

**FLORISTIC DIVERSITY OF ANGIOSPERMS IN NGENGPUI
WILDLIFE SANCTUARY, MIZORAM**

**A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY**

LALFAKAWMA

MZU REGISTRATION No. 3512 of 2010-11

Ph.D. REGN NO. MZU/Ph.D. /1016 of 26.05.2017



**DEPARTMENT OF BOTANY
SCHOOL OF LIFE SCIENCES
MAY, 2024**

**FLORISTIC DIVERSITY OF ANGIOSPERMS IN
NGENGPUI WILDLIFE SANCTUARY, MIZORAM**

BY

Lalfakawma

Department of Botany

Supervisor: Dr. Khomdram Sandhyarani Devi

Submitted

**In partial fulfillment of the requirement of the Degree of Doctor of Philosophy in Botany
of Mizoram University, Aizawl.**

Dr. Khomdram Sandhyarani Devi
Assistant Professor
Department of Botany
Phone-Office: (0389) 2330733, 2330857
Mobile: + 91 9615586093
E-mail: sandhyakhomdram@gmail.com



MIZORAM UNIVERSITY
TANHRIL: AIZAWL-796004
MIZORAM, INDIA
Gram: mzu
Post Bag No: 190
Website: www.mzu.edu.in

CERTIFICATE

This is to certify that Mr. **Lalfakawmah** has submitted the thesis entitled “**Floristic diversity of angiosperms in Ngengpui Wildlife Sanctuary, Mizoram**” under my supervision, for the requirement of the award of the Degree of Doctor of Philosophy in the Department of Botany, Mizoram University, Aizawl. The work is authentic, content of the thesis is the original work of the Research Scholar, and the nature and the presentation of the work are the first of its kind in Mizoram.

It is further certified that no portion(s) or part(s) of the content of the thesis has been submitted for any degree in Mizoram University or any other University or Institute.

(**Dr. KHOMDRAM SANDHYARANI DEVI**)

Supervisor
Department of Botany
Mizoram University

DECLARATION

Mizoram University

May, 2024

I, Mr. **Lalfakawma**, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form the basis of the award of any previous degree to me, or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to the Mizoram University for the degree of Master of Philosophy/Doctor of Philosophy in Botany.

(LALFAKAWMA)

Candidate

(Prof. F. LALNUNMAWIA)

Head

(Dr. KHOMDRAM SANDHYARANI DEVI)

Supervisor

ACKNOWLEDGEMENT

First and foremost, I thank the Almighty God for His guidance and blessings that He bestowed upon me. His unending provisions helped me in every bit of my work.

A big chunk of my gratitude goes to my supervisor, Dr. Khomdram Sandhyarani Devi, Department of Botany, Mizoram University for her compassionate and excellent guidance, valuable advice and all the support throughout my research work.

I extend my heartfelt thanks to Head of Department, Prof. F Lalnunmawia and to all the faculty members of Department of Botany, Mizoram University for providing all the necessary facility required for my research work.

I sincerely thank the leaders of the various villages I visited during my research for their kind hospitality and for sharing their valuable knowledge and information. I am indebted to all those who assisted me during my studies, especially Mr. Thangtea for guiding me in the forest, Mrs. Partei for her warm hospitality, and the sanctuary and forest office personnel for granting me permission to collect samples without any issues.

I also express my sincere gratitude to my labmates Margaret Lalhlupuii, Laltlanhlui, and Thangliankhup for their collaboration and support throughout this research. Special thanks to my friends Lalrinmuana and David Malsawmtluanga for their enthusiasm, diverse perspectives, and willingness to brainstorm ideas, making this journey both enjoyable and enriching. Their friendship and teamwork have been integral to our collective success.

I am profoundly grateful to the Council of Scientific and Industrial Research (CSIR) for their generous financial support, which made this research possible. This funding facilitated the execution of the project and provided essential resources for conducting experiments, acquiring equipment, and accessing valuable research materials.

Lastly, I express my deepest gratitude to my father, family, and friends for their unwavering support. A special thanks to my wife, Vanlalnghaki, for her constant encouragement and support from the beginning of my research to its completion. Your prayers, encouragement, and steadfast support have been invaluable throughout this journey.

Date:

(LALFAKAWMA)

TABLE OF CONTENTS

	Page
List of abbreviations and symbols	i-iii
List of figures	iv-v
List of tables	vi-viii
 Chapter 1: Introduction	 1-18
Chapter 2: Review of literature	19-29
Chapter 3: Study area	30-37
Chapter 4: Methodology	38-48
Chapter 5: Results and Discussion	49-134
Chapter 6: Summary and Conclusion	135-143
Photoplate	144-150
Appendix I: Questionnaires on Ethnobotanical data collection from Ngengpui Wildlife Sanctuary	151
Appendix II: Questionnaires on Multipurpose use of wild flora from NWS.....	152
References	153-176
Bio-data	177-182
Particulars of the candidate	183

LIST OF ABBREVIATIONS AND SYMBOLS

%	Percentage
<	Lessthan
>	Greaterthan
°C	Degree Celsius
°F	Degree Fahrenheit
BS	Bungtlang South
BSI	BotanicalSurveyof India
CDD	Cell Division Disorder
CO₂	Carbon Dioxide
cm	Centimeter
CR	Critically Endangered
CVD	Cardiovascular Disorder
DBH	Diameter at Breast Height
DC	Dental Care
D	Simpson Index of Dominance
d-d	density-diameter
DMg	Margalef’s Diversity Index
DID	Dermatological Infections Diseases
DNA	Deoxyribonucleic acid
DT	Diltlang
<i>e.g.</i>	<i>exempligratia</i> :Forexample
EN	Endangered
ENT	Ear nose throat problem
<i>et al.</i>	“ <i>et alia</i> ”:andothers
<i>etc.</i>	<i>etcetera</i> :andotherthings

Fic	Informant consensus factor
FIVI	Family Importance Value Index
Fl	Fidelity level
ft	Feet
g	Gram
GH	General Health
GHNP	Great Himalayan National Park
GIA	Gastro-Intestinal Ailments
GUA	Genito-Urinary Ailments
H'	Shannon-Wiener Diversity Index
ha	Hectare
HN	Hmunnuam
IAPS	Invasive Alien Plant Species
ISFR	India State of Forest Report
IUCN	International Union for Conservation of Nature
IVI	Important Value Index
J'	Pielou's evenness index
km²	Square Kilometres
km	Kilometre
KM	Khawmawi
LSD	Liver and Spleen Disorder
m	Metre
ml	Millilitre
mm	Millimetre
MDF	Moderately Dense Forest
MZUH	Mizoram University Herbarium
NP	Ngengpui

NWS	Ngengpui Wildlife Sanctuary
OF	Open Forest
PAs	Protected Areas
PB	Poisonous Bites
PIC	Prior informed consent
R²	Coefficient of Determination
r	Radius
RET	Rare, Endangered, Threatened
RFC	Relative frequency of citation
RSD	Respiratory Disease Syndrome
SE	Saizawh East
SIVI	Species Importance Value Index
SMSD	Skeleto-Muscular System Disorder
sp.	Species
UV	Use Value
VBD	Vector Borne Diseases
VDF	Very Dense Forest
WHO	World Health Organization

LIST OF FIGURES

- Figure 3.1:** Annual rainfall recorded from 2018-2024 within Lawngtlai District
- Figure 3.2:** Geographical map of Mizoram showing the study area (Ngengpui Wildlife Sanctuary)
- Figure 3.3:** Photos showing different sites selected for the study of the research within NWS
- Figure 5.1:** Species accumulation curve based on the rarefaction method: (a) Whole tree population; (b) six forests: BS = Bungtlang south, DT = Diltlang, HN = Hmunnuam, KM = Khawmawi, NP = Ngengpui, SE = Saizawh east
- Figure 5.2:** Boxplot with jittered data points showing the distribution of (a) basal area, (b) stem density, and (c) DBH. The horizontal line crossing the box in the center represents the median. The vertical line outside the box represents the maximum and minimum values. ALL = total forest community, BS = Bungtlang south, DT = Diltlang, HN = Hmunnuam, KM = Khawmawi, NP = Ngengpui and SE = Saizawh east
- Figure 5.3:** Overall stems recorded along with class distribution of trees with >30 cm DBH recorded in the study
- Figure 5.4a:** Bar graph showing the herbs family distribution in percentage among the angiosperm families in NWS
- Figure 5.4b:** Bar graph showing shrubs family distribution in percentage among the angiosperm families in NWS
- Figure 5.5:** Percentage of habit types of ethnomedicinal plants in NWS.
- Figure 5.6:** Percentage of ethnomedicinal plant species among the dominant families in NWS
- Figure 5.7:** Chord diagram of ethnomedicinal plant parts used in NWS
- Figure 5.8:** Ethnomedicinal plants percentage for their mode of usage in NWS
- Figure 5.9:** Relative frequency citation (RFC) of ethnomedicinal plants

used

- Figure 5.10:** Fidelity level (Fl) of the ethnomedicinal plants of NWS, Mizoram
- Figure 5.11:** Ethnomedicinal plants used against thirteen different ailments category in NWS
- Figure 5.12:** Use value (UV) of the ethnomedicinal plants of NWS
- Figure 5.13:** Correlation between RFC and UV of the ethnomedicinal plants in NWS

LIST OF TABLES

Table 1.1:	Megadiversity countries of the world
Table 1.2:	The eight hottest hotspots
Table 5.1:	Tree species recorded in NWS with scientific name, MZUH Accession no., Family, Local name and Conservation Status
Table 5.2:	Diversity indices of tree species from six different sites of Ngengpui Wildlife Sanctuary, Mizoram, India
Table 5.3:	Top ten species and families for the overall forest community recorded in the study sites of NWS
Table 5.4:	Top ten Dominant Species and Dominant Families in HN
Table 5.5:	Top ten Dominant Species and Dominant Families in NP
Table 5.6:	Top ten Dominant Species and Dominant Families in DT
Table 5.7:	Top ten Dominant Species and Dominant Families in SE
Table 5.8:	Top ten Dominant Species and Dominant Families in KM
Table 5.9:	Top ten Dominant Species and Dominant Families in BS
Table 5.10:	List of herbs with their scientific names, MZUH accession no., local name, RET status, RF, RD, RA, IVI and the rank based on IVI IUCN status and Importance value Index (IVI) found in NWS
Table 5.11:	List of shrubs with their scientific names, MZUH accession no., local name, RET status, RF, RD, RA, IVI and the rank based on IVI IUCN status and Importance value Index (IVI) found in NWS
Table 5.12:	List of Epiphytes with their IUCN status found within NWS

Table 5.13:	List of Climbers with their scientific name, family, local names and RET status found in NWS
Table 5.14:	List of grasses in NWS with scientific names, family, local names, IUCN Status
Table 5.15:	List of canes and palms in NWS with scientific names, family, local names, RET Status.
Table 6.1:	Demographic Characteristics of Informants in NWS
Table 5.16:	Analysis of species numbers along tree, herbs, shrubs and climbers
Table 5.17:	List of threatened species (RET)
Table 5.18:	Demographic Characteristics of Informants in NWS
Table 5.19:	Ailments categories of the ethnomedicinal plants from NWS, Mizoram
Table 5.20:	Ethnomedicinal plants of NWS, Mizoram with scientific names, families, voucher nos., local names, habits, part used, folk preparation/formulations, RFC, UV and IUCN status
Table 5.21:	Informant Consensus factor (Fic) as per the ailments category of NWS, Mizoram
Table 5.22:	Fidelity level (Fl) of the ethnomedicinal plants of NWS, Mizoram
Table 5.23:	Wild Edible Vegetables in NWS with scientific name, Family and Local Name
Table 5.24:	Wild Edible Fruits in NWS with scientific name, Family and Local Name

Table 5.25: Timber yielding plants in NWS with scientific name, Family and Local Name

Table 5.26: Plants used for Firewood and making Charcoal in NWS with scientific name, Family and Local Name

Table 5.27: Plants used as Fodder in NWS with scientific name, Family and Local Name

Table 5.28: Other Uses of Plants in NWS with scientific name, Family and Local Name

CHAPTER1

1. Introduction

1.1 General Introduction to Angiosperm

Angiosperms, categorized as seed-bearing vascular plants, feature reproductive structures known as flowers, wherein ovules are enclosed within an ovary. These plants thrive in diverse habitats, ranging from forests and grasslands to coastal areas and deserts, showcasing a wide array of life forms, including trees, herbs, submerged aquatics, bulbs, and epiphytes. Orchidaceae, Asteraceae, and Fabaceae stand out as the largest plant families, contributing to the remarkable diversity of angiosperms, which are estimated to comprise around 352,000 species (source: <http://www.theplantlist.org>). The evolutionary history of angiosperms is intricate and spans millions of years. Fossil evidence suggests that angiosperms emerged during the Early Cretaceous period, around 125 million years ago. The sudden appearance of angiosperms, often referred to as the "Angiosperm Explosion," marked a pivotal moment in the evolution of plant life. The rapid diversification and adaptive radiation of angiosperms are believed to have influenced the development of various terrestrial ecosystems and shaped the interactions between plants and other organisms.

Angiosperms exhibit an array of morphological features that contribute to their remarkable diversity. One of the defining characteristics is the presence of flowers, specialized reproductive structures that facilitate the transfer of pollen for fertilization. The floral organs, including sepals, petals, stamens, and carpels, contribute to the unique appearance of each species. Furthermore, the majority of angiosperms undergo double fertilization, a distinctive reproductive process involving the fusion of male and female gametes. The ovary, containing ovules, matures into a fruit after fertilization, protecting and dispersing the seeds. The diversity of fruits and seeds among angiosperms contributes to their success in colonizing various habitats, from lush rainforests to arid deserts.

1.2 The Fundamentals of Biodiversity

The inception of the term "biological diversity" can be traced back to Raymond F. Dashman in 1968 (Dashman, 1986), who amalgamated genetic diversity (the variability within species) and ecological diversity (the number of species in a community). The term "biodiversity" was abbreviated from "biological diversity" by W.G. Rosen in 1985 during the inaugural planning meeting of the "National Forum on Biodiversity" in Washington D.C. (Wilson, 1988). Lovejoy (1980) further introduced the concept of biodiversity to quantify the number of species. Biodiversity, as a concept, encompasses all life forms, ecosystems, and ecological processes, recognizing hierarchical levels at genetic, taxonomic, and ecosystem scales (McNeely *et al.*, 1990), reflecting the entirety of genes, species, and ecosystems in a given region.

According to the Convention on Biological Diversity (1992), biodiversity is defined as "the variability among living organisms from all sources including terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems" (Hawksworth, 1996). India's Biological Diversity Act (2002) defines it as "the variability among living organisms from all sources and the ecological complexes of which they are part and includes diversity within species or between species and of ecosystems" (Anon., 2002). Biodiversity is an expansive and intricate concept that permeates various facets of human life and activity (Krishnamurthy, 2004). Diversity is encapsulated in two distinct aspects: species richness, denoting the number of species per unit area, and evenness, reflecting their abundance, dominance, or spatial distribution. Species, being easily observable, are the focal point of biodiversity measurement, especially in studies related to forest ecosystems (Barnes *et al.*, 1998).

The significance of biodiversity extends beyond its complexity. It provides humankind with direct economic benefits, essential services through natural

ecosystems, and a pivotal role in regulating ecosystem function and stability. Biodiversity is not uniformly distributed on Earth and may comprise 5 to over 50 million species. It forms the bedrock of human survival and economic prosperity, embracing all life forms, ecosystems, and ecological processes while recognizing hierarchies at genetic, taxonomic, and ecosystem levels. Biodiversity is instrumental in delivering essential ecosystem services such as regulating atmospheric composition, climate, disturbance and water regulation, soil formation, nutrient processing, waste assimilation, pollination, biological control, pollution control, and recreation.

Direct benefits to humankind include timber, food, fiber, medicines, industrial enzymes, flavors, fragrances, cosmetics, emulsifiers, dyes, plant growth regulators, and pesticides. Studies indicate that biodiversity composition and quantity play a crucial role in controlling ecosystem functions and stability. Greater diversity allows increased access to resources, leading to enhanced net primary production and reduced nutrient losses. However, the relationship between biodiversity and ecosystem functions remains a challenging issue in ecology, sparking debates among ecologists. It is estimated that 5-50 million species inhabit Earth, with only 1.6 million identified thus far. According to McNeely *et al.* (1990), less than 5% of the biological diversity of the rainforest is known to science. Studies reveal that the tropical forest is diminishing at a rate of 0.8% per year, potentially resulting in a 5-10% extinction rate within the next 30 years if the current trend persists (Agarwal, 2002).

1.3 Types of Biodiversity

Biodiversity is commonly conceptualized in terms of genes, species, and ecosystems three essential and hierarchically linked levels of biological organization. This categorization is outlined in various ways, with distinctions such as genetic diversity, species or taxonomic diversity, and ecosystem diversity (McAllister, 1991; Solbrig, 1991; Groombridge, 1992; Heywood, 1994; Norse, 1994). However, Harper and Hawksworth (1994) prefer the terms genetic, organismal, and ecological diversity. Another classification involves three

interdependent sets of attributes: compositional levels (identity and variety of elements) and structural levels (ecological and evolutionary processes) (Noss, 1990). The different types of diversity are detailed below:

(a) Genetic Diversity

Genetic diversity pertains to the variation of genes within species, encompassing differences between distinct populations of the same species. It constitutes a crucial component of biodiversity (Gaston, 1996; Mallet, 1996). Genes, segments of DNA containing genetic code, are linearly arranged along the DNA, forming chromosomes. During sexual reproduction, chromosomes from two parents combine, leading to genetic differences and the emergence of individuals with altered characteristics, contributing to the diversity of life. The finer scale of biodiversity is measured by the variety of expressed genes or characters among organisms (Williams *et al.*, 1996). Although considered challenging and costly for measuring and assessing biodiversity, various methods, such as gene diversity, heterozygosity, and alleles per locus, are employed to evaluate genetic diversity. Modern studies emphasize the interconnectedness of genetic diversity and biodiversity, highlighting their mutual dependence for species survival.

Genetic diversity plays a crucial role in species survival and adaptability to changing environments. Slight gene variations are essential for adapting to environmental shifts, ensuring the organism's anatomical changes for survival. Populations with high genetic diversity possess a range of variations, enhancing adaptability and evolutionary potential. Conversely, species with low genetic variation face risks such as difficulties in reproduction and increased vulnerability to diseases.

(b) Species Diversity

Species diversity refers to the variety of species within a specific region, defined as a group of interbreeding or potentially interbreeding natural populations reproductively isolated from others (Agarwal, 2002). It is also known as taxonomic or organismal diversity (Kiestler, 2001). Measurement of species diversity involves

various approaches, including species richness, species abundance, and taxonomic or phylogenetic diversity (Magurran, 1998). Species richness counts the total number of species in a defined area, while species abundance measures the relative numbers among species.

Assessment of biodiversity in a region often relies on species richness, representing the total number of species occurring in the given geographical area. However, species richness alone does not provide a comprehensive picture of organism diversity. Taxic diversity considers the relative abundance of species in various taxonomic groups, providing a more nuanced understanding of diversity by accounting for differences in species composition.

(c) Habitat Diversity

Habitats are defined as areas providing the resource requirements for a discrete phase of a plant or animal's life (Southwood, 1981). Andrewartha and Birch (1984) elaborate on the potential influences of habitats on the survival, reproduction, distribution, and abundance of organisms through their theory of the environment. Habitat diversity, often challenging to quantify, is foundational for area-based management.

(d) Ecosystem Diversity

An ecosystem, whether aquatic (freshwater or marine) or terrestrial (forest, desert, man-made), is defined as a specific area where living organisms and non-living substances interact and exchange (Likens, 1993). Ecosystem diversity encompasses differences between ecosystem types, including the diversity of habitats and ecological processes within each ecosystem type. Defining ecosystem diversity is more complex than species or genetic diversity due to fluid boundaries of communities and ecosystems. Ecosystem diversity is generally assessed by considering the diversity of component species, relative abundance, and types of species present. It depends on the physical characteristics of the environment, diversity of species, and interactions among species and with the environment. The functional complexity of an ecosystem increases with the number and taxonomic

diversity of species, as well as the vertical and horizontal complexity of the physical environment. Some ecosystems, despite lacking physical complexity or species richness, can be functionally complex due to biochemical specializations enabling survival in harsh environments and deriving energy from inorganic chemical sources (Rothschild and Mancinelli, 2001).

1.4 Biodiversity Patterns

Whittaker (1975 and 1977) introduced a framework for understanding biodiversity patterns, distinguishing four levels of inventory diversity that can be estimated at progressively larger spatial scales:

(i) Point Diversity

On the smallest scale is point diversity, referring to the diversity of a micro-habitat or sample taken from within a homogeneous habitat.

(ii) Alpha Diversity

Alpha diversity characterizes the diversity within a homogeneous habitat and is equivalent to McArthur's (1966) concept of within-habitat diversity. It relates to a specific landscape ecosystem type or community in a homogeneous site.

(iii) Gamma Diversity

Gamma diversity represents the diversity of a larger unit, such as an island or landscape. It encompasses the diversity of species within a geographical area and is dependent on both alpha and beta diversity.

(iv) Epsilon Diversity

Epsilon diversity, or regional diversity, is the total diversity of a group of areas with gamma diversity. Whittaker envisioned epsilon diversity applying to large biogeographic areas.

1.5 Megadiversity Zones

The term "megadiversity" involves estimating the total number of organisms within an ecosystem and signifies that a particular place harbours a higher percentage of living species in its territory than would be proportional to its surface area. This concept underscores the significance of countries that possess extensive biological diversity within their borders, often characterized by numerous endemic species. While organisms are not confined by borders, a megadiverse country is one where a considerable number of species are present. The megadiversity concept highlights aspects such as species richness, threatened species, and endemic species. In contrast, the concept of hotspots is more focused on rich endemism and the level of threat or habitat destruction (Myers *et al.*, 2000).

On February 18, 2002, Ministers responsible for the Environment and delegates from Brazil, China, Colombia, Costa Rica, India, Indonesia, Kenya, Mexico, Peru, South Africa, and Venezuela convened in the Mexican resort town of Cancun. These countries collectively declared the establishment of a Group of Like-Minded Megadiverse Countries as a mechanism for consultation and cooperation. The primary objective was to promote their interests and priorities related to the preservation and sustainable use of biological diversity. Furthermore, they urged countries not party to the Convention on Biological Diversity, the Cartagena Protocol on Biosafety, and the Kyoto Protocol on climate change to become signatories to these agreements.

These megadiverse countries committed to periodic meetings at both ministerial and expert levels. It was agreed that after each annual Ministerial Meeting, the next rotating host country would assume the role of Secretary of the group. This arrangement aimed to ensure continuity, foster further cooperation among these nations, and achieve the agreements and objectives outlined in their declarations. The twelve most biodiverse countries in the world are presented in **Table 1.1.**

Table - 1.1 Megadiversity countries of the world

Sl.No	Country	Speciesrichness	Endemism	Total
1	Brazil	30	18	48
2	Indonesia	18	22	40
3	Colombia	26	10	36
4	Australia	5	16	21
5	Mexico	8	7	15
6	Madagascar	2	12	14
7	Peru	9	3	12
8	China	7	2	9
9	Philippines	0	8	8
10	India	4	4	8
11	Ecuador	5	0	5
12	Venezuela	3	0	3

(Source:Mittermeier *et al.*,1997)

1.6 Biodiversity Hotspots

A biodiversity hotspot is a biogeographic region characterized by a significant reservoir of biodiversity that faces imminent threats of destruction.

