ASSESSMENT OF SELECTED THREATENED ETHNOMEDICINAL PLANTS OF MANIPUR WITH SPECIAL REFERENCE TO ENVIRONMENTAL FACTORS

A THESIS SUBMITTED TO THE NAGALAND UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY IN BOTANY

By

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Registration No. Ph.D. 680/2015 dated 27/05/2015

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This is to certify that the thesis entitled **"Assessment of selected threatened ethno-medicinal plants of Manipur with special reference to environmental factors**" submitted to Nagaland University, Lumami in partial fulfillment for the award of the degree of Doctor of Philosophy in Botany is an original research work carried out by Hirom Dolendro Singh, bearing Registration No. Ph.D. 680 / 2015 dated 27/ 05/ 2015 under our supervision.

Further, it is certified that no part of the thesis has been submitted anywhere for any other research degree to the best of our knowledge.

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DECLARATION

I, Hirom Dolendro Singh, bearing Registration No. Ph.D. 680 / 2015 dated 27/ 05/ 2015 hereby, declare that the subject matter of my thesis entitled: **"Assessment of selected threatened ethno-medicinal plants of Manipur with special reference to environmental factors"** is the record of work done by me and the contents of this thesis did not form the basis for award of any degree to me or to anybody else to the best of my knowledge. The thesis has not been submitted to any other University / Institute. Also, it is declared that content of the thesis is free from plagiarism.

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List of Abbreviations

BRT	Boosted Regression Tree
CR	Critically Endangered
Ca	About
CAMP	Conservation Assessment and Management Prioritization
cm	Centimeter
cm^2	Centimeter square
COVID-19	Corona Virus Disease
DATA	Design and Technology Association
DD	Data Deficient
DIP	Directorate of Information and Publicity
E	East
Ed.	Edition
e.g.	exempli grata (for example)
EN	Endangered
ENM	Ecological Niche Modeling
et al.	Etallia (and others)
etc.	Etcetra
EX	Extinct
EW	Extinct in the Wild
Fig.	Figure
F.S.I.	Floor Space Index
g	Gram (s)
GAM	Generalized Additive Models

GBM	Gradient Boosting Machine
GIS	Geographic Information System
GLMs	Generalized Linear Models
I	Intermediate
IBR	Indo-Burma hotspot region
i.e.	That is
ISM	Indian System of Medicine
IUCN	International Union for the conservation of Nature and Natural Resources
Kg	Kilogram
Km	Kilometer
Km^2	Square Kilometer
L	Lower Risk
LC	Least Concern
m	Meter
m^2	Square meter
MAXENT	Maximum Entropy
mm	Millimeter
MSL	Mean Sea level
MUMP	Manipur University Museum of Plants
N	North
NE	Not Evaluated
No.	Number
NRSA	National Remote Sensing Agency

NT	Near Threatened
O	Out of danger
Pp	page
RDB	Red Data Books
RLC	Red List Category
RSF	Resource Selection Functions
SDM	Species Distribution Model
Sps.	Species
VU	Vulnerable
WHO	World Health Organization
Wt.	Weight
@	At the rate
%	Percent
^{0}C	Degree Celsius
&	and
/	minute
//	second

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CHAPTER- IV

CHAPTER- 1

INTRODUCTION AND OBJECTIVES

1.1 GENERAL INTRODUCTION

The conservation of Biodiversity includes scientific, social, and political challenges (Pelletier *et al.,* 2018). The diversity of ethno-medicinal plants and its rampant exploitation and habitat destruction make the need to undertake conservation programs, prioritization and assessment of threat status is the need of the hour and the most suitable strategy (Gowthami *et al.,* 2021). The increasing human population and anthropogenic activities, species extinction rate has increased to hundred or thousand-fold compared to background extinctions, bringing to forefront the 'sixth mass extinction' crisis (Shivanna, 2020).

The International Union for the conservation of Nature and Natural Resources (IUCN) is the accepted authority for international concern on the loss or extinction of species. IUCN'S original Red Data Book i.e., IUCN, 1966, is now revised annually and called IUCN Red List (Walter and Gillet, 1988 and IUCN 1995, 1998a, 1998b, 2000, 2001, 2003, 2008, 2010a, 2010b, 2012 a, 2012 b, 2013) which becomes electronic in recent time. The updated (IUCN Guidelines Version 13, March 2017) clearly defined nine categories into which every taxon in the world (excluding micro-organisms) can be classified. They are (1) Extinct (EX) (2) Extinct in the Wild (EW) (3) Critically Endangered (CR) (4) Endangered (EN) (5) Vulnerable (VU) (6) Near Threatened (NT) (7) Least Concern (LC) (8) Data Deficient (DD) (9) Not Evaluated (NE). Taxa in all of the IUCN Red List Categories

except LC and NE are referred to as “Red- listed” and the three categories of CR, EN and VU are assigned under Threatened category.

IUCN has estimated that globally about 40,468 species are under varying degrees of threat. Several published papers reported that 123 plants are extinct, 37 are extinct in wild and species under threatened categories, Critically Endangered (3,325), Endangered (6,063), Vulnerable (7,072) to extinction due to various reasons like habitat destruction, population loss, reproductive incompatibility and over exploitation (IUCN, 2020). India has reported species of about 18,532 vascular plants, in which 2,142 species are red, listed which is 11.53% of the total species. Out of these 8 are extinct, 432 species are threatened (CR, EN and VU) and nearly 54 species are grouped under near threatened (IUCN 2020).

It is estimated that around 7500 species of organisms are becoming extinct every year and many of them disappear before it is known by the scientific name (Myers *et al*., 2000). According to 1996 IUCN Red list, there are 33,730 threatened Plants, among them, 395 are extinct; 394 are in the category of extinct/endangered; 6019 are endangered; 7,913 are vulnerable; 14,913 are vulnerable and 4,241 are indeterminate.

India is one of the 12 mega diversity countries of the world and occupies 2.4% of world’s area with 8% of global biodiversity (Myers *et al.,* 2000, Bapat *et al.,* 2008). There are 4 (four) biodiversity hotspots (Himalayas, Indo-Burma, Sundaland and Western Ghats) in India out of the 35 global biodiversity hotspots (Jaisankar *et al.,* 2018). The existence of 15 agro-climatic zones with varied ecological habitats blessed the country with huge Phyto-diversity in India.

Red Data Books published in three volumes (Nayar and Sastry, 1987- 90) enlist 622 species of rare and endangered species elaborating the present distribution, identified threats, conservation measures taken or recommended. Kala 2000, studied the distribution pattern, population structure and conservation status of 23 rare and endangered medicinal plants in Indian trans Himalaya region. Also, Kala, 2005 reported 60 threatened medicinal plant species of which 22% are critically endangered, 16% were endangered and 27% were vulnerable in seven protected areas in the Indian Himalayas. The Red Data Book of India, 1989 estimated that of the total 0.3 million species of plants in the world, over 20,000 were either in the category of either endangered or vulnerable and threatened with extinction by the year 2020.

1.2 NORTH-EAST INDIA

The North- East India is blessed with a wide range of physiographic and eco-climatic conditions and geographical gateway for much of India's endemic flora as well as fauna. This is a zone of active speciation and hence accounts for high degree of endemism (Murthi and Joseph, 1984). It occupies 7.7 % of India's total geographical area supporting 50% of the flora (ca 8000 species), (Rao, 1994), of which 31.58% (ca 2526 species) is endemic (Nayar, 1996). It is a transitional zone between India, Indo-Burma-Malaysian and Indo-china region. The North East India supports a large number of endemics, rare and threatened species including orchids (Jain and Rao, 1983; Nayar and Sastry, 1987, 1988, 1990; Nayar, 1996).

North-Eastern region of India harbours more than 130 major tribal communities of the total 427 tribal communities found in India. North East India has a rich tradition of ethno-pharmacological practices, with its abundant flora and fauna and

diverse communities (Chakraborty et al., 2012). Already, 1500 or 10% of the flowering plants, 856 species of angiosperms and 146 species of mammals, birds and animals have entered the endangered list of the Indian bio-diversity (Khoshoo, 1990).

1.3 ETHNO-MEDICINAL PLANTS

From ancient period medicinal plants have been used in all cultures as a source of medicine and its use as herbal medicine is described in numerous ancient texts. Besides being a major source of raw material for the traditional healthcare practices (Ayurveda, Siddha, Unani, Homeopathy, Naturopathy, Sowa-Rigpa and diverse area- and community-specific folk medicine) and pharmaceutical industry. It also provides livelihood to a large Indian population (Kumar *et al.*, 2015). Indigenous and traditional systems of medicine using plants have shown potential (direct or indirect as immune boosters) against many dreaded ailments including the recent global pandemic of COVID-19.

Conservation of threatened species of medicinal plants is needed for the sustainable development of the society. Medicinal plants species are integral parts of traditional medicine systems worldwide. Traditional medicine is the substance of all the traditional viewpoints on sickness and the healing methods applied against disease which exists among the people (Yoder, 1972). Ethno-medicine-guided medicinal plants species research opened up a new vista in understanding bioactivity, as well as the isolation of many bioactive compounds. However, the domain of knowledge of ethno-medicinal plants still remains fragmented and is rapidly disappearing because of the lack of appropriate attention (Ningthoujam *et al*., 2014). Some medicinal plants species are Threatened because of their demand

and are categorized according to the status of the plants at the present situation of a particular area.

There are many other opinions on cultural, religious and communal point of view but the traditional medicine systems practiced by the *Maibas* (Male practitioner) and *Maibis* (Female practitioner) till today is a continuous process in the *Meitei* community. The traditional medicine systems of the herbal medicine practitioners can be seen from various schools of thoughts as evidenced by the old *Puyas* (Old books) of *Meitei* community.

Since times immemorial the inhabitants of Manipur have a unique history of using medicinal plants species for the treatment of various primary health ailments. As many as 1200 species are reported as medicinal plants (Sinha, 1996) and the local medicinal uses of about 130 species have also been recorded. Whereas, several of these species are facing threat of extinction on account of their narrow distribution, endemicity, degradation of their micro habitat, indiscriminate and unsustainable harvesting.

With the rapid jhuming cultivation and economic development of Manipur state, the demand for forest raw materials has increased tremendously which adversely affect the biodiversity of forest. Moreover, mass overexploitation of medicinal plants without proper collection methods also leads to the loss of medicinal plants from the wild. It is high time to share the traditional knowledge of medicinal plants with the scientific community, so as to make refinement of the scientific knowledge, to interact the multidisciplinary approach of ethno-medicine and environmental approach and conservation of the medicinal plant's species. It is imperative to find the status, depletion, threats to medicinal plants and study the

parameters to come up with better steps for the conservation and sustainable utilization of these medicinal plants.

1.4 SPECIES DISTRIBUTION MODEL

Many geographic applications have been developed in recent years that offer exciting new possibilities for understanding biological diversity (Scott *et al.,* 2002). Geographic Information System (GIS) make it possible to build maps of species richness and endemism, to prioritize areas for conservation based on principle such as complementarities, and to access the completeness of existing protected areas network (Peterson and Cohoon, 1999). The Species Distribution Model (SDM) as we see today emerged when the statistical methods from field-based habitats studies were linked with GIS-based environmental layers). Moreover, research that has highlighted on the individuals' responses of species to their environment (MacArthur, 1972; Whittaker *et al.,* 1973) provided the strong conceptual argument for modeling individual species rather than communities. Modern quantitative modeling and mapping of species distributions emerged when two parallel streams of research activity converged. On the one hand field-based ecological studies of species- habitat associations, at first reliant largely on linear multiple regression and discriminate function analyses (Capen, 1981; Stauffer, 2002), benefitted from new regression methods that provided coherent treatments for the error distributions of presence-absence and abundance data. Generalized Linear Models (GLMs) enabled pioneering regression-based SDMs that has much more sophistication and realism then was possible earlier (Austin *et al.,* 1990).

The key structural features of GLMs (non-normal error distributions, additive terms, non-linear fitted functions) continue to be useful and are part of many

current methods including resource selection functions/RSF (Manly *et al.,* 2002) Maximum Entropy Models/MAXENT (Phillips *et al.,* 2006).

At the same time, rapid methodological advances in physical geography provided new data and information systems. New data allowed robust and detailed preparation of digital models of the Earth's surface elevation, interpolation of climatic parameters, and remote sensing of surface conditions in both marine and terrestrial environments. These greatly enhanced, SDM capabilities by providing estimates of environmental conditions across entire landscapes, including retrospection at surveyed areas. Many works have been done on Ecological Niche but very few species have been studied in detail in terms of their dynamic response to environmental change, and static distribution often remains the only approach for studying the possible consequences of a changing environment on species distribution (Woodward and Cramer, 1996).

Ecological Niche Modelling (ENM) Environmental/Ecological niche Modelling (ENM), also known as 'Species Distribution Model' (SDM), Predictive Habitat Distribution Model and Climate Envelope Model' refers to the process of using computer algorithms to predict the distribution of species in geographic space on the basis of a mathematical representation of their known distribution in environmental space (realized ecological niche). Ecological niche modelling is based on the 'Hutchinsonian Niche Concept' who defined Niche as Hyper volume (or dimensional) space of resources (e.g., light, nutrients, structure, etc.) available to specifically used by organisms.

The Hutchinsonian niche views niche as an n-dimensional hyper volume, where the dimensions are environmental conditions and the resources that define the

requirements of an individual or a species to practice ‘its’ way of life. The niche concept was popularized by the Zoologist G. Evelyn Hutchinson in 1957.

An organism free of interference from other species could use the full range of conditions (biotic and abiotic) and resources in which it could survive and reproduce which is called its fundamental niche. However, as a result of Ecological niche pressure from interactions with other organisms (i.e. inter-specific competition) species are usually forced to occupy a niche that is narrower than this, and to which they are mostly highly adapted, this is termed as the realized niche.

The environment is in most cases represented by climate data (such as temperature, and precipitation), but other variables such as soil type, water depth, and land cover can also be used. These models allow for interpolating between a limited number of species occurrence and they are used in several research areas in conservation biology, ecology and evolution.

The fundamental ecological niche of a species is a critical determinant of its distribution; as such, it is define as multidimensional ecological space (MacArthur, 1972), Hutchinson (1959) provided the valuable distinction between the fundamental niche, which is the range of theoretical possibilities, and the realized niche (that part which is actually occupied, given interactions with other species such as competition).

In ecology, a niche is a term describing the relational position of a species or population in its ecosystem to each other; a shorthand definition of niche is how an organism makes a living. Thus, Ecological niche is a term for the position of a species within an ecosystem, describing both the range of conditions necessary for persistence of the species, and its ecological role in the ecosystem.

It is useful, however, to distinguish three main approaches to the niche. The first approach emphasizes environmental conditions necessary for a species presence and maintenance of its population, the second approach stresses the functional role of species within ecosystems, and the third one a dynamic position of species within a local community, shaped by species' biotic and abiotic requirements and by coexistence with other species.

The niche concept was popularized by Hutchinson (1957). An organism free of interference from other species could use the full range of conditions (biotic and abiotic) and resources in which it could survive and reproduce which is called its fundamental niche. However, as a result of Ecological niche Pressure from, and interactions with, other organisms (i.e. inter-specific competition) species are usually forced to occupy a niche that is narrower than this, and to which they are mostly highly adapted. This is termed the realized niche. Environmental niche modeling can be considered as a part of the discipline of biodiversity informatics.

Recent developments in geographic information systems and their application to conservation biology open doors to exciting new synthetic analyses. Exploration of these possibilities, however, is limited by the quality of information available. Most biodiversity data are incomplete and characterized by biased sampling. Inferential procedures that provide robust and reliable predictions of species geographic distributions thus become critical to biodiversity analyses. In this contribution, models of species ecological niches are developed using an artificial intelligence algorithm, and projected into geography to predict species distributions. Predictive species distribution models are empirical models relating field observations to environmental variables based on statistically or theoretically derived response surfaces.

The most common strategy for estimating the potential geographic distribution of a species is to characterize the environmental conditions that are suitable for that species. The spatial distribution of environments that are suitable for a species can then be estimated across a given study region. A wide variety of techniques have been developed for this purpose, including generalized linear models, generalized additive models, bioclimatic envelopes, habitat suitability indices, and the genetic algorithm for rule-set prediction (GARP). Holistic researches in exploring applications and aspects, spanning biological realms and scientific disciplines and bringing out more understanding on its application, scope and its pros and cons can open ample scope for planning species specific conservation strategies.

Considering the present status and importance of threatened medicinal plants of Manipur, the present research work aims at the following objectives given below. It will definitely be beneficial especially for young researchers to strategize conservation, policy makers in developing strategies for efficient conservation/cultivation to ensure availability of these precious resources for utilization by future generations.

1.5 OBJECTIVES OF THE STUDY

1) Survey, collection and identification for the occurrence of ethno-medicinal plants found in Manipur.

2) Documentation of medicinal uses of the ethno-medicinal plants found in Manipur.

3) Assessment of the IUCN threat status of the collected ethno-medicinal plants found in Manipur, Northeast, India.

4) Prediction of Species distribution Model (SDM) of some selected threatened Ethno-medicinal plants recorded will be analyzed in the present study.

CHAPTER-II

REVIEW OF LITERATURES

2.1 STUDIES ON THREATENED MEDICINAL PLANTS OF INDIA

Around 34,000 (8%) plant species of the world's flora are threatened with extinction (Walter and Gillett, 1998) and of the India's 15000 endemic flowering plants, about 3000 species are threatened (Jain, 2000). Since time immemorial the Himalaya and Northeast India has always been home of essential medicinal plants for native practitioners, plant explores and 'Vaidyas' (Samant *et al*., 1998). During the last 3 decades anthropogenic activities, forest fires and over exploitation have led to the decrease of medicinal plants from the wild (Dhar *et al.*, 2000; Semwal *et al*., 2007). Huge demands of herbal raw materials from the pharmacological industry have aggravated the depletion of medicinal plant species in the wild (Kala,1998).

In the Indian System of Medicine (ISM) about 400 medicinal plant species are used by the pharmaceutical industry for production of standard medicine, several of these species have been evaluated as vulnerable, endangered and threatened due to over-exploitation, deforestation and extensive loss of habitats in the wild (Chakrabarti and Varshney, 2001; Kala and Sajwan, 2007). Moreover, several anthropogenic factors like over-exploitation of plants, urbanization, regular forest fire, uncontrolled grazing and the pollution stress, there is noticeable decline in the population of several medicinal plants rendering them as rare and threatened (Jain, 2000).

The threats to the medicinal plants are due to anthropogenic activities along with the small population size, narrow distribution range, habitat specificity, land-use disturbances, improper collection methods, impact of alien species, climate changes, habitat loss and alteration, genetic drift and population bottle neck (Weekely and Race, 2001; Vergeer *et al.,* 2003; Oostermeijer *et al.,* 2003). Moreover, natural adversaries such as herbivores, seed predators and pathogens could extensively reduce the richness of medicinal plant species in any particular regions of the study.

The degree of threat for the plant species have also been specified following the different categories of rare plants as recognized by the IUCN (Melville, 1971). According to 1996 IUCN Red list, there are 33,730 threatened plants, among them, 395 are extinct; 394 are in the category of extinct/endangered; 6019 are endangered; 7,913 are vulnerable; 14,913 are vulnerable and 4,241 are indeterminate. Today we are losing at least one higher plant species per day from tropical forest alone (Mayers *et al.,* 2000).

In 1969 the 11th technical meeting of IUCN, the issues regarding threatened plants of India were first discussed. Later in 1980's the Botanical Survey of India (BSI) initiated work on rare and endangered species and published a checklist of RET species. In 1983, Jain and Rao published a list of medicinal plants across the country. Subsequently, the series of Red Data Books (RDB) of Indian Plants was published by BSI (Nayar and Sastry, 1987, 1988, 1990), focuses exclusively on the flora of India, more precisely on threatened angiosperms, gymnosperms and pteridophytes. It has been shown that about 1236 (7%) of the 17500 plants recorded for the Indian subcontinent are threatened globally (Walter and Gillett,1998). The Red Data Book however, contains only 814 species (Nayar and Sastry, 1987).

2.2 HISTORY OF IUCN RED LISTS

IUCN Plant Red Data Book was published in 1978, which provide details on the conservation status of 250 plant species (IUCN, 1997). The Red Data classifications used by International Union for Conservation of Nature and Natural resources (IUCN) to indicate the degree of threat to individual species were: Extinct, Endangered, Vulnerable, Rare, Indeterminate, out of danger and insufficiently known.

The IUCN Special Survival Commission Steering Committee in 1989 initiated to develop a more quantitative and objective approach that provided the conservation community with a convenient procedure for evaluating the threat of extinction of plant species. There was a noticeable change from qualitative to quantitative system with the publication of IUCN Red List Categories and Criteria 1994 (Version 2.3) (IUCN, 1994, 2001). The system was again re- examined and alterations in the categories and criteria were adapted during 1997 and 2000 (IUCN, 2001). The categories adopted were Extinct, Critically Endangered, Endangered, Vulnerable, Near Threatened, Data Deficient, Least Concern and Not Evaluated (Gardenfors, 2001).

The IUCN Categories and Criteria (IUCN, 1994, 2001) consider five different aspects of a taxon's life history traits, distribution trends and information on population. A taxon qualifies any of the nine IUCN Red List Categories like Extinct, Extinct in Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern, Data Deficient, Not Evaluated (IUCN, 2001), if it encounters any one of the five listed threat criteria (A, B, C, D and E). These are then used to determine the potential threat extinction to that specific taxon (IUCN,

2001). These threat categories are assigned by any one or more of the five criteria represented as Criteria A, B, C, D and E. The criteria A-D gives warning indications and criteria E states noticeable extinct risk levels with specified time frames.

At present the IUCN Red List of threatened species is accepted as one of the best convincing sources of information on the worldwide conservation status of animals and plants (Rodriguez *et a*l., 2006; De Grammot and Cuaron,2006).

2.3 IUCN RED LIST AT REGIONAL LEVEL

The IUCN Red List Categories and Criteria 1994 and 2001 were planned for the assessment of extinction threat of the species at the global level. However, need was felt to evaluate the population status at regional and local level because it is at the level where the anthropogenic activities and biodiversity strike (Pimm *et al*., 2001). Besides, the National administration can also play a significant part in conservation of species (Rodriguez *et al*.,2000).

By using the IUCN Criteria 1994 and 2001 to the population existing within a specific area, i.e., any sub-global topographical region, e.g., a continent or nation is also unrealistic and would unusually divides the living inhabitants into minor, further limited subpopulation. As the small and isolated population face a greater risk of extinction than large and wide spread population (Lande, 1993). The artificially parted sub-populations may be evaluated separately as having a greater threat of extinction than they actually face (Miller *et al*.,2007).

Regional application employed group was appointed in 1998 by the IUCN Special Survival Commission (SSC) after the agreement of a resolution on the matter at the first World Congress in Montreal to solve the problem of inappropriate

regional assessment (Gardenfors, 2001). IUCN Regional guidelines (2003) were established which implement the standard criteria for use at the regional level by taking into account the result of the sub-populations existing outside an area on the possibility of sub-populations extinction present within the region (Gardenfors *et al*., 1999; Gardenfors, 2000; IUCN, 2003). These Guidelines recommended that the regional assessments should be carried out in two steps.

At regional level three more regional categories were proposed, in addition to the 9 global categories. Thus, at regional level 11 categories were adopted which are Extinct, Extinct in Wild, Regionally Extinct, Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern, Data Deficient, Not Evaluated and Not Applicable (IUCN, 2003).

The regional or national threat lists play an important role in updating worldwide conservation efforts, particularly when the information that they include is assimilated into the global IUCN Red List (Cuaron, 1993; Rodriguez *et al*., 2000). At the regional level the threatened taxa find the strongest legal protection and also the national threat assessment can act as early threatening signs of local population reduction and consequently, sufficient protection of a specific taxon at the national level by several countries could, hypothetically, delay or prevent the species extinction globally (Miller *et al*., 2007).

The regional threat assessments are indispensable to provide the baseline data for local and regional conservation agencies to incorporate into their management and conservation programmes. Regional Red Lists would provide a more objective assessment of the threats which a taxon is facing at either regional or national level (Gardenfors, 2001). Further, the regional or national threat lists are

helpful in determination of different threat levels and the insertion of these threat levels into the National Conservation Planning (Master, 1991; Mace, 1995). Due to this background, several studies had been carried out all over the globe, where in different species have been evaluated for their conservation status in a specific region or country.

In India, the Conservation Assessment and Management Prioritization (CAMP) workshop held during 1995, 1996, 1997 and 1999 at Bangalore to evaluate the threat status of prioritized medicinal plant species of Kerala. A list of 86 medicinal plant species were categorized the Red List status of Near Threatened or above. Out of the 86 plant species assessed, 50 plant species have a global status as these are endemic to the Kerala and 21 of these Red List medicinal plant species had been known in high volume trade (Ved and Goraya,2010).

Medicinal plants species were evaluated for rarity in the Conservation Assessment and Management Prioritization (CAMP) workshop held at Kulu Himachal Pradesh in 1998 and the investigation revealed different threat categories of plant species (Ved and Tandon, 1998).

2.4 WORK DONE ON THREATENED PLANTS IN MANIPUR

India has a total area of about 75 million ha constituting about 23 % of the land area and Manipur state has an area of 15 million ha during the year 1980-81. North East India has a rich tradition of ethno-pharmacological practices, with its abundant flora and fauna and diverse communities (Chakraborty *et al*., 2012). The floristic composition of Manipur falls in the Indo-Burma hotspot region (IBR) i.e., Indo-Burma global biodiversity hotspot (Myers *et al*., 2000). Manipur has been influenced by both Indian and South East Asian culture.

The first ever floristic work on plants of Manipur was carried out by Clarke (1889) in 'Plants of Kohima and Munneypore' and recorded 248 species under 57 families of Dicotyledonous plants. In Hooker (1872-97) 'Flora of British India' on the basis of collection by Clarke in (1889) from Manipur many species occurrence was given from Manipur. Watt (1890) also mentioned the collection of economic plants from Manipur. Deb (1961a, b) published 'Dicotyledonous and Monocotyledons plants of Manipur territory'. Singh *et al.* (2002) published the flora of Manipur Vol 1. Several others floristic works on districts have also been done on Flora of Tengnoupal (Singh, 1987); Flora of Tamenglong (Singh, 1990). Recently, some others floristic woks on family level had also been done on Rattans (Devi, 2004); Verbenaceae (Devi, 2006), Pteridophytes (Devi, 2008); Liamaceae (Devi, 2010); Acanthaceae (Ningombam, 2012) and Araceae (Chakpam, 2018).

Several reports and publication on threatened ethno-medicinal plants was also done by Singh and Singh, (2009) where he reported 14 endangered species of medicinal importance available in Northeast India from Manipur. In the "Checklist of threatened plants of India" by Nayar and Sastry (1987-88) recorded 15 species from Manipur. Mao and Gogoi (2016) also reported 333 species belonging to 236 genera and 119 families from Dzukou valley which includes several threatened plants and endemic species.

Nayar & Sastry (1987 – 88) "Red Data Book plants of India" mentioned 15 species of threatened species form Manipur. In the Checklist of Rare, Endangered and Threatened plants of Manipur reported 27 species published by ENVIS Centre on Floral Diversity, Botanical Survey of India, Ministry of Environment and Forest, Government of India. Ved *et al.* (2018) conducted the CAMP (Conservation Assessment Management and Prioritization for medicinal plants of Manipur which

analyzed 43 medicinal species in which 3 were found critically endangered, 17 were endangered, 11 species were vulnerable, 7 were near threatened, 1 was Least concerned and 4 species were recorded as Data Deficient.

Singh *et al.,* 2017 also reported 18 threatened ethno medicinal plants found in Sub alpine areas of Ukhrul and Senapati districts of Manipur. Also, Singh *et al.* (2020) assessed the IUCN status of 52 threatened ethno medicinal plants where they reported vulnerable species 21 species, near threatened by 20 species, endangered by 9 species, least concern 1 species, critically endangered by 1 species.

The pressure on the wild population of the medicinal plants has increased manifold due to habitat destruction, forest fires and shifting cultivation along with the overexploitation from wild. These various major threats were the causes for depletion of medicinal plants in Manipur. The conservation and management of threatened species have become an important issue for the state.

2.5 ETHNO-MEDICINAL STUDIES OF MANIPUR

Traditional medicine is the substance of all the traditional viewpoints on sickness and the healing methods applied against disease which exists among the people (Yoder, 1972). The state is blessed with rich repositories of medicinal plants species and has age long intrinsic relationship between the ethnic communities residing in the state for the treatment of various primary health ailments. The traditional medicine systems of the herbal medicine practitioners can be seen from various schools of thoughts as evidenced by the old *Puyas* (Old books) of *Meitei* community.

The communities in the state used these medicinal plants for the treatment of various primary health care ailments. There have been many published reports in Manipur by several experts such as Sinha (1996) reported medicinal plants used by the communities in Manipur; Singh and Singh (2003) also reported medicinal plants used by the different communities in Manipur; Singh and Sundriyal (2003) about the traditional medicinal system of ethnic groups of Manipur.

Singh and Singh (2003) about ethno-medico plants of Meitei community; Khumbongmayum *et al*. (2005) about the ethno-medicinal plants in sacred grooves of Manipur; Ahmed and Singh (2007) about traditional medicinal knowledge of Muslim community used in Manipur; Salam *et al.* (2009) about medicinal plants of Tangkhul Naga tribe of Ukhrul district; Pfoze*et al*. (2011) about the wild edible plants of Senapati district; Salam *et al*.(2011) about ethno-medicinal plants of Tangkhul Naga tribe; Konsam and Choudhury (2012) about ethno-medicinal plants used by Kuki tribes; Lokho (2012) about the folk medicinal plants of Mao Naga tribe; Ningombam *et al*. (2014) about the ethno-medicinal plants of Meitei community; Devi *et al.* (2015) about the wild medicinal plants of hill districts of Manipur; Devi *etal*. (2016) about the plants used by the Mongsang tribe.

Singson *et al.* (2016) about the home remedial plants used by Thadou Kuki tribe; Yuhlung and Bhattacharyya (2016) about the indigenous medicinal plants used by Maring tribe of Manipur. Several publications of medicinal plants species use by different communities has been reported from Manipur, but very less work has been done on the status of these plants, conservation status and distribution etc. Although some ethno-botanical works had been taken up in Manipur (Srivastava and Adi Community, 2009; Khan and Yadava, 2010) extensive documentation is not available except for some effort (Sinha, 1996; Singh and Singh, 2003).

This region which is considered as Indo Burma Hot-spots is threatened due to several factors including the reduction in total forest area, over-exploitation, habitat fragmentation, forest fires, improper collection methods and Jhum cultivation. Moreover, natural phenomenon like soil erosion, climate change and exotic species have also aggravated the decline in the population. The illegal trade of medicinal plant species for decades has led to extensive population reduction, rendering them very rare and threatened.

Literature survey has revealed that some threatened medicinal plants species at National and International level has been work out, but with regards to Manipur state no comprehensive work has been done till date. Rapid jhum cultivation, economic development, demand for forest raw materials of the state has increased tremendously which adversely affect the biodiversity of forest. Considering, the above aspects, this research work is an attempt to study the habitat, present status, threats, uses of ethno-medicinal plants and also to analyse the parameters to come up with better steps for the conservation and species distribution model of these ethno medicinal plants.

2.6 MAXIMUM ENTROPY

Early approaches to ENM encompass species distributions within Geographic Information System (GIS) using simple geographic envelopes, convex hulls, and environmental matching (Nix, 1986). Many geographic applications have been developed in recent years that offer exciting new possibilities for understanding biological diversity (Scott *et al*., 2002). Geographic Information System (GIS) make it possible to build maps of species richness and endemism, to prioritize areas for conservation based on principle such as complementarities, and to access the

completeness of existing protected areas network (Peterson and Cohoon, 1999). The success of such programs and approaches however depends critically on the quality of distributional information available, which has proven to be a weak link in the process (Krohn, 1996).

The SDM as we see today emerged when the statistical methods from field-based habitats studies were linked with GIS-based environmental layers. In one of the earliest applications of this integrated approach (Ferrier *et al.*, 2002) applied Generalized Linear Model (GLMs, logistic regression) to predict the distribution of the Rufous Scrub-Bird using known locality records for the species, and remotely mapped and modelled environmental variables. Contemporary SDMs combine concepts from ecological and natural history traditions with more recent developments in statistics and information technology. However, the ecological roots of SDMs started in those early studies that described biological patterns in terms of their relationship with geographical and/or environmental gradients (Murray, 1866; Schimper, 1903; Grinnell, 1904). Moreover, research that has highlighted on the individuals' responses of species to their environment (MacArthur, 1972; Whittaker *et al.*, 1973) provided the strong conceptual argument for modelling individual species rather than communities. Modern quantitative modelling and mapping of species distributions emerged when two parallel streams of research activity converged.

Contrary, field-based ecological studies of species-habitat associations, at first reliant largely on linear multiple regression and discriminate function analyses (Capen, 1981; Stauffer, 2002), benefitted from new regression methods that provided coherent treatments for the error distributions of presence-absence and

abundance data. Generalized Linear Models (GLMs) enabled pioneering regression-based SDMs that has much more sophistication and realism than was possible earlier (Austin *et al*., 1990). The key structural features of GLMs (non-normal error distributions, additive terms, non-linear fitted functions) continue to be useful and are part of many current methods including resource selection functions /RSF (Manly *et al*., 2002); Maximum Entropy Models/MAXENT (Phillips *et al*., 2006).

At the same time, rapid methodological advances in physical geography provided new data and information systems. New data allowed robust and detailed preparation of digital models of the Earth's surface elevation, interpolation of climatic parameters, and remote sensing of surface conditions in both marine and terrestrial environments. These greatly enhanced, SDM capabilities by providing estimates of environmental conditions across entire landscapes, including retrospection at surveyed areas. Many works have been done on Ecological Niche but very few species have been studied in detail in terms of their dynamic response to environmental change, and static distribution often remains the only approach for studying the possible consequences of a changing environment on species distribution (Woodward and Cramer, 1996).

CHAPTER- III

MATERIALS AND METHODS

3.1. STUDYAREA

3.1.1 Study Area Profile

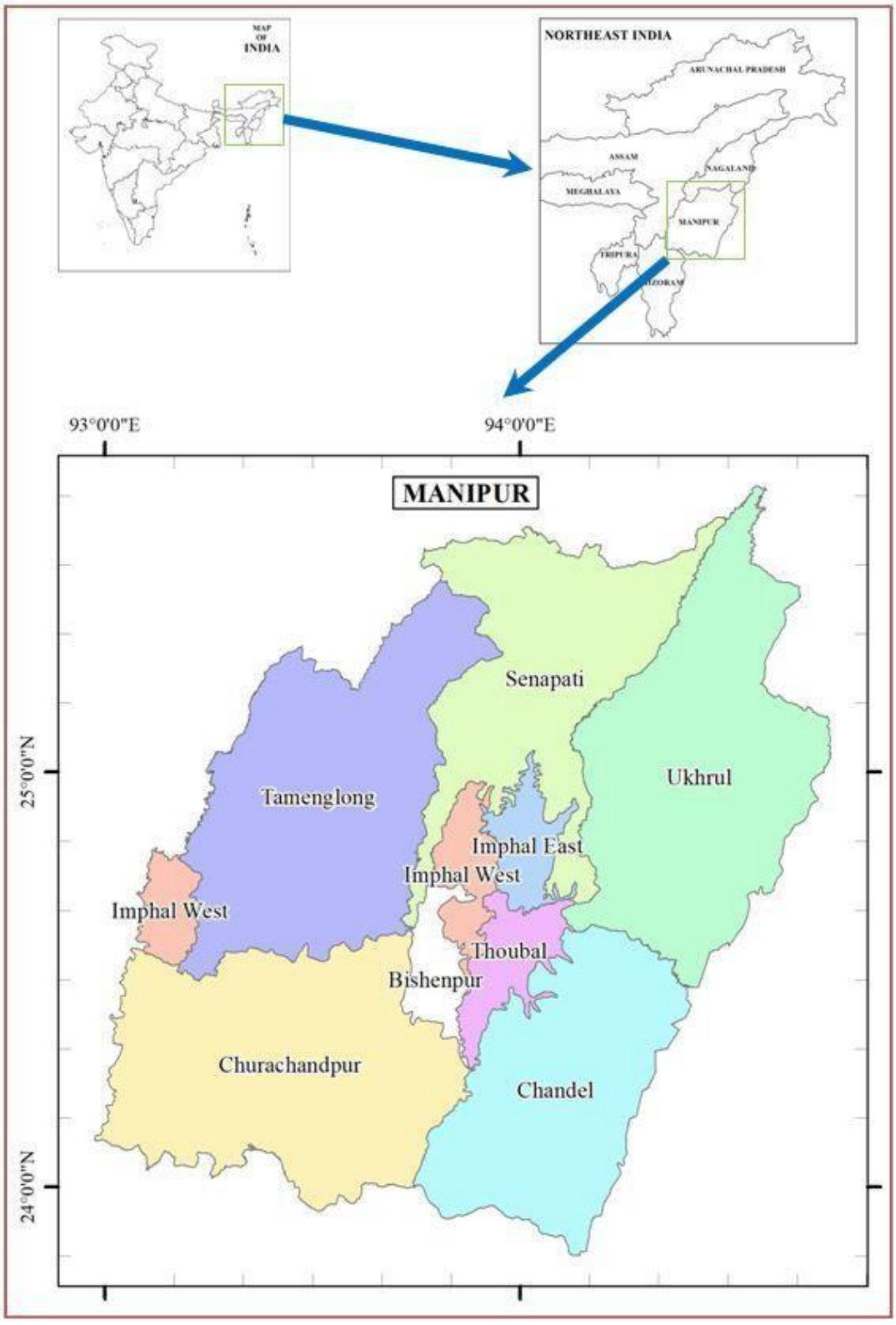
The state Manipur is one of the eight states of North-east state which comprises a genetic treasure house of many endemic flora and fauna having a rich biodiversity and is one of the distinctive parts of Himalayan region. The state lies between 23.83^0 to 25.68^0 N latitude and 93.03^0 to 94.78^0 E longitudes in the extreme North-eastern border of India. The total geographical area of Manipur is 22,327 Km^2 which is 0.07% of the India's landmass. It is surrounded by Nagaland on the north, Mizoram on south, Assam to its west, and shares an international border with Myanmar to its east.

The state of Manipur splits up naturally into two tracts viz, the hills and valley. The valley consists of four districts viz; (i) Imphal East (ii) Imphal West(iii) Thoubal and (iv) Bishnupur while the hill comprises of five districts namely (i) Ukhrul (ii) Chandel (iii) Tamenglong (iv) Senapati and (v) Churachandpur. All districts are divided into 30 sub-divisions and 165 village councils.

On 9^{th} December 2016, the state Government created 7 new districts, bringing the total number of districts upto 16 namely (i) Bishnupur (ii) Thoubal (iii) Imphal East (iv) Imphal West (v) Senapati (vi) Ukhrul (vii) Chandel (viii) Churchandpur (ix) Tamenglong (x) Jiribam (xi) Kangpokpi (Sadar Hills) (xii) Kakching (xiii)Tengnoupal (xiv) Kamjong (xv) Noney and (xvi) Pherzawl.

The 16 districts having 66 subdivisions. But in the present study, the earlier nine (9) districts of the state were taken as study area before the bifurcation of the new districts for convenience. Moreover, the administrative and political boundary of some the newly formed districts were yet to be finalized.

Manipur hills extends from the Tuensang hills in the north parallel to the south at about 24^0 N and eastern boundaries lies along the frontier between India and Myanmar and western boundary represented by the Cachar plains and hills. The hill ranges from side of the valley run practically to the same height a little over 2500 m and have flat rolling tops. Manipur central plains are a large basin and all sides are surrounded by high mountains. The South-east corner of this basin is occupied by a large lake called Loktak Lake which is the largest fresh water lake in the North-eastern India. The largest river of the state is Barak which rise from the Liyai and flows south-west for 180 km parallel to two ranges lying on either side, before turning its course first to north and then to the west through the Cachar plains of Assam.



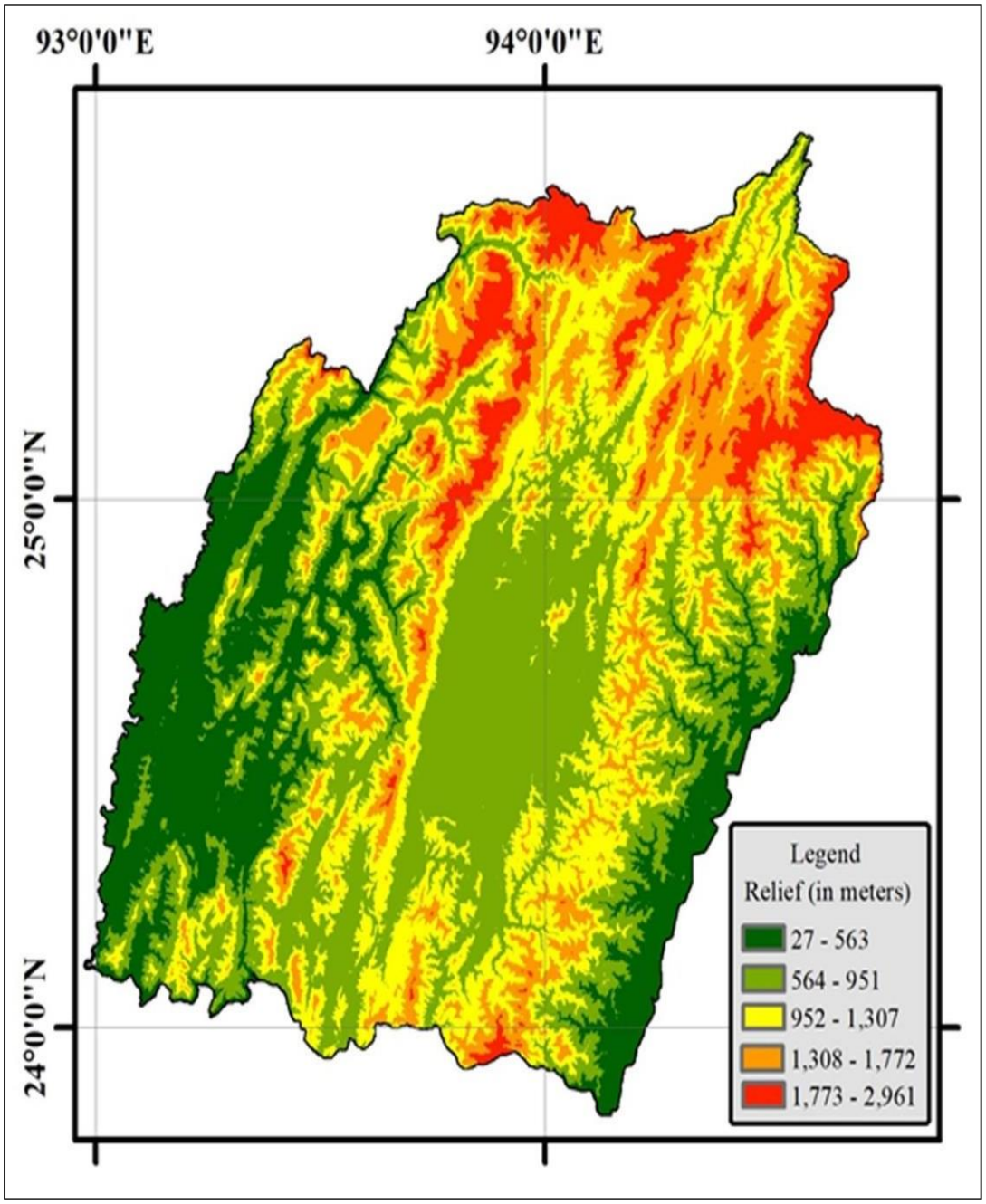
Source: *GIS, DIP, Remote Sensing Laboratory, Dept. of Earth Science, Manipur University*

Fig. 3.1: Map of Manipur showing study sites

3.1.2. Topography

The hill ranges of Manipur consisting of a series of parallel young folded ranges and formed as part of an extension of the eastern Himalayan Mountain range. These hill ranges are broadly divided into two groups i.e., the eastern hills and the western hills which lies in the east and the west of Imphal valley respectively. These two groups meet in the southern part of Manipur and extend southwards as the Mizo hills and the Chin Hills.

Eastern hills are more or less continuous and run along frontier between India and Myanmar. They are about 200 Km long and 30-50 Km wide. Mapithel, the Chingai, the Mulain, etc. are the important ranges of this group. The average height is 1,500 m, and important peaks include Khanjangbung (2833 m), Siroi (2567 m) and Kachaophung (2498 m). Limestone and shale mainly constitute the rocks of these hills. Western hills consist of parallel ranges and series of valleys. Total length from north to south is 180 Km. In the north they are about 50 Km width and in south more than 70 Km. Yangpujilong, the Mingthou, Koubru-Laima, Khoupum, the Nungba, the Kelenga, etc. are important hill ranges. Mount Tenipu (2994 m) north-west of Mao, Senapati district bordering with Nagaland state is the highest peak in the State. Other important peaks included in these hill ranges are Leikot (2831 m), Tampaba (2664 m) and Koubru (2652 m). Sandstone, shale and clay constitute the rocks in these ranges.



Source: *GIS, DIP, Remote Sensing Laboratory, Dept of Earth Science, Manipur University*

Fig. 3.2: Map showing relief map of Manipur

3.1.3. Climate

The climate of Manipur is sub-tropical monsoon. It is characterized by cold and dry winter and moderately warm summer. Manipur has four seasons namely, summer, rainy, autumn and winter in a year. Summer begins from March up to May. June to August is rainy season. During these days, highest rainfall of the year occurs and days remain the highest days of the year. Autumn starts from the month of September and lasts up to November. The days of December to February are the days of winter. January is the coldest month of the year. During summer the average temperature is 27^{o}Cwith the highest is 38^{o}C. In the winter season it is very cold and the temperature remains in between 5^{o} C to 20^{o} C. But in high altitude areas like Mao, Tengnoupal and Ukhrul sometimes temperature goes below than 5^{o}C.

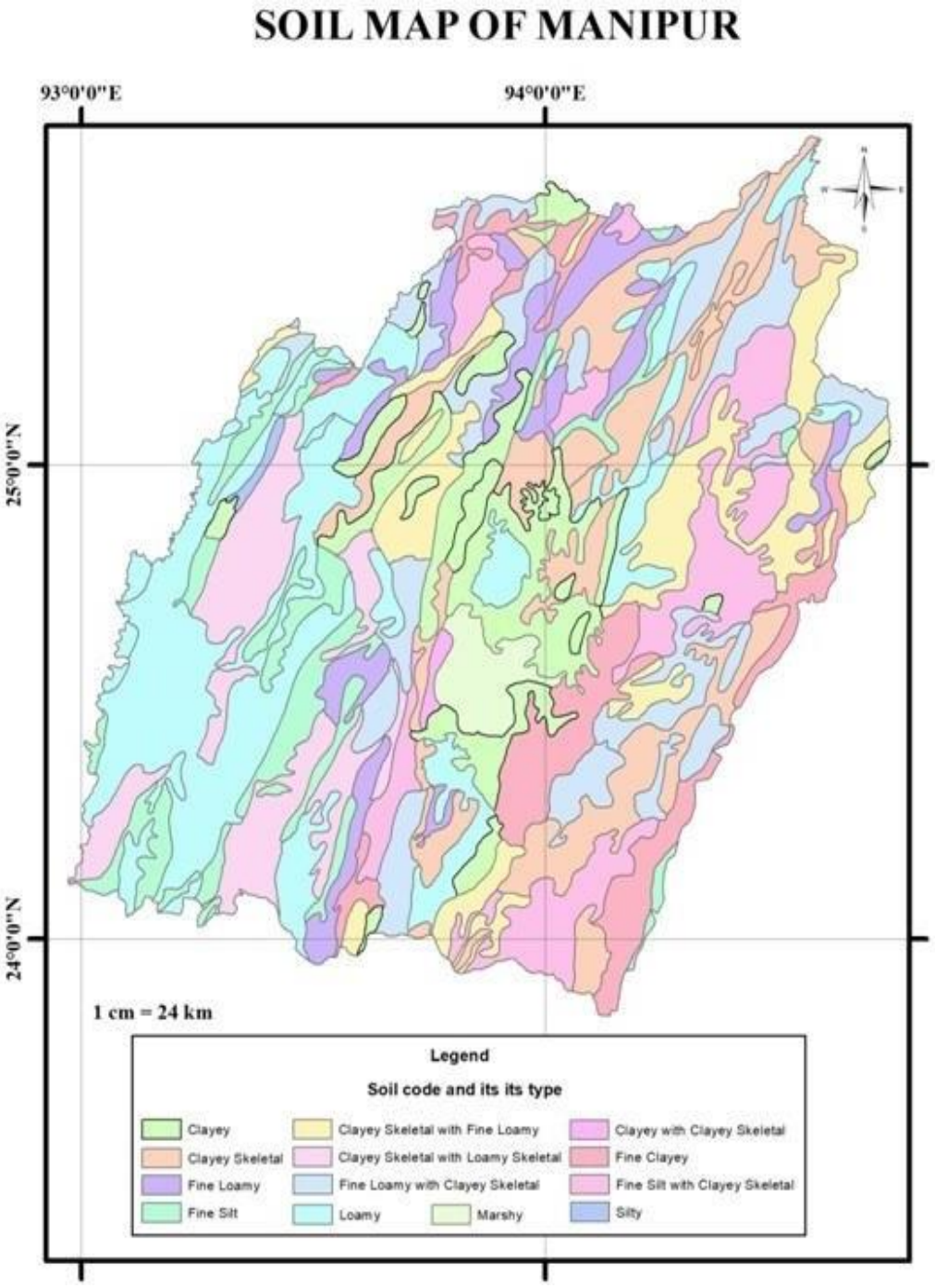
The rainy season starts from April and lingers until October. The precipitation suddenly increases from 4.32 cm in March to 10.15 cm in April, and it declined from 18.33 cm in October to 3.89 cm in November. June to August is the wettest part of the year, where the average rainfall ranges from 33.95 cm in June to 23.98 cm in August. December and January, the driest months of the year receives an average rainfall of 1.09 cm and 1.30 cm. When the south west monsoon dominates, the state receives 104.50 cm of rainfall, which account for about 64.65 percent of the total annual rainfall. The state has an average annual rainfall of 131cm.

