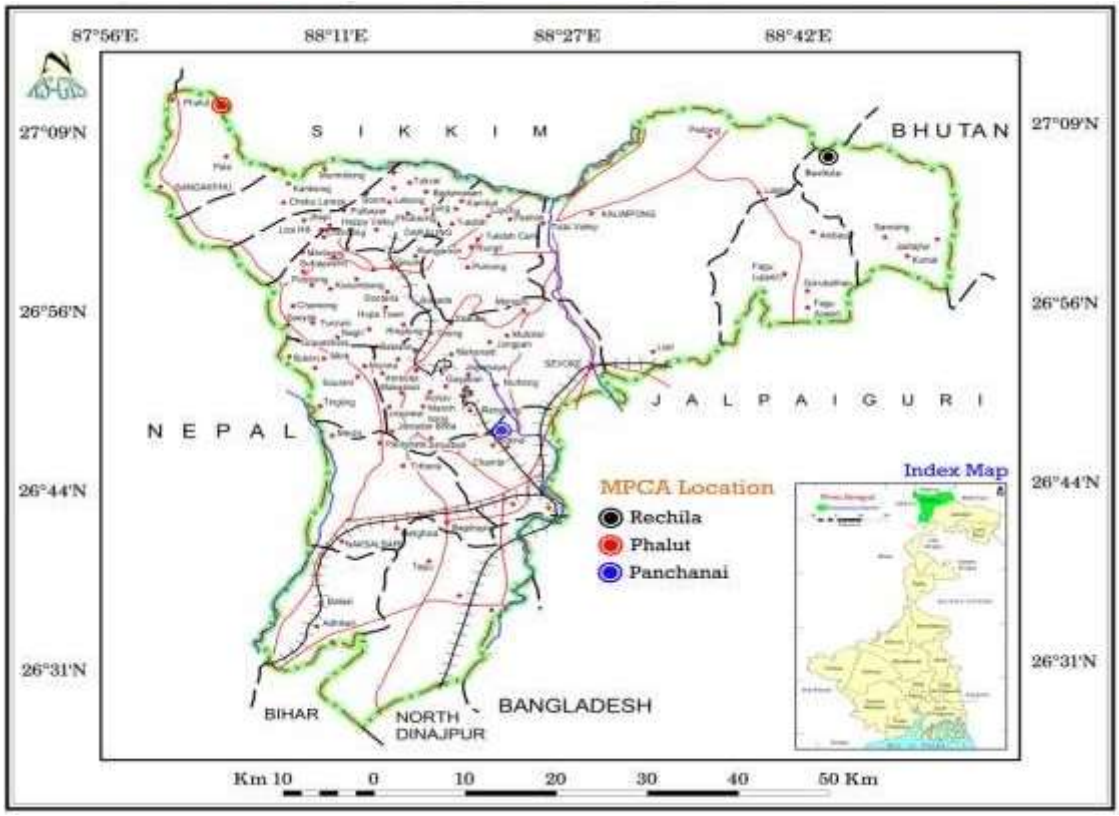


Figure 3. Location of Phalut MPCA in the Darjeeling district, West Bengal

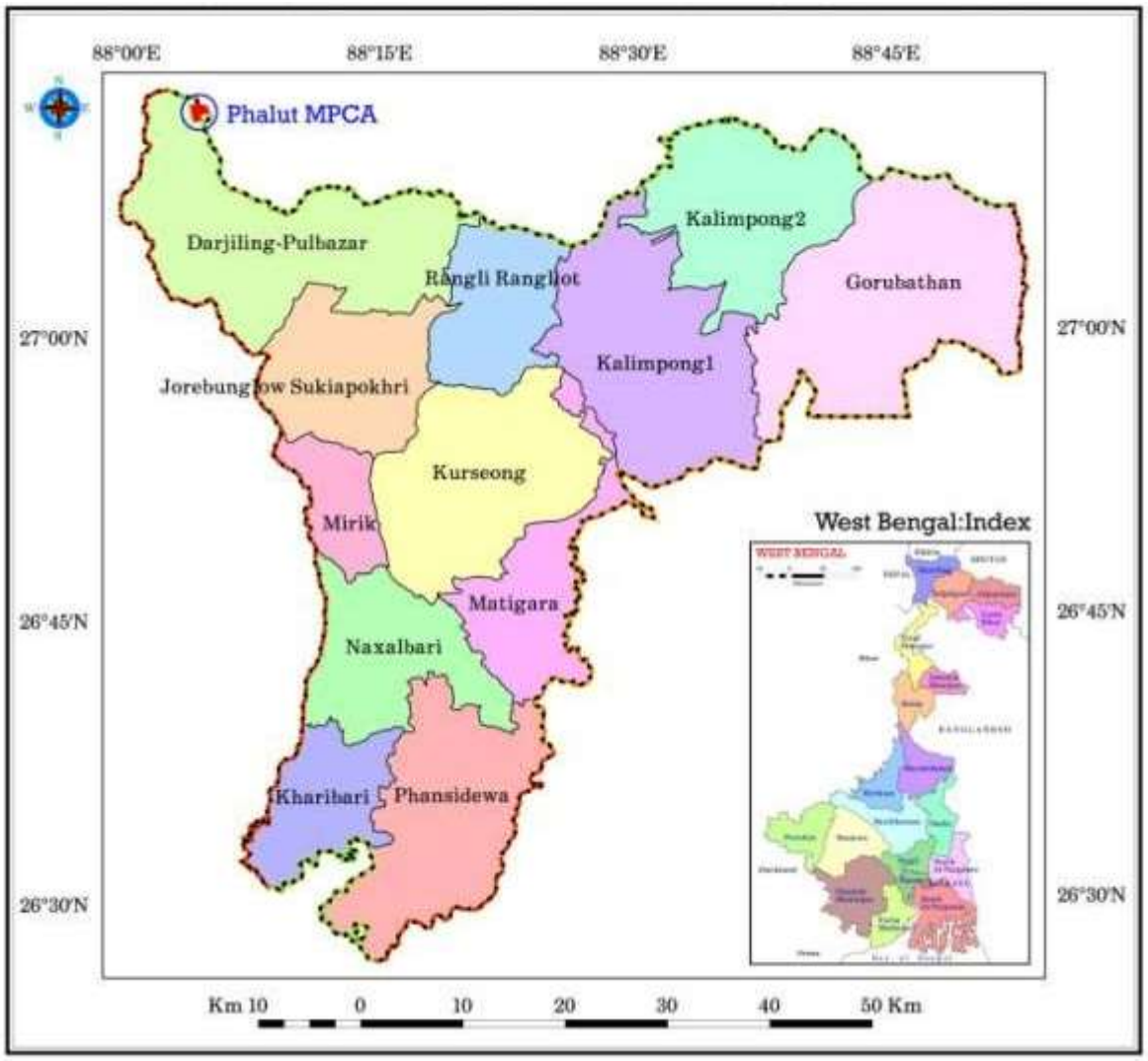
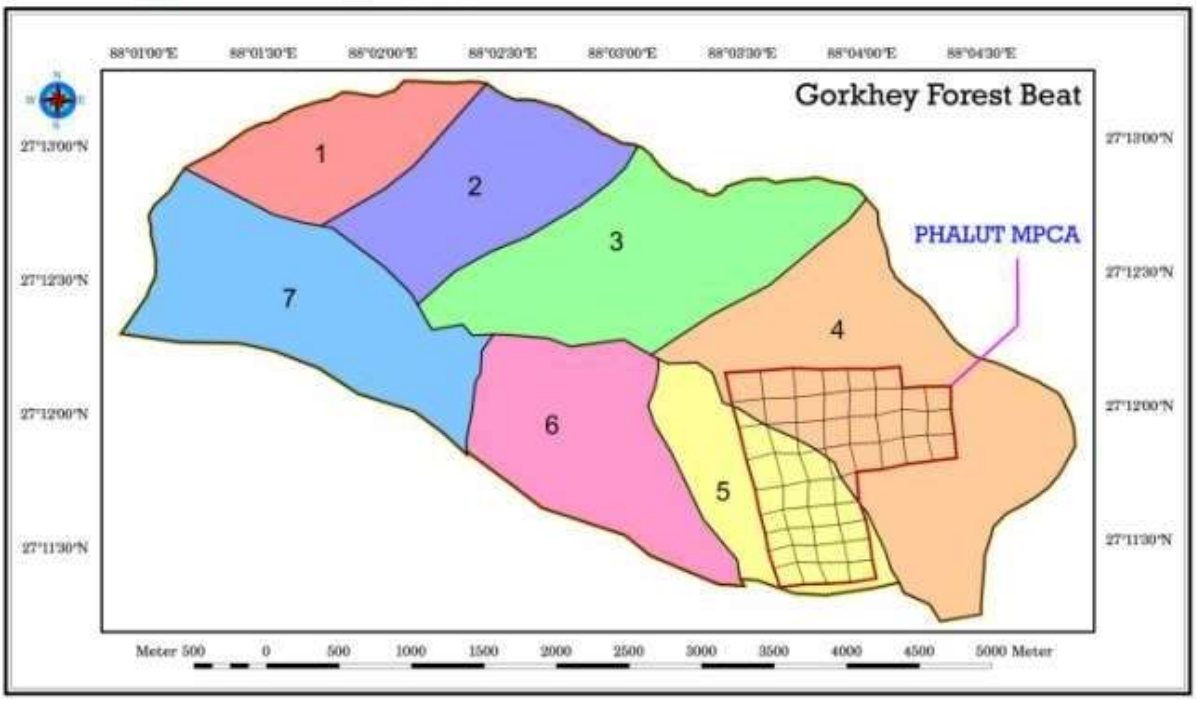


Figure 4. Location of Phalut MPCA in the Darjeeling district, West Bengal



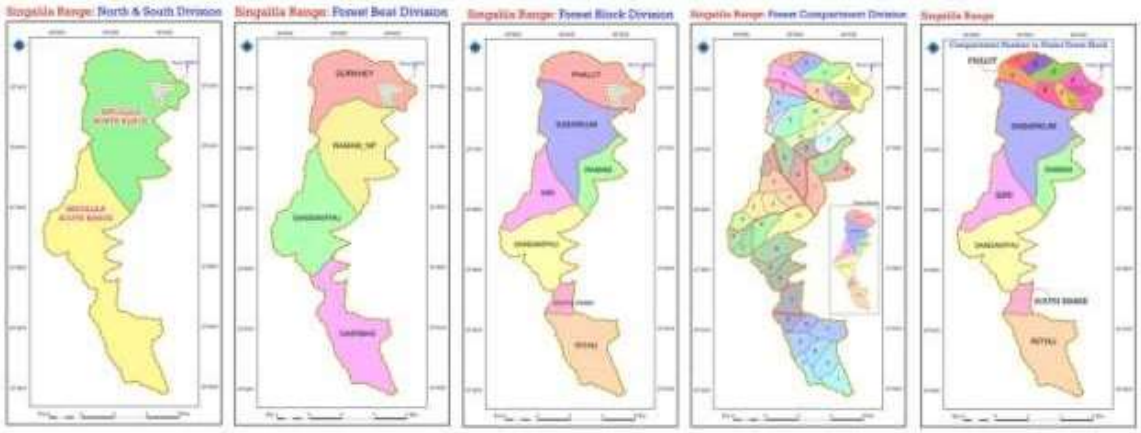
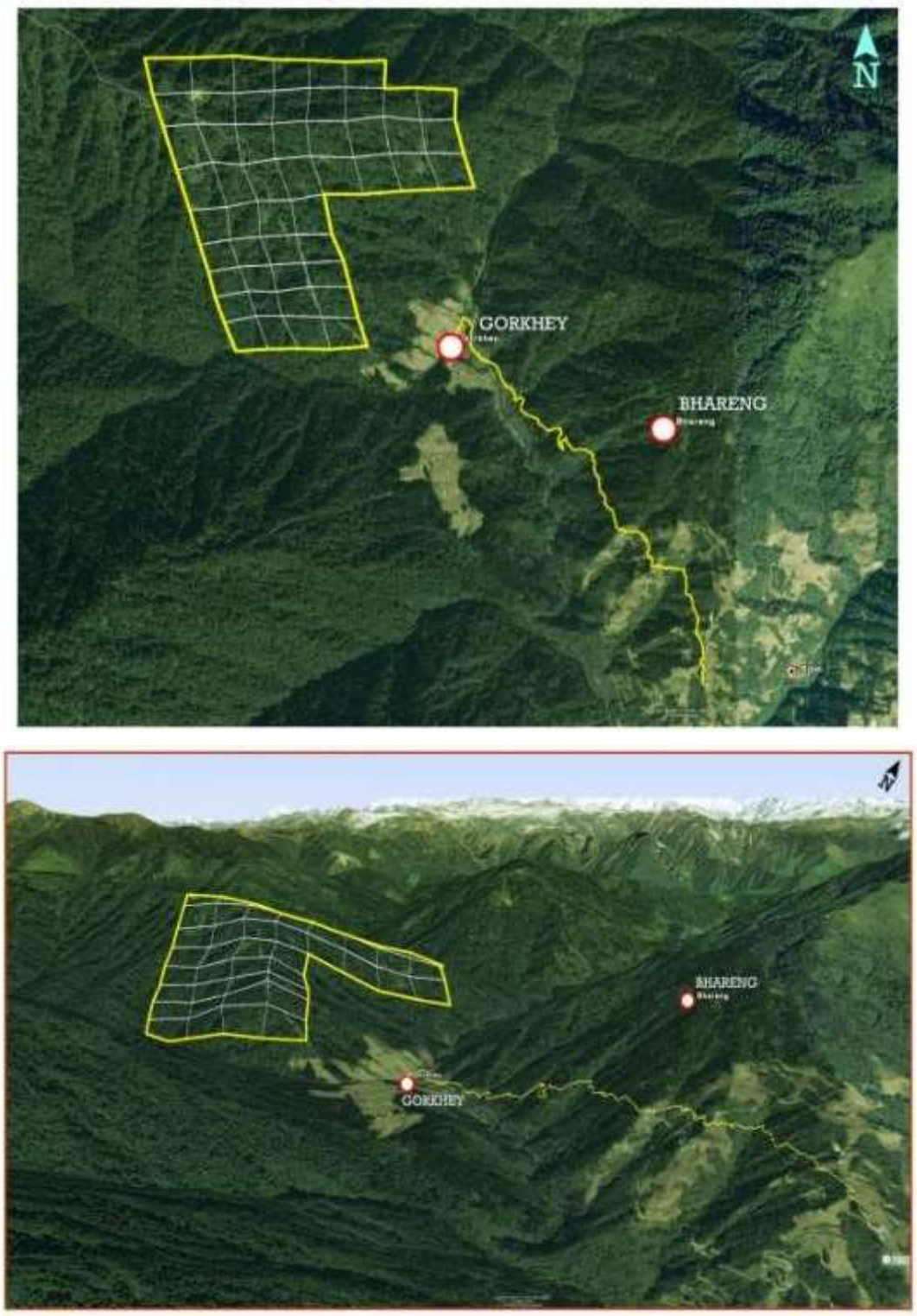


Figure 5. Topographic maps of Phalut MPCA in the Darjeeling district, West Bengal



Forest and vegetation types

Forest types of Phalut MPCA lies in the typical East Himalayan sub-alpine forest (14/C2; Champion & Seth,1968) of Northwest Bengal. It has been classified as Temperate broadleaf and mixed forest vegetation system. Phalut is one of the highest peaks of Singalila range and located at an altitude of around 3600 m from MSL. The Phulat MPCA site faced the least biotic damage in the region over time and that they are quite rich in bio- resources. Forest mouzas in and around Phalut are the least disturbed, due to terrain complexity and they represent the natural vegetation of the subtype known as sub-alpine birch/fir forest under the eastern Himalayan sub-alpine forest. These forests consist one of the last tracts of virgin wilderness in the state, sustains a unique ecosystem that still harbours a wealth of Himalayan flora especially medicinal plants. The crown density is medium, while the age structure of dominant species seems to be natural. Following are the important plant species recorded in Phalut MPCA across forest storey: top storey trees are Sour, Hemlock, Buck, Phalat, Ghogey Champ etc., middle and lower storey trees are Taxus, Ghuras, Tanga, Oak etc. There are number of orchids present in this MPCA. The undergrowth shrubs and herbs largely consist of number of bamboo species (*Bambusa* spp.) and Daphne spp. The regeneration status of plants are profuse as there are seedlings and saplings present throughout the forest floor. The presence of leaf litter and fallen tree leaves are common inside the forest floor. Climbers are largely dominated by *Smilax aspericaulis* (Kukur dahine), *Clematis* spp. (Pinase lahara), Indrini, etc. in this MPCA.

Disturbance and threat perception

There is no practice of dry fuel wood collection in Phalut MPCA. No usufruct rights and concessions within the MPCA are allowed as it is a part of a national park. Phalut MPCA is mostly visited by local forest dwellers for collecting fuel wood, NTFPs etc. Besides, the MPCA site is free from grazing and other biotic interference like illicit felling, etc. The collection of non-wood forest products from the MPCA site is not happening. Forests Village community members adjoining the MPCA areas are not dependent on forest resources and hence there are no anthropogenic activities. It is inevitable that Rachila MPCA needs some sort of protection from grazing & other human interference etc. Forest fires can be a threat to the park, especially in Spring when the accumulated debris from winter can be a hazard. Though the majority of plant species are of broad leaved deciduous in nature, but there have not been fire incidences at forest floor inside the MPCA. No major weeds are

noticed in an around the Phalut MPCA. No major erosion within this MPCA site except a few channels and gallis of smaller sizes are formed due to under current flow of rain during the monsoon which usually dries up during the month of winter. The major issues at the MPCA site are trash left on trekking routes by trekkers who frequent this route and ensuring minimal damage of flora by trekkers,

Site disturbance levels were assessed with the information documented from the literatures and field observations. Site disturbance levels were examined by scoring 15 factors that are reported to disturb the intrinsic nature of ecological and anthropological interactions present in the MPCAs, which include distance from the human habitation, nature of surroundings, access to MPCA, boundary wall/fence, presence of RET species, regeneration ability, vegetation canopy openness, trekking paths, tourist attractions, public entry inside MPCA, details of resource removal from MPCA, fire incidences, weed and invasive species, and departmental activities (Annexure 2). Based on the site disturbance scores arrived for Phalut MPCA, it can be considered as 'least disturbed' site (Table 4). Sites with low score experience least disturbance. The categorization of MPCA sites is made to examine whether the population levels of medicinal plants in MPCA are faring regardless of different levels of disturbance.

There is a trek along the Singalila Ridge to Sandakphu and Phalut, which is one of the most popular ones in the Eastern Himalayas, due to the grand vistas of the Kangchenjunga range, and the Everest range which can be seen from the ridge, and also for the seasonal wildflower blooms and birding. Besides, there are some threats perceived for this Phalut MPCA site especially for medicinal plants population:

- Lack of knowledge amongst villagers regarding use and threat of species
- Soil erosion in open areas without big trees
- Illicit tourist entry for adventure and thrill

Table 4. Assessment of disturbance levels in Phalut MPCA sites by scoring 15 factors

[Least disturbed (Score <26); Moderately disturbed (Score 26-36) and Highly Disturbed (Score >36); Allowed range of scores per factor provided = 0 to 5]

Sl. No	Site elements	Sl. No.	Score
1	Nature of surroundings – sides surrounded either by agricultural lands/plantations or human settlements 1 = One side only 2 = Two sides 3 = Three sides 4 = All four sides	1	1
2	Boundary wall/fence around MPCA especially areas bordering with human settlements/non-forest landscapes 0 = Barbed wire fencing in all four sides 1 = Barbed wire fencing in part of sides 2 = Barbed wire fencing in sites bordering roads 3 = Barbed wire fencing in sites nearing the entrance 4 = no boundary walls/fence	5	4
3	Access to MPCA site from main road/human settlement 1 = mud road 2 = Metal road/concrete road	1	1
4	Distance from human settlement 1 = >500 meters from site 2 = 100 – 500 meters from site 3 = 100 meters from site 4 = houses bordering with MPCA 5 = houses within MPCA	1	1
5	Presence of RET species 1 = > 10 species 2 = 5 – 10 species 3 = < 5 species	1	1
6	Regeneration of conservation concern species (seedling and sapling stages) 1 = > 10 species 2 = 5 – 10 species 3 = < 5 species	1	1
7	Vegetation canopy openness 1 = Small canopy gaps, but few 2 = Small canopy gaps, but many 3 = Large canopy openness	1	1
8	Number of trekking paths 1 = One		

Sl. No	Site elements	Sl. No.	Score
	2 = Two 3 = More than two		
9	Frequency of general public entry inside MPCA areas 1 = Occasional 2 = Pilgrimage times 3 = Fair & festival times	1	1
10	Presence of tourist attraction 1 = Water falls 1 = Temple structure 1 = Passage to towns 1 = Historical or ancient sites 1 = Trekking areas	5	1
11	Resource extraction 1 = Firewood 1 = Fodder 1 = Timber 1 = Medicinal plants 1 = Soil or manure 1 = Water for agricultural/domestic purpose	1,2, 3 &4	4
12	Vulnerability of fire incidences 0 = No history of fire incidences 1 = Less chance 2 = Moderate chance 3 = High chance	1	1
13	Extent of area vulnerable for fire incidences 0 = No history of fire incidences 1 = < 10 ha 2 = 10-50 ha 3 = > 50 ha	1	1
14	Presence of weed and invasive species 1 = 1-5 weed species 2 = 6-10 weed species 3 = more than 10 weed species	1	1
15	Departmental activities apart from what is approved 0 = No interventions undertaken 1 = Planting of plant materials 1 = Removal of NTFPs and fuelwood 1 = Grazing of animals	3	1
		Total	20

- Least disturbed

Management interventions

The park was declared a Wildlife Sanctuary in 1986 and was made an Indian National Park in 1992. The region had long been used as the trekking route from Manebhanjhyang to Sandakphu (the highest peak of West Bengal), and Phalut. It is bordered on the north by the state of Sikkim and on the west by the country of Nepal. The park has no significant history of human settlement. However, small settlements have grown up along the trekking route to Sandakphu and Phalut. There is a reasonably large village at Kala Pokhri, around the lake of the same name.

CHAPTER 2: MATERIALS & METHODS

Vegetation at a particular site is the result of interaction of various climatic and biotic as well as edaphic (soil) factors. This study was envisaged as a composite study related with living and non-living components as a whole in the selected MPCA areas. In the community, during the course of succession, many tree species compete with each other to establish their hold on the vacant niches. The study of association in response to community structure was also attempted with the help of ecosystem indices available for herbs, shrubs and trees. This work had field research activities to undertake a rapid population assessment of medicinal plants species of Phalut MPCA. The quantitative plant diversity inventories are the fundamental tool for conservation and management of forest ecosystems, but as far as MPCAs are concerned they are limited. Much of the current knowledge was still based on the qualitative surveys conducted as part of establishment of MPCAs, which mainly dealt with the floristic account of trees and climbers. However, quantitative inventories of medicinal plant species in Phalut MPCA were still lacking. Hence, the present investigation was undertaken.