Dr.Norman Myers originally introduced the concept of biodiversity hotspots through two articles in "The Environmentalist" (Myers 1988, 1990), later revised by Myers *et al.* in 1999 in the publication "Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions." Russell Mittermeier also contributed to

the promotion of the hotspots idea in his book "Hotspots revisited" (Mittermeier, 2004), although this work did not undergo scientific peer review, unlike other hotspot analyses. To be classified as a biodiversity hotspot according to Myers' 2000 edition of the hotspot map, a region must satisfy two stringent criteria: it must harbour a minimum of 0.5% or 1,500 species of vascular plants as endemics, and it must have experienced the loss of at least 70% of its primary vegetation (Myers *et al.*, 2000). The initial 25 hotspots worldwide have been updated to 34, including 9 new hotspots in the expansive Himalayan range and the island nation of Japan (Holsinger, 2005). These areas support nearly 60% of the world's plant, bird, mammal, reptile, and amphibian species, with a high proportion being endemic. The eight most critical hotspots are detailed in **Table 1.2**.

Biodiversity hotspots have faced severe disturbances due to various environmental factors. Five significant determinants include (i) land use (conversion of 50% of land area to agriculture); (ii) climate change (4°C or 30% change in precipitation); (iii) nitrogen deposition (20 kg/ha/yr); (iv) biotic change (arrival of 200 new species of plant/animal); and (v) atmospheric CO₂ (2.5-fold increase) by the year 2100 (Sala *et al.*, 2000). Among these, land use change has

Sl.No.	Hotspot	Endemic plants	Endemic plants/area ratio (species per 100 km ²)	Remaining primary vegetation as % of original extent
1	Madagascar	9,704	16.4	9.9
2	Philippines	5,832	64.7	3.0
3	Sundaland	15,000	12.0	7.8
4	Brazil's Atlantic Forest	8,000	8.7	7.5
5	Caribbean	7,000	23.5	11.3
6	Indo-Burma	7,000	7.0	4.9
7	Western Ghats/Sri Lanka	2,180	17.5	6.8
8	Eastern Arc and Coastal Forests of Tanzania/Kenya	1,500	75.0	6.7

been identified as the most impactful driver of global diversity changes.

Table – 1.2. The eight hottest hotspots (Source:Myerset *al.*,2000)

1.7 Loss of Biodiversity

The loss of biological diversity presents a global crisis, with ecological catastrophes affecting nearly every region on Earth. Of the 1.7 million known species inhabiting the planet, an estimated one fourth to one third face extinction within the next few decades (Spellberg, 1991). According to Myers (1979), the rate of species extinctions has exponentially increased over the last 50,000 years, from one extinction per 1,000 years to approximately 1,000 extinctions per year, with projections suggesting this figure may rise to 40,000 per year by the end of the century, equating to one species lost every hour. While habitat loss remains a significant threat to most species, overharvesting, unsustainable use, and illegal trade in certain species pose additional risks not only to their survival but also to the ecosystems they inhabit and the livelihoods of communities and local economies dependent upon them (Eldredge, 2002).

The loss of biodiversity is a matter of great concern as it represents a potential source of wealth. Current extinction rates resulting from human activities far surpass natural background levels. Ecosystem overexploitation is evident on both local and global scales, with significant adverse effects on biological diversity and the livelihood opportunities of people. Major contributors to biodiversity loss include habitat destruction, pollution, overpopulation, and species introductions (Singh *et al.*, 2010). Additionally, the loss of biological diversity has implications for the local rights of people and their cultural diversity.

1.8 Concept of Forest

The term "forest" has *various* definitions, with differences stemming from the varied emphases and concerns of different individuals. Generally, a forest is described as a dense growth of trees, accompanied by other plants, covering a

substantial land area. Forestry is the scientific discipline dedicated to the study, preservation, and management of forests. Forests are considered ecosystems—communities where plants and animals interact with each other and their physical environment. The classification of the world's forests is based on three main types or formations, primarily reflecting the climate in which the vegetation thrives. The significance of forests to the global human population is increasingly recognized, evident in multilateral environmental agreements such as the United Nations Framework Convention on Climate Change and the Convention on Biological Diversity. However, ongoing demographic, economic, and social changes exert substantial pressure on forest cover and condition worldwide. Tropical forests, covering less than 10% of the land area, constitute the largest terrestrial reservoir of biological diversity, ranging from the gene to the habitat level.

Tropical forests face challenges from rapid land use changes, including agricultural expansion, commercial logging, plantation development, mining, industry, urbanization, and road construction, resulting in deforestation (Geist and Lambin, 2002). Recent studies suggest that land use changes may have a more significant impact on biodiversity reduction than other factors like climate change, nitrogen deposition, biotic exchange, or increased carbon dioxide concentrations (Sala *et al.*, 2000). Northeastern India's extensive forest resources are under intense exploitation for timber and conversion to agriculture (Mayaux *et al.*, 2005). Forest stratification refers to the differentiation of layers within a community, often complex in communities with numerous vertical layers of species, each characterized by a specific growth form. This concept relates to the distinct layers of plants found in a forest. Older, mature forests typically exhibit several well-defined layers from the forest floor to the tree canopy, while young forests may lack clear separations between layers. The concept of "layer" or "stratum" can indicate plant-life form groups (e.g., tree, shrub, and herb layers) or age classes (e.g., tree and seedling layers) existing at characteristic heights. The relative coverage of these different forms is sometimes used to describe stands, influencing the microclimate of the area, which, in turn, significantly impacts seed germination and growth (Richardson, 1958).

1.8.1 Trees

Trees stand as nature's masterpieces of creation. In a pragmatic sense, foresters define trees as perennial woody erect plants that reach a minimum height of 3 to 4 meters, possess a well-formed crown of foliage, and achieve a diameter of 7.5 cm at 1.35 meters from ground level. A tree follows the natural cycle of birth, growth, and eventual demise (Chaudhuri, 1993). Constituting the forests, trees are a remarkable heritage that significantly contributes to a nation's prosperity. Trees with rough, coriaceous, and sticky leaf surfaces play a role in collecting soot and oil, contributing to the reduction of environmental pollution. When trees grow together, they give rise to a forest, creating an environment that initiates plant and animal successions, eventually achieving a harmonious balance. Throughout human evolution, trees have played a crucial role, serving as benefactors, friends, teachers, and preceptors. They have shaped our aesthetic sense and endowed us with faculties for love, service, sacrifice, and harmony. Indispensable to human life, the preservation of trees is imperative, considering their fundamental role as part of the world's basic elements and their presence with humanity since its beginnings. Trees hold powerful symbolic significance, becoming enduring personalities.

A forest is a highly intricate community comprising trees, shrubs, ground plants, mammals, birds, insects, and soil fauna. Dominated by trees, a forest shields its inhabitants from the impact of sun, wind, and rain. The trees in a forest may be evergreen, deciduous, or a mixture of both. The North Eastern Region of India houses six crucial vegetation types of forests, nurturing a rich diversity of plant species. This region hosts 80,000 out of 15,000 species of flowering plants, 40 out of 54 species of gymnosperms, 500 out of 1012 species of Pteridophytes, 825 out of 1145 species of orchids, 80 out of 90 species of Rhododendrons, 60 out of 110 species of bamboo, and 25 out of 56 species of canes. This diverse array belongs to approximately 200 plant families, out of 315 recorded in North East India (Anon., 1990). Some families, such as Nepanthaceae, Illiciaceae, and Clethraceae, are unique to the region (Chatterjee, 2008). According to the Indian Red Data Book, 10% of the total flowering plants are endangered, with 800 of the 1,500 species reported from North East India (Nayar and Sastry, 1887).

1.8.2 Patterns of Tree Distribution

Ngengpui Wildlife Sanctuary exhibits a tropical wet evergreen and semi-evergreen forest. Numerous studies propose the existence of zones or belts of vegetation on tropical mountains, characterized by elevation-related discontinuous variations in floristic composition or structure. As elevation increases, there is a noticeable change in the tree species present in different areas. The distribution patterns of trees in a region are significantly influenced by climate variables such as rainfall patterns and temperature. Eminent botanists and forest officers, including Hooker (1872-1897) and Champion and Seth (1968), have extensively discussed the forest or vegetation covers of North-East India. Singh *et al.* (2002) classified the forests of Mizoram primarily based on altitude, rainfall, and the dominant species composition.

1.9 Concept of Protected Area

The concept of a protected area encompasses various types, primarily including Biosphere Reserves, National Parks, Wildlife Sanctuaries, game reserves, and biosphere reserves. These areas are designated with the primary goal of providing protection to wild animals and their habitats, as well as conserving plant species. The establishment of protected areas has been a global initiative to safeguard and preserve biodiversity. As of the available data, a network of 668 Protected Areas (PAs) has been established worldwide, covering a total area of 1,61,221.57 sq. km, which constitutes approximately 4.90% of the total geographic area. This network includes 102 National Parks, 515 Wildlife Sanctuaries, 47 Conservation Reserves, and 4 Community Reserves (source: <http://www.moef.nic.in/downloads/public-information/protected-area-network.pdf>).

The establishment of many protected areas has been facilitated by the enactment of the Wildlife Protection Act of 1972. This legislation empowered state governments to establish National Parks and Wildlife Sanctuaries, while the Central Government gained additional powers through the forty-second constitutional

amendment related to forests and wildlife. In the specific case of Mizoram, the total protected area covers 1,241 sq. km, constituting 5.89% of the state's geographical area (Anon., 2011).

1.9.1 Biosphere Reserves

Biosphere Reserves play a crucial role in protecting significant vegetation from disturbances, serving as a benchmark for natural vegetation. These reserves encompass terrestrial and coastal ecosystems and aim to find solutions that balance the conservation of biodiversity with sustainable use. The primary functions of each Biosphere Reserve are threefold:

- a) Conservation Function: Contribute to the preservation of landscapes, ecosystems, species, and genetic diversity.
- b) Development Function: Foster economic and human development that is both socio-culturally and ecologically sustainable.
- c) Logistic Function: Provide support for research, monitoring, education, and information exchange related to local, national, and global issues of conservation and development.

The management of Biosphere Reserves is typically organized into three zones:

- a) Core Zone: The central area dedicated to strict conservation, preserving the most critical habitats and ecosystems.
- b) Buffer Zone: Surrounding the core zone, this area allows for limited human activity to ensure the protection of the core zone.
- c) Transitional Zone: The outermost area where sustainable development practices are encouraged, promoting the coexistence of human activities and biodiversity conservation.

1.9.2 National Park

According to the Wildlife Protection Act of 1972, a National Park is defined as an area declared, either under section 35 or section 38, and considered, under sub-section (3) of section 66, to be declared as a National Park. National Parks play a crucial role in the conservation of endangered species of both animals and plants. India's inaugural national park, initially established as Hailey National Park in 1935, is now known as Jim Corbett National Park. In Mizoram, there are currently two National Parks: Murlen National Park spanning 100 km² and Phawngpui National Park covering 50 km².

1.9.3 Wildlife Sanctuary

As per the Wildlife Protection Act of 1972, a Wildlife Sanctuary is defined as an area declared, whether under section 1[26A] or section 38, and deemed, under sub-section (3) of section 66, to be declared as a wildlife sanctuary. In India, there are over 500 wildlife sanctuaries, and Mizoram is home to seven of them, along with two National Parks and one Tiger Reserve. The wildlife sanctuaries in Mizoram include Ngengpui Wildlife Sanctuary (100 sq. km), Khawnglung Wildlife Sanctuary (41 sq. km), Lengteng Wildlife Sanctuary (60 sq. km), Tawi Wildlife Sanctuary (35.75 sq. km), and Thorang Tlang Wildlife Sanctuary (50 sq. km). These, along with Murlen National Park (100 sq. km) and Phawngpui National Park (50 sq. km), and Dampa Tiger Reserve (500 sq. km), cover a total area of 1,241 sq. km, constituting 5.89% of the state's geographical area (Anon., 2011).

Wildlife Sanctuaries, declared under Section 18 of the Wildlife Protection Act, have areas with significant ecological, faunal, floral, geomorphological, natural, or zoological importance. While ensuring wildlife and environment protection, certain rights of the people residing within the sanctuary might be permitted. The settlement of claims considers the continuation of any person's rights over the land within the sanctuary limits, with the Collector having the authority, in consultation with the Chief Wildlife Warden, to make such allowances.

1.10 Endemic and RET (Rare, Endangered, Threatened) Species

Endemic and RET species contribute significantly to the health and functioning of ecosystems. Their unique adaptations and ecological roles make them essential components of local food webs and ecosystem dynamics. The loss of an endemic species can have cascading effects, impacting other species and altering ecosystem processes. Despite their ecological importance, endemic and RET species face numerous threats, primarily driven by human activities. Habitat destruction, pollution, climate change, over-exploitation, and the introduction of invasive species are among the major challenges. Conservation strategies must address these threats comprehensively. Protected areas, such as sanctuary, national parks and reserves, play a crucial role in preserving the habitats of endemic and RET species. Additionally, community-based conservation initiatives, sustainable resource management, and international cooperation are essential components of effective conservation strategies (Brooks *et al.*, 2006).

1.10.1 Endemic Species

Endemic species are organisms that are exclusively found in a particular geographic area and nowhere else on Earth. These species have adapted to specific local conditions, such as climate, topography, or habitat type, over long periods of time. The unique characteristics of endemic species often make them crucial components of their ecosystems, contributing to overall biodiversity. Endemism is not limited to any specific taxonomic group; it can encompass plants, animals, fungi, and microorganisms. Endemic species are vulnerable to environmental changes, habitat loss, and human activities. Their localized distribution makes them particularly susceptible to threats, highlighting the importance of conservation efforts tailored to specific regions. As Balmford *et al.* (2003) argue, protecting endemic species is crucial for maintaining the resilience and functionality of ecosystems.

1.10.2 RET (Rare, Endangered, Threatened) Species:

RET species are categorized based on their risk of extinction, with the classifications determined by organizations such as the International Union for Conservation of Nature (IUCN) 1996. The three primary categories are:

1. Rare Species: These are species with small global populations or restricted distributions, making them vulnerable to various threats. While not necessarily at immediate risk of extinction, rare species warrant attention due to their limited abundance.

2. Endangered Species: This category includes species facing a high risk of extinction in the wild. Factors such as habitat loss, pollution, climate change, and over-exploitation contribute to their perilous status. Examples include the Red vanda (*Renanthera imschootiana*) and the dancing girl (*Globba wengeri*).

3. Threatened Species: This term encompasses both rare and endangered species, serving as a broader classification for species at risk. Threatened species face substantial decline in numbers and may be pushed towards endangerment or extinction if conservation actions are not implemented promptly. The identification and assessment of the conservation status of RET species are critical for directing conservation efforts effectively. The IUCN Red List of Threatened Species is a widely recognized global database that provides information on the extinction risk status of various species.

1.11 Ethnobotanical Knowledge

Ethnobotanical knowledge represents the culmination of ancient, successful experimentation with plants, providing sustenance and medicines, and reflecting the intricate interplay between humans and their environment (Trivedi and Sharma, 2011). This knowledge encompasses how local communities manage, categorize, and utilize plants within their surroundings (Martin, 1995). Coined in the late 19th century by J.W. Harsh Berger in 1896, the term 'ethnobotany' has evolved to become a crucial field, especially in recent years, contributing significantly to

healthcare development and conservation programs by exploring and preserving traditional knowledge (Cotton, 1996; Kunwar and Bussmann, 2008). Traditional communities worldwide possess profound knowledge of forest-based resources, relying on them for sustenance, shelter, medicines, fodder, agricultural tools, and other versatile purposes (Martin, 1995). Ethnobotanical studies have burgeoned into a rapidly growing multidisciplinary subject, engaging various research fields such as Botany, Anthropology, Linguistics, Agriculture, Archaeology, and Economics (Martin, 1995). The core of these studies lies in understanding indigenous knowledge about plants, their cultural interactions, and the incorporation of plant resources into local traditions and religions (Balick and Cox, 1996).

Methodologically, ethnobotanical studies employ diverse inquiry techniques contingent on their objectives. These techniques include participant observation, direct field observations, group discussions, questionnaires, and market surveys (Martin, 1995; Alexiades, 1996). Additionally, delving into ethnobotanical information involves collecting and investigating local songs, oral knowledge transmission, local names, and folk dances (Zemede, 1997). In essence, ethnobotanical studies serve as a bridge between traditional ecological knowledge and modern scientific inquiry, offering invaluable insights into the dynamic relationships between communities and the plant resources that shape their cultures and livelihoods.

1.12. Scope of research

Among the ten protected areas in Mizoram, basic research has been conducted in Tawi Wildlife Sanctuary (Lallawmkimi, 2010), Phawngpui National Park (Malsawmsanga, 2011), Murlen National Park (Lalramnghinglova, 2011), Thorang Tlang Sanctuary (Lalbiaknunga, 2012) and Lengteng Sanctuary (Lalawmpuii, 2019). However, Ngengpui Wildlife Sanctuary has not undergone proper scientific investigation. Therefore, this research serves as the initial information report, contributing significantly to wildlife management. The study of tree diversity within the Ngengpui Wildlife Sanctuary area is valuable for identifying, conserving, and managing these trees. Additionally, it can provide

crucial insights into their uses, such as timber, fuelwood, fruits, fodder, and various traditional and medicinal values.

1.13 Objectives

The research work is focused on the following objectives:

- i) To assess and document the angiosperm flora of Ngengpui Wildlife Sanctuary (NWS) through field survey, collection, identification.
- ii) Updating the nomenclatures of all the plants occurring in the NWS.
- iii) To identify endemic and RET (rare, endangered and threatened) species found in NWS.
- iv) To document ethnobotanical knowledge of the plants collected from NWS.

CHAPTER 2

2. Review of Literature

The term "biodiversity" was initially introduced by wildlife scientist and conservationist Raymond F. Dasmann in a lay book advocating nature conservation. However, it took more than a decade for the term to gain widespread acceptance, becoming commonly used in science and environmental policy during the 1980s. Thomas Lovejoy's use of the term in the foreword to a pivotal book on conservation biology played a significant role in introducing "biodiversity" to the scientific community. Before the adoption of "biodiversity," the term "natural diversity" was prevalent in conservation science circles. The Nature Conservancy's Science program, led by Robert E. Jenkins, alongside Lovejoy and other prominent conservation scientists, advocated for the use of "biological diversity" in the early 1980s to encompass the goals of biological conservation. Conservation biology, as an organized discipline, emerged in the late 1980s, emphasizing the conservation of biodiversity linked to maintaining biological integrity.

The term "biodiversity" has seen a rapid rise in importance and influence since the publication of the first book on biodiversity. It has become a catch-all for various aspects of conservation, ranging from fine-scale concerns about single species to broader focuses on ecosystem processes. Defining biodiversity presents challenges due to its comprehensive nature, leading to debates about whether it encompasses "everything." The post-positivist perspective acknowledges the value-laden nature of biodiversity, with multiple theory-bound versions and ways to value it. This perspective emphasizes the importance of describing biodiversity in ways appropriate for specific purposes and decision-makers' values. While biodiversity is commonly defined in terms of genes, species, and ecosystems, Harper and Hawksworth propose the terms genetic, organismal, and ecological diversity. Another classification highlights three interdependent sets of attributes: compositional levels (identity and variety of elements) and structural levels (ecological and evolutionary processes). The multifaceted nature of biodiversity

reflects its importance in conservation and the ongoing challenges in defining and preserving it.

Forest structure encompasses components like density, diameter size, and size distribution attributes, exhibiting diverse and gradient-dependent patterns (Huang *et al.*, 2003). The density-diameter (d-d) distribution is frequently employed to portray the population structure of forests (Anon., 1978). Population structure in a forest can provide insights into the regeneration behavior of a species (Saxena *et al.*, 1984). Ndash *et al.* (2013) conducted an assessment of tree and shrub diversity and distribution in a disturbed plot in the Takamanda Rainforest. In a tropical foothill region of the Garhwal Himalaya, Kumar and Bhatt (2006) examined the floristic diversity, dominance, and abundance to frequency ratio of various plant categories. The study revealed a contagious distribution pattern for most species on the site. Similar contagious distribution patterns were observed in tree, shrub, and herb species in the Kumaun Himalaya (Kharkwal and Singh, 2010).

Species in a community may exhibit clumped, uniform, or random distribution. Contagious distribution is the most widespread and is often attributed to small but significant variations in the environment. Regular distribution, on the other hand, occurs due to intense competition between individuals (Odum, 1971). Regular distribution is more likely in areas with a high density of individuals within a uniform area (Kershaw, 1973). In natural forest stands, contagious distribution can reflect the impact of biotic interference such as grazing and lopping (Odum, 1971). Numerous studies have reported the preponderance of contagious distribution in plant communities (Greig-Smith, 1957; Kershaw, 1973; Singh and Yadav, 1974).

A study conducted in the moist temperate forest of Pithoragarh in the Kumaun Himalayas focused on the floristic composition and distribution patterns of different tree species with reference to density, IVI (Importance Value Index), diversity index, and structural characteristics (Bhatt and Bankoti, 2016). Altitude plays a crucial role in determining species composition and structure of plant communities worldwide and influences the development of conservation strategies

(Rezende *et al.*, 2015). Altitudinal variation and rainfall are key factors contributing to diversity in the floristic pattern (Arora, 1995). Changes in altitude are reflected in alterations in floristic composition and community structure (Sakya and Baina, 1998). Micro-environmental conditions, influenced by altitude and slope, have been suggested to impact species richness and dispersion behavior of tree species (Chandra *et al.*, 2010; Ellu and Obua, 2005).

2.1 Floristic diversity at the Global level

The term biodiversity was introduced about twenty years ago, although the concept's origins trace back further in time. Many researchers had made an early attempt to reference biological diversity in the context of inter-species variation in behavior and life history. Lovejoy (1980) and Wilson (1988) further contributed to the conceptualization of biodiversity. Norman Myers coined the term "biodiversity hotspot" to describe biogeographic regions characterized by exceptional levels of plant endemism and significant habitat loss (Myers, 1988).

Despite advancements in various scientific fields, the exploration and scientific description of different organisms, including plants, animals, and microorganisms, remain incomplete. The known number of described species on Earth is between 1.7 to 1.8 million, constituting less than 15% of the actual number. Hubbell and Foster (1983, 1992) conducted studies on plant diversity in Panama, while Hare *et al.* (1997) compared the structure and tree species composition in sub-tropical dry forests in the Dominican Republic and Puerto Rico. Trees play a vital role in tropical forest ecosystems, serving as robust indicators of changes and stressors at the landscape level (Kumar *et al.*, 2006). Anthropogenic disturbances influence the regional pattern of local tree diversity (Stapanian *et al.*, 1997).

Tropical forests cover 7% of the Earth's land surface but house more than half of the world's species. However, many tropical forests face anthropogenic pressure, necessitating management interventions for biodiversity, productivity, and sustainability. The IUCN Red List of Threatened Plants estimates around 270,000 known species of vascular plants, with at least 12.5% of them threatened with

extinction globally. These threatened species are spread across 200 countries, with 91% restricted to a single country, linking their extinction potential to national economic and social conditions (Walter and Gillet, 1998).

In the Amazon, the western portion of the tropical forest reports the highest tree species richness, with studies recording 283 and 307 species (Gentry, 1988; Valencia *et al.*, 1994). Tropical rainforests exhibit a range of tree species counts per hectare, varying from about 20 to a maximum of 223 (Proctor *et al.*, 1983; Whitmore, 1984). Various studies have explored the structure, composition, and tree species diversity in different forest plots, including the Sierra Maigualida region in Venezuelan Guayana (Zent and Zent, 2004), Mount Kinabalu in Borneo (Aiba and Kitanya, 1999), and the Changbai Mountains in northeastern China (Zhang *et al.*, 2015). Sobuj and Rahman (2011) conducted a study in Khadimnagor National Park, Bangladesh, recording 26 tree species from their study.