3.1.4. Soil

The topography of the state is represented by undulating hills and mountains and valley. The vegetation varies from subtropical rain forest to coniferous, and there has been heavy rainfall with warm climatic condition, hence, the soil of

Manipur varies from place to place. The variation in the soil type is due to topography and their physical and chemical characteristics. Based from DATA from the GIS, DIP, Remote Sensing Laboratory, Dept. of Earth Science, Manipur University, the soils types found in Manipur are as follows:

1. Clayey
2. Clayey Skeletal
3. Clayey Skeletal with fine loamy
4. Clayey with Clayey Skeletal
5. Clayey with Loamy Skeletal
6. Fine Clayey
7. Fine Loamy
8. Fine Loamy with Clayey skeletal
9. Fine Silt with Clayey Skeletal
10. Fine Silt
11. Loamy and
12. Silty soils



Source: *GIS, DIP, Remote Sensing Laboratory, Dept. of Earth Science, Manipur University.*

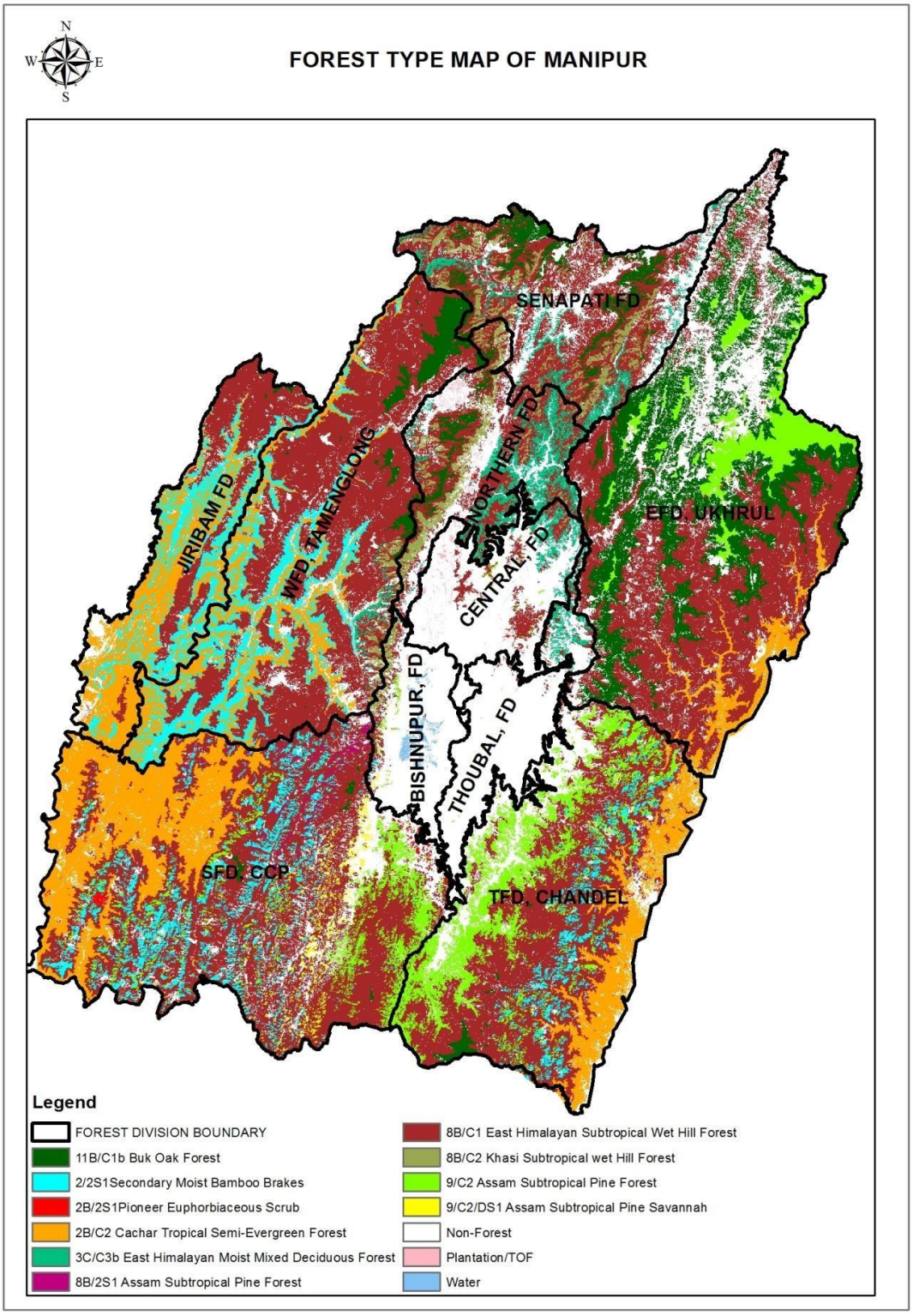
Fig. 3.3: Map showing the soil distribution of Manipur

3.1.5 Forest

Ward (1952) reported forest of Manipur as 'The forest of Manipur is of mild character containing plants that are found from the Himalayas to Malaya on the one hand and China on the other". The total area of forest in Manipur is 17,621.00 Km^2 according to F.S.I., 1995. The study area is divided into ten forest type of Manipur as per Champion and Seth (1968).

Table 3.1: Forest types of Manipur based on Champion and Seth, 1968

Forest type	Area in ha.
1. 2B/ C2 Cachar Tropical Semi- Evergreen Forests	274610.25
2. 2/ 2S1 Secondary Moist Bamboo Brakes	140626.56
3. 2B/ 2S1 Pioneer Euphorbiaceous Scrub	5182.19
4. 3/3C3b East Himalayan Moist mixed deciduous forest	52649.41
5. 8B/ C1 East Himalayan Sub-tropical wet Hill Forest	866035.74
6. 8B/ C2 Khasi Subtropical wet Hill Forest	39110.24
7. 9/ C2 Assam Subtropical pine forest	135389.72
8. 11B/ C1b Buk Oak Forest	175286.48
9. 9/ C2/ DS1 Assam Subtropical pine Savannah	7494.87
10. 8B/ 2S1 Assam Subtropical pine forest	3761.45



Source*: GIS and Remote Remote Sensing Lab, Forest Department, Govt. of Manipur.*

Fig. 3.4: Map Showing Forest type of Manipur

3.1.6. Demographic structure

Based on the traditions, customs, language, religions and cultural landscape the Manipur is inhibited by three major ethnic groups the Meitei in the valley and Naga and Kuki-chin tribes in the hills. Meitei pangals form a third community. People are predominantly Mongoloid, and speak Tibetan-Burmese languages. The *Meitei* language which is the mother tongue of the *Meitei* people is the lingua France of the state. English is the official languets and also the langue of doing business.

The major community Meitei groups resides in the valley along with few pockets with the Meitei pangals (Meitei muslim). The Scheduled tribes resides in the hill's districts of Manipur state. The Naga group consists of Zeliangrong which consists of Rongmei/Kabui, Liangmei, Zemei/Kacha Nagas, Tangkhul, Mao, Maram, Maring and Tarao. Anal, Kom, Thangal, Moyon and Monsang

The Chin-Kuki group consists of Gangte, Hmar, Paite, Thadou, Vaiphei, Zou, Aimol, Chiru, Koireng, Chothe, Lamgang, Koirao. In the Chin state of Myanmar, the 'Chins' are popular, they are called 'Kukis' in the Indian side. Other tribal groups like Paite, Zou, Gangte, and Vaiphei identify themselves as Zomi Group. Thadous people remain the major Kuki population in this Chin-Kuki group while Hmar with identity closer to the Mizo or Lushei group.

The Scheduled caste consists of *Yaithibi, Lois, Dhobi, Muchi* or *Robidas, Namsudra, Patni* and *Sutradhar* residing in few pockets of the state. The valley districts are inhabited mainly by *Meitei*'s, Manipuri Muslims and scheduled tribes which constitutes about 53.71% whereas the hilly districts are inhibited by the tribal's communities which constitutes about 8.32% of the total population of the state.

3.2. FIELD VISITS (PREPARATION OF THE INVENTORY, SPECIMEN COLLECTION, SAMPLING, POPULATION STRUCTURE AND HABITAT).

3.2.1. Inventory

Survey, sampling and documentation of traditional Knowledge of Extensive and intensive surveys were conducted during 2015 to 2020 throughout the whole state of Manipur for the occurrence of the threatened ethno- medicinal plants species based on literature-guided and earlier published reports. Field site data on geographical coordinates, soils, habitat, elevation, humidity, temperature, ecological peculiarities, forest types and threats were also recorded. Regarding plant data information regarding habitat, distribution, population, community association and others aspects were recorded as per (Simpson, 2006).

Ethno-medicinal documentation was conducted by visiting the herbal practitioners, traditional healers, birth attendant and elders using semi structured questionnaires at the field site or species occurrence area. Information regarding informant identity, local name, parts use and mode of administration, primary health ailments and ethno botanical uses were collected. Moreover, information regarding the mode of collection methods, threats, conservation aspects was also recorded. For authentication of the data the authors along with traditional healers visited the area for details study.

3.2.2. Methods of collecting plants

Documentation of plant taxa necessitates not only thoroughly recording data in the field about plant and its habitat but also procuring a physical specimen. The specimen is obtained by

1) Collecting the plant
2) Pressing and drying the plant.
3) Preparing a mounted herbarium specimen by gluing the plant and a label (listing the field data) to a sheet of standard herbarium paper. The specimen is deposited and maintained in herbarium in order to be accessible for future studies e.g., to verify its identity.

3.2.3. Sampling, population structure & habitat Field collection method

Field site data and plant data was recorded as per (Simpson, 2006). Locating specific plants may be chance or can involve prior checking of specific collection records (e.g. Herbarium sheet label information or relevant literature of Manipur) or pertinent maps to locate the likely location of a plant in a specialized habit. Once a plant of interest is located, collection is made considering its conservation status, vulnerability and care is taken so as any collecting should not endangered the local population. The photographs and unique characters were taken in their natural habitat to represent the plant properly for further references.

Table 3.2: A model of Plant collection data sheet prepared by (Simpson, 2006) with slight modification.

PLANT DATA

Coll. No: Photo No.

Collector (Primary):

Associated collector (s):

Taxon:

Ann./ Bien. /Per. Habit. Height. Branching:

Fl. Fr. Colours, others note:

Physical Habitat, Substrate:

Slope. Aspect. Exposure:

Community / Vegetation type:

I.d.by: Date: I.d. source:

Accession

Field Collection Data

Date of Collection: Time (Optional):

State/District/Sub-division/Place:

Specific locality information:

Latitude: Longitude:

Elevation:

Hill /Area

The authentic identification of the plants was done with the help of the available floristic literature such as Flora of British India vol.1-7 (Hooker,1872-1897); Flora of Assam, vol.1-5 (Kanjilal *et al*.,1934-1940); Flora of Manipur, vol. I (Singh *et al*., 2000); Deb (1961a, b) published 'Dicotyledonous and Monocotyledons plants of Manipur territory'. Several others on floristic works *Viz*., Flora of Tengnoupal (Singh, 1987); Flora of Tamenglong (Singh, 1990). Several, other floristics studies on Pteridophytes (Devi, 2008); Liamaceae (Devi 2010); and Araceae (Chakpam, 2018). The botanical names were updated using *www.theplantlist.org.*and *www.worldfloraonline.org.*

These plants were compared with deposited herbarium specimens of herbarium sheets of Botanical Survey of India, Eastern Circle, Shillong.

3.3 DOCUMENTATION OF TRADITIONAL KNOWLEDGE

The general methods for gathering ethnobotanical data were as described by Jain (1987), Rao and Hajra (1987), Rao (1989). During field work, informants were requested to accompany to the field to detect the plants and information were gathered by identifying the plants in the natural habitat which they use for different ethnobotanical aspect. For conducting interviews two types of interviews were taken, firstly of individuals and secondly of groups. Of individual's interview knowledgeable person (age group 40-90 yrs.) or the village headman were selected.

Most of the ethnobotanical information was gathered from the elderly people, who have a very long acquaintance with usage of plants. The ethno medicinal data were collected through interviews and discussions among the herbal practitioners in and around the study area by asking structured questions regarding

the plants which they use for different ailments. The local name of the plant, mode of usage, diseases it cures, parts of the plant, mode of collection, processing, administration of drug, dosages etc. are noted carefully.

3.4 PREPARING HERBARIUM SPECIMENS

Herbarium specimens were prepared following methods of Jain and Rao (1978); Forman and Bridson (1989). In this method, the collected plant materials were poisoned with 10% of formalin and then the specimens were pressed by using old newspapers and herbarium press. After poisoning and drying, the specimens were mounted on standard herbarium sheets (42 x 28 cm) with an herbarium level (14 x 12 cm) which was pasted below on the right corner of every sheet by using gum and threads. Completed herbariums were ready for identification. The collected voucher specimens are prepared and deposited for inclusion in the herbaria of Department of Botany, Nagaland University, Lumami, India.

3.5 ASSESSMENT STRATEGY APPLYING THE IUCN RED LIST CATEGORIES AND CRITERIA SYSTEM

3.5.1 A general account on the Categories and Criteria of threatened plants and Categories of Ethnomedicinal plants

Identification and conservation of species facing a high risk of extinction in the near future is one of the central objectives of modern conservation. And the categories and criteria for classifying threatened species seem to be the basic pre-requite of any conservation assessment, because it provides the mechanism for identification of the threatened species. The IUCN Red List Categories and Criteria were first published in 1994 (IUCN,1994). In order to stabilize the assessment procedure these Categories and Criteria were extensively reviewed between 1997

and 1999. The revised Categories and Criteria (IUCN Red List Categories and Criteria version 3.1) were adopted by IUCN Council in February, 2000. The latest Guidelines for using the IUCN Red List Categories and Criteria is Version -19 in August 2019.

In the present study IUCN Red List Categories and Criteria Version 3.1 is used as it provides an easy and widely understood system for classifying species at high risk of global extinction, so as to focus attention on conservation measures designed to protect them.

3.5.2 IUCN Red List Categories (Version 3.1)

IUCN has recognized species in nine categories, within three principal groupings, whose definitions are presented in the following simplified form: Extinct categories

Extinct (EX):

Taxa for which there is no reasonable doubt that the last individual has died. IUCN presumes that a taxon is extinct when exhaustive surveys in known or expected habitat, at appropriate times (diurnal, seasonal, annual), and throughout its historic range have failed to record an individual.

Extinct in the wild (EW):

Taxa known only to survive in cultivation, inactivity, or as a naturalized population (or populations) well outside the past range. IUCN presumes that a taxon is extinct in the wild when exhaustive surveys in known or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual (as described for extinct). As for the extinct status, surveys should have been over a time frame appropriate to the taxon's life cycle and lifeform.

Threatened categories:

CR – *Critically endangered* – a taxon is critically endangered when it is facing an extremely high risk of extinction in the wild in the immediate future as defined by the criteria.

EN – *Endangered* – a taxon is endangered when it is not critically endangered but is facing a very high risk of extinction in the wild in the near future as defined by the criteria.

VU – *Vulnerable* – a taxon is vulnerable when it is not critically endangered or endangered but is facing a high risk of extinction in the wild in the medium-term future as defined by the criteria.

Lower risk categories

Near threatened (NT): Taxa close to qualifying for, or likely to qualify for, a threatened category in the near future.

Least concern (LC): A taxon is classified as least concern when it has been evaluated against the criteria and does not qualify for CR, EN, VU, or NT.

Data deficient (DD): A taxon is data deficient when there is inadequate information to make a direct or indirect, assessment of its risk of extinction based on its distribution and/or population status.

Not Evaluated (NE): A taxon is not evaluated when it has been initially proposed but not discussed and not yet been evaluated against the criteria for any reason, including uncertainty about taxonomic or wild status.

3.5.3 IUCN Red List Criteria: Version3.1

A taxon is considered threatened if it meets any one of the criteria listed below. A taxon is assigned highest threat category as per the relevant criteria, if it meets two or more criteria or categories (IUCN, 2013). The five criteria are: a) Reduction in population size b) Reduction in extent of occurrence c) Reduction in area of occupancy d) Reduction in mature individuals e) Probability of extinction in the wild

A– *Population reduction* **–** (1) observed, inferred, suspected or estimated reduction, or (2) projected or predicted reduction of at least 20% (VU), or 50% (EN), or 80% (CR) in 10 years or 3 generations whichever is longer based on (a)Direct observation; (b) index of abundance appropriate for the taxon; (c) decline in areas of occupancy, extent of occurrence and/or quality of habitat; (d) actual or potential levels of exploitation; (e) effects or introduced taxa, hybridization, pathogens, pollutants, competitors, or parasites.

B – Restricted distribution – Extent of occurrence estimated to be less than 20,000 km^2 (VU), or 5,000 km^2 (EN) or 100 km^2 (CR) and/or area of occupancy estimated to be less than 2000 km^2 (VU), or 500 km^2 (EN), or 10 km^2 (CR), and qualifying for any two of the following: (1) severely fragmented, or known to exist in not more than 10 locations (VU), or 5 locations (EN), or single location (CR); (2) continuing decline, observed, inferred, projected in any (a) extent of occurrence, (b) area of occupancy; (c) area, extent and/or quality of habitat; (d) number of locations or subpopulations; (e) number of mature individuals; (3) extreme fluctuation in either (a) extent of occurrence, (b) area of occupancy, (c) number of populations or subpopulations, (d) number of mature individuals.

C – Population estimates – population estimated to number less than 10,000 (VU), or 2,500 (EN), or 250 (CR) mature individuals and either (1) estimated, continuing decline of at least 10% in 10 years or 3 generations or whichever is longer (VU), or 20% in 5 years or 2 generations, whichever is longer (EN), or 25% in 3 years or 1 generation whichever is longer (CR) or in (2) continuing decline, observed, projected, inferred, number of mature individuals and population structure in the form of either (a) severely fragmented (no subpopulation, estimated to contain more than 1000 (VU) or 250 (EN) or 50 (CR) mature individuals); (b) all individuals are in a single subpopulation.

D- Restricted populations- (1) Population estimated to number less than1000 (VU) or 250 (EN) or 50 (CR) mature individuals); (2) Population restricted in area of occupancy of less than 100 km^2 or less than 5 locations (VU).

E-Probability of extinction- quantitative analysis showing the probability of extinction in the wild is at least 10% in 100 years (VU) or 20% in 20 years or 5 generations, whichever is longer (EN), or 50% in 10 years or 3 generations, whichever is longer (CR).

3.5.4 Application of IUCN Criteria at regional level

The word regional means any sub global geographically defined area, such as a continent, country, state, or province and regional assessment denotes process for determining the relative extinction risk of a regional population according to the guidelines. According to lUCN (2003) regional assessments should be carried out in a two-step process. In step one, the lUCN Red List Criteria are applied to the regional population of the taxon, resulting in a preliminary categorization.

All data used in this initial assessment - such as number of individuals and parameters relating to area, reduction, decline, fluctuations, subpopulations, locations, and fragmentation- should be from the regional population. In step two, the existence and status of any conspecific populations outside the region that may affect the risk of extinction within the region should be investigated. If the taxon is endemic to the region or the regional population is isolated, the Red List Category (RLC) defined by the criteria should be adopted unaltered. If, on the other hand, conspecific populations outside the region are judged to affect the regional extinction risk, the regional Red List Category should be changed to a more appropriate level that reflects the extinction risk as defined by criterion E (lUCN 2001). In most cases, this will mean downgrading the category obtained in step one, because populations within the region may experience a rescue effect from populations outside the region. In other words, immigration from outside the region will tend to decrease extinction risk within the region.

Normally, such a downgrading will involve a one-step change in category, such as changing the category from Endangered (EN) to Vulnerable (VU) or from VU to Near Threatened (NT). If the region is very small and not isolated by barriers from surrounding regions, downgrading by two or more steps may be necessary.

3.6 SPECIES DISTRIBUTION MODEL (SDM)

3.6.1 Profile Methods (Methodologies of some algorithms are discussed below).

Bioclim: Bioclim is a classic 'climate-envelope-model'. Although it generally does not perform as good as some other modelling methods (Elith *et al.,* 2006), particularly in the context of climate change (Hernandez *et al.*, 2006), it is still used, among other reasons because the algorithm is easy to understand and thus useful in teaching species distribution modelling. The BioClim algorithm computes the similarity of a location by comparing the values of environmental variables at any location to a percentile distribution of the values at known locations of occurrence ('training sites'). The closer to the 50th percentile (the median), the more suitable the location is. The tails of the distribution are not distinguished, that is, 10 percentile is treated as equivalent to 90 %.

3.6.2 Domain:

The Domain algorithm (Carpenter *et al*., 1993) has been extensively used for species distribution modelling. It did not perform very well in a model comparison (Elith *et al*., 2006) and very poorly when assessing climate change effects (Hernandez *et al.,* 2006). The Domain algorithm computes the Gower distance between environmental variables at any location and those at any of the known locations of occurrence (training sites). If averaging is enabled, the value stored is the average of the "n" nearest cells. Analyses are generally conducted with n=1, but larger values can be useful in reducing effects of outlier training points

3.6.3 Mahalanobis:

The ‘Mmahal’ function implements a species distribution model based on the Mahalanobis distance (Mahalanobis, 1936). Mahalanobis distance takes into account the correlations of the variables in the data set, and it is not dependent on the scale of measurements.

3.6.4 Regression Models

Generalized Linear Models: A generalized linear model (GLM) is a generalization of ordinary least squares regression. Models are fit using maximum likelihood and by allowing the linear model to be related to the response variable via a link function and by allowing the magnitude of the variance of each measurement to be a function of its predicted value. Depending on how a GLM is specified it can be equivalent to (multiple) linear regression, logistic regression or Poisson regression (Guisan *et al*., 2002) gave an overview.

3.6.5 GLM in species distribution modelling

Generalized Additive Models (GAM): Generalized additive models (Hastie and Tibshirani, 1990; 2009; Wood, 2006) are an extension to GLMs. In GAMs, the linear predictor is the sum of smoothing functions. This makes GAMs very flexible and they can fit very complex functions. It also makes them very similar to machine learning methods.

3.6.6 Machine Learning Methods:

MaxEnt: MaxEnt (Maximum Entropy) (Phillips *et al*., 2004; 2006) is the most widely used SDM algorithm. Elith *et al.* (2006) provides an explanation of the

algorithm (software) geared towards ecologists. MaxEnt is available as a Stand-alone Java program. It uses presence of only data for model development and performs well even with small sample size. Boosted Regression trees: Boosted Regression Trees (BRT) is, unfortunately, known by a large number of different names. It was developed by Friedman (2001) who referred to it as a "Gradient Boosting Machine" (GBM). It is also known as "Gradient Boost", "Stochastic.

3.6.7 Species Occurrence Data

Occurrence data are collected from different sources. Collection can be categorized into:

a) Primary Data: Collected during 2015 to 2020.

b) Secondary Data with latitude and longitude coordinates points.

c) Secondary Data without lat/long coordinates: Some of the published literature mentioned place for collection without mentioning lat/long coordinates. If the place of the names is mentioned, the area is selected from gazetteer and geo-referenced accordingly.

3.6.8 Environmental Data

Table 3.3: For the present study 19 bioclimatic variables are used – and represented

Variables	Details
BIO1 BIO2 BIO3	Annual mean temperature Mean diurnal temperature range [mean of monthly (max temp–min temp)]

BIO4	Isothermality (P2/P7) (×100)
BIO5	Temperature seasonality (standard deviation×100)
BIO6	Max temperature of warmest month
BIO7	Min temperature of coldest month
BIO8	Temperature annual range (P5–P6)
BIO9	Mean temperature of wettest quarter
BIO10	Mean temperature of driest quarter
BIO11	Mean temperature of warmest quarter
BIO12	Mean temperature of coldest quarter
BIO13	Annual precipitation
BIO14	Precipitation of wettest month
BIO15	Precipitation of driest month
BIO16	Precipitation seasonality (coefficient of variation)
BIO17	Precipitation of wettest quarter
BIO18	Precipitation of driest quarter
BIO19	Precipitation of warmest quarter
Slope	Precipitation of coldest quarter
Aspect	Slope value from digital elevation model
Altitude	Aspect value from digital elevation model
Landcover	Elevation above sea level (m)
	Global landcover map from Global Land Cover Facility (www.landcover.org) VCF.

Bioclimatic Variables are downloaded from the WorldClim–Global climate data website (www.worldclim.org) 30 seconds resolution data are used for the modelling as these are one of the highest resolutions available so far.

Downloaded environmental layers are cropped to fit the boundary of Manipur by using DIVA-GIS, an open-source GIS tool.

Altitude data is also downloaded from Bhuyan ISRO website. Data for 30s is selected for cropping to fit the boundary of Manipur.

3.6.9 Model Development

MaxEnt algorithm was performed using the tool version 3.3 downloaded from the website http://www.cs.princeton.edu/~schapire/maxent/. This tool is developed in JAVA and can be run in any platform (Windows, Linux, MacOS, etc.) running Java Virtual Machine. Output results are exported as ArcMap ASCII format. This file is again analyzed through ArcGIS version10.5.

3.6.10 Model Evaluation

Prediction accuracy of the present model outputs was measured through receiver operating characteristics (ROC) analysis because of its wider application in the modeling studies. A ROC plot was generated by putting the sensitivity values, the true positive fraction against the false positive fraction for all available probability thresholds. A curve which maximizes sensitivity against low false positive fraction values is considered as good model and is quantified by calculating the area under the curve (AUC). An AUC statistic closer to 1.0 indicates total agreement between the model and test data and considered as good model. An AUC with value closer to 0.5 considered to be no better than random.

CHAPTER- IV

RESULTS

The chapter is on two sub-headings the first one begins with the list of Threatened ethno-medicinal plant species recorded with plant description, habitat, distribution of each plant is given. Secondly, the information regarding the ethnomedicinal uses and the photographs and distribution map of each species is given.

The Threatened ethno-medicinal plants recorded in the present study are enlisted below.

4.1: *Aconitum elwesii* Stapf, Ann. Roy. Bot. Gard. (Calcutta). 10:174. 1905.

Family: Ranunculaceae;

Local Name: *Nuishiwon* (Tangkhul)

Description: Herbs, with scandent, weak pubescent stem. Leaves palmate, 3-5 partite, pubescent; lobes ovate-cordate to narrowly rhombic, acuminate, toothed, upto 12 x 13 cm; sinus upto 1.5 cm; petiole upto 8 cm long. Panicles terminal and axillary, 2-4 flowered, rachis and pedicels pubescent. Bracts leaf like; bracteoles narrowly ovate, unlobed or 3 lobed, upto 4mm long. Pedicels upto 5 cm long. Flowers dark purplish blue; Sepals sparsely pubescent above, upper narrowly navicular; shortly beaked, upto 2 cm long; lower concave, oblique upward,1.5cm long; Petals glabrous; lip narrow, upto 6 mm long; spur reflexed, upto 4 mm long. Stamens glabrous; filaments winged, Carpels 5.

Fl. & Fr.: August to October.

Elevation: 1500 to 2600 metres above sea level

Habitat and ecology: Rare herbaceous climber growing only in small pockets of a particular microhabitat of open grasslands at an altitude 1500 m above msl.

Global distribution: Nepal, Bhutan, China and India.

India: Sikkim, Arunachal Pradesh, Manipur and Nagaland

Distribution in Manipur: Dzukou valley, Shirui hill, Mt. Esii and Khangkhui

Specimen examined: Dolen, 0552; 7/08/ 2016; Dzukou valley; 25^0 33/16.1// N, 94^0 4/ 5.8// E: 2455.39 metres above sea level; Dolen, 1262; 2/05/2017; Shirui hill; 25^0 6/ 56.6// N, 94^0 26/ 49.5// E; 2198 metres above sea level

Ethnobotanical uses: Fresh root (10 gm) is pounded and made into paste. Paste applied externally for treatment of abdominal pain twice daily for 3 days. It is also applied externally as febrifuge by the Tangkhul, Mao and Maram tribes of Manipur. Moreover, the Naga tribe used the root paste for poisoning arrows.

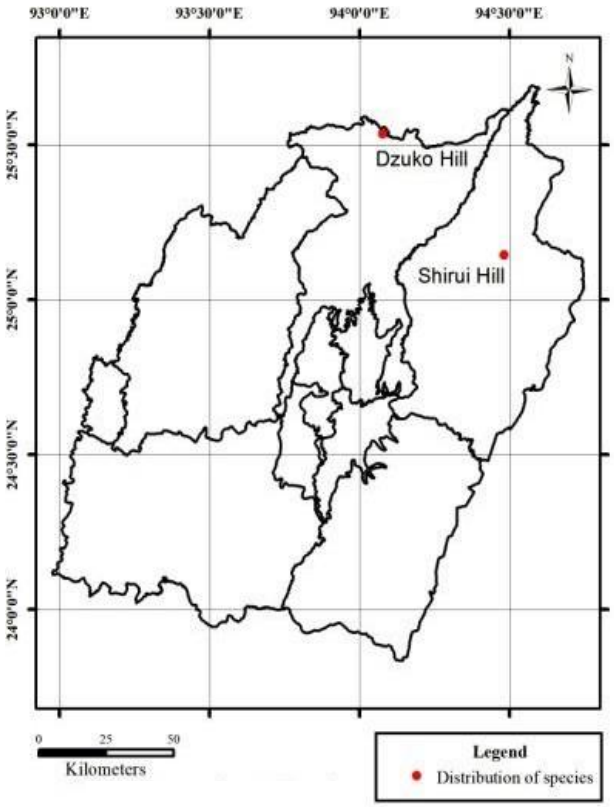


Fig. 4.1: Map showing the distribution of *Aconitum elwesii* Stapf

Plate 1: *Aconitum elwesii* Stapf

4.2: *Aconitum nagarum* Stapf, Ann. Roy. Bot. Gard. (Calcutta). 10:176. 1905.

Family: Ranunculaceae;

Local Name: Khawari/ Nuishiwon (Tangkhul)

Description: Erect, biennial herbs, apical parts pubescent, upto 1 m tall. Roots tuberous. Leaves tripartite; petioles long, upto 60 cm; blades cordate, reniform, upto 9.5 X 21 cm; lateral lobes 2 lobuled; lobules obovate lanceolate, acute, dentate. Racemes terminal and axillary, 30 cm or more. Rachis pedicels densely pubescent. Bracts foliaceous; bracteoles narrowly ovate. Flowers purplish blue. Sepals purplish blue, pubescent above, 1-1.5 cm long; upper navicular, semi-orbicular, shortly beaked; lower deflected, elliptic. Petals glabrous, upto 8 mm; lip upto 2.6 mm; spur 1.6 mm.

Fl. & Fr.: September to November.

Elevation: 1400 to 2690 metres above sea level

Habitat and ecology: It is found growing in the grassy hill slopes along with Bamboo species at an elevation 1500 metres above sea level.

Global distribution: Nepal, Bhutan, Myanmar, Yunnan (China) and India

India: Sikkim, Arunachal Pradesh, Nagaland and Manipur

Distribution in Manipur: Jesami, Shirui hills, Dzukou hills, Mao- Maram and Khayangbung.

Specimen examined: Dolen, 0564; 7/08/2016; Dzukou hills, N $25^0$33'17.2", E $94^0$4′ 7.2″ ; 2494.80 metres above sea level

Dolen, 1265; 4/05/2017: Shirui hills, $25^0$7′ 6.7″ N, $94^0$26′ 38.4″ E; 2143 metres above sea level

Ethnobotanical uses: Dried root (10 g) is pounded and made into powdered form. It mixed with little water is made into paste and applied as porridge for arthritis. Moreover, the Naga tribe used the root paste for poisoning arrow- heads.

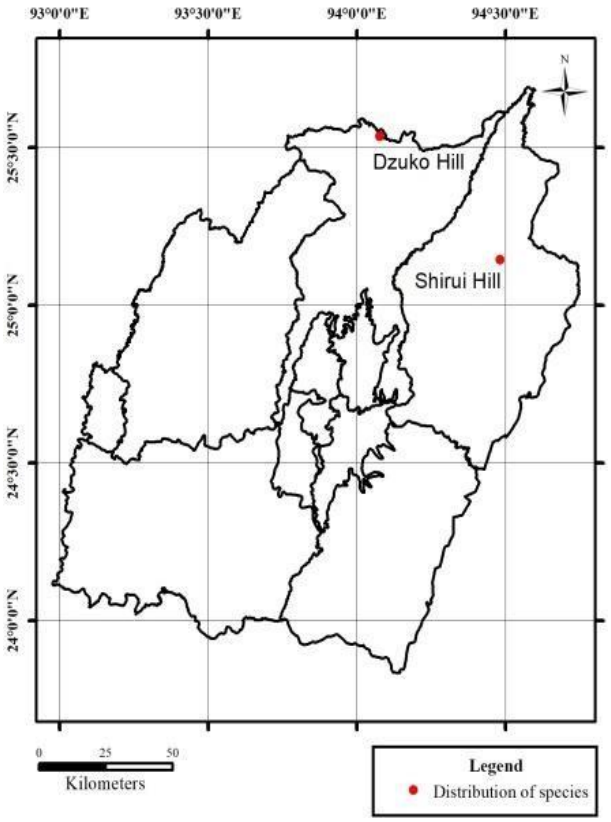


Fig. 4.2: Map showing the distribution of *Aconitum nagarum* Stapf

Plate 2:

***Aconitum nagarum* Stapf**

4.3: *Albizia myriophylla* Benth., London j. Bot. 3: 90, 1844.

Family: Leguminosae;

Local Name: Yanglee (Manipuri)

Description: Scrambling to vigorous shrub, with prickles, 5 m or more tall. Leaves bipinnate, petiolate, glandular, upto 20 cm long; stipulate; leaflets minute, linear, upto 0.4 cm long. Panicles terminal and axillary. Heads globose; flowers greenish yellow, pentamerous, sessile, bracteate, upto 0.4 cm long. Pods thin, up to 20 cm long. Seeds flat, oval, light brown.

Fl. & Fr.: March to January

Elevation: 600 to 950 metres above sea level

Habitat & ecology: It grows in forest margins, riverine, disturbed habitat at an elevation about 600 m from metres above sea level

Global distribution: Bangladesh, Bhutan, Myanmar, China, Thailand

India: Assam, Manipur, Meghalaya, Nagaland, Tripura

Distribution in Manipur: Andro, Phayeng, Sekmai, Leimaram (Chakpa caste) and Churachandpur.

Specimen examined: Dolen, 1251; 12/03/2017; Churachandpur, $24^0 23^{/}$ $14.7^{//}$ N, 93^0 $42^{/}$ $15.0^{//}$ E; Altitude 870.0 metres above sea level

Ethnobotanical uses: Root and bark (50 g) is pounded and made into paste by mixing with little water; the paste is applied for dermatological problems.

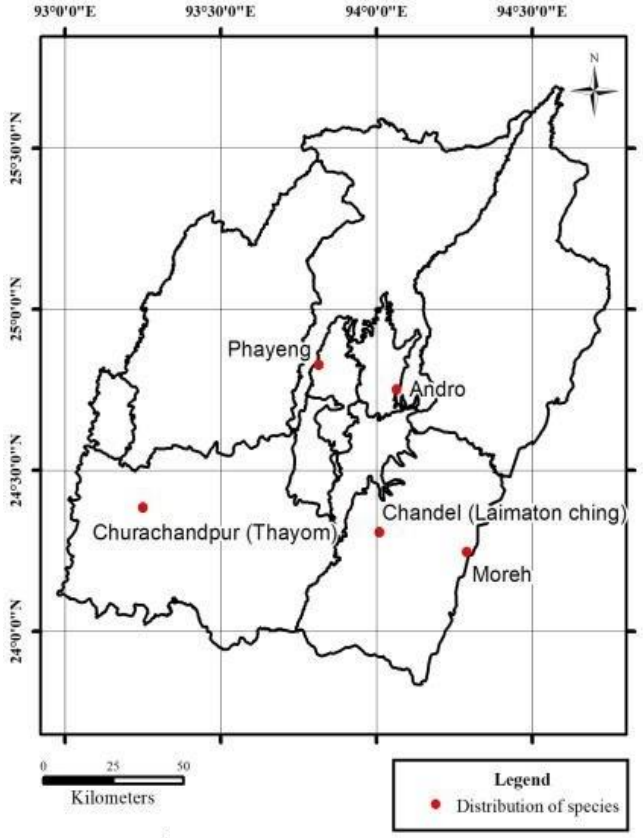


Fig. 4.3: Map showing the distribution of *Albizia myriophylla* Benth.

Plate 3: *Albizia myriophylla* Benth.

4.4: *Begonia adscendens* C.B. Clarke, J. Linn. Soc. 25:26, t. 13. 1887.

Family: Begoniaceae;

Local Name: Banhang (Rongmei)

Description: Plants up to 50 cm tall densely covered with hairs. Roots fibrous, Tubers 2.5-3.5 x 3.5-4.0 cm. Petioles 15-21 cm, 05-1.2 in diameter, pubescent. Lamina 11.5-21.8 cm across, ovate, apex acuminate, 10-11 nerves arising from base. Inflorescence biparous cymes with 40-50 flowers. Peduncle 30- 45 cm long, glabrous, bracts persistent. Male flowers: pedicel 07-16 cm; tepals 2+2; outer pair 1.5-1.8x 08-1.2 cm ovate, pink with red tinges; inner pair 0.6-0.7x 0.3-0.5 cm, obovate, pink or white, entire, apex rounded; stamens 16- 20, monadelphous; Female flower: pedicel 0.8-1.8 cm, tepals 4-5, outermost 1.2- 1.5x 0.5-0.7 cm; ovary 3 locular, Capsule. 3 winged, 3celled

Fl. & Fr.: July to September

Elevation: 1300 to 2000 metres above sea level

Habitat & ecology: It is found growing in forest floor and in rock crevices.

Global distribution: Myanmar, Nepal, Taiwan, India, Thailand and Bhutan

India: Arunachal Pradesh, Sikkim, Tripura, Nagaland, Manipur, Meghalaya and Assam.

Distribution in Manipur: Shirui hill, Lunghar and Tamenglong

Specimen examined: Dolen, 0412; 2/07/2016; Tamenglong, 25^0 $0'$ $42.0''$ N, 93^0 $31'$ $43.3''$ E; 1032.0 metres above sea level

Ethnobotanical uses: Whole plant (100 g) is boiled in 3 litres, upto 1/3 of the volume. The decoction along with the plant is taken for stomach pain and dysentery

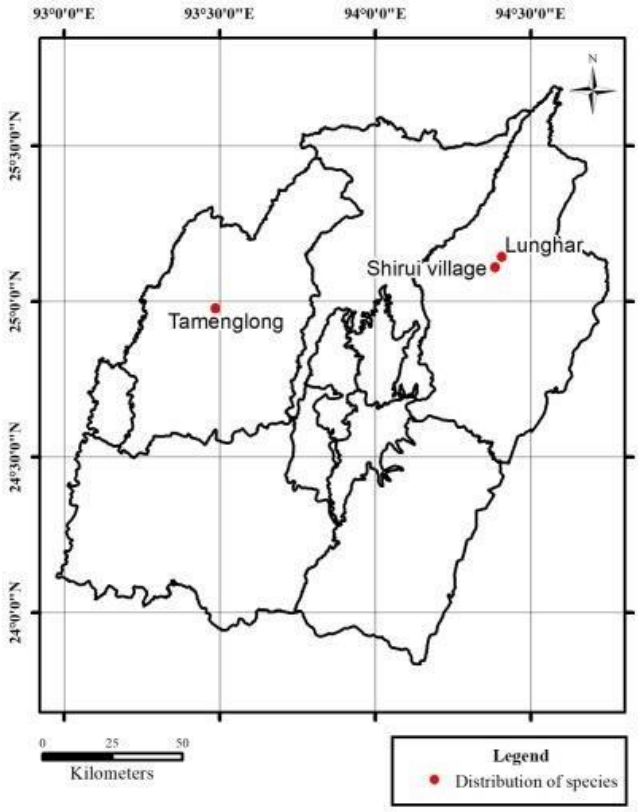


Fig. 4.4: Map showing the distribution of *Begonia adscendens* C.B. Clarke

Plate 4: *Begonia adscendens* C.B. Clarke

4.5: *Brassaiopsis bodinieri* (H.Lév.) J. Wen & Lowry, Adansonia III, 28: 182 2006.

Family: Araliaceae;

Local Name: Chom (Manipuri)

Description: Tree is an unbranched small tree, 3-8 m tall, with short prickles on the stem. Leaves are large, 30-60 cm across, deeply palmately divided or cut, lobes long pointed, toothed. Leaf stalks are 60-80 cm long. Flowers small, yellowish in roundish umbels which are arranged in panicles at the ends of branches. They look like snowflakes on the tree, inspiring its common name. Fruit is 1.6 cm long, ovoid. This tree is used medicinally and as an ornamental.

Fl. & Fr.: July to Nov.

Elevation: 540 to 950 metres above sea level

Habitat & ecology: Open areas and forest margin

Global distribution: Nepal, Myanmar, China, India and Malaya,

India: Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur and Mizoram

Distribution in Manipur: Phayeng, Churchandpur, Nongdam Tangkhul (Kamjong dist.)

Specimen examined: Dolen, 1603; 3/ 06/2019; Phayeng, $24^0 51' 8.0'' N, 93^0 47' 57.8'' E$; 858.00 metres above sea level

Ethnobotanical uses: Decoction is taken thrice daily for 7 days to control Diabetes and liver control.

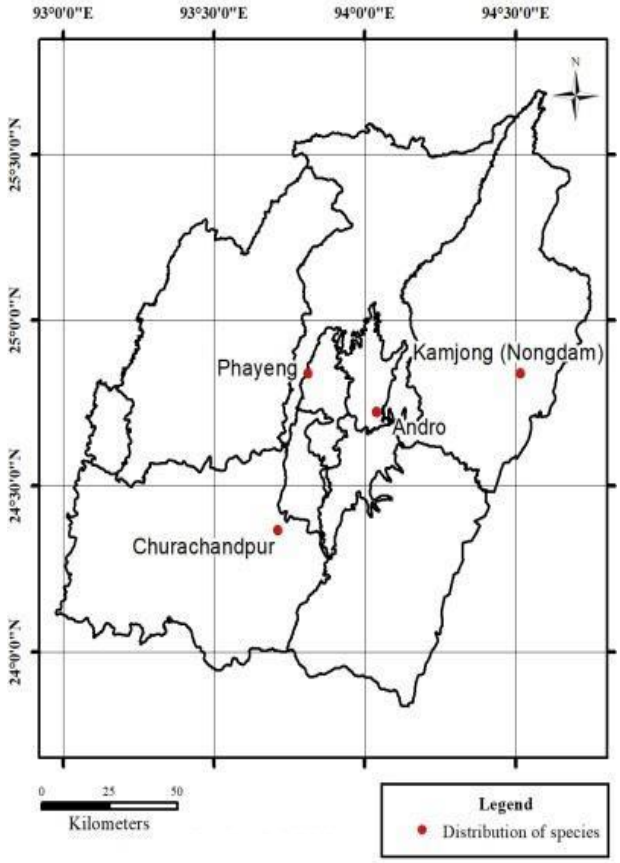


Fig. 4.5: Map showing the distribution of *Brassaiopsis bodinieri* (H.Lév.) J. Wen & Lowry

Plate 5: *Brassaiopsis bodinieri* (H. Lév.) J. Wen & Lowr

4.6: *Bulbophyllum cylindraceum* Wall. ex Lindl. Gen. Sp. Orchid. Pl. 53.1830.

Family- Orchidaceae

Local Name- *Urei* (Manipuri)

Description: Epiphytic, pseudobulb upto 7 cm long. Leaves acute, oblong-lanceolate, upto 15 X 3 cm in size. Inflorescence raceme, erect, compact, upto 17 cm long. Flower dark purplish red, upto 5.6 mm long; sepals unequal, ovate, apex obtuse or acuminate, upto 5.5 X 3 mm; petals ovate, acute, upto 2.6 X 1.1 mm; lip papillose, dark purplish red with yellow, ovate-oblong, upto 4.6 X 2.6 mm.

Fl. & Fr.: August to November

Elevation: 950 to 2300 metres above sea level

Habitat & ecology: Tree trunks or rocks in forest, up to 950-2300m

Global distribution: Myanmar, Nepal, Bhutan, China, Bangladesh and India

India: Arunachal Pradesh, Sikkim, Tripura, Nagaland, Manipur

Distribution in Manipur: Ukhrul, Senapati (Mao- Maram),Tengnoupal

Specimen examined: Dolen, 1292; 12/08/2017; Tengnoupal, 24^0 $22^/$ $13.0^{//}$ N, 94^0 $3^/$ $24.6^{//}$ E ; 1403 metres above sea level

Ethnobotanical uses: Bulb is half roasted and the cover is peel off. Fleshy paste is applied on the cracks, cuts and wounds for fast recovery.

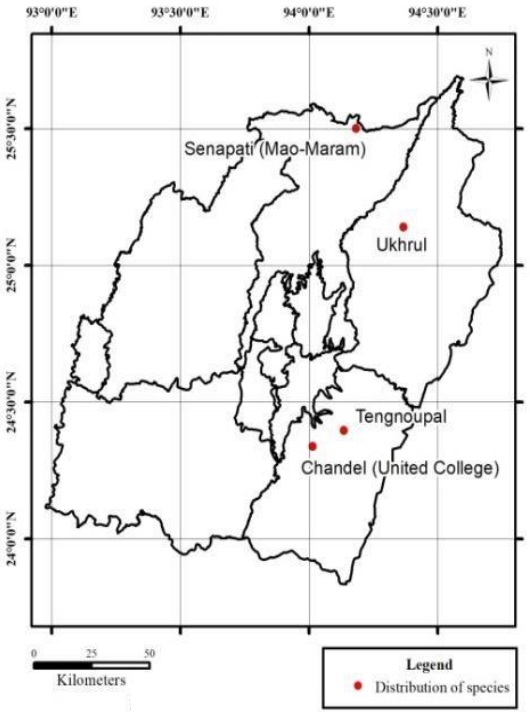


Fig. 4.6: Map showing the distribution of *Bulbophyllum cylindraceum* Wall. ex Lindl.

Plate 6: *Bulbophyllum cylindraceum* Wall.ex Lindl.

4.7: *Canarium strictum* Roxb. Fl. Ind. 138. 1832.

Family: Burseraceae;

Local Name: Mekruk / beraw (Manipuri)

Description: Smooth, aromatic, dark brown resins, greyish brown bark and straight bole. Young branchlets densely tomentose. Leaves stipulate, imparipinnate, alternate; rachis pubescent, base swollen n; leaflets 3-9 paired, petiolate; petioles upto 1 cm long; lamina broadly ovate lanceolate, apex acuminate, base cuneate, marjin minutely serrate, glabrous above, tomentose beneath, young leaves maroon, upto 18 X 7 cm. Inflorescence axillary, male plants cymose, female racemose, tomentose, upto 40 cm long. Flowers yellow, upto 6 X 9 mm; bracteate. Calyx 3, campanulate, abaxially pubescent, upto 5 - Trees, upto 50 m tall with mm long; lobes short, obtuse. Petals 3, abaxially pubescent, oblong, upto 8 mm long. Stamens 6, free, upto 1 mm long. Ovary nearly glabrous, 3 celled. Drupe obovoid or ellipsoid, bluish black, upto 5 X 2cm.

Fl. & Fr.: March to August

Elevation: 800 to 1700 metres above sea level

Habitat and ecology: Moist Evergreen and Semi-evergreen forests at an altitude of 800 -1700 metres above sea level

Global distribution: Myanmar, Bangladesh and India

India: Sikkim, Meghalaya, Karnataka, Tamil Nadu, Manipur and Nagaland

Distribution in Manipur*:* Dilong, Moreh, Chakpi -karong and Kamjong

Specimen examined: Dolen, 1276; 17/ 06/ 2017, Dialong, 25^0 $0'$ $37.8''$ N 93^0 $31'$ $44.1''$ E; 1077 metres above sea level

Ethnobotanical uses- The resin collected and lukewarm it. The paste is applied externally with massage for rheumatism.

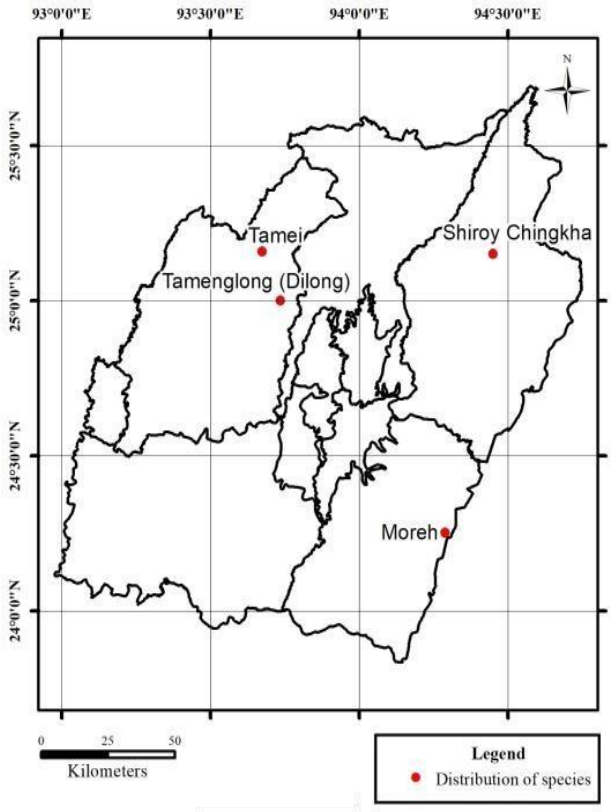


Fig. 4.7: Map showing the distribution of *Canarium strictum* Roxb.

