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

Project No. CONS/WB-01/2014

FINAL TECHNICAL REPORT

2023

Final Technical Report

On

ASSESSMENT OF MEDICINAL PLANT DIVERSITY OF BICHABHANGA 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. Chobilal Kami, FG, Lataguri for the cooperation and support extended during the field 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

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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. 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 Bichabhanga 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 350 medicinal plant species of which 14 threatened medicinal plants that are wild in the MPCA site.

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Threatened status	No. of species	Traded	High traded*
Critically Endangered	1	1	0
Endangered	8	4	4
Vulnerable	5	3	2
Near Threatened	1	1	0
Total	**14**	9	6

* Trading >100 MT of dry weight per year

As an interesting outcome of qualitative assessment four angiospermic taxa, namely, *Alpinia calcarata* (Zingiberaceae), *Gynocardia odorata* (Achariaceae), *Celastrus paniculatus* (Celastraceae), *Mesua ferrea* (Caryophyllaceae), *Pterocarpus marsupium (*Fabaceae,*) Aristolochia indica* (Aristolochiaceae), *Dioscorea prazeri* (Dioscoreaceae), *Morinda citrifolia (*Rubiaceae), *Stereospermum colais (*Bignoniaceae), *Abelmoschus moschatus* (Malvaceae) have been collected from the MPCA.

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

Piper longum L and Piper locnchites Roem. & Sch.- collection from the MPCA. Thorough explorations in adjacent regions are necessary to quantify its population and the extent of occurrence of this species.

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 84 woody plant species (>30 cm gbh) belonging to 67 genera and 39 families were recorded across the Medicinal Plants Conservation Area (MPCA)..

A total of 114 plant species (≤30 cm gbh) belonging to 92 genera and 39 families were recorded in Medicinal Plants Conservation Areas (MPCAs) in West Bengal.

The survey helped to document 152 plant species belonging to 129 genera and 48 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 15 threatened plant species recorded in the qualitative assessment, 2 plants were found in the quadrat study. Overall, 2 woody plant species belonging to threatened species category was recorded in 20m x 20m sampled quadrats, while the number of plants with ≤30 cm gbh size belonging to threatened species category was 2 species across the MPCAs. There were 4 threatened plants namely *Celastrus paniculatus*, Morinda citrifolia, *Abelmoschus moschatu* and *Mucuna pruriens* are found to have representation in sapling (5m x 5m) stages. While one threatened species viz., *Alpinia calcarata are found to have* representation in sapling (1m x 1m) stage.

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. 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 old 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 atleast 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 old 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 old MPCAs already established in West Bengal

PROJECT OBJECTIVES

Objectives

The overarching objective of this work was to survey the newly established Bichabhanga 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 Bichabhanga 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 Bichabhanga MPCA
- Population assessment of medicinal plants especially conservation concern species through quadrat study
- Major threats identified in Bichabhanga 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 Bichabhanga 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 BICHABHANGA 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 (WBFD, 2010; Saha et.al. 2022). Through organising CAMP workshop, flagship species and potential sites for the establishment of MPCAs in West Bengal were identified (WBFD, 2010). 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 Bichabhanga, Darjeeling district in West Bengal. The short listed areas in Bichabhanga 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 Bichabhanga MPCAs

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

Physical features

Table 3 : Physical features of the MPCA.

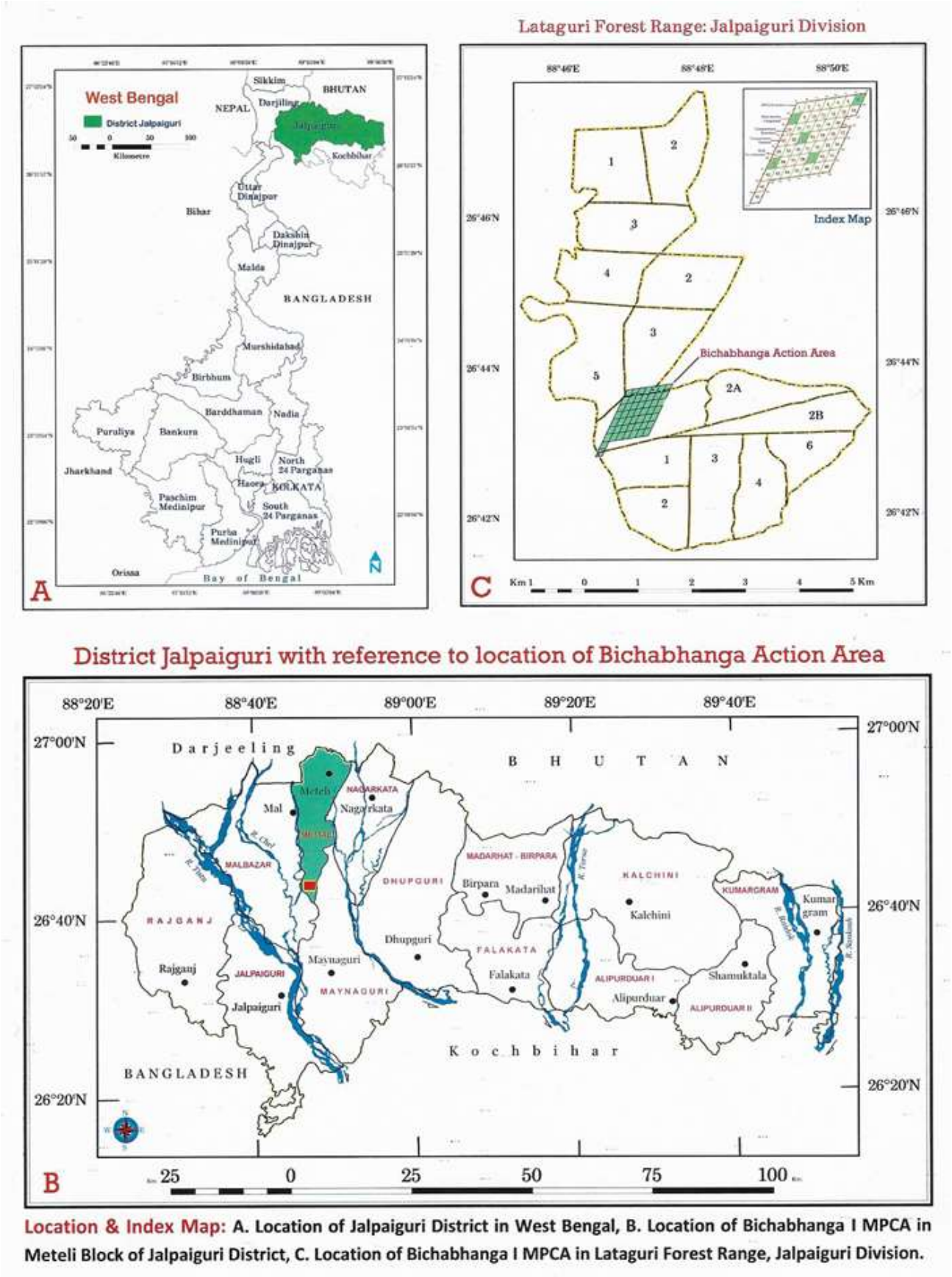
MPCA site	Bichabhanga **MPCA**
Location information	
Compartment no	Bichabhanga 1
Beat	Bichabhanga
Block	Bichabhanga
Range	Lataguri Forest Range
Forest division	Jalpaiguri Division
Panchayat	Bichabhanga
Revenue Block	Bichabhanga
District	Jalpaiguri
Boundaries	*North*: Mahakal Temple & Gorumara Forest Bunglow *South*: Lataguri – Kalipur- Ramsai Road *East*: Budhuram FVP school Gorumara National Park *West*: Malbazar – Lataguri Road & Dear Park, Lataguri,
Nearby villages	Bichabhanga Forest Village, Sursuti Village, Kaogap, Panbari, Ramsay, Katadighi Kumor Para, Uttar Kalamati,
Distance from nearest towns	Lataguri (2 km) and Siliguri (75 km)
Approach from nearby places	*Approach by Road* Siliguri & Lataguri around 75 km & 2 km respectively; *Approach by Train* Chalsa & Lataguri around 20 km & 2 km respectively *Approach by air* Bagdogra around 80 km

Area covered (in ha)	Demarcated 256.18 hector of areas
Latitude	26°43'06.7"N
Longitude	88°46'48.5"E
Altitude	99 msl
Waterbodies (inside & outside)	Rivers like Neora, Mal, Jaldhaka, Murti and Teesta and Jhora like Bamni, Biskhora Jhora.
Climate information	
Temperature in ^{0}C (at nearby station)	Maximum of 32 ^{0}C and minimum of 15.5 ^{0}C
Precipitation in mm (at nearby station)	3000 mm
Seasons & monsoons	June to September are the monsoon months bringing plenty of rains, while July receives maximum rains from South-west monsoon. Months from November to February are marked by a number of cloudy and winter days. Site experiences occasional storm weather with high to moderate wind speed during pre-monsoon showers.
Soil information	
Rock formation	Typical terai Formation, in alluvial soil with gravels on the surface
Soil type	Sandy loam, Red and yellow podzolic soil
Administration information	
Legal status	Gorumara National Park; Reserve Forests
Local community information	
FPCs/EDCs & area assigned	557.65 hector
Means of livelihood	Agriculture, NTFP collection, Eco-tourism and daily wages
Percentage of NTFP collectors	Moderate

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 Bichabhanga MPCA to arrive at a complete picture of topographic details. The mapping process was carried out to understand the topography of newly established Bichabhanga 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.

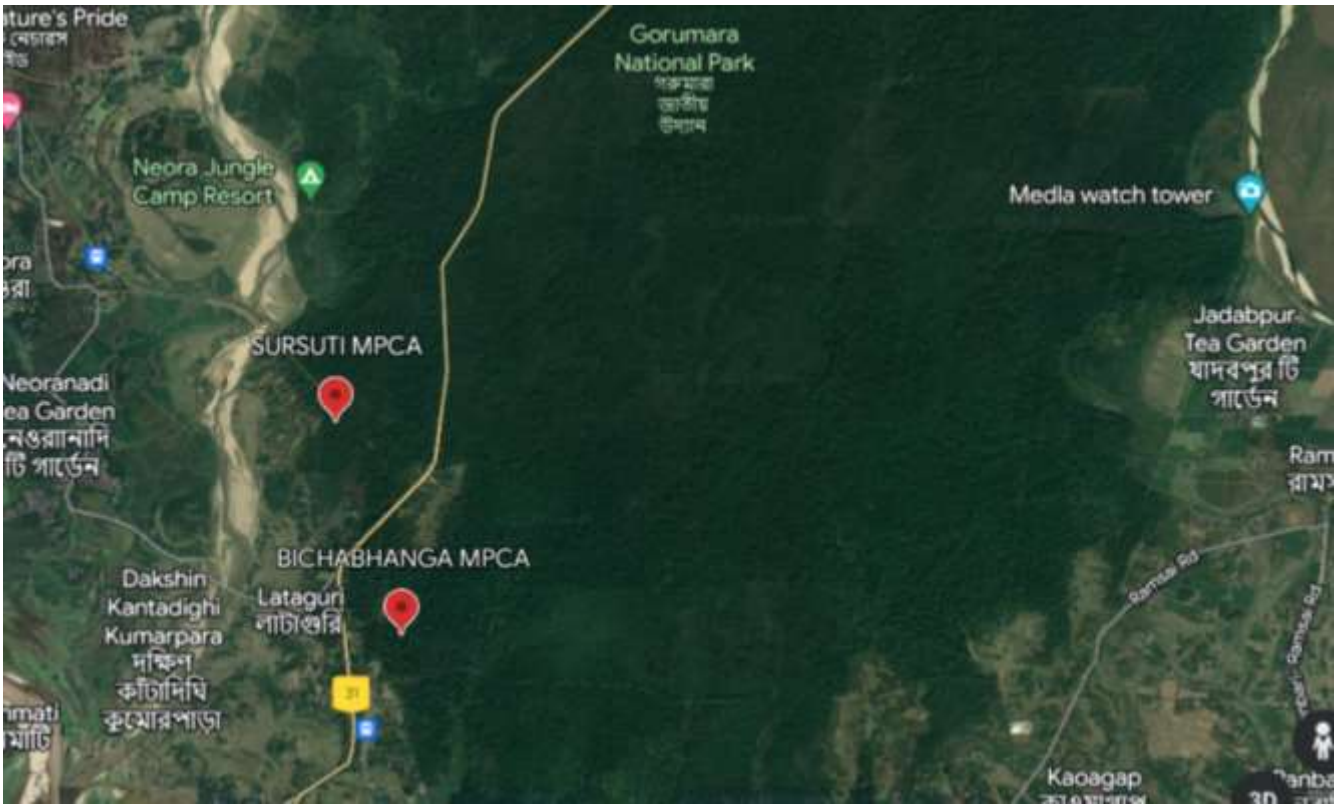
Figure 2. Locations of newly established Bichabhanga MPCA in Jalpaiguri District, West Bengal



Location & Index Map: A. Location of Jalpaiguri District in West Bengal, B. Location of Bichabhanga I MPCA in Meteli Block of Jalpaiguri District, C. Location of Bichabhanga I MPCA in Lataguri Forest Range, Jalpaiguri Division.

Figure 3. Location of Bichabhanga MPCA in the Jalpaiguri District, West Bengal

Figure 4 . Topographic maps of Bichabhanga MPCA in the Darjeeling district, West Bengal



Forest and vegetation types

Based on the composition of the forest composition, the forest types of Bichabhanga MPCA are varied from riverine forests like Khayer-Sisoo to dense mixed-wet forest. It fall under the Terai - Dooar Savannah and grasslands and another one is lower Gangetic plains moist deciduous forest. Forest types of Bchabhanga MPCA lies in the typical East Himalayan Sal Forest (3C - North India Moist Deciduous Forest). The species found are Chilaune (*Schima wallichii*), Odal (*Sterculia villosa*), Champ (*Michelia champaca*), Sal (*Shorea robusta*), Gamar (*Gmelina arborea*), Chikrasi (*Chukrasia tabularis*), Simal (*Bombax ceiba*), Pakasaj (*Terminalia* spp.) etc in the upper storey and Lahsune (Aphanomixis polystachiya), *Amoora wallichii (Lali)* in the lower storey. There is a dense undergrowth of Assam lata (*Mikania micrantha)*, Bhant (*Clerodendrum viscosum) Dheki (Diplazium esculentum), Banmara (Eupoatorium adenophorum), Chepti (Oplismenus burmanni), Anantamul (Hemidesmus indicus) and Debre lata (Spatholobus parviflorus).* The crown density is medium, while the age structure of dominant species seems to be natural. Various grasses and climbers are also very common that choke the young seedlings especially during monsoon. The major wildlife in an around this MPCA are Elephant, Rhinoceros, leopard, Indian bison, Wild Boar, Deer, Monkey etc. that come out of the nearby Gorumara National Park.

Disturbance and threat perception

Dry fuel wood collection is negligible in this MPCA. There are no usufruct rights and concessions within the MPCA are prescribed as per the Management Plan. However, rights and concessions are provided as per the relevant provisions laid under Acts and Regulations. MPCA is mostly visited by local forest dwellers for collecting fuel wood, NTFPs etc. The collection of non-wood forest products from the MPCA site is very least and occasional as per demand. Forests adjoining the MPCA areas are not allowed for grazing or other anthropogenic activities. It is inevitable that Bichabhanga MPCA needs some sort of protection from grazing & other human interference etc. Majority of plant species are of broad leaved deciduous in nature, so there is always chance of incidental fire at forest floor. Most of the incidences like wanted or unwanted fire are usually caused by the deliberate action of cattle herdsmen from outside the MPCA. No visitors and tourists can enter MPCA areas. The most common weeds in an around the MPCA are *Lantana camera*, *Mikania micrantha*, *Coffea bengalenesis* and *Boreria hispida*,. No such major erosion nearby this

Bichabhanga MPCA site except a few channels and jhoras of smaller sizes are formed due to under current flow of rain during the monsoon which usually dries up or significantly reduced during the month of winter. The important insects which are common to this MPCA are Sal borer (*Hoplocerambyxs pinicornis*), Teak defoliator (*Hybleea puera*), Skeletoniser (*Hapalia machaeralis*) and Canker grub (*Dihammus carvinus*) do considerable damage to teak plantations. Spraying with D.D.T as well as making a physical barrier by raising field corp e.g., Arhar or an associate species with evergreen crown, e.g. Setisal (*Dalbergia latifolia*), Angare (*Phobe attenuata*) have proved useful. The twig borer (*Hypsipyla robusta*) frequently attacks Tun (*Cedrela toona*) and Chikrassi resulting in heavy damage.

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 Bichabhanga MPCA, it can be considered as 'moderately 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.