2.2 Floristic diversity at the National level

India is richly endowed with diverse forest resources, featuring a variety of flora and fauna across different ecosystems. The country's forest types range from Tropical Rain Forests in the north-eastern region, Western Ghats, and Andaman and Nicobar Islands, to Desert and Thorn Forests in Gujarat and Rajasthan. Mangrove forests are prevalent in West Bengal, Orissa, Andhra Pradesh, and the Andaman and Nicobar Islands, while Dry Alpine Forests are found in the Western Himalayas. India contributes to approximately 7% of the total mangrove forests globally.

Biodiversity in India is among the richest in the world, showcasing a natural variation in life that is mirrored in the land's demography. The human population in India has historically depended on biodiversity in various ways. However, the current excessive human population is exerting survival pressure on biodiversity. Studies conducted by Champion and Seth in 1968 analyzed the vegetation and forest types of India. The country is home to over 1,15,000 identified and described species of plants and animals. Out of the 45,000 species of

flora, 15,000 are flowering plants, with 33% being endemic and concentrated in 26 endemism centers (Singh *et al.*, 2002).

Altitudinal gradients have been studied in different regions, such as the Khajjiar Wildlife Sanctuary in Chamba district, Himachal Pradesh (Verma and Kapoor, 2016), Kinnaur District in Himachal Pradesh (Singh *et al.*, 2016), Kumaun in Uttarakhand (Mathur and Joshi, 2015), the Great Himalayan National Park (GHNP) in Himachal Pradesh (Singh *et al.*, 2015), and the Shimla Water Catchment Sanctuary in Himachal Pradesh (Rana and Kapoor, 2015). Plants play a crucial role in ecosystems, forming the basis of food directly or indirectly for the fauna. A total of 417 species from 89 families were recorded from the Tiruchirapalli forest in Tamil Nadu (Kumaraguru *et al.*, 2016). As of the 14th assessment by the Forest Survey of India, the total forest cover in the country is 701,673 sq. km, constituting 21.34% of the geographical area. Madhya Pradesh has the largest forest cover (77,462 sq. km) in the country, followed by Arunachal Pradesh (67,248 sq. km). Mizoram has the highest percentage of forest cover at 88.93%, followed by Lakshadweep at 84.56%. The overall change in forest cover in compared to the previous assessment in 2013 results in an increase of 3,775 sq. km (Anon., 2015).

India boasts more than 1,700 tree species with various sizes, crown shapes, and forms. The vegetation classification initiated by H. G. Champion in 1936 was later modified by G. S. Puri and co-workers in 1990 (Puri *et al.*, 1990). The most widely accepted classification to date is Champion and Seth's classification of the forest types of India from 1968. Studies on tree species richness, composition, and diversity of riparian forests across forest and agro-ecosystem landscapes along the Cauvery River in southern India have been conducted by Sunil *et al.* (2016). Disturbed evergreen forests exhibit lower diversity compared to less disturbed forests, with variations in the class structure in the more and less disturbed forests (Murthy *et al.*, 2016). Studies were also conducted by Ravindranath *et al.* (2006) and Chaturvedi *et al.* (2011) in this region. Research on the impact of climate change on floral and faunal diversity was conducted by Kumar *et al.* (2015) in Punjab. Illegal cutting, lopping of dominant species, grazing of understory plant

species, loss of ecological sites, habitat fragmentation, and thinning of population are responsible for spatial and temporal variations in species diversity at local and regional scales (Swamy *et al.*, 2000).

2.3 Floristic diversity at North-Eastern level

The North-Eastern Region of India, consisting of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura, is renowned for its rich forest resources. The ecosystem of the regions includes tropical wet evergreen, moist deciduous sub-alpine, and alpine forests, along with freshwater lakes, rivers, swamps, marshy wetlands, and sacred groves in Meghalaya and Manipur. The ecosystem in the North-Eastern Region varies widely, encompassing tropical wet evergreen forests, moist deciduous sub-alpine and alpine forests, grasslands, as well as swamps and marshy wetlands. Sacred groves are also present, notably reported in Meghalaya and Manipur. Shifting cultivation is a prevalent land-use practice in the hilly parts of most states in this region and is deeply intertwined with the socio-cultural life of tribal communities. Previous studies have emphasized the richness of plant diversity in the sacred forests of Northeast India, especially when subject to mild disturbances (Mishra *et al.*, 2004).

Northeast India is recognized as a treasure house of plant resources, with varied physiographic and climatic conditions resulting in a wide range of vegetation from tropical to alpine. Despite covering only 7.98% of the country's geographical area, it holds nearly a fourth of the nation's forest cover. The region is home to two globally recognized biodiversity hotspots which are Indo-Burma hotspot and Eastern Himalayas. The eco-region is known its diverse species diversity and high levels of endemism which is largely due to its diverse biogeographic origins and its unique position at the junction of two continental plates (Roy *et al.*, 2012). Also the vast topography of the region characterized by complex and steep terrain further contributes to the climatic diversity creating diverse habitats that support a wide range of biodiversity as it was reported to support 50% of the total recorded flowering plants of India with 31.58% endemic species to the region (Rao and Hajra, 1986; Saikia *et al.*, 2016). However, this rich biodiversity is under severe

threat due to habitat destruction (Agarwal, 2002). The region is also recognized as one of the main centres of origin for cultivated plants with more than 50 crop plants and approximately 190 wild relatives of tropical and subtropical fruits, cereals and rice (Vavilov, 1926; Hore, 2005). Key crop plants that originated in this zone include citrus, banana and plantain, mango, rice, and various species of legumes, cucurbits, orchids, bamboos, and medicinal and aromatic plants (Anon., 2009). The region is considered the "cradle of ancient angiosperms" by Takhtajan (1969) due to the abundance of primitive and ancient flowering plants.

Studies on the forest ecosystem of North East India have been conducted by various researchers such as Rao and Verma (1982), Rao *et al.* (1990), Mishra and Jeeva (2008), and Reddy (2011). Tree diversity and population structure in the Eastern Himalaya were explored by Deb *et al.* (1987), and vegetation, soil, and microbial biomass were analyzed in Northeast India by Deb *et al.* (1987). Barik *et al.* (1992) studied species diversity in the sub-tropical forests of Meghalaya. The current forest cover in the North-Eastern region is 171,964 sq. km, constituting 65.59% of its geographical area, in contrast to the national forest cover of 21.34%. Different forest types, including very dense, moderately dense, and open forests, make up 14.81%, 43.85%, and 41.34%, respectively. The recent assessment indicates a decrease in forest cover by 628 sq. km due to biotic pressure and shifting cultivation. The floristic diversity of *Dipterocarpus tuberculatus* dominated forests in Manipur along the Indo-Myanmar border was studied by Devi and Yadava (2006), recording 123 species belonging to 48 families.

2.4 Floristic diversity at the Local level

Mizoram, covering a geographical area of 21,081 sq. km, is characterized by a substantial forest cover, accounting for 88.93% of the state's total area. This forest cover includes 138 sq. km of very dense forest, 5,858 sq. km of moderately dense forest, and 12,752 sq. km of open forest (Anon., 2015). The state comprises 2 National Parks and 8 Wildlife Sanctuaries, collectively covering 5.88% of the total geographical area. However, the literature available suggests that the plant diversity of Mizoram is not extensively studied compared to other states in North-East India.

Initial plant collections in Mizoram were made by Col. A.T. Gage in 1899, recording 317 species, including 26 species of Cryptogams. Subsequent plant collections were carried out by various researchers such as Gage (1899), Kanjilal *et al.* (1934-1940), Parry (1932), Sawmliana (2003), Lalramnghinglova (1997 and 2003), Singh *et al.* (2002), and Lalnunmawia (2003).

Lalramnghinglova (1997) published a book titled "Handbook of Common Trees of Mizoram" and conducted studies on ethno-botanically important plants, publishing a book on "Ethno-Medicinal Plants of Mizoram" in 2003. Sawmliana (2003) recorded about 966 plant species from Mizoram. Additionally, bamboo and cane species were identified by Lalramnghinglova (1997), Lalnunmawia (2003), Lalnuntluanga (2007), and Lalramnghinglova and Lalhuanawma (2010). Regarding orchids, Singh *et al.* (1990) recorded 244 species under 74 genera from the state. Orchid species were recorded by Zote *et al.* (2009), identifying 202 orchid species in Mizoram, while Vanchhawng (2016) documented 52 species of Zingiberaceae.

Studies on some plant species, including sedges and grasses, were conducted by Rao and Verma (1982). Parry (1932) made collections between 1924 and 1929 from Lunglei district, and Fischer (1938) published "The Flora of the Lushai Hills," recording 1360 species. Notably, protected areas in Mizoram have been subject to studies on plant diversity conducted by researchers like Lallawmkimi (2010), Malsawmsanga (2011), Lalbiaknunga (2012), Lalramnghinglova (2011) and Lalawmpuii (2019).

2.5 Endemic and RET Species: A Global, National, and Regional Perspective

Biodiversity conservation is a global imperative, and understanding the patterns and threats to both endemic and Rare, Endangered, and Threatened (RET) species is paramount for effective conservation strategies. At the global level, numerous studies highlight the importance of preserving endemic species for maintaining overall biodiversity. Myers *et al.* (2000) stress that a substantial percentage of Earth's biodiversity is concentrated in regions with high levels of

endemism. Conservation initiatives at the global level often emphasize the establishment of protected areas, transboundary cooperation, and sustainable development practices to address the threats faced by these unique species. The conservation of RET species has been a focal point for international organizations. The IUCN Red List, a global database assessing the conservation status of species, provides a comprehensive framework for evaluating and categorizing species based on their risk of extinction. Brooks *et al.* (2002) emphasize the role of habitat loss and extinction risk in hotspot regions, urging coordinated global efforts to mitigate these threats.

India, with its diverse ecosystems, hosts a myriad of endemic species. A study by Krishnaswamy *et al.* (2009) emphasizes the need for comprehensive conservation planning, considering both charismatic and less conspicuous endemic species. It underscores the role of protected areas and corridors in sustaining viable populations. India's commitment to conserving RET species is reflected in the Wildlife (Protection) Act. Jhala *et al.* (2008) highlights the challenges faced by flagship species like the Bengal tiger, addressing issues of habitat loss, poaching, and human-wildlife conflict. The study advocates for integrated conservation approaches involving local communities and policymakers.

The Northeastern region of India is recognized under two global biodiversity hotspot. Bhagwat *et al.* (2008) discuss the significance of endemic plant species in the Eastern Himalaya, emphasizing the need for conservation strategies that consider both ecological and cultural dimensions. In the context of RET species, a study by Lyngdoh *et al.* (2019) in Nagaland emphasizes the importance of community-based conservation. It explores the conservation potential of community reserves, acknowledging the role of indigenous knowledge and community engagement in protecting endangered species.

Mizoram, a state in Northeast India, is home to unique flora and fauna. Lalramnghinglova (2017) explores the endemic orchids of Mizoram, shedding light on their distribution and ecological preferences. The study emphasizes the need for targeted conservation efforts to safeguard these species. The conservation status of

RET species in Mizoram is addressed by Lalthanzara *et al.* (2014), focusing on the Mizoram State Action Plan for Climate Change. The study discusses the challenges posed by climate change and suggests adaptation strategies for preserving biodiversity, particularly for RET species. Some of the RET plants reported from Mizoram include *Begonia lushaiensis* C.E.C.Fisch., *Coelogyne trinervis* Lindl., *Globba wengeri* (C.E.C.Fisch.) K.J.Williams, *Globba spathulata* Roxb., *Renanthera imschootiana* Rolfe, *Paphiopedilum villosum* (Lindl.) Stein etc.

2.6 Ethnobotanical Knowledge

Indigenous knowledge holds a pivotal role in the conservation of resources, particularly with respect to indigenous plant species essential for indigenous communities (Hart 2000; Leonti 2022; Kayani *et al.* 2015). Throughout history, indigenous communities worldwide have been harvesting ethnomedicinal plants from various parts of the world, and this knowledge is passed down from generation to generation (Balick and Cox 2020; Dhillon *et al.* 2002). Preserving this knowledge is crucial, particularly in countries facing significant threats to biodiversity due to urban development, migrations, deforestation, and natural calamities. India, grappling with these challenges, witnesses a decline in indigenous knowledge, especially in regions like Northeastern India, a mega biodiversity hotspot rich in endemic flora (Mao *et al.* 2000; Barbhuiya *et al.* 2022). This region is home to approximately 1,350 medicinal plants of high economic importance used in various ethnomedicinal preparations (Dutta and Dutta 2005).

In addition to its luxuriant floristic diversity, Northeastern India boasts a rich and diverse culture, with traditional knowledge systems among 145 tribal communities (Ali & Das 2003). However, this ecological hotspot faces the threat of losing indigenous knowledge due to modern lifestyle changes and diminishing traditional practices. Assam, a significant state in Northeastern India, is part of the Indo-Burma Biodiversity Hotspot, and the Assamese community inhabiting this region heavily relies on medicinal plants for traditional healthcare practices. The district of Dibrugarh in Assam, known for being the largest tea-producing zone in India, has a long history of utilizing medicinal plants within the Assamese

community for traditional healthcare. However, factors such as modern lifestyle preferences and improved medical facilities contribute to a decline in the utilization of these plants. To counteract this decline, proper documentation and assessment of traditional knowledge are essential (Teklehaymanot, 2010). The conversion of forests and arable land into tea gardens poses a risk of losing valuable medicinal plants from their natural habitat. Consequently, the implementation of effective conservation strategies becomes imperative for preserving the floristic wealth of this region. Proper documentation and preservation of ethnomedicinal knowledge are urgently needed to prevent its loss and replacement by modern medical facilities.

Research has been conducted on various aspects of the flora in Mizoram, including studies on wild edible fruits and vegetables (Lalfakzuala *et al.*, 2007) and the edible plants native to the region (Lalramnghinglova, 2002). Additionally, investigations have focused on the ethno-medicinal uses of wild edible fruits among the Mizo tribes (Hazarika *et al.*, 2012), as well as ethnobotanical and agro-ecological surveys concerning the genetic resources of food plants in Mizoram (Lalramnghinglova, 1999). In Mizoram, traditional therapeutic knowledge is at risk due to inadequate documentation and waning interest among the younger generation. Therefore, it is crucial to implement policies that enhance the preservation, development, and sustainable use of medicinal plants and their traditional knowledge among the local people. Further studies and documentation of traditional therapeutic knowledge are essential at this juncture. Additionally, to improve the effectiveness of traditional medicines used by the local people, advanced technology and pharmacological methods, such as innovative extraction techniques like semi-bionic extraction, microwave-assisted extraction, ultrasonic-assisted extraction, and enzyme-assisted extraction, along with sophisticated methodologies and instrumentation like HPLC-MS, LC-MS, and GC-MS, enable the re-evaluation of traditional knowledge, identification of chemical components in plant extracts, discovery of active compounds, and development of novel drugs (Ralte and Singh, 2024).

While some studies on ethnomedicinal plants have been conducted on specific parts of Mizoram, India, there is a notable gap in understanding the traditional practices of the indigenous community residing around Ngengpui

Wildlife sanctuary (NWS). Furthermore, the neglect of indigenous knowledge due to the availability of modern lifestyle and medical facilities results in the rapid decline of traditional household practices in the region.

CHAPTER 3

3. STUDY AREA

3.1 A brief information about Mizoram

Mizoram, known as the "land of the hill people," is situated within the Indo–Burma biodiversity hotspot at the far end of the Himalayan Mountain range. Approximately 91% of the area is covered by forests. It is located between 92°15' and 93°26'E longitude and 21°58' and 24°35'N latitude, with an altitudinal range of 2,100 – 2,157 m above sea level. The climate is classified as moist tropical to sub-tropical, with temperatures ranging between 20°C and 30°C during summer and 7°C to 18°C in winter. The region experiences an annual rainfall ranging from 2,000 mm to 3,200 mm. The landscape is characterized by hills covered with sparse to dense forests. Mizoram shares international borders with Myanmar in the East and South (approximately 404 km) and Bangladesh in the West (approximately 306 km). It is bordered to the North by Cachar District of Assam, to the East and South-East by Myanmar, and to the West by the Chittagong Hill Tracts of Bangladesh.

The state is divided into eleven districts: Aizawl, Champhai, Kolasib, Lawngtlai, Lunglei, Mamit, Saiha, Serchhip, Khawzawl, Saitual and Hnahthial. Lunglei District is the largest, covering 4,536 sq. km, while Kolasib District is the smallest, with an area of 1,382 sq. km. Aizawl, the capital city, has an area of 3,575 sq. km. There are also Autonomous District Councils within Saiha and Lawngtlai Districts, each with its own jurisdiction. As of the 2011 census, Mizoram's total population is 1,091,014, with 552,339 males and 538,675 females. The literacy rate stands at 91.58%, with agriculture serving as the primary occupation among the population.

According to the State Forest Report, Mizoram's total geographical area is 21,081 sq. km, with 88.93% of it under forest cover. This forest cover includes 138 sq. km of very dense forest, 5,858 sq. km of moderately dense forest, and 12,752 sq. km of open forest. There has been a reduction of 306 sq. km of forest cover

compared to the State Forest Report of 2013, attributed to shifting cultivation and other biotic pressures on forest lands (Anon., 2015).

(a) Physiography

The physiography of Mizoram comprises hills and valleys. The hills are categorized into high hills (average altitude above 1300 m above mean sea level), medium hills (altitudes ranging between 500 m and 1300 m), and low hills (altitudes below 500 m). The hills run parallel to each other in the north-south direction, with valleys between them. The western part of the state is characterized by dissected hills and hillocks in most river valleys.

(b) Geology

The geology of Mizoram is characterized by repetitive sediments forming longitudinal plugging anticlines and synclines, trending approximately NNW-SSE. Two prominent geological groups, Surma and Barail, are distinguished. The Surma group in the western part exhibits ridge and valley features with a trellis drainage pattern. The Barail group in the eastern part shows a dendritic drainage pattern and denuded hills oriented differently. In the northeastern corner along the border with Myanmar, north-linear trends and sub-parallel mountain ranges with valley topography are observed due to the alteration of hard stone and soft shale beds under the Barail group.

(c) Drainage

Mizoram is drained by numerous rivers, streams, and rivulets with various patterns and lengths. Most drainage lines originate in the central part of the state and flow north or south, directed by north-south trending ridges. Valleys are narrow, carved out in softer formations, and rivers often form deep gorges, cutting across ridges to create water gaps. The drainage patterns include trellis, dendritic, and parallel patterns.

The northern part is drained by large rivers like Tlawng, Tuivawl, Tuirial, Langkaih, and Tuivai, eventually flowing into the Tuiruang River in Cachar plains

of Assam. The southern part is drained by prominent rivers like Chhimtuipui (Koladyne) with its tributaries - Mat, Tuichang, Tiau, and Tuipui, along with the Khawthlangtuipui river draining the southwestern part, eventually flowing into Bangladesh. Mizoram has a total of 25 watersheds.

(d) Climate

Mizoram experiences a moderate climate due to its tropical location, influenced by the southwest monsoon. The region receives ample rainfall, and the climate is humid tropical. The temperature is highest during May, June, and July, with monsoon onset bringing a decline. Winters are minimized in December and January, with temperatures between 11°C to 23°C. Autumn temperatures range between 18°C to 25°C, while summer temperatures range from 21°C to 31°C. Rainfall is heaviest from May to September, with an average of 250 cm per annum, increasing southward.

(e) Soil

Mizoram's soils are mainly composed of loose sedimentary formations, young, immature, and sandy. Red, loamy textured soils with high laterite content are prevalent. Soil acidity is high, with low potash and phosphorus, but nitrogen content is high in uneroded soils due to organic matter accumulation. Valleys have heavier soils brought down by rainwater from high altitudes. The soils can be classified into three orders: Entisols, Inceptisols, and Ultisols.

(f) Vegetation/Forest:

The forests of Mizoram are broadly classified into three categories based on the classification of Champion (1936) and Champion and Seth (1968):

- i) Tropical Wet Evergreen Forest: Abundant in the western and northwestern parts of the state, characterized by tall evergreen trees like *Dipterocarpus turbinatus* C.F. Gaertn., *Terminalia myriocarpa* Van Heurck & Mull. Arg., *Mangifera indica* L., and bamboo species.

- ii) Tropical Semi-Evergreen Forest: Found in the central part, featuring deciduous and evergreen species like *Artocarpus chama* Buch.-Ham., *Schima wallichii* (DC.) Korth., *Bombax insigne* Wall., and various bamboo species.
- iii) Montane Sub-tropical Pine Forest: Located in higher elevations, dominated by *Rhododendron* sp., *Lithocarpus dealbatus* (Hook.f. & Thomson ex Miq.) Rehder, *Prunus cerasoides* Buch.-Ham. ex D.Don, *Pinus kesiya* Royale, and other species. Mizoram's rich vegetation is influenced by its diverse physiography and climatic conditions.

3.2 The People and Culture

Mizoram is a state of northeast India known for its vibrant culture, rich traditions and warm hospitality of its people. The predominant ethnic group of the state is the Mizo people which belong to the larger Kuki-Chin-Mizo group of Tibeto-Burman origin. According to historical accounts, the Mizos originally migrated from the east with their ancestral homeland situated in the Mekong Valley. During the migration westward from the Chindwin region around 1466 A.D., the Mizos were without a central chief which however with each family group settled in separate villages. These subtribes which together are known as Mizos included Lusei (Lushai), Ralte, Chawngthu, Khiangte, Hauhnar, Chuange, Chhunathang, Ngente, Punte and Parte settled to the present day Mizoram between 1700 to 1730 A.D. Apart from the Mizo community, the state is also home to ethnic groups that include Chakma, Lai, Maras, Brus, Bawm, Zakhai, Khumi, Pang, Mara, Paihte, Chakma, and Matu tribes.

The Mizo language also known as Lushai which belongs to the Tibeto-Burman family in languages is the official language in Mizoram. However, some other dialects that include Chakma, Brus and Hmar are generally spoken by different ethnic communities.

The major religion in the state is Christianity as majority of Mizos are Christians. There are small communities practicing Buddhism, Hinduism and traditional animistic beliefs.

Important festivals in the state are generally associated with Jhum cultivation and harvesting of the crops by different ethnic communities which include the Chapchar Kut, Pawl Kut, Khuado Kut, Hlukhla Kut, Mim Kut, Lyuva Khutla, Anthurium festival and Christmas.

The indigenous communities of Mizoram have a number of dances which are accompanied with few musical instruments like gong and drum and include Khuallam, Cheraw, Sarlamkai/Solakia, Chailam, Chawnglaizawn, Chheihlam, Tlanglam and Zangtalam. Puandum is an indispensable traditional cloth which every girl has to take when she gets married and is used when her husband dies to cover the dead body. Puan is a traditional attire of Mizo women which is handwoven wrap around skirt adorned with intricate designs and patterns.

The staple food of Mizoram is rice which is accompanied with popular Mizo dishes typically include the ‘Mizo Bai’ which is prepared by mixing the seasonal vegetables combined with ‘saum’ (fermented pork fat), and ‘tlak’ or ‘mung’ which are simply boiled forms without salt.

The state has undergone substantial modernization in recent years which is marked by advancements in infrastructure, healthcare and telecommunications. However the state grapples with issues in connectivity, major infrastructure development and sustainable economic growth. In addition to that, the efforts to preserve and promote Mizo culture and tradition is a major challenge amidst the pressure of modern influences.