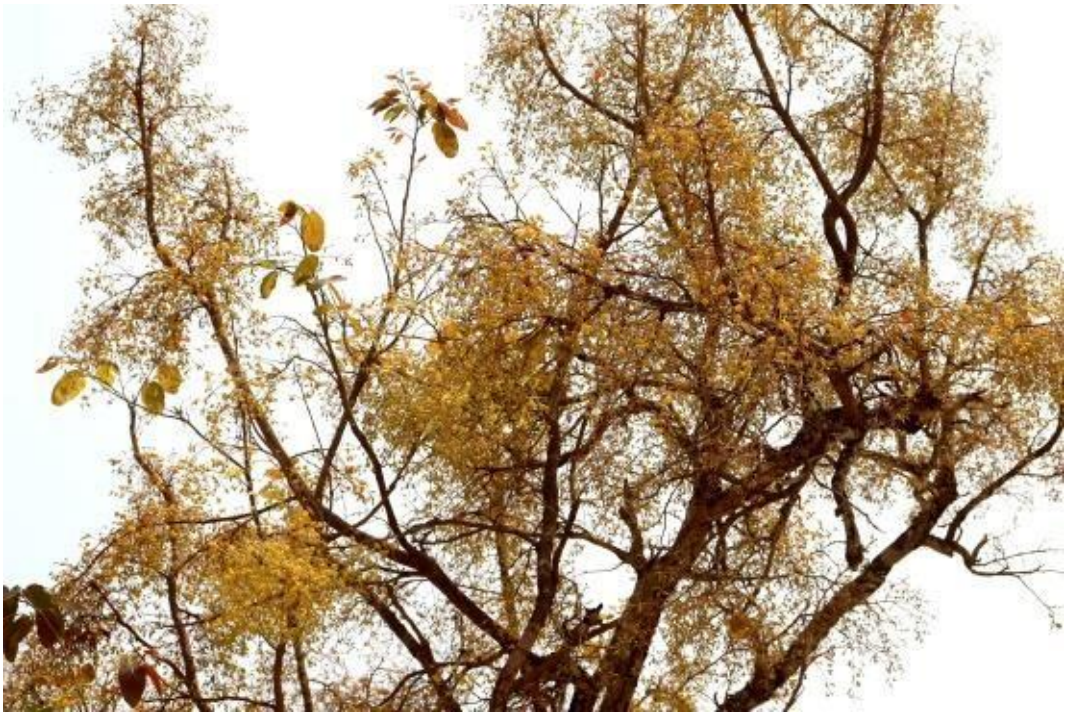


Plate 7: *Canarium strictum* Roxb.

4.8: *Cinnamomum verum* J. Presl Sp. Pl. 1: 369. 1753.

Family: Lauraceae;

Local Name: *Ushingsha*. (Manipuri)

Description: Evergreen tree, ca 10-18 m tall. Matured stem rough, dark brown or brownish grey; bark delicately aromatic. Leaves opposite, rarely alternate, ovate-lanceolate, margin entire, apex acuminate, glabrous, leathery, reddish when young, 6.5-17.5 X 3-5 cm; petiole glabrous, 1-2 cm long. Panicles lax, axillary and terminal, upto 12 cm long; peduncles silky hairy, upto 7 cm long. Flowers unisexual, greenish yellow or pale yellow, campanulate, upto 6.5 x 3 mm. Bracts small, ovate. Perianth lobes 6, oblong; fertile stamens 9, in 3 whorls, 2 glands at the base of the 3rd whorl stamens; 3 staminodes at 4th whorl; anthers 4-celled; filaments stout. Ovary superior, 1 celled; style short; stigma discoid. Fruits 1- seeded, drupe, ovoid, black, upto 1.5 cm long.

Fl. & Fr.: December to July

Elevation: 750 to 1800 metres above sea level

Habitat & ecology: Wild species is mainly found in sparsely at an altitude between 750 – 1800 metres above sea level

Global distribution: Myanmar, Sri Lanka, Malaysia & India

India: Nagaland, Manipur, Karnataka and Kerala

Distribution in Manipur: Dzukou hill, Tamenglong, Ukhrul, Chandel and Laimaton ching.

Specimen examined: Dolen-1284, 12/ 07/2017; Dzukou, $25^0 33^/ 13.9^{//}$ N , $94^0 3^/ 49.9^{//}$ E ; 2444.39 metres above sea level; Dolen , 1120; 25/10/ 2016; Tamenglong, $25^0 0^/ 35.5^{//}$ N , $93^0 31^/ 19{,}7^{//}$ E; 973 metres above sea level

Ethnobotanical uses: Bark or leaf (20 g) is boiled in 1 litre of water for 10 min, 10 ml of the decoction is taken orally for respiratory problems. (It is a traditional Indian medicine as an astringent, stimulant, expectorant and carminative).

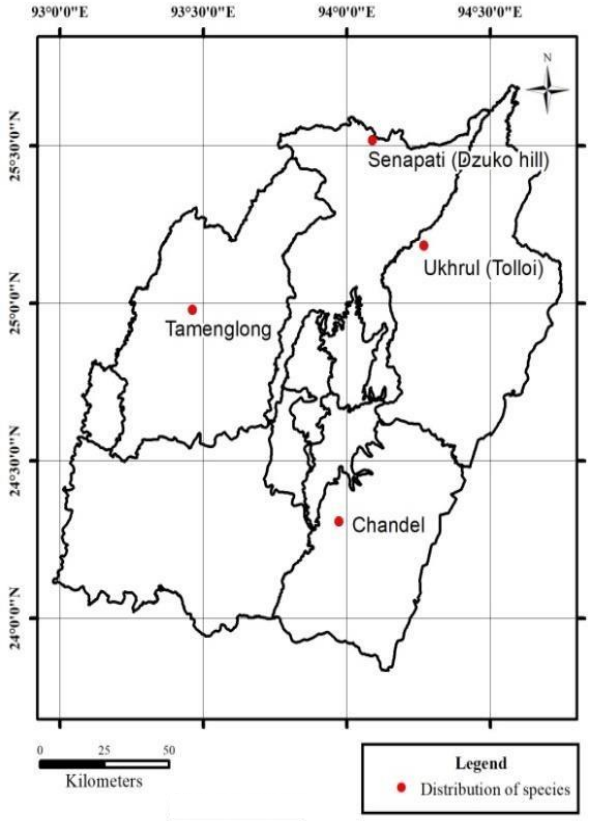


Fig. 4.8: Map showing the distribution of *Cinnamomum verum* J.Presl

Plate 8: *Cinnamomum verum* J. Presl

4.9: *Cissus javana* DC. Prodr. 1: 628. 1824.

Family: Vitaceae;

Local Name: Kongouyenlaba (Manipuri)

Description: Herbaceous, glabrous climbers with forked tendrils. Leaves green with white blotches, stipulate, ovate deltoid, base cordate, apex acuminate, margin serrate, up to 15 cm long. Inflorescence umbel, Flowers pale yellow, 0.8 cm long. Fruit maroon, 0.6 cm long.

Fl. & Fr.: August to Feb.

Elevation: 700 to 1100 metres above sea level

Habitat & ecology: Wild, climbing in forest trees.

Global distribution: Bangladesh, Bhutan, India, Nepal, Myanmar, Pakistan, NE India

India: Manipur, Sikkim, Nagaland, Tripura, Meghalaya & Mizoram

Distribution in Manipur: Thoubal, Kakching, Laimaton ching, Lamlai and Heingang ching

Specimen examined: Dolen, 1508; 5/10/2018; Thoubal, $24^0 39' 43.1'' N$, $93^0 59' 46.7'' E$; 748.00 metres above sea level

Ethnobotanical uses: Leaf (50 g) is boiled in 3 liters upto 1/3 of the volume, 500 ml of the decoction is taken orally thrice daily for stones in urinary bladder and kidney.

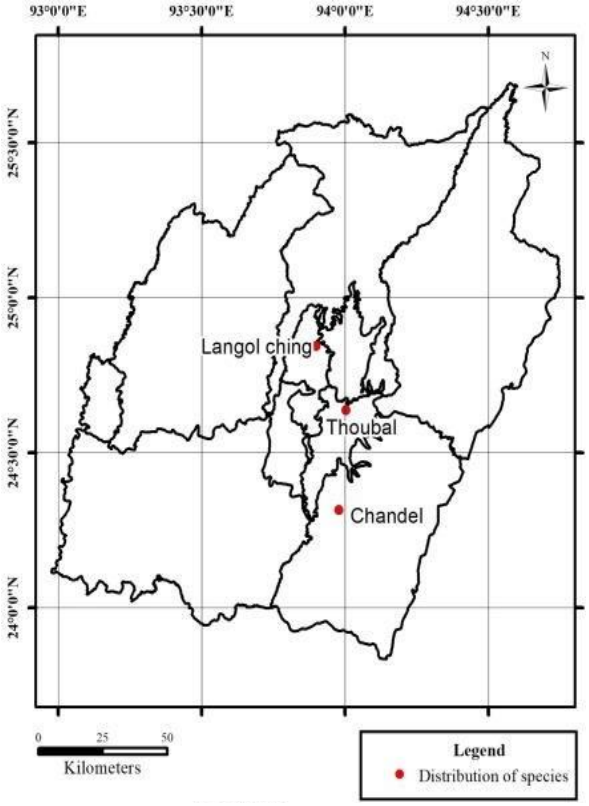


Fig. 4.9: Map showing the distribution of *Cissus javana* DC.

Plate 9:

***Cissus javana* DC.**

4.10: *Citrus hystrix* DC. Cat. Pl. Horti Monsp.971813.

Family: Rutaceae;

Local Name: Heiribob (Manipuri)

Description: Small to large tree, with spines, upto 16 m tall. Leaves ovate, apex obtuse, margin slightly crenate, up to 15 cm long; petiole winged. Inflorescence 1-6 flowered; flowers white, up to 1.5 cm long. Fruits yellow, globose to sub-globose, up to 10 cm in diameter.

Fl. & Fr.: February to December

Elevation: 950 to 1600 metres above sea level.

Habitat & ecology: It is found growing in forest margin.

Global distribution: Nepal, India, Thailand, Myanmar, China, Vietnam & Indonesia

India: Sikkim, Arunachal Pradesh, Tripura, Nagaland and Manipur

Distribution in Manipur: Kwatha village, Chandel, Tamenglong, Senapati & Churchandpur.

Specimen examined: Dolen, 1439; 4/07/2018; Chandel, 24^0 $22'$ $59.1''$N, 94^0 $5'$ $5.6''$ E; 1471 metres above sea level

Ethnobotanical uses: Infusion of ashes of pea plant kept overnight in water was mixed with fruit pulp of *Citrus hystrix*, 20 ml of the filtrate is taken thrice daily for 7 days for urinary and kidney stones.

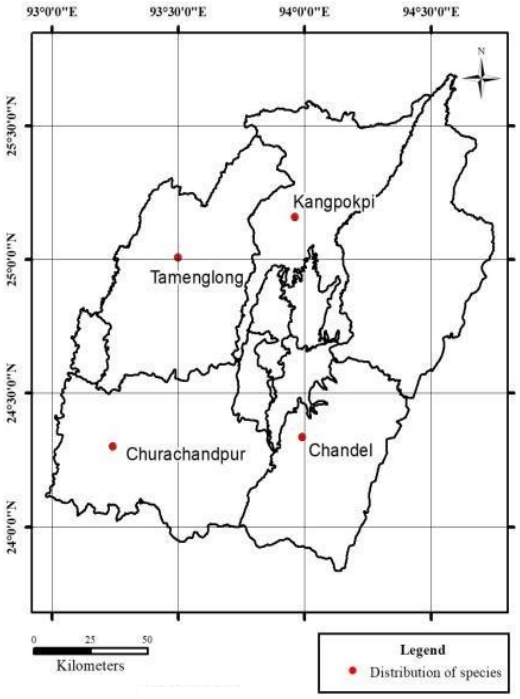


Fig. 4.10: Map showing the distribution of *Citrus hystrix* DC.

Plate 10:

***Citrus hystrix* DC.**

4.11: *Curcuma amada* Roxb. in Asiat. Res. 1 1: 334. 1810.

Family: Zingiberaceae;

Local Name: Yai Heinouman (Manipuri)

Description: Herbs, leafy stem, ca3- 4 cm tall. Leaves oblong lanceolate, large, *ca* 30-40 cm long; Inflorescence spike; flowers yellow. Rhizomes yellowish, sweet aromatic smell; i.e., green mango

Fl. & Fr.: January to March

Elevation: 800 to 1200 metres above sea level

Habitat & ecology: It is found growing in the wet or shady areas of forest floor and plain areas

Global distribution: Nepal, India, Thailand, Myanmar, China,Vietnam & Pakistan

India: Sikkim, Arunachal Pradesh, Sikkim, Nagaland and Manipur

Distribution in Manipur: Thoubal, Imphal East, Senapati, Phayeng, Tangjeng & Churchanpur

Specimen examined: Dolen, 1549; 12/02/2019; Imphal East, 24^0 $48^/$ $18.7^{//}$ N, 94^0 $1^/$ $57.3^{//}$ E; 860 metres above sea level

Ethnobotanical uses: Rhizome (20 g) is boiled in 1 litre for 10 min and the decoction mixed with ¼ of the *Rhus semilata* Murr., 20 ml of the infusion is taken 4 times daily for 2 weeks for diabetes.

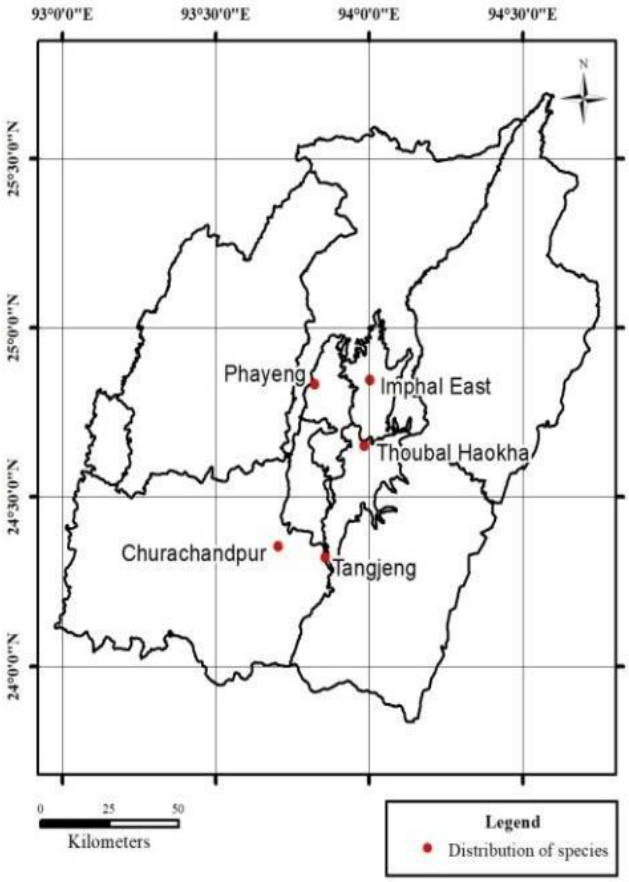


Fig. 4.11: Map showing the distribution of *Curcuma amada* Roxb.

Plate 11: *Curcuma amada* Roxb.

4.12: *Curcuma caesia*Roxb. in Asiat. Res. 1 1: 334. 1810.

Family: Zingiberaceae;

Local Name: Yaimu (Manipuri)

Description: Herbs. Root stocks large, ovoid; tubers sessile, pale grey inside. Leaves petioled, green with a broad purple-brown band in middle; Spikes densely flowered. Coma bracts red; Flowers pale yellow, Capsule trigonous; seeds arillate, white.

Fl. & Fr.: May to June

Elevation: 700 to 1400 metres above sea level

Habitat & ecology: Moist deciduous forest.

Global distribution: Nepal, India, Thailand, Myanmar, China, Vietnam

India: Sikkim, Arunachal Pradesh, Nagaland and Manipur

Distribution in Manipur: Nongmaiching, Langol, Kaina, Tamenglong and Chandel

Specimen examined: Dolen, 1422, 23/06/2018; Langol hill, 24^0 $52'$ $11.2''$ N, 93^0 $53'$ $56.7''$ E; 799 metres above sea level

Ethnobotanical uses: Crushed rhizome (30- 40 gm) is boiled in 1 litre of water up to $1/3^{rd}$ of the volume, 20 ml of the decoction is taken thrice daily for 3 days for treatment of bronchitis and cough. Moreover, crushed rhizome paste applied on bruises.

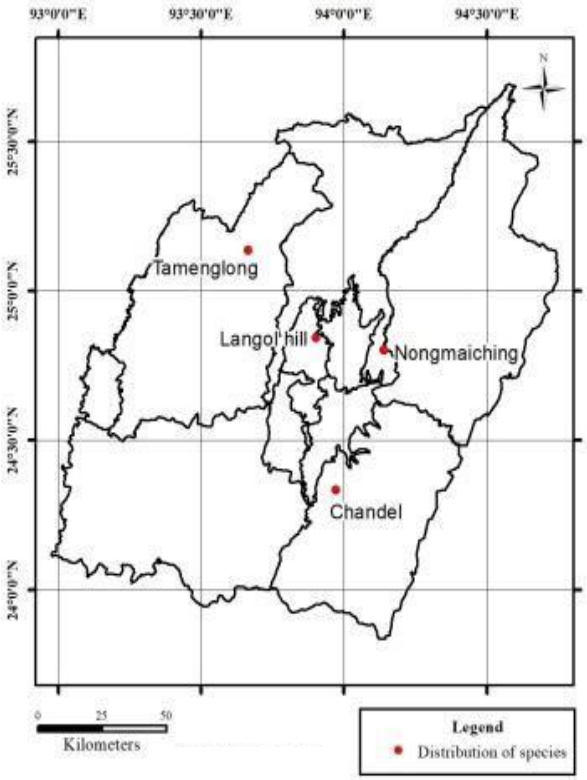


Fig. 4.12: Map showing the distribution of *Curcuma caesia* Roxb.

Plate12: *Curcuma caesia* Roxb.

4.13: *Dendrobium aphyllum*(Roxb.) C.E.C. Fisch.

Family: Orchidaceae

Local Name: Iyonglei (Manipuri); Saheikungal (Thadou)

Description: Epiphytic sometimes lithophytic, pendulous, 130 cm or more long. Leaves caduceus, lanceolate to ovate lanceolate, subacuminate, with tubular stem clasping sheathing base, upto 10 X 3 cm. Inflorescence clustered with 1-3 flowers arising from leafless stem. Flowers pale purplish with yellowish white lip, fragrant, upto 5 cm across. Capsule cylindric, club shaped, upto 5 cm long.

Fl. & Fr.: April to May

Elevation: 900 to1350 metres above sea level

Habitat & ecology: Found as epiphytes on tree trunks at an elevation of 800-1500 m above sea level

Distribution India: Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland, Sikkim, Tripura.

Global distribution: Bangladesh, Bhutan, China, Loas, Malaya, Myanmar, Nepal, Vietnam and Thailand

Distribution in Manipur: Chandel, Lunghar, Kamjong, Kangpokpi

Specimen examined: Dolen, 1372; 10/05/2018; Chandel (Modi Village), 24^0 18′ 14.4″ N, 93^0 68′ 26.6″ E: 827.0 metres above sea level.

Ethnobotanical uses: Rhizome is used for cuts and wounds.

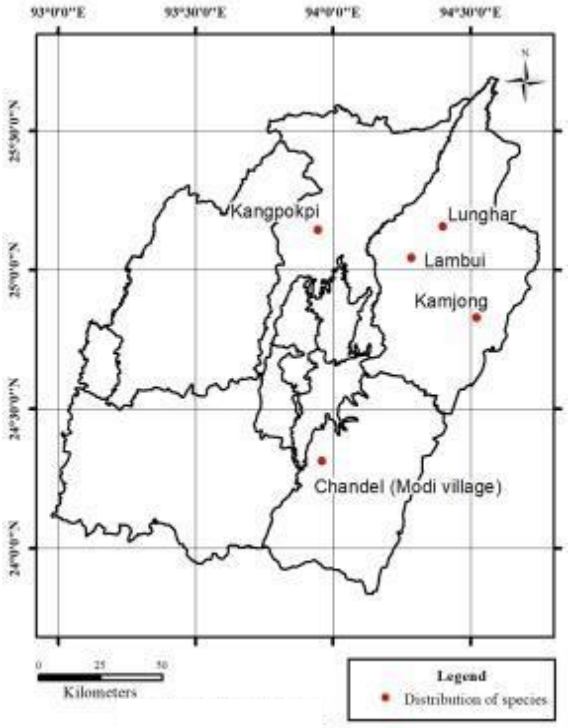


Fig. 4.13: Map showing the distribution of *Dendrobium aphyllum* (Roxb.) C.E.C. Fisch.

Plate 13: *Dendrobium aphyllum* (Roxb.) C.E.C. Fisch.

4.14: *Dendrobium denudans* D. Don, *Prodr. Fl. Nepal.* 34 1825. (Mapwrong*)*

Family: Orchidaceae;

Local Name: *Khajing/Shailengwon* (Tangkhul)

Description: Epiphyte, upto 20 cm tall. Leaves linear ovate to oblong, unequally bilobed, acute, 1.5-5.7 X 0.7-1.2 cm. Inflorescence opposite to leaf or terminal, 4-11 or more flowered. Flowers outer green, inner densely spotted with maroon, 1.9-2.2 X 2 cm. Bracts white to light brown, ovate, acuminate, 1.5-4 X 0.5 mm. Sepals ovate, acuminate, and green, 1.3-1.4 X 0.35-0.7 cm. Petals narrowly ovate, acuminate, green, 1.2 X 0.15 cm. Lip rhomboid, 0.9 x 0.5 cm. Ovary 7-8 X 0.7-1 mm.

Fl. &Fr. :-September to October.

Elevation: 950 to 1850 metres above sea level

Habitat and ecology: Epiphytic Tropical Semi- evergreen forest & Sub- tropical wet hill forest.

Global distribution: - Nepal, India and Thailand

India- Sikkim, Arunachal Pradesh, Nagaland, Mizoram and Manipur

Distribution in Manipur: Khayangbung, Tamenglong, Senapati and Chandel

Specimen examined: Dolen, 1312; 8/10/2017, Tamenglong, 25^0 $1^{/}$ $42.0^{//}$ N, 93^0 $31^{/}$ $43.3^{//}$ E; 1032 metres above sea level

Ethnobotanical uses: Whole plant (100 g) is boiled in 1 litre up to 1/3 of the volume. 10 ml of the decoction is taken thrice daily for 30 days for treatment of stomach ulcers.

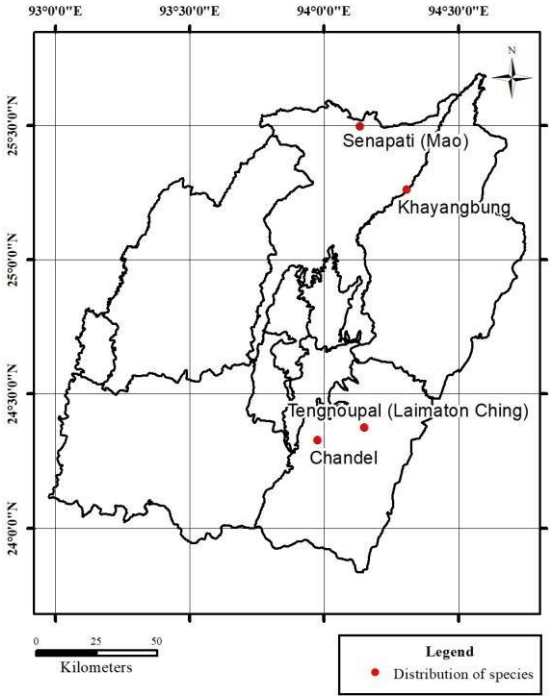


Fig.4.14: Map showing the distribution of *Dendrobium denudans* D. Don

Plate 14: *Dendrobium denudans* D. Don

4.15: *Dendrobium nobile* Lindl, Gen. Sp. Orchid. Pl. 79. 1830.

Family: Orchidaceae;

Local Name*:* Yerumlei (Manipuri)

Description: Epiphytic herb. Stems unbranched, fleshy, contracte at base, 16-35 cm long; Leaves leathery, oblong, margin entire, apex obtuse, unequally bilobed, 7.5-9.5 X 1.6-2.2 cm in size. Inflorescence aring from old stem, 2-5 cm long; Flowers white tinged with purple, bracts ovate lanceolate, upto 14 mm long. Sepals oblong, apex acute, upto 34 cm long. Petals obliquely broadly ovate, apex obtuse, upto 33 cm long; Lip broadly ovate, densely pubescent, larger than petals, upto 34 mm long. Pods are upto 2 X 7.5 cm long.

Fl. & Fr.: April- May

Elevation: 900 to 1800 metres above sea level

Habitat and ecology: Tropical Forest to temperate forests upto 1800 m

Global distribution: Bhutan, Taiwan, China, Myanmar, Nepal, Thailand and India

India- Arunachal Pradesh, Assam, Meghalaya, Sikkim, Manipur and Nagaland

Distribution in Manipur: Senapati (Willong, Mao), Ukhrul (khayangbung), Chandel, Tengnoupal (Moreh areas),

Specimen examined: Dolen, 0250; 5/04/2016; Khayangbung, $25^0$13'90" N, 94^0 44/ 83.0// E; Dolen, 1272; 17/05/2017; Chandel 24^0 19/ 29.0// N, 94^0 0/ 56.0// E; 916 metres above sea level

Ethnobotanical uses: (a) Crushed leaf and flower (60 g) is boiled with 1 litre of water up to 1/4th of the volume; 30 ml of decoction is given, 2-3 times in a day for cough and bronchial disorders.

(b) Purified leaf juice is used on the ear infection and put 3-4 drops of leaf juice at least two times a day for general debility.

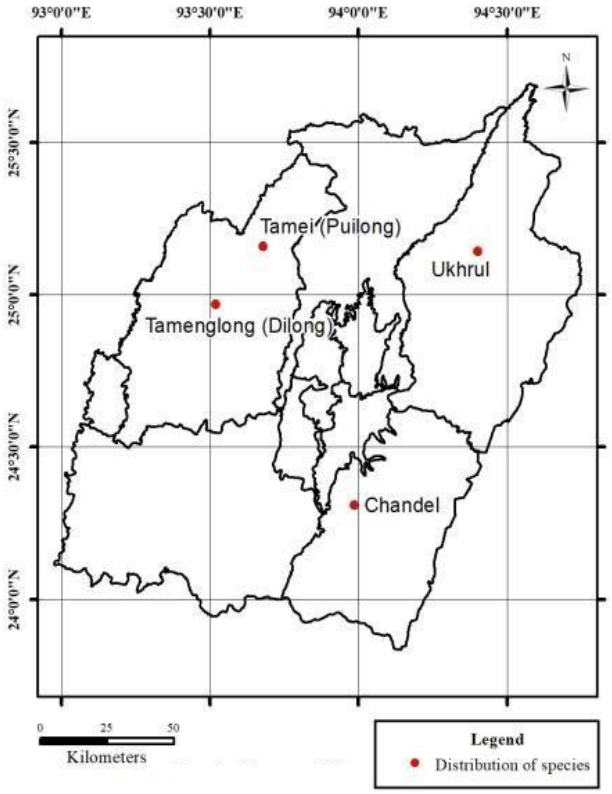


Fig.4.15: Map showing the distribution of *Dendrobium nobile* Lindl.

Plate 15: *Dendrobium nobile* Lindl.

4.16: *Dichroa febrifuga* Lour., Fl. Cochinch. 1:301. 1970

Family: Hydrangeaceae;

Local Name: Barak

Description: Shrub 1-3 m. Leaves elliptic- oblonceolate 12-15 x 3.5-7 cm, acuminate, base cuneate or attenuate, margin serrate, sparsely pubescent on both surface; petioles 1-3.5 cm. Calyx including acute lobes 3-4 mm. Petals elliptic 5-6 x1.5-2.5 mm, pale blue, becoming reflexed. Stamens 5-6 mm purplish; Styles 3-5, c.3 mm, thickened at apex. Berries sub-globose 6-8 mm diameter, metallic blue.

Fl. & Fr.: May to November

Elevation: 900 to 2400 metres above sea level

Habitat & ecology: It is growing mainly in shrub berries and damp places at an altitude of 900 to 2300m.

Global distribution: Bhutan, Taiwan, China, Myanmar, Nepal, Thailand and NE India.

India: Arunachal Pradesh, Assam, Meghalaya, Sikkim, Manipur and Nagaland

Distribution in Manipur: Ukhrul, Tamenglong, Chandel and Tamei (Puilong)

Specimen examined: Dolen, 1612; 12/07/2019, Tamei (Puilong); $25^0\ 0'\ 42.2''$ N, $93^0\ 31'\ 19.4''$ E; 971 metres above sea level

Ethnobotanical uses: Fresh plant part of about 50 g is made into extract, 10 ml of the extract is taken twice daily for 7 days for malaria. Moreover, leaves juice are also used for high fever

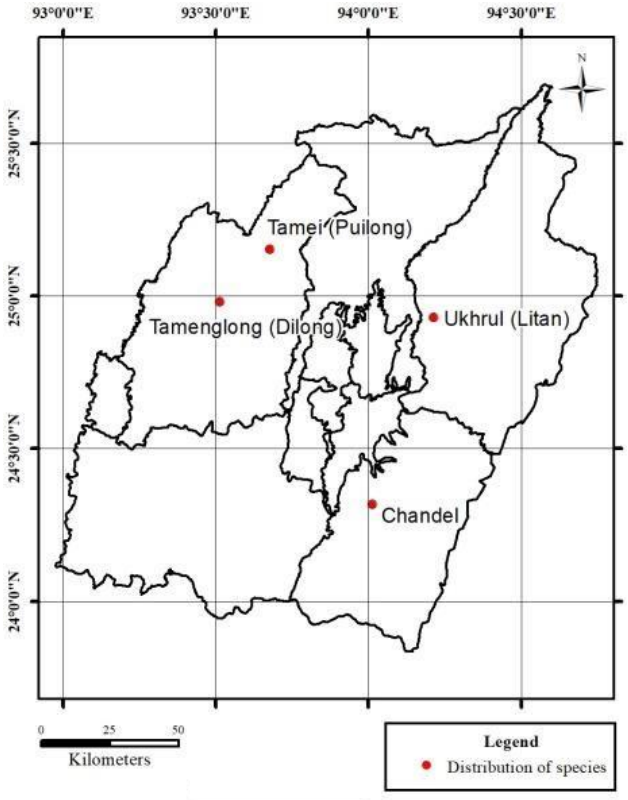


Fig. 4.16: Map showing the distribution of *Dichroa febrifuga* Lour.

Plate 16: *Dichroa febrifuga* Lour.

4.17: *Eleutherine bulbosa* (Mill.) Urb., Report. Spec. Nov. Regni Veg, 15: 305.1918; Godblatt & Snow, Ann. Missouri Bot. Gard. 78(4): 946.1991.

Family: Iridaceae

Local Name: Hoojam / Red Onion (Manipuri)

Description: Perennial bulbous herbs, 50-60 cm high. Bulbs 5-7 cm long and 3-4 cm width, ellipsoid, fleshy, red in colour and acrid; Basal leaves narrowly lanceolate, plicate, entire along the margin, glabrous, many nerved. Stem terete, comprising one long internode, with a large cauline leaf at the apex, subtending the inflorescence. Inflorescence of several stalked rhipidia, the penduncles 2.0-5.5 cm long, borne both in the axil of the cauline leaf and in umbellate fashion on a secondary axis. Spathes green glabrous. Flowers white, stellate, bracts membranous, tepals 6, white, free, in two whorls of three each, outer tepals obovate and inner ones narrowly obovate. Stamens 3, adnate to the outer tepal segment; filaments free, anthers linear to oblong with orange yellow; Ovary obovoid, tricarpellary ovules stalked arranged in axile placentation.

Fl. & Fr.: Feb. to April

Elevation: 900 to1700 metres above sea level

Habitat & ecology: Natural habitat, at an altitude of 1000 to 1800 m above the sea level.

Global distribution: Bangladesh, Bhutan, India, Nepal, Myanmar, Thailand and Vietnam

India: Assam, Tripura and Sikkim

Distribution in Manipur: Chandel, Tengnoupal and Tamenglong.

Specimen examined: Dolen, 1268; 15/05/2017: Chandel, 24^0 $17^/$ $50.3^{//}$ N, 93^0 $58^/$ $26.7^{//}$ E; 830 metres above sea level

Ethnobotanical uses: Tubers of 5-7 numbers are crushed and the juice is collected, a mixture of red onion juice and white alum is applied at the site of the snake bite.

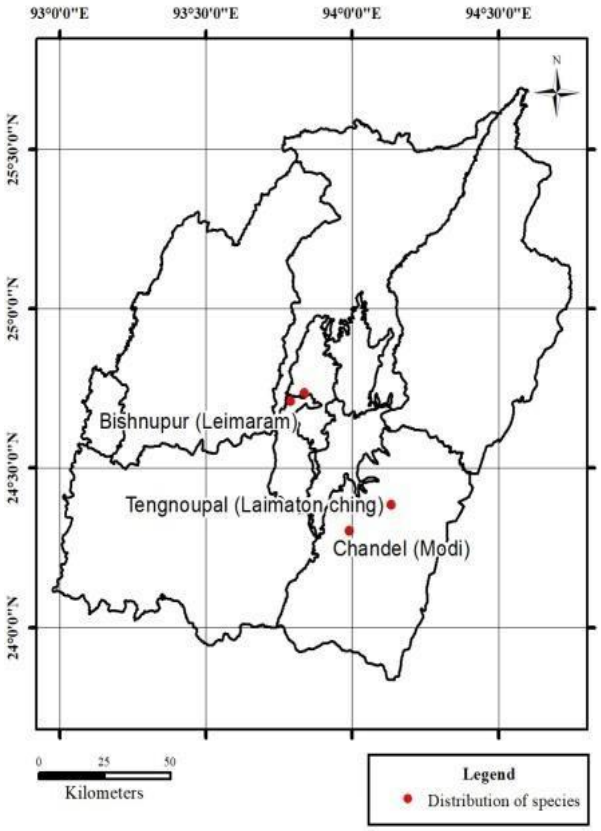


Fig.4.17: Map showing the distribution of *Eleutherine bulbosa* (Mill.) Urb.

Plate 17: *Eleutherine bulbosa* (Mill.) Urb.

4.18: *Eleutherococcus trifoliatus* (L.) S.Y. Hu, J. Arnold Arbor. 61: 110 1980.

Family: Araliaceae;

Local Name: Rangsongthei.

Description: Scandent shrubs, with short recurved prickles, upto 7 m tall. Leaves trifoliate to penta-foliate, leaflets elliptic ovate or oblong, base attenuate, apex acute or acuminate, margin serrulate, upto 10 cm long. Inflorescence umbel, flowers pentamerous, Fruit globose, black, upto 4 mm in size.

Fl. & Fr.: August to December

Elevation: 1100 to 1450 metres above sea level

Habitat & ecology: It is found on the edges of forests and thickets at an altitude of 1000 to 1450 m above sea level.

Global distribution: Bangladesh, Bhutan, India, Nepal, Myanmar and Pakistan

India: Manipur, Assam, Nagaland, Sikkim and Tripura

Distribution in Manipur: Senapati, Kangpokpi, Ukhrul, Shirui & adjacent hills

Specimen examined: Dolen, 1656; 12/10/2019; Senapati, $25^0 30' 10.3''$ N, $94^0 8' 2.3''$ E; 1621 metres above sea level

Ethnobotanical uses: A handful of fresh leaves are boiled with 2 litres of water for 10 minutes; 250 ml of the decoction is used orally taken twice for the treatment of Jaundice

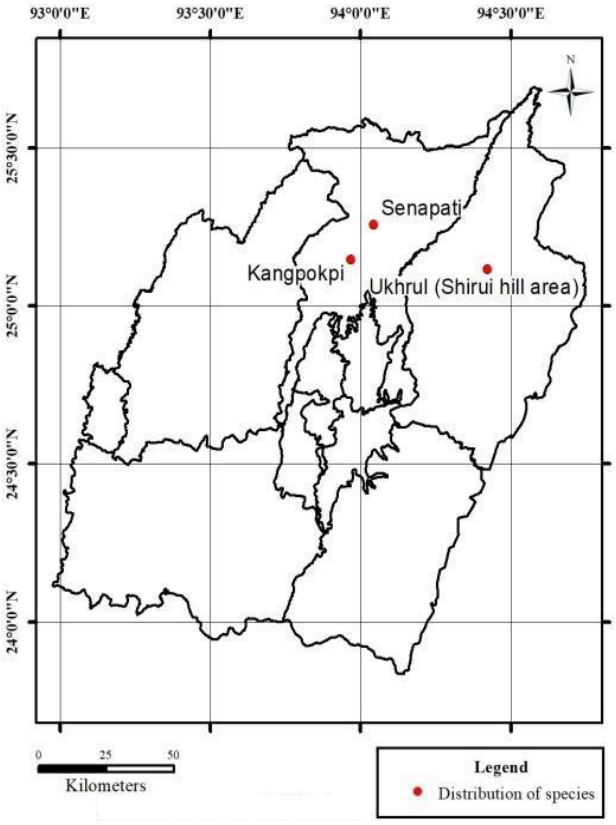


Fig.4.18: Map showing the distribution of *Eleutherococcus trifoliatus* (L.) S.Y. Hu

Plate 18:
***Eleutherococcus trifoliatus* (L.) S.Y. Hu**

4.19: *Eupatorium cannabinum* L. *Sp. Pl.* 838.1753.

Family: Compositae;

Local Name: Langthrei (Manipuri)

Description: Perennial herb, branched with glabrous stem; leaves opposite, stout petiole, lanceolate or elliptic- lanceolate, margin serrate; flowers in small head, phyllarius linear oblong, glabrous, corolla blue; fruits achene, pappus with filiform.

Fl. & Fr.: May to September;

Elevation: 600 to 1200 metres above sea level

Habitat & ecology: It is a woody perennial herb that prefers to inhabit and invade moist habitats such as swamps, marshes and stream banks.

Global distribution: Myanmar, Thailand, Vietnam, India and Indonesia

India: Manipur, Assam, Nagaland and Sikkim

Distribution in Manipur: Heingang, Kakching, Noney, Lamka and Ukhrul

Specimen examined: Dolen, 1279, 15/06/2017; Heingang, 24^0 $51^{/}$ $23.8^{//}$ N, 93^0 $56^{/}$ $40.8^{//}$ E; 762 metres above sea level

Ethnobotanical uses: A handful of fresh leaves are crushed; 50 ml of the Juice is used in stomach ulcer.

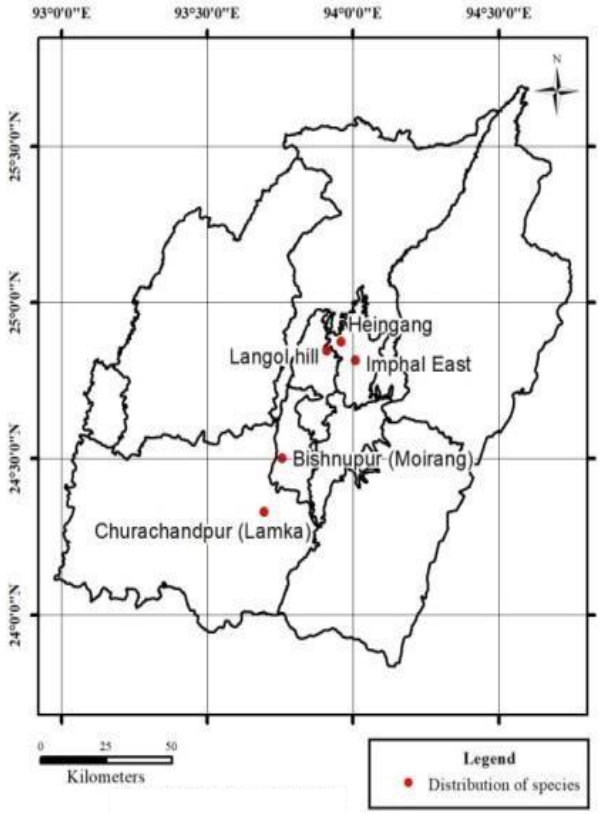


Fig.4.19: Map showing the distribution of *Eupatorium cannabinum* L.

Plate 19: *Eupatorium cannabinum* L.

4.20: *Eurya acuminata* DC. *Prodr.*1: 525. 1824.

Family: Pentaphylacaceae;

Local Name: Sijou. (Manipuri)

Description: Evergreen shrubs or small trees, with dark brown bark, upto 14 m tall. Leaves alternate, lanceolate or oblong lanceolate, base cuneate, apex acute to acuminate, margin serrate or serrulate, upto 9 cm long. Flowers are axillary, unisexual, white, 4 mm in diameter; Fruits globose, black, 5 mm in diameter.

Fl. & Fr.: Whole Year

Elevation: 1000 to1900 metres above sea level

Habitat & ecology: It is mainly found in tropical and subtropical thickets forests, at an altitude of 1000 to 1800 m above sea level.

Global distribution: Thailand, China, Myanmar, Bhutan and Thailand

India: Manipur, Nagaland, Sikkim and Meghalaya

Distribution in Manipur: Senapati, Mao, Maram and Kangpokpi

Specimen examined: Dolen, 0262; 25/05/2016; Kangpokpi, 25^0 $1^/$ $25.6^{//}$ N. 94^0 $0^/$

$56.0^{//}$E, 788 metres above sea level

Ethnobotanical uses: A handful of the leaves are boiled in 2 litres up to 1/3 rd of the volume. 20 ml of decoction used twice daily for 3 days for treatment of respiratory problems.

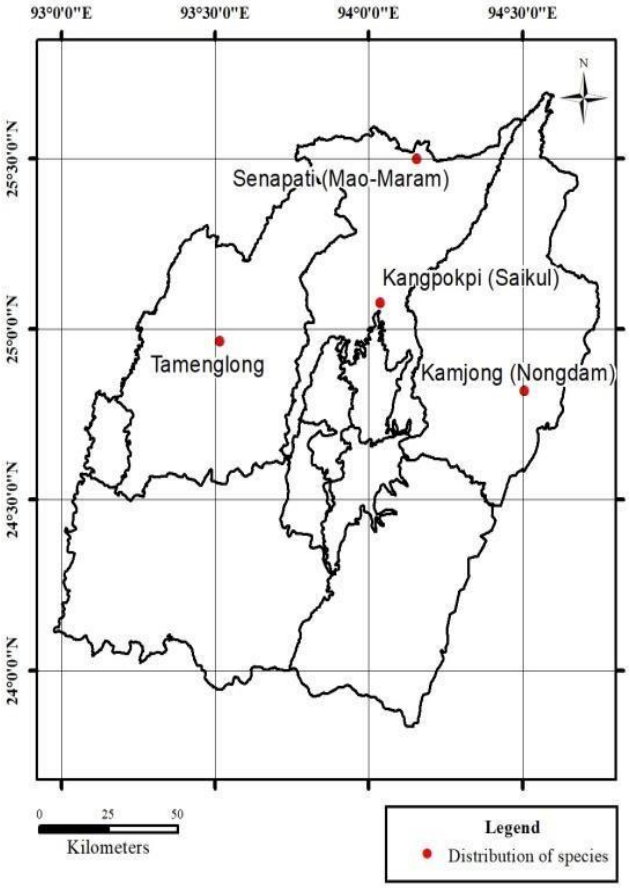


Fig. 4.20: Map showing the distribution of *Eurya acuminata* DC.

Plate 20: *Eurya acuminata* DC.

4.21: *Flacourtia jangomas* (Lour.) Raeusch. Nomencl. Bot. ed. 3: 2901797.

Family: Salicaceae;

Local Name: Heitroi. (Manipuri)

Description: Shrub or tree, with spiny trunk, up to 12 m tall. Leaves alternate, ovate-lanceolate, base rounded or obtuse, apex acuminate, margin serrate or crenate, up to 10X5 cm. Racemes axillary; flowers white to whitish green, scented, up to 4 mm long. Fruits are blackish, up to 2.5 cm in diameter.

Fl. & Fr.: April to October Fl: March – April;

Fr: - August –September.

Elevation: 600 to 1300 metres above sea level

Habitat & ecology: Wild, it is found near swamp forest margins at an altitude around 600 to 1300 m above the sea level

Global distribution: Bangladesh, Bhutan, India, Nepal and Myanmar

India: Assam, Arunachal Pradesh, Nagaland and Manipur

Distribution in Manipur: Langol hill, Phayeng, Chandel, Ukhrul and Yaingoupokpi, Thoubal

Specimen examined: Dolen, 0245; 8/04/ 2016; Langol hill, 24^0 $52^/$ $10.7^{//}$ N, 93^0 $53^/$ $58.1^{//}$ E; 808 metres above sea level

Ethnobotanical uses: a) Bark (200 g) is boiled in 3 litres for 30 minutes; bark infusion is used as gargle for sore throat

b) Washed with clean water and pounded and made into paste, it is applied on bleeding gums and toothache, Fruits are used as astringent.

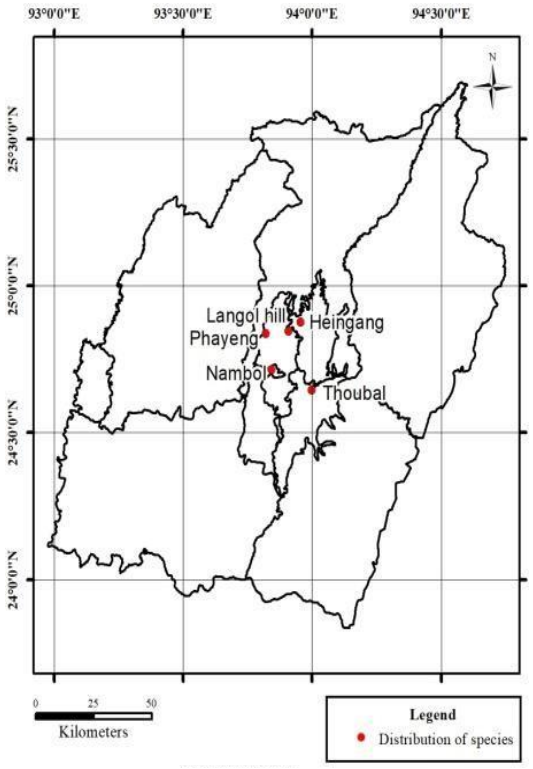


Fig.4.21: Map showing the distribution of *Flacourtia jangomas* (Lour.) Raeusch.

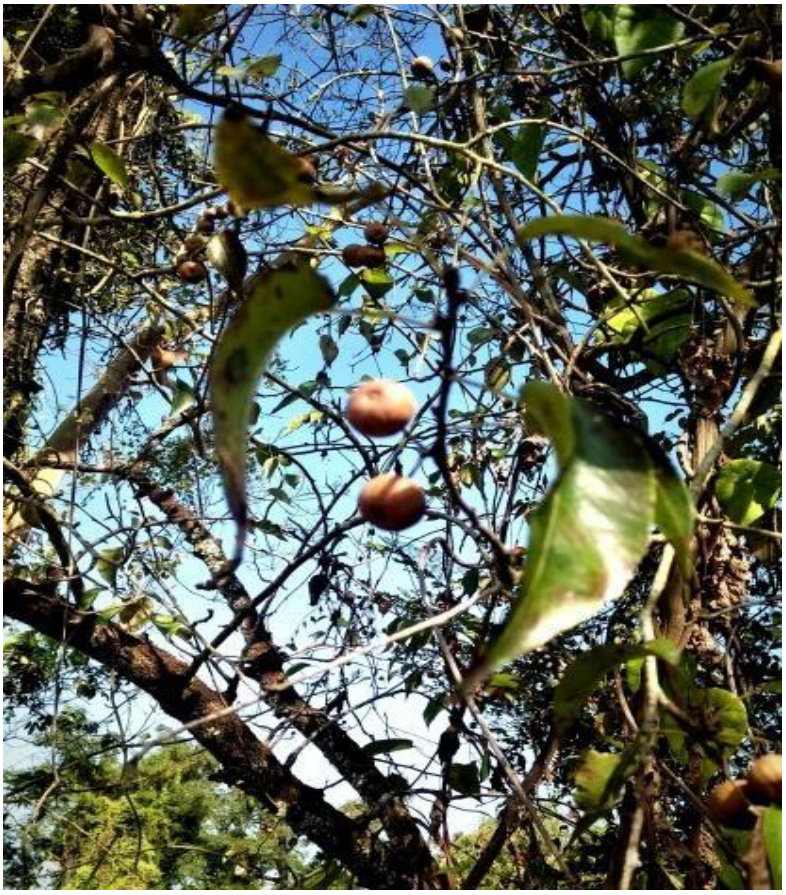


Plate 21:*Flacourtia jangomas* (Lour.) Raeusch.

4.22: *Garcinia pedunculata* Roxb. ex Buch.-Ham. Edinburgh. J. Sci. 7:45, 1827.