Following are the list of threats perceived for this Bichabhanga MPCA site especially for medicinal plants population:

- Commercial demand from outside the state
- Unscientific destructive harvesting from the wild without any proper reason.
- Unwanted Cattle sheds and grazing within the forests
- Exotic weed pressure or pressure due to invasive species
- Soil erosion in open areas without big trees
- Illicit management

Table 4. Assessment of disturbance levels in Bichabhanga 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	Decided score as per the 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	2
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	2	3
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	3	3

Sl. No	Decided score as per the site elements	SL No	Score
	2 = Two 3 = More than two		
9	Frequency of general public entry inside MPCA areas (3) 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	2	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	2	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&4	2
	Total		27

***Moderately disturbed**

Management interventions

The Bichabhanga MPCA falls under the Gorumara National Park and is located in the Japaiguri District. Eastern Himalaya. The legal status of this MPCA is a National Park. Before reservation in the year 1865 the whole tract of the Terai Forest was under sporadic shifting cultivation by the Mechis. There was Tea cultivation in the north of the Bichabhanga block. About the year 1865 monopoly right was given for working the forest for supply of Railway Sleeper coaches. This was stopped in 1867 when it was found that most of the sound big Sal trees were extracted from plains forest. There was profuse natural regeneration of Sal, whereas market demand was limited. About 1870 the Government of Bengal laid down that no tree shall be felled except by direct agency of the forest department. Subsequently, the removal of Sal trees on the basis of exploitable girth limit on permit at a fixed price per tree under the supervision of a responsible forest officer was introduced. This could not be properly supervised for shortage of staff and the easily accessible forests were depleted of good trees. The girth limit rule was also not followed. The sale of Sal trees on volume measurement was introduced to encourage removal of sound trees.

In general, a preliminary examination of the forests was made and thereafter annual scheme was used to be drawn up every year in advance fixing the number of Sal trees to be removed. As the demand was limited, these prescriptions could not be adhered to rigidly. Natural Sal trees used to be removed departmentally for making railway sleeper coaches. There was a series of plantations over 140 ha. At Bichabhanga a compartment, which is a part of the newly established MPCA, and the species grown are Sal, Teak, champ, chikrase, Gamar, Jarul, Lali, Tun, Malagiri, Pitali and Panisaj. These plantations are generally well stocked.

CHAPTER 2 : MATERIALS & METHODS

Materials & Methods

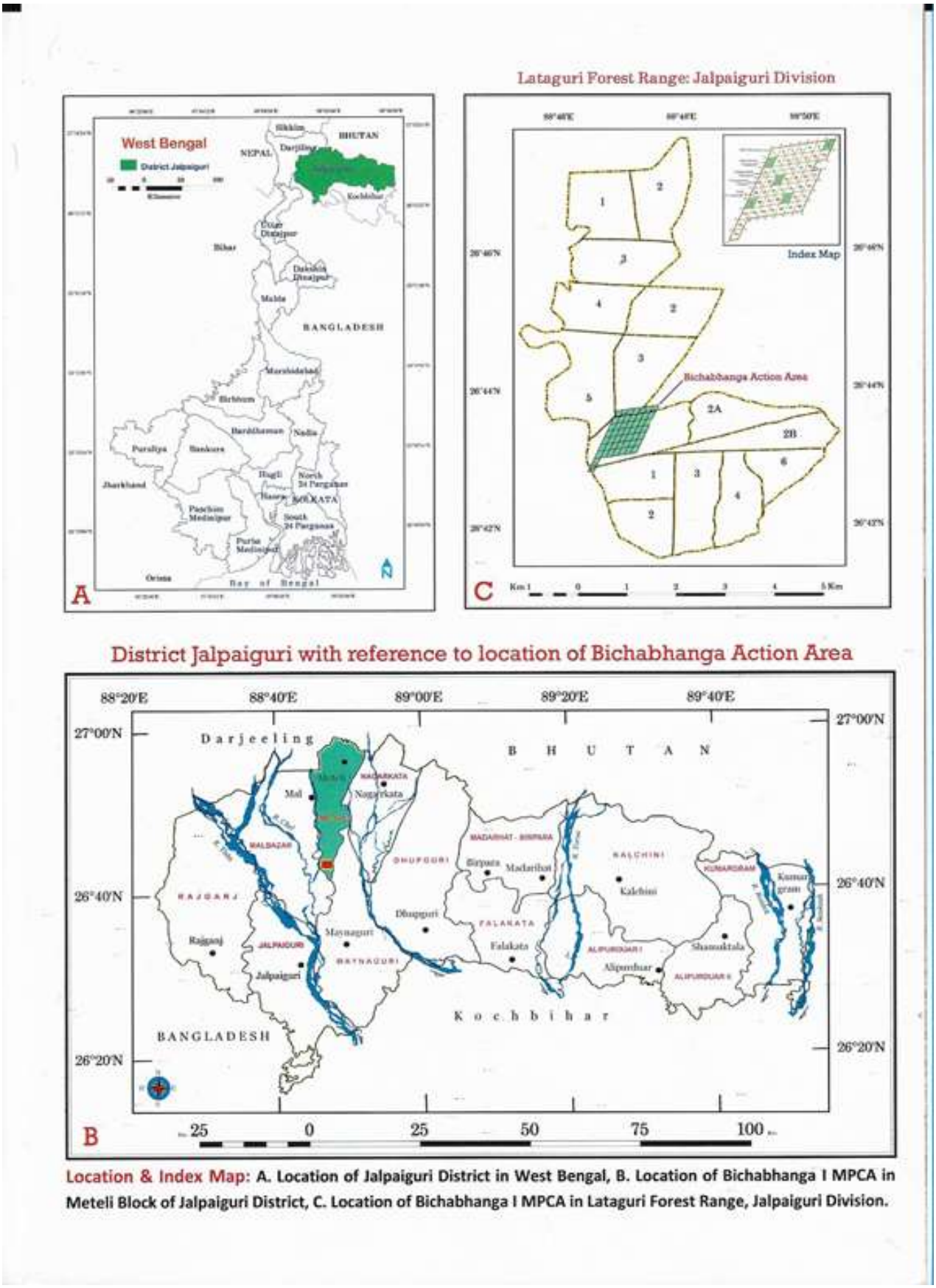
Vegetation at a particular site is the result of interaction of various climatic and biotic as well as edaphic (soil) factors. This study was envisaged as a composite study related with living and non-living components as a whole in the selected MPCA areas. In the community, during the course of succession, 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 Bichabhanga 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 Bichabhanga 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 avoid, the technique of stratified random sampling method, sampling was attempted through making grids of the MPCA area. 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. 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 Bichabhanga 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 Bichabhanga MPCA landscape. In this work, maps were generated with actual location information. The grid layouts were developed for Bichabhanga 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 5 . High resolution image of Bichabhanga MPCA with grids laid across MPCA covering the entire selected areas



Location & Index Map: **A. Location of Jalpaiguri District in West Bengal, B. Location of Bichabhanga I MPCA in Meteli Block of Jalpaiguri District, C. Location of Bichabhanga I MPCA in Lataguri Forest Range, Jalpaiguri Division.**

Figure 6. Location of Bichabhanga MPCA with reference to the coordinates.

Figure 7. Location of Bichabhanga MPCA with reference to the Lataguri Forest Range.

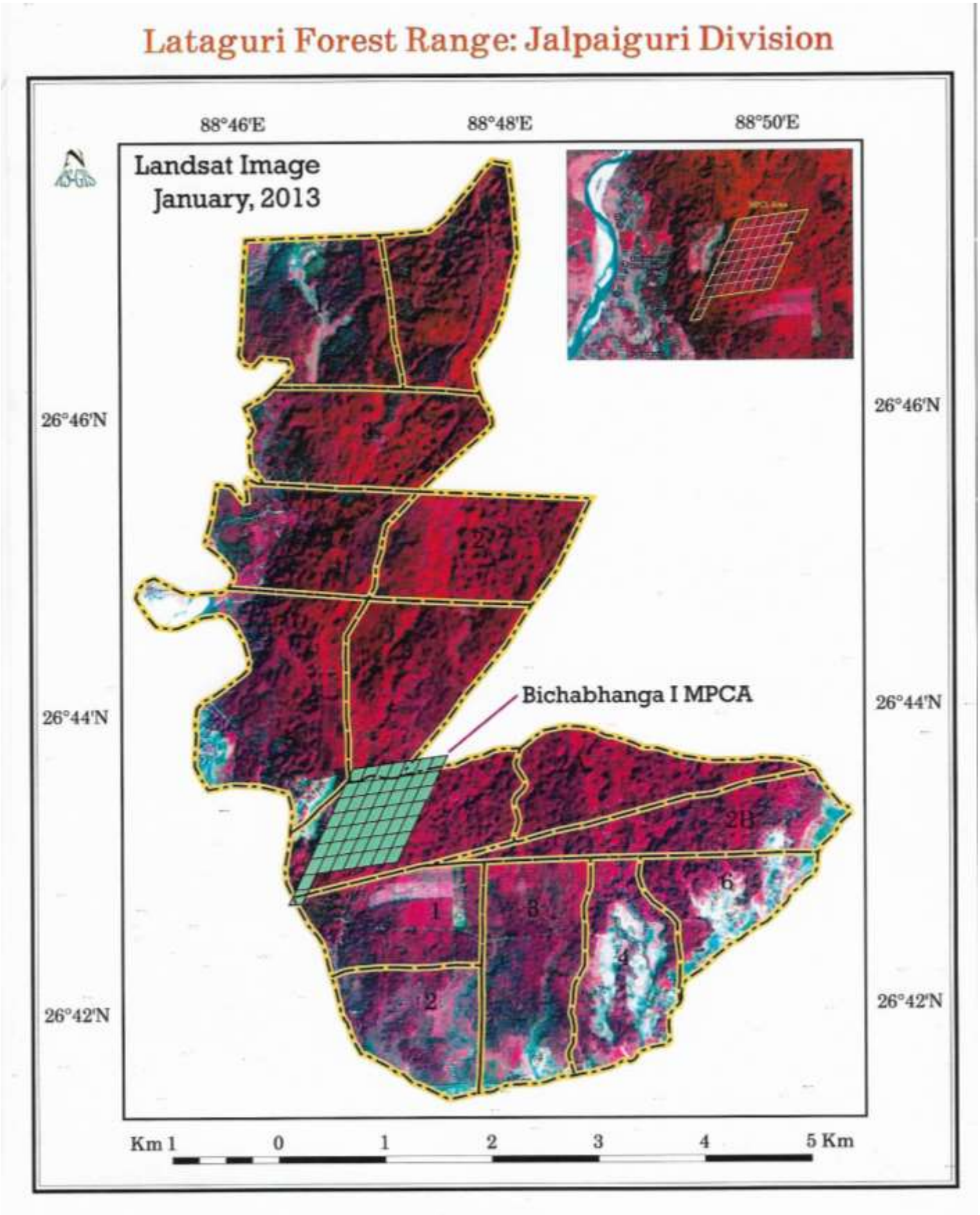


Fig 8: High resolution Ikonos image of Bichabhanga MPCA

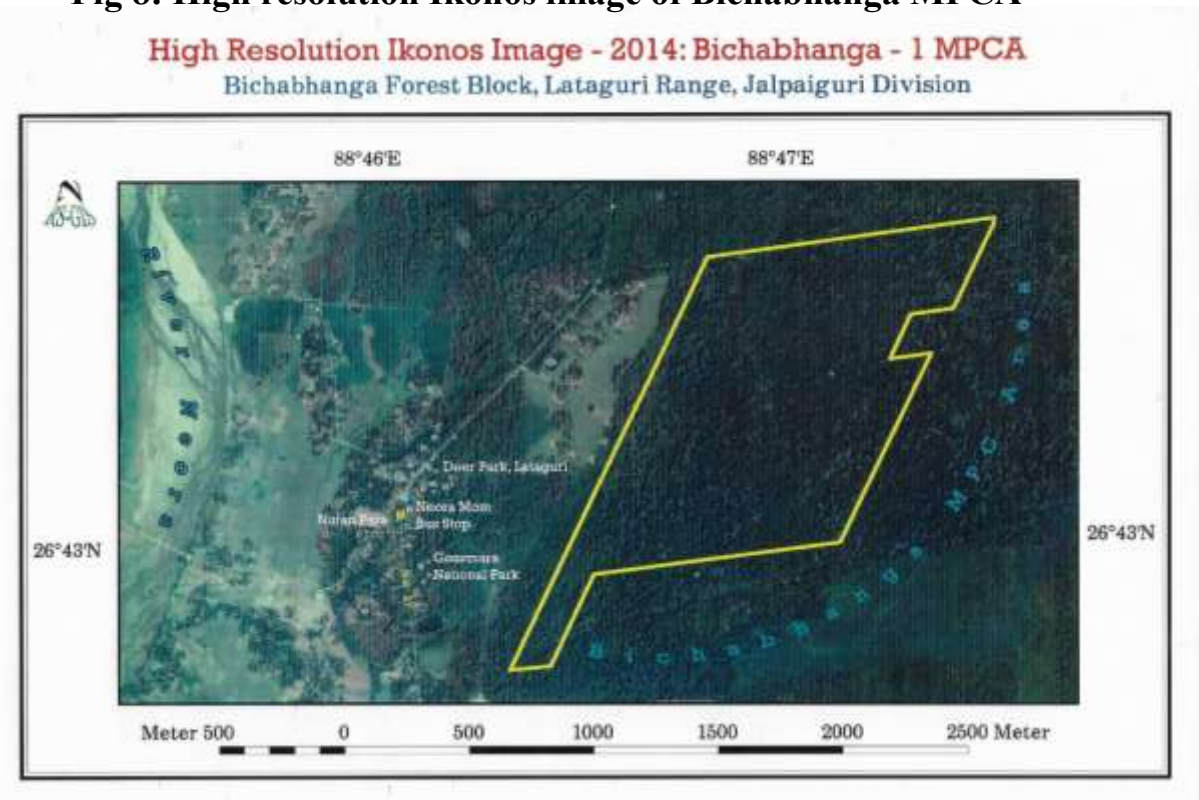


Fig 9: High resolution Ikonos image of Bichabhanga MPCA with grids

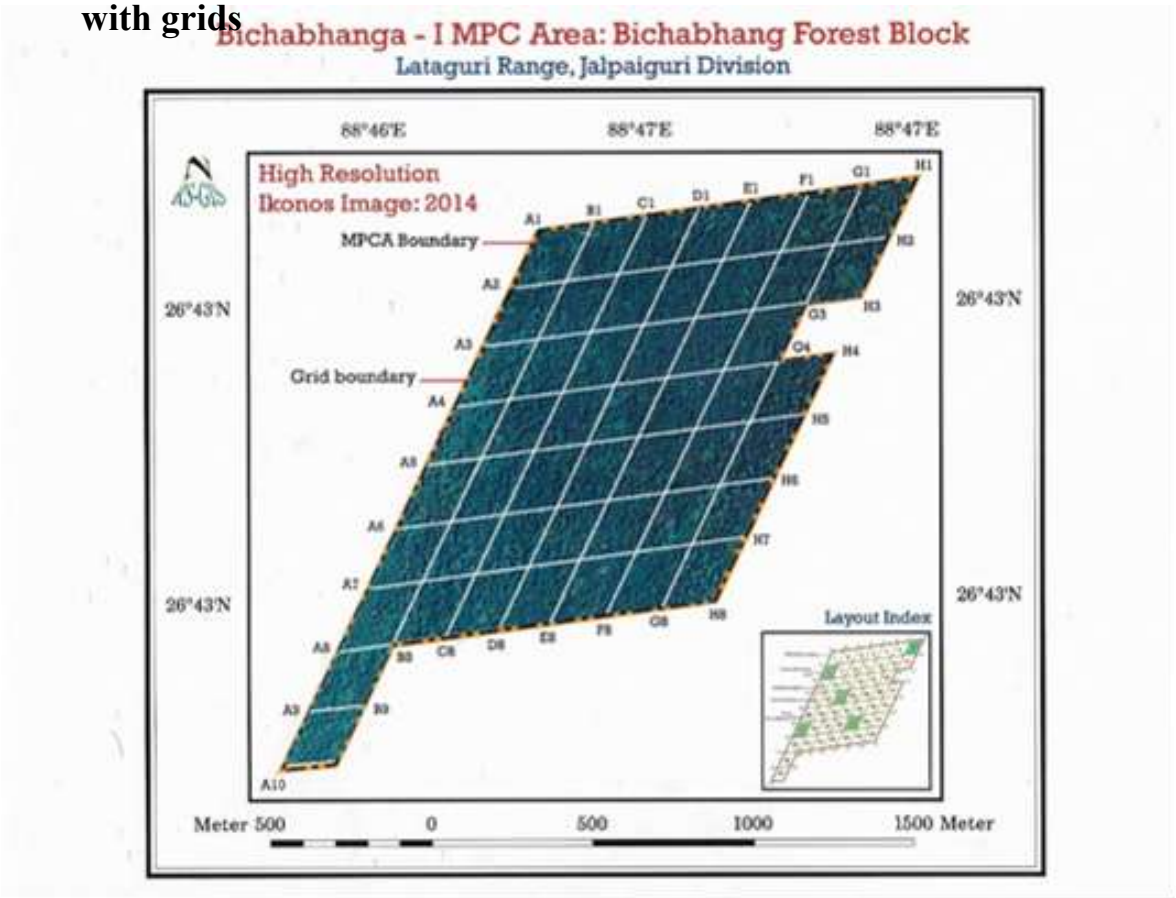


Fig 10: Layout of sampling plots and design of sampling efforts for medicinal plant species population of Bichabhanga MPCA