3.3 Ngengpui Wildlife Sanctuary

Ngengpui Wildlife Sanctuary (NWS) is a protected area under Lawngtlai district, Mizoram which is located in one of the world’s most important biodiversity hotspot and is sandwiched between the international boundaries of Bangladesh and

Myanmar. The annual rainfall recorded in the district ranged from 1411 to 2421 mm (Department of Agriculture) during our research period from 2018 to 2023(**Figure 3.1**). This substantial rainfall supports the lush green vegetation, characteristic of the sub-tropical evergreen and sub-tropical semi-evergreen forests, which harbor a wide variety of lifeforms. It is situated at a distance of 296 km from Aizawl, the capital city of Mizoram and lies between 22°21'18" - 22°30'01"N latitude and 91°44'30" - 92°50'37"E longitude covering a geographical area of 110 sq km (Verma *et al.*, 2013). NWS is surrounded by six villages, Hmunnuam (HN), Ngengpui (NP), Khawmawi(KM), Diltlang South (DT), Bungtlang South (BS), and Saizawh East (SE) (**Figure 3.2**). The fringe villages are home to different ethnic communities which comprises of eleven with the major tribes represented by Lushai, Lai, Bru and Bawm tribes, and minor by Zakhai, Khumi, Pang, Mara, Paihte, Chakma, and Matu tribes.

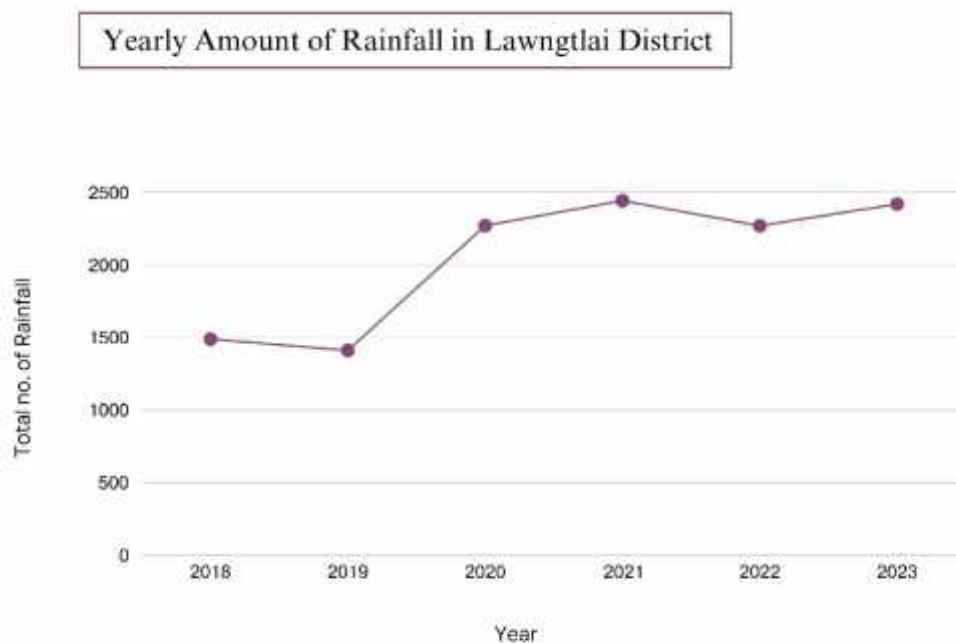


Fig 3.1: Annual rainfall recorded from 2018-2024 within Lawngtlai District

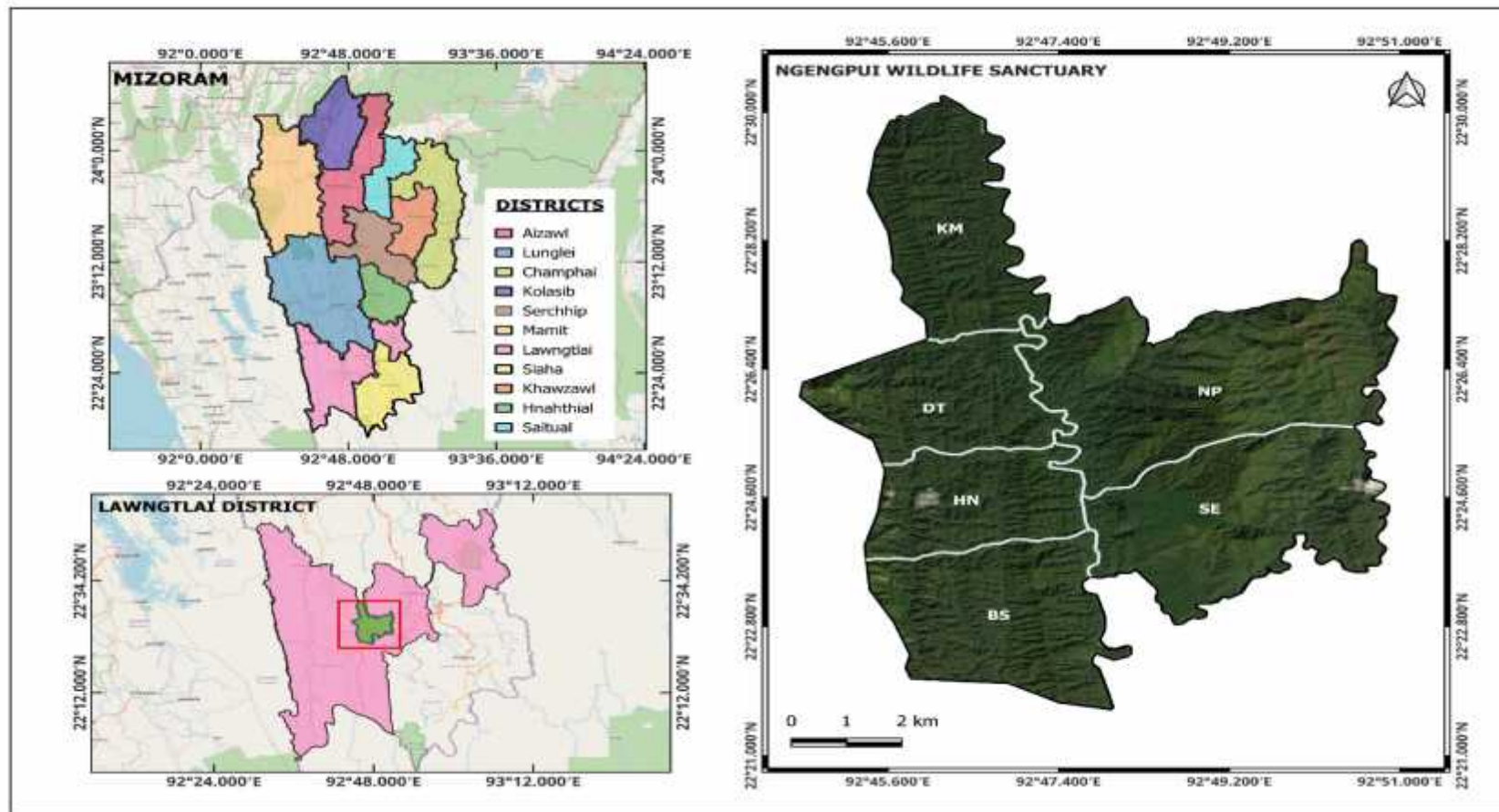


Figure 3.2:Geographical map showing (a) Mizoram (b) Lawngtlai District of Mizoram (c) Ngengpui Wildlife Sanctuary (NWS) with study sites: KM = Khawmawi; DT = Diltlang; HN = Hmunnuam; BS = Bungtlang South; SE = Saizawh East and NP = Ngengpui.

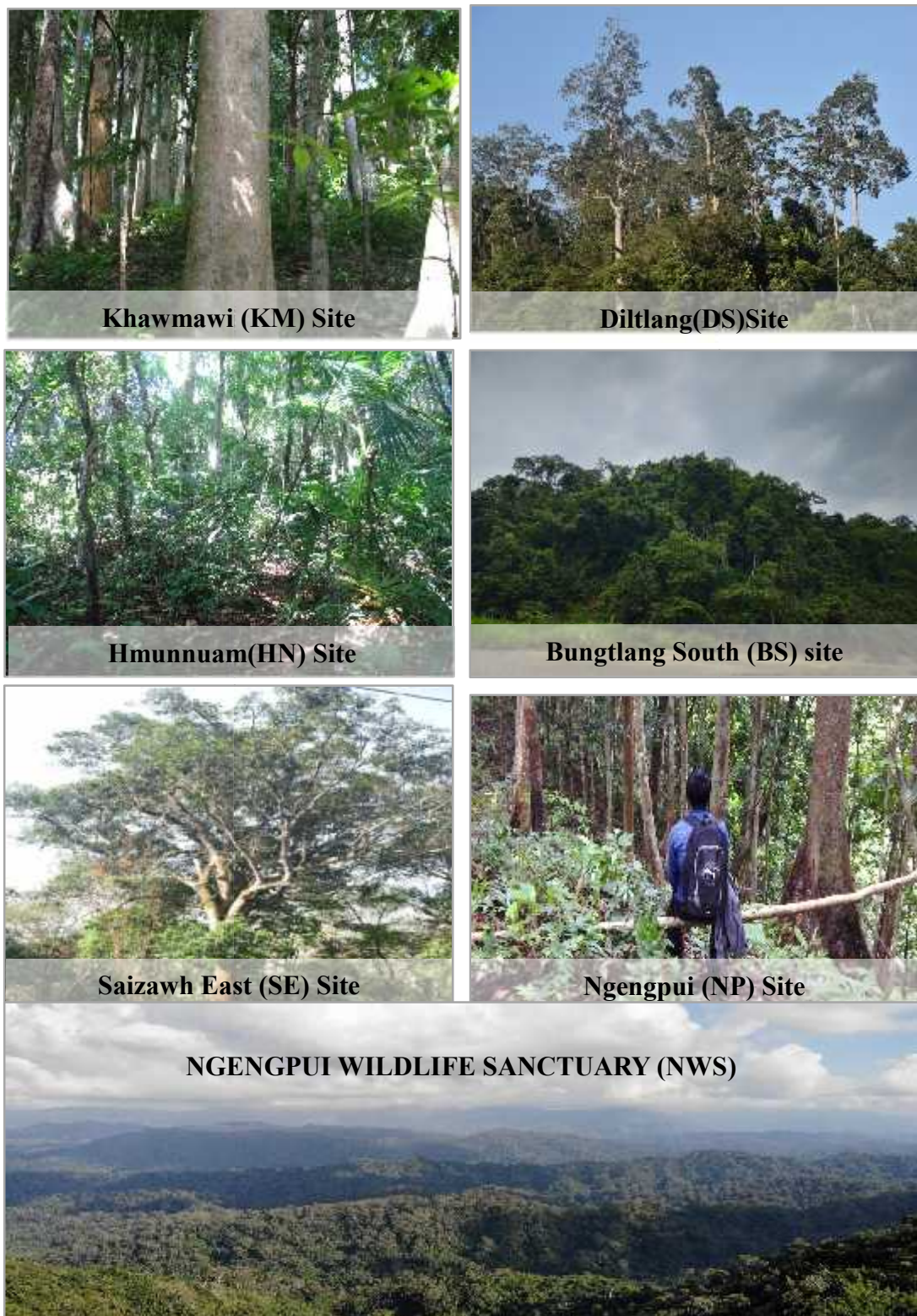


Figure 3.3. Photos showing different sites selected for the study of the research within NWS.

CHAPTER 4

4. Methodology

4.1 Sampling design, data collection

The study was carried out during the year 2018-2022 and encompasses all seasons. The forest vegetation was analyzed for trees, herbs, shrubs, epiphytes, climbers, grasses, canes and palms. Quantitative analysis was done by using stratified random sampling method following Muller-Dombois and Ellenberg (1974) by placing 250 quadrats of 10m × 10m (each 0.01ha) covering an area of 2.5ha along the nearby six villages viz, Khawmawi, Diltlang, Hmunnuam, Bungtlang south, Ngengpui and Saizawh east. Individual tree species with girth ≥ 10 cm at breast height *i.e.*, 1.3m above the ground were recorded for estimating basal area ($\text{m}^2 \text{ha}^{-1}$), density (ha^{-1}) and girth class distribution. Importance Value Index (IVI) were calculated for trees and herbs. For Phyto-sociological aspects of shrubs and herbs, random sampling was used for taking 3m × 3m size quadrats for shrub and 1m × 1m size quadrats for the herbs. All the species were identified by studying regional floras and relevant literatures (Singh *et al.*, 2002; Sinha *et al.*, 2012; Sawmliana, 2013) and assessing the herbaria in Mizoram University (MZUH), Botanical Survey of India, Shillong (ASSAM) and Botanical Survey of India, Kolkata (CAL). Voucher specimens of all the tree species were prepared following standard herbarium methods (Jain and Rao, 1977).

4.2 Quantitative Analysis

Every forest community exhibits unique traits such as species diversity, growth patterns, structure, dominance, and successional trajectory. Analyzing these aspects involves considering various parameters to understand the community's characteristics. Quantitative parameters, expressed typically on a 5-point scale, play a vital role in this analysis. These parameters include frequency, density, and abundance, among others. Quantitative data on species density, frequency, and

abundance were collected for all the study sites, utilizing the methodology described by Curtis and McIntosh (1950).

(a) Density: Density represents the numerical abundance of a species, obtained by dividing the total number of individuals for each species across all quadrats by the overall number of quadrats examined. The calculation is determined by the following equation.

$$\text{Density} = \frac{\text{Total number of individuals of species in all quadrats}}{\text{Total number of quadrats studied}} \times 100$$

(b) Frequency: This pertains to the extent of spread of individual species within a given area, expressed as a percentage. The investigation involved randomly sampling various locations within the study area and documenting the species present in each sampled unit or quadrat. The calculation is performed using the following formula.

$$\text{Frequency(\%)} = \frac{\text{Number of quadrats in which the species occurred}}{\text{Total number of quadrats studied}} \times 100$$

(c) Abundance: Abundance involves assessing the quantity of individuals across various species, achieved by summing up the number of individuals for each species across all quadrats and then dividing that sum by the total number of quadrats where the species was observed. The representation is given by the following equations:

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats in which the species occurred}} \times 100$$

4.3 Importance Value Index (IVI)

The determination of species dominance involved the consideration of all recorded tree species. To quantify the dominance and ecological success of a particular species using a single value, the Importance Value Index concept was employed. This index incorporated three key parameters: relative frequency, relative density, and relative dominance, as outlined by Misra (1968). The Importance Value Index is defined as 'the sum of the relative dominance, relative density, and relative frequency of a species,' as specified by Mueller-Dombois and Ellenberg in 1974.

(a) Relative Density (%): This involves assessing the numerical strength of a species relative to the total number of individuals across all species. The calculation

$$\text{Relative Density (\%)} = \frac{\text{Density of a species}}{\text{Total no. of density of all species}} \times 100$$

for relative density is determined as follows:

(b) Relative Frequency (%): This measures the dispersion of individual species within an area relative to the total number of occurrences of all species. The calculation for relative frequency is expressed as follows:

(c) Relative Dominance (%): The determination of a species' dominance relies on

$$\text{Relative Frequency (\%)} = \frac{\text{Frequency of a species}}{\text{Total no. of all species}} \times 100$$

the basal cover value. Relative dominance represents the coverage value of a species in relation to the total coverage of all other species in the area. The calculation for relative dominance is performed using the following formula:

$$\text{Relative Dominance (\%)} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all species}} \times 100$$

$$\text{Basal area} = \pi r^2 D$$

Where,

r = radius

D = Density

The IVI was computed for the trees and herbs and shrubs from the study site by using the formula given by Phillips (1959) as follows:

$$\text{IVI (Trees)} = \text{Relative Frequency} + \text{Relative Density} + \text{Relative Dominance}$$

$$\text{IVI (Herbs \& Shrubs)} = \text{Relative Frequency} + \text{Relative Density} + \text{Relative Abundance}$$

4.4 Species diversity indices

The exploration of species diversity within NWS was conducted utilizing the following diversity indices:

a) Shannon-Wiener (Shannon-Wiener, 1963) Diversity Index (H'): The Shannon-Wiener diversity index is a widely employed metric for assessing species diversity. This index amalgamates two measurable aspects: (1) species richness, indicating the number of species in the community, and (2) species equitability, reflecting the evenness of individual numbers among species. A higher index value corresponds to greater species diversity. The calculation for the Shannon-Wiener diversity index is determined using the formula:

$$H' = -\sum (n_i/N) \ln(n_i/N)$$

Where, N = total abundance

n_i = abundance of the i^{th} species

b) Margalef's Diversity Index (DMg): Introduced by Clifford and Stephenson in 1975 (Clifford and Stephenson, 1975), Margalef's Diversity Index (DMg) is expressed by the following equation:

$$DMg = (S-1)/\ln N$$

Where, S = number of species recorded

N = total number of individuals

$\ln$ = natural logarithm

c) Simpson (Simpson, 1949) Index of Dominance (D): The Simpson Index serves as a dominance metric by assigning greater weight to common or dominant species, thereby mitigating the impact of a few rare species with only a few representatives on the overall diversity. The calculation for the Simpson Index of Dominance (D) is performed using the following formula:

$$D = \sum n_i(n_i-1)/N(N-1)$$

Where, n_i = no. of individuals of the i^{th} species

N = total no. of individuals

d) Evenness Index (Pielou's index, 1969)

The equation is as follows:

$$J' = H'/H_{\max} \text{ or } J' = H'/\ln S$$

Where, H' = Shannon's index value

S = Total Number of species

$H_{\max}$ = Maximum diversity

4.5 Stand structural parameters

Calculations of four important stand structural parameters include: the median DBH, stem density (ha^{-1}), basal area ($\text{m}^2 \text{ ha}^{-1}$), and size class distribution of forest trees. Because variables did not always have a Gaussian distribution, we mainly employed the median as a measure of central tendency.

4.6 Herbarium Methodology

A herbarium functions as a repository for plant specimens gathered from diverse locations, systematically arranged on sheets, and organized based on a recognized classification system.

(a) Plant Collection: The collection of plant specimens within the study area involved seasonal gathering of twigs from various plant species, accompanied by their flowers or fruits. For grasses, sedges, and other herbs, the entire plant, including underground parts, was collected. These specimens were meticulously prepared and preserved in a herbarium for subsequent identification, following the methodologies outlined by Jain and Rao (1977) and Womersey (1981). Additionally, the study was enriched through the capture of photographs for various species. This photographic documentation served the dual purpose of enhancing the overall study and providing a convenient means for species identification.

(b) Field notes and field numbers: The documentation of field notes plays a crucial role in plant collection efforts, and these notes are recorded in a specialized

field notebook. Specifically designed for labelling plants and recording on-site observations, these notebooks have pages that are specially printed, punched, and perforated. The pages are sequentially numbered, each featuring six detachable tags or tickets with corresponding numbers. These tags, tied to specimens using provided thread through punched holes, serve as duplicates for the same species.

(c) Preservation of Plants Before Drying: The collected specimens are spread on regular old newspapers and bundled together. Each bundle is encased in a large polythene bag. A 30% paraformaldehyde solution is prepared by dissolving 300g of paraformaldehyde in 3000ml of lukewarm water. This solution is poured over the bundles, thoroughly soaking them. The bags are then securely tied to create an airtight seal. Upon arrival at the laboratory, the bundles are opened, allowing the specimens to be exposed to the air to dissipate any excess paraformaldehyde fumes. This meticulous preservation process ensures the integrity of the plant specimens for further study and analysis.

(d) Pressing and Drying Plant Specimens: Plant specimens are pressed flat, typically not exceeding 11 x 16 inches. If necessary, specimens larger than these dimensions are either folded or cut into sections. Larger fruits or bulbs are often sliced or halved before pressing. Each specimen includes a stem with attached leaves, flowers, or fruits, and herbaceous plant roots are also included. Careful arrangement in the press maximizes the preservation of diagnostic features, with leaves, flowers, and fruits spread out to prevent overlap and enable observation from various angles.

The collection number is clearly written on the outside of the newspaper containing each plant specimen. Keeping the plant press tight prevents shrinkage and wrinkling, producing specimens that can be securely mounted on herbarium paper. Thorough drying is essential before storage and mounting. The plant press is maintained in an oven with steady bottom heat between 95°F and 113°F, ensuring low ambient humidity and adequate airflow for rapid and thorough drying. As specimens dry, straps on the press are further tightened to minimize shrinkage and wrinkling.

(d) Fumigation: To safeguard against insect damage, Naphthalene balls are used as a repellent, strategically placed in the boxes containing mounted specimens approximately every three months. This comprehensive approach ensures the preservation and protection of plant specimens in the herbarium collection.

(e) Mounting and Stitching: Mounting is the essential process of attaching a dried, pressed plant along with its label to a sturdy sheet of heavy paper. Mounting sheets, made from durable white card measuring 28 x 42 cm (± 1 cm), are utilized. Before attachment, the specimen and its label are carefully arranged on the sheet to allow optimal observation of diagnostic features, emphasizing reproductive structures and the range of variation in vegetative components, including both sides of the leaves.

Once the specimen has been pressed, dried, and treated, fevicol (adhesive) is applied to the underside of the plant. The specimen, along with its collection number, is then affixed to the mounting sheet. These sheets, with specimens adhered using fevicol, are placed in a press for one day to ensure proper sticking and drying. In cases where items are large or bulky, they are securely sewn onto the sheet with a sturdy thread. The objective is to firmly secure the specimen to the mounting paper while allowing certain plant parts to remain loose for potential removal if needed.

(f) Labelling: Labelling is a crucial step in completing a plant specimen, providing essential field data that must be accurate. Following the mounting of specimens on herbarium sheets, each sheet is appropriately labelled, with the label affixed to the lower right-hand corner. Herbarium labels play a vital role in the completeness of the specimen, and the standard label size is 4" x 2.5".

The labels typically include the following data: (i) Collection Number and Date, (ii) Name of the Family, (iii) Name of the Genus and Species, (iv) Locality of Collection, (v) Phenology, (vi) Distribution, (vii) Notes and (viii) Collector's Name and Number.

4.7 Identification of endemic and RET species within NWS

A preliminary list of known endemic species within the study area was compiled through literature review and expert consultations. Endemic species were further validated through field surveys, focusing on species with restricted geographical ranges and unique ecological niches. Morphological, and behavioural analyses were conducted to confirm the distinctiveness of endemic species.

Species classified as Rare, Endangered, or Threatened were identified through review of the IUCN Red List and national conservation status assessments as well as based on IUCN Red List Categories and Criteria (2022). Population assessments, habitat evaluations, and threat analyses were conducted for threatened species within the study area, documenting their conservation status and associated threats. Legal protection status and existing conservation measures for threatened species were also documented, where applicable. The conservation status category was assessed following IUCN Standards and Petitions Subcommittee (2022) recommendations. The voucher specimens prepared (described in detail in section 4.8) were deposited at Mizoram University Herbarium (MZUH).

4.8 Ethnobotanical knowledge of NWS

4.8.1 Data Collection

Community representatives from the fringe villages of NWS were approached to secure Prior Informed Consent (PIC) for the collection of ethnobotanical data, while authorization was sought from forest authorities to enter the sanctuary and gather plant samples. Field surveys and interviews were conducted between 2019 and 2022, coordinated according to the availability of informants. A variety of methods, including semi-structured interviews, discussions with key informants, and informal dialogues with folk medicinal practitioners and local individuals, were employed to gather data. Informants shared insights into the ethnobotanical plants utilized in the region and their specific importance for which they were employed. Throughout the study, adherence to ethical standards was maintained by obtaining consent and authorization prior to data collection, as well as by ensuring the representation of informants from the local community.