Family: Clusiaceae;

Local Name: Heibung/ pongthai (Manipuri)

Description: Monoecious or dioecious, with smooth greyish brown trees, yellow-coloured resins, upto 20 m tall. Leaves petiolate, obovate or oblong-lanceolate, apex obtuse, base cuneate, upto 40X15 cm; Male flowers yellow, stamens numerous, upto1 cm in diameter. Female flowers bracteate, yellow or pale green, staminodes united at base, upto 2 cm in diameter. Fruits globose, smooth, yellow, upto 15 cm in diameter.

Fl. & Fr: Sept to Jan.

Elevation: 700 to 1200 metres above sea level

Habitat and ecology: Tree, Tropical semi-evergreen forest and evergreen forest

Global distribution: Global- Bangladesh, Bhutan, India, Nepal, Myanmar and Thailand

India- Assam, Arunachal Pradesh, Nagaland, Manipur, Meghalaya and Tripura

Distribution in Manipur: Ukhrul, Senapati, Tamenglong and Chandel

Specimen examined: Dolen-1648, 23/10/2019; Ukhrul 25^0 $07'$ $34.59''$ N, 94^0 $25'$ $12.99''$ E; 1803 metres above sea level

Dolen, 0315;18/06/2016; Tamenglong $24^0 59^{/} 23.3^{/\,/}$ N, $93^0 30^{/}$ $4.3^{//}$ E; 1163 metres above sea level

Ethnobotanical uses: a) Dry fruit (5-10 g) or 40-60 g fresh fruit is boiled in 2 litres of water up to 1/3rd of its volume; 250 ml of the decoction is taken twice for 7 days for urinary problems.

b) Slightly roasted fruit pulp is collected; it is applied as porridge on affected area for treatment of gout. Moreover, pulp mixed with mustard oil massage for paralysis and muscles related problems.

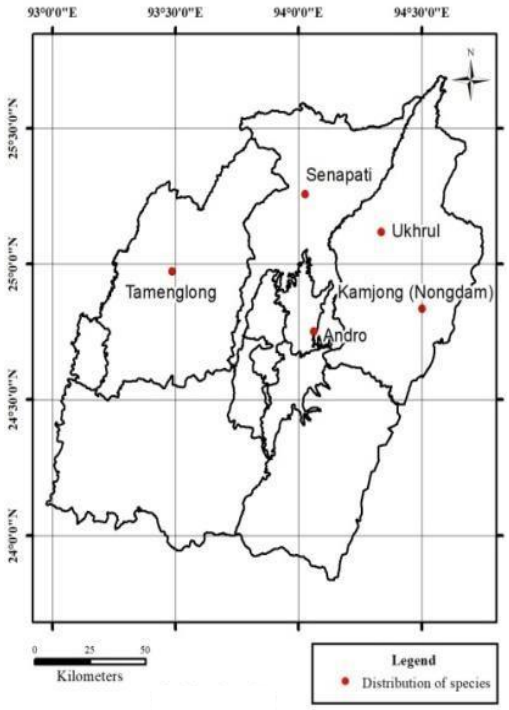


Fig. 4.22: Map showing the distribution of *Garcinia pedunculata* Roxb.

Plate 22: *Garcinia pedunculata* Roxb.

4: 23. *Garcinia xanthochymus* Hook.f. ex T. Anderson *Fl. Brit. India 1: 269 1874.*

Family- Meliaceae;

Local Name- Heirangkhoi (Manipuri)

Description: Medium sized trees, 10- 15 cm high. Leaves 30- 75 cm long; leaflets 7-19, 8- 25x 3.5- 8 cm, oblong, ovate-oblong, lanceolate to obliquely lanceolate, acute, Male flowers in panicles, female flowers in racemes, up to 30 cm long. Flowers are yellow or dull white, yellow when ripe, seed red and arillate.

Fl. & Fr.: May to Sept.

Elevation: 900 - Above metres above sea level

Habitat & ecology: It is found growing very scarcely at forest margin at an elevation up to 1500 m

Global distribution: Myanmar, Nepal, Taiwan, India, Thailand, Bhutan, China and Pakistan.

India: Manipur, Assam, Arunachal Pradesh and Sikkim.

Distribution in Manipur: Tangjeng, Phayeng, Bishnupur, Imphal East, Thoubal and Senapati

Specimen examined: Dolen, 1502; 23/09/2018; Tangjeng, $24^0 19' 3.4''$ N,

$93^0 51' 26.7''$ E; 719 m

Ethnobotanical uses: Bark is pounded and juice is taken and the juice is applied externally to the affected skin to reduce bleeding and minor abrasions and 100 gm of the bark is boiled in 2 litres of water for 30 minutes. The decoction is used for treatment of liver problems.

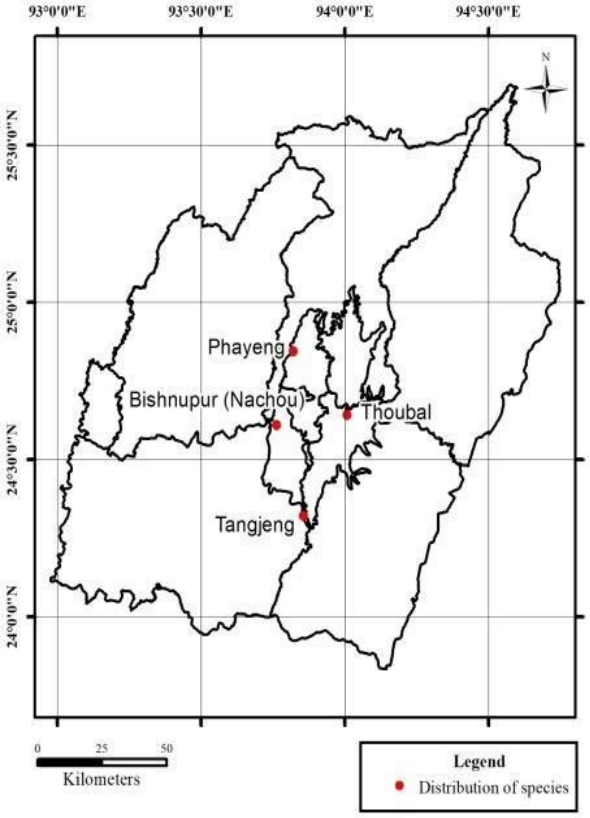


Fig.4.23: Map showing the distribution of *Garcinia xanthochymus* Hook. f. ex T. Anderson

Plate 23: *Garcinia xanthochymus* Hook.f.ex T. Anderson

4.24 : ***Glochidion coccineum*** **(Buch.-Ham.) Müll. Arg., Linnaea. 32: 60.1863.**

Family: Phyllanthaceae;

Local Name: Ningthourembi (Manipuri)

Description: Shrubs, upto2.5 m tall. Stipules lanceolate; Leaves leathery, oblong, acute, upto 10 X 5 cm in size; Inflorescence axillary; male flowers at lower axils, female at upper axils; sepals 6, arranged in two whorls, yellow, upto 0.6 cm long; pedicels negligible in female flowers. Fruit capsule, depressed, 0.8 X 1.4 cm in size.

Fl. &Fr.: July to September

Elevation: 650 to 1600 metres above sea level

Habitat & ecology: Wild species are found near forest margins at an altitude, 700 to 1600 m above the sea level.

Global distribution: Nepal, Bhutan, Myanmar and Thailand

India: Nagaland, Manipur, Arunachal Pradesh, Sikkim and Mizoram

Distribution in Manipur: Nachou, Chandel and Imphal east, Heingangching

Specimen examined: Dolen, 1299; 25/ 08/2017; Heingangching, 24^0 $51^/$ $25.2^{//}$ N, 93^0 $56^/$ $41.7^{//}$ E; 767 metres above sea level

Ethnobotanical uses: A handful of fresh reddish young leaves are collected and washed thoroughly with clean water; young fresh leaves are taken orally used as aphrodisiac.

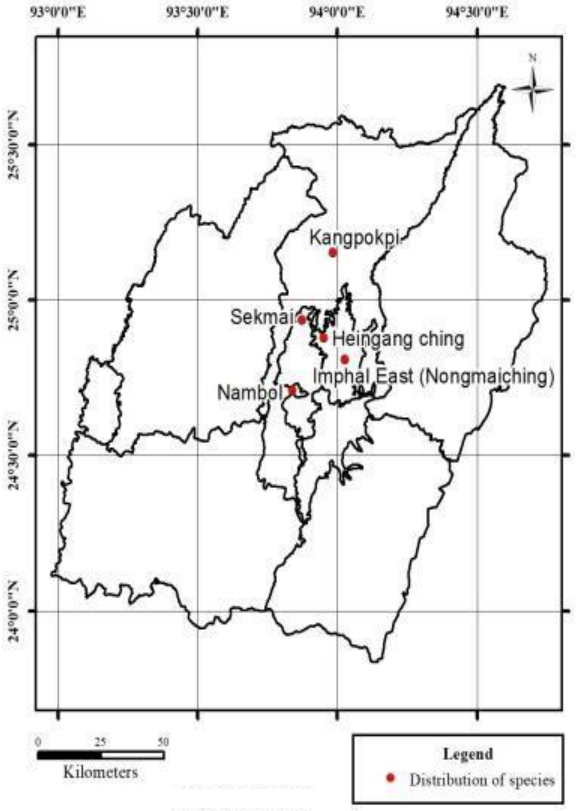


Fig. 4.24: Map showing the distribution of *Glochidion coccineum* (Buch.-Ham.) Müll.Arg.

Plate 24: *Glochidion coccineum* (Buch.-Ham.)Mull. Arg.

4.25: *Hedychium spicatum* Smith in Rees, Cycl. 17: Hedychium no. 3. 1811.

Family: Zingeberaceae;

Local Name: *Takhellei* (Manipuri)

Description: Perennial rhizomatous herb, upto 1.5 m tall. Leaves oblong lanceolate, apex acuminate, base acute, margin entire, glabrous above, pubescent beneath, upto 40 X10 cm in size. Spikes dense flowered, upto 30 cm long. Flowers pale yellow, fragrant, with oblong bracts, upto 10 cm long. Calyx 3 toothed, tubular, upto 3 cm long. Corolla pale yellow; lobes equal, lanceolate, apex acute; labellum deeply bilobed, yellow, with red blotch at base, obovate; corolla tube slender, upto 6.5 cm long Stamens shorter than the lobes, filaments pale red; anther linear; ovary trilocular, glabrous. Fruits are globose upto 2.5 cm in diameter.

Fl. & Fr.: August to December

Elevation: 900 to 2100 metres above sea level

Habitat and ecology: It is grown in subtropical to tropical forest, mainly in foothills and shady moist areas at an elevation up to 2100 metres above sea level.

Global distribution: Myanmar, Bhutan, Bangladesh, China, Thailand and India

India- Nagaland, Manipur, Arunachal Pradesh, Sikkim and West-Bengal

Distribution in Manipur: Senapati, Chandel, Tamenglong, Thoubal, Bishnupur, Imphal east and west.

Specimen examined: Dolen-1463,12/08/2018, Chandel 24^0 $19^{/}$ $29.4^{//}$ N, 94^0 $1^{/}$ $0.6^{//}$ E; 915 metres above sea level; Dolen, 0190; 15/11/ 2015; Mao- Maram, 25^0 $28^{/}$ $44.2^{//}$ N, 94^0 $8^{/}$ $13.1^{//}$ E; 1618 metres above sea level

Ethnobotanical uses: a) Sliced rhizome of 50 g is boiled in 1 litres of water making the volume up to 1/3; 250 ml of the decoction twice daily for 7 days for blood purification or as tonic.

b) Fresh rhizome is pounded and the juice is taken; the extract is used for gastrointestinal complaints.

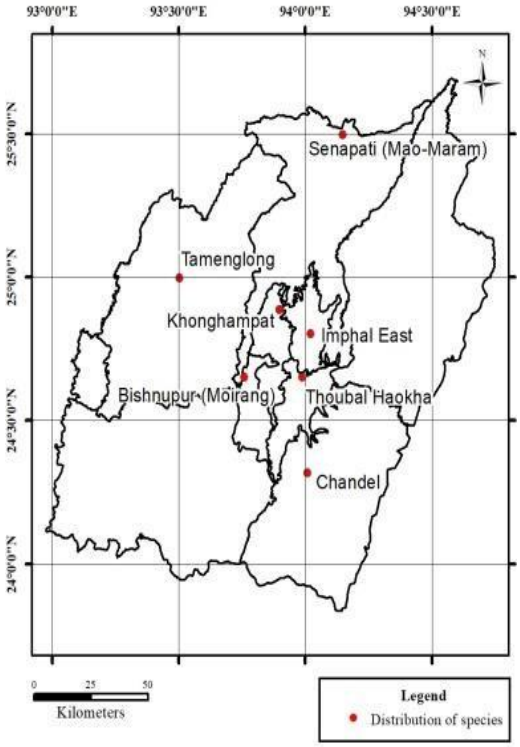


Fig. 4.25: Map showing the distribution of *Hedychium spicatum* Sm.

Plate 25: *Hedychium spicatum* Sm.

4.26: *Hippochaete debilis* (Roxb. ex Vaucher) Ching in Fl. Xizang.1: 29 1983.

Family: Equisetaceae

Local Name: *Lai- Utong* (Manipuri)

Description: Branched or unbranched, erect or creeping herbs with brown trichomes at nodes and roots, upto 200 cm tall. Internodes ridged, upto 10 cm long. Sheaths green to blackish brown, 5 mm long; teeth membranous, leathery. Strobilus sessile, solitary, terminal, shortly clavate or ellipsoid with yellowish sporangia, upto 2.5 cm long.

Fl. & Fr.: Spore during September - November

Elevation: Upto 800 metres above sea level

Habitat and ecology: It is found in moist shady exposed areas near waterfalls and streams.

Global distribution: Bangladesh, Bhutan and India.

India: Nagaland, Arunachal Pradesh, Assam, Tripura and Manipur

Distribution in Manipur: Heingang, Andro, Tamenglong, Thoubal and Chandel

Specimen examined: Dolen, 0568; 12/08/2016; Andro, $24^0\ 45^/\ 21.0^{//}$ N, $94^0\ 2^/\ 3.7^{//}$

E; 782 metres above sea level

Ethnobotanical uses: a) Fresh whole plant is crushed and the juice is collected; required amount of the juice is applied and massage for backache, arms and joins to get relief of pains

b) A handful is boiled in 3 litres of water up to 1/3 of the volume; 100 ml of decoction is taken orally twice daily for 7 days for treatment of gonorrhea.

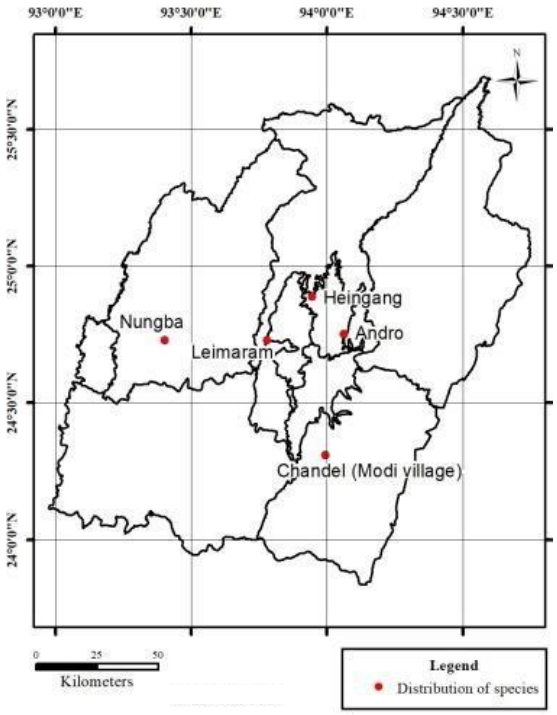


Fig. 4.26: Map showing the distribution of *Hippochaete debilis* Roxb.ex Vaucher

Plate 26: *Hippochaete debilis* Roxb.ex Vaucher

4.27: *Homalomena aromatica* (Spreng.) Schott in Schott & Endlicher, Melet. Bot. Dc 20.1832.

Family- Araceae;

Local Name: Honghoo- kaklamanbi (Manipuri)

Description: Shade loving aromatic rhizomatous herb, up to 80 cm tall. Leaves cordate, base sagittate, apex acute to acuminate; petiole upto 36 cm long. Inflorescence 1-2; spathe upto 10 cm; spadix cylindric, upto 9 cm long; Fruits are yellowish orange.

Elevation: Up to 800 metres above sea level

Habitat & ecology: It is found in moist shady forest floor, tropical semi-evergreen forest & sub- tropical wet hill forest. Wild habitat in the Jiribam sub-division, South-eastern part of Tamenglong district and North western part of Churachandpur district of Manipur.

Global distribution: Bangladesh, Bhutan and India.

India: Nagaland, Arunachal Pradesh, Assam, Tripura and Manipur.

Distribution in Manipur: Churachandpur, Jiribam, Monsang, Tamenglong, Senapati and Chandel.

Specimen examined: Dolen, 1489; 18/ 09/2018; Tamenglong, 25^0 $0'$ $52.5''$ N, 93^0 $31'$ $23.5''$ E; 966 metres above sea level

Ethnobotanical uses: Rhizome is pounded and the juice is extracted, it is applied on affected area for treating joint-pain and inflammation.

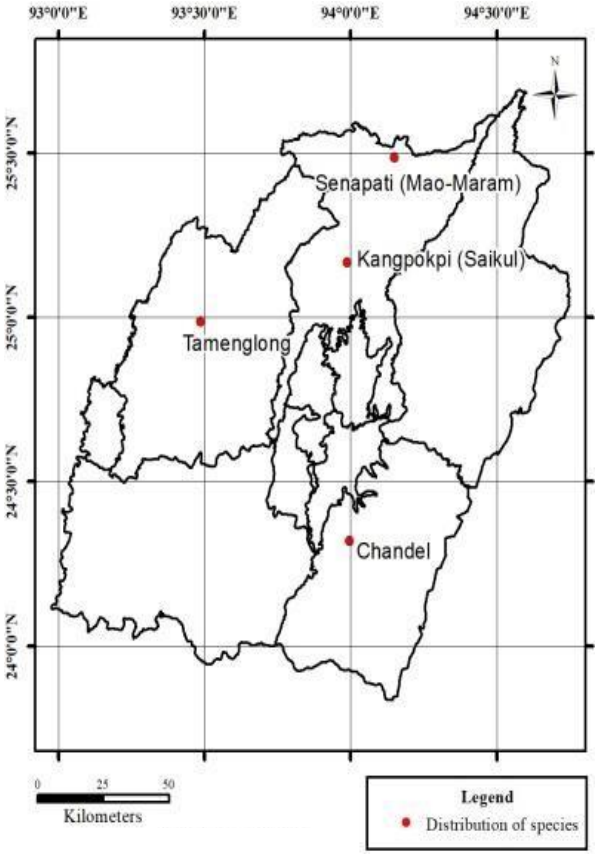


Fig. 4.27: Map showing the distribution of *Homalomena aromatica* (Spreng.) Schott

Plate 27: *Homalomena aromatica* (Spreng.) Schott

4.28: *Lilium mackliniae* Sealy in J. Roy. Hort. Soc. 74: 349. 1949.

Family: Liliaceae;

Local Name: Shirui Timrawon (Tangkhul); Siroi Lily (Manipuri)

Description: Shade loving herb, 1-3 feet tall. Bulb fleshy, ovoid, up to 2.5 cm long. Leaves sessile, elliptic, apex acute, upto 2.7 X 0.9 cm. Flowers campanulate, pale purplish pink, up to 3.5 cm long. Perianth elliptic, apex acute, up to 3.4 cm long; Stamens 6, filaments greenish, up to 1.5 cm long; Ovary 3 lobed, green, oblong, up to 0.8 cm long.

Fl. & Fr.: May to July

Elevation: 1300 to 2200 metres above sea level

Habitat and ecology: It grow along with grassy hill slope at an elevation 1800 m above.

Global distribution: India (Manipur)

India: Only Manipur

Distribution in Manipur: Only in Shirui hill.

Specimen examined; Dolen, 1289; 10/07/2017; Shirui hill, 25^0 7/ 17.8//N, 94^0 26/ 31.8// E; 2110 metres above sea level

Ethnobotanical uses: About 100-200g fleshy rhizome is boiled in 1 litre of water for 30 mins, decoction of 50ml is taken twice daily for 1 week in stomach troubles.

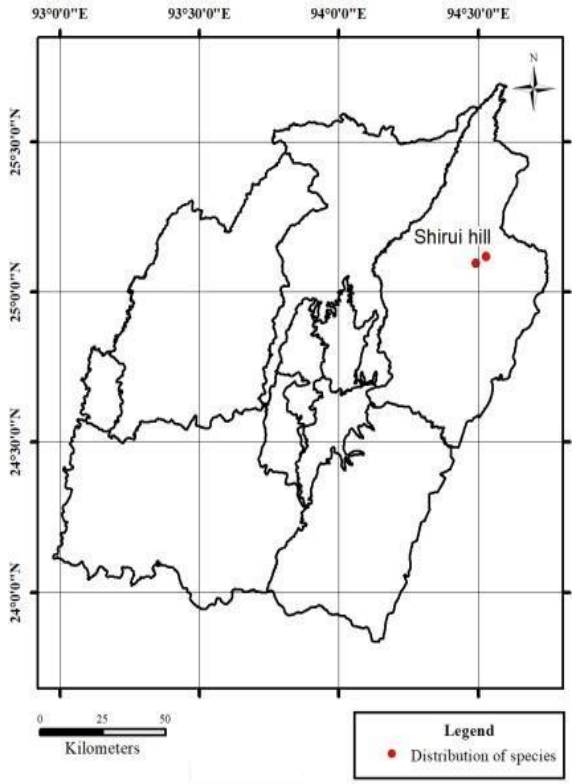


Fig.4.28: Map showing the distribution of *Lilium mackliniae* Sealy

Plate 28: Lilium *mackliniae* Sealy

4.29: *Litsea cubeba* (Lour.) Pers. Syn. Pl. 2: 4 1806.

Family: Lauraceae;

Local Name: Ngairong (Manipuri)

Description: Evergreen aromatic tree, up to 10 m tall. Leaves lanceolate, base cuneate, apex acuminate, margin entire, up to 15 X 4 cm. Inflorescence umbel; flowers unisexual, white. Fruits pepper like, globose, black, up to 5 mm in diameter.

Fl. &Fr.: April to August

Elevation: 700 to 1850 metres above sea level

Habitat & ecology: It is found in subtropical wet hill forest and moist mixed deciduous forest at an elevation up to 1800 metres above sea level.

Global distribution: Nepal, Bhutan, Myanmar, Indonesia, Malaysia and India.

India: Arunachal Pradesh, Sikkim, Meghalaya, Nagaland, Mizoram and Manipur

Distribution in Manipur; Andro, Pallel, Kamjong, and Phayeng

Specimen examined: Dolen, 1452; 7/ 07/ 2018; Phayeng, 24^0 $51^{/}$ $7.6^{//}$ N, 93^0 $47^{/}$ $57.5^{//}$ E; 858 metres above sea level

Ethnobotanical uses: (a) Fruit (5 g) is pounded and the extract is mixed with little honey; 5 ml of the infusion is taken twice daily for respiratory problems

(b) Fruit (5 g) is pounded and crushed; the crushed fruit is heated in sesame oil, and then applied over the skin to control mosquito bites, leech bites and other insect's bites.

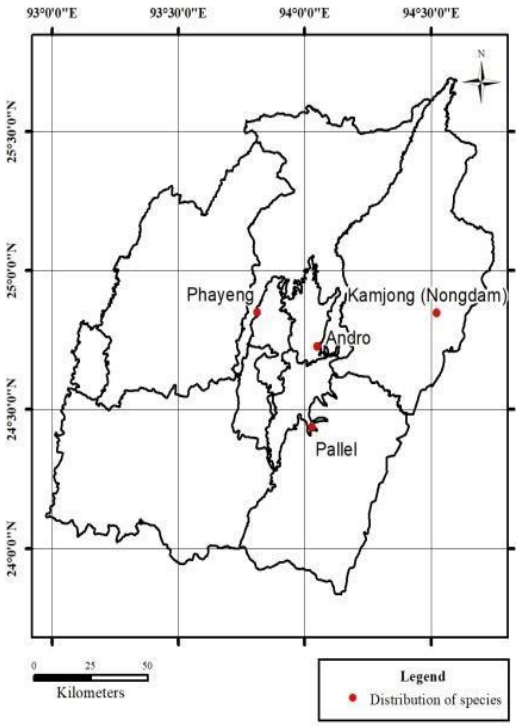


Fig. 4.29: Map showing the distribution of *Litsea cubeba* Lour.

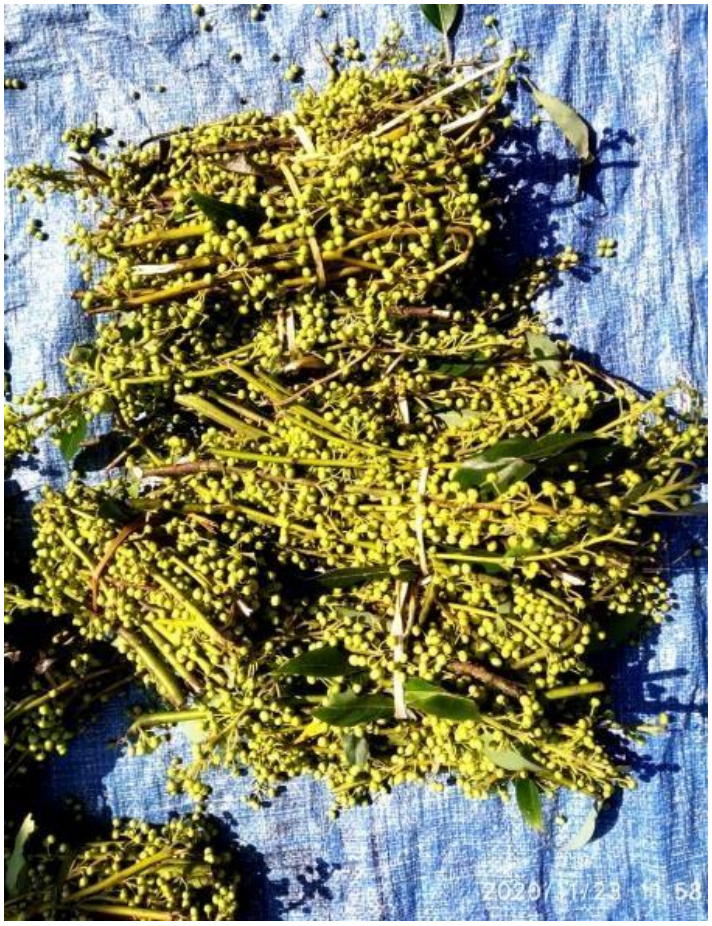


Plate 29: *Litsea cubeba* Lour.

4.30: *Litsea glutinosa* (Lour.) C.B. Rob., Philipp. J. Sci., C 6: 321 1911.

Family: Lauraceae;

Local Name: *Thang- hidak* (Manipuri)

Description: Evergreen or deciduous trees, 3-15 m tall. Young branchlets are gray-yellow velvety. Alternately arranged leaves are carried on 1-2.6 cm long gray-yellow velvety stalks. Leaves are mostly elliptic but variable, 7-15 x 3-7 cm, velvety on both surfaces when young, lateral veins 5-12 pairs. Leaf base is wedge- shaped blunt or rounded, tip blunt or shortly tapering. Flowers are borne in solitary or several, few-flowered umbels on short branchlets. Stalks carrying the umbels are 1-1.5 cm. Male flowers have petals imperfect or missing. Fertile stamens are often 15 or more. Fruit is round, 5-7 mm in diameter; fruit-stalk is 3-6 mm, slightly thickened at the top.

Fl. & Fr: May to June.

Elevation: 550 to 1200 metres above sea level

Habitat & ecology: Open Forest areas and forest margin

Global distribution: China, Malaysia, Philippines, Australia

India: North -Eastern states of India

Distribution in Manipur; Pallel, Phayeng, Nongdam, Ukhrul and Kakching Khunou

Specimen examined: Dolen, 1609; 17/ 06/2019; Kakching Khunou, 24^0 $21^/$ $58.24^{//}$N, 94^0 $11^/$ $27.63^{//}$ E; 802 metres above sea level

Ethnobotanical uses: The root bark and leaves are used medicinally to reduce fever, reduce swelling, and treat diarrhoea. The leaves, and the mucilage in the gum from the bark, have been used for making poultices. The pounded seeds are applied externally against boils.

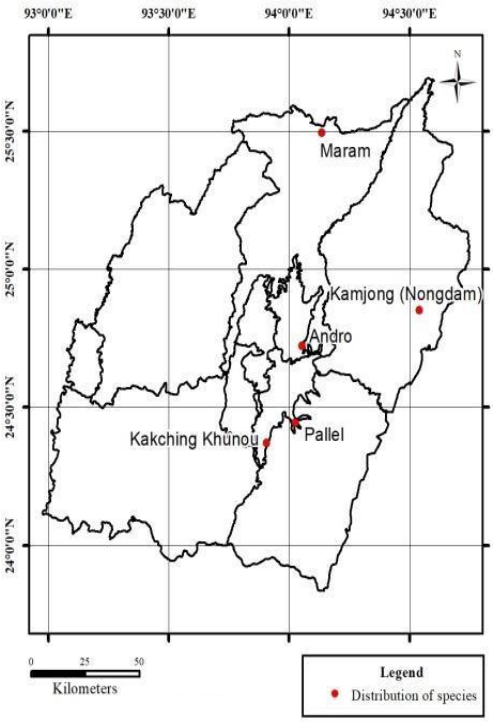


Fig. 4.30: Map showing the distribution of *Litsea glutinosa* (Lour.) C.B. Rob.

Plate 30 :*Litsea glutinosa* (Lour.) C.B. Rob.,

4.31: *Lobelia nummularia* Lam. Encycl. 3: 589. 1792.

Family: Campanulaceae

Local Name: Nungai- piruk (Manipuri)

Description: Prostrate herbs or subshrubs, up to 45 cm tall. Leaves petiolate, lobed or unlobed, ovate, triangular or saittate-lanceolate, apex acute, base cordate, margin entire, upto 4 cm long; Flowers hairy, pedicellate, yellow, axillary, upto1.5 cm long, with 5 mm long spurs; Capsule is ovoid or sub-globose, up to 5 mm long.

Fl. & Fr.: October – March

Elevation: 900 to 1800 metres above sea level

Habitat & ecology: Wild species occurs in rock crevices at an altitude of 900 to 1800 m.

Global distribution: Myanmar, Nepal, Thailand, Vietnam and NE India.

India: Nagaland, Assam, Meghalaya, Sikkim, Manipur and Tripura

Distribution in Manipur; Imphal- East, Thoubal, Bishnupur, Kaina, Langol hill & Senapati

Specimen examined: Dolen, 1725; 15/06/ 2020; Thoubal, 24^0 $29'$ $51.18''$ N, 93^0 $59'$ $03.12''$ E; 811 metres above sea level

Ethnobotanical uses: Handful of the plant is boiled in 3 litres up to 1/3 of the volume; 250 ml of the decoction is taken twice for 14 days to cure urinary stone cases.

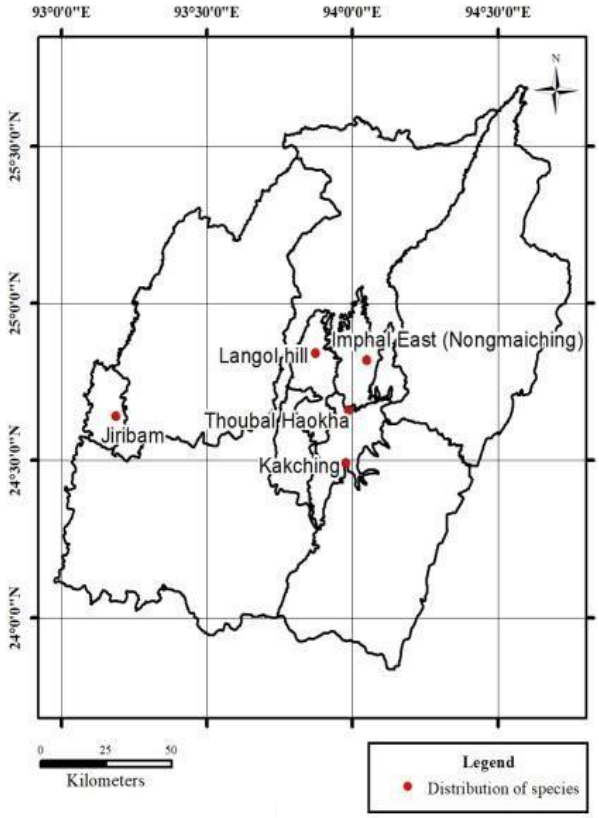


Fig. 4.31: Map showing the distribution of *Lobelia nummularia* Lam.

Plate 31: *Lobelia nummularia* Lam.

4.32: *Mahonia napaulensis* DC. *Syst. Nat.* 2: 21. 1821.

Family- Berberidaceae;

Local Name: *U-napu/ Yaingan- machurong*. (Manipuri)

Description: An evergreen shrub or small trees with light brown bark, 1.5-8 m tall. Leaves compound, stipulate; leaflets sessile, ovate lanceolate, apex acute to acuminate, base cuneate or rounded, toothed, 1.5-9 X1-5 cm. Racemes up to 40 cm long. Flowers yellow, 0.8 cm long; bracts ovate lanceolate, 0.2-0.5 cm long; sepals ovate to elliptic oblong, 0.2-0.5 X 0.1-0.4 cm; petals elliptic oblong, 0.35-0.65 X0.15-0.3 cm; stamens free. Berry bluish black, globose to oblong, 0.8 cm in diameter.

Fl. & Fr.: April to October

Elevation: 1200 to 2300 metres above sea level

Habitat and ecology; It is found in tropical semi evergreen forest, moist deciduous forest & wet hill forest.

Global distribution; Bhutan, India, Myanmar and Nepal

India: Nagaland, Manipur and Assam

Distribution in Manipur: Chandel, Tamenglong (Dailong), Senapati and Ukhrul.

Specimen examined; Dolen, 1318; 26/10/2017; Tamenglong (Dailong), 25^0 $01^/$ $41.42^{//}$ N, 93^0 $35^/$ $48.46^{//}$ E; 946 metres above sea level

Ethnobotanical uses: Shoot (50 g) is mixed in 1 litre of water is boiled up to ½ of the volume; the decoction is used as diuretic and anti-dysenteric.

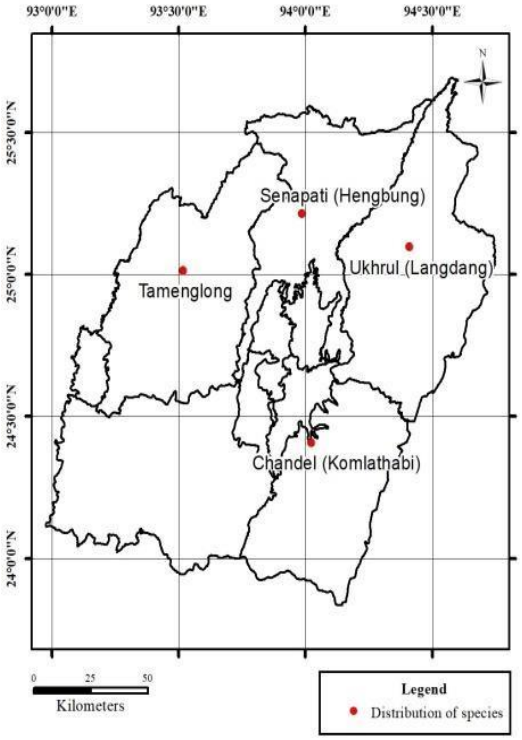


Fig.4.32: Map showing the distribution of ***Mahonia napaulensis* DC.**

Plate 32: *Mahonia napaulensis* DC.

4.33: *Millettia pachycarpa* Benth.in Miquel, Pl. Jungh. 250. 1852.

Family: Fabaceae;

Local Name: Ngamuyai (Manipuri)

Description: Shrubs or trees, with yellowish brown bark, up to 12 m tall. Leaves foliolate, up to 30 cm long; leaflets, elliptic oblong or lanceolate oblong, base cuneate, apex acute, margin entire, up to 10 cm long. Inflorescence is axillary; flowers white, 1.5 cm long. Legumes dark brown, up to 15 cm long; seeds dark brown, reniform.

Fl. & Fr.: March to December

Elevation: 900 to 1800 metres above sea level

Habitat & ecology: It is found near river bank, forest edges, at an elevation upto1800 metres above sea level.

Global distribution: Bangladesh, Bhutan, India, Myanmar, Nepal and Thailand

India: Manipur, Assam, Nagaland, Meghalaya and Sikkim

Distribution in Manipur: Chandel, Tengnoupal, Lai-maton-ching, Tamenglong and Senapati.

Specimen examined: Dolen, 1515; 13/ 11/ 2018; Lai Maton Ching, 24^0 $22^/$ $53.34^{//}$ N, 94^0 $08^/$ $44.25^{//}$ E; 1107 metres above sea level

Ethnobotanical uses: Handful of roots and stem are pounded and the juice is collected, then Collected juice is applied externally thrice daily till recovery for dermatological problems.

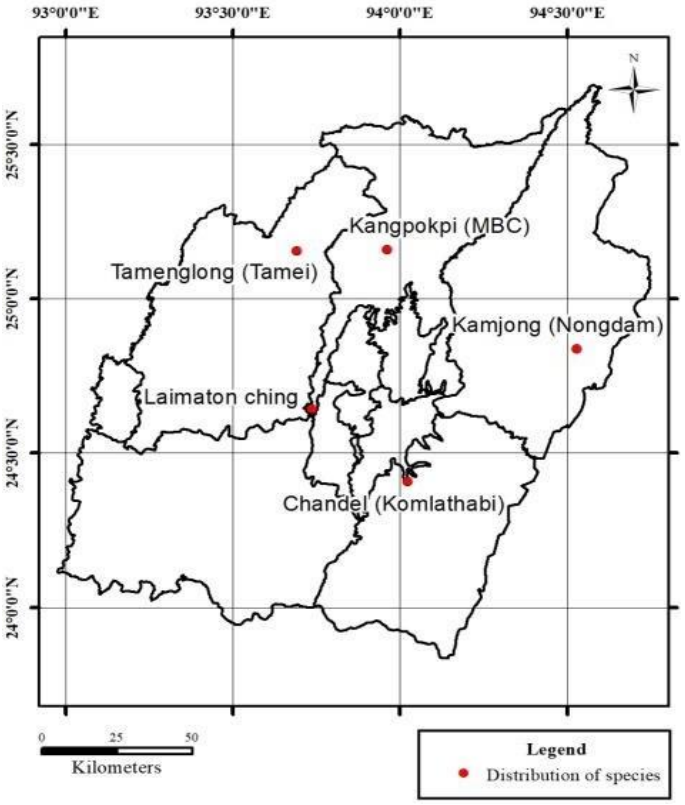


Fig. 4.33: Map showing the distribution of *Millettia pachycarpa* Benth.

Plate 33: *Millettia pachycarpa* Benth.

4.34: *Oroxylum indicum* (L.) Kurz. Forest Fl. Burma 2: 237 1877.

Family: Bignoniaceae;

Local Name: *Shamba* (Manipuri)

Description: Fruits Tree, with grayish brown bark, upto 18 m tall. Leaves pinnate, up to 1.5 cm long; leaflets ovate or obovate, base sub rounded, apex acuminate, margin entire, up to 14 cm long. Racemes terminal; flowers night bloomer, purple, up to 10 cm long sword shaped, up to 1.5 m long. Seeds flat, with wings.

Fl. & Fr.: August to December

Elevation: 600 to 950 metres above sea level

Habitat & ecology: Tropical and subtropical low altitude open forest at an elevation upto 950 metres above sea level

Global distribution: Nepal, Thailand, Bhutan, China, Myanmar and India

India: Sikkim, Arunachal Pradesh, Nagaland and Manipur

Distribution in Manipur: Phayeng, Senapati, Heingang and Shirui hill

Specimen examined: Dolen, 1591; 20/ 05/ 2019; Heingang, 24^0 $51^/$ $25.2^{//}$ N, 93^0 $56^/$ $41.7^{//}$ E; 918 metres above sea level

Ethnobotanical uses: (a) Bark (100 g) is peel upwards and the paste is collected, it is applied on the anus for Piles.

(b) Barks peel off upwards are dried and powdered; 2 g of the powder is soaked in 10 ml of water for 2 hours. The concoction taken twice daily for 2-3 days for viral fever.

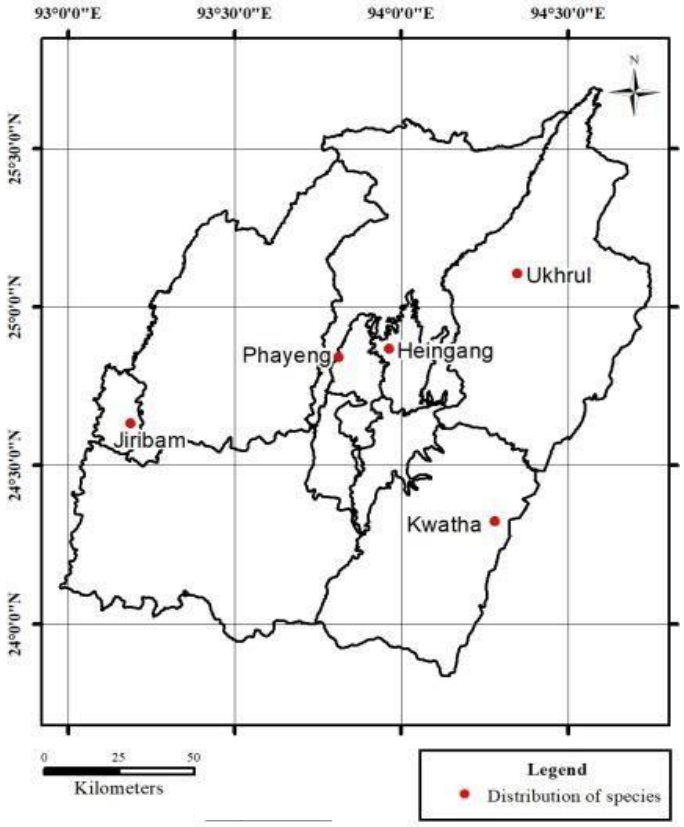


Fig. 4.34: Map showing the distribution of *Oroxylum indicum* L.

Plate 34: *Oroxylum indicum* L.

4.35: *Paederia foetida* L. Mant.Pl:52.1767;Hook. f., Fl. Brit. India 3: 195. 1881.

Family: Rubiaceae;

Local Name: *Uri- Oinum* (Manipuri)

Description: Twining glabrous shrubs. Leaves 5–12 x 2-7 cm, elliptic-ovate or ovate-lanceolate, sub-candate at base, acuminate at tip; Flowers purplish, in axillary; bracts minute, ovate or subulate; calyx tube campanulate, teeth short, triangular; corolla tomentose; Fruits are reddish.

Fl. &Fr.: May to Oct.

Elevation: 800 to 1300 metres above sea level

Habitat & ecology: It is found in moist soil of forest margin at an elevation up to 1300 metres above sea level

Global distribution: Bangladesh, NE India, Nepal, Myanmar and China

India: Assam, Nagaland, Meghalaya, Sikkim and Manipur

Distribution in Manipur: Imphal-east, Senapati, Chandel, Phayeng and Nongdam-tangkhul

Specimen examined: Dolen, 1624: 4/ 09/ 2019; Phayeng, 24^0 $51^{/}$ $7.6^{//}$ N, 93^0 $47^{/}$ $57.5^{//}$ E; 858 metres above sea level

Ethnobotanical uses: (a) Fresh (3-5) leaves are washed thoroughly; the fresh leaves are taken orally to cure piles and dysentery.

(b) Whole plant (20 g) and 3 g common salt boiled in 100 ml water; the poultice applied on the affected part for 2-4 days for bone fracture.

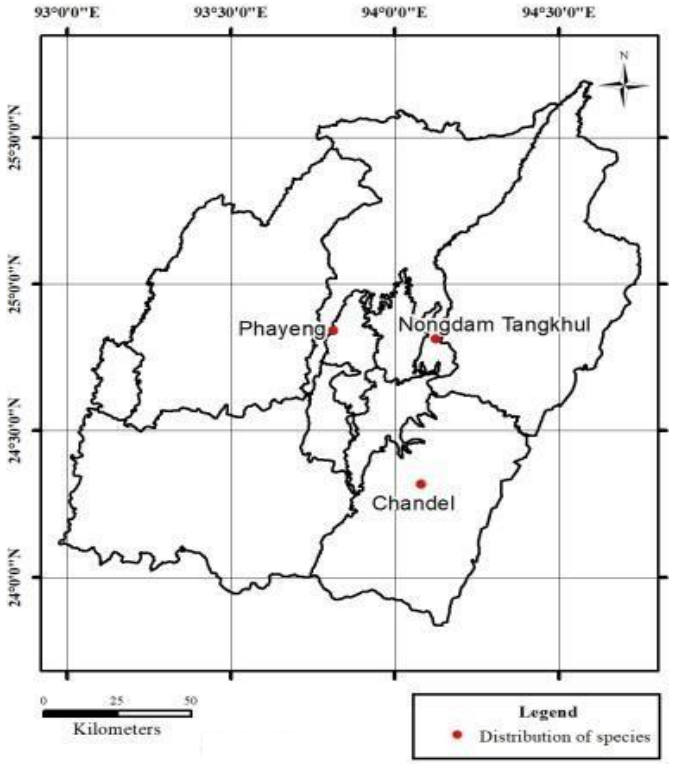


Fig. 4.35: Map showing the distribution of *Paederia foetida* L.

Plate 35: *Paederia foetida* L.

4.36: *Panax assamicus* R.N. Banerjee, Bull. Bot. Surv. India 10: 23.1968.

Family: Araliaceae;

Local Name: *Ginseng* (Manipuri)

Description: Herbs, with aromatic tuber, upto 1.3 m tall. Leaves foliolate, leaflets narrowly oblong, base rounded, apex acuminate, margin serrate, up to 8 cm long. Inflorescence umbel; Fruits are globose, red.

Fl. & Fr: April to September

Elevation: 1500 to 2400 metres above sea level

Habitat & ecology: It is found wild in shady forest floor at an elevation up to 2400 metres above sea level

Global distribution: Nepal, Bangladesh, Bhutan, Myanmar, Thailand and India

India: Sikkim, Arunachal Pradesh, Nagaland and Manipur

Distribution in Manipur: Senapati, Tamei, Ukhrul, Shirui & adjacent hills

Specimen examined: Dolen, 1458; 5/ 08/ 2018; Shirui, 25^0 06′ 57.07″ N, 94^0 26′ 48.26″ E; 2294 metres above sea level

Ethnobotanical uses: Tuber (20 g) boiled in 1 litre up to 1/3 of the volume; 20 ml of the decoction is used as stimulant and also for proving recuperative power to body.

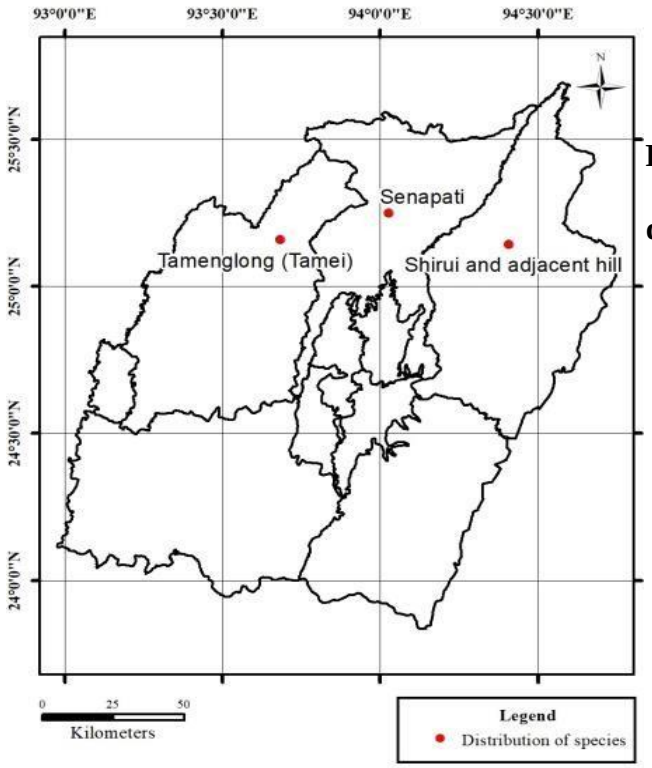


Fig.4.36: Map showing the distribution of *Panax assamicus* R.N. Banerjee

Plate 36: *Panax assamicus* R.N.Banerjee

4.37: *Panax pseudoginseng* Wall Trans. Med. Soc. Calcutta 4:117. 1829.

Family: Araliaceae;

Local Name: *Ginseng* (Manipuri)

Description: Rhizomatous herbs, up to 1 m tall. Leaves palmately compound; leaflets obovate elliptic, base attenuate, apex acuminate, margin serrate or biserrate, up to 15 cm long. Inflorescence umbel; flowers green. Fruits are globose, red to black, up to 5 mm in diameter.

Fl. & Fr.: May- June/ July- October

Elevation: 1200 to 2000 metres above sea level

Habitat & ecology: Wild species is mainly found in forest floor and shrubberies at an altitude of 1200 to 2000 metres above sea level.