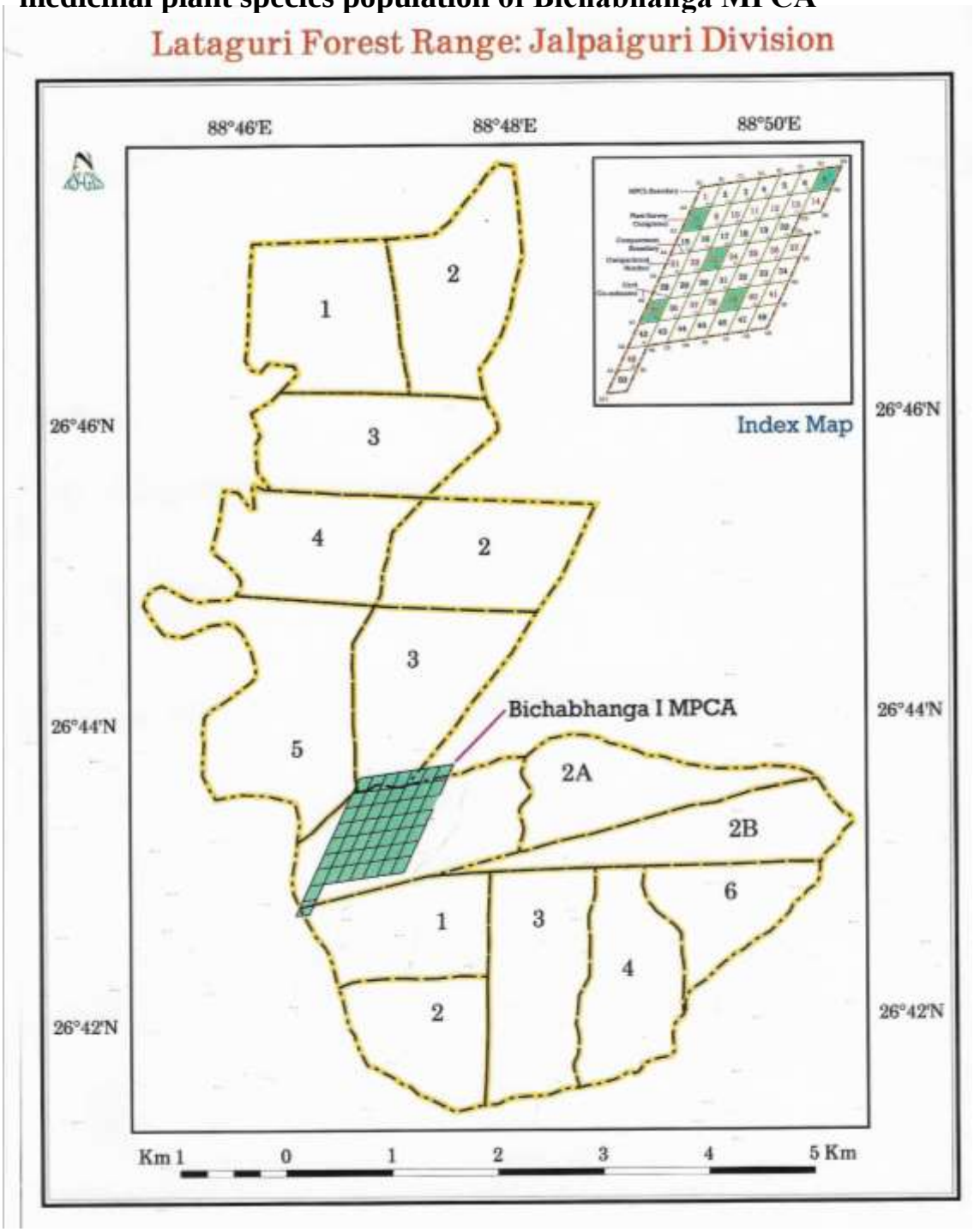
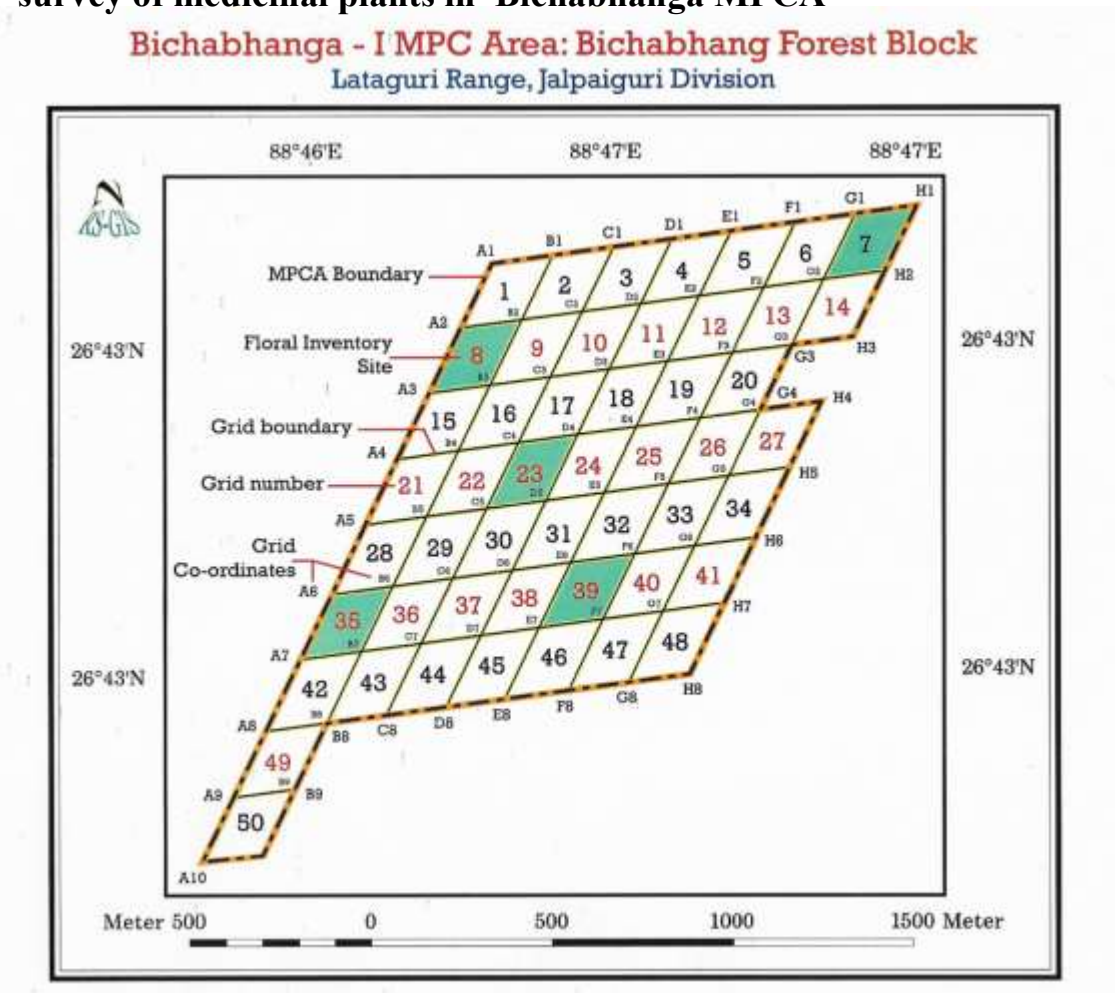


Fig 11: Map of Bichabhanga MPCA with names of surrounding places

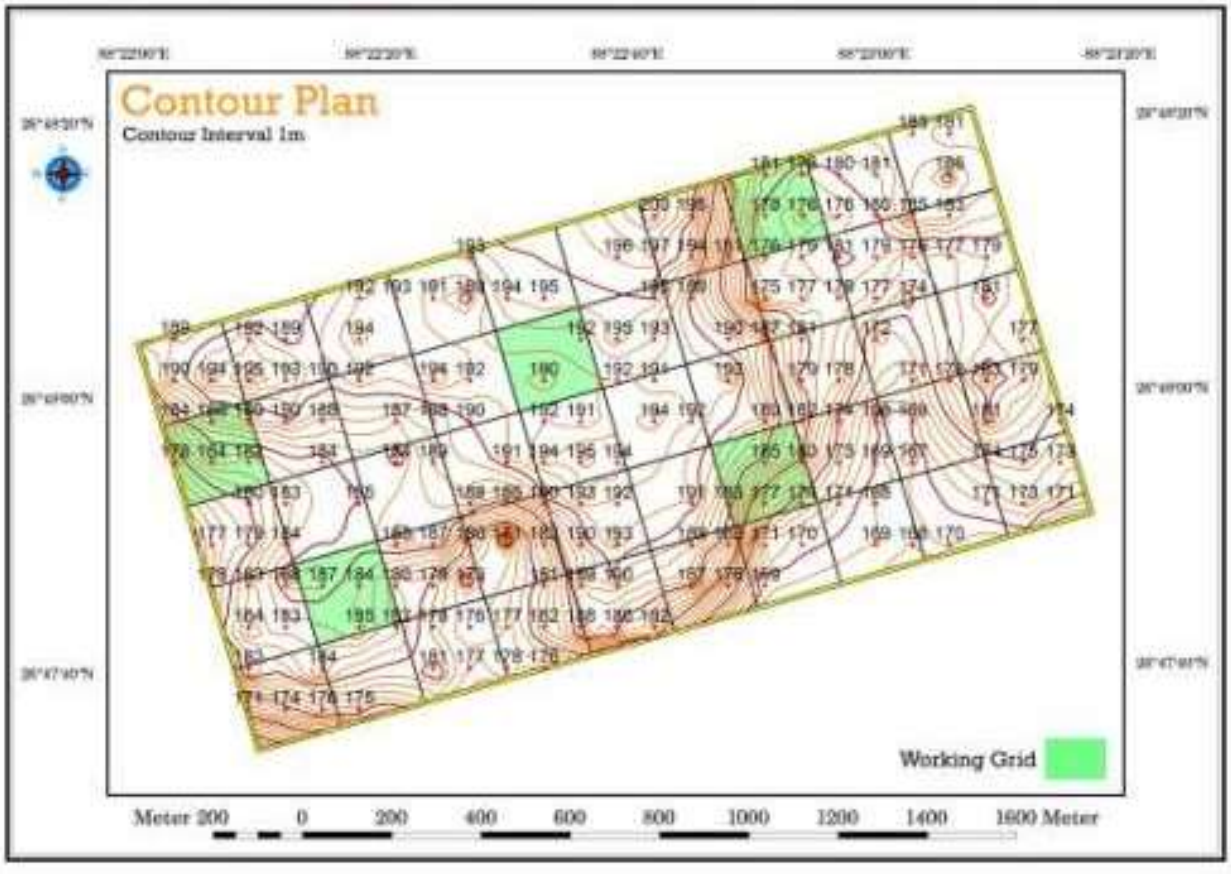
Fig 12: Layout of sampling plots and design of sampling efforts for population survey of medicinal plants in Bichabhanga MPCA



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 13. Contour maps of Bichabhanga 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 99 m 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, 125 quadrats of 1m x 1m, 25 quadrats of 5m x 5m and 5 quadrats of 20m x 20m for herbs, shrubs and trees were laid out at random for study of vegetation of all kinds.

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 were also taken in consideration. 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 David Prain (1903), Mabberley (2017) 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 has been calculated for each species. The importance value index (IVI), an integrated measure of relative frequency, relative density and relative dominance was derived following Curtis (1959). After collecting the data from field, the following indices were calculated in detail to establish the status of plants in Bichabhanga MPCA:

Figure 14. Layout of sampling plots and design of sampling efforts for medicinal plant species population assessment in Bichabhanga MPCA

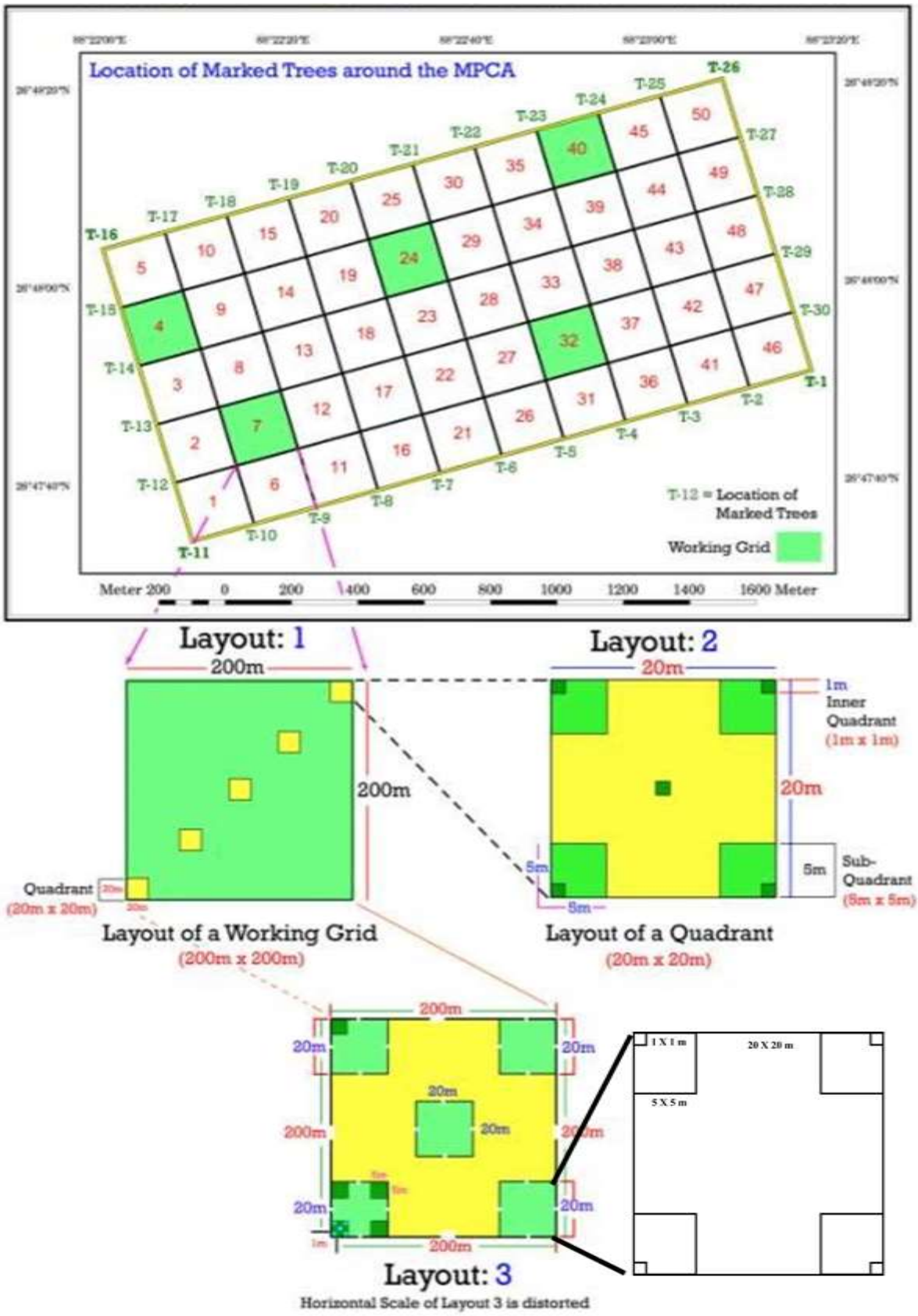
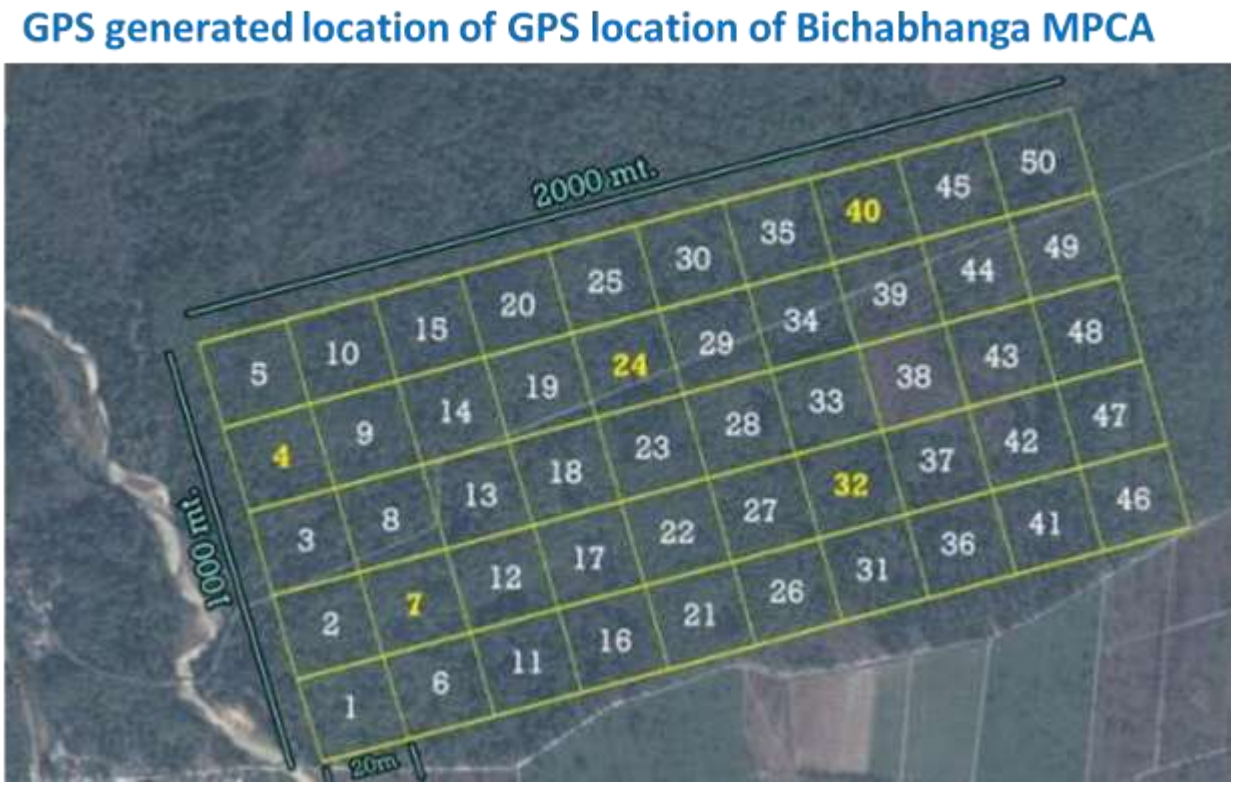


Figure 15 . Numbering of grids for sampling purpose in BIchabhanga MPCA



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.