4.8.2 Specimen collection and identification

In order to ensure precise identification of the plants documented in this study, a thorough assessment was carried out utilizing reputable literature sources, including regional and local floras and relevant literatures (Singh *et al.*, 2002; Hooker, 1872; Sawmliana, 2003; Sinha *et al.*, 2012). The plant names that were identified were cross-checked with their updated accepted names using the Plants of the World Online (<https://powo.science.kew.org>) and World Flora Online database (worldfloraonline.org). To establish a comprehensive record of the identified plant specimens, herbariums were created following standard procedures outlined by Jain and Rao (1977). All ethnomedicinal plants gathered during the study, along with associated local informants, with correct identification were deposited in the Department of Botany at Mizoram University Herbarium (MZUH) for future reference. This meticulous evaluation and the creation of herbarium specimens offer invaluable resources for subsequent research and conservation endeavours concerning the ethnomedicinal plant species within the region.

4.8.3 Ailments Categories for ethnomedicinal plants

Various diseases and dysfunctions among the ethnomedicinal plants were categorized into specific ailment groups based on the affected system, including Gastro-Intestinal Ailments (GIA), Dermatological Infections/Diseases (DID), Skeleto-Muscular System Disorder (SMSD), Vector Borne Diseases (VBD), Respiratory Disease Syndrome (RSD), Genito-Urinary Ailments (GUA), Cell division Disorder (CDD), General Health (GH), Poisonous Bites (PB), Dental Care (DC), Cardiovascular Disorder (CVD), Ear nose throat (ENT) problem, and Liver and Spleen Disorder (LSD) (Thangliankhup *et al.* 2022).

4.8.4 Quantitative ethnobotanical analysis

Quantitative data not only increases the chances of identifying potentially pharmacologically significant plants but also facilitates the evaluation of the consistency of the collected ethnobotanical information. The accurate identification of each plant is crucial for subsequent phytochemical analysis, pharmacological

screening, and pharmaceutical applications. In the present study, ethnobotanical data were evaluated using various ethnobotanical indices, including the relative frequency of citation (RFC), fidelity level (FI), use value (UV), and informant consensus factor (Fic).

(a) Relative Frequency of Citation (RFC)

The relative frequency of citation (RFC) index was employed to objectively analyse the ethnobotanical data collected. High RFC values indicate the significance of each species within the local environment. RFC is calculated by dividing the frequency of citation (FC) - the number of informants mentioning the usage of a particular plant species - by the total number of informants in the survey (N), without considering the use categories (Kayani, 2014).

RFC can be defined by formula,

$$RFC = FC/N$$

(b) Fidelity Level (FI)

Fidelity level is calculated to assess the significance of each species in treating a specific group of illnesses and is calculated by using the formula,

$$FI (\%) = \frac{Np}{N} \times 100$$

where, Np is the number of informants suggesting the plant as a medicine for a particular ailment category, while N is the total number of informants suggesting the plant for any ailment category.

A high-fidelity level indicates that a particular plant species is widely recognized and used within a culture, and may have significant cultural, medicinal, or spiritual value (Andrade-Cetto, 2009). Ethnobotanists use fidelity level as a tool for understanding the relationships between plants and people and for identifying important cultural resources that may be at risk of loss or degradation.

(c) Use Value (UV)

Use value (UV) is used to measure the relative value of a species in relation to other species (Phillips *et al.* 1994) and is obtained as the sum total of use reports of a particular species divided by the total number of informants.

$$UV = \sum U / N,$$

where U is the sum total of use reports and N is the total number of informants.

(d) Informant Consensus factor (F_{ic})

Informant Consensus Factor, F_{ic} was used to calculate the level of homogeneity among information provided by different informants (Trotter and Logan, 2019) using the following formula:

$$F_{ic} = (N_{ur} - N_t) / (N_{ur} - 1)$$

where, N_{ur} is the number of use reports from informants for a particular plant use category and N_t is the number of taxa or species that are used for that plant use category for all informants. F_{ic} ranges between 0 and 1.

A high value (around 1) indicates that the vast majority of informants utilise a limited number of taxa (typically, species), whereas a low value indicates that informants dispute on which taxa to use in therapy within a given category of illness. As a consequence, there is a high degree of agreement when informants use a small number of taxa, and the medicinal tradition is considered well-defined. The computation of the consensus factor is used to assess the consistency of an informant's expertise in treating a particular ailment category.

(e) Pearson Correlation Coefficient

Pearson correlation coefficient is used to measure how strong a relationship is between two variables (Vijayakumar *et al.*, 2015), here in our case it is measured between use value (UV) and relative frequency of citation (RFC) by using XLSTAT software (XLSTAT, 2016). This will help us in the confirmation of whether our data is significant or not among the studied variables.

CHAPTER 5

5. Results and Discussion

5.1 Diversity and Composition of Tree Species in Six Forest Communities of NWS

The study highlights the region's remarkable tree diversity and its importance for biodiversity conservation. It presented a total of 2545 individual trees across a 2.5-hectare area, comprising 250 sample plots, each measuring 0.01 hectares. The species accumulation curve for the entire tree community showed a gradual incline in cumulative species richness beyond a sample size of 40, indicating that a sufficient number of plots had been surveyed for the present study (**Figure 5.1a**). However, when examining the six various forest communities, the species accumulation curve exhibited an increasing asymptotic pattern (**Figure 5.1b**). Nevertheless, the curve distinctly noted the highest species richness (98 species) in the HN, followed by NP with 89 species, DT with 76 species, SE with 68, KM with 63 species, and BS also with 63 species. Conversely, when considering a uniform sample size of 10, BS recorded the highest average species richness of 15.76 (**Figure 5.1b**). The Shannon diversity index (H) ranged from 3.69 to 4.42, with HF displaying the highest value, as summarized in **Table 5.2**. Furthermore, Pielou's evenness (J) ranged from 0.64 to 0.85, with HF again exhibiting the highest value, as shown in **Table 5.2**.

Researchers identified 105 tree species across 40 families and 76 genera, showcasing the sanctuary's rich species variety. Euphorbiaceae emerged as the dominant family, with 10 species and the highest Family Importance Value Index (9.73%). *Dipterocarpus retusus* was identified as the most important tree species with an SIVI of 6.63%. Notably, *Dipterocarpus retusus* and *D. turbinatus* are categorized as Endangered and Vulnerable, respectively, on the IUCN Red List. These species, along with other threatened plants like *Bombax insigne* (CR), *Prunus ceylanica* (EN), and *Saurauia punduana* (CR), underscore the sanctuary's role in conserving rare and endemic flora. The study conducted in Ngengpui Wildlife Sanctuary (Mizoram), India, highlights the region's remarkable tree diversity and its

importance for biodiversity conservation. Researchers identified 105 tree species across 40 families and 76 genera, showcasing the sanctuary's rich species variety. Euphorbiaceae emerged as the dominant family(**Table 5.3**), with 10 species and the highest Family Importance Value Index (9.73%).

The observed richness of the area included 105 species from 40 different families and 76 genera (**Table 5.1**), which is found to be fewer as compared to the findings in Reiek village, where 125 species were identified under tropical moist forest conditions in Mizoram (Devi *et al.*, 2018). The greater variety of tree species in the Reiek forest can be attributed to the prolonged protection of the forest and its careful management by the local villagers. In comparison to previous studies conducted in different tropical forests (Chowdhury *et al.*, 2000; Borah and Garkoti, 2011; Nohro and Jayakumar, 2020), the present research reports a higher total number of recorded species.

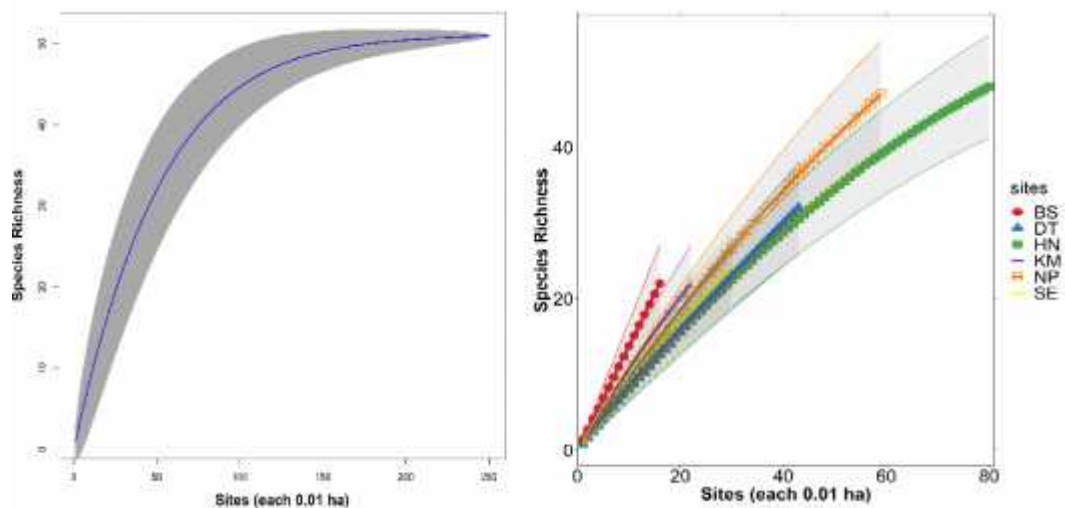


Figure 5.1: Species accumulation curve base on the rarefraction method:

(a) Whole tree population;

(b) six forests: BS = Bungtlang south, DT = Diltlang, HN = Hmunnuam, KM = Khawmawi, NP = Ngengpui, SE = Saizawh east.

Table 5.1. Tree species recorded in NWS with scientific name, MZUH accession no., Family, Local name and Conservation Status.

SN	Scientific name/ MZUH Accession no.	Family	Local name	Conservation Status
1	<i>Acrocarpus fraxinifolius</i> Wight & Arn / MZUH001117	Fabaceae	Nganbawm	Rare
2	<i>Albizia chinensis</i> (Osbeck.) Merr. / MZUH001118	Fabaceae	Vang	NE
3	<i>Albizia odoratissima</i> (L.f.) Benth. / MZUH001119	Fabaceae	Thingri	LC
4	<i>Albizia procera</i> (Roxb.) Benth. / MZUH001120	Fabaceae	Kangtek	LC
5	<i>Alphonsea lutea</i> (Roxb.) Hook.f. & Thomson / MZUH001014	Annonaceae	Zawngbalhla	LC
6	<i>Alseodaphnopsis petiolaris</i> (Meisn.) H.W.Li & J.Li / MZUH001151	Lauraceae	Bulpui	NE
7	<i>Alstonia scholaris</i> (L.) R.Br / MZUH001019	Apocynaceae	Thuamriat	LC
8	<i>Antidesma buniis</i> (L.) Spreng. / MZUH001105	Euphorbiaceae	Tuaitit	NE
9	<i>Aphananthe cuspidata</i> (Blume) Planch. / MZUH001252	Ulmaceae	Sehret/Thengreng	NE
10	<i>Aporosa octandra</i> (Buch. -Ham ex D. Don)A.R. Vickery / MZUH001106	Euphorbiaceae	Chhawntual	LC
11	<i>Artocarpus chama</i> Buch.-Ham. / MZUH001180	Moraceae	Tatkawng	NE
12	<i>Artocarpus lacucha</i> Buch.-Ham. / MZUH001181	Moraceae	Theitat	NE
13	<i>Baccaurea ramiflora</i> Lour. / MZUH001107	Euphorbiaceae	Pangkai	LC
14	<i>Balakata baccata</i> Roxb.) Esser / MZUH001108	Euphorbiaceae	Thingvawkpui	LC
15	<i>Bischofia javanica</i> Blume / MZUH001109	Euphorbiaceae	Khuangthli	LC
16	<i>Bombax ceiba</i> L. / MZUH001064	Bombacaceae	Phunchawng	NE
17	<i>Bombax insigne</i> Wall. / MZUH001065	Bombacaceae	Pang	CR
18	<i>Callicarpa arborea</i> Roxb. / MZUH001142	Lamiaceae	Hnahkiah	LC
19	<i>Calophyllum polyanthum</i> Wall. ex Choisy / MZUH001073	Calophyllaceae	Sentezel	NE
20	<i>Canarium bengalense</i> Roxb. / MZUH001069	Burseraceae	Berawchal	NE
21	<i>Cassia javanica</i> L. / MZUH001123	Fabaceae	Makpazangkang	LC
22	<i>Castanopsis tribuloides</i> A.DC. / MZUH001135	Fagaceae	Thingsia	LC
23	<i>Catunaregam spinosa</i> (Thunb.) Tirveng. / MZUH001226	Rubiaceae	Sazuk Thei	LC

24	<i>Chisocheton cumingianus</i> Harms / MZUH001174	Meliaceae	Lawngtlaibantlo	LC
25	<i>Chukrasia tabularis</i> Wight & Arn. / MZUH001175	Meliaceae	Zawngtei	LC
26	<i>Citrus macroptera</i> Montrouz. / MZUH001236	Rutaceae	Hatkawra	EN
27	<i>Cordia fragrantissima</i> Kurz / MZUH001066	Boraginaceae	Muk	LC
28	<i>Cyathocalyx martabanicus</i> Hook.f. & Thomson / MZUH001015	Annonaceae	Hreirawt	NE
29	<i>Dillenia indica</i> Blanco / MZUH001098	Dilleniaceae	Kawrthindeng	LC
30	<i>Diospyros pilosiuscula</i> G. Don / MZUH001103	Ebenaceae	Ruthei	NE
31	<i>Dipterocarpus retusus</i> Blume / MZUH001101	Dipterocarpaceae	Thingsen	EN
32	<i>Dipterocarpus turbinatus</i> C.F. Gaertn. / MZUH001102	Dipterocarpaceae	Vailawng	VU
33	<i>Drimycarpus racemosus</i> Hook.f. / MZUH001010	Anacardiaceae	Vawmbal hnahsin	NE
34	<i>Duabanga grandiflora</i> Walp. / MZUH001158	Lythraceae	Zuang	LC
35	<i>Dysoxylum excelsum</i> Blume / MZUH001176	Meliaceae	Thingthupui	NE
36	<i>Dysoxylum gotadhora</i> (Buch.-Ham.) Mabb. / MZUH001177	Meliaceae	Sahatah	NE
37	<i>Engelhardia spicata</i> Blume / MZUH001141	Juglandaceae	Hnum	LC
38	<i>Erythrina stricta</i> (Roxb.) / MZUH001125	Fabaceae	Fartuah	NE
39	<i>Eurya japonica</i> Thunb. / MZUH001248	Theaceae	Sihneh	NE
40	<i>Ficus fistulosa</i> Reinw. Ex Blume / MZUH001182	Moraceae	Theibate/Theibial	LC
41	<i>Ficus religiosa</i> L. / MZUH001183	Moraceae	Hmawng	LC
42	<i>Ficus retusa</i> L. / MZUH001184	Moraceae	Rihnim	LC
43	<i>Ficus semicordata</i> Buch.-Ham. Ex Sm. / MZUH001185	Moraceae	Theipui	LC
44	<i>Ficus variegata</i> Blume / MZUH001186	Moraceae	Chhohe	LC
45	<i>Garcinia lanceifolia</i> Roxb. / MZUH001075	Clusiaceae	Chengkek	LC
46	<i>Garcinia pedunculata</i> Roxb. / MZUH001076	Clusiaceae	Vawmva	NE
47	<i>Garcinia xanthochymus</i> Hook.f. / MZUH001077	Clusiaceae	Tuaihabet	LC
48	<i>Garuga floribunda</i> Decne. / MZUH001070	Burseraceae	Tuairam	LC
49	<i>Garuga pinnata</i> Roxb. / MZUH001071	Burseraceae	Bungbutuairam	NE

50	<i>Gmelina arborea</i> Roxb. Ex Sm. / MZUH001145	Lamiaceae	Thlanvawng	LC
51	<i>Haldina cordifolia</i> (Roxb.) Ridsdale / MZUH001228	Rubiaceae	Lungkhup	NE
52	<i>Heteropanax fragrans</i> Seem. / MZUH001031	Araliaceae	Changkhen	NE
53	<i>Hibiscus macrophyllus</i> Roxb / MZUH001164	Malvaceae	Vaiza	LC
54	<i>Homalium ceylanicum</i> (Gardner) Benth. / MZUH001137	Flacourtiaceae	Thinglung	NE
55	<i>Horsfieldia amygdalina</i> (Wall.) Warb. / MZUH001191	Myristicaceae	Sialtuai	NE
56	<i>Hydnocarpus kurzii</i> (King) Warb. / MZUH001138	Flacourtiaceae	Khawituro	DD
57	<i>Ixora nigricans</i> Zoll. Ex Miq. / MZUH001229	Rubiaceae	Thingkhim	NE
58	<i>Ixora subsessilis</i> Wall. / MZUH001230	Rubiaceae	Thingsaingal	NE
59	<i>Knema linifolia</i> (Roxb.) Warb. / MZUH001192	Myristicaceae	Thingthi	NE
60	<i>Kydia calycina</i> Roxb. / MZUH001166	Malvaceae	Thalteh	NT
61	<i>Lagerstroemia speciosa</i> (L.) Pers. / MZUH001159	Lythraceae	Thlado	NE
62	<i>Leeaequata</i> L. / MZUH001154	Leeaceae	Kawlkar	NE
63	<i>Lithocarpus dealbatus</i> Rehder / MZUH001136	Fagaceae	Fah	LC
64	<i>Macaranga denticulata</i> Müll.Arg. / MZUH001111	Euphorbiaceae	Hnahkhar pa	LC
65	<i>Macaranga peltata</i> Boiv. ex Baill. / MZUH001112	Euphorbiaceae	Hnahkhar nu	NE
66	<i>Macropanax dispermus</i> Kuntze / MZUH001032	Araliaceae	Phuanberh	LC
67	<i>Magnolia champaca</i> (L.) Baill. Ex Pierre / MZUH001160	Magnoliaceae	Ngiau	LC
68	<i>Mallotus nudiflorus</i> (L.) Kulju & Welzen / MZUH001113	Euphorbiaceae	Phaithing	LC
69	<i>Mallotus roxburghianus</i> Müll.Arg. / MZUH001114	Euphorbiaceae	Zawngtenawhlu ng	NE
70	<i>Mangifera sylvatica</i> Roxb. / MZUH001011	Anacardiaceae	Ramtheihai	LC
71	<i>Memecylon celastrinum</i> Kurz / MZUH001170	Melastomataceae	Theikawrak	NE
72	<i>Mesua ferrea</i> L. / MZUH001078	Clusiaceae	Herhse	EN
73	<i>Morus macroura</i> Miq. / MZUH001187	Moraceae	Lungli	LC
74	<i>Neolamarckia cadamba</i> (Roxb.) Bosser / MZUH001232	Rubiaceae	Thingbanphar	NE
75	<i>Oroxylum indicum</i> Vent / MZUH001062	Bignoniaceae	Archangkawm	EN

76	<i>Ostodes paniculata</i> Blume / MZUH001115	Euphorbiaceae	Bel tur	NE
77	<i>Pajanelia longifolia</i> (Wild) K. Schum / MZUH001063	Bignoniaceae	Archangkawm suak	LC
78	<i>Palaquium polyanthum</i> Engl. / MZUH001238	Sapotaceae	Hnaibung	NE
79	<i>Parkia timoriana</i> (DC.) Merr. / MZUH001131	Fabaceae	Zawngtah	LC
80	<i>Persea odoratissima</i> (Nees) Kosterm. / MZUH001152	Lauraceae	Bulfek	NE
81	<i>Phoebe attenuata</i> (Nees) Nees / MZUH001153	Lauraceae	Bul	NE
82	<i>Poikilospermum suaveolens</i> (Blume) Merr. / MZUH001257	Urticaceae	Khuangkchau	NE
83	<i>Polyalthia jenkinsii</i> (Hook.f. & Thomson) Hook.f. & Thomson / MZUH001016	Annonaceae	Zathu	LC
84	<i>Pouzolzia rugulosa</i> (Wedd.) Acharya & Kravtsova / MZUH001261	Urticaceae	Lenlang	NE
85	<i>Protium serratum</i> Engl. / MZUH001072	Burseraceae	Bil	NE
86	<i>Prunus ceylanica</i> Miq. / MZUH001225	Rosaceae	Rahphir	EN
87	<i>Pterospermum acerifolium</i> (L.) Wild. / MZUH001246	Sterculiaceae	Siksil	LC
88	<i>Pterygota alata</i> (Roxb.) R.Br. / MZUH001247	Sterculiaceae	Lenglep	NE
89	<i>Sarcosperma griffithii</i> Hook.f. / MZUH001239	Sapotaceae	Theikhawkham	LC
90	<i>Saurauia punduana</i> Wall. / MZUH001004	Actinidiaceae	Tiar	CR
91	<i>Schima khasiana</i> Dyer / MZUH001249	Theaceae	Khiang zo	LC
92	<i>Schima wallichii</i> (DC.) Korth. / MZUH001250	Theaceae	Khiang	LC
93	<i>Semecarpus anacardium</i> L.f. / MZUH001012	Anacardiaceae	Vawmbal hnahhlai	EN
94	<i>Spondias pinnata</i> (L.f.) Kurz / MZUH001013	Anacardiaceae	Tawitaw	NE
95	<i>Syzygium cumini</i> L. / MZUH001194	Myrtaceae	Lenhmui	LC
96	<i>Syzygium diospyrifolium</i> (Wall. Ex Duthie) / MZUH001195	Myrtaceae	Hnunthlum	NE
97	<i>Syzygium ramosissimum</i> (Blume) N.P.Balacr. / MZUH001196	Myrtaceae	Hmuivar	NE
98	<i>Terminalia chebula</i> Retz / MZUH001080	Combretaceae	Reraw	NT
99	<i>Terminalia myriocarpa</i> Van Heurck & Müll.Arg. / MZUH001081	Combretaceae	Char	EN

100	<i>Terminalia pendula</i> (Edgew.) Gere & Boatwr. / MZUH001259	Combretaceae	Zairum	NE
101	<i>Tetradium fraxinifolium</i> Wall. Ex Royle / MZUH001237	Rutaceae	Chingit suak	LC
102	<i>Tetrameles nudiflora</i> R. Br. / MZUH001097	Datiscaceae	Thingdawl	LC
103	<i>Toona ciliata</i> M. Roem. / MZUH001178	Meliaceae	Teipui	LC
104	<i>Trema orientalis</i> (L.) Blume / MZUH001253	Ulmaceae	Belpuar	LC
105	<i>Vitex peduncularis</i> Wall. / MZUH001150	Lamiaceae	Thinghawilu	LC

Abbreviations: CR = Critically Endangered, EN = Endangered, NT= Near Threatened, NE= Not Evaluated; LC = Least Concern

Table 5.2. Diversity indices of tree species from six different sites of Ngengpui Wildlife Sanctuary, Mizoram, India.