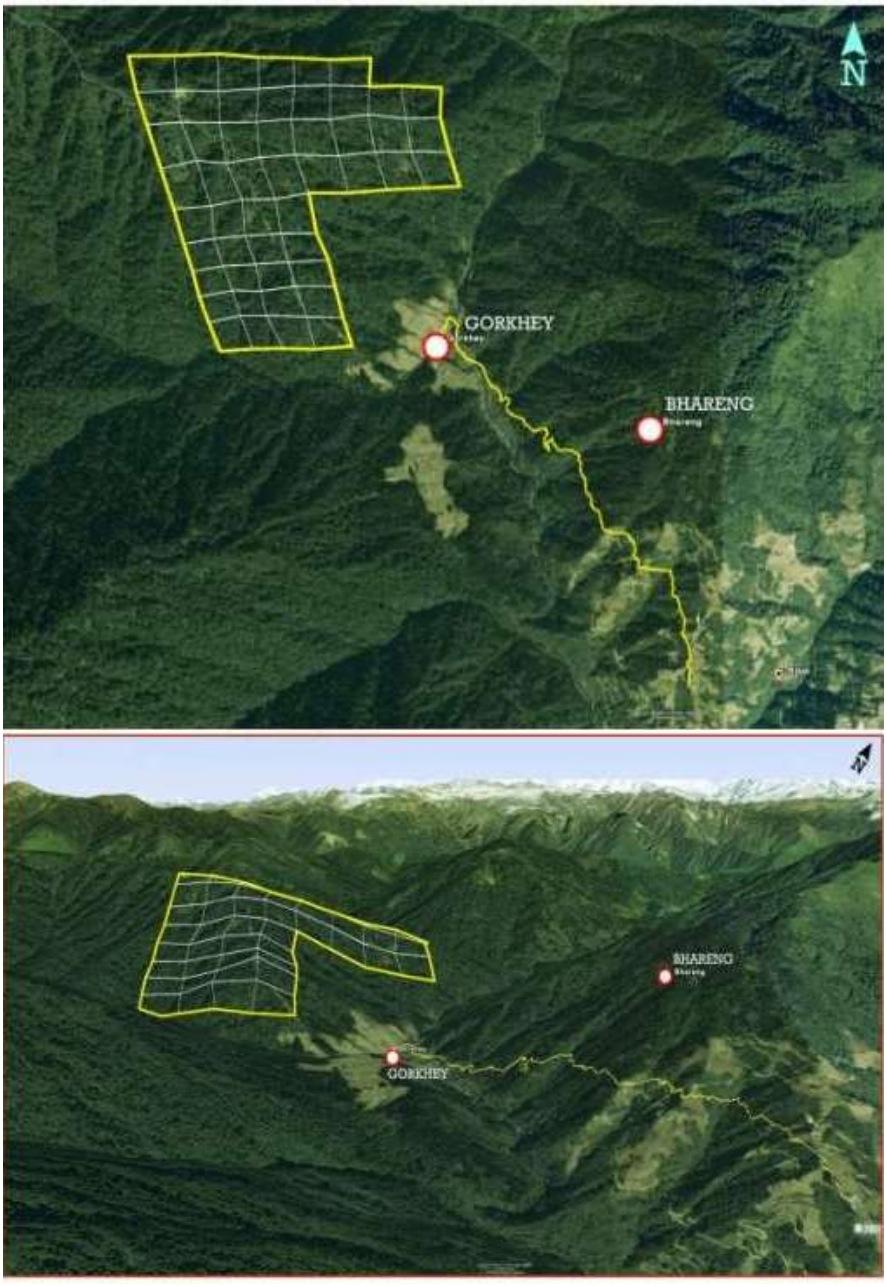
Grid layout

It is quite difficult to survey the whole area covered under MPCA as surveying takes more time and money. Therefore, the sample survey method was attempted. Out of 200 ha of total area (1000 m x 2000 m), 5 % i.e., 20 ha was selected as a sample area. The method of choosing the sample have to be unbiased and efficient one, otherwise the results would be erroneous. The samples should represent the population in all respect. Since the density of forest need not be the same across entire MPCA area to look homogenous. To avoid, the technique of stratified random sampling method of sampling was attempted through sub-divide the MPCA area into grids. These grids are known as strata coming from stratified sampling. From these strata, samples were taken randomly using random number technique of choosing the samples. The strata were allotted serial numbers as 1, 2, 3, 4….50 for consideration (Figure 5). The whole MPCA area was divided into grids of equal size with the help of GPS reading. Each grid was 4 ha size. In order to get 20 ha (5%) of areas, five such grids were selected for survey. If two grids came close to each other in the random sampling method, then again, the same technique was used to get another grid to avoid any bias. Once five grids were selected for survey, the latitude and longitude of the grids were collected for survey purpose.

The site related information documented in the Wildlife Management plans was collected. Following details: latitude, longitude, altitude, boundaries of the Phalut MPCA locations, were gathered from the records. An innovative application of using open source GIS

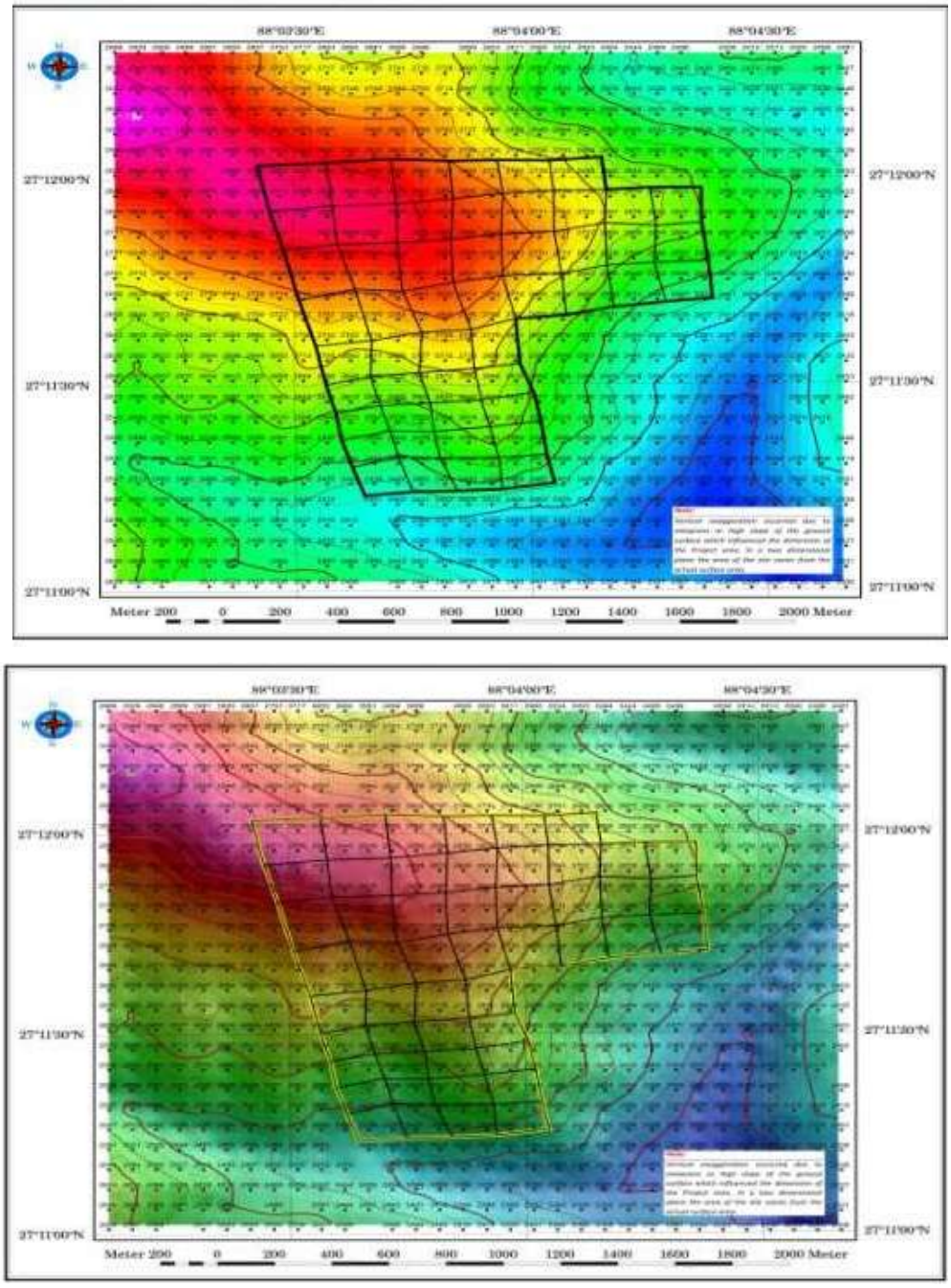
software technology was used for preparing a grid layout for Phalut MPCA landscape. In this work, maps were generated with actual location information. The grid layouts were developed for Phalut MPCA sites using GIS tool. The grids have been superimposed on the elevation to get the grid distribution correlated with topography and elevation (Figure 6). The grid layouts were processed from multiple measurements latitude and longitude coordinates collected during the field surveys of botanical team. These grids on the topographic sheet are expected to provide reliable information to researchers and botanical team and guide the field activities to be undertaken in the MPCA area.

Figure 6. High resolution image of Phalut MPCA with grids laid across MPCA covering the entire selected areas



The vegetation surveys were planned in the sites by laying quadrats as random. In open tract the vegetation study was made by belt transect on three exposures i.e. margin (nearer to forest road), centre and deeper part the forest, according to the principles of "landscape" approach as followed by Whittaker. The laying out of grids has been made on the basis of the guideline of National Working Plan Code- 2014. The points of grids and small quadrats have been made using GPS and grids were conveniently marked by serial number as per the procedure of the said code.

Figure 7 . Contour maps of Phalut MPCA showing the grids laid across selected areas of MPCA



Sampling plots layout

Sampling sites were selected randomly in 200 hectares of demarcated MPCA areas as specified by the guidelines. Topographically, the elevation of sites was around 392 ft above mean sea level as a reserved forest. Five sampling quadrats were laid down in each of five working grids (Figure 8). So totally, there were 25 quadrats of 20 m x 20 m size studied for

phytosociological analysis. In each study site quadrats were (20 m X 20 m plots for trees and 5m X 5m plots for shrubs, 1m x 1m for herbs) critically studied and data for each kind was recorded. With the help of local people, local names and common use along with medicinal values of ethnic kinds were documented. During the vegetation survey, the presence of wild fauna and some big animals, birds was observed to understand the species interaction. Vegetation in a community is a dynamic biological system consisting of a number of plant and animal species. So, for the study of constrains and dynamics parallel data was collected from nearby forest as check list of species directly and indirectly with the help of local people.

The size of the quadrats was prepared and fixed by the method of "species area curve". The numbers of quadrats required was determined by plotting the number of species against the number of quadrats. Species-area and species-individual curves have been central to community ecology for decades. The observation that the species number tends to increase, continuously and monotonically with area was first published in the work of Watson (1835) and latter it was reiterated. The species-area curve was later considered as one of the few 'laws' of community ecology. In the 20^{th} century the emphasis shifted from observing the relationships to expressing them from mathematical perspective. The increase in species number with forest area been attributed to ecological processes and also to sampling effects, whereby larger forest fragments contain more plots that sample more of the community. Loss of diversity can only be predicted using species-area relationships at the appropriate scale and in the correct place, as trajectories of species accumulation differ according to forest type and disturbance history. Most models of community structure based on habitat partitioning suggest that there will be an asymptote in the species-accumulation curve, but the real question is about reaching the flat curve at what extent of sampling (for e.g., 50 ha or beyond that). Notwithstanding, species-area curves are widely used to determine the capacity of forests of all sizes in terms of supporting species diversity.

The quadrats analyses were made by following Dombois and Ellenberg. In a grid, 25 quadrats of 1m x 1m, 25 quadrats of 5m x 5m and 5m quadrats of 20m x 20m for herbs, shrubs and trees were laid out at random for study of vegetation of all kinds (Figure 7).

For trees, five specific quadrats at each study grid for each type or exposure of the selected localities were marked by paint (yellow coloured paint) through the help of pole where the poles were natural kind. Peripheral areas were demarcated by white coloured paint by tracing double circle through the girth at breast height (GBH) of trees. Girth of each tree species

in the quadrat was recorded by red paint by using 3 inches brush. In each quadrat, the following characters were taken for calculation of result: (i) abundance of each species (for the calculation of density), (ii) basal cover of species taken by measuring girth of a tree (> 10 cm girth) at breast height i.e., at 1.37 m (4 feet 6 inches) is individually measured for all the species, (iii) data on Non Timber Forest Produce species following Economic Botany Data Collection standard, (iv) advent growth and new recruits were recorded using Slide callipers and measuring tape along with the foot rule from 2m x 2m area after pointing station by GPS, (v) photographs were taken and local names also recorded by the help of forest guards and local people working in the said field.

Similarly, for shrubs 25 quadrats (4 at the 4 corners and one at the centre of each big quadrat) of 25 square meters each and for herbs (5 quadrats in each tree quadrat) 1 square meter area for each were made. Plant species encountered in each quadrat was listed out and identified on the basis of floristic studies of regional vegetation made by Prain, Mabberley and the names was cross-checked with the help of Bennet. To know the importance of plant species, information was taken from internet. In each quadrat, the following special character was recorded. In case of herbs, above ground biomass was estimated by destructive method for calculation of abundance (dominance) of a species. Frequency density and abundance values were calculated for each species.

Diversity index of each sample stand was calculated as per Shannon and Wiener. Frequency density and abundance values will be calculated for each species. The importance value index (IVI), an integrated measure of relative frequency, relative density and relative dominance will be derived following Curtis (1959). After collecting the data from field, the following indices were calculated in detail to establish the status of plants in Phalut MPCA:

Diversity measurements

These voucher specimens were then mounted on the standard herbarium sheets, properly pasted and stitched wherever required (particularly having large fruits or capsules with seeds). They were then identified by the expert taxonomist consulting various related published flora viz., Flora of West Bengal, Flora of Bhutan, Flora of India and various herbaria and raw drugs repository viz., Herbarium in University of North Bengal, Siliguri, Herbarium in Botany Department, Calcutta University and National Herbarium on Medicinal Plants, FRLHT,

Bengaluru. They are then properly labelled with the standard labels having taxonomic and habitat information.

Figure 8. Layout of sampling plots and design of sampling efforts for medicinal plant species population assessment in Phalut MPCA

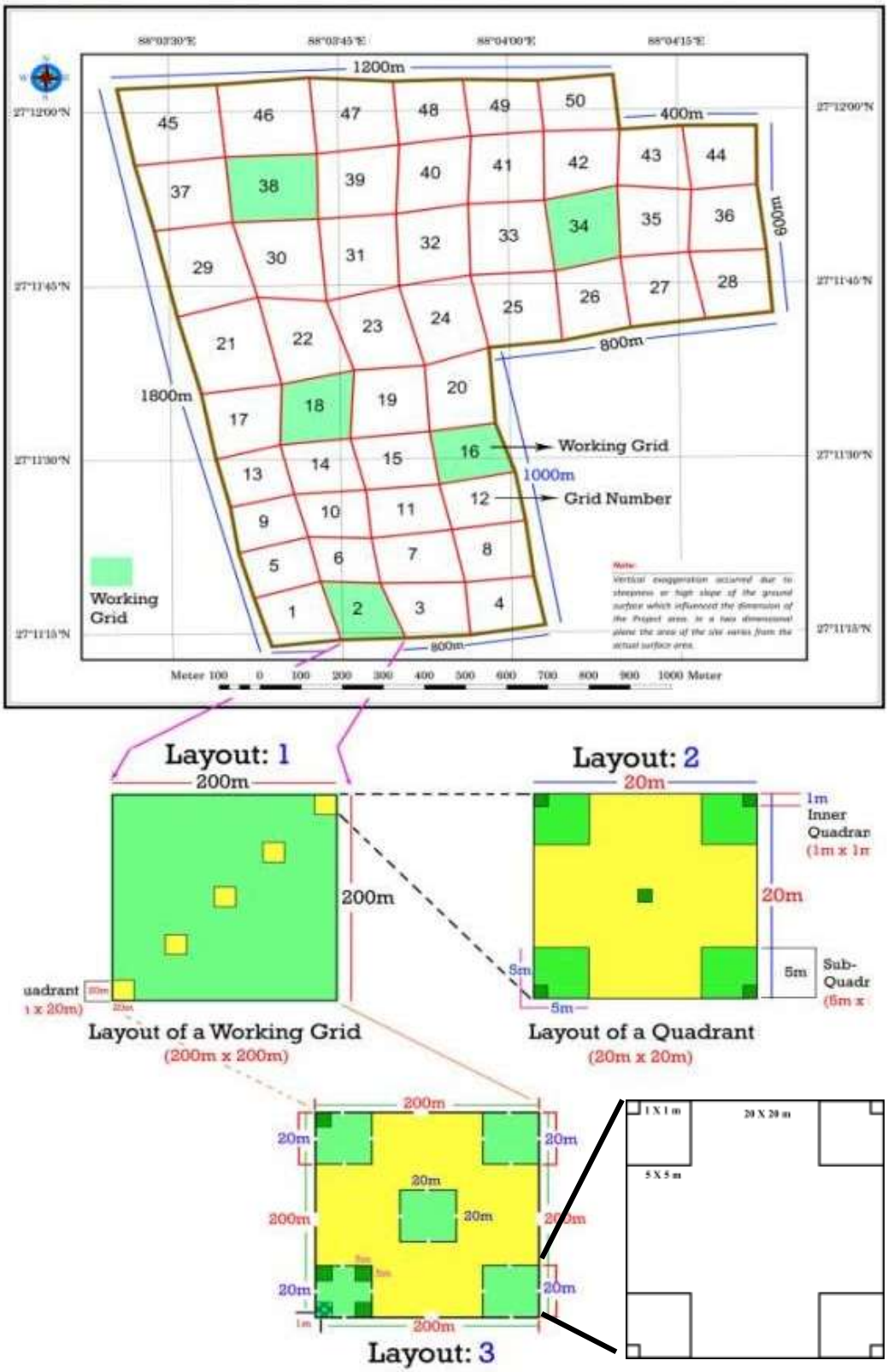
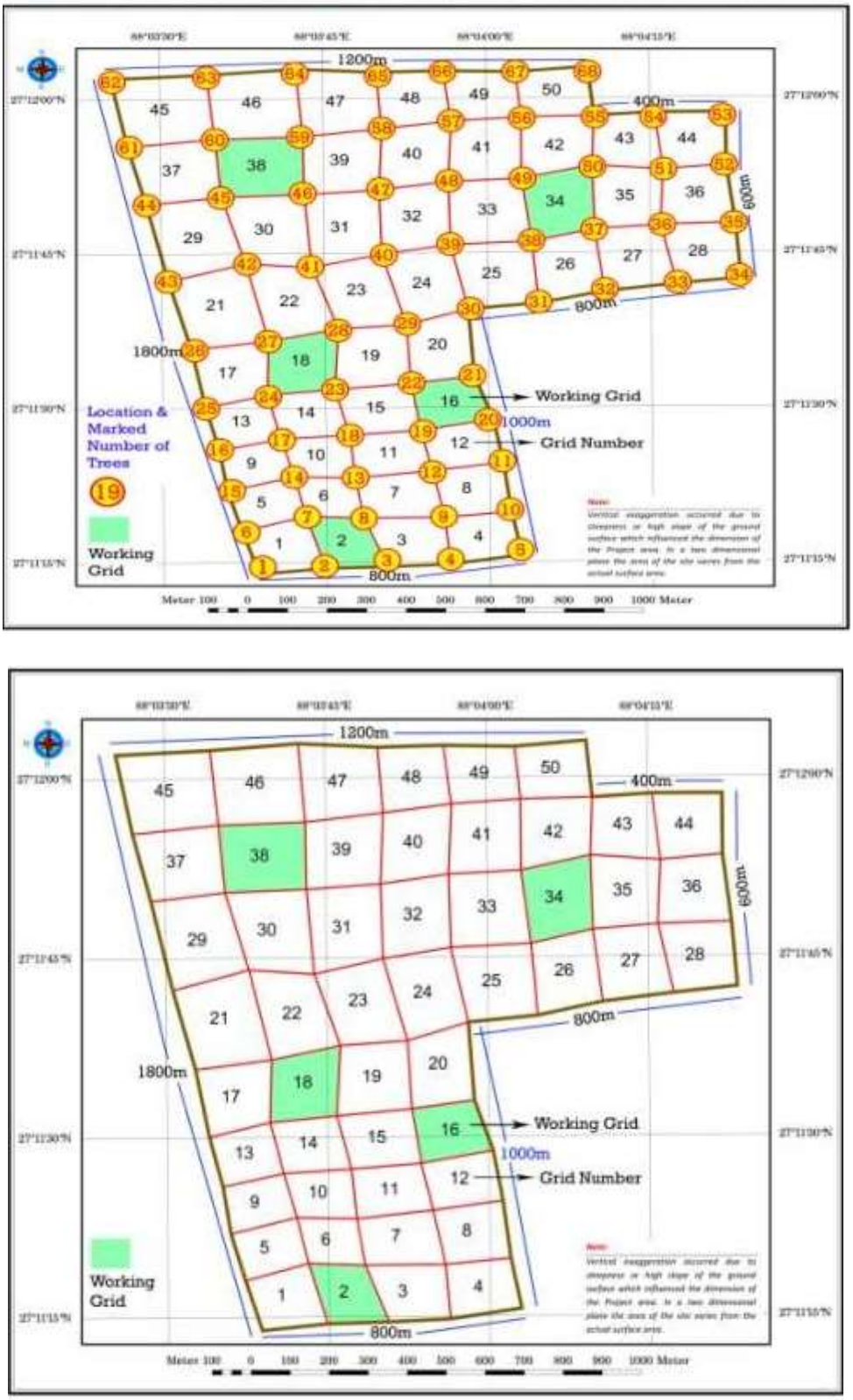
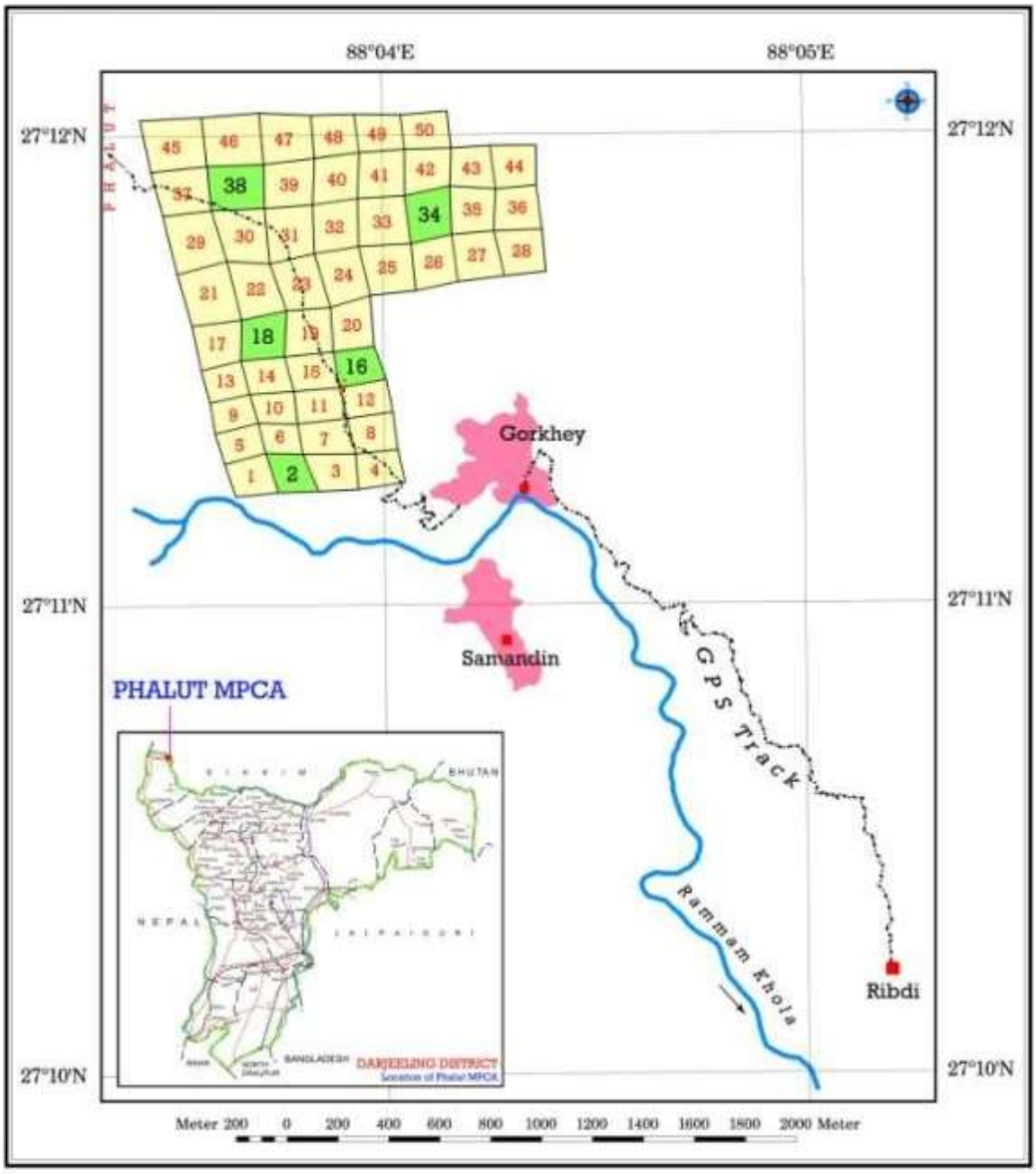


Figure 9. Numbering of grids and selection of working grids for sampling purpose in Phalut MPCA





Forest ecosystem is one of the most species-rich vegetation formations on earth. Typically, hundreds of plant species coexist in a single hectare of forest. One of the key goals of ecology is to explain the distribution and abundance of species. Diversity of a community is assessed by the proportional species abundance data either by using statistical sampling theory (Fisher α) or by a variety of nonparametric measures (Simpson, Shannon, etc.). Ecosystem diversity on a spatial and areal scale is subdivided into alpha, beta, gamma and delta diversity (Whittaker, 1972). In forest ecosystems, alpha diversity operates within forest stands. Beta diversity refers to the variation between forests stands, i.e., how species composition varies from one area to another. Gamma and delta diversity operate on large scales. Most diversity studies, especially for large extents, considered only one or two components of diversity, species richness within local communities (α-diversity), species richness within a region (γ-

diversity), or similarity between communities (β-diversity). Various indices have also been formulated for depicting species diversity. The most common of these are Simpson's heterogeneity index and the Shannon index.