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).

$$IS = (2C/A+B) \times 100$$

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)	$(GBH)^2/4\pi$ GBH – Circumference at breast height
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 given below by Simpson (1949). Its maximum value ranges between 0 -1, which basically relates to the number of chance a particular species that can be encountered in a sampling unit.

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

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 finally assessed applying the IUCN Red List Criteria and Categories. 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 old 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).

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 in 2016. There was another trip to site just prior to monsoon (April to June).

CHAPTER 3: QUANTITATIVE ASSESSMENT OF MEDICINAL PLANTS

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	*Actinodaphne obovata* (Nees) Blume	Lauraceae	Sissi
2	*Aesculus indica* (Colebr. Ex Cambess) Hook	Sapindaceae.	Akshira
3	*Aglaia perviridis* Hiern	Meliaceae	
4	*Ailanthus integrifolia* Lam.	Simaroubaceae	Gokul
5	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	Chatim
6	*Amoora rohituka* W. & A.	Meliaceae	Losuni lali
7	*Amoora sp.*	Meliaceae	Assam Lali
8	*Amoora spectabilis* (Miq.) Jain. & Bennet	Meliaceae	Dudhelali/ SadaLali
9	*Amoora wallichii* King	Meliaceae	Lali
10	*Aphanamixis polystachya* (Wall.) R.Parker	Meliaceae	Lasune
11	*Artocarpus chaplasha* Roxb.	Moraceae	Lator
12	*Baccaurea sapida* (Roxb.) Muell. Arg.	Phyllanthaceae	Latka
13	*Baccaurea ramiflora* Lour.	Phyllanthaceae	Kusum, Latka
14	*Bauhinia variegata* L.	Fabaceae	Tanki
15	*Bombax ceiba* L.	Malvaceae	Simul
16	*Bridelia stipularis* (L.) Blume	Phyllanthaceae	Kasai

17	*Callicarpa arborea* Roxb.	Lamiaceae	Gwelo
18	*Callicarpa tomentosa* (L.) Murr.	Verbenaceae	
19	*Careya arborea* Roxb.	Lecythidaceae	Kumbhi
20	*Casearia graveolens* Dalz.	Salicaceae,	Bandar Khaja
21	*Castanopsis indica* (Roxb. ex Lindl.) A.DC.	Fagaceae	Dalnekatus
22	*Castanopsis tribuloides* A. DC.	Fagaceae	Katus
23	*Chukrasia tabularis* A. Juss.	Meliaceae	Chikrashi
24	*Cinnamomum cecidodaphne* Meissn.	Lauraceae	Malagiri
25	*Cinnamomum bejolghota* (Buch.-Ham.) Sweet	Lauraceae	Janglee tejpat,
26	*Dillenia indica* L.	Dilleniaceae	Chalta, Panchphol
27	*Dillenia pentagyna* Roxb.	Dilleniaceae	Tatari
28	*Duabanga sonereoides* Ham.	Lythraceae	Lampate/ Rampate
29	*Dysoxylum binectariferum* (Roxb.) Hook.f. ex Bedd.	Meliaceae	Dhamina
30	*Elaeocarpus varuna* Ham.	Elaeocarpaceae	Bhadrasi
31	*Euonymus laxiflorus* Champ. ex Benth.	Clestraceae	
32	*Eurya acuminata* DC.	Theaceae	Sanu Jhiganae
33	*Evodia fraxinifolia* (Hook.) Benth.	Rutaceae	
34	*Ficus cordata* Thunb.	Moraceae	
35	*Ficus hispida* L. f.	Moraceae	Dumur
36	*Ficus mysorensis* var. *subrepanda* Wall. ex King	Moraceae	

37	*Flacourtia indica* (Burm.f.) Merr.	Flacourtiaceae	
38	*Garcinia sp.*	Clusiaceae	Baju
39	*Gmelina arborea* Roxb.	Verbenaceae	Gamar
40	*Gynocardia odorata* R. Br.	Achariaceae	Gante
41	*Haldina cordifolia* (Roxb.) Ridsdale	Rubiaceae	
42	*Holarrhena pubescens* (Buch.-Ham) Wall. ex Don	Apocynaceae	Kurchi
43	*Ilex godajam* Colebr. ex Hook.f.	Aquifoliaceae	Hatisura
44	*Lagerstroemia parviflora* Roxb.	Lythraceae	Sidha
45	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae	Jiga/Giga
46	*Leea guinensis* G. Don.	Vitaceae	Panchpate
47	*Lagerstroemia hirta* (Lamarck) Willdenow	Lythraceae	Jarul
48	*Litsea glutinosa* (Lour.) C B	Lauraceae	Kawla
49	*Litsea hookerii* (Meisn.) D. G. Long.	Lauraceae	Bhote Kawla
50	*Macaranga peltata* (Roxb.) Mueller	Euphorbiaceae	
51	*Machilus glaucescens* (Nees) Wight	Lauraceae	Bhati Kawla/Bhote
52	*Magnolia pterocarpa* Roxb.	Magnoliaceae	Potpote/patpate
53	*Mallotus philippensis* (Lam.) Müll.Arg.	Euphorbiaceae	Sindure
54	*Melia composite* Willd.	Meliaceae	
55	*Mesua ferrea* L.	Caryophyllaceae	Nagkesar
56	*Michelia champaca* L.	Magnoliaceae	Ranichamp
57	*Mitragyna parvifolia* (Roxb.) Korth.	Rubiaceae	
58	*Murraya paniculata* (L.) Jack	Rutaceae	Kamini

59	*Oroxylum indicum* (L.) Kurz	Bignoniaceae	Totala
60	*Persea fructifera* Kosterm	Lauraceae.	Lapche
61	*Polyalthia simiarum* (Buch.-Ham. ex Hook. f. & Thomson) Benth. ex Hook. f. & Thomson	Annonaceae	Lapche Kath
62	*Premna bengalensis* C. B. Clarke	Lamiaceae	Dhouli/ Dhowli
63	*Pterocarpus marsupium* Roxb	Fabaceae	
64	*Pterospermum acerifolium* L.	Malvaceae	Hantipahele
65	*Pterygota alata* (Roxb.) R.Br.	Malvaceae	Labshi, Narkeli,
66	*Sapium baccatum* Roxb.	Euphorbiaceae	Akahatarua
67	*Saurauia roxburghii* Wall.	Actinidiaceae	Gogdo/ Gobdo
68	*Schima wallichii* Choisy	Theaceae	Chilouni
69	*Schima wallichii* (DC.) Korth.	Theaceae	Chilauney
70	*Shorea robusta* Gaertn.	Dipterocarpaceae	Sal
71	*Sloanea sterculiacea* (Benth.) Rehder & E.H.Wilson	Elaeocarpaceae	Kadam katus
72	*Sterculia guttata* Roxb. ex G.Don	Malvaceae	Odal
73	*Sterculia villosa* Roxb.	Sterculiaceae	Odal
74	*Stereospermum colais* (Buch.-Ham. ex Dillwyn) Mabb.	Bignoniaceae	Parari
75	*Symplocos glomerata* King ex C.B. Clarke (Male plant)	Symplocaceae	Kharane
76	*Syzygium cumini* (L.) Skeels	Myrtaceae	Jam
77	*Syzygium formosum* (Wall.) Masam	Myrtaceae	Godajam/Kathja m
78	*Terminalia bellerica* Roxb.	Combretaceae	Bahera
79	*Terminalia chebula* Retz.	Combretaceae	Horitaki

80	*Terminalia myriocarpa* Van Heurck & Müll. Arg.	Combretaceae	Terminalia myriocarpa
81	*Tetrameles nudiflora* R. Br.	Combretaceae	Mayna
82	*Trewia nudiflora* L.	Euphorbiaceae	Pithali
83	*Turpinia pomifera* DC.	Staphyleaceae	Thali
84	*Wrightia arborea* (Dennst.) Mabb.	Apocynaceae	Khira

SHRUBS, CLIMBERS AND LIANA

Sl. No.	***Species Name***	**Family**	**Local name**
1	*Acacia caesia* L.	Fabaceae	
2	*Acacia pennata* (L.) Willd.	Fabaceae	
3	*Alangium chinense* (Lour.) Harms	Alangiaceae	
4	*Allophylus simplicifolius* Radlk.	Sapindaceae	
5	*Ampelocissus barbata* (Wall.) Planch.	Vitaceae	Jangli angur
6	*Ampelocissus latifolia* (Roxb.) Planch	Vitaceae	
7	*Antidesma acidum* Retz.	Phyllanthaceae	
8	*Ardisia elliptica* Thunb.	Myrsinaceae	
9	*Ardisia solanacea* (Poir.) Roxb.	Myrsinaceae	Damai Phool
10	*Argyreia roxburghii* (Sweet) Choisy	Convolvulaceae	
11	*Aristolochia indica* L.	Aristolochiaceae	Iswarmul
12	*Aristolochia tagala* Cham.	Aristolochiaceae	
13	*Ayenia grandifolia* (DC.) Christenh. & Byng	Malvaceae	
14	*Bauhinia acuminata* Vell.	Fabaceae	

15	*Bauhinia vahlii* Wight & Arn.	Fabaceae	
16	*Benkara fasciculata* (Roxb.) Ridsdale	Rubiaceae	
17	*Berchemia floribunda* (Wall.) Brongn.	Rhamnaceae	
18	*Bridelia scandens* (Roxb) Willd	Phyllanthaceae	
19	*Caesalpinia crista* L.	Fabaceae	
20	*Canthium rheedei* DC.	Rubiaceae	
21	*Capparis acutifolia* Sweet	Capparaceae	
22	*Casearia graveolens* Dalzell	Salicaceae	
23	*Catunaregam longispina* (Link) Tirveng.	Rubiaceae	
24	*Cayratia trifolia* (L.) Domin	Vitaceae	Amal lata
25	*Celastrus paniculatus* Willd.	Celastraceae	Malkaguni
26	*Chonemorpha fragrans* (Moon) Alston.	Apocynaceae	
27	*Cissampelos pareira* var. *hirsuta* (Buch.-Ham. ex DC.) Forman	Menispermaceae	Batulepati
28	*Cissus pallida* (Wight &Arn.) Steud.	Vitaceae	
29	*Cissus woodrowii* (Stapf ex T. Cooke) Santapau	Vitaceae	
30	*Clerodendrum viscosum* Vent.	Verbenaceae	Bhant, Ghentu
31	*Colebrookea oppositifolia* Sm.	Lamiaceae	Dhursil
32	*Croton caudatus* Geiseler	Euphorbiaceae	Khashase
33	*Cryptolepis sinensis* (Lour.) Merr.	Apocynaceae	Kankrashringi
34	*Cyclea bicristata* (Griff.) Diels	Menispermaceae	
35	*Cyclea peltata* (Lam.) Hook.f. & Thomson	Menispermaceae	
36	*Dalbergia stipulacea* Roxb.	Fabaceae	

37	*Decaspermum fruticosum* J.R.Forst. & G.Forst.	Myrtaceae	
38	*Dendrocnide sinuata* (Blume) Chew	Urticaceae	
39	*Dioscorea bulbifera* L.	Dioscoreaceae	Gittha Tarul
40	*Dioscorea oppositifolia* L.	Dioscoreaceae	
41	*Dioscorea pentaphylla* L.	Dioscoreaceae	Ban Tarul, Bhegur
42	*Dioscorea prazeri* Prain & Burkill	Dioscoreaceae	Kukur tarul
43	*Diospyros montana* Roxb.	Dioscoreaceae	
44	*Embelia tsjeriam-cottam (Roem. & Schult.) A.DC.*	Myrsinaceae	
45	*Entada rheedii* Spreng	Mimosaceae	Gila
46	*Flemingia macrophylla* (Willd.) Merr.	Fabaceae	
47	*Glycosmis pentaphylla* (Retz.) DC.	Rutaceae	Ban jamir
48	*Gnetum montanum*.Markgr.	Gnetaceae	Mamelet
49	*Gouania leptostachya* DC.	Rhamnaceae	
50	*Grewia serrulata* DC.	Malvaceae	
51	*Hemidesmus indicus* (L.) R. Br. ex Schult.	Apocynaceae	
52	*Hiptage benghalensis* (L.) Kurz	Malpighiaceae	
53	*Hodgsonia macrocarpa* (Blume) Cogn.	Cucurbitaceae	
54	*Holmskioldia sanguinea* Retz.	Lamiaceae	
55	*Ichnocarpus frutescens* (L.) W.T. Aiton	Apocynaceae	Dudhe Lahara
56	*Ixora anthroantha* Bremek.	Rubiaceae	
57	*Jasminum flexile* Vahl	Oleaceae	

58	*Leea guineensis* G.Don	Vitaceae	
59	*Leea indica* (Burm. f.) Merr.	Vitaceae	
60	*Maesa indica* (Roxb.) A. DC.	Myrsinaceae	Bilauney
61	*Melastoma malabathricum* L.	Melastomataceae	
62	*Meyna spinosa* Roxb. ex Link	Rubiaceae	Moyna kata
63	*Mezoneuron cucullatum* (Roxb.) Wight & Arn.	Fabaceae	
64	*Micromelum minutum* (G.Forst.) Wight & Arn.	Rutaceae	
65	*Mikania cordata* (Burm.f.) B.L.Rob.	Asteraceae	
66	*Momordica charantia* subsp. *abbreviata* (Ser.) Greb.	Cucurbitaceae	Karela
67	*Morinda angustifolia* Roxb.	Rubiaceae	Haldi kath
68	*Morinda citrifolia* L.	Rubiaceae	
69	*Mucuna pruriens* (L.) DC. *var. utilis*	Fabaceae	Alkushi
70	*Mussaenda sp.*	Rubiaceae	Katmatia Saag
71	*Naravelia zeylanica* DC.	Ranunculaceae	Chhagalbati
72	*Parthenocissus semicordata* (Wall.) Planch.	Vitaceae	
73	*Pavetta indica* L.	Rubiaceae	
74	*Pegia nitida* Colebr.	Anacardiaceae	
75	*Pericampylus glaucus* (Lam.) Merr.	Menispermaceae	Pipal-pati Lahara