Parameters	All	HN	NP	DT	SE	KM	BS
Total sampled area (ha)	2.5	0.8	0.59	0.43	0.3	0.22	0.16
Total Individuals	2545	757	559	383	320	276	250
Total species richness	105	98	89	76	68	63	63
Total genus richness	87	81	72	64	56	54	49
Total family richness	40	39	32	27	22	22	20
Simpson index (H')	0.98	0.9865	0.9826	0.9771	0.9762	0.968	0.9631
Shannon index (1-D)	4.02	4.42	4.23	4.05	3.96	3.78	3.69
Pielou's Evenness (J)	0.75	0.85	0.77	0.75	0.77	0.69	0.64
Margalef's index (Dmg)	12.48	14.63	13.91	12.61	11.62	11.03	11.05
Fisher's alpha index (α)	27.77	30	29.84	28.45	26.42	25.51	26.4
Dominant family	Euphorbiaceae	Magnoliaceae	Euphorbiaceae	Euphorbiaceae	Euphorbiaceae	Euphorbiaceae	Euphorbiaceae
Dominant species	<i>Dipterocarpus retusus</i>	<i>Magnolia champaca</i>	<i>Dipterocarpus retusus</i>	<i>Dipterocarpus retusus</i>	<i>Dipterocarpus retusus</i>	<i>Dipterocarpus retusus</i>	<i>Dipterocarpus retusus</i>

Abbreviations: HN= Hmunnuam; NP= Ngengpui; DT= Diltlang South; SE= Saizawh East; KM= Khawmawi; BS= South Bungtlang

Table 5.3 and **Table 5.4** present the Importance Value Index (IVI) of top ten trees for overall forest communities and six distinct forests of NWS, which was calculated for both species (SIVI) and families (FIVI). Additionally, these tables display information on species richness, family composition, stem density, basal area, their respective contributions to the overall forest community, as well as insights into different forest communities. Our analysis revealed that the three most significant species based on their Species Importance Value Index (SIVI), were *Dipterocarpus retusus* (6.63%), *Palaquium polyanthum* (5.59%), and *Dysoxylum gotadhora* (4.23%) while *Castanopsis tribuloides* shows the highest IVI value in case of a study conducted in Phawngpui National Park, another protected area in Mizoram (Malsawmsanga, 2011). The variation in the species with the highest Importance Value Index (IVI) can be attributed to the distinct locations of Phawngpui (2157 msl), situated on a mountain) and Ngengpui (200 msl), located in a low-altitude region. These dominant tree species stood out as the key contributors to the forest ecosystem composition and structure. *D. retusus* stands out not only as the species with the highest Importance Value Index (IVI) but also holds paramount ecological significance. Many members of Dipterocarpaceae members being dominant species in many tropical forests relies on a distinctive blend of ecological and morphological features that include orthotropic branching pattern, mass fruiting and winged seeds as a strategy against seed predation and dispersal, establishment of mycorrhizal association and presence of protective resins (Bansal *et al.*, 2022). The dominant species *D. retusus* is categorized as Endangered in IUCN Red List (Ly *et al.*, 2017), underscoring the critical need for conservation efforts. Beyond its ecological importance, *D. retusus* possesses noteworthy medicinal properties, demonstrating efficacy in various areas. The intersection of high ecological value and medicinal properties highlights the importance of safeguarding and studying this species for both ecological and medical purposes. Similarly, at the family level, we identified the following top three families with the highest Family Importance Value Index (FIVI): Euphorbiaceae (9.73%), Moraceae (7.73%) and Fabaceae (6.50%). Euphorbiaceae exhibited the highest diversity among families, housing a total of 10 different species, as indicated in **Table 5.3**.

Table 5.3. Top ten species and families for the overall forest community recorded in the study sites of NWS.

Species	Family	Stem Density (ha ⁻¹)	Stem Density (%)	Basal area (m ² ha ⁻¹)	Basal area (%)	SIVI (%)
<i>Dipterocarpus retusus</i>	Dipterocarpaceae	56.40	5.54	18.43	28.63	6.63
<i>Palaquium polyanthum</i>	Sapotaceae	36.80	3.60	3.34	5.19	5.59
<i>Dysoxylum gotadhora</i>	Meliaceae	29.20	2.87	1.91	2.97	4.23
<i>Magnolia champaca</i>	Magnoliaceae	12.80	1.26	3.48	5.41	3.64
<i>Mallotus nudiflorus</i>	Euphorbiaceae	29.60	2.91	1.10	1.71	3.14
<i>Lagerstroemia speciosa</i>	Lythraceae	20.40	2.00	2.19	3.40	2.72
<i>Castanopsis tribuloides</i>	Fagaceae	24.00	2.36	1.03	1.60	2.29
<i>Albizia chinensis</i>	Fabaceae	6.80	0.67	0.68	1.06	1.83
<i>Terminalia myriocarpa</i>	Combretaceae	20.00	1.97	2.74	4.26	1.69
<i>Duabanga grandiflora</i>	Lythraceae	18.80	1.85	1.08	1.68	1.22
Families	Richness	Stem Density (ha ⁻¹)	Stem Density (%)	Basal area (m ² ha ⁻¹)	Basal area (%)	FIVI (%)
Euphorbiaceae	10	142.80	14.03	5.38	8.36	9.73
Moraceae	8	60.40	5.93	2.85	4.43	7.73
Fabaceae	7	37.20	3.65	1.83	2.84	6.50
Dipterocarpaceae	2	69.60	6.84	18.74	29.12	5.73
Meliaceae	5	70.00	6.87	3.01	4.68	5.13
Rubiaceae	5	42.00	4.13	1.52	2.36	4.90
Combretaceae	3	37.60	3.69	3.23	5.02	3.80
Anacardiaceae	4	25.20	2.48	1.51	2.35	3.43
Clusiaceae	4	40.40	3.97	1.64	2.55	3.36
Lauraceae	3	13.20	1.30	0.62	0.96	3.10

In HN, the three most dominant species, characterized by their higher Species Importance Value Index (SIVI), were *Magnolia champaca* (4.49%), *Dipterocarpus retusus* (4.09%), and *Palaquium polyanthum* (3.55%). In the case of NP, *Dipterocarpus retusus* (16.77%), *Magnolia champaca* (3.62%), and *Palaquium polyanthum* (3.44%) were reported as the most dominant species, showcasing their significant role in this forest type. The DT exhibited dominance by species like *Dipterocarpus retusus* (17.59%), *Palaquium polyanthum* (5.10%), and *Terminalia myriocarpa* (4.29%). Within the SE, the most prevalent species were *Dipterocarpus retusus* (15.12%), *Palaquium polyanthum* (4.31%), and *Castanopsis tribuloides* (3.17%). In the context of KM, the species with the highest Importance Value Index (IVI) included *Dipterocarpus retusus* (22.98%), *Palaquium polyanthum* (7.41%), and *Bischofia javanica* (4.51%), signifying their dominance in this particular forest type. Lastly, in the BS, the most dominant species were *Dipterocarpus retusus* (18.99%), *Dysoxylum gotadhora* (7.47%), and *Palaquium polyanthum* (6.18), as detailed in **Table 5.4**. *Dipterocarpus retusus* was identified as the most important tree species with SIVI of 6.63%. Notably, *Dipterocarpus retusus* and *D. turbinatus* are categorized as Endangered and Vulnerable, respectively, on the IUCN Red List. These species, along with other threatened plants like *Bombax insigne* (CR), *Prunus ceylanica* (EN), and *Saurauia punduana* (CR), underscore the sanctuary's role in conserving rare and endemic flora.

Table 5.4. Top ten Dominant Species and Dominant Families in **Hmunnuam Forest** (HN)

Species	Family	Stem Density (ha ⁻¹)	Stem Density (%)	Basal area (m ² ha ⁻¹)	Basal area (%)	SIVI (%)
<i>Magnolia champaca</i>	Magnoliaceae	12.50	1.32	4.09	7.64	4.49
<i>Dipterocarpus retusus</i>	Dipterocarpaceae	15.00	1.59	3.48	6.5	4.09
<i>Palaquium polyanthum</i>	Sapotaceae	18.75	1.98	2.81	5.25	3.55
<i>Terminalia myriocarpa</i>	Combretaceae	16.25	1.78	2.57	4.8	3.33
<i>Lagerstroemia speciosa</i>	Lythraceae	20.00	2.11	1.98	3.7	3.11
<i>Memecylon celastrinum</i>	Melastomataceae	20.00	2.11	1.98	3.7	2.86
<i>Daubanga grandiflora</i>	Lythraceae	21.25	2.25	1.43	2.67	2.43
<i>Castanopsis tribuloides</i>	Fagaceae	25.00	2.64	1.05	1.96	2.34
<i>Mangifera sylvatica</i>	Anacardiaceae	10.00	1.10	1.98	3.7	2.27
<i>Artocarpus chaplasha</i>	Moraceae	17.50	1.85	1.39	2.60	2.23
Families	Richness	Stem Density (ha ⁻¹)	Stem Density (%)	Basal area (m ² ha ⁻¹)	Basal area (%)	FIVI (%)
Euphorbiaceae	10	12.5	10	4.74	8.86	8.82
Fabaceae	9	11.25	9	1.87	3.50	7.42
Moraceae	7	8.75	7	3.22	6.02	6.15
Rubiaceae	5	6.25	5	1.88	3.51	4.65
Meliaceae	5	6.25	5	2.58	5.10	4.36
Anacardiaceae	4	5.00	4	2.38	4.7	4.26
Combretaceae	3	3.75	3	3.04	6.02	3.98
Dipterocarpaceae	2	2.50	2	3.83	7.58	3.78
Lythraceae	2	2.50	2	3.41	6.75	3.51
Clusiaceae	4	5.00	4	1.70	3.36	3.48

Table 5.5. Top ten Dominant Species and Dominant Families in Ngengpui Forest (NP)

Species	Family	Stem Density (ha ⁻¹)	Stem Density (%)	Basal area (m ² ha ⁻¹)	Basal area (%)	SIVI (%)
<i>Dipterocarpus retusus</i>	Dipterocarpaceae	38.98	4.12	11.04	29.61	16.77
<i>Magnolia champaca</i>	Magnoliaceae	11.86	1.25	2.26	6.06	3.62
<i>Palaquium polyanthum</i>	Sapotaceae	30.51	3.22	1.33	3.57	3.44
<i>Dysoxylum gotadhora</i>	Meliaceae	28.81	3.04	0.91	2.44	2.89
<i>Duabanga grandiflora</i>	Lythraceae	27.12	2.86	1.00	2.68	2.65
<i>Vitex peduncularis</i>	Lamiaceae	23.73	2.50	0.91	2.44	2.65
<i>Mesua ferrea</i>	Clusiaceae	22.03	2.33	0.81	2.17	2.40
<i>Calophyllum polyanthum</i>	Calophyllaceae	25.42	2.68	0.67	1.79	2.33
<i>Gmelina arborea</i>	Lamiaceae	25.42	2.68	0.75	2.01	2.31
<i>Terminalia myriocarpa</i>	Combretaceae	15.25	1.61	0.34	2.20	2.19
Families	Richness	Stem Density (ha ⁻¹)	Stem Density (%)	Basal area (m ² ha ⁻¹)	Basal area (%)	FIVI (%)
Dipterocarpaceae	2	3.39	2.24	11.34	32.00	12.11
Euphorbiaceae	10	16.95	11.22	2.48	7.00	9.07
Moraceae	8	13.56	8.98	1.00	2.82	6.51
Fabaceae	6	10.17	6.73	1.26	3.55	5.59
Rubiaceae	5	8.47	5.61	1.70	4.80	4.74
Meliaceae	5	8.47	5.61	1.58	4.46	4.63
Lamiaceae	3	5.08	3.36	1.69	4.77	4.00
Clusiaceae	4	6.78	4.49	1.20	3.39	3.47
Burseraceae	4	6.78	4.49	0.27	0.76	3.05
Anacardiaceae	4	6.78	4.49	0.75	2.12	3.05

Table 5.6. Top ten Dominant Species and Dominant Families in **Diltlang Forest (DT)**

Species	Family	Stem Density (ha ⁻¹)	Stem Density (%)	Basal area (m ² ha ⁻¹)	Basal area (%)	SIVI (%)
<i>Dipterocarpus retusus</i>	Dipterocarpaceae	58.14	6.52	15.52	36.21	17.59
<i>Palaquium polyanthum</i>	Sapotaceae	30.23	3.39	3.47	8.10	5.10
<i>Terminalia myriocarpa</i>	Combretaceae	23.25	2.61	3.49	8.14	4.29
<i>Mallotus nudiflorus</i>	Euphorbiaceae	30.23	3.39	1.00	2.33	2.96
<i>Castanopsis tribuloides</i>	Fagaceae	30.23	3.39	0.73	1.7	2.65
<i>Dillenia indica</i>	Dilleniaceae	27.91	3.13	0.75	1.75	2.65
<i>Calophyllum polyanthum</i>	Calophyllaceae	30.23	3.39	0.63	1.50	2.56
<i>Dysoxylum gotadhora</i>	Meliaceae	25.58	2.87	0.88	2.05	2.54
<i>Memecylon celastrinum</i>	Melastomataceae	20.93	2.35	1.09	2.54	2.44
<i>Mesua ferrea</i>	Clusiaceae	20.93	2.35	1.09	2.54	2.32
Families	Richness	Stem Density (ha ⁻¹)	Stem Density (%)	Basal area (m ² ha ⁻¹)	Basal area (%)	FIVI (%)
Dipterocarpaceae	2	4.65	2.74	15.71	38.31	14.60
Euphorbiaceae	8	18.60	10.96	1.68	4.10	8.67
Moraceae	6	13.95	8.22	2.13	5.19	7.21
Combretaceae	2	4.65	2.74	3.81	9.29	4.92
Fabaceae	4	9.30	5.48	1.19	2.90	4.62
Sapotaceae	1	2.33	1.37	3.47	8.50	3.74
Myrtaceae	3	6.98	4.11	0.86	2.10	3.44
Anacardiaceae	3	6.98	4.11	0.64	1.56	3.26
Burseraceae	3	6.98	4.11	0.39	0.95	3.06
Rubiaceae	3	6.98	4.11	0.29	0.71	2.98

Table 5.7: Top ten Dominant Species and Dominant Families in **Saizawh East Forest (SE)**

Species	Family	Stem Density (ha ⁻¹)	Stem Density (%)	Basal area (m ² ha ⁻¹)	Basal area (%)	SIVI (%)
<i>Dipterocarpus retusus</i>	Dipterocarpaceae	80	74.28	18.23	30.83	15.12
<i>Palaquium polyanthum</i>	Sapotaceae	36.67	34.05	3.64	6.16	4.31
<i>Castanopsis tribuloides</i>	Fagaceae	33.33	30.95	1.70	2.87	3.17
<i>Dysoxylum gotadhora</i>	Meliaceae	33.33	30.95	1.70	2.87	2.97
<i>Dillenia indica</i>	Dilleniaceae	36.67	34.05	1.18	2.00	2.93
<i>Terminalia myriocarpa</i>	Combretaceae	20.00	18.57	2.83	4.79	2.91
<i>Mallotus nudiflorus</i>	Euphorbiaceae	33.33	30.95	1.64	2.77	2.80
<i>Gmelina arborea</i>	Lamiaceae	26.67	24.76	2.00	3.38	2.79
<i>Hydnocarpus kurzii</i>	Flacourtiaceae	33.33	30.95	9.00	15.22	2.52
<i>Calophyllum polyanthum</i>	Calophyllaceae	30.00	27.85	0.98	1.66	2.47
Families	Richness	Stem Density (ha ⁻¹)	Stem Density (%)	Basal area (m ² ha ⁻¹)	Basal area (%)	FIVI (%)
Dipterocarpaceae	2	6.67	3.07	18.55	32.64	13.21
Euphorbiaceae	9	30	13.82	5.56	9.78	11.87
Moraceae	6	20	9.21	1.55	2.73	6.24
Meliaceae	5	16.67	7.68	3.25	5.72	6.17
Myrtaceae	3	10	4.61	2.79	4.91	4.90
Combretaceae	3	10	4.61	3.40	5.98	4.69
Clusiaceae	3	10	4.61	2.24	3.94	3.99
Fabaceae	3	10	4.61	1.21	2.13	3.96
Lythraceae	2	6.67	3.07	2.94	5.16	3.68

Lamiaceae	2	6.67	3.07	2.29	4.03	3.53
-----------	---	------	------	------	------	------

Table 5.8. Top ten Dominant Species and Dominant Families in **Khawmawi Forest (KM)**

Species	Family	Stem Density (ha ⁻¹)	Stem Density (%)	Basal area (m ² ha ⁻¹)	Basal area (%)	SIVI (%)
<i>Dipterocarpus retusus</i>	Dipterocarpaceae	122.73	9.92	35.62	36.78	22.98
<i>Palaquium polyanthum</i>	Sapotaceae	77.27	6.25	7.72	7.97	7.41
<i>Bischofia javanica</i>	Euphorbiaceae	13.64	1.10	7.34	7.58	4.51
<i>Terminalia myriocarpa</i>	Combretaceae	36.36	2.94	4.64	4.79	4.11
<i>Langerstroemia speciosa</i>	Lythraceae	31.82	2.57	4.10	4.23	3.10
<i>Leea aequata</i>	Leeaceae	68.18	5.51	0.91	0.94	2.93
<i>Balakata baccata</i>	Euphorbiaceae	31.82	2.57	3.07	3.17	2.81
<i>Castanopsis tribuloides</i>	Fagaceae	45.45	3.68	2.04	2.11	2.77
<i>Dysoxylum gotadhora</i>	Meliaceae	31.82	2.57	3.15	3.25	2.61
<i>Knema linifolia</i>	Myristicaceae	54.55	4.41	1.05	1.08	2.51
Families	Richness	Stem Density (ha ⁻¹)	Stem Density (%)	Basal area (m ² ha ⁻¹)	Basal area (%)	FIVI (%)
Euphorbiaceae	9	40.91	21.77	13.83	14.28	13.77
Dipterocarpaceae	1	4.55	1.64	35.62	36.78	13.39
Combretaceae	3	13.64	4.92	5.15	5.32	5.17
Moraceae	4	18.18	6.56	3.44	3.55	5.12
Fabaceae	4	18.18	6.56	2.08	2.15	4.66
Clusiaceae	3	13.64	4.92	2.70	2.79	4.32
Lythraceae	2	9.09	3.27	5.98	6.17	4.32
Sapotaceae	1	4.54	1.64	7.72	7.97	3.79
Rubiaceae	3	13.64	4.92	0.72	0.74	3.64
Meliaceae	2	9.09	3.28	3.19	3.29	3.36

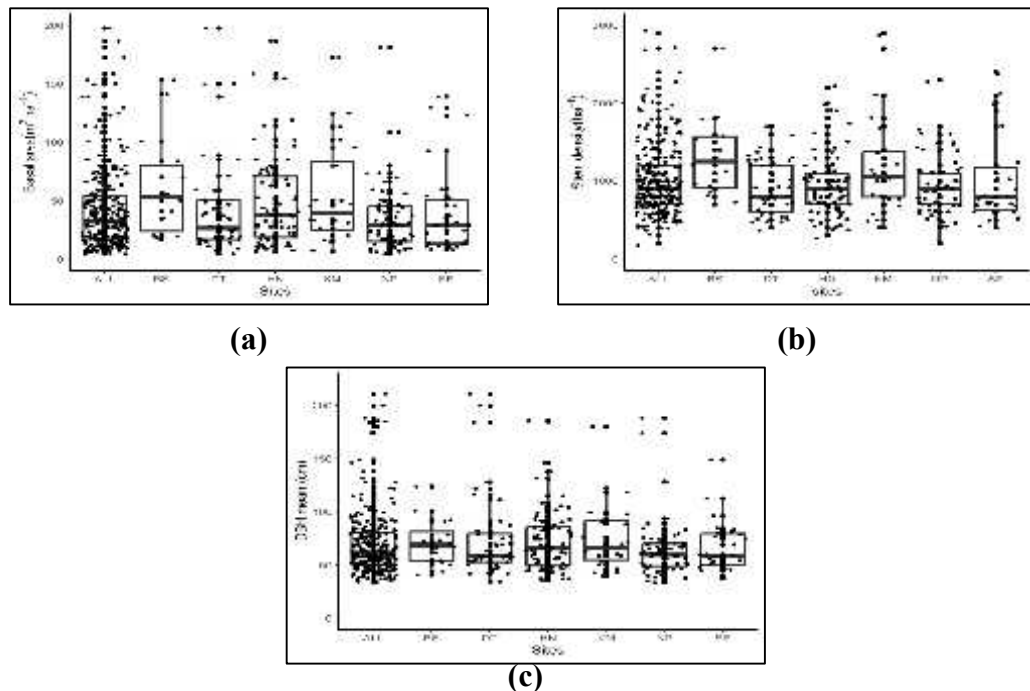
Table 5.9. Top ten Dominant Species and Dominant Families in **Bungtlang South Forest (BS)**

Species	Family	Stem Density (ha ⁻¹)	Stem Density (%)	Basal area (m ² ha ⁻¹)	Basal area (%)	SIVI (%)
<i>Dipterocarpus retusus</i>	Dipterocarpaceae	8.23	82.30	42.48	38.52	18.99
<i>Dysoxylum gotadhora</i>	Meliaceae	7.41	74.07	8.82	7.98	7.47
<i>Palaquium polyanthum</i>	Sapotaceae	7.41	74.07	4.60	4.17	6.18
<i>Lagerstroemia speciosa</i>	Lythraceae	5.35	53.5	5.93	5.38	5.24
<i>Balakata baccata</i>	Euphorbiaceae	4.94	49.38	5.36	4.86	4.77
<i>Ixora nigricans</i>	Rubiaceae	3.70	37.03	1.06	0.96	2.55
<i>Vitex peduncularis</i>	Lamiaceae	3.29	32.92	1.47	1.33	2.54
<i>Terminalia myriocarpa</i>	Combretaceae	1.65	16.46	4.75	4.31	2.49
<i>Dillenia indica</i>	Dilleniaceae	2.88	28.80	2.22	2.01	2.46
<i>Mangifera sylvatica</i>	Anacardiaceae	1.65	16.46	4.63	4.20	2.45
Families	Richness	Stem Density (ha ⁻¹)	Stem Density (%)	Basal area (m ² ha ⁻¹)	Basal area (%)	FIVI (%)
Dipterocarpaceae	1	6.25	2.98	1.86	1.71	14.11
Euphorbiaceae	8	50.00	23.81	8.91	8.17	10.00
Moraceae	6	37.50	17.86	3.17	2.91	5.83
Combretaceae	3	18.75	8.93	5.75	5.27	5.40
Meliaceae	2	12.50	5.95	9.59	8.80	5.34
Lythraceae	2	12.50	5.95	7.82	7.17	4.81
Fabaceae	5	31.25	14.88	3.14	2.88	4.60
Lamiaceae	3	18.75	8.93	1.89	1.73	4.22
Sapotaceae	2	12.50	5.95	4.68	4.29	3.86

Rubiaceae	2	12.50	5.95	2.12	1.95	3.08
-----------	---	-------	------	------	------	------

5.1.2 Forest structure

As an overall during the study, we documented a median stem DBH of 61.56 cm, a stem density of 900 individuals ha⁻¹, and a basal area of 33.51 m² ha⁻¹ which is comparatively lower than that reported from Gibbon Wildlife Sanctuary with 90.29 m² ha⁻¹ (Borah *et al.*, 2011) and Palak wetland reserve, Mizoram with 59.54 m² ha⁻¹ (Nohro and Jayakumar, 2020). Among the various forest communities, KM displayed the greatest median stem DBH (76.41 cm). Similarly, BS exhibited the highest stem density (1350 individuals per hectare) and the greatest basal area, approximately 56.12 square meters per hectare. These variations may be attributed to factors such as topography, soil composition, and historical land use patterns, emphasizing the importance of considering



local context in forest management and conservation strategies. (Figure 5.2).

Figure 5.2. Boxplot with jittered data points showing the distribution of (a) basal area, (b) stem density, and (c) DBH. The horizontal line crossing the box in the center represents the median. The vertical line outside the box represents the maximum and minimum values. ALL = total forest community, BS = Bungtlang South, DT = Diltlang, HN = Hmunnuam, KM = Khawmawi, NP = Ngengpui and SE = Saizawh East.