Species similarity

In vegetations studies it is often desirable to compare two plant communities and determine how similar they are. This can be accomplished with a similarity index. The similarity index determines the interspecific association between the species of plant communities.

Sorensen's species similarity index (SS) between the transects and the two sites. It gives greater "weight" to species that are common to the quadrats than to those found in only one quadrat. It uses presence/absence data and was calculated using following formula:

$$SS = 2a/(2a + b + c), \text{ where}$$

a = number of species common to both quadrats; b = number of species unique to the first quadrat; c = number of species unique to the second quadrat

SS usually is multiplied by 100% (i.e., SS = 67%), and may be represented in terms of dissimilarity (i.e., DS = 1.0 - SS).

Jaccard similarity index (SJ) between the transects and the two sites was calculated following formula: uses presence/absence data (i.e., ignores info about abundance)

$$SJ = a/(a + b + c), \text{ where,}$$

SJ = Jaccard similarity coefficient; a = number of species common to (shared by) quadrats; b = number of species unique to the first quadrat, and c = number of species unique to the second

To avoid individual variation, the degree of similarity is expressed mathematically on the basis of any quantitative character (Number of species in the present case). The indices of similarity of community coefficient (IS) between any two sample sites or communities is made by the formula of Sorensen (1948) as described by Muller- Dombois and Ellenberg (1974).

$$IS = (2C/A+B) \text{ X } 100$$

Where, A= Number of species in one stand / Community.

B= Number of species in another stand / Community.

C= Number of species common to both the communities.

Diversity indices

Basal area (m^2)	$(GBH)^2/4\pi$
Important Value Index (IVI)	R. density + R. frequency + R. basal area
Relative Density	No. of individuals of species A X 100 / Total no. of individuals
Relative frequency	No. of quadrats/plots having species A X 100 / Total no. of quadrats/plots sampled
Relative basal area	Basal area (m^2) of species A X 100 / Total basal area of all species

Shannon-Wiener Index (H') is the most commonly used index of diversity in ecological studies as it fairly sensitive to actual site differences. The values range from 0 to 5, usually ranging from 1.5 to 3.5. It is easily calculated using below equations:

$$H' = -\sum\left[\left(\frac{n_i}{N}\right)\times \ln\left(\frac{n_i}{N}\right)\right]$$

n_i = number of individuals or amount (e.g., biomass or density) of each species (the i^{th} species); N = total number of individuals (or amount) for the site, and ln = the natural log of the number.

Simpson's Index (λ) is a measure of dominance. Therefore, (1-λ) estimates species diversity. It gives the probability that any two individuals drawn at random from an infinitely large community belong to different species. It is less sensitive to species richness and heavily weighted towards the most abundant species. It is calculated using following equation

$$\lambda = \sum \frac{n(n-1)}{N(N-1)}$$

n_i = number of individuals or amount of each species (i.e., the number of individuals of the i^{th} species); N = total number of individuals for the site

Dominance concentration (CD) - Concentration of Dominance (Cd) of each stand will be calculated following the formula givenbelow by Simpson (1949).

$$Cd = (ni / N)^2$$

Where 'ni' is the IVI of individual species and 'N' is the total IVI of all the species.

Evenness Index (e)

Evenness Index (e) will be calculated according to Pielou (1966).

$$e = H / \overline{\log S}$$

Where, H = Shannon index and S = Number of species.

Species Richness Index (D)

Species Richness index (d) will be calculated according to Margalef (1958).

$$d=S-1 / \log N.$$

Where, S= Number of species, N = Importance Value and, d= Species richness.

Threatened status

The most critical aspect in the biodiversity conservation is the prioritisation of species as there may be number of species in need of immediate action. One of the ways to prioritise species especially plants is based on the threatened category the particular species belongs to. Apart from that how important the particular species is in the commercial trade market fetching more price value and also in great demand. In general, there is a RED data book published by the Botanical Survey of India with periodical updates while there is also an IUCN Red list of Threatened plants. In specific to medicinal plants, FRLHT has been organising number of Conservation Assessment and Management Prioritisation (CAMP) workshop at state level to conduct threat assessment for medicinal plants involving subject experts and taxonomists by following IUCN guidelines. The list of threatened medicinal plant species has been prepared for almost all states in India. Plant species that are listed as threatened species are given priority when it comes to undertaking any conservation actions.

Rapid assessment of threats to the medicinal plants of West Bengal was done through CAMP workshop held at state level. This workshop aimed at assigning the IUCN's qualitative Red List system to categorise each species to a degree of endangerment based on the estimates of the threats to the population and habitat. A total of 148 medicinal plant species was proposed for the assessment of which 43 species were assessed according to the IUCN Red List Criteria. Subject experts and taxonomists from West Bengal assessed their distribution and prepared the taxon sheets for each of 43 medicinal plant species priorised for conservation in West Bengal. The number of medicinal plant species across different threatened status categories are: 14 Vulnerable; 19 Endangered; 1 Near Threatened; 6 Critically Endangered. Among trees, there

are 24 species in Vulnerable, 7 in Endangered and 3 in Near Threatened category. There are 6 trees and 4 climbers in Vulnerable category. Out of 15 herbs assessed, 8 species are in Endangered category. Out of 43 medicinal plant species having threatened status in West Bengal, 40 medicinal plant species are recorded in already established seven MPCAs.

Data analysis

Species diversity indices such as the Shannon, Simpson and Fisher's α (as in Magurran, 1988) were calculated. To understand a species' share in the plant community, the species importance value index (sum of the relative density (Rd), relative frequency (Rf) and relative dominance (Rdm) as per Cottom and Curtis, 1956) and family importance value index (sum of the relative diversity (Rdi), relative density (Rd) and relative dominance (Rdm) based on Mori et al. 1983) were calculated. The program EstimateS v.5 (Colwell, 1997) was used for raising species-area curves plotted as species increment with every quadrat placed. Spatial patterns of species (whether individuals of tree species are random/uniform/clumped in distribution), represented by >50 individuals in each site, were determined by the quadrat count method using standardized Morisita index (Krebs, 1989). A ratio of zero indicates random dispersion pattern, above zero clumped pattern and less than zero uniform pattern. This quantitative spatial pattern is not strongly influenced by species richness and sample size, although it is sensitive to the abundance of the most abundant species. The frequency distribution of plant size (gbh) classes between the MPCA sites was compared using Kolmogorov-Smirnov one-sample test (Zar, 1999).

Coefficient of variation (CV- standard deviation/mean for a species) was computed to identify whether there is an oligarchy in plant species. This would provide information on site differentiation with respect to species composition, whether species with a low CV regardless of absolute density are equitably distributed, or those with a high CV show a large degree of variability in their distribution. To examine the species similarity among the ten sites an agglomerative hierarchical clustering analysis was performed, using Sorensen's index (Magurran, 1988) and unweighted paired group arithmetic average (UPGMA) using Biodiversity Pro (1997).

Details of field visits

The field work was conducted multiple times in 2015 onward. First visit was made between October and December months followed by January and March. There was another trip to site just prior to monsoon (April to June).

CHAPTER 3: QUANTITATIVE ASSESSMENT OF MEDICINAL PLANTS

Number of medicinal plants recorded

Table 5 : Checklist of plant species: trees, shrubs and herbs recorded in the surveyed area.

Sl. No.	Species Name	Family	Local name
Tree species			
1	*Abies densa* Griffith	Pinaceae	Talispatra
2	*Acer campbellii* Hook.f. & Thomson ex Hiern	Sapindaceae	Kapsi, Doomkung
3	*Alnus nepalensis* D.Don	Betulaceae	Utis
4	*Aralia leschenaultii (*DC.) J.Wen Syn. *Pentapanax fragrans* (D.Don) Ha	Araliaceae	Chinde
5	*Betula alnoides.* Buch.-Ham. ex D.Don	Betulaceae	Bhojpatra
6	*Castanopsis hystrix* Miq.	Fagaceae	Patle katus
7	*Cinnamomum bejolghota* (Buch.-Ham.) Sweet	Lauraceae	Dalchini
8	*Corylus ferox* Wall.	Betulaceae	
9	*Cotoneaster pannosus* Franchet	Rosaceae	
10	*Cryptomeria japonica* (Thunb. ex L.f.) D.Don	Cupressaceae	Dhuupi
11	*Daphne papyracea* Wall. ex G. Don	Thymelaeaceae	
12	*Elaeocarpus sikkimensis* Masters	Elaeocarpaceae	Bhadrase
13	*Endospermum chinense* Benth	Euphobiaceae	Setikhat
14	*Eurya japonica* Thunb.	Pentaphylacaceae	Jhigini
15	*Evodia lunu-ankenda* (Gaertn.) Merr.	Rutaceae	
16	*Exbucklandia populnea* (R.Br. ex Griff.) R.W.Br.	Hamamelidaceae	Pipli
17	*Gamblea ciliata* C.B.Clarke	Araliaceae	
18	*Ilex sikkimensis* Kurz	Aquifoliaceae	
19	*Juglans regia* L.	Juglandaceae	
20	*Lindera assamica* (Meisn.) Kurz	Lauraceae	
21	*Lithocarpus fenestratus* (Roxb.) Rehder	Fagaceae	

22	*Lithocarpus pachyphyllus* (Kurz) Rehder	Fagaceae	
23	*Litsea albescens* (Hook.f.) D.G.Long	Lauraceae	
24	*Litsea elongata (*Nees) Hook.f.	Lauraceae	
25	*Litsea javanica* Blume	Lauraceae	
26	*Lyonia ovalifolia* (Wall.) Drude	Ericaceae	Lek Angeri
27	*Machilus edulis* King ex Hook.f.	Lauraceae	Lacpche kawala
28	*Machilus glaucescens* (Nees) Wight	Lauraceae	
29	*Maesa chisia* Buch.-Ham. Ex D. Don	Primulaceae	Belouni
30	*Magnolia campbellii* Hook.f. & Thomson	Magnoliaceae	Ghoge Champ
31	*Magnolia doltsopa (Buch.-Ham. ex DC.) Figlar*	Magnoliaceae	Rani/Mithe Champ
32	*Neolitsea cuipala (D.Don) Kosterm.*	Lauraceae	
33	*Osmanthus suavis King ex C.B.Clarke*	Oleaceae	
34	*Photinia integrifolia Lindl.*	Rosaceae	Phalame
35	*Piptanthus nepalensis (Hook.) Sweet*	Fabaceae	
36	*Prunus napaulensis (Ser.) Steud.*	Rosaceae	
37	*Quercus lamellosa Sm.*	Fagaceae	Buk
38	*Quercus lineata Blume*	Fagaceae	Phalant
39	*Quercus pachyphylla Kurz.*	Fagaceae	Sungure Katus/ Bante
40	*Rhododendron arboreum Sm.*	Ericaceae	Gurans
41	*Rhododendron grande Wight*	Ericaceae	Patle Korlinga
42	*Salix thomsoniana Andersson*	Salicaceae	
43	*Schefflera rhododendrifolia (Griff.) Frodin Syn. Schefflera impressa*	Araliaceae	Bhalu Chinde

	(C.B.Clarke) Harms		
44	*Sorbus foliolosa (Wall.) Spach*	Rosaceae	Thulo Pasi
45	*Symplocos dryophila C.B.Clarke*	Symplocaceae	
46	*Symplocos glomerata King ex C. B. Clarke*	Symplocaceae	Kharane
47	*Symplocos theifolia (Hayata) Hayata*	Symplocaceae	Kharane
48	*Taxus wallichiana Zucc.*	Taxaceae	Dhyangre Salla
49	*Tetradium fraxinifolium (Hook.) T.G.Hartley*	Rutaceae	Khanakpa
50	*Tsuga dumosa (D. Don) Eichler*	Pinaceae	Thingre Sall
51	*Viburnum erubescens Wall. ex DC.*	Viburnaceae	Asare
52	*Vitex heterophylla*	verbenaceae	panchapate
53	*Zanthoxylum armatum DC*	Rutaceae	Bokey Timbur
Shrubs			
1	*Aconitum palmatum D.Don Syn. Aconitum bisma (Buch.-Ham.) Rapaics*	Ranunculaceae	
2	*Agapetes serpens (Wight) Sleumer*	Ericaceae	
3	*Berberis aristata DC.*	Berberidaceae	
4	*Berberis hookeri Lem.*	Berberidaceae	
5	*Berberis insignis J. D. Hooker & Thomson*	Berberidaceae	
6	*Berberis thomsoniana C.K.Schneid.*	Berberidaceae	
7	*Buddleja colvilei Hook.f.*	Scrophulariaceae	
8	*Cotoneaster microphyllus Wall. ex Lindl.*	Rosaceae	
9	*Daphne bholua Buch.-Ham. ex D.Don*	Thymelaeaceae	
10	*Daphne papyracea Wallich ex G. Don*	Thymelaceae	
11	*Daphnephyllum himalayense*	Daphniphyllaceae	

12	*Elsholtzia fruticosa (D.Don) Rehder*	Lamiaceae	Sano Simal
13	*Euonymus frigidus Wall.*	Celastraceae	
14	*Eurya acuminata DC.*	Ericaceae	
15	*Ficus neriifolia J.E. Smith*	Moraceae	Dudhilo
16	*Gaultheria fragrantissima Wall.*	Ericaceae	
17	*Helwingia himalaica Hook.f. & Thomson ex C.B.Clarke*	Helwingiaceae	Pipli
18	*Hydrangea aspera Buch.-Ham. ex D.Don*	Hydrangeaceae	
19	*Hypericum choisyanum Wall. ex N.Robson*	Hypericaceae	
20	*Hypericum hookerianum Wight & Arn.*	Hypericaceae	Mehendi phul
21	*Hypericum oblongifolium Choisy*	Hypericaceae	
22	*Hypericum patulum Thunb.*	Hypericaceae	
23	*Ilex dipyrena Wall.*	Aquifoliaceae	
24	*Lasianthus sikkimensis Hook.f.*	Fabaceae	
25	*Leucosceptrum canum Sm.*	Lamiaceae	
26	*Ilex sikkimensis Kurz*	Aquifoliaceae	
27	*Maesa indica (Roxb.) DC.*	Myrsinaceae	*Bilauney*
28	*Mahonia acanthifolia Wall. ex G. Don*	Berberidaceae	
29	*Mahonia japonica (Thunb.) DC.*	Berberidaceae	
30	*Mahonia nepalensis DC. ex Dippel*	Berberidaceae	Kesari/Chtro
31	*Malus sikkimensis (Wenz.) Koehne ex C.K.Schneid.*	Rosaceae	
32	*Myriacts nepalensis Less.*	Asteraceae	
33	*Myrsine semiserrata Wall.*	Primulaceae	Kalikath
34	*Neillia thyrsiflora D. Don*	Rosaceae	
35	*Ochna pumila Buch.-Ham. ex D.Don*	Ochnaceae	
36	*Osbeckia stellata var. crinita (Benth.*	Melastomataceae	

	ex Naud.) C.Hansen		
37	*Oxyspora paniculata DC.*	Melastomataceae	
38	Ribes takare D.Don **Syn.** Ribes acuminatum Wall. ex G.Don	Grossulariaceae	
39	*Rhododendron triflorum Hook.f.*	Ericaceae	
40	*Rhus insignis*	Anacardiaceae	Bhalayo
41	*Ribes takare D.Don Syn. Ribes acuminatum Wall. ex G.Don*	Grossulariaceae	
42	*Rosa sericea Lindl.*	Rosaceae	Jangli Golap
43	*Rubus ellipticus Sm.*	Rosaceae	Aselu
44	*Rubus moluccanus L.*	Rosaceae	
45	*Rubus wardii Merr.*	Rosaceae	Kanre Aselu
46	*Sambucus adnata Wall. ex DC.*	Viburnaceae	
47	*Schisandra neglecta A. C. Smith*	Schisandraceae	
48	*Skimmia laureola Franch.*	Rutaceae	
49	*Smilax munita S.C.Chen*	Smilacaceae	
50		Poaceae	
51	Sarocalamus racemosus (Munro) Stapleton **Syn.** Arundinaria racemosa Munro	Poaceae	
52	*Ilex kingiana* Cockerell	Aquifoliaceae	Kharane
53	*Talauma hodgsonii Hook.f. & Thomson*	Magnoliaceae	
54	Viburnum mullaha Buch.-Ham. ex D.Don	Viburnaceae	
55	*Viburnum erubescens Wall. ex DC*	Viburnaceae	
56	*Yushania maling(Gamble)R.B.Majumdar*	Poaceae	
57	*Zanthoxylum oxyphyllum Edgew.*	Rutaceae	Timbur

Herbs			
1	*Achyranthes bidentata Blume*	Amaranthaceae	
2	*Aconitum spicatum (Brühl) Stapf*	Ranunculaceae	
3	*Aeschynanthus hookeri C.B.Clarke*	Gesneriaceae	
4	*Agapetes hookeri (C. B. Cl.) Sleum.*	Ericaceae	
5	*Ageratum houstonianum Miller*	Asteraceae	
6	*Ainsliaea aptera DC.*	Asteraceae	
7	*Ainsliaea latifolia (D. Don) Sch.Bip*	Asteraceae	
8	*Ajuga lobata D.Don*	Lamiaceae	
9	*Anaphalis contorta (D.Don) Hook.f.*	Asteraceae	Bukiphul
10	*Anaphalis margaritacea (L.) Benth. & Hook.f.*	Asteraceae	
11	*Anaphalis triplinervis(Sims)Sims.ex C.B.Clarke.*	Asteraceae	
12	*Arisaema concinnum Schott*	Araceae	Cobra lily/Gurbo
13	*Arisaema erubescens (Wall.) Schott*	Araceae	
14	*Arisaema jacquemontii Blume*	Araceae	
15	*Arisaema speciosum (Wall.) Mart.*	Araceae	Gurbo
16	*Arisaema tortuosum (Wall.) Schott*	Araceae	
17	*Artemisia indica Willd.*	Asteraceae	
18	*Artemisia vulgaris L.*	Asteraceae	
19	*Arundinaria racemosa Munro*	Poaceae	
20	*Astilbe rivularis Buch.-Ham. ex D.Don*	Saxifragaceae	Buro Okhati
21	*Begonia aconitifolia A.DC.*	Begoniaceae	
22	*Bulbophyllum bisetum Lindl.*	*Orchidaceae*	
23	*Calceolaria mexicana Benth.*	Calceolariaceae	
24	*Carex cruciata Wahlenb.*	Cyperaceae	

25	*Carex decora Boott*	Cyperaceae	
26	*Carex filicina Nees*	Cyperaceae	
27	*Carex fusiformis Nees*	Cyperaceae	
28	*Carex munda Boott*	Cyperaceae	
29	*Carex pulchra Boott*	Cyperaceae	
30	*Cayratia trifolia (L.) Domin*	Vitaceae	
31	*Chlorophytum nepalense (Lindl.) Baker*	Asparagaceae	
32	*Cirsium falconeri (Hook.f.) Petr.*	Asteraceae	
33	*Clematis buchananiana DC.*	Ranunculaceae	Chiple Ghans
34	*Clinopodium umbrosum (M. Bieb.) C. Koch*	Lamiaceae	
35	*Commelina sikkimensis C.B.Clarke*	Commelinaceae	
36	*Corydalis chaerophylla DC.*	Papaveraceae	
37	*Corydalis longipes DC.*	Papaveraceae	
38	*Craniotome furcata (Link) Kuntze*	Lamiaceae	
39	*Craterostigma nummulariifolium (D.Don) Eb.Fisch., Schäferh. & Kai Müll.*	Linderniaceae	
40	*Cyathula tomentosa (Roth) Moq.*	Amaranthaceae	
41	*Cynoglossum lanceolatum Forssk.*	Boraginaceae	
42	*Dendrobium longicornu Lindl.*	Orchidaceae	
43	*Deparia japonica (Thunb.) M.Kato*	Aspleniaceae	
44	*Diplazium japonicum (Thunb.) Bedd.*	Athyriaceae	
45	*Dryopteris chrysocoma (Christ) C. Chr.*	Dryopteridaceae	
46	*Dryopteris nodosa (C.Presl) Li Bing Zhang* ***Syn.*** *Acrophorus stipellatus T.Moore*	Polypodiaceae	
47	*Dryopteris paleacea Fomin*	Polypodiaceae	
48	*Dryopteris sikkimensis*	Polypodiaceae	
49	*Elatostema monandrum (Buch.-*	Urticaceae	

	HamexD.Don)		
50	*Elatostema sessile J.R.Forst. & G.Forst.*	Urticaceae	Gagleto
51	*Elsholtzia blanda (Benth.) Benth.*	Lamiaceae	Ban Silam
52	*Elsholtzia fruticosa (D. Don) Rehder*	Lamiaceae	Sano Simal
53	*Equisetum ramosissimum Desf.*	Equisetaceae	
54	*Eriocapitella vitifolia (Buch.-Ham. ex DC.) Nakai*	Ranunculaceae	
55	*Fragaria daltoniana J.Gay*	Rosaceae	
56	*Fragaria nubicola (Lindl. ex Hook.f.) Lacaita*	Rosaceae	Bhuin Aselu
57	*Galinsoga parviflora Cavanilles*	Asteraceae	
58	*Galium aparine L.*	Rubiaceae	
59	*Galium elegansWall.Ex.Roxb.*	Rubiaceae	Lahare Kuro
60	*Gallium mollugoL.*	Rubiaceae	
61	*Gaultheria hookeri C.B.Clarke*	Ericaceae	
62	*Gaultheria nummularioides D.Don*	Ericaceae	
63	*Gentiana capitata Buch.-Ham. ex D. Don*	Gentinaceae	
64	*Geranium donianum Sweet*	Geraniaceae	
65	*Girardinia diversifolia (Link) Friis*	Urticaceae	Bhyangrey ShishnuR/ L/ S
66	*Gleichenia glauca (Thunb. ex Houtt.) Hook.*	Gleicheniaceae	
67	*Globba racemosa Sm.*	Zingiberaceae	
68	*Hedychium thyrsiforme Sm.*	Zingiberaceae	
69	*Helichrysum luteoalbum (L.) Rchb*	Asteraceae	