76	*Persicaria hydropiperoides* (Michx.) Small	Menispermaceae	
77	*Phlogacanthus thyrsiflorus* Nees	Acanthaceae	
78	*Phyllanthus reticulatus* Poir.	Phyllanthaceae	Bhui amla
79	*Piper attenuatum* Buch.-Ham. ex Miq.	Piperaceae	
80	*Piper betleoides* DC.	Piperaceae	
81	*Piper locnchites* Roem. & Sch.	Piperaceae	
82	*Piper longum* L.	Piperaceae	Pipal, Pipla
83	*Piper sylvaticum* Roxb.	Piperaceae	
84	*Pothas scandens* L.	Araceae	
85	*Premna mollissima* Roth	Lamiaceae	
86	*Pueraria sikkimensis* Prain	Fabaceae	
87	*Rhaphidophora decursiva* (Roxb.) Schott	Araceae	
88	*Rhynchotechum ellipticum* (Wall. ex D.Dietr.) A.DC.	Gesneriaceae	
89	*Saccolabiopsis pussila* (Lindl.) Seidenfaden & Garay	Orchidaceae	
90	*Saurauia roxburghii* Wall.	Actinidiaceae	
91	*Senegalia pennata* (L.) Maslin	Fabaceae	
92	*Smilax griffithii* A.DC.	Smilacaceae	
93	*Smilax lanceifolia* Roxb.	Smilacaceae	
94	*Smilax ovalifolia* Roxb. ex D.Don	Smilacaceae	Kukurdainey
95	*Smilax zeylanica* L.	Smilacaceae	
96	*Solanum torvum* Sm.	Solanaceae	Gothbegun

97	*Spatholobus parviflorus* (DC.)Kuntze	Fabaceae	
98	*Spermacoce prostrata* Aubl.	Rubiaceae	
99	*Stephania glabra* (Roxb.) Miers	Menispermaceae	Tamarke Lahara
100	*Stephania japonica* var. *discolor* (Blume) Forman	Menispermaceae	Tamarki
101	*Tabernaemontana alternifolia* L.	Apocynaceae	
102	*Tabernaemontana divaricata* (L.) R.Br. ex Roem. & Schult.	Apocynaceae	Tagar
103	*Tephrosia candida* (Roxb.) DC.	Fabaceae	Ban nim
104	*Tetrastigma serrulatum* (Roxb.) Planch.	Vitaceae	
105	*Thunbergia coccinea* Wall.	Acanthaceae	
106	*Thunbergia fragrans* Roxb.	Acanthaceae	
107	*Toddalia asiatica* (L.) Lam.	Rutaceae	Belkanta
108	*Trachelospermum lucidum* (D.Don) K.Schum	Apocynaceae	
109	*Trichosanthes lepiniana* Cogn.	Cucurbitaceae	
110	*Wattakaka volubilis* (L. f.) Stapf	Apocynaceae	Chhint
111	*Zanonia indica* L.	Cucurbitaceae	
112	*Zehneria umbellata* (Klein ex Willd.) Thwaites	Cucurbitaceae	
113	*Ziziphus nummularia* (Burm. f.) Wight & Arn.	Rhmanaceae	
114	*Zizyphus rubiginosa* Long & Rac.	Rhmanaceae	Kul kata
	HERBS SPECIES		
1	*Abelmoschus moschatus* Medik	Malvaceae	Ban

			Dharash/Hari n Kasturi
2	*Achyranthes aspera* L.	Amaranthaceae	
3	*Achyrospermum densiflorum* Blume	Lamiaceae	
4	*Acmella paniculata* (Wall. ex DC.) R.K.Jansen	Asteraceae	
5	*Aerva sanguinolenta* (L.) Blume	Amaranthaceae	Lopang
6	*Aeschynanthus micranthus* C.B.Clarke	Gesneriaceae	
7	*Ageratum conyzoides* L.	Asteraceae	Elame jhar
8	*Alocasia fallax* Schott	Araceae	Kalo kachu
9	*Alpinia calcarata* (Andrews) Roscoe	Zingiberaceae	
10	*Alpinia nigra* (Gaertn.) Burtt.	Zingiberaceae	Purundi
11	*Amischotolype hookeri* (Hassk.) H.Hara	Commelinaceae	
12	*Amorphophalua napalensis* (Wall.) Bogner & Majo	Araceae	Ban oll
13	*Ampelopteris prolifera* (Retz.) Copel.	Thelypteridaceae	Lal Dhaki
14	*Anisomeles indica* (L.) Kuntze	Lamiaceae	Gopali
15	*Arisaema cuspidatum* Engl.	Araceae	
16	*Asplenium erectum* Bory ex Willd.	Aspleniaceae	
17	*Athyrium biserrulatum* Christ	Aspleniaceae	
18	*Axonopus compressus* (Sw.) P.Beauv.	Poaceae	Das pane ghas
19	*Barleria strigosa* Willd.	Acanthaceae	Nil Jati

20	*Bidens pilosa* L.	Asteraceae	
21	*Boehmeria macrophylla* Hornem var. macrophylla	Urticaceae	
22	*Boehmeria macrophylla* var. *scabrella* (Roxb.) D.G.Long	Urticaceae	
23	*Borreria stricta* (L. f.) DC.	Rubiaceae	Alujhar
24	*Brachiaria eruciformis* (Sm.) Griseb.	Poaceae	
25	*Brachiaria reptans* (L.) Garden & Hubb.	Poaceae	Athia
26	*Bridelia stipularis* (L.) Blume	Phyllanthaceae	Dataon
27	*Bulbophyllum roxburghii* (Lindl.) Reichb	Orchidaceae	
28	*Bulbophyllum sarcophyllum (King & Pantl.) J.J.Sm.*	Orchidaceae	
29	*Caesalpinia cucullata* Roxb.	Caesalpiniaceae	Arari
30	*Calamus latifolius* Roxb.	Arecaceae	Bet Lahari
31	*Carex inanis* Kunth	Cyperaceae	
32	*Cassia hirsuta* L.	Fabaceae	
33	*Centella asiatica* (L.) Urb.	Apiaceae	Thankuni
34	*Chloranthus elatior* R. Br.	Chloranthaceae	Zibre pata
35	*Chlorophytum tuberosum* (Roxb.) Baker	Asparagaceae	
36	*Christella dentata* (Forsk.) Brownsey & Jermy	Thelypteridaceae	Bis Dhekia
37	*Chromolaena odorata* (L.) R.M.King & H.Rob.	Asteraceae	
38	*Cleome rutidosperma* DC.	Cleomaceae	
39	*Clerodendrum viscosum* Vent.	Lamiaceae	Bhat
40	*Clinopodium gracile* (Bentham) Matsumur	Lamiaceae	
41	*Coffea benghalensis* B.Heyne ex Schult.	Rubiaceae	Coffea
42	*Combretum wallichii* var. *flagrocarpum* (C.B.Clarke) M.G	Combretaceae	Gante lata
43	*Commelina benghalensis* L.	Commelinaceae	Kane jhar

44	*Commelina longifolia* Lam.	Commelinaceae	
45	*Costus speciosus* (J.Koenig) Sm.	Zingiberaceae	Kemuk
46	*Crinum asiaticum* L.	Amaryllidaceae	
47	*Crotalaria montana* Heyne ex Roth	Fabaceae	
48	*Curculigo aromatica* Salisb.	Hypoxidaceae	Ban halud
49	*Curculigo orchioides* Gaertn.	Hypoxidaceae	Talmuli
50	*Curcuma aromatica* Salisb.	Zingiberaceae	Ban Chandal
51	*Curcuma zedoaria* (Christm.) Roscoe	Zingiberaceae	Kala haldi
52	*Cyathula prostrata* (L.) Blume	Amaranthaceae	
53	*Cynodon dactylon* (L.) Pers.	Poaceae	Dubo
54	*Cyperus compressus* L.	Cyperaceae	
55	*Cyperus pangorei* Rottb.	Cyperaceae	Motha
56	*Deeringia amaranthoides* (Lam.) Merr.	Amaranthaceae	Chhorachhurisag
57	*Dendrobium densiflorum* Lindl.	Orchidaceae	
58	*Dendrobium stuposum* Lindl.	Orchidaceae	
59	*Dendrocnide sinuata* (Blume) Chew	Urticaceae	Damal
60	*Desmodium gangeticum* (L.) DC.	Fabaceae	Ban Gahate
61	*Desmodium gyrens* (L.) DC.	Fabaceae	Ban Chandal
62	*Desmodium heterocarpon* var. *strigosum* Meeuwen	Fabaceae	
63	*Desmodium laxiflorum* DC.	Fabaceae	

64	*Desmodium oblongum* Wallich ex Bentham	Fabaceae	
65	*Desmodium triflorum* (L.) DC.	Fabaceae	
66	*Dichanthium annulatum* (Forssk.) Stapf	Poaceae	
67	*Dicliptera bupleuroides* Nees	Acanthaceae	
68	*Dicliptera roxburghii* Nees	Acanthaceae	Jhanti
69	*Dictyospermum montanum* Wight	Commelinaceae	
70	*Digitaria ciliaris* (Retz.) Koeler	Poaceae	Kalo Banso
71	*Diplazium esculentum* (Retz.) Sw.	Aspleniaceae	Dhaki
72	*Drymaria cordata* (L.) Willd	Caryophyllaceae	
73	*Dryopteris sikkimensis* (Bedd.) Kuntze	Polypodiaceae	
74	*Elatostema platyphyllum* Wedd.	Urticaceae	
75	*Elephantopus scaber* L.	Asteraceae	Gajialata
76	*Equisetum ramosissimum* Desf.	Equisetaceae	
77	*Eragrostis gangetica* (Roxb.) Steud.	Poaceae	
78	*Eranthemum pulchellum* Andrews	Acanthaceae	
79	*Eupoatorium adenophorum* Spreng.	Asteraceae	Banmara
80	*Flickengeria macraei* (Lindl.)	Orchidaceae	
81	*Floscopa scandens* Lour.	Commelinaceae	Cana jhar
82	*Gastrochilus obliquus* (Lindl.) Kuntze	Orchidaceae	
83	*Gomphostemma lucidum* Wall. ex Benth.	Lamiaceae	
84	*Gomphostemma parviflorum* Wall ex Benth.	Lamiaceae	Ban till
85	*Hedychium wardii* C.E.C.Fisch.	Zingiberaceae	
86	*Hedyotis scandens* Roxb.	Rubiaceae	Kali Angare

87	*Helminthostachys zeylanica* (L.) Hook.	Ophioglossaceae	
88	*Hemidesmus indicus* R. Br.	Apocynaceae	Anantamul
89	*Hibiscus sabdariffa* L.	Malvaceae	
90	*Hippeastrum reginae* (L.) Herb.	Amaryllidaceae	Bon Pianj
91	*Hyptis suaveolens* (L.) Poit	Lamiaceae	Bon tulsi
92	*Ichnocarpus frutescens* (L.) R. Br.	Apocynaceae	Antamul
93	*Impatiens balsamina* L.	Balsaminaceae	Dopati
94	*Impatiens jurpia* Buch.-Ham. ex Hook.f. & T. Thomson	Balsaminaceae	
95	*Lasia spinosa* (L.) Thwaites	Araceae	Marangu Kachu
96	*Leea guinensis* G. Don.	Vitaceae	Hantubhanga
97	*Lepidagathis incurva* Buch.-Ham. ex D. Don Var. incurva	Acanthaceae	
98	*Limnophila chinensis* (Osbeck) Merr.	Scrophulariaceae	
99	*Lindenbergia grandiflora* Benth.	Orobanchaceae	
100	*Ludwigia hyssopifolia* (G.Don) Exell	Onagraceae	
101	*Lygodium microphyllum* (Cav.) R.Br	Lydiaceae	
102	*Mariscus compactus* (Retz.) Bold.	Cyperaceae	
103	*Melastoma malabathricum* L.	Melastomataceae	Putki
104	*Merremia vitifolia* (Burm .f.) Hailler f.	Convolvulaceae	Latta Jhar
105	*Mikania micrantha* H.B.K.	Asteraceae	Mikenia
106	*Mimosa pudica* L.	Fabaceae	Lajjapati
107	*Mucuna pruriens* (L.) DC.	Fabaceae	Mechi Pata
108	*Mussaenda roxburghii* Hook. f.	Rubiaceae	Ban Masunda
109	*Oplismenus burmanni* (Retz.) P.Beauv.	Poaceae	Chepti

110	*Oplismenus compositus* (L.) P.Beauv.	Poaceae	
111	*Oplismenus wallichiana* (Kunth.) Hook. f.	Poaceae	Sirughas
112	*Otochilus fuscus* Lindl.	Orchidaceae	
113	*Oxalis corniculata* L.	Oxalidaceae	Amrul
114	*Pandanus unguifer* Hook.f.	Pandanaceae	Keya
115	*Panicum nodatum* Hitchc. & Chase	Poaceae	
116	*Papilionanthe teres* (Roxb.) Schltr.	Orchidaceae	
117	*Persicaria chinensis* (L.) H. Gross	Polygonaceae	Thotne
118	*Phaulopsis imbricata* (Foresst.) Sweet	Acanthaceae	
119	*Phlogacanthus thyrsiflorus* (Roxb.) Nees	Acanthaceae	Rambasak
120	*Phylla nudiflora* (L.) Greene	Verbenaceae	Bhuiokre
121	*Phyllanthus fraternus* Webster	Phyllanthaceae	Bhuiamla
122	*Phyllanthus urinaria* L.	Phyllanthaceae	Bhui amla,
123	*Piper peepuloides* Roxb.	Piperaceae	Pipli
124	*Pogostemon benghalensis* (Burm.f.) Kuntze	Lamiaceae	Rudhilo
125	*Polygonum chinense* L.	Polygonaceae	Bis katha
126	*Polygonum plebeium* R. Brown	Polygonaceae	
127	*Potentilla indica* (Andrews) Th.Wolf	Rosaceae	
128	*Pouzolzia zeylanica* (L.) Benn.	Urticaceae	Habit
129	*Pteris semipinnata* L.	Pteridaceae	
130	*Puereria sikkimensis* Prain	Fabaceae	Kalai Lata
131	*Pupalia lappacea* (L.) Juss.	Amaranthaceae	

132	*Richardia scabra* L.	Rubiaceae	
133	*Sabia paniculata Edgw.* Ex Hook f. & Thomson	Sabiaceae	Chimni
134	*Salomonia ciliata* (L.) DC.	Polygalaceae	
135	*Sauropus compressus* var. *puberulus* (Kurz) Chakrab. & M.Gangop.	Phyllanthaceae	
136	*Senna occidentalis* L.	Fabaceae	
137	*Setaria pamifolia* (J Koeign.) Stapf.	Poaceae	Banspata
138	*Sida alnifolia* L.	Malvaceae	
139	*Sida cordata* (Burm.f.) Borss. Waalk.	Malvaceae	
140	*Spermacoce alata* Aubl.	Rubiaceae	
142	*Stephania glabra* (Roxb.) Miers.	Menispermaceae	Bhuikumra
143	*Thunbergia grandiflora* (Roxb. ex Rttl.) Roxb.	Acanthaceae	Thunberghia
144	*Toddalia asiatica* (L.) *Lam.*	Rutaceae	Bagkanta
145	*Torenia diffusa* D. Don	Linderniaceae	
146	*Triumfetta pentandra* A. Rich.	Malvaceae	
147	*Uraria lagopodoides* (L.) DC.	Fabaceae	
148	*Urtica dioica* L.	Urticaceae	Bichuti, Sisnu
149	*Vallaris solanacea* Kuntz.	Apocynaceae	Suti, Haparmali
151	*Vernonia albicans* DC.	Asteraceae	
152	*Zingiber rubens* Roxb.	Zingiberaceae	

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

Tree species recorded	
# of species recorded	84
# of genera	67
# of families	39
# of threatened species	4
Shrub species recorded	
# of species recorded	114
# of genera	92
# of families	39
# of threatened species	5
Herb species and seedlings recorded	
# of species recorded	152
# of genera	129
# of families	48
# of threatened species	5

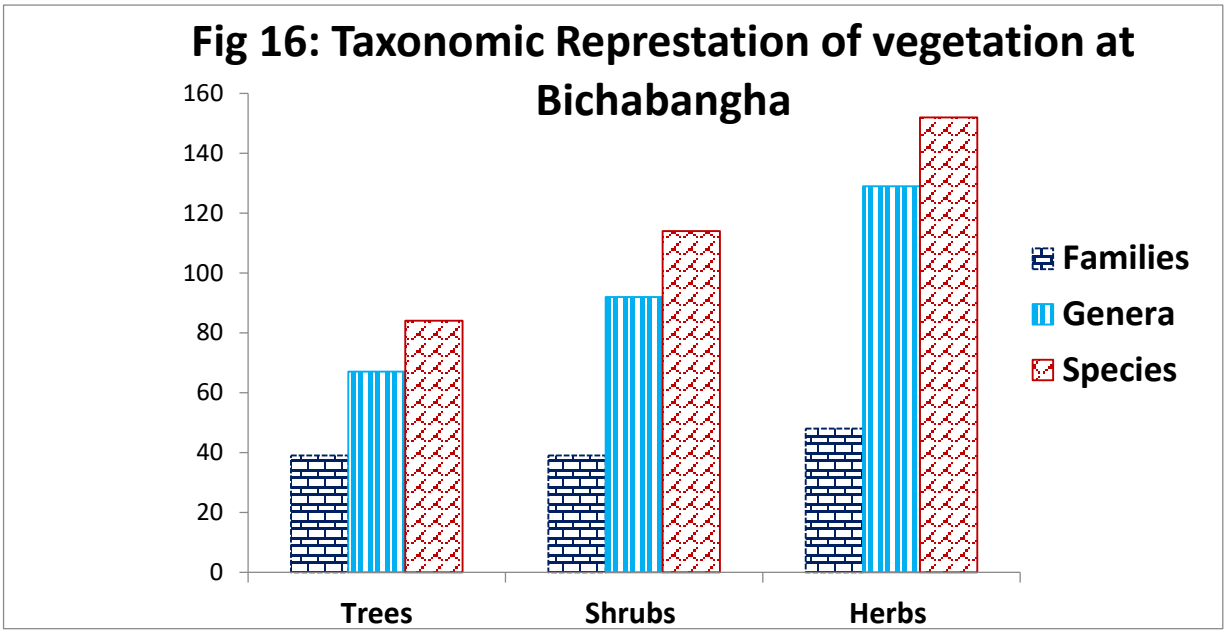


Fig 16: Taxonomic Represtation of vegetation at Bichabangha
160
140
120
100
80
60
40
20
0
Trees
Shrubs
Herbs
Families
Genera
Species