Global distribution: Nepal, S.W. China, Myanmar, Tibet, Bhutan and India

India: Sikkim, Arunachal Pradesh, Nagaland, Uttarakhand, Meghalaya and Manipur

Distribution in Manipur: Ukhrul, Senapati, and Tamenglong

Specimen examined: Dolen, 1512; 15/ 10/2018; Senapati, 25^0 18/ 16.00// N, 94^0 02/ 39.75// E; 1019 metres above sea level

Ethno botanical uses: Tuber (20 g) is boiled in 1 litre of water up to 1/3 of the volume; 20 ml of the decoction used for relieve pain, reduce swelling, cholesterol and blood purifier and it is also taken orally as it provides recuperative power to body.

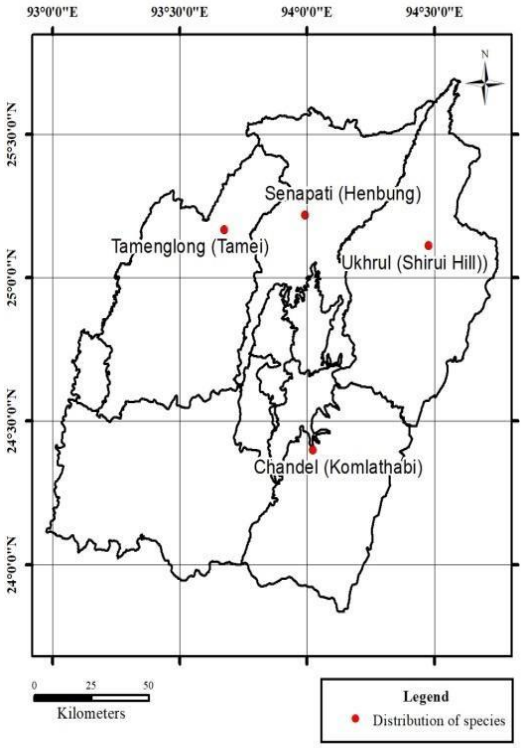


Fig.4.37: Map showing the distribution of *Panax pseudoginseng* Wall.

Plate 37: *Panax pseudoginseng* Wall.

4.38: *Paris polyphylla* Smith in Rees, Cycl. 26: Paris no. 2. 1813.

Family: Melanthiaceae;

Local Name: *Ginseng-manbi/ Pan-manbi* (Manipuri), Tangkhul (*Kazeapai*), Mao (*Katupa*).

Description: Rhizomatous perennial herbs, upto 100 cm tall. Leaves 6-10, arranged in a single whorl, lamina oblong lanceolate, base cuneate, apex acuminate, upto 24X14 cm. Petiole upto 7.5 cm. Flowers green or yellowish green, terminal; peduncle upto 20 cm long or more; outer tepals ovate lanceolate, acuminate, upto 12X3.5 cm; inner tepals narrowly linear, shorter or longer than outer. Stamens 8; filaments 1 cm long; anthers dark brown, 1.2 cm long; Ovary sub-globose, ribbed, one locule or tuberculate; Capsules are purplish black, sub-globose or tuberculate. Seeds enclosed by bright red aril.

Fl.: March to Sept. & **Fr**.: May to January.

Elevation: 1200 to 1900 metres above sea level

Habitat and ecology: Moist shady temperate forests with high humus. It is mainly found in Buk Oak Forest, Sub tropical wet hill forest and Sub tropical pine forest.

Global distribution: Nepal, Bhutan, Pakistan, Japan, China and India.

India: Jammu & Kashmir, H.P., Sikkim, Arunachal Pradesh, Nagaland and Manipur

Distribution in Manipur: Mapithel, Maram, Tamei, Senapati, Shirui hill and Chandel.

Specimen examined: Dolen, 1620; 15/ 07/ 2019; Shirui area, 25^0 07/ 00.77// N, $94^0$26/44.09// E; 2281 metres above sea level

Ethnobotanical uses: Tuber (10 g) is boiled in 1 litre of water up to 1/3 of the volume; 10 ml of the decoction is used in bronchitis and respiratory problems and it is taken orally as it provides recuperative power to body.

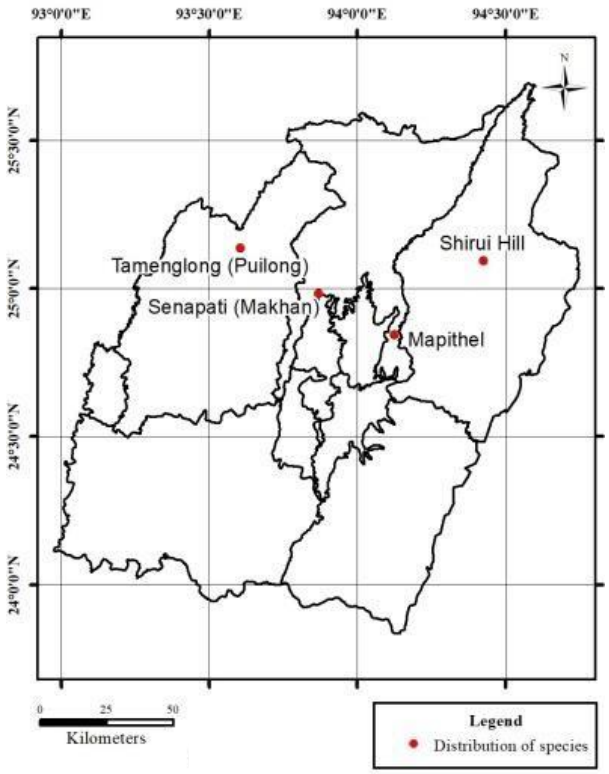


Fig. 4.38: Map showing the distribution of *Paris polyphylla* Sm.

Plate 38: *Paris polyphylla* Sm.

4.39: *Phyllanthus urinaria*L. Sp. Pl. 982. 1753.

Family: Phyllanthaceae;

Local Name: *Chakpa-heikru/ Lam-heikru* (Manipuri)

Description: Glabrous Herb, upto 70 cm high. Leaves oblong or oblong lanceolate, base rounded, apex rounded, mucronate, margin entire, upto 1.5 cm long. Flowers axillary, greenish white, upto 0.7 mm long; Fruit sub-globose, slightly lobed, and brown, up to 3 mm in diameter

Fl. & Fr.: July to September

Elevation: 700 to 1200 metres above sea level

Habitat & ecology: It is found in wild mainly forest margins, wastelands, dry fields, at elevation of 500 to 900 metres above sea level.

Global distribution: NE India, Bhutan, Bangladesh, Pakistan and Sri Lanka

India: Manipur, Nagaland, Tripura, Meghalaya and Sikkim.

Distribution in Manipur: Imphal east, Andro, Bishnupur, Thoubal, and Phayeng

Specimen examined: Dolen, 1638; 13/ 09/ 2019; Imphal East, 24^0 45/ 21.0// N, 94^0 2/ 3.8// E; 783 metres above sea level

Ethnobotanical uses: a) Crushed herb of about 100-200 g is boiled with 3 litres of water and make upto 1/3 of the volume; 100 ml of the decoction is taken 2 times in day in leucoderma and irregular menses. b) Handful of plant is crushed and juice is used as appetizer, cough, bronchitis and asthma.

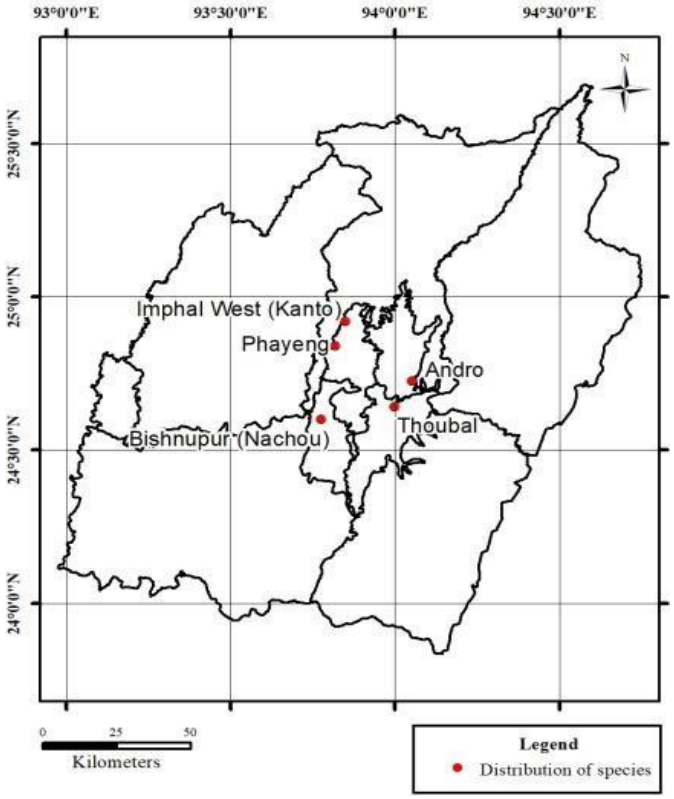


Fig. 4.39: Map showing the distribution of *Phyllanthus urinaria* L.

Plate 39: *Phyllanthus urinaria* L.

4.40: *Piper griffithii* C.DC. Seem. J. Bot. 163.1866.

Family- Piperaceae

Local Name: Ching-marik

Description: Climber; Leaves ovate or elliptic oblong, apex acute to acuminate, base acute or obtuse, up to 10 cm long. Spikes solitary, up to 10 cm long; Fruits globose, black

Fl. & Fr.: July to December

Elevation: 1200 to 2100 metres above sea level

Habitat and ecology: Wild species are mostly found at an elevation up to 2100 m.

Global distribution: NE India, China, Bhutan, Nepal and Bangladesh.

India: Sikkim, Arunachal Pradesh, Meghalaya, Assam, Manipur and Nagaland.

Distribution in Manipur: Chandel, Andro, Phayeng, Imphal West,

Specimen examined: Dolen, 1488; 16/ 09/ 2018 Imphal West, 24^0 $51^/$ $3.3^{//}$ N, 93^0 $48^/$ $35.2^{//}$ E; 811 metres above sea level

Ethnobotanical uses: Seed (200 g) is pounded and boiled in 1 litre up to 1/3 of the volume; 100 ml of the decoction is used twice for 3 days in gastrointestinal problems.

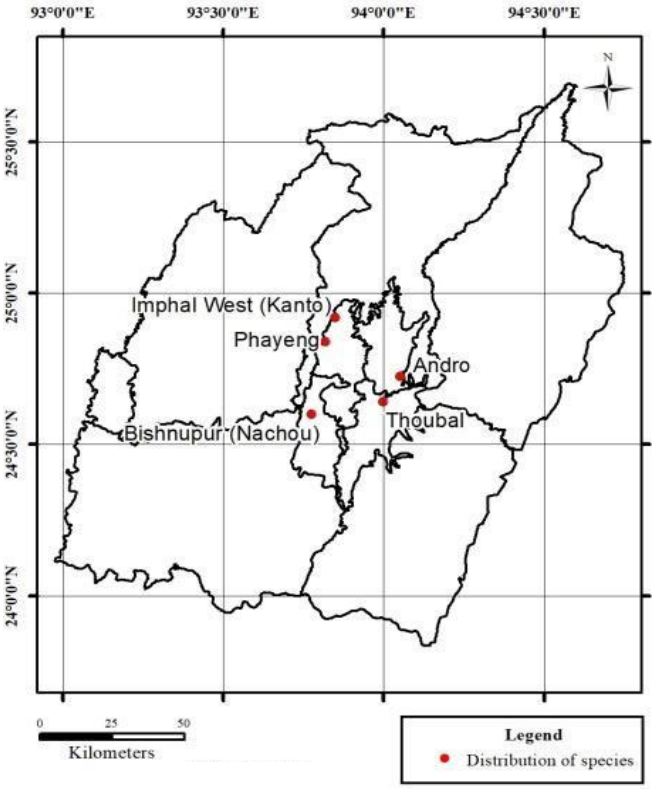


Fig. 40: Map showing the distribution of *Piper griffithii* C.DC

Plate 40: *Piper griffithii* C.DC

4.41: *Piper peepuloides* Roxb. Fl. Ind. 1: 159. 1820.

Family: Piperraceae

Local Name: Uchithi

Description: Perennial, herbaceous, glabrous climber, reached up to 1 m high. Leaves elliptic oblong or ovate lanceolate, 6-10 cm long, 4-5 cm broad. Spikes solitary; bracts orbicular, peltate. Berries small, clustered on a receptacle, turned black when matured or dried.

Fl. & Fr.: June to Sept.

Elevation: 1500 to 2300 metres above sea level

Habitat & ecology: Wild species are mostly found at an altitude between 1500 to 2300 m

Global distribution: Bangladesh, NE India, Bhutan and Vietnam.

India: Manipur, Nagaland, Tripura, Assam and Arunachal Pradesh.

Distribution in Manipur: Senapati, Tamei, Chandel, Tamenglong and Ukhrul

Specimen examined: Dolen, 1525; 24/ 06/ 2018; Tamenglong, $25^{0}22^{/}$ $02.13^{//}$ N, $93^{0}48^{/}$ $32.37^{//}$ E; 1731 metres above sea level

Ethnobotanical uses: Leaf and seed (300 mg) is pounded and extract is taken; the juice with little honey is used for the treatment of gastrointestinal and respiratory problems.

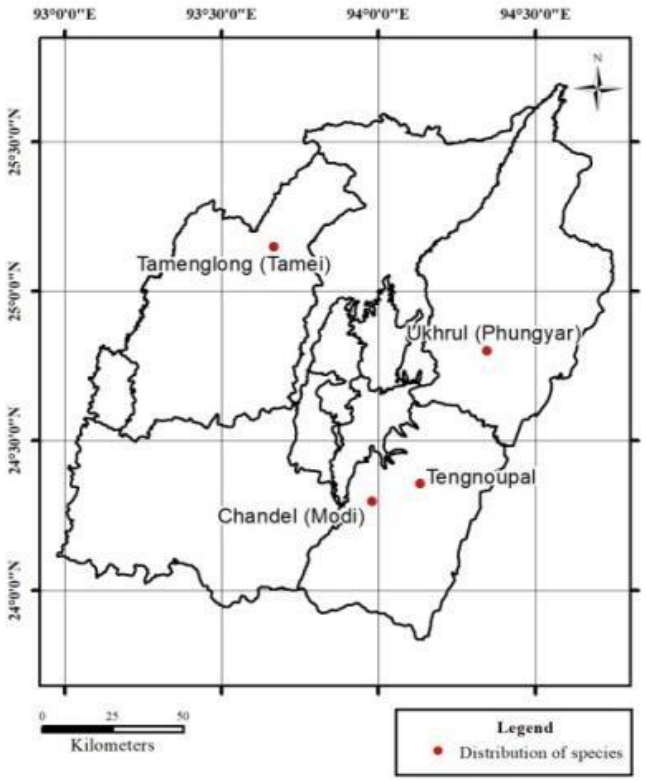


Fig. 4.41: Map showing the distribution of *Piper peepuloides* Roxb.

Plate 41: *Piper peepuloides* Roxb.

4.42: *Quercus lamellose* Sm. Cycl. 29: 23. 1819.

Family- Fagaceae;

Local Name: Uyung; (Manipuri)

Description: An evergreen tree, upto 40 m tall. Leaves leathery, ovate elliptic, base cuneate, apex acuminate, margin serrate, upto 40 cm long. Cupule semi-globose, with numerous lamellae, upto 5 cm in diameter. Acorn up to 3X4 cm. Nut oblate, upto 4 cm in diameter.

Fl. & Fr.: April to September

Elevation: 1200 to 2500 metres above sea level

Habitat and ecology: Evergreen tree associated with *Rhododendron arboreum*, *Arundina elegans* of temperate forest found at an elevation up to 2500 metres above sea level.

Global distribution: Nepal, Bhutan, Myanmar, China and India

India: Manipur, Nagaland, Arunachal Pradesh and North Bengal

Distribution in Manipur: Mao, Dzukou, Shirui and Tamenglong

Specimen examined: Dolen, 0277; 28/05/2016; Shirui (Ukhrul), 25^0 $07^/$ $32.30^{//}$ N, $94^0 25^/$ $08.51^{//}$ E; 1803 metres above sea level

Ethnobotanical uses: Bark of about 200 g is boiled with 1 litre of water to make up to 1/3 of the volume; 100 ml of the decoction of bark and acorms are used as astringent

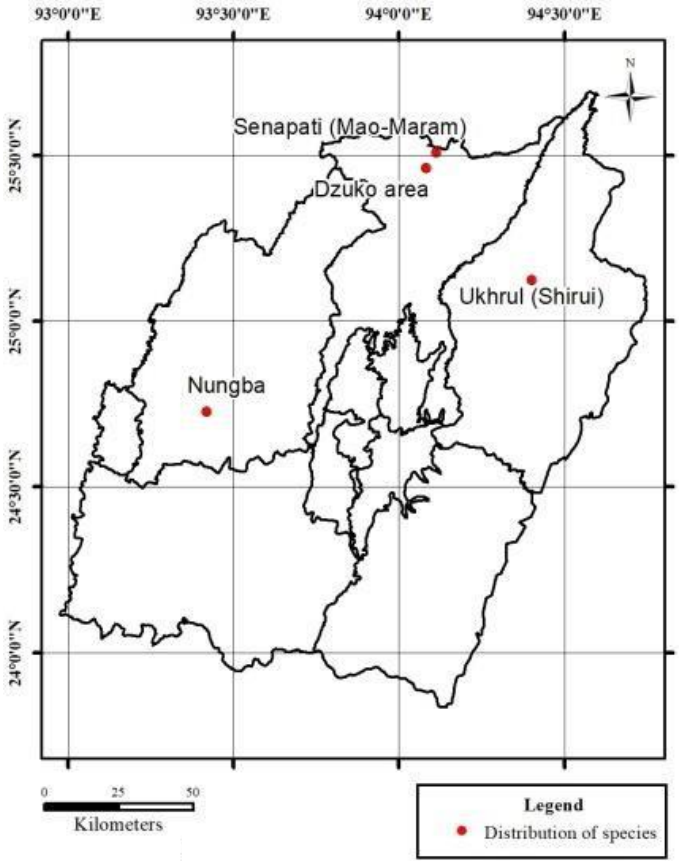


Fig. 4.42: Map showing the distribution of *Quercus lamellose* Sm.

Plate 42: *Quercus lamellose* Sm.

4.43: *Rhododendron arboreum* Smith, Exot. Bot. 1: 9. 1805.

Family: Ericaceae

Local Name: Chingleihao (Manipuri), Kokloiwon (Tangkhul)

Description: Evergreen tree, largest among Rhododendron, up to 20 m tall. Leaves oblong lanceolate, base cuneate, apex acute, margin rolled under, leathery, lower surface silvery white, tomentose, petiolate, upto 15 X 4.5 cm. Inflorescence crowded. Flowers red, rarely white, campanulate, upto 5 cm long. Capsule cylindric.

Fl. & Fr.: June to November

Elevation: Upto 2000 metres above sea level

Habitat and ecology: It is commonly found in the lower hill slopes, up to 2000 m.

Global distribution: Bhutan, India, Myanmar, Nepal, Sri Lanka, Pakistan and Thailand

India: Western Ghats, Arunachal Pradesh, Sikkim, Manipur and Nagaland

Distribution in Manipur: Ukhrul, Dzukou hill, Senapati and Tamenglong

Specimen examined: Dolen, 0270; 28/05/ 2016; Shirui peak, 25^0 $06^{/}$ $56.6^{//}$ N, 94^0 $26^{/}$ $49.5^{//}$ E; 2266 metres above sea level

Ethnobotanical uses: About 2-3 teaspoon juice extracted from the young shoot is mixed with honey used 2-3 times in a day. Decoction of young shoots and flowers are used for easy delivery in child birth, diarrhoea and dysentery.

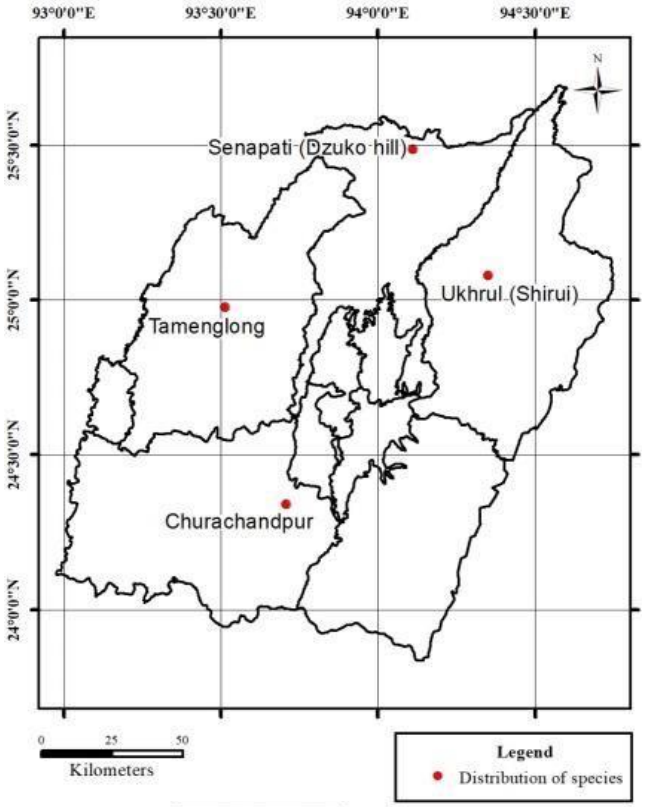


Fig.4.43: Map showing the distribution of *Rhododendron arboreum* Smith

Plate 43: *Rhododendron arboretum* Smith

4.44: *Rubia cordifolia* L., Syst. Nat., ed. 12. 3: 229. 1768.

Family: Rubiaceae

Local Name: Moyum (Manipuri)

Description: Perennial herbaceous climber, with quadrangular ribbed stem, puberulous or glabrous, upto 3 m or more. Leaves arranged in whorl, 4 or more in 1 whorl; lamina ovate or ovate lanceolate, apex acute, base cordate, sometimes truncate or rounded, margin slightly serrate, upto 8 X 3 cm in size. Panicles thyrsoid, many flowered, terminal and axillary. Flowers bracteate, greenish to pale yellow, upto 5 mm in diameter; bracts minute, linear to lanceolate, upto 3 mm long; corolla lobes lanceolate, apex acuminate. Berry globose, orange to black, upto 5.5 mm in size.

Fl. & Fr.: June to November

Elevation: 800 to1500 metres above sea level

Habitat and ecology: It is commonly found in moist sub-tropical forest at an elevation up to 1500m.

Global distribution: Asia, Africa, Australia and India

India: Manipur, Meghalaya and Assam

Distribution in Manipur: Lunghar, Khayangbung, Langol hill, Noney and Kangpokpi

Specimen examined: Dolen, 1472; 15/ 08/ 2018; Kangpokpi, 24^0 $48^{/}$ $26.7^{//}$ N, 94^0 $8^{/}$ $34.7^{//}$ E; 839 metres above sea level

Ethnobotanical uses: Root (10 g) is pounded and the juice is used in rheumatism and anti- inflammatory and as antimicrobial.

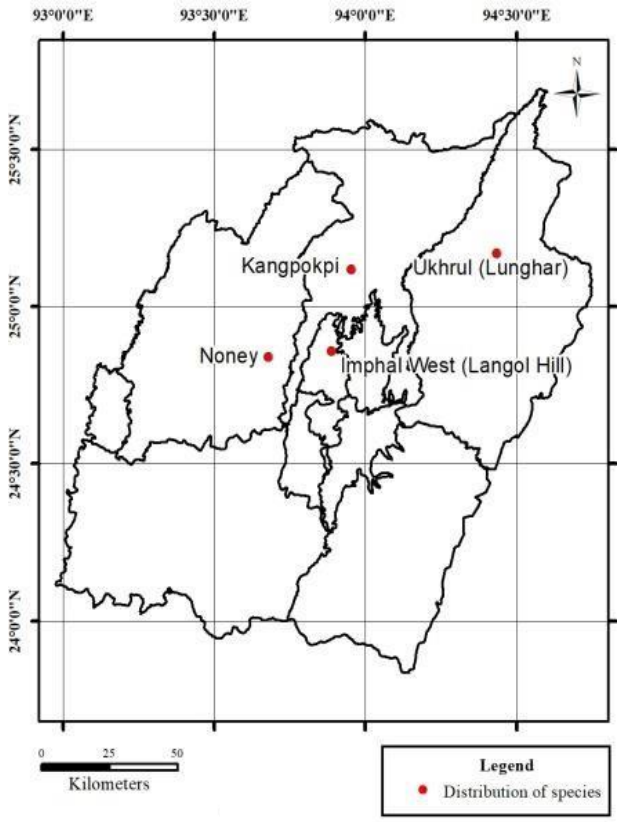


Fig.4.44: Map showing the distribution of *Rubia cordifolia* L.

Plate 44: *Rubia cordifolia* L.

4.45: *Scutellaria discolour* Colebr. Pl. Asiat. Rar.1: 66. 1830.

Family: Lamiaceae;

Local Name: Yenakhat (Manipuri)

Description: Bicolor Skullcap, with 1 to few stems, 1-2 ft tall. Flowers are blue, tubular 2-lipped, in long slender loose leafless spikes, 8-25 cm long. Flowers are 1.3- 1.8 cm long, with slender, curved tube. Upper lips are entire, hooded, and the lower one is broad, 3-lobed and often paler in color. Cup of sepals is 2 mm long, enlarging in fruit and covering the nutlets.

Fl. & Fr.: July to Nov.

Elevation: 700 to 2300 metres above sea level.

Habitat & ecology: It is found in shady banks at an altitude of 700 to 2300 m

Global distribution: Myanmar, Nepal, Thailand, Vietnam, India and Indonesia

India: Maharashtra, Assam, Manipur and Tripura

Distribution in Manipur: Imphal West, Churachandpur, Thoubal, and Nongdam tangkhul.

Specimen examined: Dolen, 1632; 6/ 09/ 2019, Nongdam Tangkhul, $24^{0}59^{/}01.40^{//}$ N, $94^{0}37^{/}20.82^{//}$ E ; 1362 metres above sea level

Ethnobotanical uses: a) Leaves of *Scutellaria discolou*r, *Achyranthes aspera* and *Verbena officinal* of 50 g each boiled in 1 litre of water up to 1/3 of the volume;200 ml of the filtrate after sweetening with little honey is taken twice daily for a week for white discharge

b) Handful of the leaves is boiled in 1 litres of water up to 1/3 of the volume;20 ml of the decoction is taken orally twice daily as an antidote to snake bites and stings of poisonous insects. One or two leaves are taken every day to control hypertension.

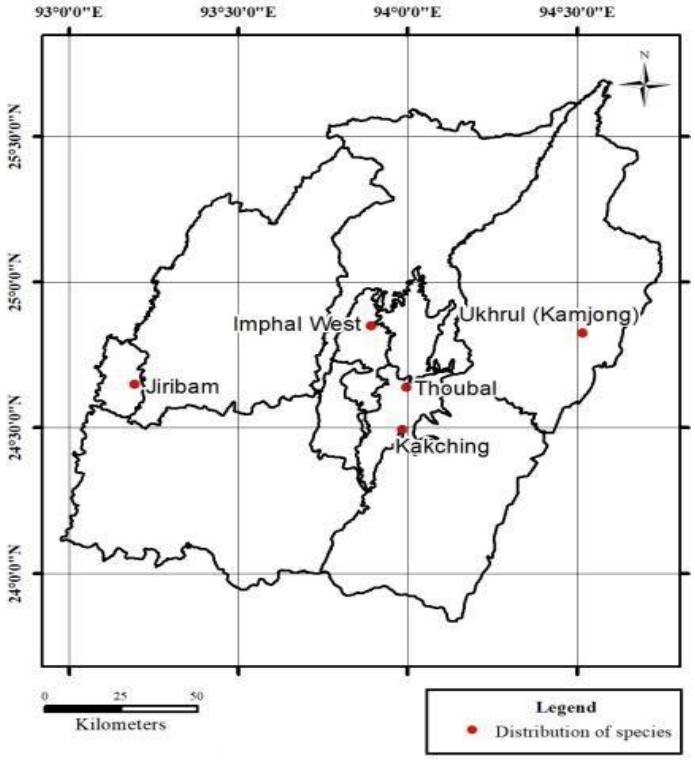


Fig.4.45: Map showing the distribution of *Scutellaria discolour* Colebr.

Plate 45: *Scutellaria discolour* Colebr.

4.46: *Smilax ovalifolia* Roxb. ex D. Don, Prodr. Fl. Nepal.49.1825.

Family: Smilacaceae;

Local Name: Kwa-manbi/Keisoom.(Manipuri)

Description: Branched or unbranched prickly climber, up to 11 m long. Leaves petiolate, ovate, oblong or orbicular, base rounded, with tendrils, apex acute to acuminate, margin entire, upto18 x 12 cm. Inflorescence umbel. Flowers white, bracteate, up to 0.6 cm long. Berries red, globose to sub-globose.

Fl. : May **& Fr**.: Sept- Oct.

Elevation: 900 to 1800 metres above sea level

Habitat and ecology: The wild species are commonly found in forest floor at an elevation up to 1800 metres above sea level

Global distribution: India, Myanmar, Bhutan and Bangladesh.

India: Tripura, Assam, Meghalaya and Manipur

Distribution in Manipur: Langol hill, Mapithel, Imphal east and Laimaton ching.

Specimen examined: Dolen, 1589; 12/ 05/2019, Langol hill, $24^0\,52^{/}\,17.1^{//}$ N, $93^0\,53^{/}\,59.1^{//}$ E; 811 metres above sea level

Ethnobotanical uses: Root of about 50 g is pounded and the juices are collected; it is used in skin diseases, muscular sprain, stomach pain and rheumatic problems.

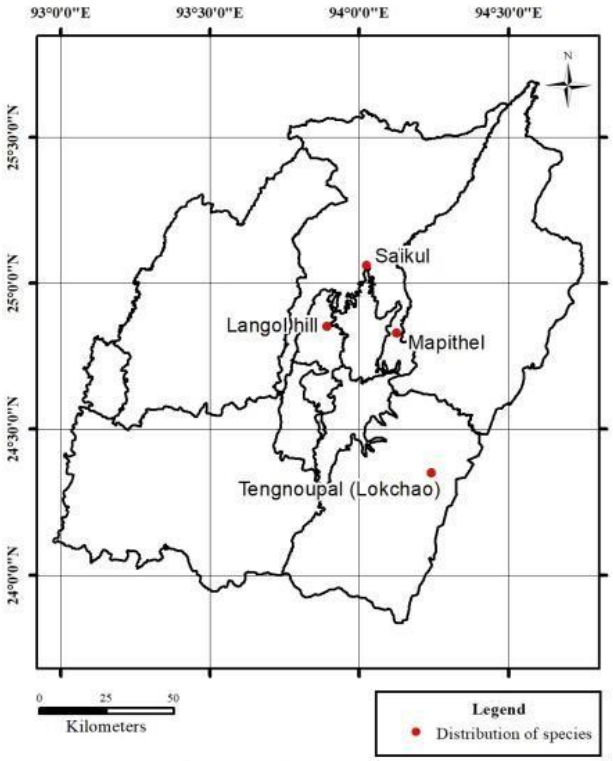


Fig.4.46: Map showing the distribution of *Smilax ovalifolia* Roxb.

Plate 46: *Smilax ovalifolia* Roxb.

4.47: *Swertia angustifolia* Buch.-Ham. ex D. Don, Prodr. Fl. Nep.: 127. 1825.

Family: Gentianaceae;

Local Name: Chiraita.

Description: Branched annual herbs, with sub quadrangular stem, up to 70 cm tall. Leaves sessile, lanceolate to linear-lanceolate, base attenuate, apex acute, margin entire, up to 7 X 1 cm. Panicles spreading. Flowers greenish white to yellowish white, spotted with purple, tetramerous; Calyx lobes oblong lanceolate, apex acute, up to 8 mm long; corolla lobes oblong, apex acuminate, up to 1 cm long; filaments 5 mm long. Capsules up to 8 mm long.

Fl. & Fr.: September to November

Elevation: Up to 1600 metres above sea level

Habitat and ecology: A small herb found in the hilly grasslands of high altitude up to 1600 metres above sea level

Global distribution: Bhutan, Thailand, Myanmar, Nepal and India

India: Manipur, Nagaland, Tripura, Assam, Sikkim

Distribution in Manipur: Shiruichingkha, Dzukou hill, Chandel and Churachanpur.

Specimen examined: Dolen, 1315; 12/10/2017; Shirui, $25^0\ 06'\ 26.02''$ N, $94^0\ 27'\ 41.02''$ E: 2417 metres above sea level

Ethnobotanical uses: *Swertia chirata* (20 g) and leaves of *Phlogacanthus thysiflormis* and *Scutellaria discolour* 40 g each boiled in 1 litre of water in a closed vessel and steam is exposed to the abdominal parts for few minutes. The concoction is also taken daily for 3 days for irregular women menstrual problem.

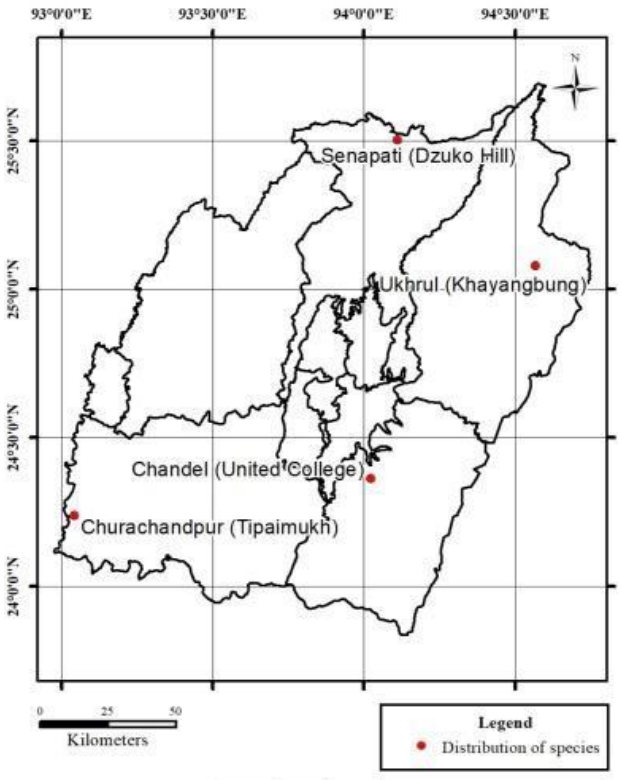


Fig.47: Map showing the distribution of *Swertia angustifolia* Buch-Ham

Plate 47: *Swertia angustifolia* Buch-Ham

4.48: *Syzygium nervosum* A. Cunn ex DC. *Prodr.* 3: 260. 1828.

Family: Myrtaceae

Local Name: Tom Heinou (Manipuri)

Description: Medium sized trees up to 15 m high. Leaves 10 – 20 x 2.5 – 5 cm, oblong – lanceolate, lanceolate or ovate – lanceolate, acuminate at apex, base cuncate; lateral nerves raised beneath. Flowers 4-5 cm across, white or dull white, in panicles; calyx *ca* 1.5 cm across, obconic, reflexed; petals obovate, rounded. Berries ca 3 cm across, yellowish to pink.

Fl. & Fr.: April to September

Elevation: 700 to 1500 metres above sea level

Habitat & ecology: Wild species is found in moist habitats such as stream banks, at an elevation of 700 to 1500 metres above sea level

Global distribution: Myanmar, Thailand, Bhutan, Nepal and Bangladesh.

India: Assam, Nagaland, Tripura, Sikkim and Manipur.

Distribution in Manipur: Laimatonching, Tengnoupal, Chandel andTamenglong

Specimen examined: Dolen, 1412; 4/ 06/ 2018; Lai Maton Ching, $24^0 15' 27.43'' N$, $94^0 02' 07.72'' E$; 1532 metres above sea level

Ethnobotanical uses: About 10 leaves fresh or dried are boiled in 1 litre of water for 10 minutes; 300 ml of the decoction is taken thrice daily for gall bladder or kidney stone case.

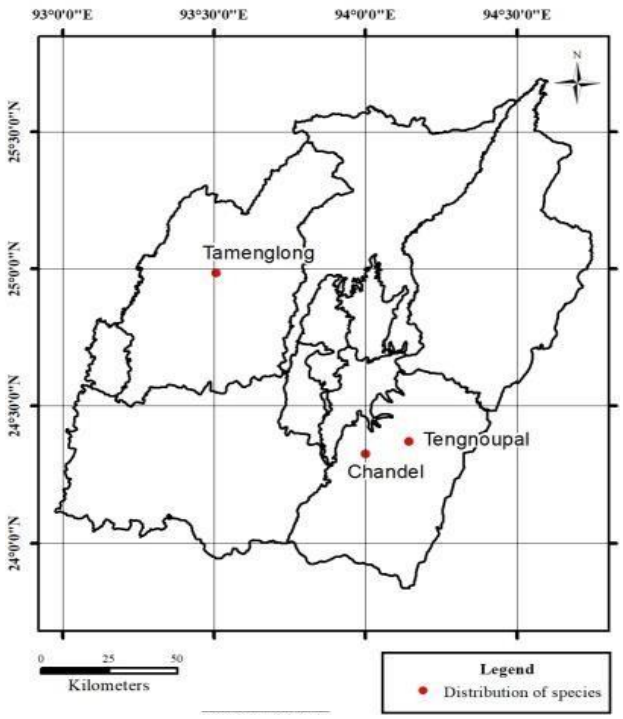


Fig. 4.48: Map showing the distribution of *Syzygium nervosum* A. Cunn. ex DC.

Plate 48: *Syzygium nervosum* A. Cunn. ex DC.

4.49: *Taxus wallichiana* Zucc, Abh.Bayer. Akad.Wiss.3: 803. 1843.

Family: Taxaceae;

Local Name: Uchanmanbi (Manipuri)

Description: Irregular, spreading branched trees with reddish brown bark, upto 15 m tall. Leaves linear, base cuneate, apex acute, slightly mucronate, lower surface pale green, upto 3 cm long. Cones solitary, ovoid, upto 0.7 cm long. Male cones pale yellowish with 5-10 sporophylls. Female flowers green, scales 3 paired. Seeds ovoid, olive green, young seeds partially covered by red aril, up to 0.75 long.

Fl. & Fr.: March to September

Elevation: 1100 to 2400 metres above sea level

Habitat and ecology: It is found in upper temperate forest at an elevation up to 2400 metres above sea level

Global distribution: Bhutan, Myanmar, Nepal, Pakistan, Philippines, Vietnam, India and China

India: Arunachal Pradesh, Assam, Sikkim and Manipur

Distribution in Manipur: Shirui hills to Khayangbung, Chandel and Tamenglong

Specimen examined: Dolen, 1577; 12/ 04/ 2019; Khayangbung. 25^0 03/ 10.44// N, 94^0 24/ 26.25// E; 1688 metres above sea level.

Ethnobotanical uses: a) About 30-50 g crushed needles is boiled in 1 litre up to 1/3 of the volume, 60 ml of decoction of leaf is taken 2 times in a day for cold, cough and fever.

b) The 10 g of the fruit is boiled in 1 litre for 10 minutes; 20 ml of the decoction is used for Hypertension & dizziness.

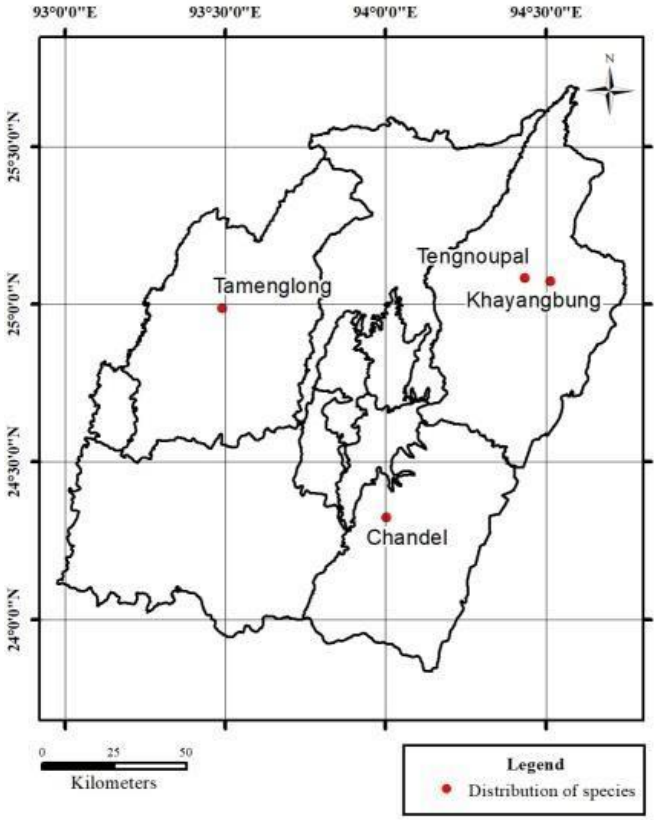


Fig. 4.49: Map showing the distribution of *Taxus wallichiana* Zucc.

Plate 49: *Taxus wallichiana* Zucc.

4.50: *Thalictrum foliolosum* DC. Syst. Nat. 1:175. 1817.

Family: Ranunculaceae;

Local Name: Umang-peruk (Manipuri); Kharuri.

Description: Erect herbs up to 2.5 m tall. Leaves pinnately decompounds; leaflets 1.5- 4 × 2.5-3.5 cm, broadly ovate, acute, bluntly toothed, glaucous beneath. Flowers in much branched axillary or terminal panicles, white or pale green, sepals ovate, caduceus; anthers mucronate, 2-3 mm long; style deciduous. Achene ellipsoid, 0.2-0.4 cm long, strongly ribbed.

Fl. &Fr.: May to Sept.

Elevation: 1100 to 2400 metres above sea level

Habitat and ecology: It is commonly found in the forest floor and valley areas at an elevation above 1500 metres above sea level

Global distribution: Bangladesh, Nepal, Bhutan, Thailand, Malaysia, Myanmar and India

India: Manipur, Assam, Tripura, Sikkim, west- Bengal and Meghalaya

Distribution in Manipur: Shirui hill, Mao-Maram and Dzukou hill

Specimen examined: Dolen ,0300; 12/06/2016; Mao-Maram, $25^0 30' 48.42'' N$, $94^0 06' 40.07'' E$; 2194 metres above sea level

Ethnobotanical uses: About 10 g of crushed tuber root is boiled in 1 litre of water upto 1/3 of its volume; 60 ml decoction of the root is taken 2-3 times daily for scabies, diuretic and astringent.

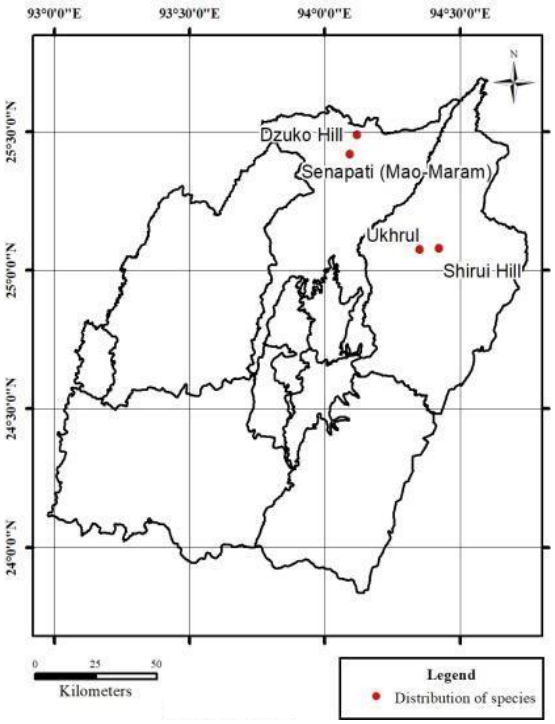


Fig.4.50: Map showing the distribution of *Thalictrum foliolosum* DC.

Plate 50: *Thalictrum foliolosum* DC.

4.51: *Zanthoxyllum acanthopodium* DC. Prodr. 1; 727. 1824

Family- Rutaceae,

Local Name: Mukthrubi. (Manipuri)

Description: Thorny, aromatic, straggling shrub or small trees, upto 5.5 m tall. Leaves 3-9 foliate with winged rachis; leaflets ovate elliptic to lanceolate, apex acute, base rounded, margin crenate, upto 10 cm long. Inflorescence axillary. Flower yellowish green, o.15 cm long. Fruits black with red follicles.

Fl.: March to April & **Fr**.*:* June to Nov.

Elevation: 700 to 1500 metres above sea level

Habitat & ecology: It is grown in upland open forests and thickets up to 1500 metres above sea level

Global distribution: Bangladesh, Nepal, Bhutan, Thailand and Malaysia

India: Nagaland, Manipur, Assam, Tripura, Sikkim and west- Bengal

Distribution in Manipur: Heingang hill, Ukhrul, Chandel, Thoubal and Langol hills.

Specimen examined: Dolen, 1287; 12/ 07/ 2017; Langol hill, 24^0 $52^/$ $12.1^{//}$ N, 93^0 $53^/$ $57.1^{/\,/}$ E; 800 metres above sea level

Ethnobotanical uses: a). Leaf or fruit (100 g) is boiled in 1 litre of water for 10 minutes; 100 ml of decoction is taken orally twice daily for 3 days for gastric problems, tonsil and typhoid.

b) Leaves and fruit are pounded with little water and the extract is collected, the extract is applied on skin diseases.

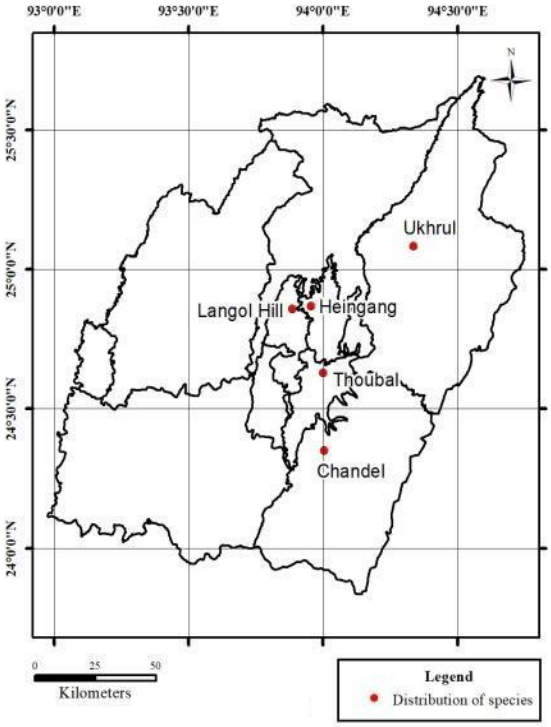


Fig.4.51: Map showing the distribution of *Zanthoxyllum acanthopodium* DC.

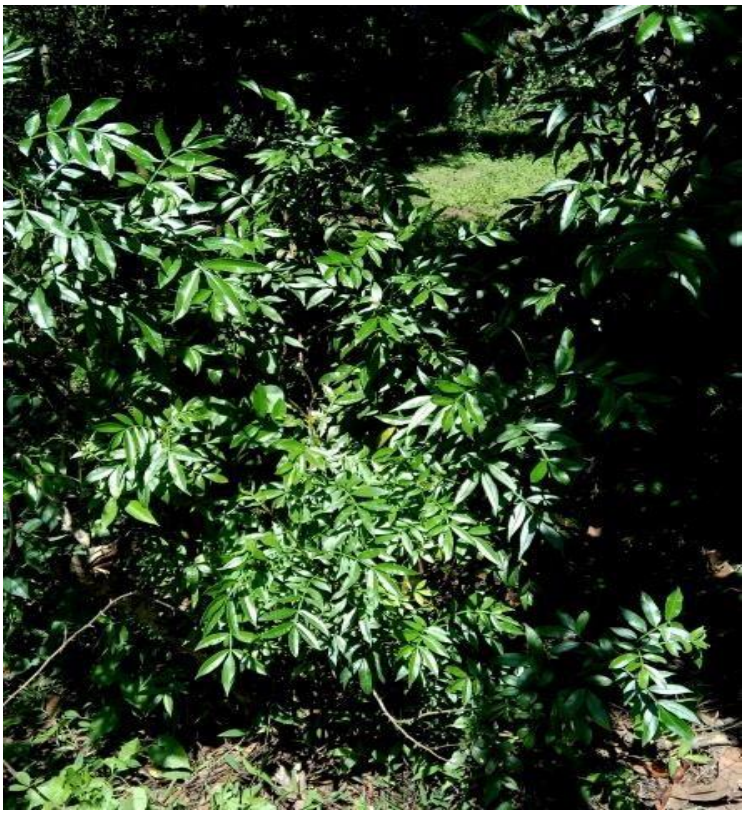


Plate 51: *Zanthoxyllum acanthopodium* DC.

4.52: *Zanthoxylum rhetsa* DC. Prodr. 1: 728. 1824

Family: Rutaceae;

Local Name: Ngang (Manipuri)

Description: Small evergreen trees, with a crown of branches and trunk studed with corky prickles. Leaves large, imparipinnate; leaflets 15-21, opposite, oblong-lanceolate, oblique cordate- acuminate, glabrous with a large reddish pedicelled dot at each sinus. Flowers minute, greenish white, tetramerous, in trichotomous cymes arranged in close set terminal panicles, sepals 4, ovals-triangular; petals 4, elliptic-oblong, stamens 4, *ca* 2.5 mm long.

Fl. & Fr.: March to November.

Elevation: 900 to 1700 metres above sea level

Habitat & ecology: Deciduous tree rarely found in open forest at an elevation between 900-1700 metres above sea level.

Global distribution: Bangladesh, Bhutan, Myanmar, Thailand and Sri- Lanka.

India: Nagaland, Assam, Tripura, Sikkim, Manipur, Kerala and Tamil Nadu.