70	*Hemiphragma heterophyllum Wall.*	Plantaginaceae	Lalgeri Jhar
71	*Henckelia urticifolia (Buch.-Ham. ex D.Don) A.Dietr.*	Gesneriaceae	
72	*Heracleum wallichii DC.*	Apiaceae	
73	*Herminium clavigerum (Lindl.) X.H.Jin, Schuit., Raskoti & Lu Q.Huang*	Orchidaceae	
74	*Hydrocotyle himalaica P.K.Mukh.*	Araliaceae	Athanejhar
75	*Hypericum elodeoides Choisy*	Hypericaceae	
76	*Hypericum japonicum Thunb.ex Murray*	Hypericaceae	
77	*Impatiens arguta Hook.f. & Thomson*	Balsaminaceae	
78	*Impatiens discolor DC.*	Balsaminaceae	
79	*Impatiens radiata Hook. f*	Balsaminaceae	
80	*Polygonum molle D. Don*	Polygonaceae	
81	*Lactuca dissecta D.Don*	Asteraceae	Dude jhar
82	*Lecanthus peduncularis (Royle) Wedd.*	Urticaceae	
83	*Liparis bootanensis Griffith*	Orchidaceae	
84	*Lobelia montana Reinw. ex Blume*	Campanulaceae	Eklebir
85	*Lobelia nummularia Lam.*	Campanulaceae	
86	*Lycopodium clavatum L.*	Lycopodiaceae	
87	*Melanoseris decipiens var. multifida (Hook.f.) Ghafoor, Qaiser & Roohi Bano*	Asteraceae	
88	*Melanoseris graciliflora (DC.) N.Kilian*	Asteraceae	

89	*Miscanthus nepalensis (Trin.) Hack.*	Poaceae	
90	*Myriactis nepalensis Less.*	Asteraceae	Tuke phul
91	*Neillia thyrsiflora D.Don*	Rosaceae	
92	*Odontosoria chinensis (L.) J.Sm.*	Lindsaeaceae	
93	*Oleandra pistillaris (Sw.) C.Chr.*	Polypodiaceae	
94	*Ophiopogon intermedius D.Don*	Asparagaceae	Kaligeri
95	*Oplismenus compositus (L.) P.Beauv.*	Poaceae	
96	*Oxalis acetosella L.*	Oxalidaceae	
97	*Panax pseudoginseng Wall.*	Araliaceae	Satpate
98	*Paris polyphylla Sm.*	Melanthiaceae	Satuwa
99	*Parochetus communis D.Don*	Fabaceae	
100	*Peperomia tetraphylla (G.Forst.) Hook. & Arn.*	Piperaceae	
101	*Persicaria campanulata*	*Polygonaceae*	
102	*Persicaria hydropiper (L.) Delarbre*	Polygonaceae	*Biskuthuli*
103	*Persicaria lapathifolia (L.) Delarbre*	Polygonaceae	
104	*Picrorhiza kurroa Royle ex Benth.*	Plantaginaceae	
105	*Pilea ternifolia Wedd.*	Urticaceae	
106	*Pilea umbrosa Wedd. ex Blume*	Urticaceae	
107	*Pimpinella diversifolia DC.*	Apiaceae	
108	*Plagiogyria pycnophylla (Kunze) Mett.*	Cyatheaceae	
109	*Plantago asiatica subsp. erosa (Wall.) Z.Yu Li*	Plantaginaceae	Nasey jhar

110	*Plantago erosa var. fengdouensis Z.E.Chao & Yong Wang*	Plantaginaceae	
111	*Plantago erosa Wall.*	Plantaginaceae	
112	*Podophyllum hexandrum Royle*	Berberidaceae	
113	*Polygonatum oppositifolium (Wall.) Royle*	Asparagaceae	
114	*Polystichum lentum (D.Don) T.Moore*	Polypodiaceae	
115	*Potentilla fruticosa L.*	Rosaceae	
116	*Potentilla indica (Andrews) Th.Wolf*	Rosaceae	
117	*Pouzolzia zeylanica (L.) Benn.*	Urticaceae	
118	*Pratia montana (Reinw. ex Blume) Hassk.*	Campanulaceae	
119	*Pteris aspericaulis Wall. ex J.Agardh*	Pteridaceae	
120	*Pteris quadriaurita Retz.*	Pteridaceae	
121	*Ranunculus diffusus DC.*	Ranunculaceae	
122	*Ranunculus microphyllus Hand.-Mazz.*	Ranunculaceae	
123	*Rohdea nepalensis (Raf.) N.Tanaka*	Asparagaceae	
124	*Rubia manjith Roxb.*	Rubiaceae	
125	*Rubia sikkimensis Kurz*	Rubiaceae	
126	*Rubia wallichiana Decne.*	Rubiaceae	
127	*Rubus hypargyrus - (Wall. ex D.Don.)Hara.*	Rosaceae	
128	*Rubus rosifolius Sm.*	Rosaceae	
129	*Rubus rugosus Sm.*	Rosaceae	
130	*Rubus splendidissimus H.Hara*	Rosaceae	
131	*Rubus wardii Merr.*	Rosaceae	
132	*Rumex nepalensis Spreng.*	Polygonaceae	
133	*Sanicula elata D.Don*	*Umbelliferae*	
134	*Saxifraga strigosa Wall. ex Ser.*	Saxifragaceae	
135	*Scutellaria discolor Wall. ex Benth.*	Lamiaceae	

136	*Selaginella monospora Spring*	Selaginellaceae	
137	*Selinum wallichianum*	*Apiaceae*	
138	*Selliguea erythrocarpa (Mett.) X.C.Zhang & L.J.He* ***Syn.*** *Phymatodes erythrocarpa (Mett.) Ching*	Polypodiaceae	
139	*Senecio scandens Buchanan-Hamilton ex D. Don*	Asteraceae	
140	*Smilax elegans Wall. ex Kunth*	Smilacaceae	
141	*Smilax munita S.C.Chen* ***Syn.*** *Smilax rigida subsp. myrtillus (A.DC.) T.Koyama*	Smilacaceae	
142	*Stellaria media (L.) Vill.*	Caryophyllaceae	
143	*Strobilanthes pentastemonoides (Nees) T.Anderson var. dalhousieana Kuntze*	Acanthaceae	
144	*Swertia bimaculata (Siebold & Zucc.) Hook.f. & Thomson ex C.B.Clarke*	Gentianaceae	Bhale Chirowto
145	*Swertia chirata Buch.-Ham. ex Wall.*	Gentinaceae	
146	*Swertia chirayita (Roxb.) H.Karst.*	Gentianaceae	
147	*Swertia ciliata (D.Don) B.L.Burtt*	Gentianaceae	
148	*Swertia hookeri C.B.Clarke*	Gentianaceae	
149	*Swertia paniculata Wall.*	Gentianaceae	
150	*Swertia purpurascens (D.Don) C.B.Clarke* ***Syn.*** *Swertia ciliata (D.Don) B.L.Burtt*	Gentianaceae	
151	*Synotis cappa (Buch.-Ham. ex D.Don) C.Jeffrey & Y.L.Chen*	Asteraceae	
152	*Thalictrum foliolosum DC.*	Ranunculaceae	
153	*Thunbergia lutea T.Anderson*	Acanthaceae	
154	*Trifolium pratense L.*	Fagaceae	

155	*Urtica dioica L.*	Urticaceae	Sisnu
156	*Valeriana hardwickei Wall.*	Rubiaceae	
157	*Viola hookeri Thomson*	Violaceae	
158	*Viola sikkimensis* W.Becker	Violaceae	Bunufsa
159	*Viola pilosa Blume*	Violaceae	Bunufsa
160	*Zeuxine goodyeroides Lindl.*	Orchidaceae	

Table 5a: Summary of inventorization undertaken in Phalut Medicinal Plants Conservation Area (MPCA) in West Bengal

Tree species recorded	
# of species recorded	53
# of families	24
# of genera	43
# of threatened species	1
Shrub species recorded	
# of species recorded	57
# of families	30
# of genera	43
# of threatened species	1
Herb species and seedlings recorded	
# of species recorded	157
# of families	52
# of genera	107
# of threatened species	3

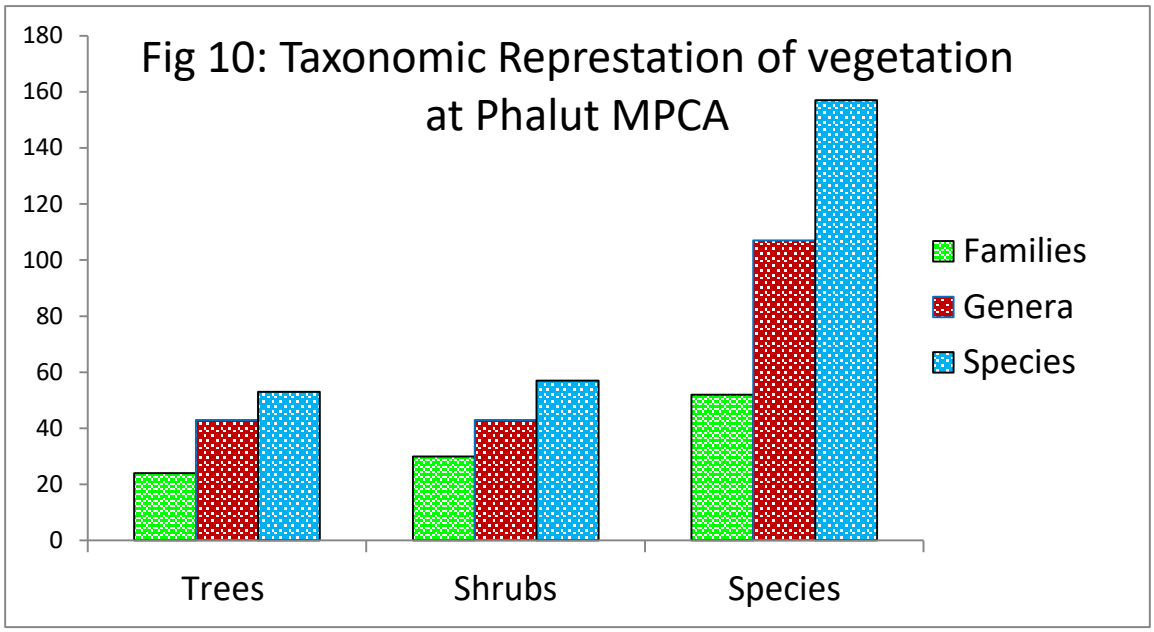


Fig 10: Taxonomic Represtation of vegetation at Phalut MPCA
180
160
140
120
100
80
60
40
20
0
Trees
Shrubs
Species
Families
Genera
Species

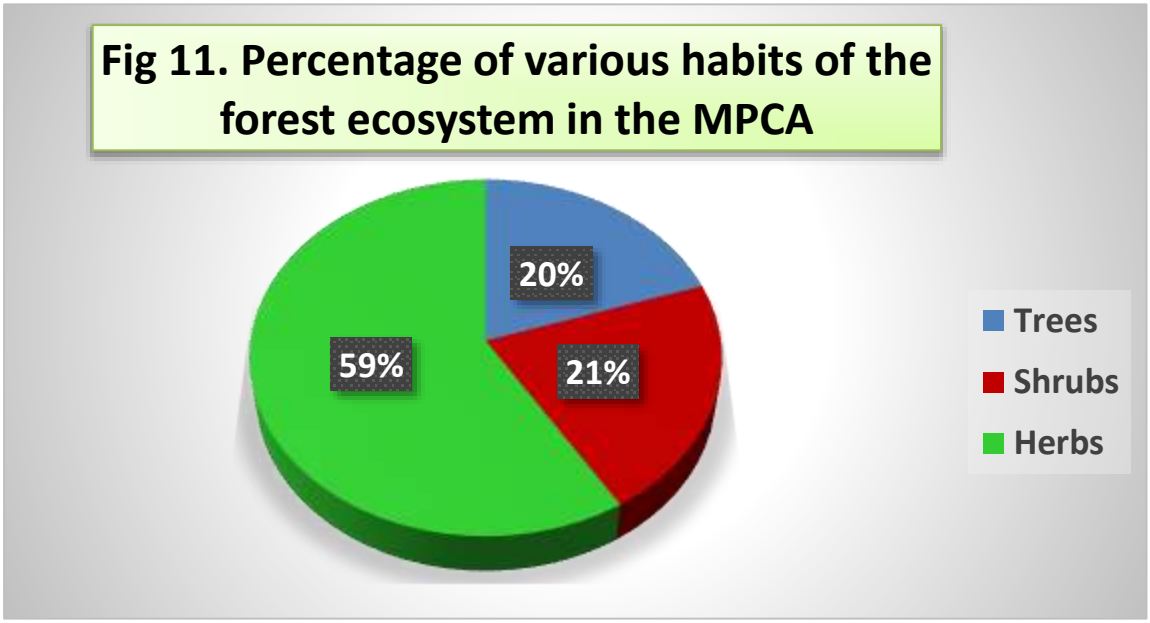


Fig 11. Percentage of various habits of the forest ecosystem in the MPCA
20%
21%
59%
Trees
Shrubs
Herbs

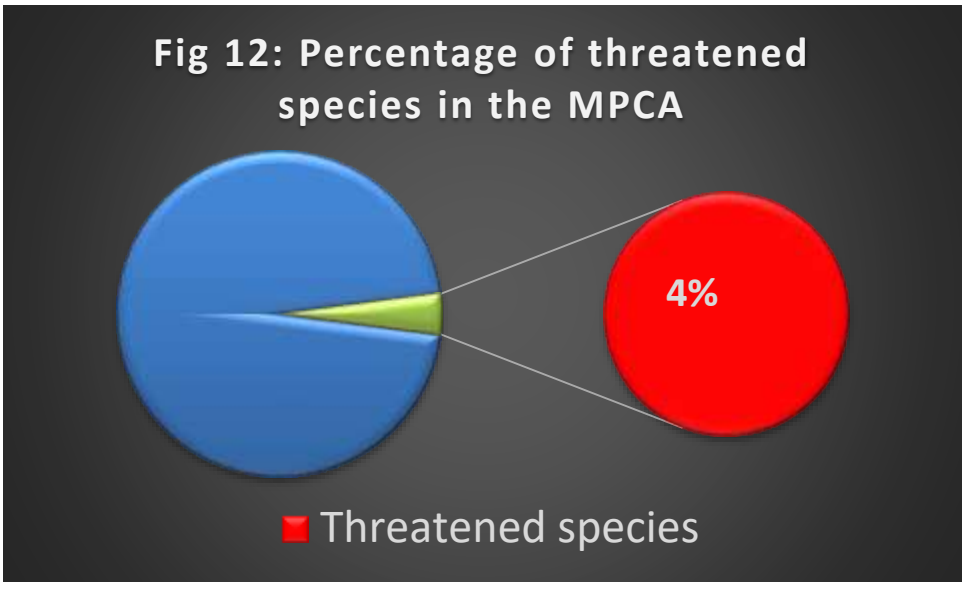


Fig 12: Percentage of threatened species in the MPCA
4%
Threatened species

Table 6: An account of relative frequency, relative density and relative dominance of tree species recorded in the 20 x 20 m quadrats during the surveys held in October 2015

Sl. No.	**Species Name**	**Relative density**	**Relative frequency**	**Relative dominance**	**IVI**
1	Photinia integrifolia Lindl.	3.097345	4.123711	0.534582	7.755638
2	Quercus lamellosa Sm.	0.884956	2.061856	0.384278	3.33109
3	Quercus lineata Blume	11.50442	11.34021	16.10666	38.95129
4	Quercus pachyphylla Kurz.	25.66372	16.49485	29.37676	71.53532
5	Symplocos theifolia (Hayata) Hayata	5.752212	8.247423	0.427841	14.42748
6	Tsuga dumosa (D. Don) Eichler	16.81416	17.52577	34.30285	68.64278
7	Maesa chisia Buch.-Ham. Ex D. Don	0.884956	2.061856	0.084701	3.031512
8	Betula alnoides	2.212389	3.092784	0.061747	5.36692
9	Rhododendron arboreum	3.982301	5.154639	0.711909	9.848849
10	Taxus wallichiana Zucc.	7.964602	7.216495	4.952573	20.13367
11	Endospermum chinense	1.327434	3.092784	0.182953	4.60317
12	Machilus edulis	2.212389	5.154639	3.155013	10.52204
13	Ilex sikkimensis Kurz	2.212389	3.092784	1.387735	6.692908
14	Rhododendron grande Wight	12.38938	7.216495	6.449483	26.05536
15	Acer campbellii Hook.f. & Thomson ex Hiern	1.327434	2.061856	0.036139	3.425428
16	Vitex heterophylla	1.769912	2.061856	1.844779	5.676547
	Total	**100**	**100**	**100**	**300**

Table 7: Results of species diversity indices (Shannon-Weiner index and Simpson index) analysed for tree species recorded in the 20 x 20 m quadrats during the surveys held in October 2015 and January 2016.

Sl. No.	**Species Name**	**pi2**	**pilnpi**
1	Photinia integrifolia Lindl.	0.000104	0.046785
2	Quercus lamellosa Sm.	0.000416	0.079425
3	Quercus lineata Blume	0.002603	0.151813
4	Quercus pachyphylla Kurz.	0.000104	0.046785
5	Symplocos theifolia (Hayata) Hayata	0.000416	0.079425
6	Tsuga dumosa (D. Don) Eichler	0.000104	0.046785
7	Maesa chisia Buch.-Ham. Ex D. Don	0.000104	0.046785
8	Betula alnoides	0.003748	0.171013
9	Rhododendron arboreum	0.000416	0.079425
10	Taxus wallichiana Zucc.	0.014994	0.25715
11	Endospermum chinense	0.000937	0.106725
12	Machilus edulis	0.292482	0.332427
13	Ilex sikkimensis Kurz	0.000104	0.046785
14	Rhododendron grande Wight	0.000104	0.046785
15	Acer campbellii Hook.f. & Thomson ex Hiern	0.000104	0.046785
16	Vitex heterophylla	0.000104	0.046785
	Total	**0.137207**	**2.280868**

Simpson index = 0.137207, i.e., concentration of dominance of tree species.

Shanon-weiner index = 2.280868, i.e., measure of tree species diversity

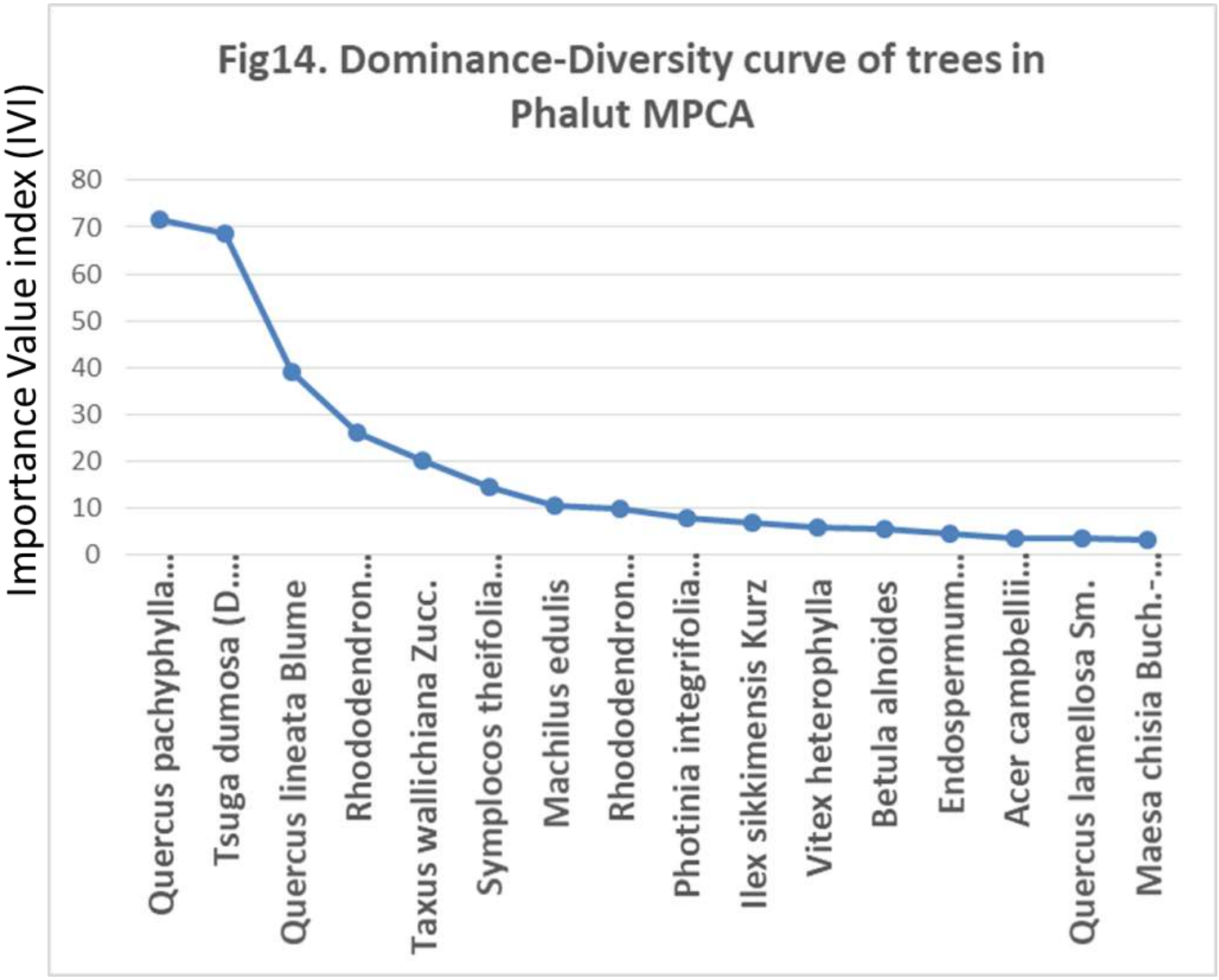


Fig14. Dominance-Diversity curve of trees in Phalut MPCA
Importance Value index (IVI)
80
70
60
50
40
30
20
10
0
Quercus pachyphylla...
Tsuga dumosa (D....
Quercus lineata Blume
Rhododendron...
Taxus wallichiana Zucc.
Symplocos theifolia...
Machilus edulis
Rhododendron...
Photinia integrifolia...
Ilex sikkimensis Kurz
Vitex heterophylla
Betula alnoides
Endospermum...
Acer campbellii...
Quercus lamellosa Sm.
Maesa chisia Buch.-...

Table 8; An account of shrub species and saplings, number of individuals recorded in the 5 m x 5 m quadrats during the surveys held in October 2015.