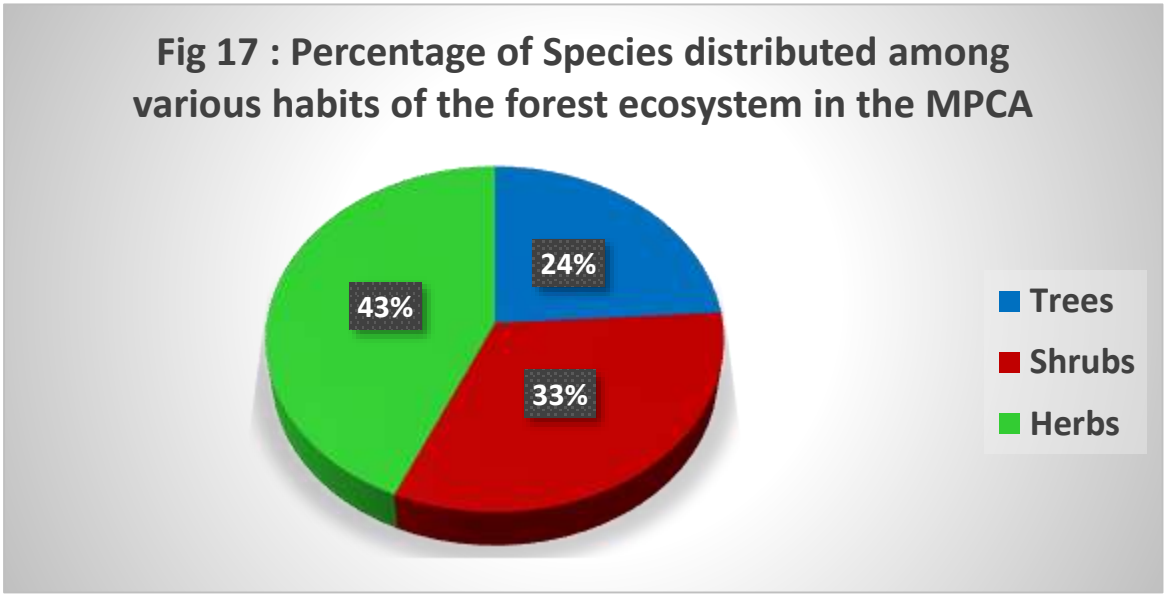


Fig 17 : Percentage of Species distributed among various habits of the forest ecosystem in the MPCA
24%
43%
33%
Trees
Shrubs
Herbs

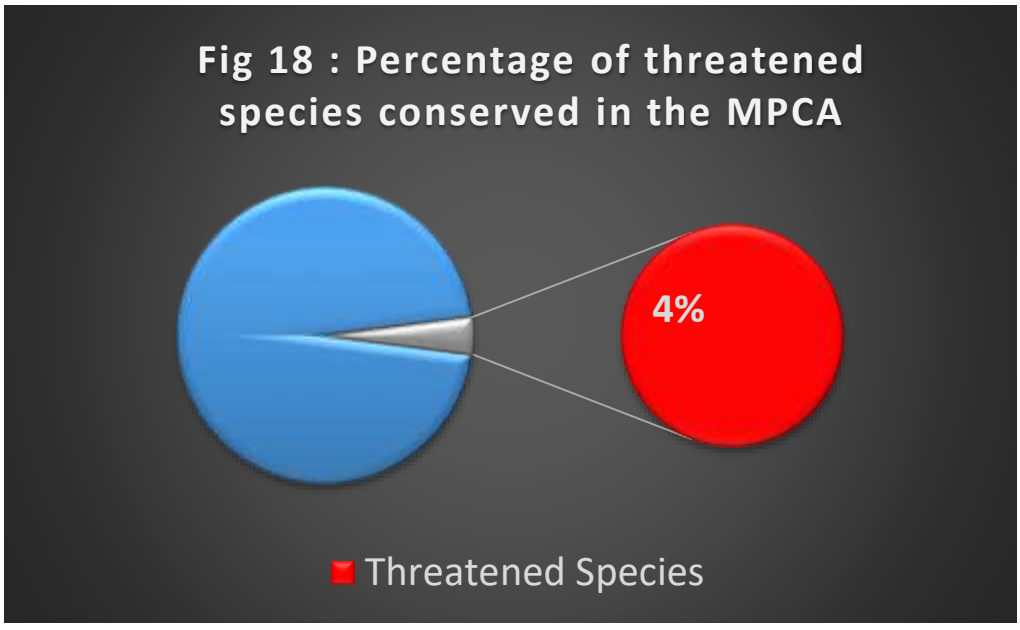


Fig 18 : Percentage of threatened species conserved in the MPCA
4%
Threatened Species

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*	Density/ ha	Relative density	Relative frequency	Relative dominance	IVI
1	*Actinodaphne obovata* (Nees) Blume	1.3	0.398406	0.877193	0.616791	1.892391
2	*Aesculus indica* (Colebr. Ex Cambess) Hook	1.3	0.398406	0.877193	0.616791	1.892391
3	*Ailanthus integrifolia* Lam.	3.8	1.195219	1.754386	1.462024	4.411629
4	*Alstonia scholaris* (L.) R. Br.	5.0	1.593625	3.508772	2.467165	7.569563
5	*Amoora wallichii* King	59.7	19.08351	14.03509	17.27587	50.43446
6	*Amoora spectabilis* (Miq.) Jain. & Bennet	37.5	11.95219	11.40351	10.87609	34.23179
7	*Schima wallichii* Choisy	74.7	23.90438	15.78947	20.81671	60.51056
8	*Aphanamixis polystachya* (Wall.) R.Parker	35.9	11.55378	14.03509	12.25075	37.83962
9	*Artocarpus chaplasha* Roxb.	2.5	0.796813	1.754386	1.233583	3.784781
10	*Baccaurea ramiflora* Lour.	1.3	0.398406	0.877193	0.616791	1.892391
11	*Bombax ceiba* L.	10.0	3.187251	5.263158	4.146208	12.59662
12	*Lagerstroemia hirta* (Lamarck) Willdenow	16.3	5.179283	3.508772	4.744548	13.4326
13	*Chukrasia tabularis* A. Juss.	2.5	0.796813	1.754386	0.856655	3.407853
14	*Michelia velutina* DC.	25.0	7.968127	7.017544	7.5694	22.55507

15	*Gynocardia odorata* R. Br.	3.8	1.195219	2.631579	1.850374	5.677172
16	*Litsea glutinosa* (Lour.) C B	3.7	1.195219	0.877193	1.119362	3.191774
17	*Shorea robusta* Gaertn.	10.0	3.187251	4.385965	3.777847	11.35106
18	*Elaeocarpus varuna* Ham.	1.3	0.398406	0.877193	0.616791	1.892391
19	*Amoora rohituka* W. & A.	12.5	3.984064	6.140351	4.996009	15.12042
20	*Sloanea sterculacea* (Benth.) Rehder & Wilson.	1.3	0.398406	0.877193	0.616791	1.892391
21	*Syzygium cumini* (L.) Skeels	1.3	0.398406	0.877193	0.616791	1.892391
22	*Terminalia bellerica* Roxb.	2.5	0.796813	0.877193	0.856655	2.53066
	Total	312.8	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

Sl. No.	Species Name	pi2	pilnpi
1	*Actinodaphne obovata* (Nees) Blume	1.59E-05	*0.02201*
2	*Aesculus indica* (Colebr. Ex Cambess) Hook	1.59E-05	*0.02201*
3	*Ailanthus integrifolia* Lam.	0.000143	*0.05291*
4	*Alstonia scholaris* (L.) R. Br.	0.000254	*0.06596*
5	*Amoora wallichii* King	0.036571	*0.31635*
6	*Amoora spectabilis* (Miq.) Jain. & Bennet	0.014285	0.253895
7	*Schima wallichii* Choisy	0.057142	0.342098
8	*Aphanamixis polystachya* (Wall.) R.Parker	0.013349	*0.24935*
9	*Artocarpus chaplasha* Roxb.	6.35E-05	*0.0385*
10	*Baccaurea ramiflora* Lour.	1.59E-05	*0.02201*
11	*Bombax ceiba* L.	0.001016	*0.10983*
12	*Lagerstroemia hirta* (Lamarck) Willdenow	0.002682	0.153333
13	*Chukrasia tabularis* A. Juss.	6.35E-05	0.038504
14	*Michelia velutina DC.*	0.006349	*0.20157*
15	*Gynocardia odorata R. Br.*	0.000143	0.05291
16	*Litsea glutinosa (Lour.) C B*	0.000143	0.05291

17	*Shorea robusta* Gaertn.	0.001016	0.109833
18	*Elaeocarpus varuna* Ham.	1.59E-05	0.022014
19	*Amoora rohituka* W. & A.	0.001587	0.128401
20	*Sloanea sterculacea* (Benth.) Rehder & Wilson.	1.59E-05	0.022014
21	*Syzygium cumini* (L.) Skeels	1.59E-05	0.022014
22	*Terminalia bellerica* Roxb.	6.35E-05	0.038504
	Total	**0.129966**	**2.296954**

Simpson index = **0.129966**, i.e., concentration of dominance of tree species.

Shanon-weiner index = **2.296954**, i.e., measure of tree species diversity

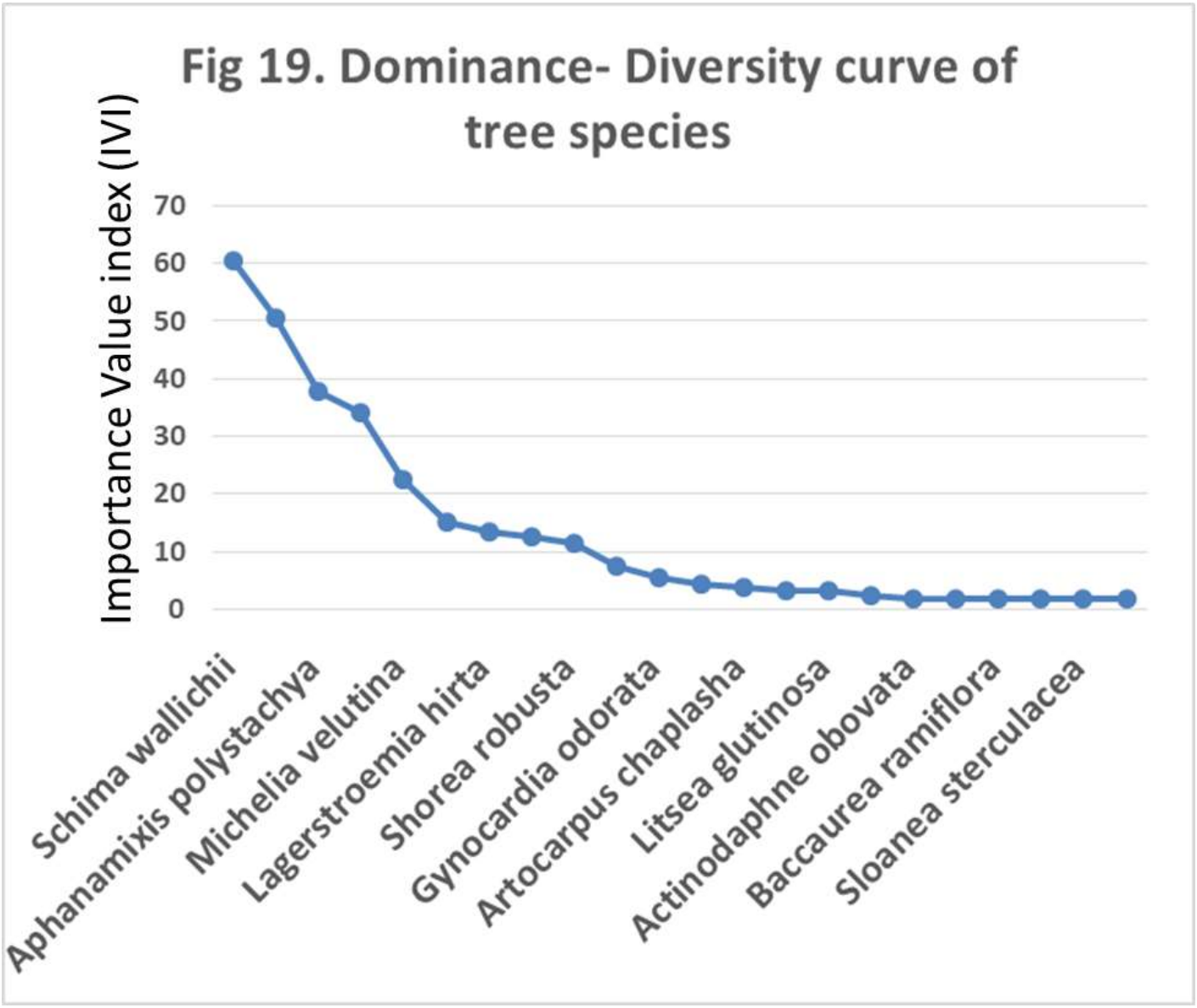


Fig 19. Dominance- Diversity curve of tree species
Importance Value index (IVI)
70
60
50
40
30
20
10
0
Schima wallichii
Aphanamixis polystachya
Michelia velutina
Lagerstroemia hirta
Shorea robusta
Gynocardia odorata
Artocarpus chaplasha
Litsea glutinosa
Actinodaphne obovata
Baccaurea ramiflora
Sloanea sterculacea

Table 8 . An account of **shrubs** 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***	**Density/ ha**	**Relative density**	**Relative frequency**	**Relative Abundance**	**IVI**
1	*Abelmoschus moschatus* Medik	0.0105	0.826772	1.8	1.756694	4.383466
2	*Alangium chinense* (Lour.) Harms	0.0105	0.826772	1.2	2.635042	4.661813
3	*Ampelocissus barbata*	0.073	5.748031	5.3	4.147882	15.19591
4	*Ampelopteris prolifera* (Retz.) Copel.	0.0155	1.220472	1.9	2.456731	5.577203
5	*Aristolochia indica*	0.0035	0.275591	0.5	2.108033	2.883624
6	*Cayratia trifolia* (L.) Domin	0.0205	1.614173	2.2	2.806148	6.620322
7	*Cayratia trifolia* (L.) Domin	0.063	4.96063	4.7	4.03666	13.69729
8	*Celastrus paniculatus*	0.0445	3.503937	4.5	2.978015	10.98195
9	*Chonemorpha fragrans* (Moon) Alston.	0.0205	1.614173	2.3	2.684142	6.598315
10	*Clerodendrum viscosum* Vent	0.1505	11.85039	6.6	6.867078	25.31747
11	*Dioscorea prazeri* Prain & Burkill	0.0445	3.503937	3.3	4.06093	10.86487
12	*Entada rheedii* Spreng	0.0035	0.275591	0.3	3.513389	4.08898
13	*Glycosmis pentaphylla* (Retz.) DC.	0.0605	4.76378	6.3	2.891973	13.95575
14	*Leea indica* (Burm. f.) Merr.	0.067	5.275591	6.8	2.96719	15.04278
15	*Lygodium microphyllum*	0.0105	0.826772	0.7	4.517214	6.043986