Distribution in Manipur: -Leimaram, Heirok, Andro, Makhan, Imphal- east, Bishnupur, Tamenglong and Chandel

Specimen examined: Dolen, 1644; 15/09/2019 Bishnupur, 24^0 $36^/$ $29.8^{/\,/}$ N, 93^0 $45^/$ $4.0^{/\,/}$ E; 784 metres above sea level

Ethnobotanical uses: About 10 g of the fruit is boiled in 1 litres of water up to 1/3 of its volume; decoction is used to treat asthma, bronchitis and rheumatism and the dried fruit is chewed for toothache.

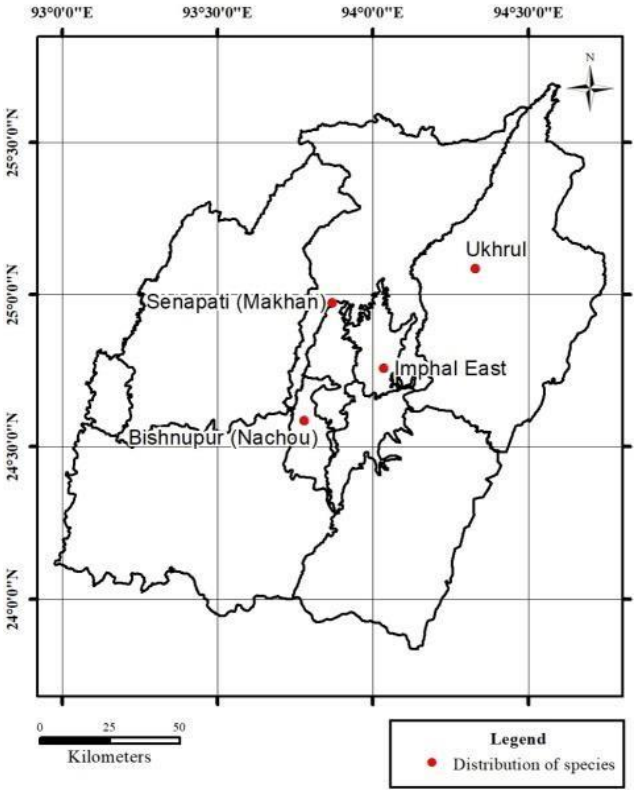


Fig.4.52: Map showing the distribution of *Zanthoxylum rhetsa* DC.

Plate 52: *Zanthoxylum rhetsa* DC.

CHAPTER -V

IUCN RED LIST CATEGORIES AND CRITERIA OF THE RECORDED ETHNO- MEDICINAL PLANTS OF MANIPUR

5.1 Assessment rationale, threats and conservation aspect

This chapter deals with the assessment of the collected 52 ethnomedicinal plants recorded from Manipur in the present study. The details of species distribution, data on population reduction, extent of occurrence, area of occupancy were recorded. The data were analysed using IUCN Red list Categories and Criteria Version 3.1. The Assessment rationale, threats and conservation aspects of each and every species is given.

The diversity of living organisms or biodiversity is of paramount importance for keeping the various processes and phenomenon operative in the biosphere. Biodiversity offers 13 types of ecosystem amenities is one of the main livelihood options (Singh, 2007). Biodiversity is diminishing with rapid pace, due to habit destruction and over-exploitation (Samant *et al*., 1998).

Fragmentation, over-exploitation, pollution, invasion of alien species and climatic change are the major threats to biodiversity. At present time, the alarming rate of diminishing plant species is assessed to be between 100 and 1000 times greater than predictable natural extinction rate (IUCN, 2003). The rapid population decline crises have stimulated many researchers to assess and observe the danger of extinction challenged by the species globally.

TAXON DATA SHEET (Sample)

<table>
<tr><td>1. Scientific name</td><td>Aconitum nagarum Stapf</td></tr>
<tr><td>2. Synonym(s)</td><td>1. Aconitum venatorium Diels</td></tr>
<tr><td>3. Family</td><td>Ranunculaceae</td></tr>
<tr><td>4. Vernacular names</td><td>Manipuri- Nuishiwon/ Khawari (Tangkhul)
Common Name: Aconites</td></tr>
<tr><td>5. Habit</td><td>Herb, found in 2200- 2590 m</td></tr>
<tr><td>6. Habitat & ecology</td><td>Usually occur in the high altitude & moist evergreen forest.</td></tr>
<tr><td>7. Environmental Factors</td><td><table><tr><td>Soil</td><td>Temp.</td><td>Rainfall</td><td>Climate</td></tr><tr><td>Alluvium, lateritic and Ferruginous soil.</td><td>3 to 33^0 C</td><td>1600 to 2100</td><td>Temperate</td></tr></table></td></tr>
<tr><td>8. Community Association</td><td>The Common associated species recorded were Sinarundinella species, Gaultheria species & Fragaria sps. A.nagarum was growing healthy where these associated species were available.</td></tr>
<tr><td>9. Original global distribution</td><td>Global: Myanmar, Yunnan & India
India: Arunachal Pradesh, Nagaland & Manipur</td></tr>
<tr><td>10. Current regional distribution in Manipur with Coordinates</td><td>1.Dzukou hills – N-25^{0}33.372’ E-94^{0}4.244’
2.Lunghar- N-25º17’05.5” E- 94º44’07.3”
3.Jesami- N- 25^{0}62’24.68” E- 94^{0}54’36.21”
4.Khayangbung- N25º12’93.91” E94º42’31.95”</td></tr>
<tr><td>11. Population Reduction-PR</td><td><table><tr><td><30%</td><td>30-<50%</td><td>50- <80%</td><td>>80%</td></tr><tr><td></td><td></td><td>50-<80%</td><td></td></tr></table></td></tr>
<tr><td>11a. Time/Rate (10 yrs or 3 generations whichever is longer)</td><td>10 yrs.</td></tr>
<tr><td>11b. Generation length-</td><td>3- 4 yrs</td></tr>
<tr><td>12. Extent of Occurrence-EO</td><td><5000 km^2</td></tr>
<tr><td>13. Area Of Occupancy-AOO</td><td><500 km^2</td></tr>
<tr><td>14. No. of locations/sub-populations</td><td>4</td></tr>
</table>

14a. Data quality (of life history)	Good | Medium | Poor | Medium |
15. Threats in the state	1. This species is continuously declining due to Habitat destruction, forest fire & jhumming. 2. Over- growth of *Arundanaria* (Tenwa)
16.Trade:	Parts Used - Tubers Extent of trade – Local & Regional
17. Other comments	1. The plants is used as poison for Killing wild animals. 2. The root is used in poisoning arrowheads by the Naga.
18. Status	Endangered
19. IUCN Red List Criteria and Category.	A2c & EN
20.Assessment Rationale	1. Low populations & Restricted fragmented distribution.
21. Percentage (%) of global presence	<10%
22. Do the populations outside the state also face similar threats/pressures?	Yes, (Nagaland , Sikkim, Tripura)
23. Existing Conservation measures	No
24. Recommendations	The main factors of declining are due to forest fire, restricted fragmented population and habitat destruction. So, In case of my research work, the plant has been assessed as Endangered.
A. Research/Management	
a)*in-situ*	No, but the local NGOs started some conservation measure to protect the habitat.
b)ex-situ	
B. i) Cultivation	No
25. Existing cultivation -	
26. Previous assessment	No

Species-1	**:**	*Aconitum nagarum* Stapf.
Reported Locations in Manipur	**:**	Dzukou hill, Shirui hills, Mao, Maram, Khayangbung
Population Reduction-PR	**:**	50 to < 80%
Extent of Occurrence EOO	**:**	< 5,000 Km^2
Area of Occupancy-AOO	**:**	< 500 Km^2
IUCN Red List Category	**:**	**EN**
IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale/Threats	**:**	This species is declining due to soil erosion and loss of habitat. On account of population reduction estimated at 50 to <80%. It has been assessed as EN.
Conservation Aspects	**:**	Some local youth started conservation in their natural habitat
Species-2	**:**	*Aconitum elwesii* Stapf.
Reported Locationsin Manipur	**:**	Dzukou valley, Shirui hill, Mt. Esiiand Khangkhui
Population Reduction-PR	**:**	50 to < 80%
Extent of Occurrence EOO	**:**	< 5,000 Km^2
Area of Occupancy-AOO	**:**	< 500Km^2
IUCN Red List Category	**:**	**EN**
IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale/Threats	**:**	The wild population is adversely affected due to soil erosion and loss of habitat. It

		has been assessed as EN following the IUCN Criteria A2c.
Conservation Aspects	**:**	Local NGOs started *in-situ* conservation measures but very difficult as it is high altitude species
Species-3	**:**	*Albizia myriophylla* Benth
Reported Locations in Manipur	**:**	Churachandpur, Andro, Phayeng, Chandel, Ukhrul, Senapati and Tamenglong
Population Reduction-PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000 Km2
Area of Occupancy-AOO	**:**	< 2000Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	The main threats are edaphic factors, harvest for food, medicine and parts of the plant. This species has been assessed as VU following IUCN Criteria A2cd
Conservation Aspects	**:**	Need awareness programme for proper collection of root and bark for medicine.

Species-4	**:**	*Begonia adscendens* C.B. Clarke
Reported Locations in Manipur	**:**	Tamenglong, Shirui hills, Lunghar, Tungjoi
Population Reduction-PR	**:**	30 to < 50 %
Extent of Occurrence EOO	**:**	< 20,000Km^2
Area of Occupancy-AOO	**:**	< 2000 Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	Population declined due to habitat loss and forest fires. So, the plant has been assessed as VU on account of population decline of 30 to < 50%.
Conservation Aspects	**:**	Immediate awareness should be given to avoid habitat destruction and forest fire.

Species-5	**:**	*Brassaiopsis bodinieri* (H. Leveille) J. Wen & Lowry
Reported Locations in Manipur	**:**	Phayeng, Churchandpur, Kamjong, Andro, Ukhrul, Tamenglong, and Senapati.
Population Reduction-PR	**:**	< 30 %
Extent of Occurrence EOO	**:**	>20,000 Km2
Area of Occupancy-AOO	**:**	> 2000Km2
IUCN Red List Category	**:**	**NT**

IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale/Threats	**:**	This species is collected from wild in an indiscriminate way and population is declining continuously. It has been assessed as NT in Manipur.
Conservation Aspects	**:**	To conduct regular training camps for the farmers for cultivation, harvesting and sustainable utilization.

Species-6	**:**	*Bulbophyllum cylindraceum* Lindley
Reported Locations in Manipur	**:**	Senapati, Ukhrul, Tengnoupal, Chandel
Population Reduction-PR	**:**	30 to < 50 %
Extent of Occurrence EOO	**:**	< 20,000Km^2
Area of Occupancy-AOO	**:**	< 2000Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	The wild population is affected by harvest for medicine and others. It has been assessed as VU following IUCN Criteria A2cd.
Conservation Aspects	**:**	Some local NGOs started both *in-situ* and *ex- situ* conservative measures.

Species-7	**:**	*Canarium strictum* Roxb.
Reported Locations in Manipur	**:**	Dailong, Moreh, Shirui Chingkha, Tamei, Kamjong
Population Reduction-PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000Km^2
Area of Occupancy-AOO	**:**	< 2000Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	The species is declining due to harvest for medicine, habitat loss and trade for parts of the plants. This species has been assessed as VU in Manipur
Conservation Aspects	**:**	The species is traded locally and nationally. So, planted in reserved forest area by the Forest Department, Government of Manipur.
Species-8	**:**	*Cinnamomum verum* J. Presl.
Reported Locations in Manipur	**:**	Tamenglong, Ukhrul, Chandel, Dzukou hills, Senapati, Phayeng and Senapati.
Population Reduction-PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000 Km^2
Area of Occupancy-AOO	**:**	< 2000Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	The wild population is adversely affected

		by habitat destruction, trade and over exploitation. On account of population decline of 30 to 50%, this species has been assessed as VU.
Conservation Aspects	**:**	Awareness on habitat destruction, trade, human interference and encouraging *in-situ* conservation.
Species-9	**:**	*Cissus javana* D C.
Reported Locations in Manipur	**:**	Thoubal, Langol Ching, Chandel, Heingang Ching, Tamenglong and Senapati
Population Reduction-PR	**:**	< 30%
Extent of Occurrence EOO	**:**	> 20,000Km^2
Area of Occupancy-AOO	**:**	> 2000Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	The species has declined due to low seed germination and habitat destruction. It has been assessed as NT following IUCN Criteria A2cd.
Conservation Aspects	**:**	Encouraging *in- sit* conservation measure in wild population.

Species-10	**:**	*Citrus hystrix* DC
Reported Locations in Manipur	**:**	Chandel, Churachandpur, Tamenglong, Kangpokpi
Population Reduction-PR	**:**	< 30 %
Extent of Occurrence EOO	**:**	>20,000 Km^2
Area of Occupancy-AOO	**:**	> 2000Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale/Threats	**:**	The wild population has declined due to human interference, edaphic factors and disease. On account of population reduction estimated at <30%, it has been assessed as NT in Manipur**.**
Conservation Aspects	**:**	Need immediate awareness programme for proper collection methods and commercial cultivation.

Species-11	**:**	*Curcuma amada* (Roxb)
Reported Locations in Manipur	**:**	Imphal east, Phayeng, Churchandpur, Thoubal, Torbung Bangla.
Population Reduction-PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000 Km^2
Area of Occupancy-AOO	**:**	< 2000Km^2
IUCN Red List Category	**:**	**VU**

IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale /Threats:		Population declines due to low regeneration, harvest for medicine and trade. It has been assessed as VU on account of estimated population decline of 30 to <50%.
Conservation Aspects	**:**	Scattered in hills of Manipur. It needs awareness for proper collection methods for sustainable uses.

Species-12	**:**	*Curcuma caesia* Roxb.
Reported Locations in Manipur	**:**	Langol hill, Tamenglong, Chandel, Nongmaiching hill**,** Ukhrul and Senapati.
Population Reduction-PR	**:**	< 30%
Extent of Occurrence EOO	**:**	> 20,000Km^2
Area of Occupancy-AOO	**:**	> 2000Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale/Threats	**:**	The wild population is declining due to harvest for medicine and parts of the plant. It has been assessed as NT following IUCN CriteriaA2c.
Conservation Aspects	**:**	Mass awareness programme for proper collection methods and to start up commercial cultivation.

Species 13	**:**	*Dendrobium aphyllum* (Roxb.)
Reported Locations in Manipur	**:**	Lunghar, Chandel, Kamjong, Senapati, Kangpokpi.
Population Reduction-PR	**:**	< 30%
Extent of Occurrence EOO	**:**	> 20,000 Km^2
Area of Occupancy-AOO	**:**	> 2000 Km2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	The wild population of the species are largely affected by various natural anthropogenic activities. This species has been assessed as NT on account of population decline of < 30%.
Conservation Aspects	**:**	Need awareness to stop rampant forest fires and illegal trade.

Species-14	**:**	*Dendrobium denudans* D. Don
Reported Locations in Manipur	**:**	Tamenglong, Chandel, Khayangbung, Senapati, Tengnoupal.
Population Reduction-PR	**:**	50 to <80%
Extent of Occurrence EOO	**:**	< 5000 Km^2
Area of Occupancy-AOO	**:**	< 500 Km^2
IUCN Red List Category	**:**	**EN**
IUCN Red List Criteria	**:**	**A2cd**

Assessment Rationale/ Threats:		Wild population has been declined due to habitat destruction, forest fire and harvest for medicine. This species assigned as EN on account of population reduction of 50 to < 80%.
Conservation Aspects	**:**	Avoid habitat destruction and illegal trade of the whole plants.

Species-15	**:**	*Dendrobium nobile* Lindl.
Reported Locations in Manipur	**:**	Khayangbung, Chandel, Senapati, Tamenglong.
Population Reduction-PR	**:**	50 to <80%
Extent of Occurrence EOO	**:**	< 5000 Km^2
Area of Occupancy-AOO	**:**	< 500Km^2
IUCN Red List Category	**:**	**EN**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/ Threats	**:**	This species has been declined due to harvest for medicine, loss of habitat and trade. On account of population reduction estimated, this species has been assigned as EN.
Conservation Aspects	**:**	Need awareness for proper collection and its medicinal importance.

Species-16	**:**	*Dichroa febrifuga* Lour.
Reported Locations in Manipur	**:**	Tamei (Puilong), Ukhrul, Chandel, Tamenglong and Senapati
Population Reduction-PR	**:**	< 30%
Extent of Occurrence EOO	**:**	> 20,000 Km^2
Area of Occupancy-AOO	**:**	> 2000Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale/Threats	**:**	The species is decreasing due to improper collection, harvest for medicine and encroachment. This species has been assessed as NT in Manipur following IUCN CriteriaA2c**.**
Conservation Aspects	**:**	Local NGOs started *in situ* conservation in their natural habitat.

Species-17	**:**	*Eleutherine bulbosa* (Mill).
Reported Locations in Manipur	**:**	Chandel, Tengnoupal, Tamenglong, Ukhrul and Senapati
Population Reduction-PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000 Km^2
Area of Occupancy-AOO	**:**	< 2000Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2cd**

Assessment Rationale/Threats	**:**	Declined due to forest fires and medicine. This species has been assessed as VU on account of population reduction of 30 to < 50%.
Conservation Aspects	**:**	Awareness for proper collection methods and importance of plants.
Species-18	**:**	*Eleutherococcus trifoliatus* (L.)
Reported Locationsin Manipur	**:**	Senapati, Tamenglong, Kangpokpi, Ukhrul.
Population Reduction-PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000 Km^2
Area of Occupancy-AOO	**:**	< 2000 Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	Over- exploitation of roots and harvest for medicine are the main threats. It has been assigned as VU following IUCN Criteria A2cd.
Conservation Aspects	**:**	Both *in situ* and *ex situ* conservation measures are necessary.

Species-19	**:**	*Eupatorium cannabinum* L.
Reported Locations in Manipur	**:**	Heingang, Langol hill, Kakching, Noney, Churachandpur
Population Reduction-PR	**:**	<30%
Extent of Occurrence EOO	**:**	> 20,000Km^2
Area of Occupancy-AOO	**:**	> 2000Km^2
IUCN Red List Category	**:**	**LC**
IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale/Threats	**:**	Loss of habitat, improper collection method and forest fire are the main threats. This species has been assessed as LC in Manipur**.**
Conservation Aspects	**:**	Improper collection leading to decline of the plants. Awareness of the importance of medicinal value is needed.

Species-20	**:**	*Eurya acuminata* DC.
Reported Locations in Manipur	**:**	Kangpokpi, Kamjong, Senapati, Tamenglong and Churchandpur.
Population Reduction-PR	**:**	< 30%
Extent of Occurrence EOO	**:**	> 20,000 Km^2
Area of Occupancy-AOO	**:**	> 2000 Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2cd**

Assessment Rationale/Threats	**:**	The wild population is affected due to harvest for food and medicine. It has been assigned as NT following IUCN Criteria A2cd.
Conservation Aspects	**:**	*In- situ* conservation is important within the habitat.

Species-21	**:**	*Flacourtia jangomas* (Lour).
Reported Locationsin Manipur	**:**	Heingang,Langol hill, Phayeng, Thoubal, Ukhrul
Population Reduction-PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000 Km^2
Area of Occupancy-AOO	**:**	< 2000 Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	This species has been declined due to habitat destruction and over exploitation. On account Population reduction, this species has been assigned as VU.
Conservation Aspects	**:**	Both *In situ* and *ex situ* conservation are encouraged.

Species-22	**:**	*Garcinia pedunculata* Roxb.
Reported Locationsin Manipur	**:**	Ukhrul, Senapati, Tamenglong,Chandel
Population Reduction-PR	**:**	< 30%
Extent of Occurrence EOO	**:**	< 20,000 Km^2
Area of Occupancy-AOO	**:**	< 2000 Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	This species is declining due to harvest for medicine, loss of habitat and trade. It has been assessed as NT following IUCN Criteria A2cd.
Conservation Aspects	**:**	Forest clearance and forest fires leads to loss of microhabitat.

Species-23	**:**	*Garcinia xanthochymus* Hook.f. ex T. Anderson
Reported Locations in Manipur	**:**	Tangjeng, Thoubal, Bishnupur, Imphal East, Senapati
Population Reduction-PR	**:**	< 30%
Extent of Occurrence EOO	**:**	> 20,000 Km^2
Area of Occupancy-AOO	**:**	> 2000 Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	Unsustainable collection, forest clearance

		and encroachment are the main threat. This species has been assigned as NT in Manipur.
Conservation Aspects	**:**	Avoid Forest fire, improper collection and human interference.
Species-24	**:**	*Glochidion coccineum* (Buch. -Ham).
Reported Locations in Manipur	**:**	Heingangching, Sekmai, Imphal east, Nachou
Population Reduction-PR	**:**	<30%
Extent of Occurrence EOO	**:**	< 20,000Km^2
Area of Occupancy-AOO	**:**	< 2000Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale/Threats	**:**	The wild population is decreasing due to forest clearance & harvest for medicine. On account of population reduction, this species has been assigned as NT.
Conservation Aspects	**:**	Awareness programme to stop rampant forest fires and habitat destruction.

Species-25	**:**	*Hedychium spicatum Smith*.
Reported Locations in Manipur	**:**	Chandel, Mao Maram, Nongmaiching, Ukhrul, Tamenglong and Bishnupur.
Population Reduction-PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000 Km^2
Area of Occupancy-AOO	**:**	< 2000 Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	Habitat destruction, harvest for medicine &ornamental purpose are the main threats. So, the plant has been assessed as VU following IUCN CriteriaA2cd.
Conservation Aspects	**:**	Need to check forest fires and habitat destruction.
Species-26	**:**	*Hippochaete debilis* (Roxb. ex Vaucher) Ching
Reported Locations in Manipur	**:**	Andro, Heingang, Nungba, Leimaram, Chandel, Ukhrul and Tamenglong
Population Reduction-PR	**:**	< 30%
Extent Of Occurrence EOO	**:**	> 20,000 Km^2
Area of Occupancy-AOO	**:**	> 2000 Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	This species has been declined due to

		harvest for medicine, loss of habitat and encroachment. On account of population reduction, it has been assigned as NT in Manipur.
Conservation Aspects	**:**	Need *in- situ* conservation in their natural habitat.
Species-27	**:**	*Homalomena aromatica* (Spreng.)Schott.
Reported Locations in Manipur	**:**	Tamenglong, Kangpokpi, Senapati, Chandel
Population Reduction-PR	**:**	50 to < 80%
Extent of Occurrence EOO	**:**	< 5 000 Km^2
Area of Occupancy-AOO	**:**	< 500 Km^2
IUCN Red List Category	**:**	**EN**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	Habitat destruction, harvest for medicine and trade are the main threats. So, the plant has been assessed as EN following IUCN Criteria A2cd.
Conservation Aspects	**:**	Need immediate awareness for proper collection methods and importance of plants.

Species-28	**:**	*Lilium mackliniae* Sealy.
Reported Locations in Manipur	**:**	Shirui hills, Khyangbung & Khamsomhills
Population Reduction-PR	**:**	50 to <80%
Extent of Occurrence EOO	**:**	< 5000 Km^2
Area of Occupancy-AOO	**:**	< 500 Km^2
IUCN Red List Category	**:**	**EN**
IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale/Threats	**:**	This species is continuously declining due to habitat destruction, over exploitation. On account of population reduction estimated, So the plant has been assigned as EN following IUCN CriteriaA2c.
Conservation Aspects	**:**	Need to check forest fires and overgrowth of *Yushaniarolloana*.

Species-29	**:**	***Litsea cubeba* (Lour.) Pers.**
Reported Locations in Manipur	**:**	Phayeng, Andro, Pallel, Kamjong, Senapati, Ukhrul and Chandel
Population Reduction-PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000Km^2
Area of Occupancy-AOO	**:**	< 2000Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	Improper collection methods and harvest

		for medicine are the main threats. This species has been assessed as VU following IUCN Criteria A2cd.
Conservation Aspects	**:**	Encouraging *in- situ* conservation measures in wild population.
Species-30	**:**	*Litsea glutinosa* (Lour.) C.B. Roxb.
Reported Locations in Manipur	**:**	Kakching Khunou, Kamjong, Maram, Phayeng, Ukhrul and Senapati
Population Reduction-PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000 Km^2
Area of Occupancy-AOO	**:**	< 2000 Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	The wild population is declining due to Over-exploitation, harvest for food, medicine. On account of Population reduction declined, this species has been assigned as VU.
Conservation Aspects	**:**	To conduct regular training camps for the farmers for cultivation, harvesting and sustainable utilization.
Species-31	**:**	*Lobelia nummularia* Lam.
Reported Locations in Manipur	**:**	Thoubal, Imphal east, Langol hill, Senapati, Ukhrul and Chandel

Population Reduction-PR	**:**	< 30%
Extent of Occurrence EOO	**:**	> 20,000 Km^2
Area of Occupancy-AOO	**:**	> 2000 Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale/Threats	**:**	The wild population is affected due to low regeneration and harvest for medicine. This species has been assigned as NT following Criteria A2c.
Conservation Aspects	**:**	Need immediate awareness for proper collection methods and importance of plants.

Species-32	**:**	*Mahonia napaulensis* D C.
Reported Locations in Manipur	**:**	Tamenglong (Dailong), Senapati, Ukhrul, Chandel
Population Reduction-PR	**:**	30 to < 50%
Extent Of Occurrence EOO	**:**	< 20,000 Km^2
Area of Occupancy-AOO	**:**	< 2000 Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale / Threats	**:**	The wild population is adversely affected by habitat destruction and harvest for medicine. This species has been assessed as VU in Manipur.

Conservation Aspects	**:**	Awareness on proper collection of bark and young shoots leading to death of the plants.
Species-33	**:**	*Millettia pachycarpa* Benth.
Reported Locationsin Manipur	**:**	Lai maton Ching, Tamenglong, Kangpokpi, Ukhrul, Chandel and Senapati.
Population Reduction-PR	**:**	< 30%
Extent of Occurrence EOO	**:**	> 20,000 Km^2
Area of Occupancy-AOO	**:**	> 2000 Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	It is collected from wild in an indiscriminate way and population is decreasing continuously. So, the plant has been assessed as NT in Manipur.
Conservation Aspects	**:**	Mass awareness programme for proper collection methods, harvest for medicine and encouraging *in- sit* conservation.
Species-34	**:**	*Oroxylum indicum* (L.) Kurz.
Reported Locations in Manipur	**:**	Heingang hill, Phayeng, Ukhrul, Senapati, Ukhrul, Chandel,

		Churchandpur and Tamenglong.
Population Reduction-PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000 Km^2
Area of Occupancy-AOO	**:**	< 2000 Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/ Threats	**:**	The wild population is affected by habitat destruction, over exploitation and forest fires. This species has been assigned as VU following IUCN. Criteria A2cd
Conservation Aspects	**:**	Awareness should be given to localities for sustainable use of medicinal plants.

Species-35	**:**	*Paederia foetida* L.
Reported Locations in Manipur	**:**	Phayeng, Nongdam Tangkhul, Chandel, Ukhrul, Senapati, Churchandpur, Thoubal and Bishnupur
Population Reduction-PR	**:**	< 30%
Extent of Occurrence EOO	**:**	> 20,000 Km^2
Area of Occupancy-AOO	**:**	> 2000 Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale/Threats	**:**	Loss of habitat, improper collection method and forest fire are the main

threats. So, the plant has been assigned as NT following IUCN Criteria A2c.

Conservation Aspects : Need awareness for proper collection and its medicinal importance.

Species-36 : *Panax assamicus* R.N. Banerjee.

Reported Locations in Manipur : Shirui hill, Senapati, Tamenglong (Tamei)

Population Reduction-PR : 50 to < 80%

Extent of Occurrence EOO : < 5000 Km^2

Area of Occupancy-AOO : < 500 Km^2

IUCN Red List Category : **EN**

IUCN Red List Criteria : **A2c**

Assessment Rationale/Threats : Uprooting of rhizome, harvest for medicine and trade leads to death of the plants. On account of population reduction, this species has been assigned as EN in Manipur.

Conservation Aspects : Awareness for proper collection and its medicinal value.

Species-37 : *Panax pseudoginseng* Wall.

Reported Locations in Manipur : Senapati, Tamenglong, Ukhrul.

Population Reduction-PR : >80%

Extent of Occurrence EOO	**:**	< 100 Km^2
Area of Occupancy-AOO	**:**	< 10 Km^2
IUCN Red List Category	**:**	**CR**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	Population reduction due to forest fire, habitat destruction and harvest for medicine are the main threats. So, the plant has been assigned as CR following IUCN Criteria A2cd.
Conservation Aspects	**:**	Awareness should be given to localities for sustainable use of medicinal plants.

Species-38	**:**	*Paris polyphylla* Sm.
Reported Locations in Manipur	**:**	Shirui area, Tamei, Mapithel, Senapati
Population Reduction-PR	**:**	50 to < 80%
Extent of Occurrence EOO	**:**	< 5000 Km^2
Area of Occupancy-AOO	**:**	< 500 Km^2
IUCN Red List Category	**:**	**EN**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	Declined due to over- exploitation, uprooting of rhizome leads to death of the whole plants. This species has been assessed as EN on account of estimated population decline 50 to<80%.

Conservation Aspects	**:**	Need awareness for proper collection and its medicinal importance to localities.
Species-39	**:**	*Phyllanthus urinaria* L.
Reported Locations in Manipur	**:**	Imphal east, Thoubal, Phayeng, Ukhrul, Senapati, Tamenglong and Chandel.
Population Reduction-PR	**:**	< 30%
Extent of Occurrence EOO	**:**	> 20,000 Km^2
Area of Occupancy-AOO	**:**	> 2000 Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale/Threats	**:**	Population reduction due to harvest for medicine, forest fire and pesticides. So, the plant has been assigned as NT in Manipur
Conservation Aspects	**:**	Awareness should be given to localities for sustainable use of medicinal plants.
Species-40	**:**	*Piper griffithii* C. DC.
Reported Locations in Manipur	**:**	Senapati, Phayeng, Andro, Thoubal, Ukhrul, Chandel and Churchandpur
Population Reduction-PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000 Km^2
Area of Occupancy-AOO	**:**	< 2000 Km^2

IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale /Threats	**:**	Loss of habitat, forest fires, and harvest for medicine are the main threats. This species has been assessed as VU following the IUCN Criteria A2cd.
Conservation Aspects	**:**	Awareness on sustainable utilization should been encouraged.

Species-41	**:**	*Piper peepuloides* Wall.
Reported Locations in Manipur	**:**	Tamenglong, Senapati, Ukhrul, Tengnoupal
Population Reduction -PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000 Km^2
Area of Occupancy-AOO	**:**	< 2000 Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	Wild population is declined due to forest fires, improper collection method and harvest for medicine. So, the plant has been assigned as VU following the IUCN CriteriaA2cd.
Conservation Aspects	**:**	*In situ* conservation by establishment of biosphere natural reserves.

Species-42	**:**	*Quercus lamellose* Sm.
Reported Locations in Manipur	**:**	Shirui (Ukhrul), Mao, Dzukouhills
Population Reduction- PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000 Km^2
Area of Occupancy-AOO	**:**	< 2000 Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale/Threats	**:**	Population declined due to harvest for parts, loss of habitat due to shifting cultivation and fire. On account of PR estimated at 30 to <50% over 150 years, this species has been assigned as VU.
Conservation Aspects	**:**	It needs to check forest clearance & proper collection methods.

Species-43	**:**	*Rhododendron arboretum* Sm.
Reported Locations in Manipur	**:**	Shirui peak, Dzukou hill, UKhrul, Senapati and Tamenglong
Population Reduction-PR	**:**	< 30%
Extent of Occurrence EOO	**:**	> 20,000 Km^2
Area of Occupancy-AOO	**:**	> 2000 Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2c**

Assessment Rationale/Threats	**:**	Improper collection, harvest for medicine, forest fire are the main threats. On account of PR, this species has been assigned as NT in Manipur.
Conservation Aspects	**:**	Awareness to stop rampant forest fires and habitat destruction.

Species-44	**:**	*Rubia cordifolia* L.
Reported Locations in Manipur	**:**	Kangpokpi, Imphal west, Ukhrul, Noney, Tamenglong, Chandel and Senapati
Population Reduction-PR	**:**	50 to <80%
Extent of Occurrence EOO	**:**	< 5000 Km^2
Area of Occupancy-AOO	**:**	< 500 Km^2
IUCN Red List Category	**:**	**EN**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale / Threats	**:**	Population declines due to harvest for medicine, parts, habitat loss and trade. So, the plant has been assessed as EN following the IUCN Criteria A2cd.
Conservation Aspects	**:**	Need awareness for proper collection methods and its medicinal importance.

Species-45	**:**	*Scutellaria discolour* Colebr
Reported Locations in Manipur	**:**	Nongdam Tangkhul, Thoubal, Imphal west, Thoubal, Ukhrul, Senapati, Chandel and Churchandpur
Population Reduction-PR	**:**	50 to <80%
Extent of Occurrence EOO	**:**	< 5000 Km^2
Area of Occupancy-AOO	**:**	< 500 Km^2
IUCN Red List Category	**:**	**EN**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	Harvest for medicine, forest fire, improper collection methods are the main threats. On account of PR estimated at 50 to < 80%, this species has been assigned as EN.
Conservation Aspects	**:**	To conduct training camps for the farmers for cultivation, harvesting and sustainable utilization.

Species-46	**:**	*Smilax ovalifolia* Roxb. ex D.Don.
Reported Locationsin Manipur	**:**	Langol hill, Mapithel, Tamemglong, Senapati, Ukhrul, Chandel, Churchandpur and Bishnupur.
Population Reduction-PR	**:**	< 30%
Extent of Occurrence EOO	**:**	> 20,000 Km^2

Area of Occupancy-AOO	**:**	> 2000 Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	Wild population is reducing due harvest for food, medicine, forest fire and trade. So, the plant has been assessed as NT in Manipur.
Conservation Aspects	**:**	Awareness should be given to localities for sustainable use of medicinal plants.
Species-47	**:**	*Swertia angustifolia* Buch. - Ham. Ex D.Don.
Reported Locations in Manipur	**:**	Shirui hill, Dzukou, andSenapati
Population Reduction-PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000Km^2
Area of Occupancy -AOO	**:**	< 2000 Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale/Threats	**:**	The major threats to the wild population of this plant species are loss of habitat and harvest for medicine. On account of PR, this species has been assigned as VU.
Conservation Aspects	**:**	Both *In-situ* and *Ex- situ* conservation measures are necessary for sustainable uses.

Species-48	**:**	*Syzygium nervosum* A.Cunn. ex DC.
Reported Locationsin Manipur	**:**	Lai matonching, Tamenglong, Chandel, Thoubal, Churchandpur, Bishnupur and Senapati.
Population Reduction-PR	**:**	30 to < 50 %
Extent of Occurrence EOO	**:**	< 20,000 Km^2
Area of Occupancy-AOO	**:**	< 2000 Km^2
IUCN Red List Category	**:**	**VU**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	The wild population is adversely affected by habitat destruction, harvest for medicine and over exploitation. This species has been assessed as VU following the IUCN CriteriaA2cd.
Conservation Aspects	**:**	Awareness should be given to localities for sustainable use of medicinal plants.

Species-49	**:**	*Taxus wallichiana* Zucc.
Reported Locations in Manipur	**:**	Khayangbung, Tamenglong and Senapati
Population Reduction-PR	**:**	> 80%
Extent of Occurrence EOO	**:**	< 100 Km^2
Area of Occupancy-AOO	**:**	< 10Km^2
IUCN Red List Category	**:**	**CR**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	The wild population is adversely affected

		due to harvest for medicines, loss of habitat and trade. On account of PR, this species has been assigned as CR following the IUCN CriteriaA2cd.
Conservation Aspects	**:**	Awareness should be given to localities for sustainable use of medicinal plants.

Species-50	**:**	*Thalictrum foliolosum* DC.
Reported Locations in Manipur	**:**	Mao- Maram, Shirui hill, Dzukou hill and Ukhrul.
Population Reduction-PR	**:**	50 to <80%
Extent of Occurrence EOO	**:**	< 5000 Km^2
Area of Occupancy-AOO	**:**	< 500 Km^2
IUCN Red List Category	**:**	**EN**
IUCN Red List Criteria	**:**	**A2cd**
Assessment Rationale/Threats	**:**	The wild population is declining due to improper collection method, harvest for medicine and loss of habitat. So, the plant has been assigned as EN following the IUCN CriteriaA2cd.
Conservation Aspects	**:**	Awareness should be given for proper collection, harvest for medicine to the farmers.

Species-51	**:**	*Zanthoxylum acanthopodium* DC.
Reported Locations in Manipur	**:**	Langol hill, Ukhrul, Chandel, Heingang hill, Thoubal, Senapati, Bishnupur, Tamenglong and Churchandpur.
Population Reduction-PR	**:**	< 30%
Extent of Occurrence EOO	**:**	> 20,000 Km^2
Area of Occupancy-AOO	**:**	> 2000 Km^2
IUCN Red List Category	**:**	**NT**
IUCN Red List Criteria	**:**	**A2c**
Assessment Rationale/Threats	**:**	Loss of habitat, forest fires, edaphic factors, and harvest for medicine are the main threats. On account of PR, this species has been assigned as NT in Manipur
Conservation Aspects	**:**	Some local NGOs started *in situ* conservation measures for sustainable uses.
Species-52	**:**	*Zanthoxylum rhetsa* (Roxb.) DC.
Reported Locationsin Manipur	**:**	Bishnupur, Makhan, Tamenglong, Ukhrul, Thoubal, Andro, Senapati and Chandel.
Population Reduction-PR	**:**	30 to < 50%
Extent of Occurrence EOO	**:**	< 20,000 Km^2
Area of Occupancy-AOO	**:**	< 2000 Km^2
IUCN Red List Category	**:**	**VU**

IUCN Red List Criteria	:	**A2c**
Assessment Rationale / Threats	:	The wild population is reducing due to harvest for medicine, over exploitation, forest fire and loss of habitat. So, the species has been assigned as VU.
Conservation Aspects	:	To conduct regular training camps for the farmers for cultivation, harvesting and sustainable utilization

The threatened species list can be utilize to: (1) inspire research and monitoring progress for species (2) encourage and update management strategies (3) Observe the status of diversity (4) Target biological diversity regions for conservation development (5) aware community consciousness of social effect on biodiversity (6) set priorities for the distribution of insufficient conservation resources (Bennum *et al*., 2000; Rodriquez *et al.*, 2004).

The first step to initiate conservation actions for threatened organisms is to identify the species that are faced with the threat of extinction or in decline (Caughley, 1994; Brooks *et al.*, 2006).

Increasing awareness about the possible extinction of some species is mainly credited to the development of the World Conservation Union's (IUCN) Red List and Red Data Books (RDB) concept (Magin *et al*., 1994). Red Lists and Red Data Books are in simple methods for finding decreasing taxa, which will permit conservation researchers to establish the nature and degree of such declines, research and the monitoring of such species and introduce conservation actions (Ferrar, 1991; Sutherland, 2001).

CHAPTER -VI

PREDICTION OF SPECIES DISTRIBUTION MODEL FOR SELECTED THREATENED ETHNOMEDICINAL PLANTS OF MANIPUR

The chapter deals with the development of Species Distribution Model (SDM) of 5 (Five) species namely *Aconitum nagarum* Stapf. (EN), *Paris polyphylla* Sm (EN), *Rubia cordifolia* Linn., *Thalictrum foliolosum* DC. (EN) and *Taxus wallichiana* Zucc. (CR). The 5 (five) species were selected for SDM based on the most endangered status and medicinal importance basis against the 52 ethnomedicinal plants recorded from Manipur in the present study.

6.1. GENERAL OUTLINE OF SPECIES DISTRIBUTION MODEL.

The geographic distribution of a plant species is influences by multiple factors including the ecological traits of the plant and interactions with biotic and abiotic factors to define its habitats, e.g., species composition, microclimate and topography, especially for the dominating species in the forest (Chen *et al*., 2010;). The dynamics of species distribution and potential adaptation are key issues in biodiversity conservation. A SDM is a mathematical method to study species distribution patterns. There are various approaches for estimating SDM. Among the many alternative methods for species distribution modelling, the MaxEnt method is a popular one. It is considered to have the advantages of high accuracy, small sample size and simple operation (Phillips *et al*.,2006). It has been used to predict species distribution in natural, potentially introduced and planted areas, the adaptation of pests and disease, the interactions between species distribution and environments (Matyukhina *et al*., 2014; Costa *et al*., 2015).

Information on the habitat's distribution, population statues and conservation strategy of many threatened ethnomedicinal plants of Manipur are rare. In this study, selected 5 (five) threatened ethnomedicinal plants are studied for their habitat suitability using MaxEnt modelling.

6.1.1 Species Occurrence Data

Occurrence data are collected from different sources. Collection can be categorized into a). Primary and b) Secondary data.

***(a) Primary data*:** Data were collected during field visit from January, 2016 to December, 2019 in various places of Manipur. Out of the 52 species selected for the study, five important species were selected for the modelling on the basis of their IUCN status and its medicinal importance. The coordinates of the studied species are given in the table below by using GPS (*eTrex* 10) were used as occurrence points are shown in the following table (6.1) and figure (6.1)

Table 6.1: Location of the selected threatened ethnomedicinal plants

Species	**Latitude**	**Longitude**
1.*Aconitum nagarum* Stapf.	25º06′56.6″ 25º06′26.02″ 25º10′43.54″ 25º31′08.34″ 25º31′10.51″ 25º32′55.52″ 25º33′16.1″ 25º7′6.708″ 25º30′49.788″ 25^{0}14′30.012″	94º26′49.5″ 94º27′41.02″ 94º28′48.51″ 94º06′10.75″ 94º06′20.84″ 94º04′06.16″ 94º4′5.8″ 94º26′38.4″ 94º08′11.004″ 94º45′23.004″
2. *Paris polyphylla* Sm.	25º32′53.48″ 25º14′51.87″	94º04′25.64″ 93º43′23.59″

	25º21′31.86″ 25º07′00.77″ 25º30′00.50″ 24º59′01.40″ 25º0′37.8″ 24º50′15.7884″ 25º13′33.924″ 24º18′14.4″	93º58′05.68″ 94º26′44.09″ 94º22′59.14″ 94º37′20.82″ 93º31′44.112″ 94º5′15.216″ 94º42′31.968″ 94º8′26.592″
3. *Rubia cordifolia* Linn.	25º07′34.59″ 25º30′48.42″ 25º22′02.13″ 24º46′12.49″ 24º15′27.43″ 25º10′12.684″ 24º22′53.328″ 25º17′5.712″ 25º7′22.404″ 24º22′12.684″	94º25′12.99″ 94º06′40.07″ 93º48′32.37″ 94º01′38.52″ 94º02′07.72″ 93º44′15.144″ 94º8′44.268″ 94º40′7.608″ 94º26′27.096″ 94º5′22.884″
4. *Taxus wallichiana* Zucc.	24º55′32.95″ 25º03′10.44″ 25º27′10.02″ 25º30′38.94″ 25º09′33.75″ 25º28′44.184″ 25º07′16.608″ 25º25′26.472″ 25º48′32.904″ 25º18′15.984″	94º41′59.76″ 94º24′26.25″ 94º07′02.71″ 94º05′30.23″ 94º35′07.47″ 94º08′13.092″ 94º26′36.996″ 94º06′27.324″ 94º08′28.608″ 94º02′39.768″
5. *Thalictrum foliolosum* D. C	25º02′39.86″ 25º07′32.30″ 25º06′55.08″ 25º26′45.44″ 25º21′11.13″ 24º27′45.9″ 24º48′26.784″ 24º24′57.6″ 24º19′28.992″ 25º0′43.596″	94º24′17.33″ 94º25′08.51″ 94º36′39.91″ 93º53′20.00″ 93º50′51.64″ 94º09′44.1″ 94º08′42.322″ 94º03′18.9″ 94º0′56.016″ 93º31′37.812″

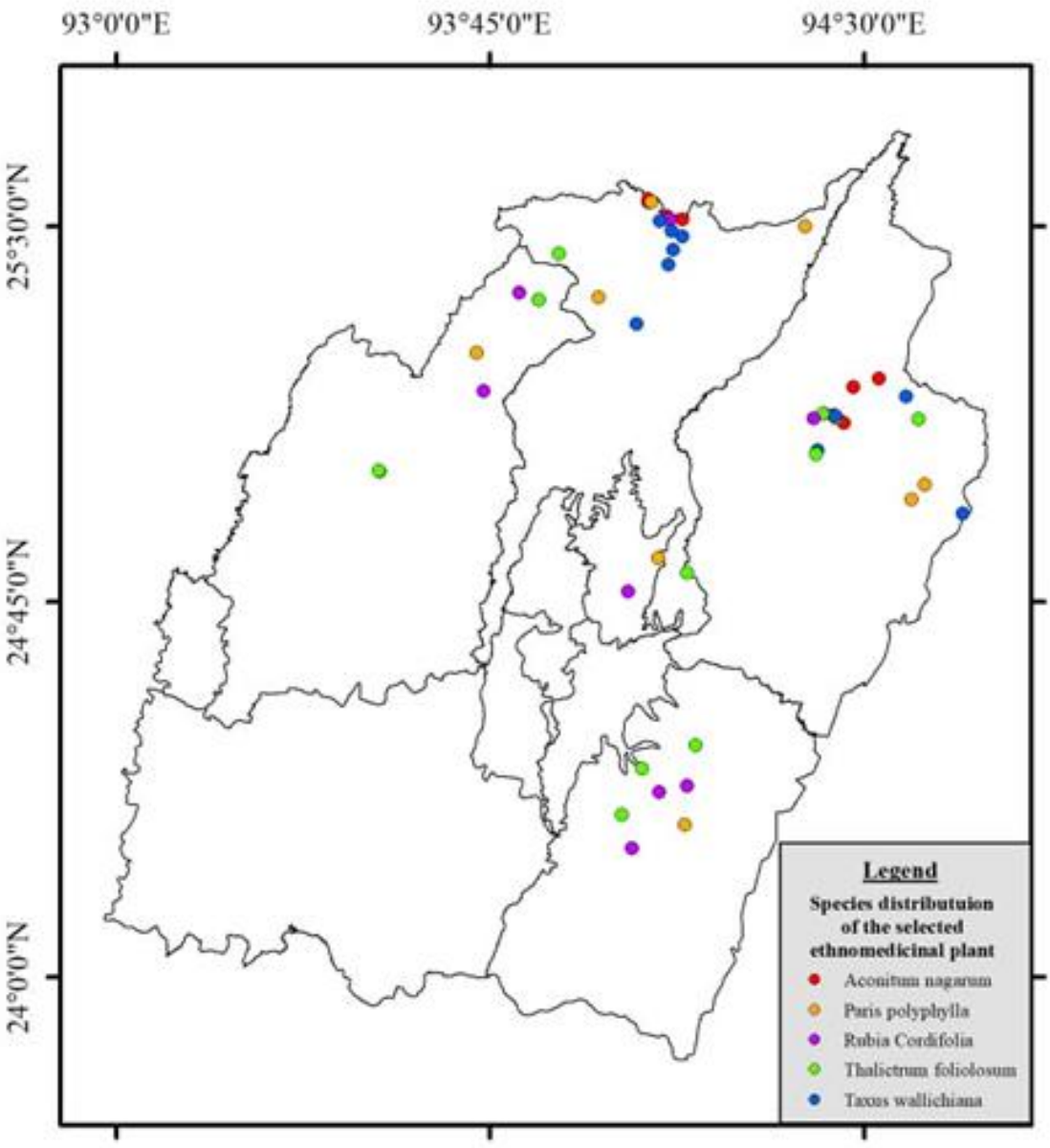


Fig. 6.1: Map showing species occurrence of selected 5 (five) threatened ethnomedicinal plants of Manipur

***(b) Secondary data*:** Coordinate point of the species are also collected from other published literatures. There is also a secondary data without location coordinates where the published literature mentioned place for collection but not the coordinates. If the places of the names are mentioned, the area is selected from gazetteer and geo-referenced accordingly.

6.1.2 Environmental Data

Environmental variables are meaningful to explain the habitats distribution based on the ecological niche of the species. For the present study Bioclimatic Variables are downloaded from the WorldClim–Global climate data website (www.worldclim.org). Thirty seconds (30″) resolution data are used for the modelling as these are one of the highest resolutions available so far.

Prediction variables are derived from the monthly temperature and rainfall values in order to generate more biologically meaningful variables. These variables represent annual trends (e.g., mean annual temperature, annual precipitation) seasonality (e.g., annual range in temperature and precipitation) and extreme or limiting environmental factors (e.g., temperature of the coldest and warmest month, and precipitation of the wet and dry quarters). The quarter represented in this variable is represented by a period of three months (1/4 of the year). Land cover data are downloaded from Global Land Cover Facility. Altitude data are downloaded from Bhuvan ISRO website. Variables showing multicollinearity are filtered out. The present study 19 bioclimatic variables are used which are represented by the table below:

Table 6.2: The 19 Environmental variables used for MaxEnt analysis

Variables	Details
BIO1	Annual mean temperature
BIO2	Mean diurnal temperature range [mean of monthly (max temp–min temp)]
BIO3	Isothermality (P2/P7) (×100)
BIO4	Temperature seasonality (standard deviation×100)
BIO5	Max temperature of warmest month
BIO6	Min temperature of coldest month
BIO7	Temperature annual range (P5–P6)
BIO8	Mean temperature of wettest quarter
BIO9	Mean temperature of driest quarter
BIO10	Mean temperature of warmest quarter
BIO11	Mean temperature of coldest quarter
BIO12	Annual precipitation
BIO13	Precipitation of wettest month
BIO14	Precipitation of driest month
BIO15	Precipitation seasonality (coefficient of variation)
BIO16	Precipitation of wettest quarter
BIO17	Precipitation of driest quarter
BIO18	Precipitation of warmest quarter
BIO19	Precipitation of coldest quarter
Slope	Slope value from digital elevation model
Aspect	Aspect value from digital elevation model
Altitude	Elevation above sea level (m)
Landcover	Global landcover map from Global Land Cover Facility (www.landcover.org) VCF.