Sl. No	Species Name	No. of individual	Dn (m^2)
1	*Yushania maling(Gamble)R.B.Majumdar*	3273	1.6365
2	*Daphne bholua Buch.-Ham. ex D.Don*	53	0.0265
3	*Quercus lineata Blume*	39	0.0195
4	*Quercus pachyphylla Kurz.*	33	0.0165
5	*Quercus lamellosa Sm.*	10	0.005
6	*Myriacts nepalensis Less.*	25	0.0125
7	*Mahonia acanthifolia Wall. ex G. Don*	5	0.0025
8	*Photinia integrifolia Lindl.*	20	0.01
9	*Polygonum runcinatum Buchanan-Hamilton ex D. Don*	20	0.01
10	*Rhododendron arboreum Sm.*	11	0.0055
11	*Rubus moluccanus L.*	25	0.0125
12	*Rubus ellipticus Sm.*	33	0.0165
13	*Rubus lineatus Reinwardt*	19	0.0095
14	*Smilax munita S.C.Chen*	219	0.1095
15	*Symplocos theifolia (Hayata) Hayata*	139	0.0695
16	*Symplocos glomerata King ex C.B.Clarke*	107	0.0535
17	*Strobilanthes divaricata (Nees) T.Anderson*	14	0.007
18	*Zanthoxylum oxyphyllum Edgew*	7	0.0035
19	*Neillia thyrsiflora D. Don*	59	0.0295
20	*Tsuga dumosa (D. Don) Eichler*	29	0.0145
21	*Berberis aristata DC.*	51	0.0255
22	*Ficus neriifolia* J.E. Smith	5	0.0025
23	*Hypericum hookerianum Wight &*	2	0.001

	Arn.		
24	Viburnum erubescens Wall. ex DC.	3	0.0015
25	Talama hodgsonii	3	0.0015
26	Rhododendron grande Wight	17	0.0085
27	Daphnephyllum himalayense	6	0.003
28	Rhus insignis	6	0.003
	Total	**4233**	**2.12**

Table 9: An account of relative frequency, relative density and relative area of shrub species and saplings recorded in the 5 x 5 m quadrats during the surveys held in October 2015.

Sl. No	**Species Name**	**Rd**	**Rf**	**Ra**	**IVI**
1	*Yushania maling(Gamble)R.B.Majumdar*	77.32105	24.27184	77.32105	178.9139
2	*Daphne bholua Buch.-Ham. ex D.Don*	1.252067	6.796117	1.252067	9.300251
3	*Quercus lineata Blume*	0.921332	3.236246	0.921332	5.078911
4	*Quercus pachyphylla Kurz.*	0.779589	2.588997	0.779589	4.148175
5	*Quercus lamellosa Sm.*	0.236239	0.647249	0.236239	1.119727
6	*Myriacts nepalensis Less.*	0.590598	2.912621	0.590598	4.093817
7	*Mahonia acanthifolia Wall. ex G. Don*	0.11812	1.294498	0.11812	1.530737
8	*Photinia integrifolia Lindl.*	0.472478	1.941748	0.472478	2.886704
9	*Polygonum runcinatum Buchanan-Hamilton ex D. Don*	0.472478	2.265372	0.472478	3.210328

.

10	*Rhododendron arboreum Sm.*	0.259863	1.618123	0.259863	2.137849
11	*Rubus moluccanus L.*	0.590598	2.588997	0.590598	3.770192
12	*Rubus ellipticus Sm.*	0.779589	3.559871	0.779589	5.119048
13	*Rubus lineatus Reinwardt*	0.448854	2.265372	0.448854	3.163081
14	*Smilax munita S.C.Chen*	5.173636	10.03236	5.173636	20.37963
15	*Symplocos theifolia (Hayata) Hayata*	3.283723	9.385113	3.283723	15.95256
16	*Symplocos glomerata King ex C.B.Clarke*	2.527758	5.825243	2.527758	10.88076
17	*Strobilanthes divaricata (Nees) T.Anderson*	0.330735	1.618123	0.330735	2.279592
18	*Zanthoxylum oxyphyllum Edgew*	0.165367	0.970874	0.165367	1.301608
19	*Neillia thyrsiflora D. Don*	1.393811	5.177994	1.393811	7.965615
20	*Tsuga dumosa (D. Don) Eichler*	0.685093	1.294498	0.685093	2.664685
21	*Berberis aristata DC.*	1.204819	3.883495	1.204819	6.293134
22	*Ficus neriifolia* J.E. Smith	0.11812	0.647249	0.11812	0.883488
23	*Hypericum hookerianum Wight & Arn.*	0.047248	0.323625	0.047248	0.41812
24	Viburnum erubescens Wall. ex DC.	0.070872	0.647249	0.070872	0.788993
25	Talama hodgsonii	0.070872	0.647249	0.070872	0.788993
26	Rhododendron grande Wight	0.401606	1.941748	0.401606	2.74496
27	Daphnephyllum himalayense	0.141743	0.970	0.141743	1.254361

			874		
28	Rhus insignis	0.141743	0.647249	0.141743	0.930736
		100	**100**	**100**	**300**

Table 10: Results of species diversity indices (Shannon-Weiner index and Simpson index) analysed for shrub species and saplings recorded in the 5 x 5 m quadrats during the surveys held in October 2015

Sl. No	**Plant Name**	**pi2**	**pilnpi**
1	*Yushania maling(Gamble)R.B.Majumdar*	0.597854	0.198873
2	*Daphne bholua Buch.-Ham. ex D.Don*	0.000157	0.054845
3	*Quercus lineata Blume*	8.49E-05	0.043184
4	*Quercus pachyphylla Kurz.*	6.08E-05	0.037842
5	*Quercus lamellosa Sm.*	5.58E-06	0.014288
6	*Myriacts nepalensis Less.*	3.49E-05	0.030308
7	*Mahonia acanthifolia Wall. ex G. Don*	1.4E-06	0.007963
8	*Photinia integrifolia Lindl.*	2.23E-05	0.025301
9	*Polygonum runcinatum Buchanan-Hamilton ex D. Don*	2.23E-05	0.025301
10	*Rhododendron arboreum Sm.*	6.75E-06	0.015469
11	*Rubus moluccanus L.*	3.49E-05	0.030308
12	*Rubus ellipticus Sm.*	6.08E-05	0.037842
13	*Rubus lineatus Reinwardt*	2.01E-05	0.024266
14	*Smilax munita S.C.Chen*	0.002677	0.153222
15	*Symplocos theifolia (Hayata) Hayata*	0.001078	0.112178

16	*Symplocos glomerata King ex C.B.Clarke*	0.000639	0.092967
17	*Strobilanthes divaricata (Nees) T.Anderson*	1.09E-05	0.01889
18	*Zanthoxylum oxyphyllum Edgew*	2.73E-06	0.010591
19	*Neillia thyrsiflora D. Don*	0.000194	0.059559
20	*Tsuga dumosa (D. Don) Eichler*	4.69E-05	0.034141
21	*Berberis aristata DC.*	0.000145	0.053239
22	*Ficus neriifolia* J.E. Smith	1.4E-06	0.007963
23	*Hypericum hookerianum Wight & Arn.*	2.23E-07	0.003618
24	Viburnum erubescens Wall. ex DC.	5.02E-07	0.00514
25	Talama hodgsonii	5.02E-07	0.00514
26	Rhododendron grande Wight	1.61E-05	0.022158
27	Daphnephyllum himalayense	2.01E-06	0.009297
28	Rhus insignis	2.01E-06	0.009297
		0.603183	**1.143191**

Simpson index = 0.603183, i.e., concentration of dominance of shrub species

Shanon-weiner index = 1.143191, i.e., measure of shrub species diversity

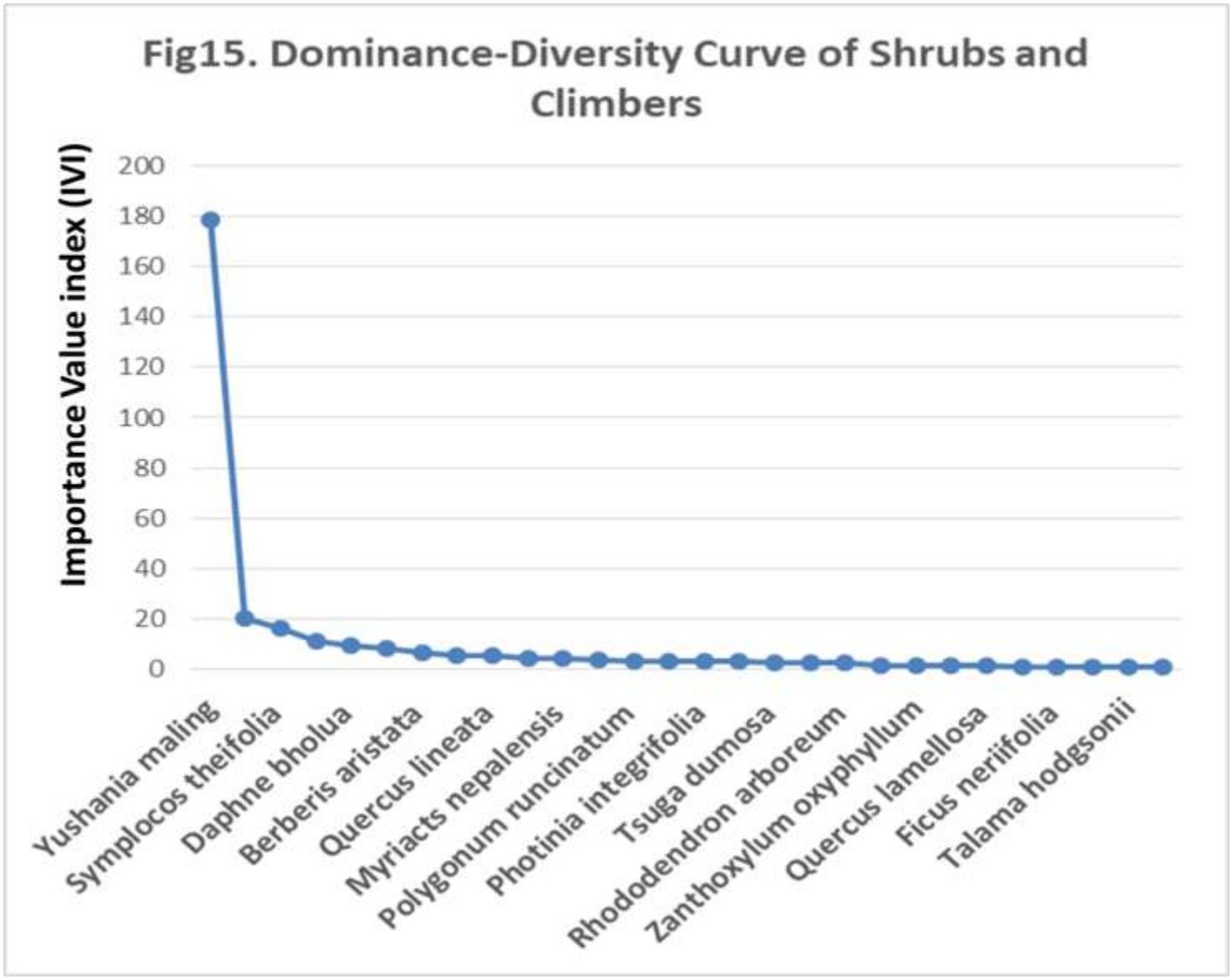


Fig15. Dominance-Diversity Curve of Shrubs and Climbers
Importance Value index (IVI)
200
180
160
140
120
100
80
60
40
20
0
Yushania maling
Symplocos theifolia
Daphne bholua
Berberis aristata
Quercus lineata
Myriacts nepalensis
Polygonum runcinatum
Photinia integrifolia
Tsuga dumosa
Rhododendron arboreum
Zanthoxylum oxyphyllum
Quercus lamellosa
Ficus neriifolia
Talama hodgsonii

Table11: An account of herb species and seedings, number of individuals recorded in the 1 m x 1 m quadrats during the surveys held in October 2015.

Sl. No	**Species Name**	**Individual**	**Dn (m^2)**
1	Ajuga lobata D.Don	20	0.57
2	Agapetes hookeri (C. B. Cl.) Sleum.	2	0.06
3	Ainsliaea latifolia (D. Don) Sch.Bip	3	0.09
4	Carex cruciata Wahlenb.	57	3.75
5	Dryopteris chrysocoma (Christ) C. Chr.	41	1.33
6	Fragaria nubicola (Lindl. ex Hook.f.) Lacaita	5	0.14
7	Hemiphragma heterophyllum Wall.	4	0.2
8	Myriactis nepalensis	25	2.79
9	Oleandra pistillaris (Sw.) C.Chr.	1	0.04
10	Ophiopogon intermedius D.Don	38	2.45
11	Polystichum lentum (D.Don) T.Moore	3	0.07
12	Potentilla indica (Andrews) Th.Wolf	18	0.72
13	Plantago asiatica subsp. erosa (Wall.) Z.Yu Li	8	0.25
14	Pteris aspericaulis Wall. ex J.Agardh	8	0.25
15	Rubia wallichiana Decne.	9	0.23
16	Scutellaria discolor Wall. ex Benth.	5	0.11
17	Smilax elegans Wall. ex Kunth	5	0.11
18	Swertia chirayita (Roxb.)	2	0.04

	H.Karst.		
19	Viola hookeri Thomson	15	0.53
20	Hemiphragma heterophyllum	1	0.1
21	Ranunculus diffusus DC.	1	0.03
22	Anaphalis triplinervis(Sims)Sims.ex C.B.Clarke.	2	0.06
23	Arundinaria racemosa Munro	2	0.11
24	Selaginella monospora Spring	4	0.17
25	Sanicula elata D.Don	1	0.05
26	Bulbophyllum bisetum Lindl.	1	0.03
27	Viola pilosa	3	0.06
28	Selinum wallichianum	1	0.03
29	Oxalis acetosella L.	2	0.04
30	Hydrocotyle himalaica P.K.Mukh.	1	0.01
31	Plagiogyria pycnophylla (Kunze) Mett. Syn. Plagiogyria scandens Mett.	3	0.09
32	Persicaria campanulata	1	0.01
33	Elatostema monandrum (Buch.-HamexD.Don)	1	0.03
34	Gallium elegansWall.Ex.Roxb.	1	0.01
35	Pilea ternifolia Wedd.	1	0.02
36	Hypericum japonicum Thunb.ex Murray	1	0.04

Table12 : An account of relative frequency, relative density and relative area of herbs/seedlings recorded in the 1 m x 1 m quadrats during the surveys held in October 2015.

Sl. No	Species Name	Rd	Rf	Ra	IVI
1	Ajuga lobata D.Don	3.898769	6.756757	3.898769	14.55429

2	Agapetes hookeri (C. B. Cl.) Sleum.	0.410397	0.675676	0.410397	1.496469
3	Ainsliaea latifolia (D. Don) Sch.Bip	0.615595	1.013514	0.615595	2.244704
4	Carex cruciata Wahlenb.	25.64979	19.25676	25.64979	70.55635
5	Dryopteris chrysocoma (Christ) C. Chr.	9.097127	13.85135	9.097127	32.04561
6	Fragaria nubicola (Lindl. ex Hook.f.) Lacaita	0.957592	1.689189	0.957592	3.604374
7	Hemiphragma heterophyllum Wall.	1.367989	1.351351	1.367989	4.087329
8	Myriactis nepalensis	19.08345	8.445946	19.08345	46.61284
9	Oleandra pistillaris (Sw.) C.Chr.	0.273598	0.337838	0.273598	0.885033
10	Ophiopogon intermedius D.Don	16.75787	12.83784	16.75787	46.35357
11	Polystichum lentum (D.Don) T.Moore	0.478796	1.013514	0.478796	1.971106
12	Potentilla indica (Andrews) Th.Wolf	4.924761	6.081081	4.924761	15.9306
13	Plantago asiatica subsp. erosa (Wall.) Z.Yu Li	1.709986	2.702703	1.709986	6.122675
14	Pteris aspericaulis Wall. ex J.Agardh	1.709986	2.702703	1.709986	6.122675
15	Rubia wallichiana Decne.	1.573187	3.040541	1.573187	6.186915
16	Scutellaria discolor Wall. ex Benth.	0.752394	1.689189	0.752394	3.193977
17	Smilax elegans Wall. ex Kunth	0.752394	1.689189	0.752394	3.193977
18	Swertia chirayita (Roxb.) H.Karst.	0.273598	0.675676	0.273598	1.222871
19	Viola hookeri Thomson	3.625171	5.067568	3.625171	12.31791
20	Hemiphragma heterophyllum	0.683995	0.337838	0.683995	1.705827
21	Ranunculus diffusus DC.	0.205198	0.337838	0.205198	0.748235

22	Anaphalis triplinervis(Sims)Sims.ex C.B.Clarke.	0.410397	0.675676	0.410397	1.496469
23	Arundinaria racemosa Munro	0.752394	0.675676	0.752394	2.180464
24	Selaginella monospora Spring	1.162791	1.351351	1.162791	3.676933
25	Sanicula elata D.Don	0.341997	0.337838	0.341997	1.021832
26	Bulbophyllum bisetum Lindl.	0.205198	0.337838	0.205198	0.748235
27	Viola pilosa	0.410397	1.013514	0.410397	1.834307
28	Selinum wallichianum	0.205198	0.337838	0.205198	0.748235
29	Oxalis acetosella L.	0.273598	0.675676	0.273598	1.222871
30	Hydrocotyle himalaica P.K.Mukh.	0.068399	0.337838	0.068399	0.474637
31	Plagiogyria pycnophylla (Kunze) Mett. Syn. Plagiogyria scandens Mett.	0.615595	1.013514	0.615595	2.244704
32	Persicaria campanulata	0.068399	0.337838	0.068399	0.474637
33	Elatostema monandrum (Buch.-HamexD.Don)	0.205198	0.337838	0.205198	0.748235
34	Gallium elegansWall.Ex.Roxb.	0.068399	0.337838	0.068399	0.474637
35	Pilea ternifolia Wedd.	0.136799	0.337838	0.136799	0.611436
36	Hypericum japonicum Thunb.ex Murray	0.273598	0.337838	0.273598	0.885033

Table13: Results of species diversity indices (Shannon-Weiner index and Simpson index) analysed for herb species and seedings recorded in the 1 m x 1 m quadrats during the surveys held in October 2015.

Sl. No	**Species Name**	**pi2**	**Pilnpi**
1	Ajuga lobata D.Don	0.00152	0.126496
2	Agapetes hookeri (C. B. Cl.) Sleum.	1.68E-05	0.022555
3	Ainsliaea latifolia (D. Don) Sch.Bip	3.79E-05	0.031336
4	Carex cruciata Wahlenb.	0.065791	0.349

5	Dryopteris chrysocoma (Christ) C. Chr.	0.008276	0.218077
6	Fragaria nubicola (Lindl. ex Hook.f.) Lacaita	9.17E-05	0.044514
7	Hemiphragma heterophyllum Wall.	0.000187	0.058712
8	Myriactis nepalensis	0.036418	0.316088
9	Oleandra pistillaris (Sw.) C.Chr.	7.49E-06	0.016146
10	Ophiopogon intermedius D.Don	0.028083	0.299346
11	Polystichum lentum (D.Don) T.Moore	2.29E-05	0.025576
12	Potentilla indica (Andrews) Th.Wolf	0.002425	0.148279
13	Plantago asiatica subsp. erosa (Wall.) Z.Yu Li	0.000292	0.069574
14	Pteris aspericaulis Wall. ex J.Agardh	0.000292	0.069574
15	Rubia wallichiana Decne.	0.000247	0.06532
16	Scutellaria discolor Wall. ex Benth.	5.66E-05	0.03679
17	Smilax elegans Wall. ex Kunth	5.66E-05	0.03679
18	Swertia chirayita (Roxb.) H.Karst.	7.49E-06	0.016146
19	Viola hookeri Thomson	0.001314	0.120257
20	Hemiphragma heterophyllum	4.68E-05	0.034097
21	Ranunculus diffusus DC.	4.21E-06	0.0127
22	Anaphalis triplinervis(Sims)Sims.ex C.B.Clarke.	1.68E-05	0.022555
23	Arundinaria racemosa Munro	5.66E-05	0.03679
24	Selaginella monospora Spring	0.000135	0.051795
25	Sanicula elata D.Don	1.17E-05	0.019419

26	Bulbophyllum bisetum Lindl.	4.21E-06	0.0127
27	Viola pilosa	1.68E-05	0.022555
28	Selinum wallichianum	4.21E-06	0.0127
29	Oxalis acetosella L.	7.49E-06	0.016146
30	Hydrocotyle himalaica P.K.Mukh.	4.68E-07	0.004985
31	Plagiogyria pycnophylla (Kunze) Mett. Syn. Plagiogyria scandens Mett.	3.79E-05	0.031336
32	Persicaria campanulata	4.68E-07	0.004985
33	Elatostema monandrum (Buch.-HamexD.Don)	4.21E-06	0.0127
34	Gallium elegansWall.Ex.Roxb.	4.68E-07	0.004985
35	Pilea ternifolia Wedd.	1.87E-06	0.009021
36	Hypericum japonicum Thunb.ex Murray	7.49E-06	0.016146
	TOTAL	0.145501	2.396184

Simpson index = 0.145501 i.e., concentration of dominance of herbs and seedlings

Shanon-weiner index = 2.396184 i.e., measure of herb species and seedlings diversity

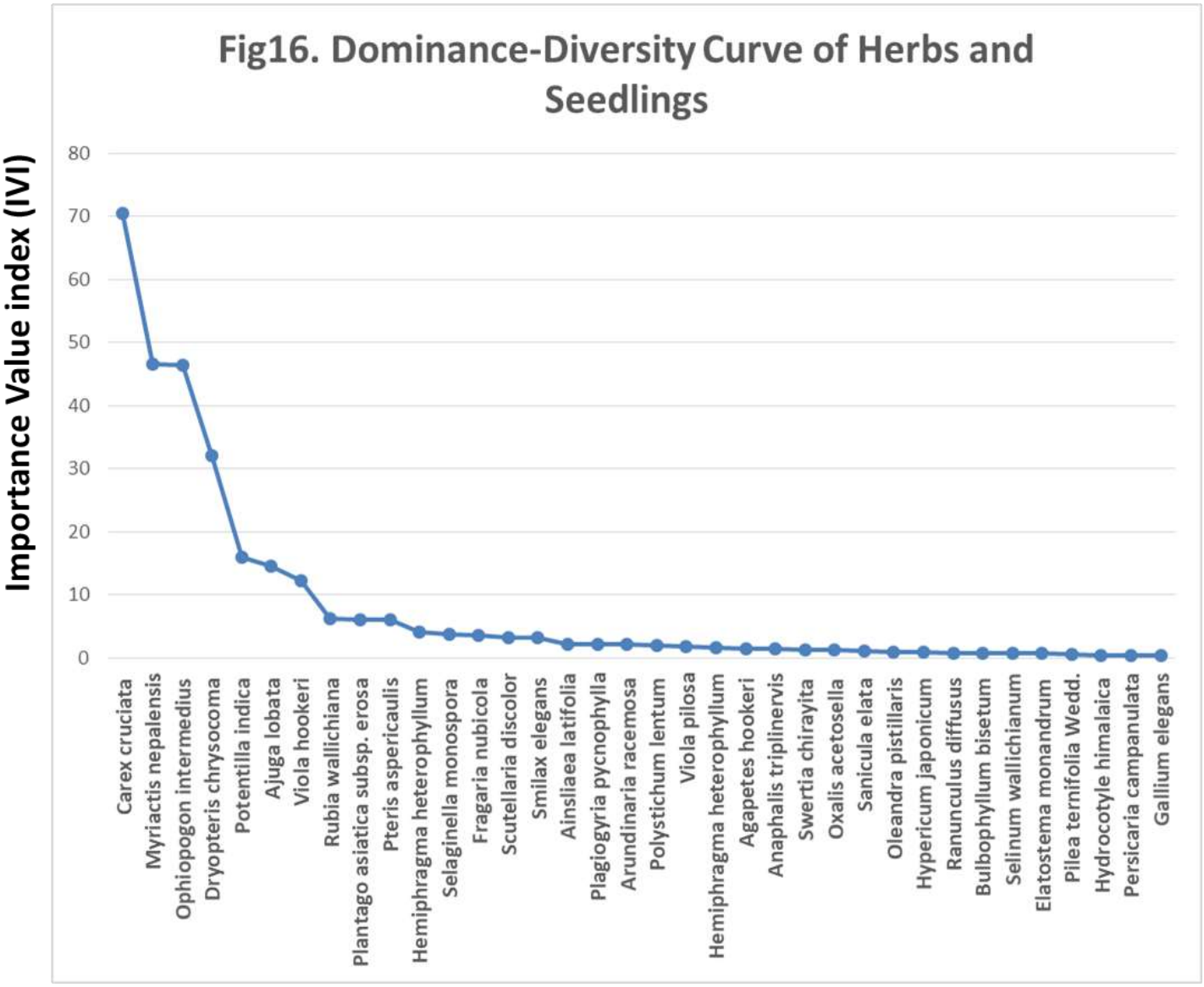


Fig16. Dominance-Diversity Curve of Herbs and Seedlings
Importance Value index (IVI)
80
70
60
50
40
30
20
10
0
Carex cruciata
Myriactis nepalensis
Ophiopogon intermedius
Dryopteris chrysocoma
Potentilla indica
Ajuga lobata
Viola hookeri
Rubia wallichiana
Plantago asiatica subsp. erosa
Pteris aspericaulis
Hemiphragma heterophyllum
Selaginella monospora
Fragaria nubicola
Scutellaria discolor
Smilax elegans
Ainsliaea latifolia
Plagiogyria pycnophylla
Arundinaria racemosa
Polystichum lentum
Viola pilosa
Hemiphragma heterophyllum
Agapetes hookeri
Anaphalis triplinervis
Swertia chirayita
Oxalis acetosella
Sanicula elata
Oleandra pistillaris
Hypericum japonicum
Ranunculus diffusus
Bulbophyllum bisetum
Selinum wallichianum
Elatostema monandrum
Pilea ternifolia Wedd.
Hydrocotyle himalaica
Persicaria campanulata
Gallium elegans