	(Cav.) R.Br					
16	*Mikania micrantha* H.B.K.	0.012	0.944882	1.6	2.258607	4.803489
17	*Morinda citrifolia* L.	0.0355	2.795276	3.3	3.239618	9.334894
18	*Mucuna pruriens* (L.) DC.	0.054	4.251969	4.9	3.31877	12.47074
19	*Parthenocissus semicordata* (Wall.) Planch.	0.1255	9.88189	7	5.399147	22.28104
20	*Phlogacanthus thyrsiflorus* Nees	0.0225	1.771654	2.4	2.823259	6.994913
21	*Piper locnchites* Roem. & Sch.	0.0445	3.503937	2.9	4.621058	11.025
22	*Piper sylvaticum* Roxb.	0.078	6.141732	4.7	4.997769	15.8395
23	*Smilax ovalifolia* Roxb. ex D.Don	0.0855	6.732283	6.7	3.843003	17.27529
24	*Solanum torvum* Sm	0.0025	0.19685	0.2	3.764345	4.161196
25	*Spatholobus parviflorus* (DC.)Kuntze	0.098	7.716535	6.3	4.684519	18.70105
26	*Stephania glabra* (Roxb.) Miers	0.0035	0.275591	0.5	2.108033	2.883624
27	*Tabernaemontana alternifolia* L.	0.0225	1.771654	2.1	3.226582	7.098235
28	*Tetrastigma serrulatum* (Roxb.) Planch	0.0725	5.708661	6.7	3.258687	15.66735
	Trachelospermum lucidum (D.Don) K.Schum	0.0155	1.220472	2.3	2.029473	5.549946
		1.2681	**100**	**100**	**100**	**300**

Table 9. 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	*Abelmoschus moschatus* Medik	7.60E-06	0.016243
2	*Alangium chinense* (Lour.) Harms	0.001808	0.134268
3	*Ampelocissus barbata*	2.27E-03	0.145016
4	*Ampelopteris prolifera* (Retz.) Copel.	1.49E-04	0.053773
5	*Aristolochia indica*	6.84E-05	0.039647
6	*Cayratia trifolia* (L.) Domin	0.003259	0.16345
7	*Cayratia trifolia* (L.) Domin	6.84E-05	0.039647
8	*Celastrus paniculatus*	0.005954	0.197683
9	*Chonemorpha fragrans* (Moon) Alston.	0.000781	0.099994
10	*Clerodendrum viscosum* Vent	0.009765	0.228713
11	*Dioscorea prazeri* Prain & Burkill	0.014043	0.252746
12	*Entada rheedii* Spreng	3.14E-04	0.071455
13	*Glycosmis pentaphylla* (Retz.) DC.	6.84E-05	0.039647
14	*Leea indica* (Burm. f.) Merr.	0.001228	0.117427
15	*Lygodium microphyllum* (Cav.) R.Br	0.002783	0.155212
16	*Mikania micrantha* H.B.K.	7.60E-06	0.016243
17	*Morinda citrifolia* L.	8.93E-05	0.044049
18	*Mucuna pruriens* (L.) DC.	0.003772	0.171358

19	*Parthenocissus semicordata* (Wall.) Planch.	0.001228	0.117427
20	*Phlogacanthus thyrsiflorus* Nees	3.88E-06	0.012265
21	*Piper locnchites* Roem. & Sch.	2.46E-03	0.148999
22	*Piper sylvaticum* Roxb.	3.30E-03	0.164182
23	*Smilax ovalifolia* Roxb. ex D.Don	0.004532	0.181654
24	*Solanum torvum* Sm	7.60E-06	0.016243
25	*Spatholobus parviflorus* (DC.)Kuntze	2.61E-04	0.066606
26	*Stephania glabra* (Roxb.) Miers	0.000149	0.053773
27	*Tabernaemontana alternifolia* L.	0.000314	0.071455
28	*Tetrastigma serrulatum* (Roxb.) Planch	0.000261	0.066606
29	*Trachelospermum lucidum* (D.Don) K.Schum	0.001228	0.117427
	Total	0.060244	3.00321

Simpson index = 0.060244, i.e., concentration of dominance of shrub species

Shanon-weiner index = 3.00321, i.e., measure of shrub species diversity

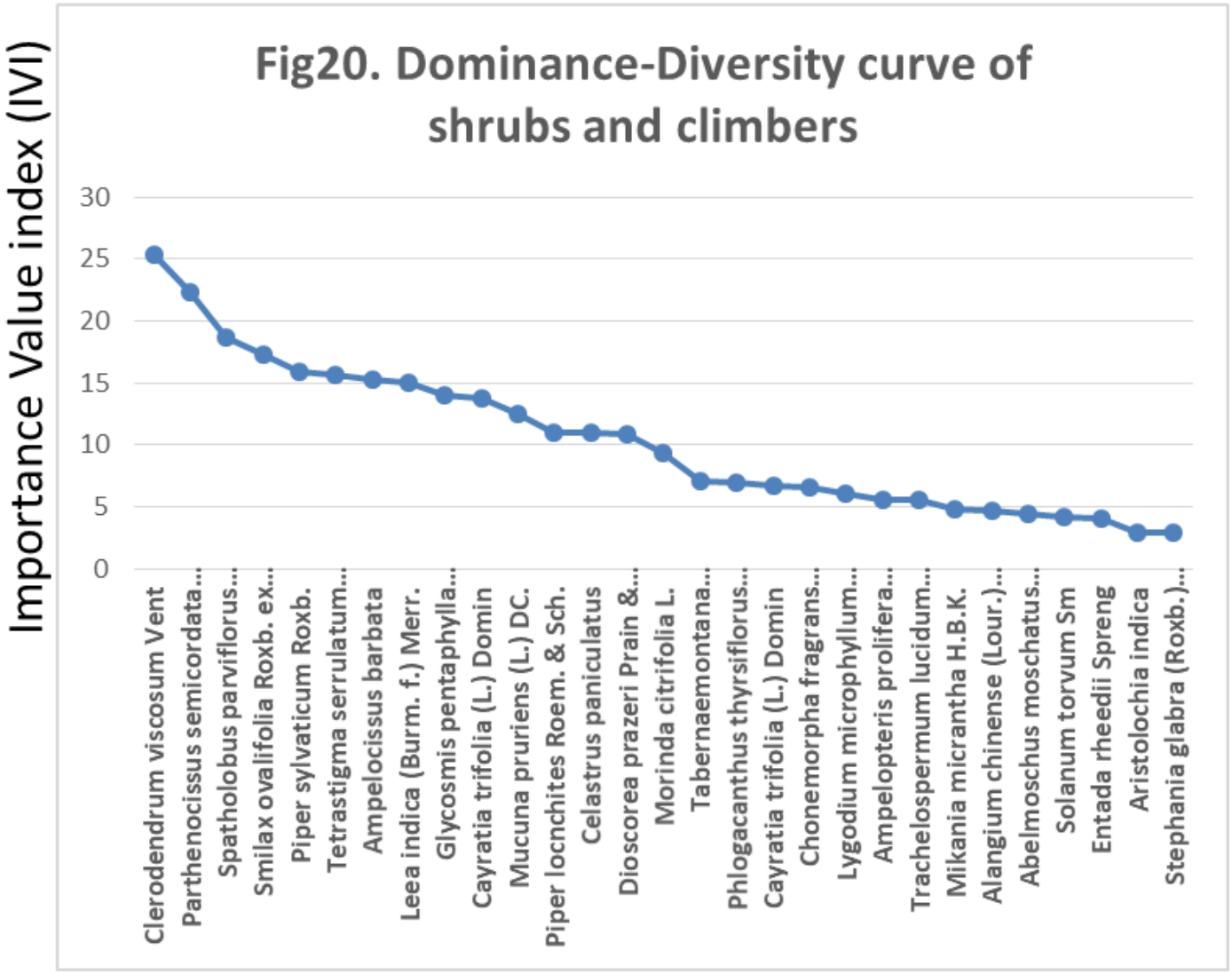


Fig20. Dominance-Diversity curve of shrubs and climbers
Importance Value index (IVI)
30
25
20
15
10
5
0
Clerodendrum viscosum Vent
Parthenocissus semicordata...
Spatholobus parviflorus...
Smilax ovalifolia Roxb. ex...
Piper sylvaticum Roxb.
Tetrastigma serrulatum...
Ampelocissus barbata
Leea indica (Burm. f.) Merr.
Glycosmis pentaphylla...
Cayratia trifolia (L.) Domin
Mucuna pruriens (L.) DC.
Piper locnchites Roem. & Sch.
Celastrus paniculatus
Dioscorea prazeri Prain &...
Morinda citrifolia L.
Tabernaemontana...
Phlogacanthus thyrsiflorus...
Cayratia trifolia (L.) Domin
Chonemorpha fragrans...
Lygodium microphyllum...
Ampelopteris prolifera...
Trachelospermum lucidum...
Mikania micrantha H.B.K.
Alangium chinense (Lour.)...
Abelmoschus moschatus...
Solanum torvum Sm
Entada rheedii Spreng
Aristolochia indica
Stephania glabra (Roxb.)...

Table10 . 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*		Rd	Rf	Ra	IVI
1	*Achyranthes aspera* L.	0.33	1.5625	1.724138	3.229054	6.515692
2	*Alpinia calcarata* (Andrews) Roscoe	0.18	0.852273	0.804598	3.774219	5.431089
3	*Anisomeles indica* (L.) Kuntze	0.17	0.804924	1.149425	2.495178	4.449528
4	*Boehmeria macrophylla* Hornem var. macrophylla	0.43	2.035985	4.022989	1.803238	7.862211
5	*Bridelia stipularis* (L.) Blume	0.67	3.172348	2.643678	4.275625	10.09165
6	*Chloranthus elatior* R. Br.	0.53	2.50947	2.758621	3.241285	8.509376
7	*Christella dentata* (Forsk.) Brownsey & Jermy	0.33	1.5625	3.908046	1.424583	6.895129
8	*Combretum wallichii* var. *flagrocarpum* (C.B.Clarke) M.G	0.13	0.61553	0.574713	3.816155	5.006398
9	*Costus speciosus* (J.Koenig) Sm.	0.05	0.236742	0.229885	3.66938	4.136007
10	*Curculigo aromatica* Salisb.	0.17	0.804924	1.494253	1.919368	4.218545
11	*Curcuma aromatica* Salisb.	0.3	1.420455	2.873563	1.761302	6.05532
12	*Cyperus pangorei* Rottb.	0.87	4.119318	6.091954	2.409328	12.6206
13	*Dendrocnide sinuata* (Blume) Chew	1.2	5.681818	5.172414	3.914005	14.76824
14	*Desmodium gyrens* (L.) DC.	0.97	4.592803	7.471264	2.190337	14.2544
15	*Dictyospermum montanum*	1.11	5.255682	9.54023	1.962897	16.75881

	Wight					
16	*Diplazium esculentum* (Retz.) Sw.	1.97	9.327652	5.172414	6.425491	20.92556
17	*Elatostema platyphyllum* Wedd.	0.87	4.119318	4.022989	3.648412	11.79072
18	*Eragrostis gangetica* (Roxb.) Steud	0.22	1.041667	1.149425	3.229054	5.420146
19	*Eranthemum pulchellum* Andrews	3.01	14.25189	7.241379	7.012592	28.50587
20	*Gomphostemma lucidum* Wall. ex Benth.	2.3	10.89015	4.597701	8.439573	23.92743
21	*Mikania micrantha* H.B.K.	0.02	0.094697	0.114943	2.935504	3.145143
22	*Phlogacanthus thyrsiflorus*	1.13	5.350379	5.172414	3.685688	14.20848
23	*Piper peepuloides* Roxb.	1.53	7.244318	5.172414	4.990356	17.40709
24	*Polygonum chinense* L.	1.4	6.628788	9.885057	2.389363	18.90321
25	*Sabia paniculata Edgw.* Ex Hook f. & Thomson	0.16	0.757576	0.574713	4.696806	6.029094
26	*Setaria pamifolia* (J Koeign.) Stapf.	0.45	2.130682	2.068966	3.66938	7.869027
27	*Thunbergia grandiflora* (Roxb. ex Rttl.) Roxb.	0.45	2.130682	3.793103	2.00148	7.925265
28	*Urtica dioica* L.	0.17	0.804924	0.574713	4.990356	6.369993
	Total	**21.12**	**100**	**100**	**100**	**300**

Table11 . 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	*Achyranthes aspera* L.	0.000244	0.064983
2	*Alpinia calcarata* (Andrews) Roscoe	7.26E-05	0.040611
3	*Anisomeles indica* (L.) Kuntze	6.48E-05	0.038815
4	*Boehmeria macrophylla* Hornem var. *macrophylla*	0.000415	0.079285
5	*Bridelia stipularis* (L.) Blume	0.001006	0.109468
6	*Chloranthus elatior* R. Br.	0.00063	0.092476
7	*Christella dentata* (Forsk.) Brownsey & Jermy	0.000244	0.064983
8	*Combretum wallichii var. flagrocarpum* (C.B.Clarke) M.G	3.79E-05	0.031333
9	*Costus speciosus* (J.Koenig) Sm.	5.60E-06	0.014313
10	*Curculigo aromatica* Salisb.	6.48E-05	0.038815
11	*Curcuma aromatica* Salisb.	0.000202	0.060429
12	*Cyperus pangorei* Rottb.	0.001697	0.131385
13	*Dendrocnide sinuata* (Blume) Chew	0.003228	0.162949
14	*Desmodium gyrens* (L.) DC.	0.002109	0.14149
15	*Dictyospermum montanum*	0.002762	0.154825

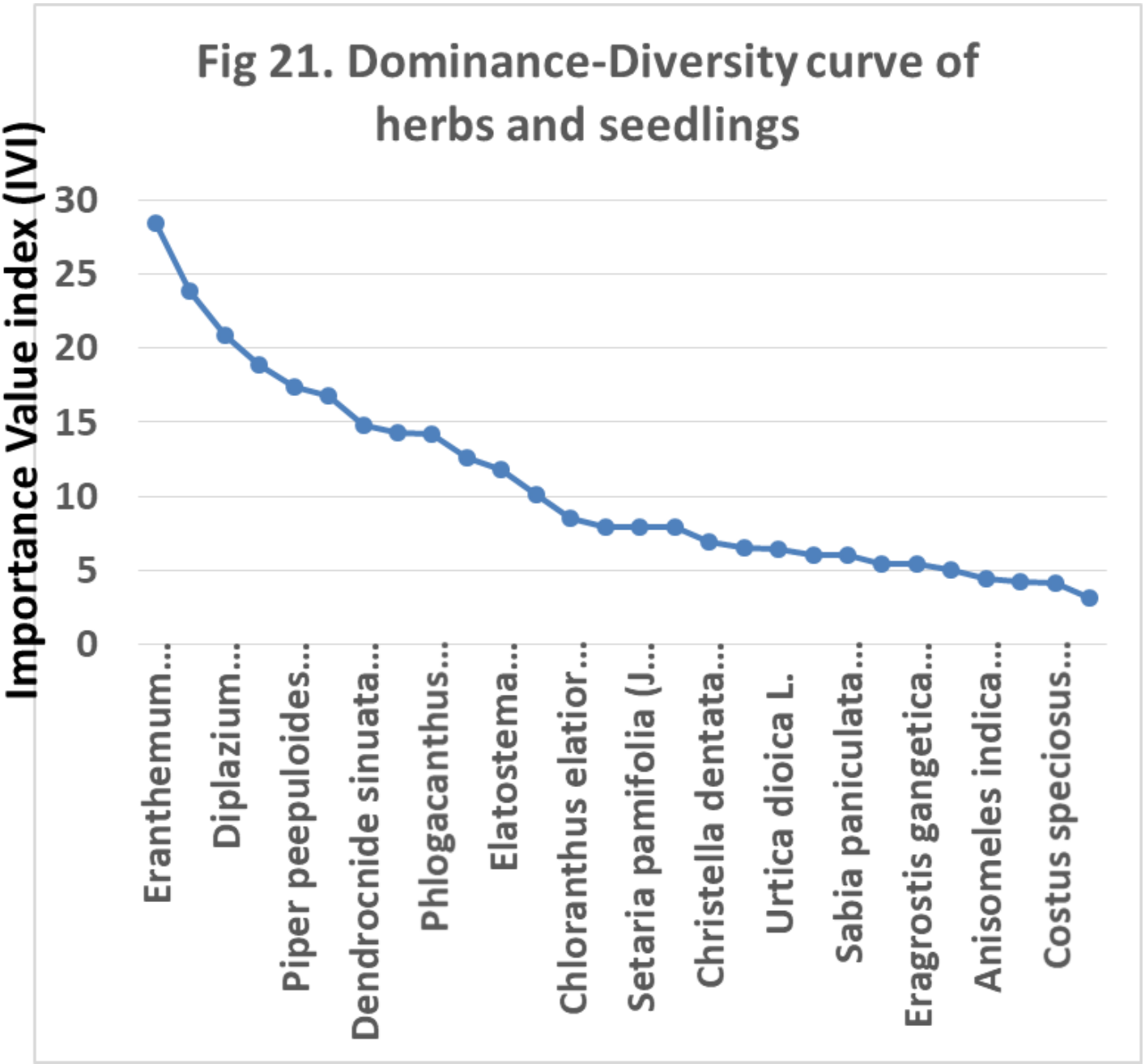
	Wight		
16	*Diplazium esculentum* (Retz.) Sw.	0.008701	0.221269
17	*Elatostema platyphyllum* Wedd.	0.001697	0.131385
18	*Eragrostis gangetica* (Roxb.) Steud	0.000109	0.047545
19	*Eranthemum pulchellum* Andrews	0.020312	0.277667
20	*Gomphostemma lucidum* Wall. ex Benth.	0.01186	0.241469
21	*Mikania micrantha* H.B.K.	8.97E-07	0.006593
22	*Phlogacanthus thyrsiflorus*	0.002863	0.156659
23	*Piper peepuloides* Roxb.	0.005248	0.19016
24	*Polygonum chinense* L.	0.004394	0.179889
25	*Sabia paniculata* Edgw. Ex Hook f. & Thomson	5.74E-05	0.036991
26	*Setaria pamifolia* (J Koeign.) Stapf.	0.000454	0.082004
27	*Thunbergia grandiflora* (Roxb. ex Rttl.) Roxb.	0.000454	0.082004
28	*Urtica dioica* L.	6.48E-05	0.038815
	Total	0.068896	2.918509

Simpson index = 0.068896 i.e., concentration of dominance of herbs and seedlings

Shanon-weiner index = 2.918509 i.e., measure of herb species and seedlings diversity

Table 12 . 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)	Species diversity
Trees	0.129966	0.870034	7.69432	2.296954
Shrub & Climber	0.060244	0.939756	16.59916	3.00321
Herbs	0.068896	0.931104	14.51463	2.918509



Threatened plants

Table 13. An account of plant species that are categorised as 'Threatened plants' and conservation conceren species recorded in Bichabhanga MPCA.