Boundary of Manipur is based on published by Survey of India. Downloaded environmental layers are crop to fit the boundary of Manipur by using DIVA-GIS, an open-source GIS tool.

6.1.3 Model Development

MaxEnt algorithm was performed using the tool version 3.3 downloaded from the website http://www.cs.princeton.edu/~schapire/maxent/. This tool is developed in JAVA and can be run in any platform (Windows, Linux, MacOS, etc.) running Java Virtual Machine. Output results are exported as ArcMap ASCII format. This file is again analysed through ArcGIS version 10.5 (ESRI, 2008). After the MaxEnt modelling analysis, the export file was uploaded to ArcGIS. The grades of suitable habitats were reclassified using Spatial Analyst Tools.

The habitats suitability curves for each variable were calculated, and the contributions of each variable to the selected species habitats model were calculated using the software's built-in jackknife test with ten repetitions (Hill *et al*., 2012). The results of the built-in jackknife test reflect how much gain is obtained from each variable in isolation or from all the variables in combination. A greater gain value with an individual variable indicates that more information or contribution towards species habitats distribution contained in the variable (Wang *et al*., 2017).

6.1.4 Model Evaluation

Prediction accuracy of the present model outputs was measured through receiver operating characteristics (ROC) analysis because of its wider application in the modelling studies (Yates *et al*., 2010). A ROC plot was generated by putting the sensitivity values, the true positive fraction against the false positive fraction for all available probability thresholds. A curve which maximizes sensitivity against low false positive fraction values is considered as good model and is quantified by calculating the area under the curve (AUC). An AUC statistic closer to 1.0 indicates total agreement between the model and test data and considered as good model. An AUC with value closer to 0.5 considered to be no better than random. In general, the AUC should be between 0.5 and 1: when the AUC equal to 0.5, the performance of the model is equivalent to pure guessing; thus, the model performance is graded as fail (0.5-0.6), poor (0.6-0.7), fair (0.7–0.8), good (0.8–0.9), or excellent (0.9–1) (Phillips *et al*.,2006).

6.2. RESULTS AND DISCUSSION

Different models predicted by MaxEnt algorithm for 5 (five) species are presented in the following sections. The potential distribution or the threshold values ranges from 0 to 1. Present study gives preference only to threshold value equal to 1.

Aconitum nagarum Stapf.

Prediction of habitat suitability of *Aconitum nagarum* was done on the basis of data collected from (i) Shirui peak and adjacent village of Ukhrul district and (ii) Dzukou hill and Mao Maram of Senapati district. Red colour on the map

indicates high suitability with green with low suitability. Graphical results have been shown in the Fig. 6.2. As the habitat data are based on these areas suitability maps are confined to these areas and nearest surrounding areas having similar bioclimatic variables. From the finding it can be observed that habitat suitability of this particular species is found in limited area nearly covering the northern part of the state.

The calibrated model of *Aconitum nagarum* (Fig. 6.2) gives a regularized training gain of 2.482, training AUC of 0.982 and unregularized training gain of 2.888. From the result it is observed that Bio9 (Mean temperature of wettest quarter) contributed the maximum (Table 6.3) of 81.4 % followed by Bio5 (Temperature seasonality) of 17.6 % and Bio13 (Annual precipitation) contributing 0.9 % respectively. Least gain is observed in Bio14 and Bio 15 which means the precipitation of the wettest month and precipitation of the driest month respectively.

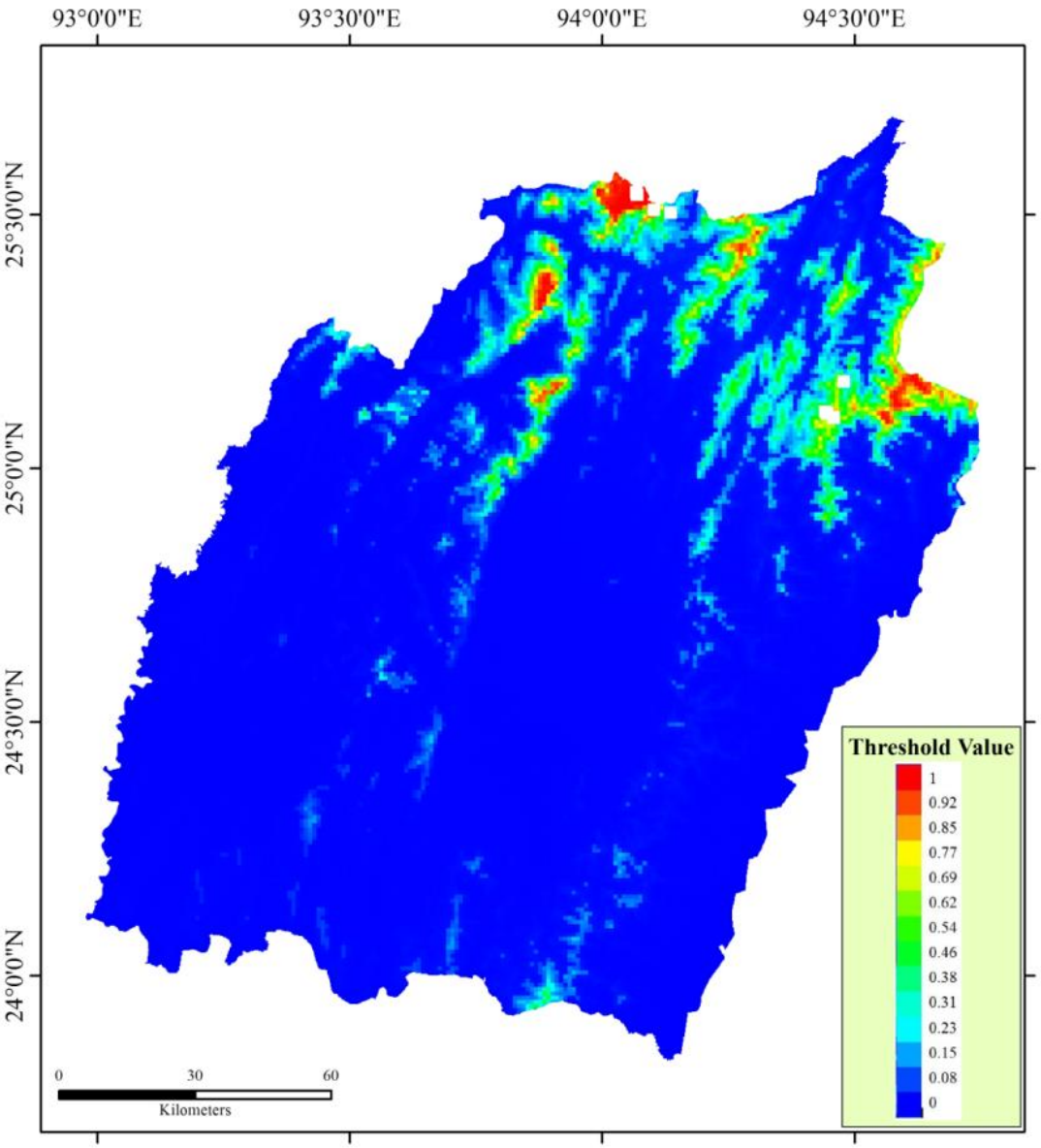


Fig. 6.2: Predicted distribution map of *Aconitum nagarum*

From the model obtained a map (Fig. 6.3) showing only the predicted distribution of *Aconitum nagarum* with maximum threshold value equal to 1 has been prepared. It came to know that the distribution or the availability of the species is confined with less area of about 108 km^2 which is only 0.48 %.

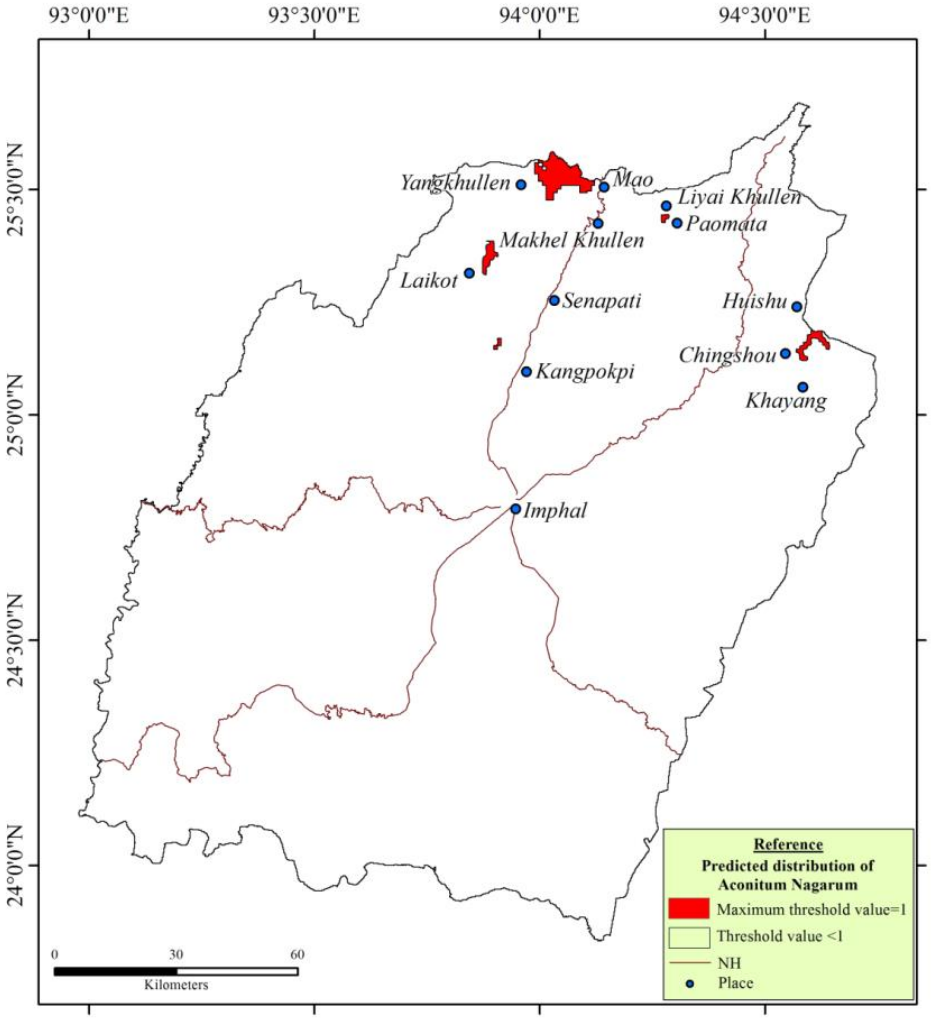


Fig. 6.3: Predicted distribution map of *Aconitum nagarum* with maximum threshold value

The following picture (Fig. 6.4) shows the results of the jackknife test of variable importance. The environmental variable with highest gain when used in isolation is Bio9, which therefore appears to have the most useful information by itself. The environmental variable that decreases the gain the most when it is omitted is Bio11, which therefore appears to have the most information that isn't present in the other variables. Here temperature plays an important role in predicting the model for the species.

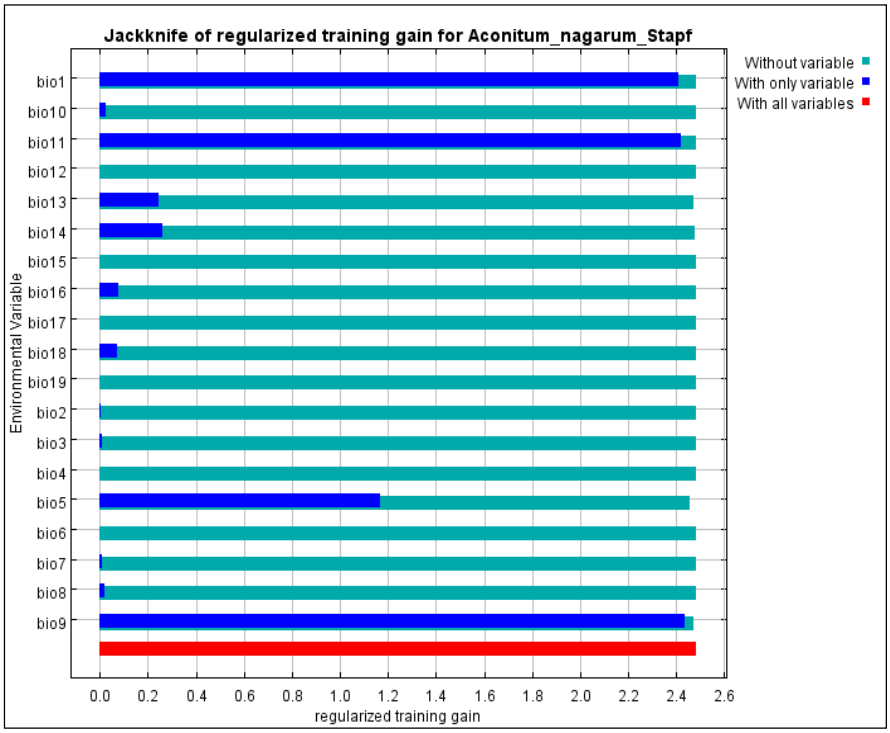


Fig. 6.4: Jacknife test result for *Aconitum nagarum*

***Paris polyphylla* Sm:** Prediction of habitat suitability of *Paris polyphylla* was done on the basis of data collected from Puilong (Tamenglong district), Shirui peak and Mapithel (Ukhrul district), and Makhan (Senapati district). Red colour on the map indicates high suitability and green with low suitability. The results have been shown in the Fig. 6.5. As the habitat data are based on these areas suitability maps are confined to these areas and nearest surrounding area sharing similar

bioclimatic variables. From the finding it can be observed that habitat suitability of this particular species is found in limited area nearly covering the northern part of the state.

The calibrated model of *Paris polyphylla* (Fig. 6.5) gives a regularized training gain of 0.551, training AUC of 0.877 and unregularized training gain of 0.944. From the result it is observed that Bio9 (Mean temperature of wettest quarter) contributed the maximum (Table 6.4) of 32.9 % followed by Bio10 (Mean temperature of warmest quarter) of 20.1 % and Bio6 (Min temperature of coldest month) contributing 18.3 % respectively. Least gain is observed in Bio 15 (means the precipitation of the driest month) which is almost negligible.

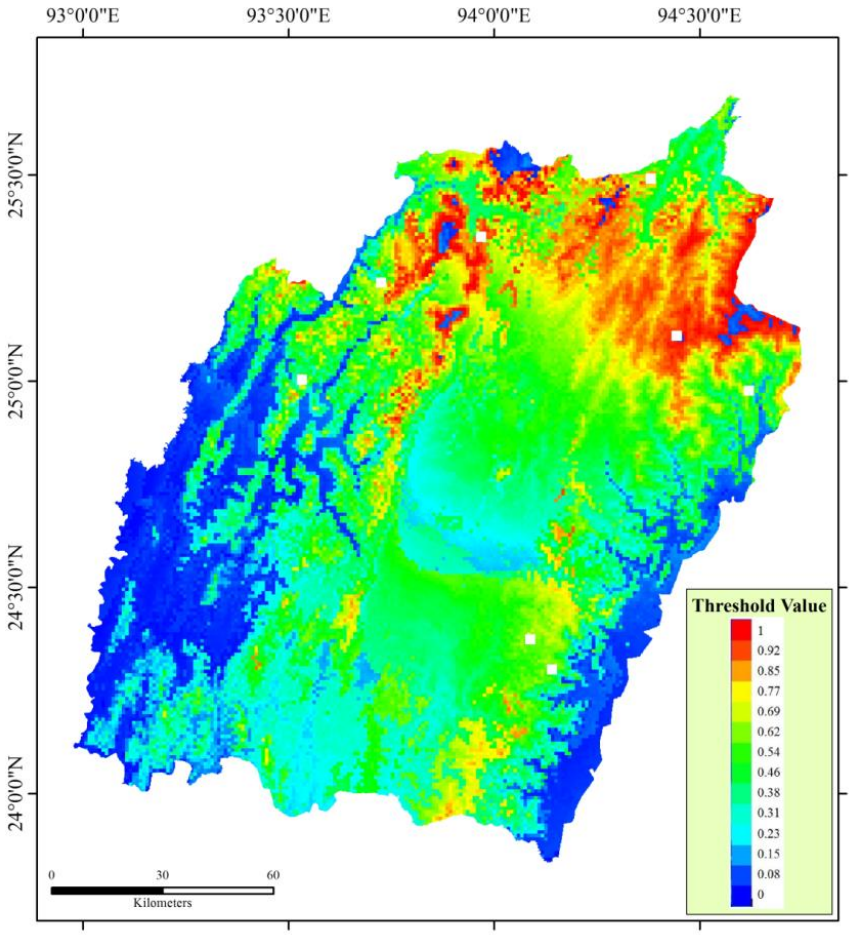


Fig. 6.5: Predicted distribution model of *Paris polyphylla*

From the model obtained a map (Fig. 6.6) showing only the predicted distribution of *Paris polyphylla* with maximum threshold value equal to 1 has been prepared. It came to know that the distribution or the availability of the species is confined with less area of about 108 km^2 which is only 0.48 %.

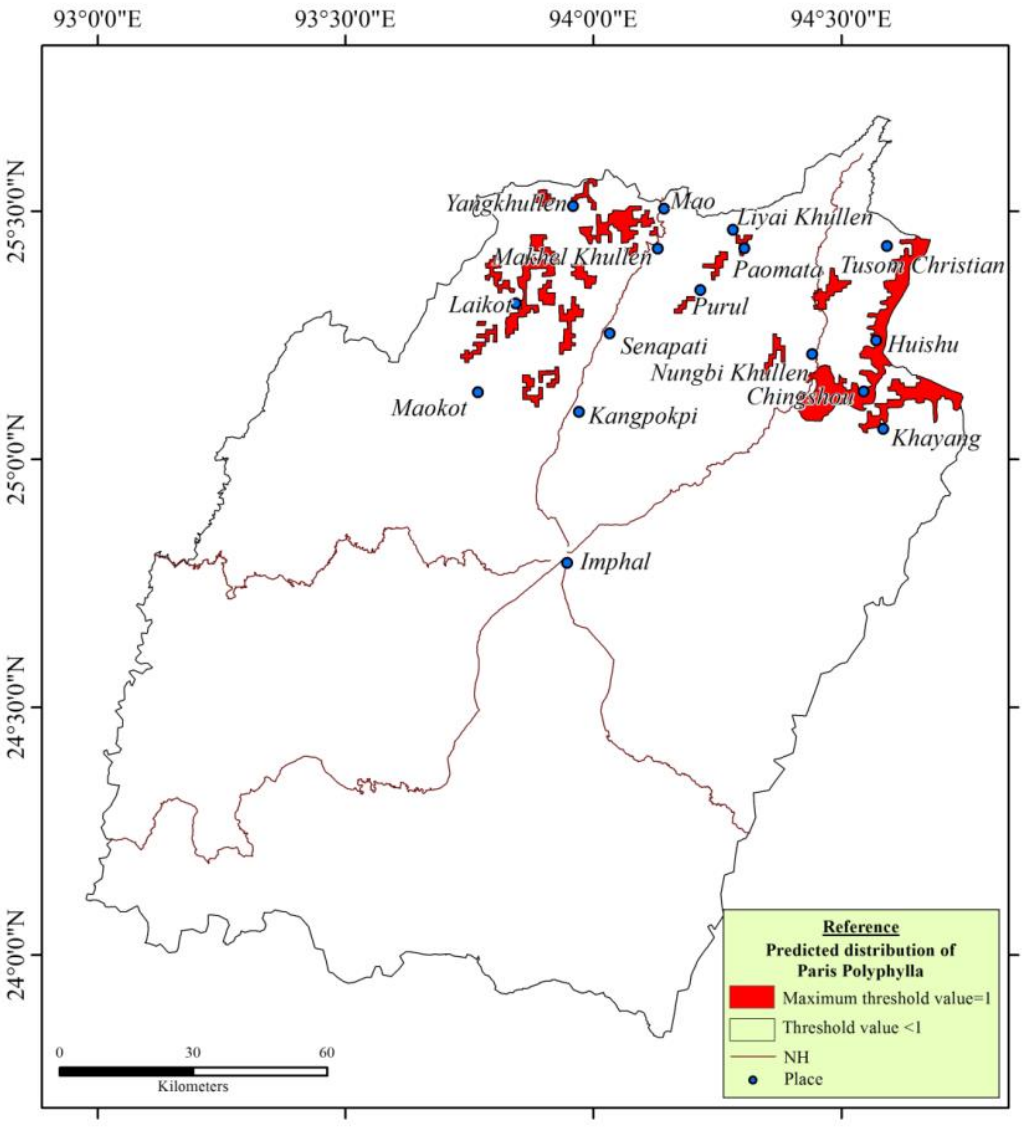


Fig. 6.6: Predicted distribution map of *Paris polyphylla* with maximum threshold value

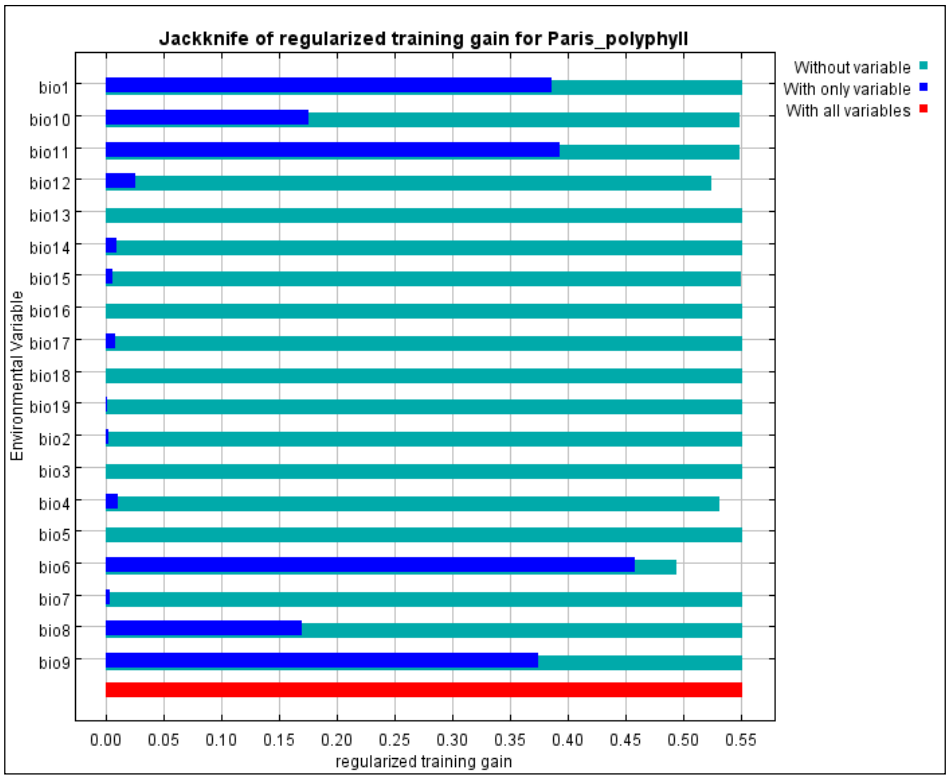


Fig. 6.7: Jacknife test result for *Paris polyphylla*

The environmental variable with highest gain when used in isolation is Bio9, which therefore appears to have the most useful information by itself. The environmental variable that decreases the gain the most when it is omitted is Bio11, which therefore appears to have the most information that isn't present in the other variables. Here temperature also plays an important role in predicting the model for the species.

***Rubia cordifolia* Linn.**

Data for *Rubia cordifolia* were collected from Lunghar (Ukhrul), Noney(Tamenglong), Kangpokpi (Senapati) and Mapithel (Ukhrul). It is then carried out for prediction suitability. From the result obtained it can be said that the habitat suitability of *Rubia cordifolia* is widely distributed in the northern part of the state.

The calibrated model of *Rubia cordifolia* (Fig. 6.8) gives a regularized training gain of 0.566, training AUC of 0.869 and unregularized training gain of 0.872. From the result it is observed that Bio9 (Mean temperature of wettest quarter) contributed the maximum (Table 6.5) of 81.4 % followed by Bio5 (Temperature seasonality) of 17.6 % and Bio13 (Annual precipitation) contributing 0.9 % respectively. Least gain is observed in Bio14 and Bio 15 which means the precipitation of the wettest month and precipitation of the driest month respectively.

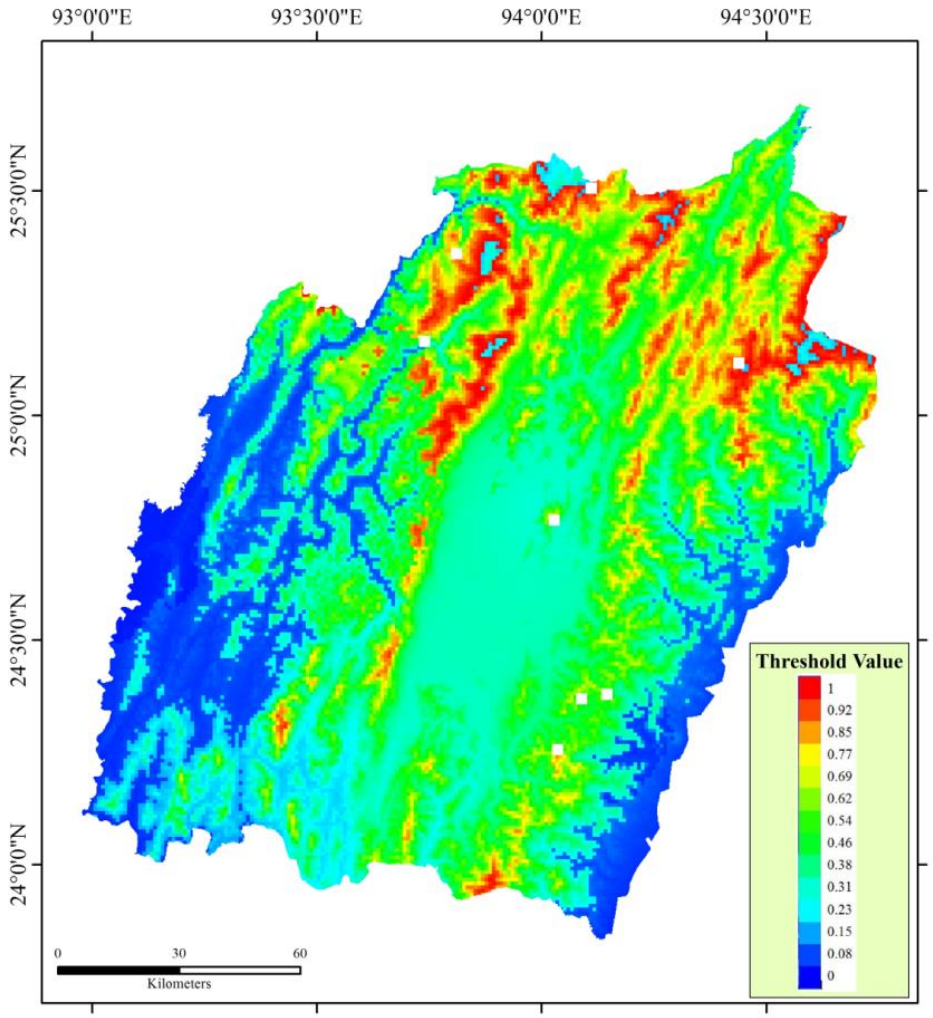


Fig. 6.8: Predicted distribution model of *Rubia cordifolia*

From the model obtained a map (Fig. 6.9) showing only the predicted distribution of *Rubia cordifolia* with maximum threshold value equal to 1 has been prepared. Here the distribution or the availability of the species is found with more area compared to *Aconitum nagarum*. It covers an area of 597 km^2 (approx) with a percentage distribution of 2.66 %.

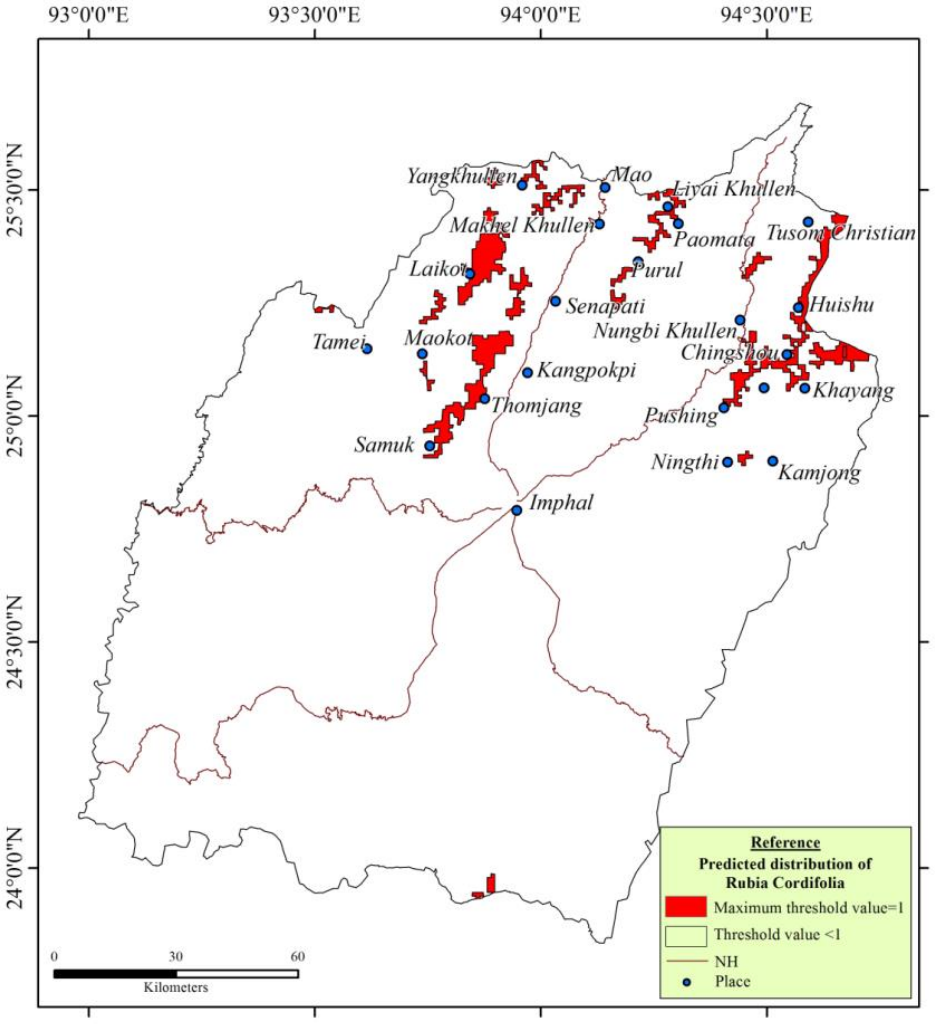


Fig. 6.9: Predicted distribution map of *Rubia cordifolia* with maximum threshold value

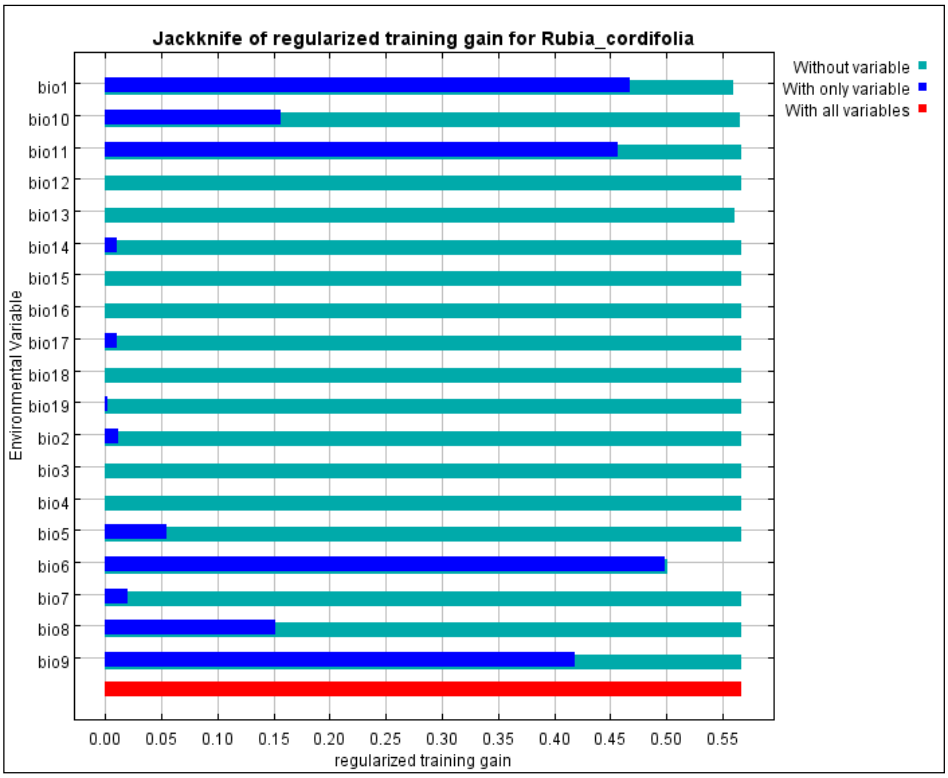


Fig. 6.10: Jacknife test result of *Rubia cordifolia*

Fig. 6.10 shows the jackknife test of variable importance for *Rubia cordifolia*. Bio6 (Min temperature of coldest month) shows the highest gain environmental variable. Here temperature also plays an important role in predicting the model for the species

***Taxus wallichiana* Zucc.**

Prediction of habitat suitability of *Taxus wallichiana* was done on the basis of data collected from (i) Shirui peak and adjacent village of Ukhrul district and (ii) Dzukou hill and Mao Maram of Senapati district. It is observed that habitat suitability of this particular species is found in limited area nearly covering the northern part of the state.

The calibrated model of *Taxus wallichiana* (Fig. 6.11) gives a regularized training gain of 0.915, training AUC of 0.98 and unregularized training gain of 1.423. Bio5 contributed the maximum environmental variable with a contribution of 37.1 % which is shown in Table 6.6**.** Next variable is contributed by Bio11 having a contribution of 34 %. Bio19 shows the lowest contribution in the model.

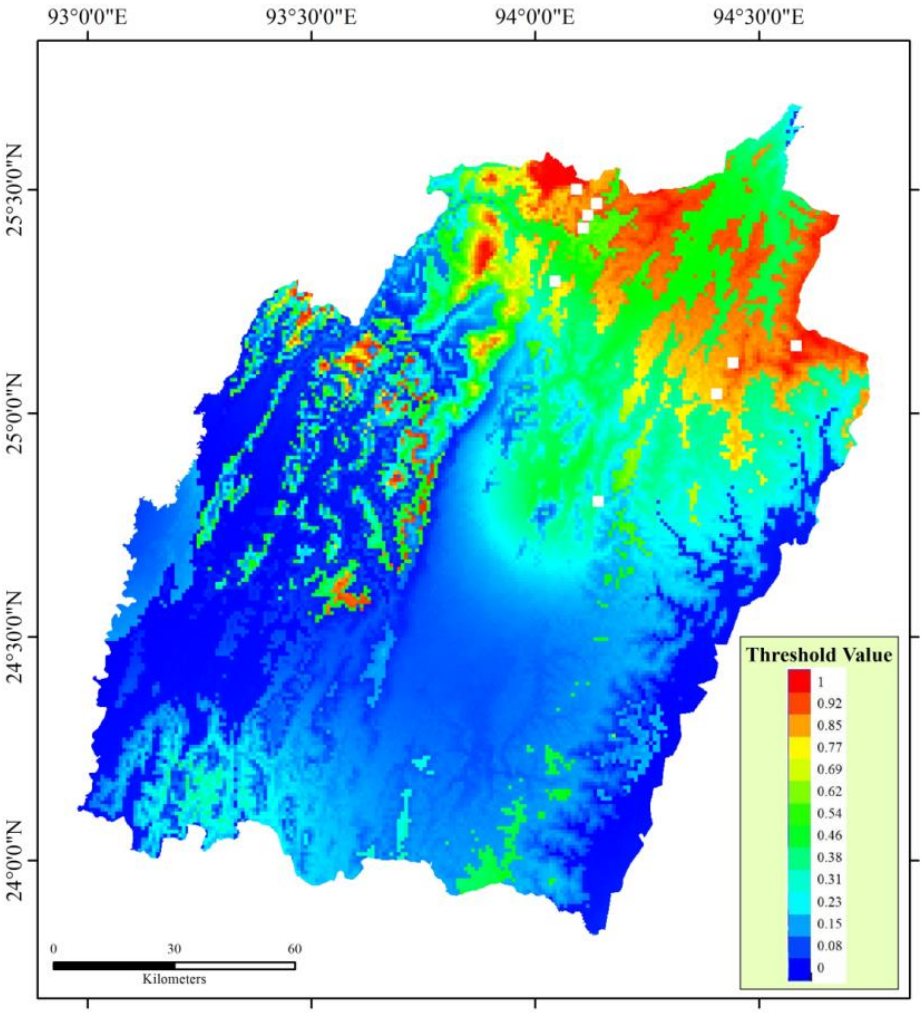


Fig. 6.11: Predicted distribution model of *Taxus wallichiana*

Fig 6.12 shows the predicted distribution map of *Taxus wallichiana* with maximum threshold value equal to 1. Here the distribution or the availability of the species is also found in northern part of the state. It occupies an area of 161 km^2 (approx) with a percentage of 0.71 %.

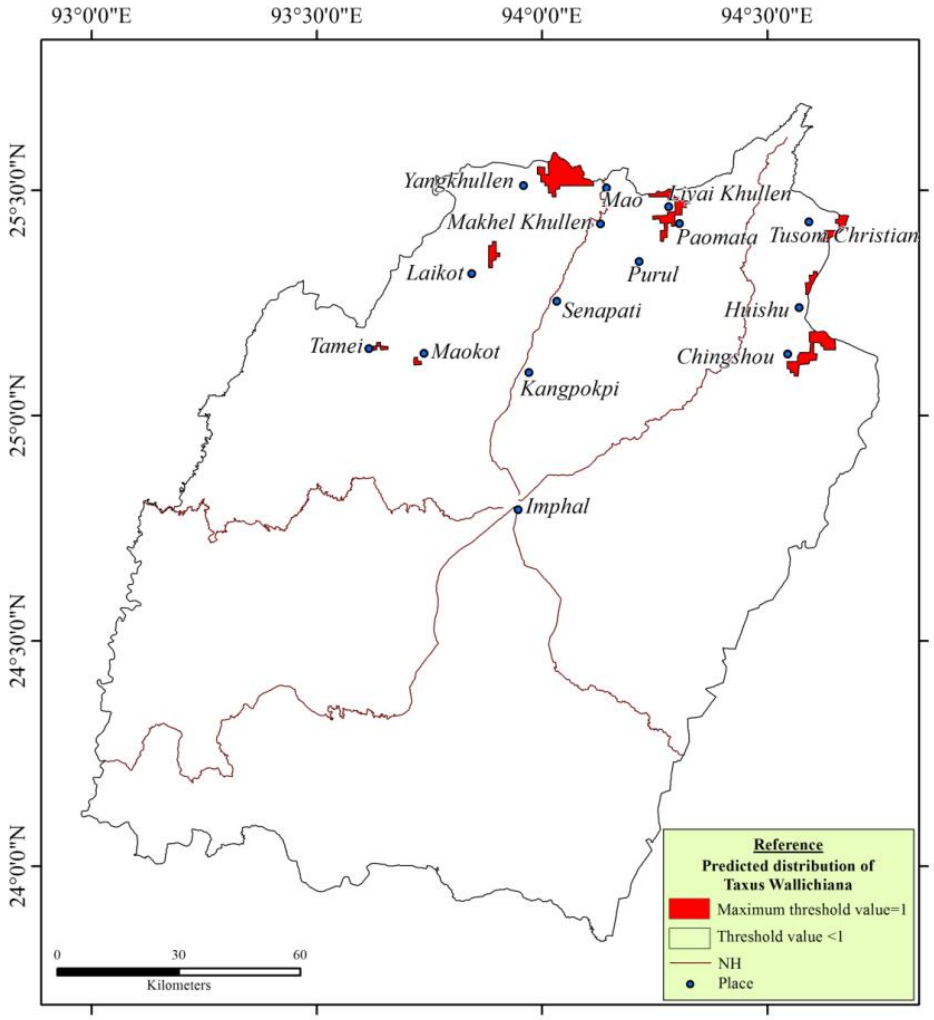


Fig. 6.12: Predicted distribution map of *Taxus wallichiana* with maximum threshold value

The jackknife test result for *Taxus wallichiana* in Fig. 6.13. Bio6 (Min temperature of coldest month) shows the highest gain environmental variable. Here temperature also plays an important role in predicting the model for the species.

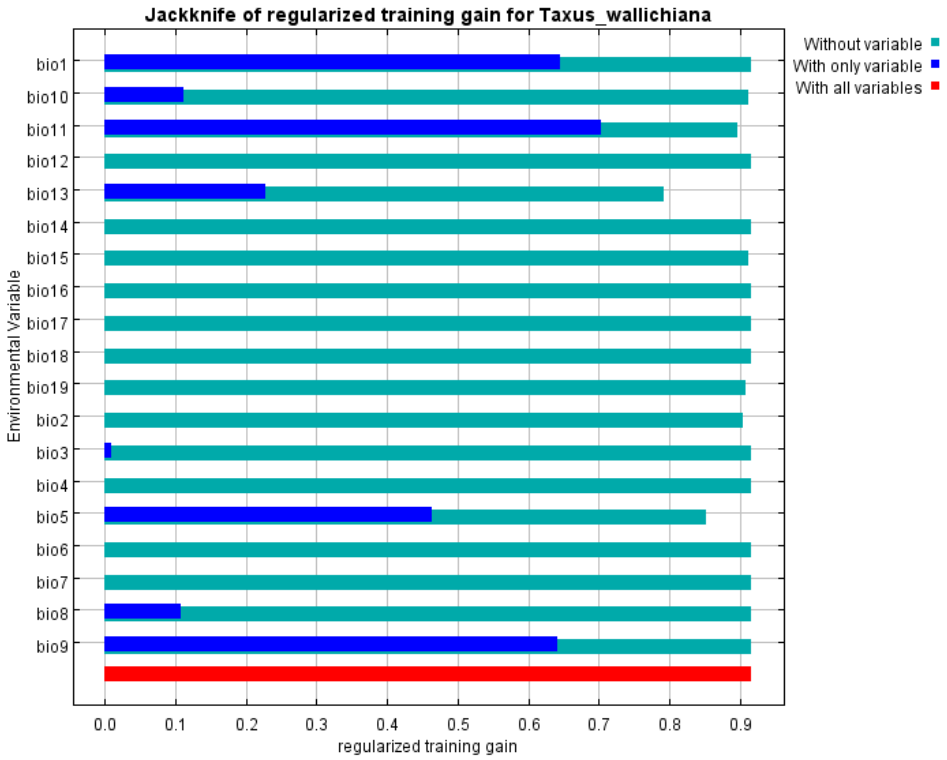


Fig. 6.13: Jacknife test result of *Taxus wallichiana*

***Thalictrum foliolosum* DC.**

Species data of *Thalictrum foliolosum* was collected from (i) Shirui peak of Ukhrul district and (ii) Dzukou hill and Mao Maram of Senapati district. It can be observed that *Thalictrum foliolosum* is found in the northern part of the state which is on the western side of the National Highway.

The calibrated model of *Thalictrum foliolosum* (Fig. 6.14) gives a regularized training gain of 0.447, training AUC of 0.872 and unregularized training gain of 0.886. From the result it is observed that Bio10 (Mean temperature of warmest quarter) contributed the maximum (Table 6.7) of 35.7 % followed by Bio1 (Annual mean temperature) of 33.9 % and Bio6 (Precipitation of wettest

month) contributing 12.6 % respectively. Least gain is observed in Bio4 (Temperature seasonality).

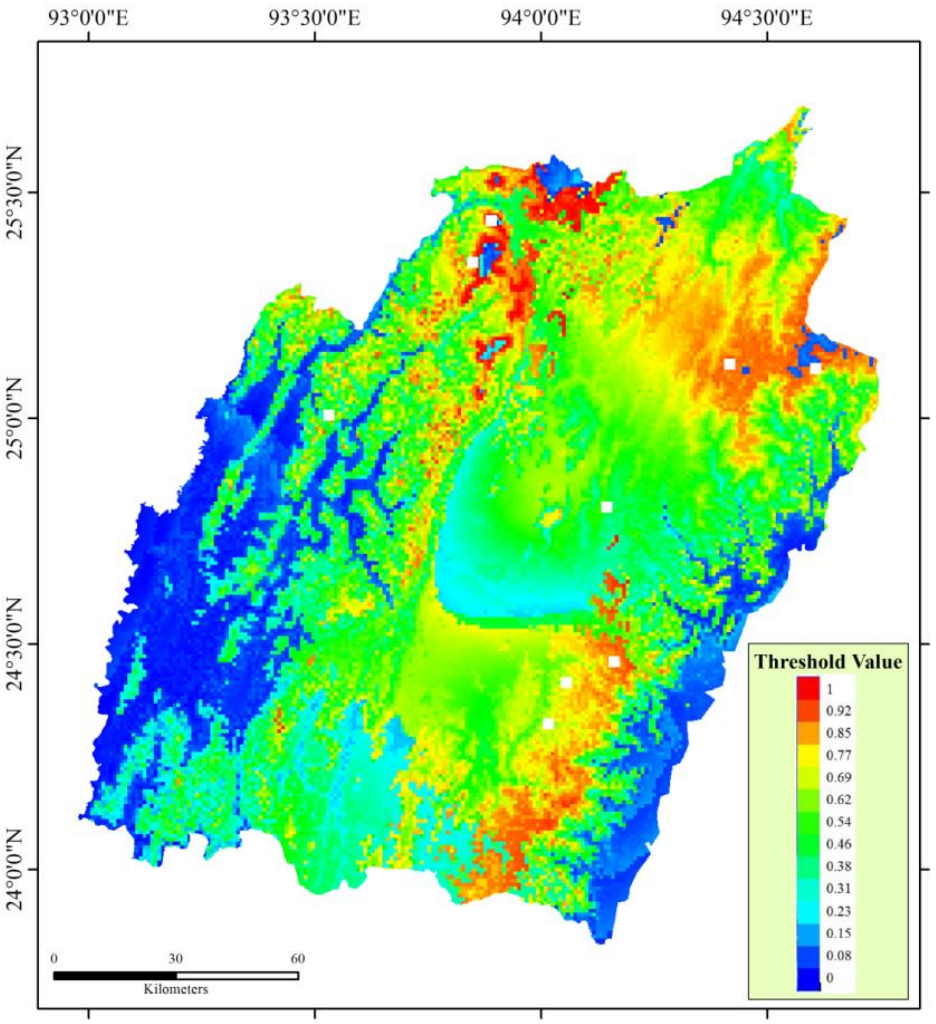


Fig. 6.14: Predicted distribution model of *Thalictrum foliolosum*

A map (Fig. 6.14) displaying only the maximum threshold value equal to 1 has been prepared for *Thalictrum foliolosum* is shown Fig. 6.15. Here the distribution or the availability of the species is found to occupy an area of 166 $km^2$with a percentage distribution of 0.74 %.