Table 14: An account of relative frequency, relative density and relative dominance of tree species recorded in the 20 x 20 m quadrats during the surveys held in January 2016

Sl. No.	**Species Name**	**Relative density**	**Relative frequency**	**Relative dominance**	**IVI**
1	Photinia integrifolia Lindl.	3.097345	4.123711	0.534582	7.755638
2	Quercus lamellosa Sm.	0.884956	2.061856	0.384278	3.33109
3	Quercus lineata Blume	11.50442	11.34021	16.10666	38.95129
4	Quercus pachyphylla Kurz.	25.66372	16.49485	29.37676	71.53532
5	Symplocos theifolia (Hayata) Hayata	5.752212	8.247423	0.427841	14.42748
6	Tsuga dumosa (D. Don) Eichler	16.81416	17.52577	34.30285	68.64278
7	Maesa chisia Buch.-Ham. Ex D. Don	0.884956	2.061856	0.084701	3.031512
8	Betula alnoides	2.212389	3.092784	0.061747	5.36692
9	Rhododendron arboreum	3.982301	5.154639	0.711909	9.848849
10	Taxus wallichiana Zucc.	7.964602	7.216495	4.952573	20.13367
11	Endospermum chinense	1.327434	3.092784	0.182953	4.60317
12	Machilus edulis	2.212389	5.154639	3.155013	10.52204
13	Ilex sikkimensis Kurz	2.212389	3.092784	1.387735	6.692908
14	Rhododendron grande Wight	12.38938	7.216495	6.449483	26.05536
15	Acer campbellii Hook.f. & Thomson ex Hiern	1.327434	2.061856	0.036139	3.425428
16	Vitex heterophylla	1.769912	2.061856	1.844779	5.676547
	Total	100	100	100	300

Table 15: Results of species diversity indices (Shannon-Weiner index and Simpson index) analysed for tree species recorded in the 20 x 20 m quadrats during the surveys held in January 2016

Sl. No.	**Species Name**	**pi2**	**pilnpi**
1	Photinia integrifolia Lindl.	0.000959	0.107621
2	Quercus lamellosa Sm.	7.83E-05	0.041835
3	Quercus lineata Blume	0.013235	0.248776
4	Quercus pachyphylla Kurz.	0.065863	0.34905
5	Symplocos theifolia (Hayata) Hayata	0.003309	0.164259
6	Tsuga dumosa (D. Don) Eichler	0.028272	0.299788
7	Maesa chisia Buch.-Ham. Ex D. Don	7.83E-05	0.041835
8	Betula alnoides	0.000489	0.084316
9	Rhododendron arboreum	0.001586	0.128362
10	Taxus wallichiana Zucc.	0.006343	0.201517
11	Endospermum chinense	0.000176	0.057371
12	Machilus edulis	0.000489	0.084316
13	Ilex sikkimensis Kurz	0.000489	0.084316
14	Rhododendron grande Wight	0.01535	0.258731
15	Acer campbellii Hook.f. & Thomson ex Hiern	0.000176	0.057371
16	Vitex heterophylla	0.000313	0.071402
	Total	**0.137207**	**2.280868**

Simpson index = **0.13720**, i.e., concentration of dominance of tree species.

Shanon-weiner index = **2.280868** i.e., measure of tree species diversity

Table 16: An account of shrub species and saplings, number of individuals recorded in the 5 m x 5 m quadrats during the surveys held in January 2016.

Sl. No	Plant Name	Individual	Dn(m^2)
1	*Yushania maling(Gamble)R.B.Majumdar*	3273	1.6365
2	*Daphne bholua Buch.-Ham. ex D.Don*	53	0.0265
3	*Quercus lineata Blume*	39	0.0195
4	*Quercus pachyphylla Kurz.*	33	0.0165
5	*Quercus lamellosa Sm.*	10	0.005
6	*Myriacts nepalensis Less.*	25	0.0125
7	*Mahonia acanthifolia Wall. ex G. Don*	5	0.0025
8	*Photinia integrifolia Lindl.*	20	0.01
9	*Polygonum runcinatum Buchanan-Hamilton ex D. Don*	20	0.01
10	*Rhododendron arboreum Sm.*	11	0.0055
11	*Rubus moluccanus L.*	25	0.0125
12	*Rubus ellipticus Sm.*	33	0.0165
13	*Rubus lineatus Reinwardt*	19	0.0095
14	*Smilax munita S.C.Chen*	219	0.1095
15	*Symplocos theifolia (Hayata) Hayata*	139	0.0695
16	*Symplocos glomerata King ex C.B.Clarke*	107	0.0535
17	*Strobilanthes divaricata (Nees) T.Anderson*	14	0.007
18	*Zanthoxylum oxyphyllum Edgew*	7	0.0035
19	*Neillia thyrsiflora D. Don*	59	0.0295
20	*Tsuga dumosa (D. Don) Eichler*	29	0.0145
21	*Berberis aristata DC.*	51	0.0255
22	*Ficus neriifolia* J.E. Smith	5	0.0025
23	*Hypericum hookerianum Wight & Arn.*	2	0.001
24	Viburnum erubescens Wall. ex DC.	3	0.0015

25	Talama hodgsonii	3	0.0015
26	Rhododendron grande Wight	17	0.0085
27	Daphnephyllum himalayense	6	0.003
28	Rhus insignis	6	0.003

Table 17: An account of relative frequency, relative density and relative area of shrub species and saplings recorded in the 5 x 5 m quadrats during the surveys held in January 2016.

Sl. No	Species Name	Rd	Rf	Ra	IVI
1	*Yushania maling(Gamble)R.B.Majumdar*	77.32105	24.27184	77.32105	178.9139
2	*Daphne bholua Buch.-Ham. ex D.Don*	1.252067	6.796117	1.252067	9.300251
3	*Quercus lineata Blume*	0.921332	3.236246	0.921332	5.078911
4	*Quercus pachyphylla Kurz.*	0.779589	2.588997	0.779589	4.148175
5	*Quercus lamellosa Sm.*	0.236239	0.647249	0.236239	1.119727
6	*Myriacts nepalensis Less.*	0.590598	2.912621	0.590598	4.093817
7	*Mahonia acanthifolia Wall. ex G. Don*	0.11812	1.294498	0.11812	1.530737
8	*Photinia integrifolia Lindl.*	0.472478	1.941748	0.472478	2.886704
9	*Polygonum runcinatum Buchanan-Hamilton ex D. Don*	0.472478	2.265372	0.472478	3.210328
10	*Rhododendron arboreum Sm.*	0.259863	1.618123	0.259863	2.137849
11	*Rubus moluccanus L.*	0.590598	2.588997	0.590598	3.770192
12	*Rubus ellipticus Sm.*	0.779589	3.559871	0.779589	5.119048
13	*Rubus lineatus Reinwardt*	0.448854	2.265372	0.448854	3.163081
14	*Smilax munita S.C.Chen*	5.173636	10.03236	5.173636	20.37963

15	*Symplocos theifolia (Hayata) Hayata*	3.283723	9.385113	3.283723	15.95256
16	*Symplocos glomerata King ex C.B.Clarke*	2.527758	5.825243	2.527758	10.88076
17	*Strobilanthes divaricata (Nees) T.Anderson*	0.330735	1.618123	0.330735	2.279592
18	*Zanthoxylum oxyphyllum Edgew*	0.165367	0.970874	0.165367	1.301608
19	*Neillia thyrsiflora D. Don*	1.393811	5.177994	1.393811	7.965615
20	*Tsuga dumosa (D. Don) Eichler*	0.685093	1.294498	0.685093	2.664685
21	*Berberis aristata DC.*	1.204819	3.883495	1.204819	6.293134
22	*Ficus neriifolia* J.E. Smith	0.11812	0.647249	0.11812	0.883488
23	*Hypericum hookerianum Wight & Arn.*	0.047248	0.323625	0.047248	0.41812
24	Viburnum erubescens Wall. ex DC.	0.070872	0.647249	0.070872	0.788993
25	Talama hodgsonii	0.070872	0.647249	0.070872	0.788993
26	Rhododendron grande Wight	0.401606	1.941748	0.401606	2.74496
27	Daphnephyllum himalayense	0.141743	0.970874	0.141743	1.254361
28	Rhus insignis	0.141743	0.647249	0.141743	0.930736
		100	100	100	300

Table 18: Results of species diversity indices (Shannon-Weiner index and Simpson index) analysed for shrub species and saplings recorded in the 5 x 5 m quadrats during the surveys held in January 2016.

Sl. No	**Species Name**	**pi2**	**Pilnpi**
1	*Yushania maling(Gamble)R.B.Majumdar*	0.597854	0.198873
2	*Daphne bholua Buch.-Ham. ex D.Don*	0.000157	0.054845

3	*Quercus lineata Blume*	8.49E-05	0.043184
4	*Quercus pachyphylla Kurz.*	6.08E-05	0.037842
5	*Quercus lamellosa Sm.*	5.58E-06	0.014288
6	*Myriacts nepalensis Less.*	3.49E-05	0.030308
7	*Mahonia acanthifolia Wall. ex G. Don*	1.4E-06	0.007963
8	*Photinia integrifolia Lindl.*	2.23E-05	0.025301
9	*Polygonum runcinatum Buchanan-Hamilton ex D. Don*	2.23E-05	0.025301
10	*Rhododendron arboreum Sm.*	6.75E-06	0.015469
11	*Rubus moluccanus L.*	3.49E-05	0.030308
12	*Rubus ellipticus Sm.*	6.08E-05	0.037842
13	*Rubus lineatus Reinwardt*	2.01E-05	0.024266
14	*Smilax munita S.C.Chen*	0.002677	0.153222
15	*Symplocos theifolia (Hayata) Hayata*	0.001078	0.112178
16	*Symplocos glomerata King ex C.B.Clarke*	0.000639	0.092967
17	*Strobilanthes divaricata (Nees) T.Anderson*	1.09E-05	0.01889
18	*Zanthoxylum oxyphyllum Edgew*	2.73E-06	0.010591
19	*Neillia thyrsiflora D. Don*	0.000194	0.059559
20	*Tsuga dumosa (D. Don) Eichler*	4.69E-05	0.034141
21	*Berberis aristata DC.*	0.000145	0.053239
22	*Ficus neriifolia* J.E. Smith	1.4E-06	0.007963
23	*Hypericum hookerianum Wight & Arn.*	2.23E-07	0.003618
24	Viburnum erubescens Wall. ex DC.	5.02E-07	0.00514
25	Talama hodgsonii	5.02E-07	0.00514
26	Rhododendron grande Wight	1.61E-05	0.022158
27	Daphnephyllum himalayense	2.01E-06	0.009297
28	Rhus insignis	2.01E-06	0.009297
	Total	**0.603183**	**1.143191**

Simpson index = **0.603183** i.e., concentration of dominance of shrub species.

Shanon-weiner index = **1.143191**, i.e., measure of shrub species diversity

Table 19: An account of herb species and seedings, number of individuals recorded in the 1 m x 1 m quadrats during the surveys held in January 2016.

Sl. No	Species Name	Individual	Rd
1	Ajuga lobata D.Don	57	4.039688
2	Agapetes hookeri (C. B. Cl.) Sleum.	6	0.42523
3	Ainsliaea latifolia (D. Don) Sch.Bip	9	0.637845
4	Carex cruciata Wahlenb.	362	25.65556
5	Dryopteris chrysocoma (Christ) C. Chr.	133	9.425939
6	Fragaria nubicola (Lindl. ex Hook.f.) Lacaita	16	1.133948
7	Hemiphragma heterophyllum Wall.	275	19.48972
8	Myriactis nepalensis	4	0.283487
9	Oleandra pistillaris (Sw.) C.Chr.	239	16.93834
10	Ophiopogon intermedius D.Don	7	0.496102
11	Polystichum lentum (D.Don) T.Moore	70	4.961021
12	Potentilla indica (Andrews) Th.Wolf	25	1.771793
13	Plantago asiatica subsp. erosa (Wall.) Z.Yu Li	23	1.63005
14	Pteris aspericaulis Wall. ex J.Agardh	23	1.63005
15	Rubia wallichiana Decne.	11	0.779589
16	Scutellaria discolor Wall. ex Benth.	11	0.779589
17	Smilax elegans Wall. ex Kunth	4	0.283487

18	Viola hookeri Thomson	53	3.756201
19	Hemiphragma heterophyllum	8	0.566974
20	Ranunculus diffusus DC.	3	0.212615
21	Anaphalis triplinervis (Sims) Sims.ex C.B.Clarke.	6	0.42523
22	Arundinaria racemosa Munro	11	0.779589
23	Selaginella monospora Spring	17	1.204819
24	Sanicula elata D.Don	5	0.354359
25	Bulbophyllum bisetum Lindl.	3	0.212615
26	Viola pilosa	6	0.42523
27	Selinum wallichianum	3	0.212615
28	Ficus neriifolia J.E. Smith	1	0.070872
29	*Hypericum hookerianum Wight & Arn.*	9	0.637845
30	Viburnum erubescens Wall. ex DC.	1	0.070872
31	Talama hodgsonii	3	0.212615
32	Rhododendron grande Wight	1	0.070872
33	Daphnephyllum himalayense	2	0.141743
34	Rhus insignis	4	0.283487
	Total	1411	100

Table 20 : An account of relative frequency, relative density and relative area of herb species and seedlings recorded in the 1 m x 1 m quadrats during the surveys held in January 2016.

Sl. No	**Plant Name**	**Rd**	**Rf**	**Ra**	**IVI**
1	Ajuga lobata D.Don	4.039688	6.920415	2.371139	13.33124
2	Agapetes hookeri (C. B. Cl.) Sleum.	0.42523	0.692042	2.495936	3.613208
3	Ainsliaea latifolia (D. Don) Sch.Bip	0.637845	1.038062	2.495936	4.171844
4	Carex cruciata Wahlenb.	25.65556	19.72318	5.283794	50.66254
5	Dryopteris chrysocoma	9.425939	14.18685	2.698857	26.31165

	(Christ) C. Chr.				
6	Fragaria nubicola (Lindl. ex Hook.f.) Lacaita	1.133948	1.384083	3.327914	5.845945
7	Hemiphragma heterophyllum Wall.	19.48972	8.650519	9.151765	37.29201
8	Myriactis nepalensis	0.283487	0.346021	3.327914	3.957422
9	Oleandra pistillaris (Sw.) C.Chr.	16.93834	13.14879	5.232707	35.31984
10	Ophiopogon intermedius D.Don	0.496102	1.038062	1.941283	3.475448
11	Polystichum lentum (D.Don) T.Moore	4.961021	6.228374	3.235472	14.42487
12	Potentilla indica (Andrews) Th.Wolf	1.771793	2.768166	2.599933	7.139892
13	Plantago asiatica subsp. erosa (Wall.) Z.Yu Li	1.63005	2.768166	2.391938	6.790154
14	Pteris aspericaulis Wall. ex J.Agardh	1.63005	3.114187	2.126168	6.870404
15	Rubia wallichiana Decne.	0.779589	1.730104	1.830353	4.340046
16	Scutellaria discolor Wall. ex Benth.	0.779589	1.730104	1.830353	4.340046
17	Smilax elegans Wall. ex Kunth	0.283487	0.692042	1.663957	2.639486
18	Viola hookeri Thomson	3.756201	5.190311	2.939658	11.88617
19	Hemiphragma heterophyllum	0.566974	0.346021	6.655829	7.568823
20	Ranunculus diffusus DC.	0.212615	0.346021	2.495936	3.054572
21	Anaphalis triplinervis(Sims)Sims.ex C.B.Clarke.	0.42523	0.692042	2.495936	3.613208
22	Arundinaria racemosa Munro	0.779589	0.692042	4.575882	6.047513
23	Selaginella monospora Spring	1.204819	1.384083	3.535909	6.124811
24	Sanicula elata D.Don	0.354359	0.346021	4.159893	4.860272
25	Bulbophyllum bisetum Lindl.	0.212615	0.346021	2.495936	3.054572
26	Viola pilosa	0.42523	1.038062	1.663957	3.12725

27	Selinum wallichianum	0.212615	0.346021	2.495936	3.054572
28	*Ficus neriifolia* J.E. Smith	0.346021	0.831979	1.248871	4.68E-07
29	*Hypericum hookerianum Wight & Arn.*	1.038062	2.495936	4.171844	3.79E-05
30	Viburnum erubescens Wall. ex DC.	0.346021	0.831979	1.248871	4.68E-07
31	Talama hodgsonii	0.346021	2.495936	3.054572	4.21E-06
32	Rhododendron grande Wight	0.346021	0.831979	1.248871	4.68E-07
33	Daphnephyllum himalayense	0.346021	1.663957	2.151721	1.87E-06
34	Rhus insignis	0.346021	3.327914	3.957422	7.49E-06
	Total	**100**	**99.99997**	**300**	**0.138262**

Table 21: Results of species diversity indices (Shannon-Weiner index and Simpson index) analysed for herb species and seedlings recorded in the 1 m x 1 m quadrats during the surveys held in January 2016.

Sl. No	Plant Name	pi2	Pilnpi
1	Ajuga lobata D.Don	0.00152	0.126496
2	Agapetes hookeri (C. B. Cl.) Sleum.	1.68E-05	0.022555
3	Ainsliaea latifolia (D. Don) Sch.Bip	3.79E-05	0.031336
4	Carex cruciata Wahlenb.	0.061309	0.345637
5	Dryopteris chrysocoma (Christ) C. Chr.	0.008276	0.218077
6	Fragaria nubicola (Lindl. ex Hook.f.) Lacaita	0.00012	0.049411
7	Hemiphragma heterophyllum Wall.	0.035381	0.314273
8	Myriactis nepalensis	7.49E-06	0.016146
9	Oleandra pistillaris (Sw.) C.Chr.	0.026724	0.296069
10	Ophiopogon intermedius D.Don	2.29E-05	0.025576

11	Polystichum lentum (D.Don) T.Moore	0.002292	0.145509
12	Potentilla indica (Andrews) Th.Wolf	0.000292	0.069574
13	Plantago asiatica subsp. erosa (Wall.) Z.Yu Li	0.000247	0.06532
14	Pteris aspericaulis Wall. ex J.Agardh	0.000247	0.06532
15	Rubia wallichiana Decne.	5.66E-05	0.03679
16	Scutellaria discolor Wall. ex Benth.	5.66E-05	0.03679
17	Smilax elegans Wall. ex Kunth	7.49E-06	0.016146
18	Viola hookeri Thomson	0.001314	0.120257
19	Hemiphragma heterophyllum	2.99E-05	0.028499
20	Ranunculus diffusus DC.	4.21E-06	0.0127
21	Anaphalis triplinervis(Sims)Sims.ex C.B.Clarke.	1.68E-05	0.022555
22	Arundinaria racemosa Munro	5.66E-05	0.03679
23	Selaginella monospora Spring	0.000135	0.051795
24	Sanicula elata D.Don	1.17E-05	0.019419
25	Bulbophyllum bisetum Lindl.	4.21E-06	0.0127
26	Viola pilosa	1.68E-05	0.022555
27	Selinum wallichianum	4.21E-06	0.0127
28	*Ficus neriifolia* J.E. Smith	4.68E-07	0.004985
29	*Hypericum hookerianum Wight & Arn.*	3.79E-05	0.031336
30	Viburnum erubescens Wall. ex DC.	4.68E-07	0.004985
31	Talama hodgsonii	4.21E-06	0.0127
32	Rhododendron grande Wight	4.68E-07	0.004985
33	Daphnephyllum himalayense	1.87E-06	0.009021
34	Rhus insignis	7.49E-06	0.016146

	Total	**0.138262**	**2.305146**

Simpson index = **0.138262** i.e., concentration of dominance of herb species and seedlings

Shanon-weiner index = **2.305146,** i.e., measure of herb species and seedlings diversity

Table 22: Details of parameters analysed in the data such as dominance, species richness and diversity indices.

Layers	**Conc. of Dominance (D)**	**SDI (1-D)**	**RSI (1/D)**	**Mehnick index**	**Species diversity**
October 2015					
Trees	0.137207	2.280868	0.862793	7.288242	1.064304
Shrub & Climber	0.603183	1.143191	0.39687	1.657873	0.414992
Herbs	0.145501	2.396184	0.854499	6.87281	0.941518
January 2016					
Trees	0.137207	2.280868	0.862793	7.288242	1.064304
Shrub & Climber	0.603183	1.143191	0.39687	1.657873	0.414992
Herbs	0.138262	2.305146	.861738	7.232652	0.958383

Threatened plants

Table 23: An account of plant species that are categorised as 'Threatened plants' and conservation conceren species recorded in Phalut MPCA.