The distribution of tree size classes serves as a valuable indicator of a forest population structure and is widely employed to gain insights into its regeneration status (Saxena and Singh, 1984). The current evaluation has revealed a distribution pattern that resembles an inverted J-shaped, indicating the presence of uneven-aged forests. It reveals the greatest concentration of individuals in the 30 to 50 cm DBH class, while the lowest number of individuals falls within the 350 to 370 cm DBH class (**Figure 5.3**). The reduction in the number of larger trees within the sanctuary can be attributed to the predominant activity of those residing in the vicinity, primarily involving the logging or felling of trees. Given that the sanctuary has been under protection for only approximately 30 years, the practices of loggers contribute significantly to the observed decrease in the population of larger trees. This type of distribution pattern is also similar with work reported from Eastern Himalayas, Sikkim and various other forest communities (Bhutia *et al.*, 2019). This pattern suggests a sustainable process of reproduction and regeneration, with a substantial presence of young individuals capable of replacing the aging mature trees within the stand (Vetaas, 2000). The variations in the parameters among different forest communities highlight the heterogeneity within the studied ecosystem, indicating varying stages of growth and ecological dynamics. Understanding these differences is crucial for effective forest management and conservation, as it helps to identify areas where interventions might be needed to ensure the long-term health and sustainability of the forest. Further research and monitoring efforts can build upon this foundation to develop informed conservation and management plans tailored to the specific needs of each forest community. The study recorded a high tree density of 1076 stems per hectare, indicative of favorable growth conditions. The forest's uneven-aged structure, reflected in an inverted J shape, is vital for regeneration. Diversity indices showed a balanced distribution of species, with high richness and evenness. These findings underscore Ngengpui Wildlife Sanctuary's

exceptional tree diversity, abundance, and well-preserved ecosystem, highlighting the need for effective management to mitigate anthropogenic threats and preserve this critical habitat.

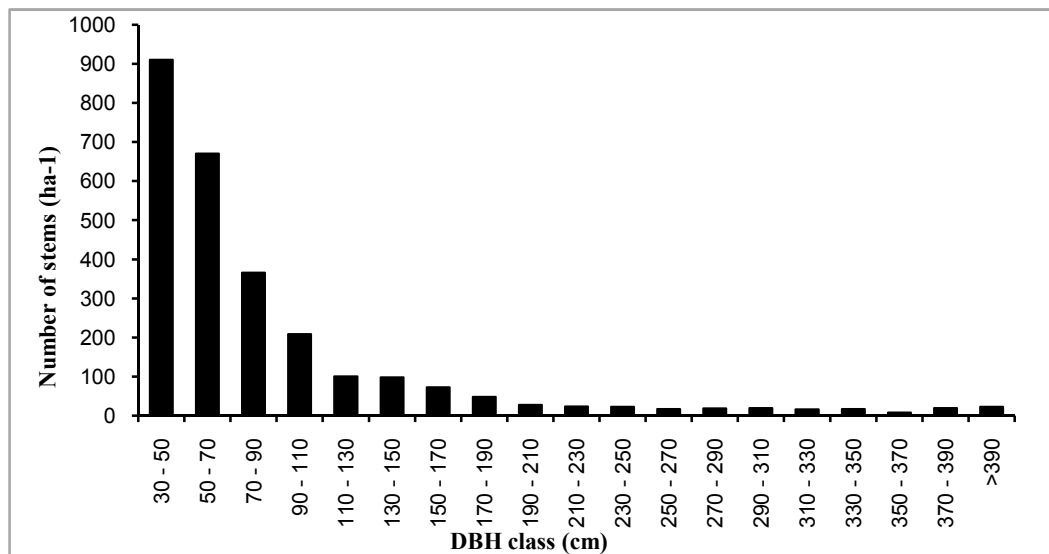


Figure 5.3: Overall stems recorded along with class distribution of trees with >30 cm DBH recorded in the study sites in NWS.

5.1.3 Diversity and composition of Herbs within NWS

A total of 134 herb species from 45 families have been reported in the present study from NWS. The top ten species of herbs, securing the highest ranks based on their Importance Value Index (IVI), include *Homalomena aromatica*, *Tacca integrifolia*, *Aglaonema hookeri*, *Hellenia speciosa*, *Musa ornata*, *Ageratum conyzoides*, *Amomum maximum*, *Ageratina adenophora*, *Bidens pilosa* and *Ageratina riparia* (**Table 5.10**) emphasizing their ecological importance and prevalence within the herbaceous community. The top five dominant taxa in the tropical forest of NWS are the perennial plants which have been evolved to adapt to the environmental conditions and occupying the understorey of the tropical rain forest. However, another major concern regarding the report on the invasive alien plant species from Asteraceae members in the wildlife sanctuary is a major concern as these species could outcompete the native taxa and alter

the ecosystem processes and reduce the native species diversity in tropical rainforest which houses many unique taxa. Among the herbaceous members, the family Asteraceae got the highest percentage of species representation showing significant species diversity. **(Figure 5.4a)**. The well representation of Asteraceae members which include many invasive alien plant species could lead to habitat fragmentation and act as pervasive invaders that could generate adverse influence on native ecosystems.

Some of the important families reported from the study with many endemic taxa include the Zingiberaceae, Araceae and Begoniaceae which play significant roles in tropical rain forest. These families are not only crucial for the biodiversity and ecological balance of tropical rain forests, but also serve as indicators of the health and richness of these habitats. Their presence and diversity contribute to the overall resilience and functioning of the intricate ecosystem, making them vital components of the tropical rainforest biome. Zingiberaceae species are known for their ability to thrive in various environmental conditions, including tropical forests, wetlands, and montane habitats, making them well-suited to the ecological conditions of the research site. Additionally, the Zingiberaceae family encompasses a wide range of plant species contributing to their numerical dominance in the area (Kress *et al.*, 2002). This combination of adaptability and species diversity increases the likelihood of encountering Zingiberaceae individuals and underscores their ecological significance within the ecosystem.

Table 5.10. List of herbs with their scientific names, MZUH accession no., Family, Local name, RET status, RF, RD, RA, IVI and the rank based on Importance Value Index (IVI) found in NWS.

SN	Scientific Names / MZUH Accession No.	Family	Local Names	RET Status	RF	RD	RA	IVI	Rank
1.	<i>Achyranthes aspera</i> L. / MZUH001116	Amaranthaceae	Ui hlo	LC	0.79	0.69	0.49	1.97	52
2.	<i>Acmella ciliata</i> (Kunth) Cass. / MZUH001044	Asteraceae	Ansate	NE	0.86	0.65	0.42	1.93	58
3.	<i>Aeginetia indica</i> L. / MZUH001204	Orobanchaceae	Sanghar Vaibel	NE	0.50	0.48	0.54	1.53	101
4.	<i>Agave americana</i> L. / MZUH001293	Asparagaceae	Kumza-pal	LC	0.36	0.36	0.57	1.29	113
5.	<i>Ageratina adenophora</i> (Spreng) R.M. King & H. Rob / MZUH001045	Asteraceae	Bihar-hlo	NE	1.65	1.70	0.58	3.93	8
6.	<i>Ageratina riparia</i> (Regel) R.M.King & H.Rob. / MZUH001294	Asteraceae	Hlo-thar	NE	1.87	1.45	0.44	3.76	10
7.	<i>Ageratum conyzoides</i> L. / MZUH001046	Asteraceae	Vailenhlo	LC	1.94	1.94	0.56	4.44	6
8.	<i>Ageratum houstonianum</i> Mill. / MZUH001047	Asteraceae	Vailenhlo	NE	1.65	1.41	0.48	3.55	12

9.	<i>Aglaonema hookerianum</i> Schott / MZUH001023	Araceae	Tubal	NE	3.09	3.07	0.56	6.72	3
10.	<i>Alocasia macrorrhizos</i> (L.) G.Don / MZUH001289	Araceae	Sai-dawl	LC	0.65	0.73	0.63	2.01	51
11.	<i>Alpinia conchigera</i> Griff. / MZUH001262	Zingiberaceae	Aichal chikhat	LC	1.15	0.93	0.45	2.53	37
12.	<i>Alpinia malaccensis</i> (Burm.f.) Roscoe / MZUH001263	Zingiberaceae	Aichal / Du pawl	NE	1.37	1.21	0.50	3.08	25
13.	<i>Alternanthera philoxeroides</i> (Mart.) Griseb. / MZUH001006	Amaranthaceae	Nghateril thau chi	NE	0.72	0.69	0.54	1.94	55
14.	<i>Alternanthera sessilis</i> (L.) DC. / MZUH001007	Amaranthaceae	Nghateril thau chi	LC	1.15	0.97	0.47	2.59	34
15.	<i>Amaranthus spinosus</i> L. / MZUH001009	Amaranthaceae	Lenhling	LC	0.65	0.53	0.46	1.63	90
16.	<i>Amaranthus viridis</i> L. / MZUH001008	Amaranthaceae	Lenhling hling nei lo	NE	0.79	0.65	0.46	1.90	61
17.	<i>Amomum maximum</i> Roxb. / MZUH001264	Zingiberaceae	Aidu	LC	2.09	1.62	0.44	4.14	7
18.	<i>Amorphophallus bulbifer</i> (Schott) Blume / MZUH001024	Araceae	Telhawng nu	LC	1.44	1.33	0.52	3.29	21
19.	<i>Amorphophallus napalensis</i> (Wall.) Bogner et Mayo. / MZUH001025	Araceae	Telhawng pa	NE	1.51	1.41	0.53	3.45	15

20.	<i>Ananas comosus</i> (L.) Merr. / MZUH001068	Bromeliaceae	Lakhuith thei	NE	0.86	0.73	0.47	2.06	48
21.	<i>Arisaema album</i> N.E.Br. / MZUH001026	Araceae	Mitthi vaimim	NE	0.50	0.57	0.63	1.70	84
22.	<i>Arisaema consanguineum</i> Schott / MZUH001027	Araceae	Zo telhawng	NE	1.08	1.09	0.57	2.74	32
23.	<i>Artemisia vulgaris</i> L. / MZUH001295	Asteraceae	Sai		0.22	0.69	1.79	2.70	33
24.	<i>Begonia annulata</i> K.Koch / MZUH001057	Begoniaceae	Sekhupthur	NE	0.94	0.93	0.56	2.42	40
25.	<i>Begonia dioica</i> Buch.-Ham. ex. D.Don / MZUH001058	Begoniaceae	Sekhupthur	NE	0.79	0.65	0.46	1.90	62
26.	<i>Begonia hatacoa</i> Buch.-Ham. ex. D.Don / MZUH001	Begoniaceae	Lalruanga dar nawnha	NE	0.58	0.61	0.59	1.77	76
27.	<i>Begonia palmata</i> D.Don	Begoniaceae	Sekhupthur	NE	0.22	0.32	0.84	1.38	109
28.	<i>Begonia roxburghii</i> (Miq.) A.DC. / MZUH001060	Begoniaceae	Sekhupthur	NE	1.22	1.49	0.69	3.41	18
29.	<i>Begonia thomsonii</i> A.DC. / MZUH001061	Begoniaceae	Lalruanga dar nawnha	NE	1.73	1.25	0.41	3.39	19
30.	<i>Bidens pilosa</i> L. / MZUH001048	Asteraceae	Vawkpui thal	NE	2.01	1.41	0.40	3.82	9
31.	<i>Blumea lanceolaria</i> (Roxb.) Druce / MZUH001049	Asteraceae	Buarze	LC	1.73	1.33	0.44	3.49	14

32.	<i>Boehmeria nivea</i> (L.) Gaudich. / MZUH001365	Urticaceae	-	NE	0.58	0.69	0.67	1.93	56
33.	<i>Bonnaya ruelloides</i> (Colsm.) Spreng. / MZUH001156	Linderniaceae	Thasuih	LC	0.58	0.65	0.63	1.85	71
34.	<i>Canna indica</i> L. / MZUH001311	Cannaceae	Kungpui-mu-thi	NE	0.14	0.20	0.79	1.14	123
35.	<i>Cardamine hirsuta</i> L. / MZUH001308	Brassicaceae	Phai-an-tam	NE	0.14	0.28	1.11	1.53	96
36.	<i>Celosia argentea</i> L. / MZUH001280	Amaranthaceae	Zamzo	LC	0.07	0.12	0.95	1.14	120
37.	<i>Centella asiatica</i> (L.) Urb / MZUH001018	Apiaceae	Lambak	LC	0.65	0.69	0.60	1.93	57
38.	<i>Chenopodium album</i> L. / MZUH001281	Amaranthaceae	Kawlbuh	NE	0.14	0.24	0.95	1.34	112
39.	<i>Colocasia esculenta</i> (L.) Schott / MZUH001028	Araceae	Dawl	LC	0.94	1.13	0.68	2.75	30
40.	<i>Crassocephalum crepidioides</i> (Benth.) S.Moore / MZUH001051	Asteraceae	Buar thau	NE	0.50	0.73	0.81	2.04	49
41.	<i>Cuphea carthagenensis</i> J.F.Macbr. / MZUH00117	Lythraceae		NE	0.43	0.24	0.32	0.99	129
42.	<i>Curculigo capitulata</i> (Lour.) Kuntze / MZUH001140	Hypoxidaceae	Phaiphak	LC	0.14	0.24	0.95	1.34	111
43.	<i>Curcuma longa</i> L. / MZUH001265	Zingiberaceae	Aieng	NE	0.36	0.69	1.08	2.12	45

44.	<i>Cyanotis cristata</i> (L.) D.Don / MZUH001082	Commelinaceae	Vawmkur	LC	0.50	0.65	0.72	1.87	65
45.	<i>Cyclocodon axillaris</i> (Oliv.) W.J.de Wilde & Duyfjes / MZUH001309	Campanulaceae		NE	0.22	0.28	0.74	1.24	116
46.	<i>Datura stramonium</i> L. / MZUH001243	Solanaceae	Tawtawrawt par	NE	0.50	0.48	0.54	1.53	102
47.	<i>Dichrocephala integrifolia</i> (L.f.) Kuntze / MZUH001296	Asteraceae	Vawk-ek-a-tum-tual	NE	0.14	0.36	1.42	1.93	59
48.	<i>Drymaria cordata</i> Willd. ex Schult. / MZUH001074	Caryophyllaceae	Changkalrit	NE	0.79	0.65	0.46	1.90	63
49.	<i>Dysphania ambrosioides</i> (L.) Mosyakin & Clemants / MZUH001282	Amaranthaceae	Mexican tea	NE	0.07	0.08	0.63	0.79	133
50.	<i>Eclipta prostrata</i> (L.) L. / MZUH001297	Asteraceae	Hnakhapui	LC	0.14	0.16	0.63	0.94	132
51.	<i>Elsholtzia communis</i> (Collett & Hemsl.) Diels / MZUH001144	Lamiaceae	Lengser	NE	0.14	0.12	0.47	0.74	134
52.	<i>Emilia sonchifolia</i> (L.) DC / MZUH001298	Asteraceae		NE	0.36	0.57	0.89	1.81	74
53.	<i>Ensete glaucum</i> (Roxb.) Cheesman / MZUH001188	Musaceae	Saisu	NE	0.50	0.57	0.63	1.70	85
54.	<i>Eranthemum strictum</i> Colebr. ex Roxb. / MZUH001001	Acanthaceae	Kawrkampar	NE	0.36	0.53	0.82	1.71	82

55.	<i>Erigeron bonariensis</i> L. / MZUH001299	Asteraceae	Buar-zen	NE	0.22	0.36	0.95	1.53	104
56.	<i>Eryngium foetidum</i> L. / MZUH001017	Apiaceae	Bahkhawr	NE	0.29	0.44	0.87	1.60	94
57.	<i>Etlingera linguiformis</i> (Roxb.) R.M.Sm. / MZUH001266	Zingiberaceae	Aidu chhia	NE	1.58	1.37	0.49	3.44	16
58.	<i>Euphorbia heterophylla</i> L. / MZUH001322	Euphorbiaceae	Ruihthing	LC	0.14	0.20	0.79	1.14	124
59.	<i>Euphorbia hirta</i> L. / MZUH001323	Euphorbiaceae	Zawhte-hlo	NE	0.22	0.44	1.16	1.82	73
60.	<i>Evolvulus nummularius</i> (L.) L. / MZUH001087	Convolvulaceae	-	NE	0.79	0.65	0.46	1.90	64
61.	<i>Fagopyrum esculentum</i> Moench / MZUH001352	Polygonaceae	An-bawng	NE	0.14	0.28	1.11	1.53	97
62.	<i>Floscopa scandens</i> Lour. / MZUH001083	Commelinaceae	-	LC	0.65	0.65	0.56	1.86	67
63.	<i>Galinsoga parviflora</i> Cav. / MZUH001300	Asteraceae	Sazu(pui)chaw	NE	0.58	0.73	0.71	2.01	50
64.	<i>Gamochaeta pensylvanica</i> (Willd.) Cabrera / MZUH001301	Asteraceae	-	NE	0.14	0.32	1.27	1.73	78
65.	<i>Glinus oppositifolius</i> (L.) Aug.DC. / MZUH001336	Molluginaceae	-	LC	0.14	0.28	1.11	1.53	98
66.	<i>Globba orixensis</i> Roxb. / MZUH001267	Zingiberaceae	-	LC	0.72	0.65	0.51	1.87	66

67.	<i>Globba racemosa</i> Sm. / MZUH001268	Zingiberaceae	Aichhia	LC	1.58	1.25	0.45	3.28	22
68.	<i>Gomphrena celosioides</i> Mart. / MZUH001283	Amaranthaceae	Chuai lo par	NE	0.22	0.36	0.95	1.53	105
69.	<i>Grona triflora</i> (L.) H.Ohashi & K.Ohashi / MZUH001126	Fabaceae	-	NE	0.50	0.48	0.54	1.53	103
70.	<i>Hedychium coccineum</i> Buch.-Ham. ex Sm. / MZUH001269	Zingiberaceae	Aichhe par sen	NE	0.50	0.57	0.63	1.70	86
71.	<i>Hedychium greenii</i> W.W.Sm. / MZUH001370	Zingiberaceae	Ainawn	NE	0.65	0.65	0.56	1.86	69
72.	<i>Hedychium stenopetalum</i> G.Lodd. / MZUH001270	Zingiberaceae	Aichhia	NE	0.36	0.32	0.51	1.19	117
73.	<i>Heliconia rostrata</i> Ruiz & Pav. / MZUH001139	Heliconiaceae	Changel	NE	1.22	1.45	0.67	3.35	20
74.	<i>Heliotropium indicum</i> L. / MZUH001307	Boraginaceae	-	NE	0.07	0.32	2.53	2.93	26
75.	<i>Hellenia speciosa</i> (J.Koenig) S.R.Dutta / MZUH001090	Costaceae	Sumbul	NE	3.45	2.54	0.42	6.41	4
76.	<i>Homalomena aromatica</i> (Spr eng.) Schott / MZUH001030	Araceae	Anchiri	EN	4.24	3.03	0.40	7.68	1
77.	<i>Hypoestes phyllostachya</i> Baker / MZUH001274	Acanthaceae	Hypoetes	NE	0.22	0.57	1.48	2.26	41
78.	<i>Impatiens drepanophora</i> Hook.f. / MZUH001054	Balsaminaceae	Nuai eng	NE	0.29	0.28	0.55	1.12	127

79.	<i>Impatiens laevigata</i> Wall. ex Hook.f. & Thomson / MZUH001055	Balsaminaceae	Nuaieng	NE	0.22	0.32	0.84	1.38	108
80.	<i>Impatiens pulchra</i> Hook.f. & Thomson / MZUH001	Balsaminaceae	Hmehzial	NE	0.58	0.65	0.63	1.85	72
81.	<i>Impatiens tripetala</i> Roxb. ex DC. / MZUH001306	Basalminaceae	Hmehzial	NE	0.43	0.53	0.69	1.64	89
82.	<i>Lepidagathis incurva</i> Buch.-Ham. ex D.Don / MZUH001275	Acanthaceae	Vangvattur	NE	0.50	0.97	1.08	2.56	35
83.	<i>Lindernia dubia</i> (L.) Pennell / MZUH001329	Linderniaceae	-	LC	0.29	0.48	0.95	1.72	81
84.	<i>Lobelia nummularia</i> Lam. / MZUH001400	Campanulaceae	Vakep	NE	0.22	0.32	0.84	1.38	110
85.	<i>Lobelia zeylanica</i> L. / MZUH001310	Campanulaceae	-	LC	0.14	0.20	0.79	1.14	125
86.	<i>Ludwigia prostrata</i> Roxb. / MZUH001197	Onagraceae	-	NE	0.65	0.65	0.56	1.86	68
87.	<i>Mazus pumilus</i> (Burm.f.) Steenis, anthur / MZUH001331	Mazaceae	-	NE	0.22	0.24	0.63	1.09	128
88.	<i>Mimosa diplotricha</i> C.Wright / MZUH001128	Fabaceae	-	NE	1.22	1.13	0.52	2.88	27
89.	<i>Mimosa pudica</i> L. / MZUH001129	Fabaceae	Hlo nuar	NE	1.65	1.41	0.48	3.55	13

90.	<i>Mitracarpus hirtus</i> (L.) DC. / MZUH001359	Rubiaceae		NE	0.14	0.32	1.27	1.73	79
91.	<i>Musa × paradisiaca</i> L. / MZUH001341	Musaceae	Balhla	NE	1.58	1.13	0.40	3.12	24
92.	<i>Musa balbisiana</i> Colla / MZUH001189	Musaceae	Changthir	NE	1.08	1.17	0.61	2.86	28
93.	<i>Musa ornata</i> Roxb. / MZUH001190	Musaceae	Changvandawt	LC	2.01	1.90	0.53	4.44	5
94.	<i>Ocimum americanum</i> L. / MZUH001146	Lamiaceae	Runhmui	NE	0.79	0.69	0.49	1.97	53
95.	<i>Ocimum tenuiflorum</i> L. / MZUH001147	Lamiaceae	Tulsi	LC	0.65	0.57	0.49	1.71	83
96.	<i>Oxalis corniculata</i> L. / MZUH001343	Oxalidaceae	Siakthur	NE	0.07	0.20	1.58	1.86	70
97.	<i>Oxalis debilis</i> Kunth / MZUH001344	Oxalidaceae	Siakthur-chi-khat	NE	0.14	0.28	1.11	1.53	99
98.	<i>Parahellenia mizoramensis</i> Lalfakawma, S.D. Khomdram & S.D. Yumkham / MZUH001091	Costaceae	ZZR Sumbul	NE	0.22	0.20	0.53	0.95	130
99.	<i>Peperomia pellucida</i> (L.) Kunth / MZUH001348	Piperaceae	Kaitha	NE	0.58	1.29	1.27	3.13	23
100.	<i>Persicaria chinensis</i> (L.) H.Gross / MZUH001353	Polygonaceae	Kel hmarcha	NE	0.36	0.57	0.89	1.81	75
101.	<i>Persicaria hydropiper</i> (L.) Delarbre / MZUH001354	Polygonaceae	Taham	LC	0.43	0.32	0.42	1.18	119