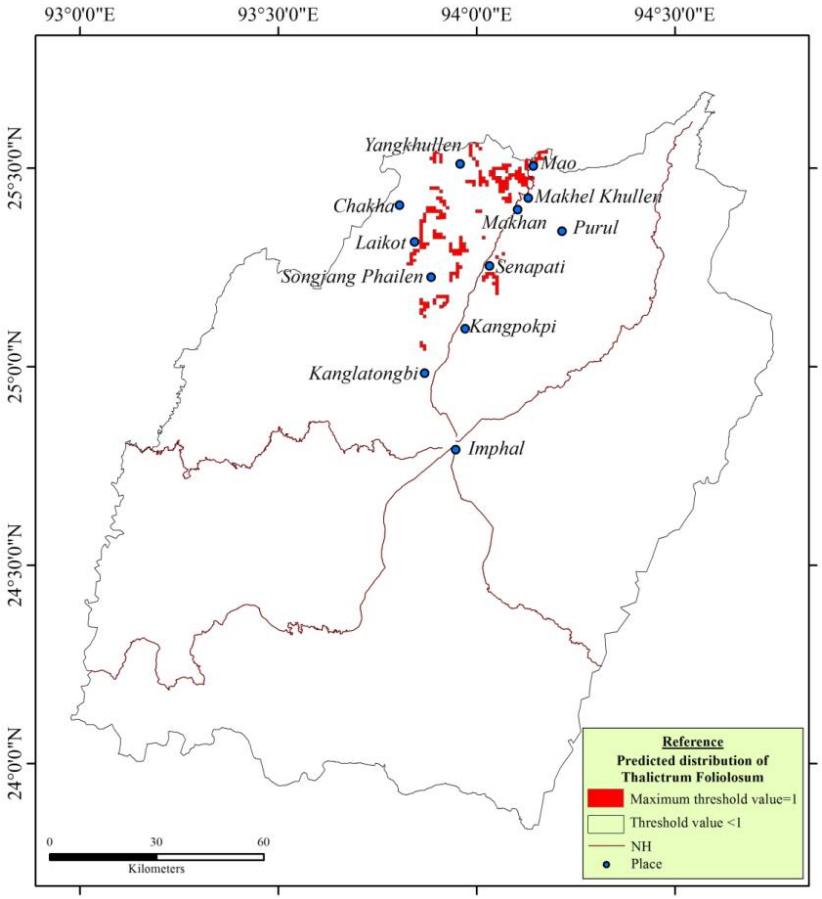


Fig. 6.15: Predicted distribution map of *Thalictrum foliolosum* with maximum threshold value

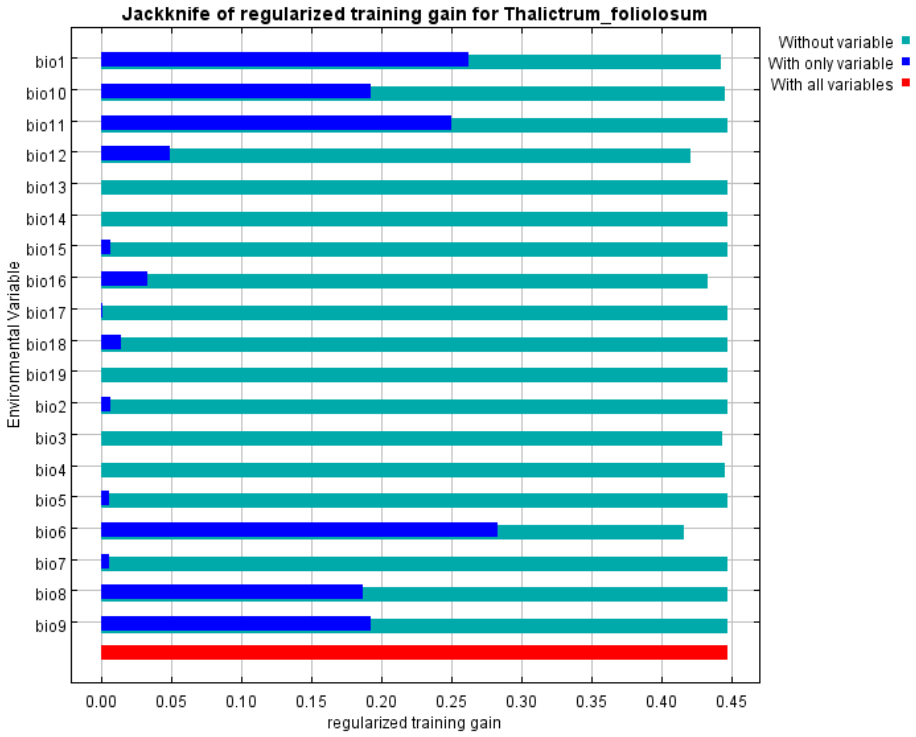


Fig. 6.16: Jacknife test result of *Thalictrum foliolosum*

Analysis of variable contributions

The following table gives estimates of relative contributions of the environmental variables to the Maxent model.

Table 6.3: Table showing the environmental variables contribution of *Aconitum nagarum*

Variable	Percent contribution	Permutation importance
bio3	0	0
bio12	0	0
bio19	0	0
bio4	0	0
bio14	0.1	0.5
bio15	0.1	1.3
bio18	0	0
bio17	0	0
bio7	0	0
bio2	0	0
bio10	0	0
bio9	81.4	95.9
bio8	0	0
bio6	0	0
bio5	17.6	1.3
bio16	0	0
bio13	0.9	1
bio11	0	0
bio1	0	0

Table 6.4: Table showing the environmental variables contribution of *Paris polyphylla*

Variable	Percent contribution	Permutation importance
bio3	0	0
bio12	4.8	27.4
bio19	0	0
bio4	2.3	9
bio14	0	0
bio15	0.1	0
bio18	0	0
bio17	0	0
bio7	0	0
bio2	0	0
bio10	20.1	32.9
bio9	32.9	0
bio8	2	0
bio6	18.3	11.3
bio5	0	0
bio16	0	0
bio13	0	0
bio11	8.7	19.5
bio1	10.9	0

Table 6.5: Table showing the environmental variables contribution of *Rubia cordifolia*

Variable	Percent contribution	Permutation importance
bio3	0	0
bio12	0	0
bio19	0	0
bio4	0	0
bio14	0	0
bio15	0	0
bio18	0	0
bio17	0	0
bio7	0	0
bio2	0	0
bio10	8.2	2.9
bio9	0	0
bio8	0	0
bio6	19.3	3.7
bio5	0	0
bio16	0	0
bio13	0.8	9.5
bio11	0	0
bio1	71.7	83.9

Table 6.6: Table showing the environmental variables contribution of *Taxus wallichiana*

Variable	Percent contribution	Permutation importance
bio3	0	0.5
bio12	0	0
bio19	0.8	0
bio4	0	0
bio14	0	0
bio15	0	8.3
bio18	0	0
bio17	0	0
bio7	0	0
bio2	1.7	2.4
bio10	2.8	26
bio9	0	0
bio8	0	0
bio6	0	0
bio5	37.1	13.6
bio16	0	0
bio13	21.1	23.2
bio11	34	26.1
bio1	0	0

Table 6.7: Table showing the environmental variables contribution of *Thalictrum foliolosum*

Variable	Percent contribution	Permutation importance
bio3	1	3.7
bio12	8.4	21
bio19	0	0
bio4	0.5	1.9
bio14	0	0
bio15	0	0
bio18	0	0
bio17	0	0
bio7	0	0
bio2	0	0
bio10	35.7	39.1
bio9	0	0
bio8	0	0
bio6	12.6	1.9
bio5	0	0
bio16	7.9	16.1
bio13	0	0
bio11	0	0
bio1	33.9	16.3

Model Evaluation

Prediction accuracy of the present model outputs was measured through receiver operating characteristics (ROC). Area under the curve is an important statistic to evaluate the model under study. An AUC analysis has been done for these distribution models. The Area Under the [Receiver Operator Characteristic] Curve (AUC) is a threshold-independent statistic of model performance. AUC is a convenient index because it provides a single measure of overall prediction accuracy that is not dependent upon a particular threshold. However, AUC as implemented in MaXent measures the model's ability to correctly rank sites with respect to their relative suitability.

The value closer to 1.0 indicates greater applicability of the model in predicting the distribution. Results are shown in the following table.

Table 6.8: AUC values for the selected five plant species

Sl no	Species	AUC
1	*Aconitum nagarum*	0.982
2	*Paris polyphylla*	0.877
3	*Rubia cordifolia*	0.869
4	*Taxus Wallichiana*	0.928
5	*Thalictrum foliolosum*	0.872

For the *Thalictrum foliolosum*, regularized training gain is 0.447, training AUC is 0.872, unregularized training gain is 0.886. For, *Taxus wallichiana*, regularized training gain is 0.915, training AUC is 0.928, unregularized training

gain is 1.423. For, *Rubia cordifolia*, regularized training gain is 0.566, training AUC is 0.869, unregularized training gain is 0.872. For, *Paris polyphylla*, regularized training gain is 0.551, training AUC is 0.877, unregularized training gain is 0.944.

The calculated ROC showed that the average AUC value of the datasets was between 0.8 to 1 (Table 6.8), which indicated the model is graded as good for our dataset. In all the cases, training AUC ranges from 0.8 to more than 0.9, greater applicability of the models are expected. These models could represent the habitat suitability of these species in Manipur.

The areas with habitats suitability for *Aconitum nagarum* were observed in place near Yanghullen, Dzukou, Laikot, Paomata and Chingshou.

The areas with habitats suitability for *Paris polyphylla* were observed in Purul, Liyai, Makhan Khullen, Paomata, Yanghullen, Dzukou, Laikot, Senapati, Kangpokpi, Chingshou and Khayang.

Rubia cordifolia were observed in Purul, Liyai Khullen, Makhan Khullen, Paomata, Yangkhullen, Laikot, Maokot, Samuk, Kangpokpi, Thomjang, Nungbi Khullen, Chingshou, Ningthi,Huishu and Tusom Christian.

Taxus Wallichiana is observed in Tamei, Maokot, Yanghullen, Dzukou, Liyai Khullen, Paomata, Tusom Christian and Chingshou.

Thalictrum foliolosum Yangkhullen, Makhel Khullen, Makhan, Mao, Senapati, Somgjang and Phailen.

The built-in jackknife test from MaxEnt showed that Bio9 and Bio11 have more contributions to species distribution modelling, and the second most important environmental variable for modelling is precipitation Bio1 for *Aconitum nagarum*. For *Paris polyphylla*, Bio6 has maximum contribution and next it has most contribution from Bio1 and Bio11. Also, in *Rubia cordifolia* Bio6 has more contribution and secondly by Bio1 and Bio11. *Taxus Wallichiana* has more contribution from Bio11 followed by Bio1. Lastly *Thalictrum foliolosum* has the maximum contribution of Bio6 and the second most by Bio1.

The response curves of variables and suitability will provide more detailed information on the habitats requirement of species, if the predictive statistical response for distribution is in close proximity to the real ecological response of species. Therefore, these values could serve as a reference range for population ecology and biology research. Both temperature and precipitation were considered the most important ecological factors for plant distribution and expansion potential (Manske, 2003), and Isothermality (Bio3) may be useful and significant for the species distribution in pantropical areas (O'Donnell and Ignizio, 2012). Isothermality (Bio3) indicates how large the day-to-night temperature oscillation is relative to summer-to-winter oscillation, it reflects larger or smaller temperature fluctuation within month to year. Additionally, the temperature seasonality (Bio4) is an alternative measure of temperature change over the course of the year, the larger the standard deviation, the greater the variability of temperature.

Species distribution modelling always considers climate and geographic factors; however, other factors are able to affect species distribution, e.g.,

adaptability, interspecies competition, and land use change etc. (Cauwer *et al*., 2014). As we didn't consider other potential threats than climate change, it is likely that habitats of high suitability (P>0.60) for *Aconitum nagarum*, *Paris polyphylla*, *Rubia cordifolia*, *Taxus Wallichiana* and *Thalictrum foliolosum*will decrease in a wider range or more drastically as our model results predict. From our field survey, the natural distribution of these species decreased rapidly because of overharvesting, land use change and interspecies competition.

Suitable habitats for the five plant species were predicted with good accuracy by using species distribution modelling. The results provide detailed information on the potential distribution and on the environmental requirements of the species, which will be considered in the forest resource survey and in the biology character research. The potential and realized distribution is very similar in Manipur at least. The distribution of *Aconitum nagarum* is mainly influenced by mean temperature of driest quarter, maximum temperature of warmest month, precipitation of wettest month which suggests that this species is sensitive to high temperature and rainfall. Likewise, *Paris polyphylla* is mainly influenced by mean temperature of driest quarter, mean temperature of warmest quarter, minimum temperature of coldest month, mean temperature of coldest quarter, annual mean temperature and annual precipitation. This plant is mostly suited from low to high temperature and rainfall. In case of *Rubia cordifolia* its distribution is mainly influence by annual mean temperature, minimum temperature of coldest month, mean temperature of warmest quarter and precipitation of wettest month. For *Taxus wallichiana* environmental factors like maximum temperature of warmest month, mean temperature of coldest quarter, precipitation of wettest month,

precipitation of wettest quarter, temperature seasonality and precipitation of coldest quarter. The environmental variable contribution for *Thalictrum foliolosum* are mean temperature of warmest quarter, annual mean temperature, minimum temperature of coldest month, precipitation of wettest quarter, temperature seasonality and annual precipitation. Summarising all the environmental factors it can be said that the selected five ethnomedicinal plants are sensitive to temperature and rainfall.

CHAPTER – VII

GENERAL DISCUSSION AND CONCLUSION

7.1 GENERAL DISCUSSION

A total of 52 species of threatened ethno-medicinal plants were recorded from Manipur. The maximum ethno-medicinal species was recorded in tree (14 sps) follows by Herbs (18 sps), shrubs (7 sps), climber (6 sps), orchid (4 sps) and creeper (3sps).

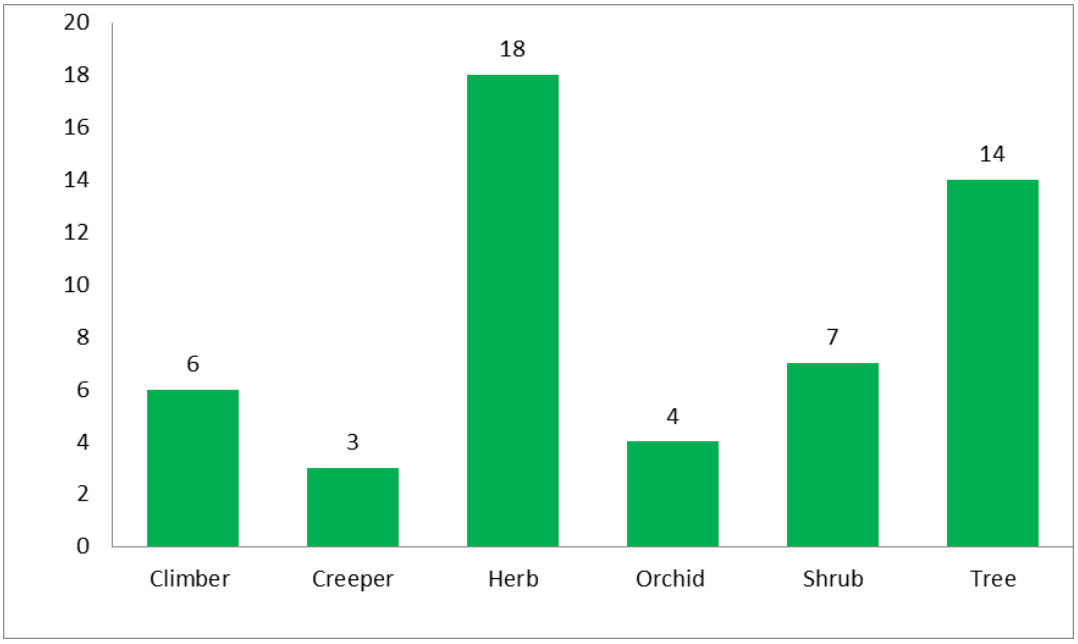


Fig.7.1: Showing the Habit of the ethno-medicinal plants of Manipur

A total of 34 (Thirty-four) plant families were recorded in which the maximum of 4 (four) species was recorded in the Orchidaceae and Araliaceae, followed by 3 species in Ranunculaceae, Rutaceae, Zingiberaceae and Lauraceae, 2 (two) species each was recorded from Fabaceae, Phyllanthaceae, Piperaceae and Rubiaceae. The remaining 24 (Twenty-four) species was represented by each family

namely: Araceae, Begoniaceae, Berberidaceae, Bignoniaceae, Burseraceae, Clusiaceae, Compositae, Equisetaceae, Ericaceae, Fagaceae, Gentianaceae, Hydrangeaceae, Lamiaceae, Liliaceae, Melanthiaceae, Meliaceae, Myrtaceae, Pentaphylacaceae, Campanulaceae, Salicaceae, Smilaxcaceae, Taxaceae, Vitaceae and Iridaceae.

Regarding the part used of the ethno-medicinal plants collected from Manipur, it was recorded that the maximum use is leaf and whole plant which is represented by 8 (eight) species each, followed by root with 7 (Seven) species, rhizome 6 (Six) species, fruit by 4 (four) species, tuber by 3(three) species and bark by 2(two) species. The multiple part used of the same species were also recorded which is depicted in the table given below.

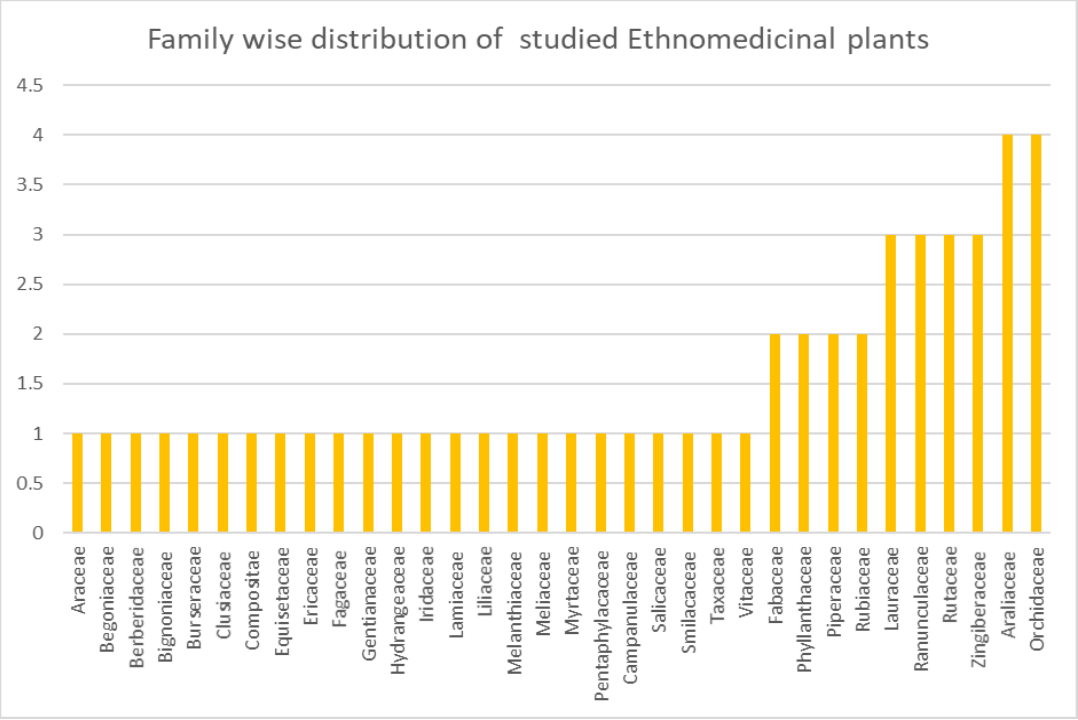


Fig. 7.2: Showing the number of species in a family of ethnomedicinal plants

The part used of the threatened ethnomedicinal plants show that single part was recorded in 33 (thirty-three) species whereas multiple part use is recorded in 19 (nineteen) species. The maximum part use is recorded in "whole plant" follows by leaves and root's part with 7 (seven) species, rhizome by 6 (six) species, 4 (four) in fruits, bark, tuber, leaves and seeds are recorded with respective 3 (three) species each. Multiple uses of plant part were recorded highest in whole plant part.

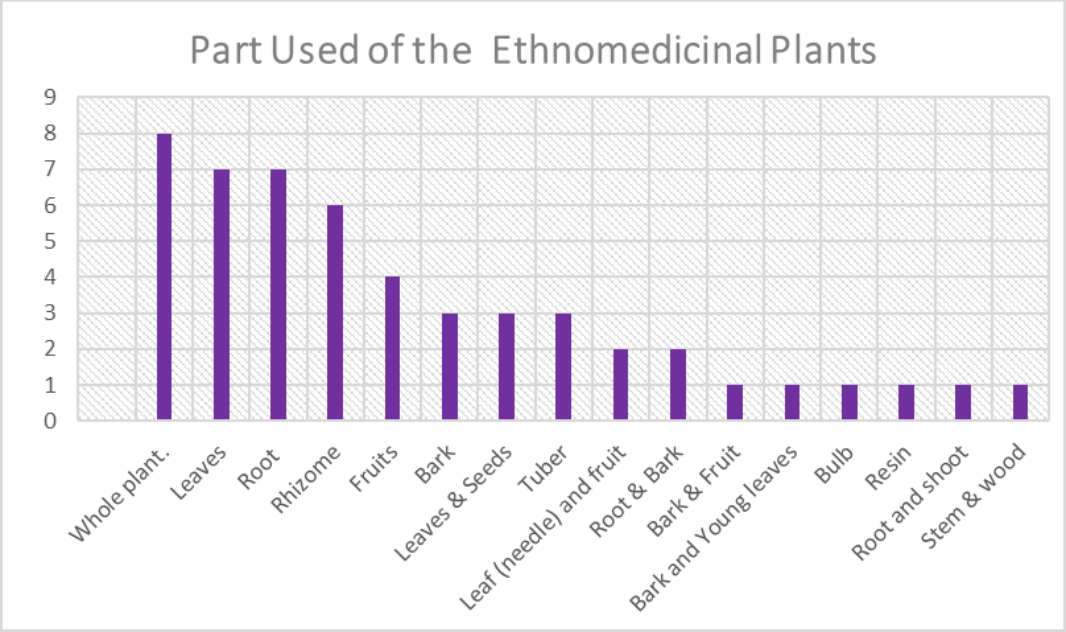


Fig. 7.3: Showing the plant part used of the 52 ethno-medicinal plants used in Manipur.

The mode of preparation of the plant part used for medicinal or treatment of primary health ailments are given below (Fig. 7.4). Altogether there are 18 different modes of preparation in which the maximum was found in the decoction which is represented by 22 species follows by juice represent by 6 species and the third was recorded in fresh leaves and paste. Regarding, mode of preparation the maximum was recorded in decoction which is can be considered as safe method for oral consumption.

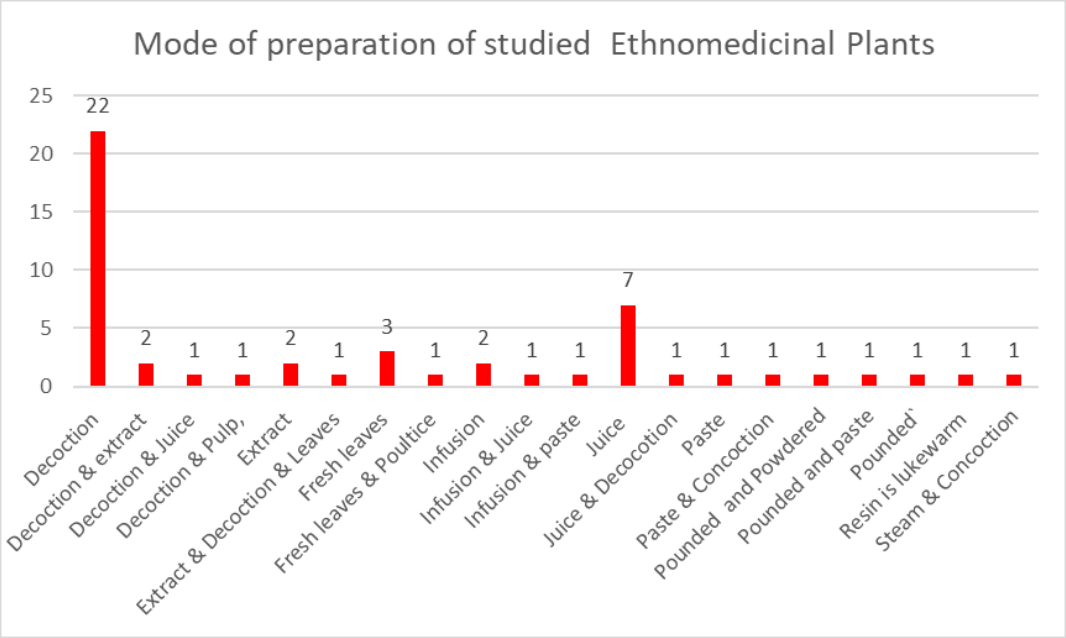


Fig. 7.4: Showing the mode of preparation of ethno-medicinal plants used in Manipur.

The ethno-medicinal plants were used by different communities residing in the state. It was recorded that the medicinal plants were used by majority of the communities where as very few species were used by some particular communities only. The primary health ailments treated are gastrointestinal complaints, orthopaedical problems, dermatological problems, urology problems, snake and dog bite etc.

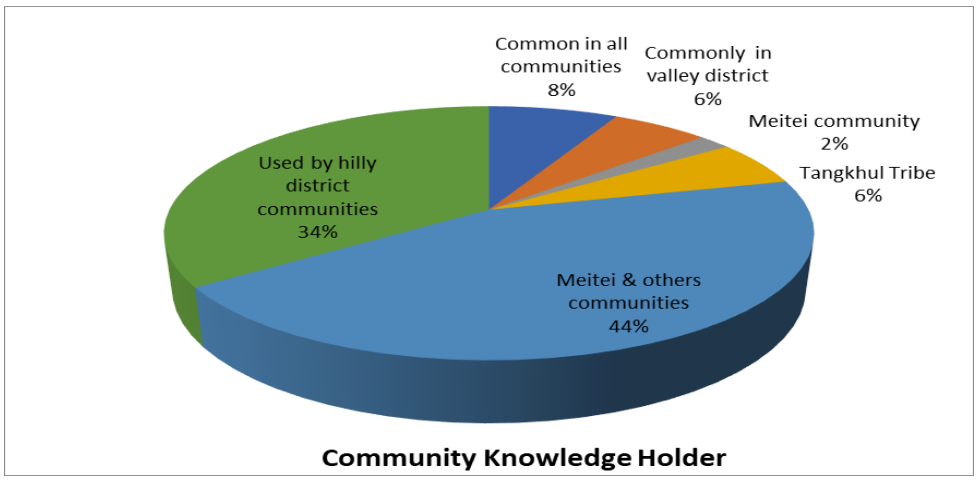


Fig. 7.5: Pie-chart showing medicinal uses by the Communities in Manipur

The present survey and documentation works reveals these species are closely associated with the treatment of primary health ailments of several communities residing in the state since time immemorial. Interestingly, the medicinal uses were more in far flung areas because of its easy accessibility, substantial herbal knowledge and also deprived of medicinal facilities. Although, some of the medicinal uses are in public domain or home remedies other are left hidden in the knowledgeable traditional healers. The rich traditional knowledge is fading day by day as it is orally transmitted from generation to generations along with some religious restrictions and in near future will soon be lost in time to come if not properly documented.

In the present research worked a total of 52 ethnomedicinal plants were collected form varied habitats of the Manipur. The status of the ethnomedicinal using IUCN RED list categories and Criteria Version 3.1 shows that Vulnerable (VU) is represented by 20 species follows by Near threatened (NT) is 18 species, Endangered (EN) by 11 species, critically Endangered (CR) by 2 species and Least Concern (LC) by 1 species. The assessment data shows that Critically Endangered (CR) status was found in *Panax pseudoginseng* Wall. and *Taxus wallichiana* Zucc which shows similar IUCN status with Ved *et al* 2016, CAMP report Manipur.

The status of Near Threatened (NT) species is represented by 20 species *Brassaiopsis bodinieri* (H. Leveille) J. Wen & Lowry, *Cissus javana* DC., *Citrus hystrix* DC., *Dichroa febrifuga* Lour., *Dendrobium aphyllum* (Roxb.), *Eurya acuminata* DC., *Garcinia xanthochymus* Hook.f. ex T. Anderson, *Glochidion coccineum* (Buch.-Ham) Mull. Arg., *Lobelia*

nummularia Lam., *Millettia pachycarpa* Benth., *Rhododendron arboretum* Sm., *Phyllanthus urinaria* L., *Paederia foetida* L, and *Zanthoxylum acanthopodium* DC.

Interestingly, *Garcinia pedunculata* Roxb., *Hippochaete debilis* (Roxb. ex Vaucher) Ching, *Smilax ovalifolia* Roxb. ex D. Don. shows similar IUCN status with Ved *et al* 2016, CAMP report Manipur. On the contrary, *Curcuma caesia* Roxb. is reported as Vulnerable species.

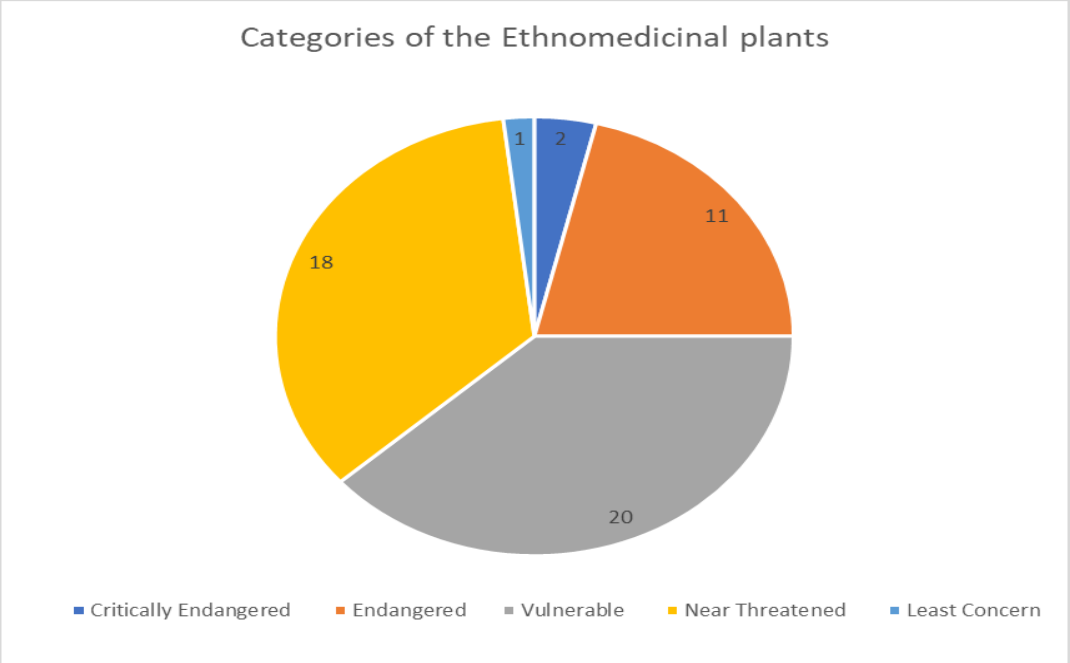


Fig. 7.6: Showing the IUCN Status of ethno-medicinal plants used in Manipur.

The category of Vulnerable (VU) was found in 19 species *Albizia myriophylla* Benth, *Begonia adscendens* C.B. Clarke, *Bulbophyllum cylindraceum* Lindley, *Cinnamomum verum* J. Presl., *Curcuma amada* (Roxb.), *Eleutherine bulbosa* (Mill.), *Eleutherococcus trifoliatus* (L.) S.Y. Hu., *Flacourtia jangomas* (Lour) Raeusch., *Litsea glutinosa* (Lour.) C.B. Roxb., *Mahonia napualensis* D C., *Piper griffithii* C.DC., *Piper peepuloides*

Wall., and *Swertia angustifolia* Buch.-Ham. Ex D. Don., and *Syzgium nervosum* A. Cunn. ex DC.

Interestingly, *Canarium strictum* Roxb., *Hedychium spicatum* Sm, *Litsea cubeba* (Lour) Pers., and *Zanthoxylum rhetsa* (Roxb.) DC. shows similar IUCN status with Ved *et al* 2016, CAMP report Manipur. On the contrary, *Oroxylum indicum* (L.) Kurz, is reported as Near Threatened and *Quercus lamellosa* Sm., as Endangered species.

Regarding, Endangered (EN) status it is represented by 9 species *Lilium mackliniae* Sealy (similar with Nayar & Sastry,1987), *Scutellaria discolour* Colebr. and *Thalictrum foliolosum* DC.

Interestingly, *Aconitum elwesii* Stapf (similar with ENVIS,2012)., *Dendrobium denudans* D. Don, *Dendrobium nobile* Lindl., *Panax assamicus* R.N. Banerjee, *Paris polyphyll*a Sm., *Rubia cordifolia* L. shows similar IUCN status with Ved *et al* 2016, CAMP report Manipur. *On the contrary Aconitum nagarum* Stapf. and *Homalomena aromatica* (Spreng.) Schott. is reported as Vulnerable status.

The Least concern (LC) status was recorded in *Eupatorium cannabinum* L. species only.

In the present assessment of IUCN criteria, it was found that two types of criteria namely A2cd and A2c represented by 34 and 18 species respectively. The assessment shows 34 species under A2cd were *Albizia myriophylla* Benth, *Begonia adscendens* C.B. Clarke, *Bulbophyllum cylindraceum* Lindley, *Canarium strictum*

Roxb., *Cinnamomum verum* J. Presl, *Cissus javana* DC., *Curcuma amada* (Roxb), *Dendrobium aphyllum* (Roxb), *Dendrobium denudans* D. Don, *Dendrobium nobile* Lindl, *Eleutherine bulbosa* (Mill), *Eleutherococcus trifoliatus* (L.), *Eurya acuminata* DC., *Flacourtia jangomas* (Lour), *Garcinia pedunculata* Roxb, *Garcinia xanthochymus* Hook.f. ex T. Anderson, *Hedychium spicatum* Smith, *Hippochaete debilis* (Roxb. ex Vaucher) Ching, *Homalomena aromatica* (Spreng.) Schott, *Litsea cubeba* (Lour.) Pers., *Litsea glutinosa* (Lour.) C.B. Roxb, *Millettia pachycarpa* Benth., *Oroxylum indicum* (L.) Kurz, *Panax bipinnatifolius* Seem., *Paris polyphylla* Sm., *Piper griffithii* C.DC., *Piper peepuloides* Wall, *Rubia cordifolia* L., *Scutellaria discolour* Colebr, *Smilax ovalifolia* Roxb. Ex D. Don, *Syzygium nervosum* A.Cunn. ex DC, *Taxus wallichiana* Zucc, *Thalictrum foliolosum* DC., and *Zanthoxylum rhetsa* (Roxb.) DC.

The remaining 18 species *Aconitum elwesii* Stapf., *Aconitum nagarum* Stapf., *Brassaiopsis bodinieri* (H. Leveille) J. Wen & Lowry, *Citrus hystrix* DC., *Curcuma caesia* Roxb., *Dichroa febrifuga* Lour., *Eupatorium cannabinum* L., *Glochidion coccineum* (Buch.-Ham), *Lilium mackliniae* Sealy., *Lobelia nummularia* Lam., *Mahonia napaulensis* DC., *Paederia foetida* L. Mant., *Panax assamicus* R.N. Banerjee, *Phyllanthus urinaria* L., *Quercus lamellose* Sm., *Rhododendron arboretum* Sm, *Swertia angustifolia* Buch.-Ham. ex D. Donand and *Zanthoxylum acanthopodium* DC. are under A2c criteria.

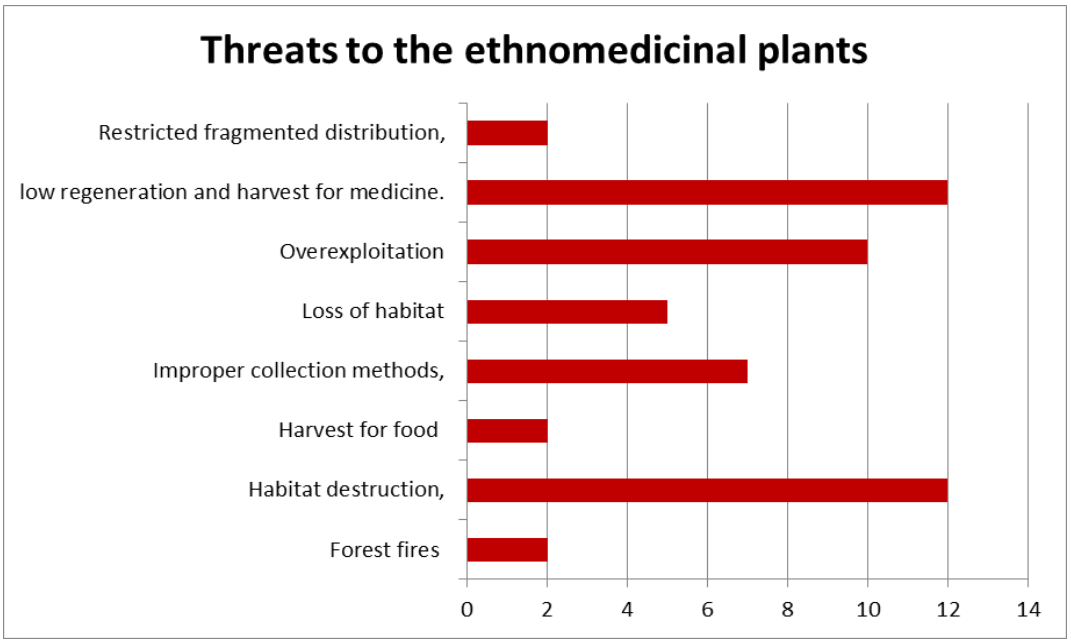


Fig. 7.7: Showing the major threats to ethno-medicinal plants used in Manipur.

It was recorded that major threats to the medicinal plants were mainly due to Habitat destruction, Low regeneration, harvesting for medicine contribute the most**.** The other degree of threats to natural population of medicinal plants leading to population decline was due to extreme anthropogenic pressures like overexploitation, forest fires, loss of habitat, harvest for food and improper collection methods. Moreover, increase in demand coupled with improper collection methods threatened the survival of many of the ethno medicinal plants. The conservation status reveals that majority of the species falls under the Threatened category which can be concluded that there is a severe multiple threat in their habitats.

7.1.1 Species Distribution Model

Prediction of habitat suitability of *Aconitum nagaram* was done on the basis of data collected from the present study. It was formed that the distribution or the availability of the species is confined with less area of about 108 km^2 which is only 0.48 %. The environmental variable that decreases the gain the most when it is omitted is Bio-11, which therefore appears to have the most information that isn't present in the other variables. Here temperature plays an important role in predicting the model for the species. The areas with habitats suitability for *Aconitum nagarum* are observed in place near Yanghullen, Dzukou, Laikot, Paomata and Chingshou.

Prediction of habitat suitability of *Paris polyphylla* from the finding it can be observed that habitat suitability of this particular species is found in limited area nearly covering the northern part of the state. The environmental variable with highest gain when used in isolation is Bio9, which therefore appears to have the most useful information by itself. Temperature also plays an important role in predicting the model for the species. The areas with habitats suitability for *Paris polyphylla*are observed in Purul, Liyai, Makhan Khullen, Paomata, Yanghullen, Dzukou, Laikot, Senapati, Kangpokpi, Chingshou and Khayang.

Prediction of habitat suitability of *Rubia cordifolia* shows it is widely distributed in the northern part of the state. Temperature also plays an important role in predicting the model for the species. The areas with habitat suitability for *Rubia cordifolia* are observed in Purul, LiyaiKhullen, Makhan Khullen, Paomata, Yangkhullen, Laikot, Maokot, Samuk, Kangpokpi, Thomjang, Nungbi Khullen, Chingshou, Ningthi, Huishu and Tusom Christian.

Prediction of habitat suitability of *Taxus wallichiana* reveals that suitability of this particular species is found in limited area nearly covering the northern part of the state, the distribution or the availability of the species is also found in northern part of the state. It occupies an area of 161 km^2 (approx) with a percentageof0.71%. Here, also temperature plays an important role in predicting the model for the species. The areas with habitat suitability for *Taxus Wallichiana*are observed in Tamei, Maokot, Yanghullen, Dzukou, LiyaiKhullen, Paomata, Tusom Christian and Chingshou.

Prediction of habitat suitability of *Thalictrum foliolosum* reveals that it is found in the northern part of the state which is on the western side. Here the distribution or the availability of the species is found to occupy an area of 166 km^2 with a percentage distribution of 0.74 %. The areas with habitat suitability for *Thalictrum foliolosum* are Yangkhullen, Makhel Khullen, Makhan, Mao, Senapati, Somgjang and Phailen.

Species distribution modelling always considers climate and geographic factors; however, other factors are able to affect species distribution, e.g., adaptability, interspecies competition, and land use change etc. As we didn't consider other potential threats than climate change, it is likely that habitats of high suitability ($P > 0.60$) for *Aconitum nagarum*, *Paris polyphylla*, *Rubia cordifolia*, *Taxus wallichiana* and *Thalictrum foliolosum* will decrease in a wider range or more drastically as our model results predict.

The distribution of *Aconitum nagarum* is mainly influenced by mean temperature of driest quarter, maximum temperature of warmest month,

precipitation of wettest month which suggests that this species is sensitive to high temperature and rainfall.

Likewise, *Paris polyphylla* is mainly influenced by mean temperature of driest quarter, mean temperature of warmest quarter, minimum temperature of coldest month, mean temperature of coldest quarter, annual mean temperature, annual precipitation. This plant is mostly suited to low to high temperature and rainfall.

In case of *Rubia cordifolia* its distribution is mainly influence by annual mean temperature, minimum temperature of coldest month, mean temperature of warmest quarter and precipitation of wettest month.

For *Taxus wallichiana* environmental factors like maximum temperature of warmest month, mean temperature of coldest quarter, precipitation of wettest month, precipitation of wettest quarter, temperature seasonality and precipitation of coldest quarter. The environmental variable contribution for *Thalictrum foliolosum* are mean temperature of warmest quarter, annual mean temperature, minimum temperature of coldest month, precipitation of wettest quarter, temperature seasonality and annual precipitation. Summarizing all the environmental factors it can be said that the selected five ethno medicinal plants are sensitive to temperature and rainfall.

7.2 CONCLUSION

The state is bestowed with complex ecosystem with diverse ethno- medicinal plant diversity. The diversity pertains due to the variations in altitudes, landscapes, climatic factors create micro habitats which favours for growth of many rare and endemic medicinal plants. The rich diversity of medicinal plants plays a significant role in treatment of primary health ailments in the state of Manipur.

The ethno-medicinal plants and traditional knowledge needs to be properly documented and their scientific validations for effective utilization should be done. The indigenous knowledge could be exploited for strengthening health care systems for future options. Unfortunately, with the ever-increasing human interventions and large-scale habitat destruction, overexploitation and other threats has made ethno-medicinal plants to become threatened status.

The assessment of the IUCN status will definitely help to come up with conservation strategies and measures for sustainable utilization at the earliest. Moreover, the Species Distribution Model (SDM) predicts the best area or habitat suitable for a particular species for introduction or plantation. Considering environmental parameters and different attributes analysis, the present finding will give a base line data or area specific data of a particular species towards future conservation efforts for in-situ and *ex-situ* conservation.

Additionally, mass reproduction, cultivation of commercially viable species, mass awareness for proper collection methods and conservation are suggested. Moreover, there should be strict and priority measures from Forest department and stakeholders for taking up effective conservation measures. Such efforts will help in sustainable utilization of ethno-medicinal plants and also develop state's economy.

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ANNEXURE - 1: IUCN TAXON SHEET

1. Scientific name				
2. Synonym(s)				
3. Family				
4. Vernacular names				
5. Habit				
6. Habitat & ecology				
7. Environmental Factors	Soil	Temp.	Rainfall	Climate
8. Community Association				
9. Original global distribution				
10. Current regional distribution in Manipur with Coordinates				
11. Population Reduction-PR	<30%	30-<50%	50- <80%	>80%
11a. Time/Rate (10 yrs or 3 generations whichever is longer)				
11b. Generation length-				
12. Extent of Occurrence-EO				
13. Area Of Occupancy-AOO				

14. No. of locations/sub-populations	
14a. Data quality (of life history)	Good / Medium / Poor
15. Threats in the state	
16.Trade:	
17. Other comments	
18. Status	
19. IUCN Red List Criteria and Category.	
20.Assessment Rationale	
21. Percentage (%) of global presence	
22. Do the populations outside the state also face similar threats/pressures?	
23. Existing Conservation measures	
24. Recommendations	

A. Research/Management	
a) *in-situ*	
b) ex-situ	
B. i) Cultivation	
25. Existing cultivation -	
26. Previous assessment	

ANNEXURE- 2: PAPER PUBLISHED

1. HiromDolendro Singh, Limasenla and Singh, P.K. (2017). **Status of threatened ethno-medicinal plants found in sub- alpine areas of Ukhrul and Senapati districts of Manipur.** International journal of Applied Research. 3 (6) :544-548

2. HiromDolendro Singh, DS Ningombam, Limasenla (2020) **Diversity, distribution and uses of threatened ethno medicinal plants of Manipur**. Journal of Biodiversity and Environmental Sciences (JBES). Volume 17, No (3), September 2020.Pp. 74 -92

ANNEXURE -3: WORKSHOP& SEMINAR ATTENDED

1. Participated and Contributed to the "**Conservation Assessment and Management prioritisation (CAMP) process Using IUCN Red list categories and criteria, for the wild medicinal plants of Nagaland**", held during 22-25 September 2015 at Dimapur, Nagaland, jointly organised by Nagaland Forest Dept. and foundation for revitalization of local health tradition (FRLHT) Bangalore.

2. Participated and Contributed to the "**Conservation Assessment and Management Prioritization (CAMP) process Using IUCN Red list categories and criteria, for the wild medicinal plants of Manipur**", held during 9th to 11th November 2016 at Imphal, Manipur, jointly organised by

Manipur Biodiversity Board and Foundation for Revitalisation of Local Health Traditions (FRLHT), Bangalore.

3. International Conference on "**Natural Resources Management and Technology Trends** (ICNRM-17), Organised by CSA, Department of Life Sciences, Manipur University and SLNA, Planning Department, Manipur 27th March, 2017 to 29th March, 2017.

4. Participated and presented a Paper entitled "**Assessment of Threatened Ethno- Medicinal Plants of Manipur**" in Environmental Sciences Section of 105th Indian Science Congress held at Manipur University, Imphal from 16th to 20th March, 2018.

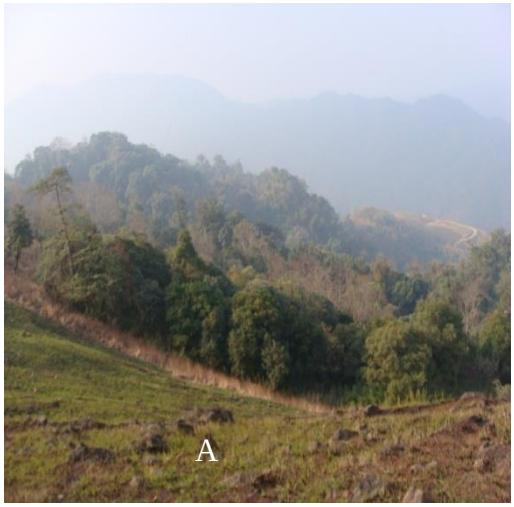
5. Participated in the National Workshop on "**Harvesting and Sustainable use of Medicinal plants, Herbal Remedies use by the Traditional Medicinal Practitioners of different Ethnic Communities of North East India**" Organized

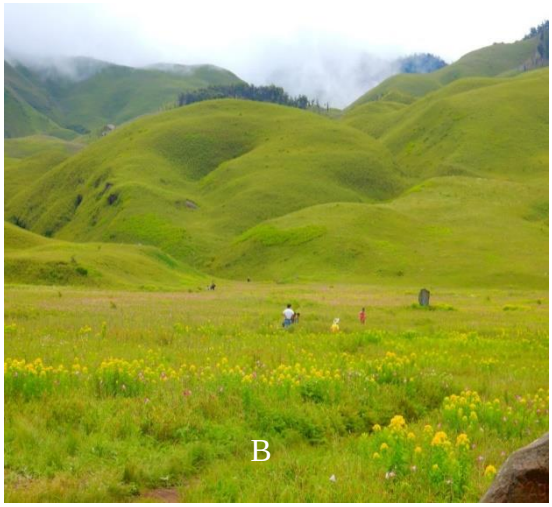
6. by North Eastern Institute of Folk Medicine, Pasighat on 12th February 2020 and was sponsored by National Medicinal Plant Board, New Delhi.

7. Participated in the State Level Conference on Medicinal Plants for Stakeholders held on 27th – 28th March, 2018 under the theme "**Market Promotion of Medicinal Plants of the State**" conducted by Forest Development Agency Northern Forest Division, Kangpokpi under the aegis of National Medicinal Plants Board, Ministry of AYUSH, Government of India.

8. Paper presented in the "**National Workshop on Integrated Water Resources Management Strategies & Challenges in the North East India**" held on 29-30 June, 2017 at the D.M. College of Science, Imphal.

9. Participated in the National Workshop on "**Scientific Writing, Research Communication & IPR Issues**" held on August 28-29, 2014 Organized by Institutional Biotech Hub & Department of Botany Nagaland University.





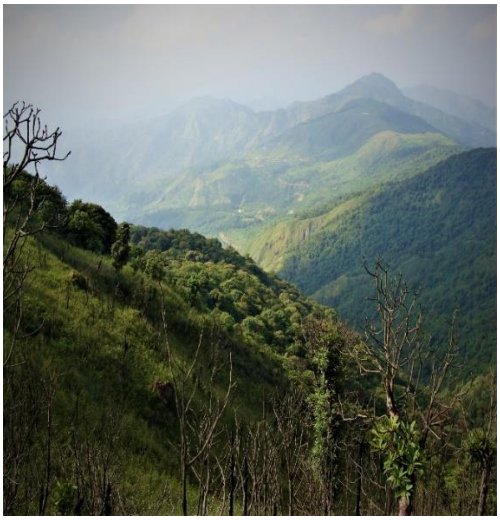


Photo plate-I: Showing the various landscape of Manipur

Photo plate-II: Showing the various landscape of Manipur

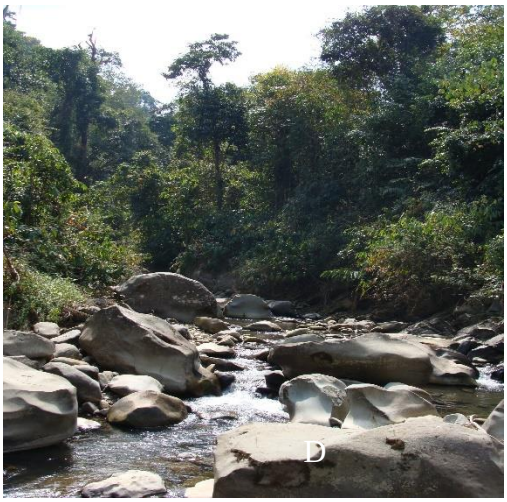


Photo plate-III: Showing the various landscape of Manipur

Photo plate-IV: Showing the Research scholar with informants at various sites

A

B

C


D

Photo plate-V: Showing various villages and landmarks of survey sites

A

B

C


D

E

F

Photo plate-VI: Showing various villages and landmarks of survey sites

Photo plate-VII: Showing the various threats to the habitats and species in particular.