	Name of the species	Family	Local Names	Status
1	*Alpinia calcarata*	Zingiberaceae	Purundi	Endangered
2	*Ampelocissus barbata*	Vitaceae	Bon angur	Endangered
3	*Aristolochia indica*	Aristolochiaceae	Eswaramooli	Vulnerable
4	*Celastrus paniculatus*	Celastraceae	Kijri. Malkangani	Endangered
5	*Cinnamomum bejolghota*	Lauraceae	Ramtejpat, Sin kaule	Vulnerable
6	*Dioscorea prazeri*	Dioscoreaceae	Bon Alu	Endangered
7	*Gynocardia odorata*	Achariaceae	Gante; Chaulmoogra	Endangered
8	*Helminthostachys zeylanica*	Ophioglossaceae	Kamraj	Endangered
9	*Machilus glaucescens*	Lauraceae	Kawla	Critically Endangered
10	*Mesua ferrea*	Caryophyllaceae	Nageshwar	Endangered
11	*Morinda citrifolia*	Rubiaceae	Nani	Vulnerable
12	*Pericampylus glaucus*	Menispermaceae	Baral-prati	Vulnerable
13	*Pterocarpus marsupium*	Fabaceae	Piyasal,	Endangered
14	*Stereospermum colais*	Bignoniaceae	Parul	Vulnerable
15	*Abelmoschus moschatus Medik*	Malvaceae	Harin Kasturi	Near Threatened

Table 14 :Medicinal uses of important plants recorded in Rachela MPCA

Name of the species	Family	Local Name	Parts Used	Uses
Alpinia calcarata	Zingiberaceae	Purundi	Rhizome	Bronchitis, Cough and respiratory ailments, asthma
Ampelocissus barbata	Vitaceae	Bon angur	Whole plant	Plant extracts can be used for the development of anti-thrombotic agents for the healing of related cardiovascular diseases; as an antivenom/antiophidic agent
Aristolochia indica	Aristolochiaceae	Eswaramooli	Root	Skin disease; Snake-bite and other toxic effect of all poisons.
Celastrus paniculatus	Celastraceae	Kijri. Malkangani	Seeds	Used to alleviate cognitive issues and promote intestinal health
Cinnamomum bejolghota	Lauraceae	Ramtejpat, Sin kaule	Bark	Antifungal, anticancer
Dioscorea prazeri	Dioscoreaceae	Bon Alu	Tubers	Tubers are used in leprosy, burns, fungal diseases, rheumatisma and as contraceptive,
Gynocardia odorata	Achariaceae	Gante; Chaulmoogra	Seeds oil	several skin conditions and diseases; Oil was prescribed for leprosy
Helminthostachys zeylanica	Ophioglossaceae	Kamraj	Rhizome	Treatment of inflammation; also used as herbal tonic.
Machilus glaucescens	Lauraceae	Kawla	Fruits	Edible as fresh fruits; for curing various gastro-intestinal ailments;
Mesua ferrea	Caryophyllaceae	Nageshwar	Seeds and flowers	Used in rheumatism, asthma, inflammation, fever, dyspepsia, renal diseases, dysentery, bleeding piles, a bacterial and fungal infection.

Morinda citrifolia	Rubiaceae	Nani	Root, leaf, fruit	Cathartic, febrifuge, asthama.
Pericampylus glaucus	Menispermaceae	Baral-prati	Leaves and Roots	Fever, cough, pulmonary disease, asthma, fractures, boils and tumours; Roots used as antidote
Pterocarpus marsupium	Fabaceae	Piyasal,	Gum, leaves	Kino gum collected from barks uses as astringent, anti-diarrhoeal, and anti-haemorrhagic properties; leaves used externally to treat boils, sores, and other skin diseases, while flowers are febrifuge.
Stereospermum colais	Bignoniaceae	Parul	Root barks	Root bark used in Ayurvedic "Dashmula" preparation used as tonic, diuretic; roots anti-inflammatory, anti-asthmatic, antiemetic and febrifuge,; biliary and stimulant of cardiotonic, diuretic and used in piles and nervous disorders;
Abelmoschus moschatus	Malvaceae	Harin Kasturi	Seeds and leaves	aromatic seeds of this plant are aphrodisiac, ophthalmic, cardio tonic, antispasmodic and used in the treatment of intestinal complaints

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 Bichabhanga MPCAs are proving to be a gene pool of medicinal plants of the state especially 14 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 coordination of field offices.

Table15: 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

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Annexure I

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

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 IV

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 collected during the field survey

Grid wise Herbs at Bichabhanga MPCA under Jalpaiguri Research Range, Silviculture (N), Siliguri Report of Phase-IV (April to June, 2015)

Grid No.	Quadrat No./Small No.	Sl. No.	Name	Scientific Name	Number
7	Q1/A				
		1	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	6
	Q1/B	1	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	2
		2	Ban Halud	Curcuma aromatica salisb.	-
		3	Anantamul	Hemidesmus indicus R. Br.	21
		4	Dioscoria	Dioscorea bulbifera L.	-
	Q1/C	1	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	3
		2	Ban Halud	Curcuma aromatica salisb.	-
		3			
		4			
	Q1/D	1	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	2
		2	Pipli	Piper peepuloides Roxb.	3
		3			
		4			
		5			
	Q1/E	1	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	2
		2	Antamul	Ichnocarpus frutescens (L.) R. Br.	4
		3	Ban Halud	Curcuma aromatica salisb.	-

Grid No.	Big Quadrat No./Small No.	Sl. No.	Name	Scientific Name	Number
7	Q2/A	1	Pipli	Piper peepuloides Roxb.	3
		2	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	7
		3	Antamul	Ichnocarpus frutescens (L.) R. Br.	3
	Q2/B	1	Pipli	Piper peepuloides Roxb.	10
		2	Antamul	Ichnocarpus frutescens (L.) R. Br.	3
		3	Cheptigrass	Oplismenus burmanii (Retz.) P. Beauv.	2

	Q2/C	1	Ban halud	Curculigo aromatica Salisb.	-
		2	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	3
		3	Antamul	Ichnocarpus frutescens (L.) R. Br.	3
		4	Pipli	Piper peepuloides Roxb.	4
	Q2/D	1	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	3
	Q2/E	1	Ban Halud	Curculigo aromatica Salisb.	-
		2	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	2
		3	Antamul	Ichnocarpus frutescens (L.) R. Br.	3
		4	Pipli	Piper peepuloides Roxb.	5

Grid No.	Big Quadrat No./Small No.	Sl. No.	Name	Scientific Name	Number
7	Q3/A	1	Pipli	Piper peepuloides Roxb.	3
	Q3/B	1	Pipli	Piper peepuloides Roxb.	4
	Q3/C	1	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	2
		2	Antamul	Ichnocarpus frutescens (L.) R. Br.	5
		3	Arari	Caesalpinia cucullata Roxb.	-
		4	Pipli	Piper peepuloides Roxb.	3
		5	Micanialata	Mikania scandens (L.) Willd.	2
	Q3/D	1	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	2
		2	Antamul	Ichnocarpus frutescens (L.) R. Br.	3
	Q3/E	1	Pipli	Piper peepuloides Roxb.	5
		2	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	-

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Grid No.	Big Quadrat No./Small No.	Sl. No.	Name	Scientific Name	Number
7	Q4/A	1	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	2
		2	Pipli	Piper peepuloides Roxb.	2
	Q4/B	1	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	3

		2	Pipli	Piper peepuloides Roxb.	8
	Q4/C	1	Pipli	Piper peepuloides Roxb.	8
		2	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	2
	Q4/D	1	Pipli	Piper peepuloides Roxb.	3
		2	Banspata	Setaria pamifolia (J Koeign.) Stapf.	3
	Q4/E	1	Pipli	Piper peepuloides Roxb.	3
		2	Antamul	Ichnocarpus frutescens (L.) R. Br.	3
		3	Chepti	Oplismenus burmanii (Retz.) P. Beauv.	-

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

Plate 1: Images of Bichabhanga Medicinal Plants Conservation Area in Lata Guri, Gorumara N.P.

Plate 2: Images of Bichabhanga Medicinal Plants Conservation Area (MPCA)

Plate 3: Images of various habitats in the Bichabhanga Medicinal Plants Conservation Area (MPCA) showing a perennial stream and keystone species like *Ficus hispida*.

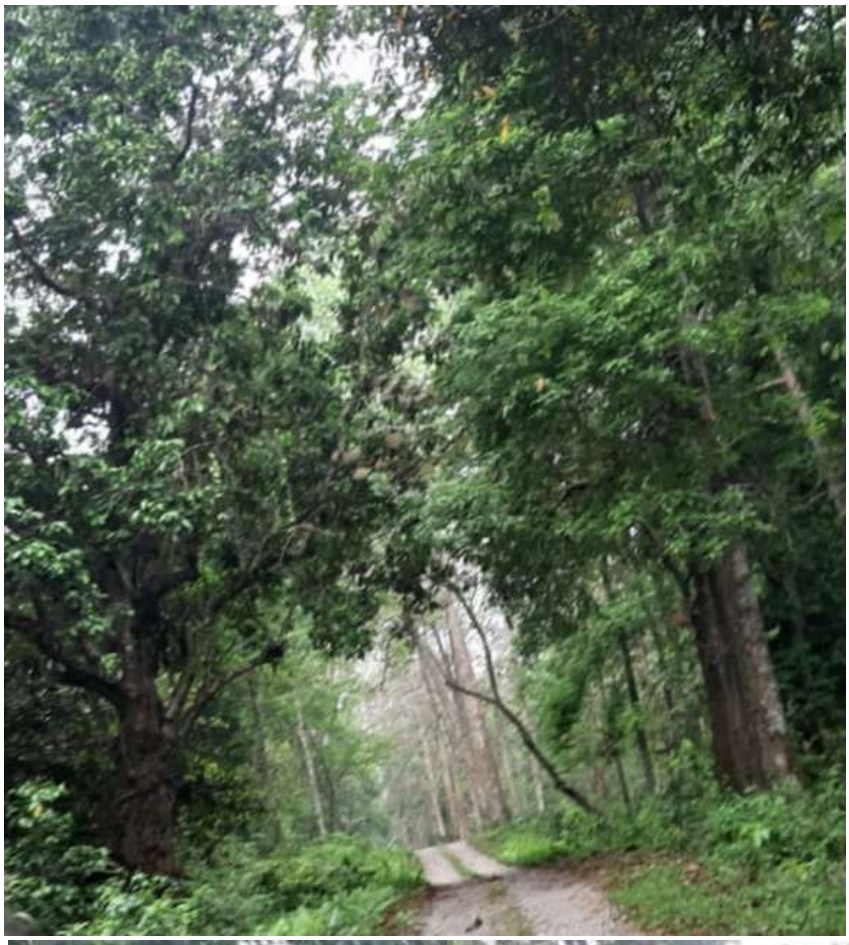

Plate 4: Images of *Gynocardia odorata* (Chalmoogra), one of the Endangered (EN) Medicinal Plants recorded in the Bichabhanga MPCA

Plate 5: Image of a matured tree of *Gynocardia odorata* (Chalmoogra), with profusely fruiting bole.

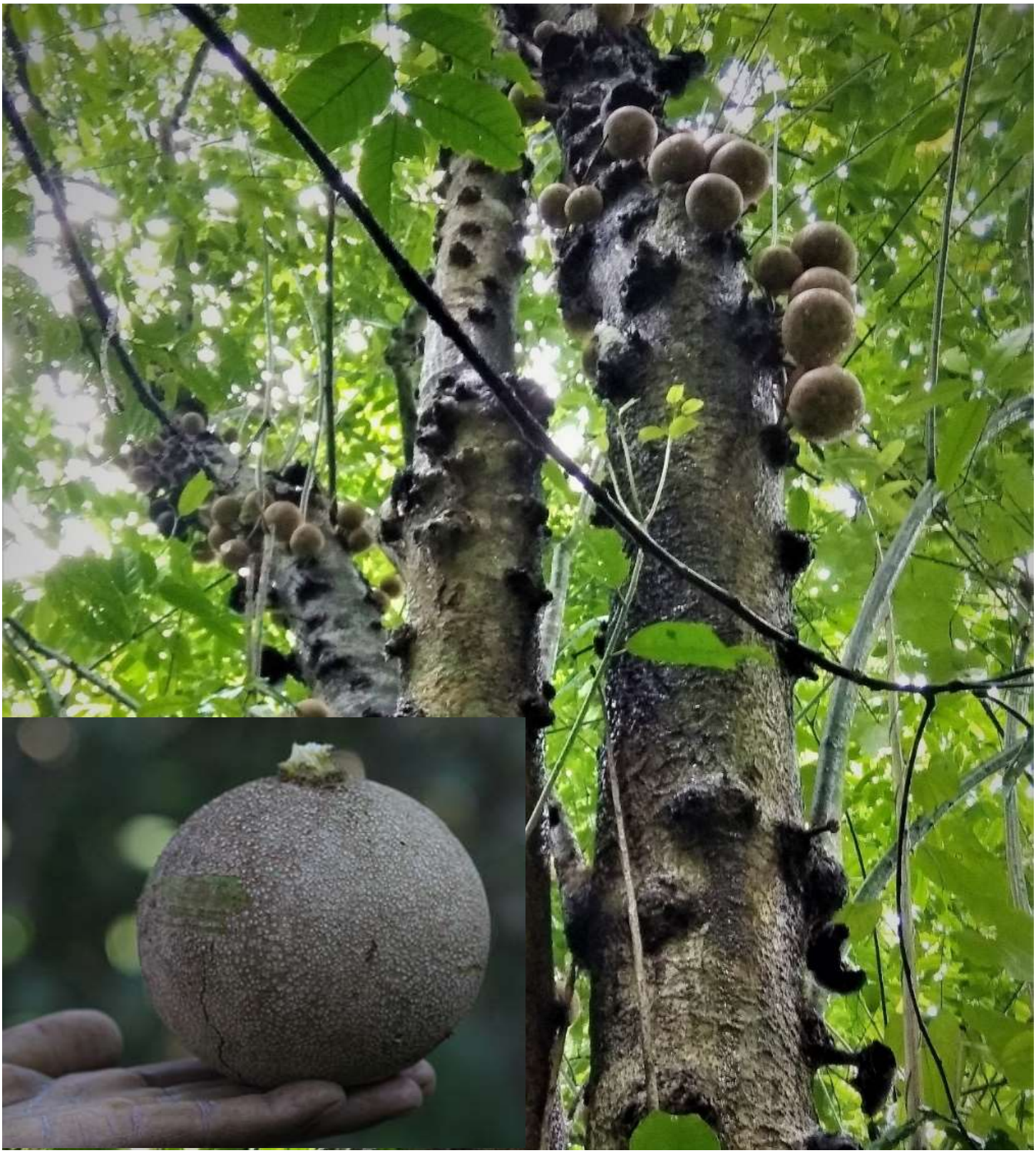

Plate 6: Images of *Morinda citrifolia* one of the threatened Medicinal Plants of the MPCA






Plate 7: Images of *Stereospermum colais* one of the threatened Medicinal Plants of the MPCA

Plate 8: Images of *Aphanamixis polystachyar* **an important Medicinal Plants in the MPCA**

Plate 9: Images of *Cinnamomum bejolghota* **an important Medicinal Plants in the MPCA**

Plate 10: Image of *Cinnamomum bejolghota* **tree recorded during the survey**

Plate11: Image of vegetation survey to estimate the population status of important medicinal plants

Plate 12: Image of vegetation survey to estimate the population status of important medicinal