	Name of the species	**Family**	**Habitat**	**Local Names**	**Status**
1	Taxus wallichiana Zucc.	Taxaceae	1500-2800 m hill high montane forests	Dhyangre Salla	CR
2	Berberis aristata DC.	Berberidaceae	1500-2800 m hill high montane forests	Chutro	VU
3	Panax pseudoginseng Wall.	Araliaceae	1900-2800 msl	Salanay	CR
4	*Swertia chirayita (Roxb.) H.Karst.*	Gentianaceae	1500-2800 msl	Chiroto	CR
5	Aconitum palmatum D.Don	Ranunculaceae	2800-3600 msl	Seto Bikhuma	EN

6	Cinnamomum bejolghota (Buch.-Ham.) Sweet	Lauraceae	1800 – 2500 msl	Dalchini	VU
7	Aconitum spicatum (Brühl) Stapf	Ranunculaceae	2800-3600 msl	Bikh	EN
8	Podophyllum hexandrum Royle	Berberidaceae	2800-3600 msl	Papari	CR
9	Picrorhiza kurroa Royle ex Benth.	Plantaginaceae	2700-3660 msl	Kutki	CR
10	Valeriana hardwickei Wall.	Rubiaceae	1500-3400 msl	Bhale Jatamanshi	EN
11	Thalictrum foliolosum DC.	Ranunculaceae	1500 – 2500 msl	Chitrey	VU
12	Paris polyphylla Sm.	Melanthiaceae	1500-2800 msl	Satuwa	EN

Table 24: Medicinal uses of important plants recorded in Phalut MPCA

Name of the species	Family	Parts Used	Local Name	Uses
Zanthoxylum armatum DC. Bokey	Rutaceae	Fruits	Timbur	To relieve stomach pain, toothache, fever
Zanthoxylum oxyphyllum Edgew.	Rutaceae	Stem barks, Fruits	Lahare Timbur	Skin diseases, rheumatism, varicose ulcers and varicose veins, leg pains
Rhododendron grande Wight	Ericaceae	Flower,	Gorus, Patle Korlinga	Gouty and rheumatic condition
Rubia manjith	Rubiaceae	Roots and stem bark	Manjith	Blood purifier, urinary disorder
Aconitum palmatum D.Don	Ranunculaceae	Rootstock	Seto Bikhuma	Rheumatism
Cinnamomum bejolghota (Buch.-Ham.) Sweet	Lauraceae	Bark	Dalchini	Antifungal, anticancer
Aconitum spicatum (Brühl) Stapf	Ranunculaceae	Root	Bikh	Fever, lung infection
Podophyllum	Berberidaceae	Rootstock	Papari	Fever, jaundice, liver disorders

hexandrum Royle				
Picrorhiza kurroa Royle ex Benth.	Plantaginaceae	Roots	Kutki	Treatment of disorder of liver, dyspepsia, chronic diarrhea and scorpion sting
Valeriana hardwickei Wall.	Rubiaceae	Roots	Bhale Jatamanshi	Rheumatism, joint pains, cardiac diseases, blood disorders, herpes and leprosy
Thalictrum foliolosum DC.	Ranunculaceae	Roots	Chitrey	Detoxication, Swelling, dyspepsia,jaundice, skin disease
Taxus wallichiana Zucc.	Taxaceae	Leaves and barks	Dhyangre Salla	Anticancer, locally used in cold, cough, fever and pain
Berberis aristata DC.	Berberidaceae	Root, stem and leaves	Chutro	To treat eye disorders, skin disorders with itching, diabetes, urinary tract diseases; beneficial for patients of menorrhagia and leucorrhoea
Panax pseudoginseng Wall.	Araliaceae	Rootstock	Salanay	Diabetes, cancer, and heart disease; used as revitalizer
Swertia chirayita (Roxb.) H.Karst.	Gentianaceae	Whole plant	Chiroto	bitter tonic, carminative, anti-helmintic

CHAPTER 4: CONCLUSION AND RECOMMENDATIONS

Conclusion

One of the most critical issues of global, local and national agenda is the need to preserve biodiversity for future generations (Myers et al. 2000). Concurrently there is also a necessity to understand the biodiversity-associated indigenous knowledge base for sustainable resource management practices (Saha and Ved. 2014). The medicinal plant resources are getting depleted at an alarming rate. Around 90% of medicinal plants that are consumed domestically and exported are collected from the wild. Only 70 out of around 700 species in the trade are obtained purely from cultivated sources. The ever-increasing demand of herbal products has put the valuable plant resources under great stress and brought many medicinal plants at the verge of extinction (Goraya and Ved. 2017). In this regard the establishment of MPCAs and regular botanical survey at frequent intervals would help conserving medicinal plants in general and threatened plant species in specific (Ved et al., 2003).

In addition to this, other threats to the medicinal plants are deforestation, destructive harvesting because of the use of plant parts like root, stem, bark, wood and whole plant in case of herb, extensive industrialization, forest fire and climate change. Further, unsustainable collection and high voulume trade has brought many species on the verge of extinction (CITES .2017; Menon et al., 1994) It is estimated that in India about 246 plants species are threatened, a bulk of which are medicinal plants (IUCN 2011; Pollock et al., 2003). Of these, seven species are already extinct and 44 are critically endangered (IUCN 2011). Thus, there is an urgent need to conserve the wild populations of medicinal plant diversity (Shankar and Rawat. .2013).

This pioneering work of in-situ conservation programs initiated by the State Forest Departments across India with the support of the Foundation for Revitalisation of Local Health Traditions (FRLHT) through establishing the Medicinal Plants Conservation Areas (MPCAs) resulted in numerous significant conservation outcomes (Ved et al., 2003). Noteworthy among these is a notable shift in the conservation priorities of the forestry sector. After witnessing the novel conservation activities in the MPCAs, the Forest managers all over the country admit the need for broadening the conservation priorities in the forestry sector so as to cover the hitherto ignored medicinal plants. Thus, the MPCA program caused a significant change especially in the area of in-situ conservation principles in the entire forestry sector in the country (Saha et.al. 2022). The in-situ conservation program is focused on identifying habitats, which contain viable and breeding populations of prioritised taxa. Through this MPCA program, medicinal plant taxa that are in high volume trade and belong to endemic and threatened category could

be prioritised and conserved in-situ in their natural habitats (.Saha and Ved . 2014). Another interesting aspect of this program is that state forest departments implement this program in collaboration with (1) research institutes, who are capable of undertaking further research works including population studies, threat assessment, genetic and microbiome studies, etc., (2) local community institutions to develop alternate livelihood options for reducing the forest dependence of community members who dwell neighbouring MPCA areas.

Having realised the importance of conserving medicinal plants and traditional knowledge associated with them, the State Forest Department of West Bengal has been a pioneer in introducing a number of conservation activities especially making sure of conservation concern medicinal plants are well protected within their existing network of Protected Areas (PAs). As part of their conservation action initiatives, under the CF-II National Program on Promoting Conservation of Medicinal Plants and Traditional Knowledge for Enhancing Health and Livelihood Security, in the year between 2007 and 2009, the department established a network of seven Medicinal Plants Conservation Areas (MPCAs) across the state with the support of the FRLHT, Bengaluru. The selection of MPCA sites was primarily on the basis of inputs from the Conservation Assessment and Management Prioritisation (CAMP) workshop, which is an exercise to identify important medicinal plants areas for in-situ conservation of medicinal plants. Just after the establishment of MPCAs, the research institutions were involved to undertake plant taxonomical studies to develop a checklist of medicinal plants for each MPCA.

In this project, such floristic inventory with geo-referencing and diversity studies are expected to provide a greater understanding of species composition and the diversity status of forests, which also offer vital information for forest conservation. Further, geo-spatial tools would be useful in monitoring the land use and land cover changes in and around the MPCAs. MPCA areas, while ensuring the conservation of the medicinal plants, as part of contiguous forest landscapes, play a greater role in terms of ensuring overall biodiversity conservation and associated ecosystem services such as pollinator availability, recharging ground water, carbon sequestration, check soil erosion, etc.

The overarching outcome of this project is very promising in a way that the Phalut MPCAs are proving to be a gene pool of medicinal plants of the state especially 12 number of conservation concern species with good and viable population.. MPCAs representing different forest ecosystems and landscapes of the state are found to be rich in medicinal plant diversity in terms of number of species, number of threatened species, etc. Through this project, the checklist of

plant species was updated and there are still more potential medicinal plants rich forest sites, which could be established as MPCAs.

The populations of these threatened plants were enumerated during the quadrat study and found to have good representation in all plant stages starting from adult (>30 cm gbh), sapling (≤30 cm gbh) and seedling stages (if they are trees and lianas), shrubs and herbs. It is proven that MPCAs are one such network of sites acting as refugia or natural repository of state medicinal plants being conserved in-situ. The addition of more potential forest areas would ensure the maintenance of viable population of all conservation concern medicinal plants within the MPCA network.

The current population survey and subsequently the analysis of the data has witness few important facts of the community structure in the MPCA area. Different ecological communities can be pretty diverse in terms of the types and numbers of species they cover. For example, the biotic communitiesin the polar region include just a few species, while some tropical rainforest communities have huge numbers of species packed into each cubic meter. One way to define this variance is to put forth the fact that the communities have different structures. Community structure is essentially the composition of a community, including the number of species in that community and their relative numbers. It can also be understood more broadly by attention towords all kinds of interaction between these different species.

The Phalut MPCA area, although demonstrates the dominance of species such as *Quercus pachyphylla, Tsuga dumosa, Quercus lineata, Symplocos theifolia, Taxus wallichiana, Rhododendron grande , Machilus edulis, Acer campbellii, Ilex sikkimensis, Betula alnoides* etc (Fig. 12), nevertheless the composition of the forest shows good diversity. The resource allocation in the community is reasonably homogenous in nature (Fig. 12, 13 &14). This resource allocation strategy of the community has allowed more species to establish and thrive enriching the overall diversity in the forest especially in the MPCA area

Local community people settled in the surroundings of MPCA are reported to have good knowledge and understanding of medicinal plants and their uses. Besides, they have the practice of using them for their health care needs on a regular basis. Such health traditions have to be recognised, preserved from being lost, while they have to be mainstreamed for the benefit of community members. During the questionnaire survey conducted among local community members, it was understood that there has been a regular practice of fuelwood extraction, medicinal plants collection, fodder collection, wood collection for charcoal making, etc. When

asked about the chances of implementing sustainable concepts for medicinal plants conservation, respondents informed about various opportunities available locally including (a) the cultivation of medicinal plants for commercial sale; (b) homestay business; (c) eco-tourism and the use of local craft skill; (d) improved agriculture with proper irrigation system as water scarcity is one of the emerging issues in the villages around MPCA areas; (e) women empowerment through involving them in decision making. It is also understood that there has been less awareness among local community members, irrespective of the distance of their settlements from MPCA, about the importance of MPCA in the conservation of medicinal plants. There has been no orientation given to them about the role they can play in the sustainable management of forest resources especially medicinal plants. The involvement of local community members in the resource management has to be made necessary.

The healthy status of MPCA is the proof of effective management of West Bengal Forest Department especially the role played by the frontline officers in making sure of protection of these forest patches. Though they are aware of the MPCA physically, however the importance and necessity of MPCA for medicinal plants conservation are not informed to them. It is critical that these frontline officers like watchers, guards and temporary workers in the state forest department are given proper orientation and training on the conservation of medicinal plants through establishing MPCAs across state (Ved et al., 2003; Biswash et al., 2017).

8.2 Recommendations

Further, in-situ conservation program of the MPCAs can be strengthened through collaboration among important stakeholders such as i) State Forest Department, ii) Local communities residing in the vicinity of MPCAs, iii) Research institutions and persons interested in research on medicinal plants, iv) Institutions undertaking medicinal plants related conservation education programme, v) Government departments/ organisations concerned with medicinal plants conservation, vi) Organisations like medicinal plants boards engaged in the work of conservation of medicinal plants, etc. As MPCA sites are the solely protected areas envisaged as hands off areas to provide long-term conservation of medicinal plant species, designing and implementing suitable management practices is very important. Some of the management interventions such as fire management, weed control and enrichment of native vegetation, soil and water conservation, maintenance of boundaries and paths are necessary in some of these MPCAs. Limited collection or removal of resources may be allowed for research and breeding purposes but the illicit removals, grazing and commercial harvest of any produce from MPCAs

should be strictly suspended. In addition, creating income generation activities for local dependent communities and educational programmes to promote conservation may help in better management of MPCAs. A definite role for local communities in management of MPCAs has to be built in the management scheme and the local communities need to be encouraged and facilitated in formation of local MPCA Management Committee. In all cases, the support of local communities for protection of Medicinal Plants Conservation Areas (MPCAs) is crucial.

Site specific Work Plan/Management Plan incorporating various management issues and prescriptions may be needed for each MPCA on simple formats for easy understanding in the field. The management of MPCAs, as per the Work Plan prescriptions, has to be the joint responsibility of the State Forest Department and the local communities through their local MPCA management committee. Watchers from the community may be engaged at some places to afford physical protection for MPCAs. The involvement of local community members has to be compensated with materials benefits in terms of reasonable wages in order to keep their spirits high during the activities. This will increase the morale and trust in forest management system especially at the time of less employment opportunities in the outside world. By way of providing remuneration, they would be discouraged to exploit the forest resources by making illegal wild collection of plant materials for petty cash during the employment lean period.

The local forest-dependent communities are closely associated with forest resources for their livelihoods, health security and cultural, religious and emotional bonding. They exert a lot of pressure and influence on the resources by way of collecting plant materials for medicine, fuel, etc., collecting or hunting small animals/insects, using other ecosystem services like water, pollinators, organic soil, etc. In that case, it is ideal to make them part of forest resource management system, thereby orienting them towards sustainable utilisation of resources. The complete banning of resource extraction has not shown to be successful conservation action in any landscape. Instead, the involvement of local institutions like JFMCs to create awareness and capacity building of community members on resource specific sustainable principles and methods to field implement. While making the community members to understand the implementation of sustainable wild collection through regular field trainings, the forest department may allow activities in forest fringe areas, JFMC forest areas, and to some extent into the buffer zone forest areas. Areas can be demarcated for undertaking the collection of forest resources, so that JFMCs and its members can only be allowed for such activities. These interventions like imparting the knowledge of medicinal plants and mainstreaming sustainable

resource use practices through institutional framework would ensure least anthropogenic pressures from villages neighbouring MPCAs and other protected areas.

The establishment of MPCA to conserve the medicinal plants in any natural habitats may be a new initiative for various stakeholders who get involved in this process. There is a need to sensitize different target groups to the need and approaches of conservation in general and of medicinal plants. With the proper education programmes, building the capacity to undertake conservation action programme is also very important. Some of the facilities which support education programme at MPCA sites may include i) set of signage, ii) appropriate educational materials, iii) nature trails, iv) demonstration gardens, v) interpretation centre. These facilities may be developed according to specific user needs in respect of a particular MPCA and there may not be necessary to have all these facilities and activities at all the MPCAs (Saha and Sundriyal. 2010; Saha et.al. 2022) . Therefore, the education programme should be site-specific and user-specific. After sensitizing the stakeholders about the conservation imperatives and their role in such initiatives through conservation education programmes, they need to be enabled to take up the responsibility of conservation action programmes (Saha and Sundriyal. 2012). In this case, building the capacity of various stakeholders involved in the process of establishment of conservation areas and its management is important.

Beside JFMCs, the other institutions like Self Help Groups (SHGs), constituted involving local women, can act as a good institutional machinery for carrying out number of Government schemes at local level such as laying of village roads, restoration of village ponds/lakes, tree planting, subsidies for agri/horti farming exercises, food processing, handicraft making, etc. These SHGs with the involvement of local women members can be instrumental in raising nurseries for medicinal plants, and also developing a number of value added, processed/semi-processed medicinal plant-based products. Some of the alternative livelihood options that can be offered to local community members are: (i) engagement of local community resource persons as trained tourist eco-guides with good knowledge of forest landscapes and its resources including medicinal plants found in MPCA and adjoining forest areas; (ii) developing homestay as a professional hospitality business model by introducing minimal standards and infrastructure and showcasing community's traditional lifestyle and food habits. Forest trails and nature walks in the buffer zone forest areas can be part of the homestay business model to cater to nature lovers and ecotourists; (iii) forming community clusters in the settlements near MPCAs to start activities like cultivation of medicinal plants, cash crops, plantation crops like cardamomum, ginger, etc. depending on the availability of local resources like water, soil

quality, etc. Prior to start cultivation practices, the chances of crop damages due to wildlife have to be checked, so that the choice of appropriate crops/plants can be made to avoid the crop losses; (iv) other livelihood options like honey beekeeping, value addition of locally available unique food items, drinks, etc.

In order to maintain the existing MPCAs and also to establish another set of MPCAs in the state, the West Bengal state forest department can avail funding from a number of sources. One of the most relevant funding bodies for MPCA related activities is the National Medicinal Plants Board (NMPB), Govt. of India. They have introduced Central Sector Scheme for supporting projects and activities related to conservation, development and sustainable management of medicinal plants in India. The above provided recommendations are converted into activities or projects that are eligible for fundings from the NMPB through Central Sector scheme. The projects listed in the table have to be proposed by the West Bengal State Forest Department as an implementing agency. These project proposals have to be prepared in the formats prescribed by the NMPB. The Forest department need a technical partner in terms of preparing proposals initially and executing the project with a coordrination of field offices.

Table 25: Summary of proposed medicinal plants and MPCA related activities for West Bengal state under various components given in the central sector scheme on Conservation, Development and Sustainable Management of Medicinal Plants called by the National Medicinal Plants Board (NMPB), Govt. of India.

Components of Central Sector Schemes	**Proposed activities/projects**
Conservation of medicinal plant through multi-pronged strategy	
In-situ Conservation - Medicinal Plants Conservation & Development Areas (MPCDAs)	
a. Setting up MPCDAs b. Revisiting/reviewing/documentation of existing MPCAs c. Mainstreaming medicinal plant management in management approaches	➢ Organising Conservation Assessment and Management Prioritisation (CAMP) workshop for identifying threatened medicinal plants and potential sites for MPCDAs ➢ Establishing a new network of MPCDAs in West Bengal in addition to existing 7 MPCAs ➢ Improving the status of existing 7 MPCAs in terms of upgradation, improving protection, geo-referencing, removal of exotic plants, fire management, etc. ➢ Mainstreaming medicinal plant conservation in management approaches
In-situ Resource augmentation	
Assisted Natural Regeneration (ANR) or Artificial regeneration (AR)	➢ Resource augmentation of selected RET and high traded medicinal plant species in selected forest divisions in West Bengal
Ex-situ Conservation	
Plantations of medicinal plants in lands outside of forests, in private lands	➢ Formation of a cluster of cultivators to raise selected medicinal plants in the private lands through buy back arrangements (Ideal MPCA sites are North Sevoke, Sursuti, North Rajabhatkhawa, Bonnie Camp and Tonglu)
Support to JFMCs/BMCs/Van Panchayats	
a. Creation of infrastructure facilities b. Providing packaging/handling/value addition equipment c. Buyer/seller meets, marketing support	➢ Implementation of sustainable wild collection, value addition, storage and marketing of selected medicinal plants with the involvement of JFMCs located near MPCAs in West Bengal

d. Training & capacity building e. Exposure visits, organic certifications, etc.	
Research & Development	
Population assessments and conservation biology	➢ Population assessment of selected conservation concern medicinal plants with specific reference to intrinsic and extrinsic threats to plant survival under natural conditions ➢ Developing species recovery plans for selected medicinal plants that are critically endangered and with highly commercial value ➢ Collection of germ plasm for research and propagation (in-situ and ex-situ methods)
Climate change impact studies	➢ Documenting and studying the impacts of different climate change scenarios on plant functional systems like phenotypic elements (leafing, flowering & fruiting), growth parameters (stem girth size), reproductive traits (germination, fruit maturity, delay/early arrival of pollinators, etc. ➢ Developing policy note on global warming and its impact plant growth and survival and various mitigation strategies for policy makers and general public
IEC & Training	
Awareness Building, Exposure Visits, Education and Capacity Building of Stakeholders through Information Education and Communication (IEC) strategy: a. Publicity through regular participation in Exhibitions/Fairs b. Setting up of Facilitation Centres c. Organizing Workshops/Seminars/Conferences/Arogya Fair d. Training and Capacity Building initiatives	➢ Division level Training of Trainers (ToT) or Master Trainers training program on conservation and sustainable use of medicinal plant resources in West Bengal ➢ JFMC level community training programme on conservation and sustainable use of medicinal plant resources in West Bengal ➢ State level consultation meeting on mainstreaming the conservation and sustainable use of medicinal plant resources ➢ Short-term training on state medicinal plants to forest frontline officers ➢ Developing brochures, pamphlets, other IEC materials on medicinal plants and MPCAs to create awareness among general public

	➢ Establishing interpretation centres in each MPCA to explain about medicinal plant diversity of the MPCA and also to share the importance of MPCA for medicinal plants conservation
Herbal Garden	
a. Home herbal garden b. School herbal garden c. Institutional garden	➢ Establishment of Home Herbal Gardens in the neighbourhoods of MPCA sites to improve the use of medicinal plants for daily healthcare needs at local households ➢ Establishment of School Herbal Gardens in the selected local panchayat schools that are located close to MPCA sites to create awareness about medicinal plants and its uses for daily healthcare needs at local households ➢ Establishment of institutional Gardens in the selected institution at forest division level to create general awareness about medicinal plants and its uses for daily healthcare needs
Marketing & trade	
Documenting trade practices	➢ Studying the supply value chain and demand and supply of medicinal plants that are sourced from and/or passed through West Bengal focussing Siliguri and Kolkata plant markets ➢ Assessment study on the socioeconomic aspects of trade nad marketing of medicinal plant materials on the livelihoods and income generation of local commununity members

References:

Biswas S. Rawat M. S., Tantray F., Sharma S. 2017. Medicinal plants conservation and development areas (MPCDAs)-An initiative towards conservation of medicinal plants.

IUCN .2020. The IUCN red list of threatened species. Version 2020–1. https://www.iucnredlist.org. Accessed on 4.04.2020.

West Bengal Forest Department (WBFD). 2010. State Report on National Programme on Promoting Medicinal Plants conservation and traditional knowledge for Enhancing Health and Livelihood Security for West Bengal. Research Circle, Directorate of Forest, Govt. of West Bengal. pp 148

Saha, D., Begum N., Dhathchanamoorthy, N, Ghosh, B, Kareem, A., Sangeetha, S., Rajashree G.M., Ghosh, C., Biswash, K., Maity, D., 2022. Revisiting of Seven Old Medicinal Plants Conservation Areas (MPCAs) in West Bengal. West Bengal Forest Department (WBFD), The University of Trans-Disciplinary Health Science and Technology (TDU), Bengaluru & National Medicinal Plants Board, New Delhi.

Kunhikannan C., Venkatasubramanian N., Sivalingam R., Pramod Kumar N., Thomas S, Thampan S. 2011. Diversity of woody species in the Medicinal Plant Conservation Area (MPCA) of Silent Valley National Park, Kerala, Biodiversity, 12:2, 97-107, DOI: 10.1080/14888386.2011.602930

Saha, D. and Ved, D.K. 2014. Rapid Threat Assessment – A Doctor's Approach to Save Helpless Plants. Heritage Amruth. The Medicinal Plant Conservation Society. FRLHT. Bengaluru-560106. India. 10(1):12-16

Goraya, G.S. and D.K. Ved. 2017. Medicinal Plants in India: An Assessment of their Demand and Supply. National Medicinal Plants Board, Ministry of AYUSH, Govt. of India, New Delhi, Indian Council of Forestry Research and Education, Dehradun. P 393.

Prain, D. 1903. Bengal Plants. Vol. 2, Botanical Survey of India, Calcutta, 1184.

Ved D.K., Kinhal G.A., Haridasan K., Ravikumar K., Ghate U., Shankar R.V., Indresha J. H. 2003. Conservation assessment and management prioritization (CAMP) for the medicinal plants of Arunachal Pradesh, Assam, Meghalaya and Sik- kim- Proceedings of the workshop held at Guwahati during 27th February to 1st March 2003. FRLHT, Bangalore.

Mabberley, D. 2017. Plant-book- A Portable Dictionary of Plants, their Classification and Uses. Oxford University Press.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Da Fonseca, G.A.B. and Kent, J. .2000. Biodiversity Hotspots for Conservation Priorities, Nature, 403:853–858

Shankar R and Rawat MS .2013. Conservation and cultivation of threatened and high valued medicinal plants in North East India. International Journal of Biodiversity and Conservation, 5(9): 584-591.

Jain SK and Rao RR 1983. An assessment of threatened plants of India, botanical survey of India, Howrah, pp. 1–334.

Pollock C, Mace GM, Hilton-Taylor C., 2003. The revised IUCN Red List Categories and Criteria, Version 3.1. In: de Iongh HH, Ba´nki OS, Bergmans W, van der Werff ten Bosch, MJ (eds) The Harmonization of Red Lists for Threatened Species in Europe. Leiden (The Netherlands):

CITES .2017. CITES listed species. https://www.cites.org/eng/ disc/species.php. Accessed on 3.1.2020.

Mitra, S., and Mukherjee, S. K. 2013. Some Lesser known plants from Maldah District of West Bengal used for the treatment of Arthritis, Rheumatism and Gout. Indian J. Pharmaceutical Research and Bio Sci.2 (4): 337-45.

Bhujel RB, Studies on the Dicotyledonous Flora of Darjeeling district. *Ph. D. Thesis*, University of North Bengal, Raja Rammohanpur, Darjeeling (1996).

Chettri,D.R,Basnet. D,Chiu.P.F, Kalikotay.S,Chettri.G& Parajuli.S.2005.Current status of ethnomedicinal Plants in the Darjiling Himalaya.Curr.Sci.89(2),264-268.

Cowan AM and Cowan JM, The trees of north Bengal including shrubs, woody climbers, bamboos, palms and tree ferns. Bengal Secretariat Book Depot. Calcutta (1929).

Das, A.P. & Lahiri,A.k.1997. Phytosociological studies on the ground covering flora in different types of vegetation in Tiger Hill,Darjeeling district,west Bengal (India).*Indian For*.123(12):1176-1187.

Das, A.P.2004. Floristic studies n Darjeeling Hills.*Bull.Bot.Surv.India*. 46(1-4):1-18

Hooker JD, *Flora of British India*. Vols. I-VII. International Book Distributors, Dehra-Dun (1872-1897). Noltie HJ, *Flora of Bhutan*. Royal Botanic Garden. Edinburgh. (1994-2000); 3(1, 2).

Rai PC, Sarkar A, Bhujel RB, Das AP, Ethnobotanical studies in some fringe areas of Sikkim and Darjeeling Himalayas. *Jour. Hill Res*. Sikkim (1998); 11(1): 12-21.

Saha, D. and Sundriyal, R. C. 2010. Stand structure, phenology and fruit yield of Illicium griffithii in Western Arunachal Pradesh, North East India. Indian Journal of Forestry. 33(4):475-488

Rai SK and Bhujel RB, Ethnic uses of some monocotyledonous plants in the Darjeeling Himalayan region. *Perspectives of Plant Biodiversity* (ed: Das AP.) (2002); pp. 635-644. Bisen Singh Mahendrapal Singh, Dehra-Dun.

Rai SK and Bhujel RB, Note on some less known ethnomedicinal plants from the Darjeeling Himalayas. *Jour. Hill. Res*. (1999); 12 (2):160-163. Sikkim.

Rai SK and Bhujel RB, Studies on the Ethnobotany of Darjeeling Himalaya. *Ph. D. Thesis*, University of North Bengal, Raja Rammohonpur, Darjeeling (2002).

Yonzone GS, Yonzone KN, Tamang KK, Medicinal plants of Darjeeling district. *Journ. Eco. Tax. Bot*. Jodhpur (1984); 5 (3): 605-616. Yonzone R, Mondal S and Chandra S, A contribution to the ethnobotany of Darjeeling hills. *Trans. Bose Res. Inst*. (1981); 44(3): 75-81. Pal,S.K.2014. STUDY OF ACTIVITY OF SOME ETHNOMEDICINAL FERNS OF DARJEELING. International Journal of Pharmacology Research.Vol 4(1),pp23-26.

Chakravarty, R.K., Srivastava, R.C., Mitra, S., Bandyopadhyay, Subhojit and Bandyopadhyay, Subir.1999.West Bengal. In: Floristic Diversity and Conservation Strategies in India. (Eds. Mugal, V. and Hajra, P. K.) Botanical Survey of India, Calcutta. Pp. 1575-1630

Berneth, J. 2000. Production and marketing of medicinal plants. International journal of horticultural science. 6(2): 63-65

Kuniyal, C. P., Kuniyal, P. C., Butola, J. S., Sundriyal R.C. 2013. Trends in the marketing of some important medicinal plants in Uttarakhand, India. International Journal of Biodiversity Science, Ecosystem Services & Management. Taylor & Francis.

Karki, M. 2001. Certification and marketing strategies for sustainable commercialization of medicinal and aromatic plants in Chhatisgarh; Paper presented at the National Research Seminar on Herbal Conservation, Cultivation, Marketing and Utilization with special emphasis on Chhatisgarh, The Herbal State; December 13-14, 2001; Raipur, India.

Bhadula S.K, Singh A, Lata H., Kuniyal C.P, Purohit, A.N. 2000.Distribution pattern, population diversity and propagation of some high altitude medicinal herbs from Garhwal Himalaya: problems and prospects for conservation. In: Pangtey YPS, editor. High altitudes of Himalaya-II: Biodiversity, ecology and environment. Nainital: Gyanodaya Publication; p. 389–413

Saha, D. and Sundriyal, R. C. 2012. *Perspectives of Tribal Communities on NTFP Resource Use in a Global Hotspot: Implications for Adaptive Management*. Journal of Natural Sciences Research. The International Institute for Science, Technology and Education (IISTE), USA. 3 (4):125

Saha, D. and Sundriyal, R. C. 2010. *Prioritization of Non-Timber Forest Produces for income generation: A participatory approach. Journal of Non-Timber Forest Products.* 17(4):387-394.

Schippmann U, Leaman DJ, Cunningham AB, Walter S. 2005. Impact of cultivation and collection on the conservation of medicinal plants: In: Jatisatienr A, Paratasilpin T, Elliott S, Anusarnsunthorn V, Wedge D, Craker LE and Gardner ZE, editors. Proceedings of WOCMAP III, The Third World Congress on Medicinal and Aromatic Plants. Leuven: International Society

for Horticultural Science (Acta Horticulturae 676); p. 31–44.
Ved DK, Goraya GS. 2008. Demand and supply of medicinal plants in India. New Delhi: National Medicinal Plants Board; p. 216.
Karki, M. 2001) Institutional and Socio-economic factors and Enabling Policies for Non-timber Forest Products-based Development in Northeast India — In: Consultation on NTFP-led Development in NE India; Confidential report No. 1145-In, 106 March, 2000, International Fund for Agriculture Development (IFAD), Rome; 1-16 p..
Saha, D., Sundriyal, M., and Sundriyal, R.C. 2014. Diversity of food composition and nutritive analysis of edible wild plants in a multiethnic tribal land, North East India: an important facet for food supply. Indian Journal of Traditional Knowledge. 13(4): 698-705
Mitra, S., and Mukherjee, S. K. 2013. Some Lesser known plants from Maldah District of West Bengal used for the treatment of Arthritis, Rheumatism and Gout. Indian J. Pharmaceutical Research and Bio Sci.2 (4): 337-45.
Saha, D. and Sundriyal, R. C. 2012. Utilization of non-timber forest products in humid tropics: implication for management and livelihood. Forest Policy and Economics. 14(1):28-40.
Basak, R. K. 1979. Some noteworthy Plant from Birbhum District, West Bengal.Indian Forester.105 (6): 477-81.
Chopra, R. N., Nayar, S. L. and Chopra, I. C. 1956. Glossary of Indian Medicinal Plants. CSIR, New Delhi. 330p
Bennet, S.S.R. 1979. Flora of Howrah District. Best Book Publication. New Delhi, India.
Chakraborty, Nihar Ranjan & Duary, Budhadeb.2014. Utilization of some Weeds as Medicine by the local people in Birbhum District of West Bengal, India. Int. J. Bio –Reso. Stress Mang. 5(1): 148-52.
Chopra, R. N., Nayar, S. L. and Chopra, I. C. 1980. Glossary of Indian Medicinal Plants. CSIR, New Delhi.
Jain, S.K. and Rao, R.R..1976.. A Handbook of Field and Herbarium Methods. Today and Tomorrow Publishers, New Delhi.
.
https://cites.org/eng/app/index.php
https://www.wwfindia.org/about_wwf/enablers/traffic/about_traffic/
http://www.pharmabiz.com/NewsDetails.aspx?aid=144964&sid=1

ANNEXURES

Annexure I

Threatened medicinal plants of West Bengal as per the Conservation Assessment and Management Prioritization (CAMP) exercise conducted applying *criteria and categories of IUCN* in West Bengal during 2007.

SI. No.	Botanical Name	Family	Synonym	Trade Name	Local Name	Habit	Parts traded	Threat
1.	*Abelmoschus moschatus* Medik	Malvaceae	*Hibiscus abelmoschus*	Muskdana, Lata kasturi	Lata Kasturi, Kal Kasturi,	Undershrub	Seeds	Near threatened
2.	*Aconitum bisma*	Ranunculaceae	*Aconitum palmatum*	--	Bikhma	Perennial -	Root	Endangered
3.	*Aconitum ferox*	Ranunculaceae	--	Atish meethi	Bish	Perennial-	Root	Endangered
4.	*Aconitum spicatum*	Ranunculaceae	*Aconitum ferox var.*	--	--	Perennial herb	Root	Endangered
5.	*Alpinia calcarata*	Zingiberaceae	--	--		Herb	Rhizome	Endangered
6.	*Ampelocissus barbata*	Vitaceae	*Vitis barbata*	--		Liana (Climber)	Stem	Critically Endangered
7.	*Aphanamixis polystachya* (Wall.) Parker	Meliaceae	*Aglaia polystachya, Amoora rohituka,*	Rohitak	Tiktaraj, Pittaraj, Harin-hara	Tree	Stem bark and seeds	Least concern
8.	*Aristolochia indica* Linn.	Aristolochiaceae	--	Ishwar mul	Ishwarmul, Sapsan,	Climber	Leaves and roots.	Vulnerable
9.	*Asparagus racemosus*	Liliaceae	--	Satawari	Satamuli, Shatawari	Shrub	Leaves	Endangered
10.	*Berberis aristata* DC.	Berberidaceae	*Barberis sikkimensis*	--	Chotra	Shrub	Branchlets, fruits,bark,	Vulnerable

SI.	Botanical Name	Family	Synonym	Trade Name	Local Name	Habit	Parts traded	Threat Status
11.	*Celastrus paniculatus* Willd.	Celastraceae	*Celastrus multiflorusC.mutans,C.rothiana Swertia paniculata*	Malkangni	Mulkangni, Jyostimati,Kujari	Climber	Seeds and	Endangered
12.	*Cinnamomum bejolghota* (Buch.-Ham.) Sweet	Lauraceae	*Laurus bejolghota, Cinnamomum obtusifolium*	Bejolghota	BhaleSinkohli, Tezpata	Tree	Leaves and bark	Vulnerable
13.	*Cinnamomum cecidodaphne* Meissn.	Lauraceae	--	--	Malagiri	Tree	Wood and seeds	Endangered
14.	*Desmodium motorium*	Fabaceae	*Desmodium gyrans*	Ban Chandal	Ban Chandal	Undershrub		Vulnerable
15.	*Dioscorea prazeri* Prain & Burkill	Dioscoreaceae	*Dioscorea clarkei, D.deltoideauar.sikkimensis*	Kukur, Tarul	Kukur, Tarul	Climber	Underground root tuber and bulbils	Endangered
16.	*Drosera burmannii*	Droseraceae	--	'Sun-dew'	Surija-sisir	Herb		Endangered
17.	*Gloriosa superba*	Liliaceae	--	Kali Hari	UlatChandal, Agnisikha	Tendril climber	Tubers	Vulnerable
18.	*Gymnema sylvestre* R.Br.	Asclepiadaceae	*Periplocoa sylvestris*	Gurmar	Gurmar, Mesh shringi,	Climber	Entire plant	Vulnerable
19.	*Gynocardia odorata*	Flacourtiaceae	--_	Chaulmoogra	Chaulmgra	Tree		Endangered
20.	*Helminthostachys zeylanica* (Linn.) Hook. F.	Ophioglossaceae	*Helminthostachys dulcis*	Ekbir	Ekbir	Rhizomatous herb	Whole Plant and	Endangered
21.	*Ipomoea mauritiana* Jacq.	Convolvulaceae	*Ipomoea digitata, I. paniculata, Convolvulus paniculata*	Bhumikumra, Bhumikus-	Bhumikumra, Bhumikushmanda	Climber	Roots and tubers	Near threatened

SI. No.	Botanical Name	Family	Synonym	Trade Name	Local Name	Habit	Parts traded	Threat Status
22.	*Litsaea glutinosa* (Lour.) Robinson	Lauraceae	*Sebifera glutinosa, Litsaea chinensis, L. Sebifera*	Maida Lakri, Maida Lakadi	Piplus, Kukur Chita, Maida Lakadi	Tree	Leaves, flower buds,	Least concern
23.	*Lumnitzera racemosa* Willd.	Combretaceae	--	--	Kripa	Small tree	Leaves, barks, fruits	Critically Endangered
24.	*Lycopodiella cernua* (Linn.) Pichli-Sermolli	Lycopodiaceae	*Lycopodium cernuum,*	Lycopodium	Nag beli	Herb (Perennial)	Whole plant	Endangered
25.	*Mesua ferrea* Linn.	Clusiaceae	--	Nagkesar	Nagkesar	Tree	Bark.	Endangered
26.	*Morinda citrifolia* Linn.	Rubiaceae	--	Noni	Ach, Chaili, Bartundi,Surangi, Aal	Small tree	Leaves, stems, fruits and roots	Vulnerable
27.	*Mucuna pruriens* (Linn.) DC.	Fabaceae	*Dolichos pruriens, Carpopogon pruriens, Mucuna prurita*	Kanso, Kuach	Kanso, Kuachi	Climber	Pod and seed	Endangered
28.	*Nipa fruticans*	Arecaceae	--	Golpata	Golpata	Tree	Leaves and fruits.	Vulnerable
29.	*Olax nana Wall.* ex	Olacaceae	--	Bhadu, Olax	Bhadu Shak, Merom Met	Undershrub	Leaves and	Vulnerable
30.	*Ophioglossum reticulatum* Linn.	Ophioglossaceae	*Ophioglossum cordifolium*	Adder's tongue/ Ektir	Ektir	Terrestrial Fern	Tuber	Endangered
31.	*Panaxpseudo ginseng* Wall.	Araliaceae	*Panax sikkimensis*	Ginseng	Jara-okhati, Mangan	Herb	Rhizome	Critically Endangered
32.	*Pericampylus glaucus* (Lamk.) Merr.	Menispermaceae	*Pericampylus incanus*	Pipal- pati	Pipal-pati, Lahara	Climber	Root tuber	Vulnerable

SI.	Botanical Name	Family	Synonym	Trade Name	Local Name	Habit	Parts traded	Threat Status
33.	*Perseaglaucescens* (Nees.) Long	Lauraceae	*Machilus villosa*	Kawla	Kawla, Atilo	Tree	Bark and wood.	Critically Endangered
34.	*Picrorhiza kurroa* Royle ex Benth.	Scrophulariaceae	*Picrorhiza kurrooa*	Kutki	Kutki, Kutaki	Perennial herb	Whole plant	Critically Endangered
35.	*Podophyllum hexandrum* Royle	Podopbyllaceae	*P. emodi, P. emodi var. Jaeschkei*	Ban kakri	Ban Kakri, Panchpatey	Perennial herb	Whole plant, fruit and root.	Critically Endangered
36.	*Pterocarpus marsupium* Roxb.	Fabaceae	--	Bijasal	Bijasal, Piyasal	Tree	Bark, wood and gum.	Vulnerable
37.	*Rauwolfia serpentina* (Linn.)Benth.	Apocynaceae	*Ophioxylon serpentinum*	Rauwolfia, Sarpagandha	Sarpagandha Chandra,	Shrub	Leaves, seeds, roots	Endangered
38.	*Sonneratia caseolaris* (Linn.) Engl.	Sonneratiacaeae	*Rhizophora caseolaris, Sonneratia acida*	Archa, Ora	Ochra, Archa, Archaka	Tree	Fruits and wood.	Endangered
39.	*Stereospermun colais*(Dillwyn) Mabb.	Bignoniaceae	*S. tetragonun, S. personatum*	Parao, Padri	Parania, Padri	Tree	Bark	Vulnerable
40.	*Swertia chirayita Roxb.*ex	Gentianaceae	*Gentiana chirayita, Ophelia chiraita*	Chirayata	Chireta, Chirayata	Herb	Whole plant	Critically Endangered
41.	*Taxus wallichiana* Zucc.	Taxaceae	*Taxus baccata sub. sp. Wallichiana*	Taxus	Dhengresalla	Tree	Leaf twigs and barks.	Critically Endangered
42.	*Thalictrum foliolosum* DC.	Ranunculaceae		Dampate	Dampate	Herb	Whole plant and root.	Vulnerable

43.	*Toona ciliate* Roem.	Meliaceae	*Cedrella toona*	Toon	Toon	Tree	Seed, bark and wood.	Vulnerable
SI.	**Botanical Name**	**Family**	**Synonym**	**Trade Name**	**Local Name**	**Habit**	**Parts traded**	**Threat**
44.	*Tylophora indica* (Burm. f.) Merr.	Asclepiadaceae	*Tylophora asthmatica, Cynanchum indicum*	Anantamul	Anantamul, Ananthamul	Perennial climber	Leaves and roots.	Near
45.	Viscum articulatum Burm. f.	Viscaceae	*Viscum nepalense*	Viscum	Bunda, Mandada	Shrub	Whole plant	Least
46.	*Xylocarpus granatum* Koer.	Meliaceae	*X.obovatus, Carallia obovata,*	Pussur	Pussur, Dhandul	Tree	Wood	Vulnerable

Annexure II

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Listed medicinal plants of India with their appendices (having various rules of international restrictions for trade)

Sl. No.	Species	Common Name	CITES	IUCN
1	*Cycas beddomei*	Beddome's Cycad	I	**EN**
2	*Vanda coerulea*	Blue Vanda	I	
3	*Saussurea costus*	Kuth	I	**CR**
4	*Paphiopedilium species*	Lady's slipper orchids	I	
5	*Nepenthes khasiana*	Pitcher Plant	I	**EN**
6	*Renathera mschootiana*	Red Vanda	I	
7	*Rauvolfia serpentina*	Sarpagandha	II	
8	*Ceropegia* spp.			
9	*Frerea indica*	Shindal Mankundi		
10	*Podophyllum hexandrum*	Indian Podophyllum	II	
11	*Cyatheaceae* species	Tree Ferns		
12	*Cycadaceae* species			
13	*Dioscorea deltoidea*	Elephant's Foot	II	
14	*Euphorbia* spp.	Euphorbias	II	
15	*Orchidaceae species*	Orchids		
16	*Pterocarpus santalinus*	Red Sanders	II	**NT**
17	*Taxus wallichiana*	Common Yew or Birmi	II	**EN**
18	*Aquilaria malaccensis*	Agarwood	II	**CR**
19	*Aconitum species*			
20	*Coptis teeta*			**EN**
21	*Coscinium fenestratum*	Calumba wood		**DD**
22	*Dactylorhiza hatagirea*	Wanpolagpa, Hathajodi,	II	**LC**
23	*Gentiana kurroo*	Kuru, Kutki		**CR**
24	*Gnetum* species			
25	*Kamphergia galenga*	Galangal, Chandramula		
26	*Nardostachys grandiflora*	Jatamansi	II	**CR**
27	*Panax pseudoginseng*	Ginseng	II	
28	*Picrorhiza kurrooa*	Kutki	II	
29	***Swertia chirata***	**Charayata**		

Annexure III

Estimated annual consumption of highly traded MAPs extracted from the wild (TRAFFIC- India)

Common Name	Scientific Name	Parts used	Estimated current annual consumption (Dry weight in mt)	IUCN Red list	FRLHT CAMP Red list
Jatamansi	*Nardostachys grandiflora*	Root (Rhizome)	500-1,000	Critically Endangered	Critically Endangered
Agarwood	*Aquilaria malaccensis*	Bark (Stem), Heart Wood	50-100	Critically Endangered	Critically Endangered
Queen Sago	*Cycas circinalis*	Flower, Pith	<10	Endangered	Critically Endangered
Himalayan Yew	***Taxus wallichiana***	**Leaf**	**100-200**	**Endangered**	**Critically Endangered**
Red Sanders	*Pterocarpus santalinus*	Wood	200-500	-	Critically Endangered
Ginseng	***Panax pseudoginseng***	**Root**	**<10**	**--**	**Critically Endangered**
Salampanja	*Dactylorhiza hataqirea*	Root (Tuber)	10-50	--	Critically Endangered
Kutki	***Picrorhiza kurrooa***	**Root (Tuber)**	**1,000-2,000**	**--**	**Critically Endangered**
Himalayan May apple	***Podophyllum hexandrum***	**Fruit, Root**	**10-50**	**--**	**Critically Endangered**
Elephant's Foot	*Dioscorea deltoidea*	Root	10-50	--	Endangered

Annexure IV

Sample data format
PHALUT October 2015

Grid 2 (N27:11.223 E088:03.729)

P2/1/1	Plant Name	Indiv
	Dhangra	4
	Banta	3
	payeli	1
P2/1/2	chimal	5
	banta	5
	kapasa	1
P2/1/3	seti kat	1
	5 patey	1
	kawlo	2
P2/1/4	zingani	1
	guras	2
	Tsuga	5

Grid 16 (N27:11.428 E088:03.901)

P2/2/1	Name	Indiv
	phalant	5
	Baklopata	2
P2/2/2	guras	2
	seti kat	2
	banta	6
P2/2/3	Payeli	2
	5patey	2
P2/2/4	banta	10

Grid 34 (N27:11.877 E088:03.718)

P2/3/1	Name	Indiv
	banta	5
	dhangra	3
	thengar	5
P2/3/2	phlant	5
	kharani	5
P2/3/3	buk	2
	kawlo	3
	Chimal	5
P2/3/4	kapasa	1
	phalant	4
	dhanga	4

Grid 18 (N27:11.622 E088:03.755)

P2/4/1	Name	Indiv
	banta	6
	phalant	3
	chimal	1
P2/4/2	bklopata	4
	chimal	3
	phalant	4
P2/4/3	Chimal	4
	Banta	6
	Kharani	7
P2/4/4	Banta	11
	photina	2

Grid 38 (N27:11.783 E088:04.095)

P2/4/1	Name	Individual
	Photina	5
	Symplocus	3
	phalant	4
P2/4/2	thengra	3
	Dhangra	5
	chimal	3
P2/4/3	Guras	2
	dhangra	3
P2/4/4	banta	5
	chimal	2
	guras	1

Grid 2 Shrub (N27:11.223 E088:03.729)

	Name	Indiv
P2/1/1	Malingo	10
	kholma	5
	Bakloptaa	6
	banta	11
	lokti	2
P2/1/2	kukurdaina	5
	malingo	50
	Kholma	7
	phalant	2
	Baklpotata	3
	banta	4
P2/1/3	Malingo	90
	kholma	6
	Bakloptaa	10
	phalant	7
	kukurdaina	8
P2/1/4	Malingo	80
	kholma	7
	Bakloptaa	
	phalant	5
	timbur	5
	chutro	2
	zingani	2

	Name	Indiv
P2/2/1	Malingo	90
	kholma	20
	ceropegia	3
	baklopata	2
	lokti	6
P2/2/2	Rubus	4
	malingo	110
	Kholma	6
	phalant	2
	Baklpotata	3
	akhla	3
	kharani	3
P2/2/3	Malingo	20
	smilex	10
	kholma	9
	dhangra	20
	rubus	2
	kharana	15
P2/2/4	Malingo	25
	kholma	5
	kharana	3
	thotna	4

PLATES OF IMAGES RELATED TO THE BOTANICAL INVENTORISATION, ECOLOGICAL SURVEY AND THREATENED PLANT SPECIES OF THE MPCA

Plate 1: Images of Phalut Medicinal Plants Conservation Area (MPCA), Singalila N.P., West Bengal

Plate 2: Images of *Taxus wallichiana* and *Panax pseudoginseng* in Phalut MPCA

Plate 3: Images of *Zanthoxylum oxyphyllum* and *Swertia chirayita* in Phalut MPCA

Plate 4: Images of *Rubia manjith* and *Yushania maling* in Phalut MPCA

Plate 5: Images of *Aconitum palmatum* and *Paris polyphylla* in Phalut MPCA

Plate 6: Images of *Rhododendron grande* in Phalut MPCA, Singalila N.P., West Bengal

Plate 7: Images of vegetation survey for documentation of population status