102.	<i>Phrynium pubinerve</i> Blume / MZUH001167	Marantaceae	Hnahthialnu	NE	1.58	1.45	0.52	3.55	11
103.	<i>Phyllanthus urinaria</i> L. / MZUH001347	Phyllanthaceae	Mitthi sunhlu	NE	0.14	0.28	1.11	1.53	95
104.	<i>Pilea symmeria</i> Wedd. / MZUH001256	Urticaceae	Khup - nal	NE	0.43	0.57	0.74	1.74	77
105.	<i>Plantago major</i> L. / MZUH001209	Plantaginaceae	Kelba-an	NE	0.36	0.61	0.95	1.91	60
106.	<i>Pogostemon sp.</i> / MZUH001328	Lamiaceae		NE	0.14	0.28	1.11	1.53	100
107.	<i>Pollia secundiflora</i> (Blume) Bakh.f. / MZUH001084	Commelinaceae		NE	0.86	1.01	0.66	2.53	39
108.	<i>Potentilla indica</i> (Andrews) Th.Wolf / MZUH001358	Rosaceae		NE	0.07	0.12	0.95	1.14	121
109.	<i>Rumex crispus</i> L. / MZUH001355	Polygonaceae	Anbawng	NE	0.07	0.24	1.90	2.21	44
110.	<i>Rumex nepalensis</i> Spreng. / MZUH001356	Polygonaceae		NE	0.07	0.12	0.95	1.14	122
111.	<i>Rungia pectinata</i> (L.) Nees / MZUH001276	Acanthaceae		NE	0.36	0.93	1.46	2.74	31
112.	<i>Scoparia dulcis</i> L. / MZUH001210	Plantaginaceae	Perhpawng chaw/ Hlothlum	NE	0.72	0.85	0.66	2.23	43
113.	<i>Sesamum indicum</i> L. / MZUH001207	Pedaliaceae	Chhibung	NE	0.50	0.57	0.63	1.70	87

114.	<i>Sigesbeckia orientalis</i> L. / MZUH001302	Asteraceae		NE	0.58	0.53	0.51	1.61	92
115.	<i>Solanum americanum</i> Mill. / MZUH001244	Solanaceae	Anhling	NE	0.65	0.53	0.46	1.63	91
116.	<i>Sonchus oleraceus</i> L. / MZUH001304	Asteraceae	Khuanglawi- suak	NE	0.36	0.48	0.76	1.60	93
117.	<i>Sonchus wightianus</i> DC. / MZUH001303	Asteraceae	Khuanglawi	NE	0.07	0.16	1.27	1.50	106
118.	<i>Sonerila maculata</i> Roxb. / MZUH001172	Melastomataceae	Thaksenhlo	NE	1.29	1.05	0.46	2.80	29
119.	<i>Spermacoce ocymoides</i> Burm.f. / MZUH001361	Rubiaceae	Khuangbaibu	NE	0.29	0.61	1.19	2.08	47
120.	<i>Stachyphrynium</i> <i>placentarium</i> (Lour.) Clausager & Borchs. / MZUH001168	Marantaceae	Hnahthialpa	NE	1.58	1.37	0.49	3.44	17
121.	<i>Staurogyne argentea</i> Wall. / MZUH001002	Acanthaceae	-	NE	0.50	0.57	0.63	1.70	88
122.	<i>Stellaria media</i> (L.) Vill. / MZUH001313	Caryophyllaceae	-	NE	0.22	0.57	1.48	2.26	42
123.	<i>Synedrella nodiflora</i> (L.) Gaertn. / MZUH001305	Asteraceae	-	NE	1.15	0.93	0.45	2.53	38
124.	<i>Tacca integrifolia</i> Ker Gawl. / MZUH001100	Dioscoreaceae	Thialkha	NE	3.81	2.54	0.38	6.73	2
125.	<i>Tadehagi alatum</i> (DC.) H. Ohashi / MZUH001134	Fabaceae	Uifawmaring	NE	0.29	0.48	0.95	1.72	80

126.	<i>Tagetes erecta</i> L. / MZUH001053	Asteraceae	Derhken	NE	0.14	0.16	0.63	0.94	131
127.	<i>Torenia crustacea</i> (L.) Cham. & Schltdl. / MZUH001330	Linderniaceae		LC	0.50	0.44	0.50	1.45	107
128.	<i>Torenia violacea</i> (Azaola) Pennell / MZUH001240	Scrophulariaceae	Arawkeu	NE	0.36	0.69	1.08	2.12	46
129.	<i>Trigastrotheca pentaphylla</i> (L.) Thulin / MZUH001337	Molluginaceae	Va-Umim- Bung	NE	0.14	0.20	0.79	1.14	126
130.	<i>Zephyranthes candida</i> Herb. / MZUH001284	Amaryllidaceae	White rain lily	NE	0.22	0.48	1.27	1.97	54
131.	<i>Zephyranthes minuta</i> (Kunth) D.Dietr. / MZUH001285	Amaryllidaceae	Large Anther rain Lily	NE	0.22	0.65	1.69	2.55	36
132.	<i>Zingiber mizoramense</i> Ram.Kumar, Sushil K.Singh & S.Sharma / MZUH001271	Zingiberaceae	-	NE	0.43	0.32	0.42	1.18	118
133.	<i>Zingiber murlenica</i> Ram.Kumar, Sushil K.Singh & S.Sharma / MZUH001272	Zingiberaceae	-	NE	0.43	0.36	0.47	1.27	114
134.	<i>Zingiber officinale</i> Roscoe / MZUH001273	Zingiberaceae	Sawhthing	LC	0.29	0.32	0.63	1.24	115

Abbreviations: NE= Not Evaluated; LC = Least Concern; RF = Relative Frequency; RD = Relative Dominance; RA = Relative Abundance; IVI=Importance Value Index

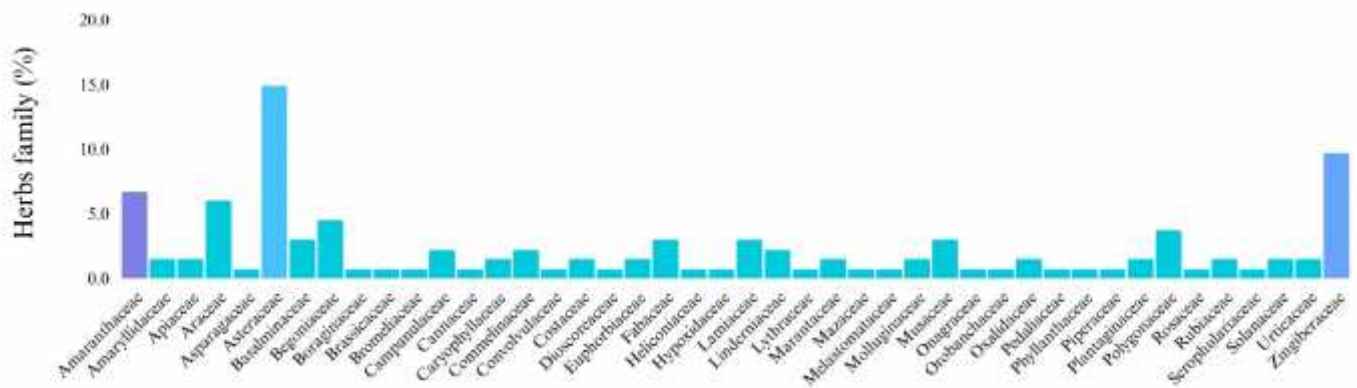


Figure 5.4a: Bar graph showing the herbs family distribution in percentage among the angiosperm families in NWS.

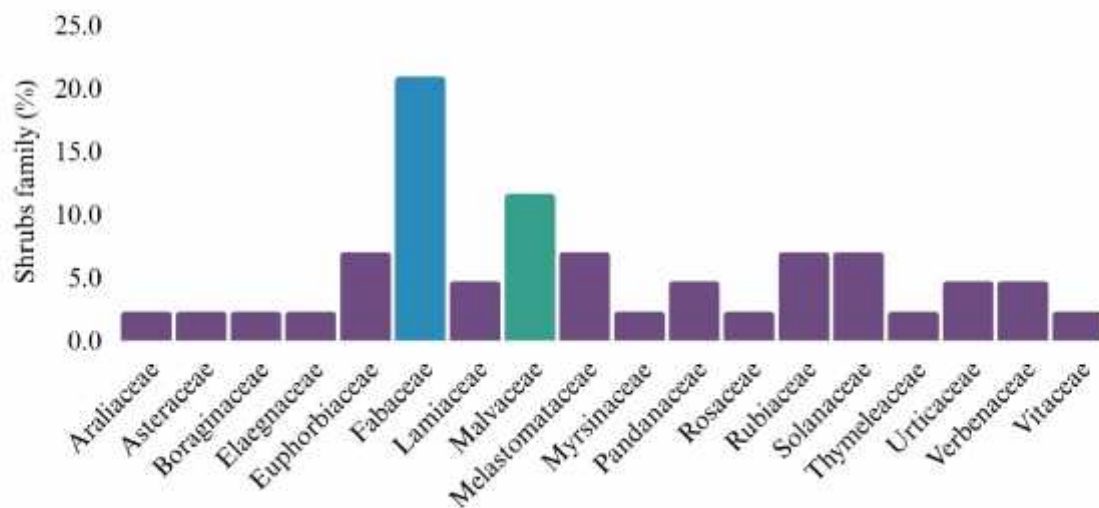


Figure 5.4b: Bar graph showing shrubs family distribution in percentage among the angiosperm families in NWS

5.1.4 Diversity and composition of Shrubs in NWS

In the course of the study, 43 shrub species were identified within the NWS. Notably, among these, the Fabaceae family exhibited the highest diversity, followed by Malvaceae and Solanaceae as shown in **Figure 5.4b**. The top ten species most dominant among shrubs are *Chromolaena odorata* followed by *Mussaenda macrophylla*, *Osbeckia stellata*, *Jatropha curcas*, *Senegalia pruinescens*, *Solanum torvum*, *Clerodendrum inforatum*, *Embelia vestita*, *Barleria cristata* and *Vitex lucens*. Among the species, *Chromolaena odorata* ranks first in Importance Value Index (IVI), indicating its presence as a major concern as the plant is identified as one of the most aggressive invasive alien plant species with the capability to replace many native species (**Table 5.11**). The paradoxical dominance of *Chromolaena odorata*, an invasive plant species, with the highest Importance Value Index (IVI) underscores the complexity of its ecological role. This dominance may be attributed to factors such as its rapid colonization abilities, competitive advantage over native vegetation, and allelopathic effects on neighboring plants. However, while the high IVI of *Chromolaena odorata* underscores its ecological importance, its invasive nature poses challenges for native biodiversity, ecosystem functioning, and management efforts.

Table 5.11. List of shrubs with their scientific names, MZUH accession no., Local name, RET status, RF, RD, RA, IVI and the rank based on IVI IUCN status and Importance Value Index (IVI) found in NWS.

SN	Scientific Names	Family	Local Names	RET Status	RF	RD	RA	IVI	Rank
1	<i>Abelmoschus moschatus</i> Medik. / MZUH001380	Malvaceae	Uichhuhlo	LC	2.91	2.21	1.60	6.72	14
2	<i>Barleria cristata</i> L. / MZUH001372	Acanthaceae	Angkab	NE	3.15	2.90	1.94	8.00	9
3	<i>Cajanus cajan</i> (L.) Millsp. / MZUH001121	Fabaceae	Behliang	NE	1.45	2.07	3.01	6.53	17
4	<i>Catunaregam spinosa</i> (Thunb.) Tirveng. / MZUH001226	Rubiaceae	Sazuk thei	LC	0.48	0.55	2.41	3.44	40
5	<i>Cestrum nocturnum</i> L. / MZUH001241	Solanaceae	Zanlalnu	LC	1.45	1.80	2.61	5.86	23
6	<i>Chromolaena odorata</i> (L.) R.M.King & H.Rob. / MZUH001050	Asteraceae	Tlangsam	LC	11.86	10.79	1.91	24.57	1
7	<i>Clerodendrum infortunatum</i> L. / MZUH001143	Lamiaceae	Phuihnam-chhia	NE	2.91	4.01	2.91	9.82	7
8	<i>Crotalaria micans</i> Link / MZUH001375	Fabaceae	Diral	LC	1.69	1.80	2.23	5.73	27
9	<i>Duranta erecta</i> L. / MZUH001259	Verbenaceae	Kawldai	LC	1.45	1.80	2.61	5.86	24

10	<i>Elaeagnus caudata</i> Schltdl. ex Momiy. / MZUH001104	Elaegnaceae	Sarzuk	LC	1.94	2.21	2.41	6.56	16
11	<i>Embelia vestita</i> Roxb. / MZUH001193	Myrsinaceae	Tling	LC	2.91	3.60	2.61	9.11	8
12	<i>Flueggea virosa</i> (Roxb. ex Willd.) Royle / MZUH001110	Euphorbiaceae	Saisiak	NE	1.69	1.94	2.41	6.04	21
13	<i>Gossypium arboreum</i> L. / MZUH001162	Malvaceae	La	NE	1.94	2.07	2.26	6.27	19
14	<i>Grewia laevigata</i> Vahl / MZUH001163	Malvaceae	Varitabelkan g	NE	0.97	0.97	2.10	4.04	37
15	<i>Hibiscus rosa-sinensis</i> L. / MZUH001165	Malvaceae	Midum pangpar	NE	2.42	2.49	2.16	7.08	11
16	<i>Jatropha curcas</i> L. / MZUH001274	Euphorbiaceae	Komu / Kang damdawi	NE	4.60	5.12	2.34	12.06	4
17	<i>Lantana camara</i> L.	Verbenaceae	Shillong tlangsam	NE	1.45	1.80	2.61	5.86	22
18	<i>Leea compactiflora</i> Kurz / MZUH001155	Vitaceae	Kumtintuai	NE	1.69	1.80	2.23	5.73	28
19	<i>Linostoma decandrum</i> (Roxb.) Steud. / MZUH001251	Thymeleaceae	Ngaihhih	NE	0.48	0.55	2.41	3.44	41
20	<i>Melastoma malabathricum</i> L. / MZUH001169	Melastomataceae	Bui-lu-kham	NE	1.94	1.80	1.95	5.69	30
21	<i>Mussaenda macrophylla</i> Wall. / MZUH001231	Rubiaceae	Vakep	NE	9.93	9.27	1.97	21.16	2

22	<i>Oreocnide integrifolia</i> (Gaudich.) Miq. / MZUH001255	Urticaceae	Zuk buh	NE	4.36	1.80	0.87	7.03	12
23	<i>Osbeckia stellata</i> Buch.-Ham. ex D.Don / MZUH001173	Melastomataceae	Builukham pa	LC	5.08	4.98	2.06	12.13	3
24	<i>Oxyspora paniculata</i> (D.Don) DC. / MZUH001171	Melastomataceae	Khampui	NE	1.69	2.07	2.58	6.35	18
25	<i>Pandanus utilis</i> Bory / MZUH001381	Pandanaceae	Ram lakhuih	NE	0.73	0.69	2.00	3.42	42
26	<i>Pandanus odorifer</i> (Forssk.) Kuntze / MZUH001205	Pandanaceae	Ram lakhuih	LC	1.94	2.07	2.26	6.27	20
27	<i>Pavetta indica</i> L. / MZUH001234	Rubiaceae	Thainu rual	NE	0.97	1.11	2.41	4.48	35
28	<i>Phyllodium elegans</i> (Lour.) Desv. / MZUH001132	Fabaceae	-	LC	0.73	0.97	2.81	4.50	34
29	<i>Pogostemon elsholtzioides</i> Benth. / MZUH001148	Lamiaceae	-	NE	1.69	1.80	2.23	5.73	29
30	<i>Ricinus communis</i> L. / MZUH001374	Euphorbiaceae	Mutih	NE	0.24	0.41	3.61	4.27	36
31	<i>Rosa multiflora</i> Thunb. / MZUH001382	Rosaceae	-	NE	0.24	0.28	2.41	2.92	43
32	<i>Rotula aquatica</i> / MZUH001067	Boraginaceae	Tuipuisuthlah	NE	0.48	0.97	4.21	5.66	31

33	<i>Sarcochlamys pulcherrima</i> Gaud. / MZUH001258	Urticaceae	Lehngo	NE	2.42	2.21	1.92	6.56	15
34	<i>Senegalia pennata</i> (L.) Maslin / MZUH001335	Fabaceae	Khanghu	LC	0.97	1.24	2.71	4.92	32
35	<i>Senegalia pruinescens</i> (Kurz) Maslin, Seigler & Ebinger / MZUH001376	Fabaceae	Khangpawl	NE	4.60	4.01	1.84	10.45	5
36	<i>Senna occidentalis</i> (L.) Link / MZUH001377	Fabaceae	Rengan	LC	0.48	0.41	1.80	2.70	44
37	<i>Senna tora</i> (L.) Roxb. / MZUH001378	Fabaceae	Kelbe	NE	0.73	0.83	2.41	3.96	39
38	<i>Sida acuta</i> Burm.f. / MZUH001383	Malvaceae	Khingkhieh	LC	1.69	2.49	3.09	7.28	10
39	<i>Solanum torvum</i> Sw./ MZUH001378	Solanaceae	Tawkpui	NE	5.08	3.73	1.55	10.37	6
40	<i>Solanum violaceum</i> Ortega / MZUH001245	Solanaceae	Tawkte	LC	1.21	1.24	2.16	4.62	33
41	<i>Tadehagi triquetrum</i> (L.) H. Ohashi / MZUH001116	Fabaceae	Uifawma ring	NE	1.45	1.80	2.61	5.86	25
42	<i>Trevesia palmata</i> (Roxb. ex Lindl.) Vis. / MZUH001373	Araliaceae	Kawhtebel	LC	2.91	2.35	1.70	6.96	13
43	<i>Vachellia farnesiana</i> (L.) Wight & Arn. / MZUH001379	Fabaceae	Khanghu	LC	0.97	0.97	2.10	4.04	38

Abbreviations: NE= Not Evaluated; LC = Least Concern; RF = Relative Frequency; RD = Relative Dominance; RA = Relative Abundance; IVI=Importance Value Index

5.1.5 Diversity and Composition of orchids and climbers within NWS

In our research, conducted over a specific timeframe, we documented the presence of 13 taxa from Orchidaceae family including one ground orchid, as detailed in **Table 5.12**. Additionally, our findings included the documentation of twenty-one climbing plant species, as presented in **Table 5.13**. Notably, among the epiphytes observed, *Dendrobium chrysanthum* and *Dendrobium devonianum* were classified as endangered, indicating a critical threat to their survival. Furthermore, *Aerides rosea* was categorized as vulnerable (VU) based on its status in the IUCN Red List database, signifying a significant risk of extinction in the wild. Numerous orchid species have become extinct in various regions globally (Swarts & Dixon, 2009). It is fortunate that we still have a diverse array of orchid varieties within the sanctuary, not to mention the even greater abundance found throughout Mizoram as a whole. These findings illuminate the importance of monitoring and conservation efforts to safeguard the delicate ecosystems that support these plant species. Additionally, they highlight the need for further research to understand the specific threats facing these plants and to develop targeted conservation strategies to mitigate these risks and ensure the preservation of their biodiversity.

Table 5.12. List of Orchids found in NWS with Scientific Name, Habitat, Local Name and RET status.

SN	Scientific Names	Habitat	Local Names	RET Status
1.	<i>Aerides rosea</i> Lodd. ex Lindl. & Paxton / MZUH001198	Epiphyte	Nauban	VU
2.	<i>Cymbidium aloifolium</i> (L.) Sw. / MZUH001407	Epiphyte	-	NE
3.	<i>Dendrobium aphyllum</i> (Roxb.) C.E.C.Fisch. / MZUH001199	Epiphyte	Nauban	LC
4.	<i>Dendrobium chrysanthum</i> Wall. ex Lindl. / MZUH001201	Epiphyte	Nauban	EN
5.	<i>Dendrobium devonianum</i> Paxton / MZUH001202	Epiphyte	Lenpatkung mam	EN
6.	<i>Dendrobium nobile</i> Lindl. / MZUH001401	Epiphyte	Nauban	NE
7.	<i>Liparis viridiflora</i> (Blume) Lindl. / MZUH001406	Epiphyte	-	NE
8.	<i>Pinalia spicata</i> (D.Don) S.C.Chen & J.J.Wood / MZUH001203	Epiphyte	Nauban	NE
9.	<i>Renanthera imschootiana</i> Rolfe / MZUH001402	Epiphyte	Senhri	EN
10.	<i>Rhynchostylis retusa</i> (L.) Blume / MZUH001405	Epiphyte	Foxtail orchid	EN
11.	<i>Spathoglottis pubescens</i> Lindl. / MZUH001408	Terrestrial	-	NE
12.	<i>Vanda coerulea</i> Griff. ex Lindl. / MZUH001403	Epiphyte	Lawhlei	EN
13.	<i>Vanda testacea</i> (Lindl.) Rchb.f. / MZUH001404	Epiphyte	-	NE

Table 5.13. List of Climbers found in NWS with their Scientific Name, Family, Local Names and RET status

S.no	Scientific Name	Family	Local Names	IUCN Status
1	<i>Argyreia nervosa</i> (Burm.f.) Bojer / MZUH001315	Convolvulaceae	-	NE
2	<i>Aristolochia</i> sp / MZUH001043	Aristolochiaceae	-	-
3	<i>Ayenia grandifolia</i> (DC.) Christenh. & Byng / MZUH001161	Malvaceae	Zawng luang hrui	NE
4	<i>Benincasa hispida</i> (Thunb.) Cogn. / MZUH001092	Cucurbitaceae	Mai pawl	NE
5	<i>Cissus discolor</i> Blume / MZUH001368	Vitaceae		NE
6	<i>Cissus repanda</i> (Wight & Arn.) Vahl / MZUH001261	Vitaceae	Hrui pawl	NE
7	<i>Cuscuta reflexa</i> Roxb. / MZUH001086	Convolvulaceae	Japan hlo ral	LC
8	<i>Decalepis khasiana</i> (Kurz) Ionta ex Kambale / MZUH001020	Apocynaceae	Thei kelki	NE
9	<i>Dioscorea bulbifera</i> L. / MZUH001320	Dioscoreaceae	Phungbachim	NE
10	<i>Dioscorea alata</i> L. / MZUH001099	Dioscoreaceae	Bachhim	NE
11	<i>Entada phaseoloides</i> (L.) Merr. / MZUH001124	Fabaceae	Kawihrui	NE
12	<i>Ipomoea cairica</i> (L.) Sweet / MZUH001316	Convolvulaceae		LC
13	<i>Ipomoea hederifolia</i> L. / MZUH001088	Convolvulaceae	Nipui par	NE
14	<i>Ipomoea batatas</i> (L.) Lam. / MZUH001089	Convolvulaceae	Kawlbahra	LC
15	<i>Mikania micrantha</i> Kunth / MZUH001052	Asteraceae	Japan hlo	NE
16	<i>Millettia pulchra</i> (Voigt) Kurz / MZUH001127	Fabaceae	Kaikuang ru	NE

17	<i>Mucuna pruriens</i> (L.) DC. / MZUH001130	Fabaceae	Uite me	NE
18	<i>Paederia foetida</i> L. / MZUH001233	Rubiaceae	Vawihuih hrui	LC
19	<i>Passiflora napalensis</i> Wall. / MZUH001206	Passifloraceae	Nauawium	LC
20	<i>Phanera scandens</i> (L.) Lour. ex Raf / MZUH001325	Fabaceae	Zawnga Leilawn	NE
21	<i>Piper betle</i> L. / MZUH001208	Piperaceae	Ram panhnah	NE
22	<i>Piper longum</i> L. / MZUH001349	Piperaceae	Voko-hrui	NE
23	<i>Rhaphidophora decursiva</i> (Roxb.) Schott / MZUH001290	Araceae	Thiallawn	NE
24	<i>Smilax zeylanica</i> L. / MZUH001363	Smilacaceae	Kai-tluang	NE
25	<i>Thunbergia alata</i> Bojer ex Sims / MZUH001003	Acanthaceae	Zawnga fian	NE
26	<i>Thunbergia coccinea</i> Wall. ex D.Don / MZUH001277	Acanthaceae	-	NE
27	<i>Thunbergia grandiflora</i> Roxb. / MZUH001278	Acanthaceae	Vokohrui	NE
28	<i>Tinospora cordifolia</i> (Willd.) Hook.f. & Thomson / MZUH001171	Menispermaceae	Hruivankai	NE
29	<i>Trichosanthes tricuspidata</i> Lour. / MZUH001319	Cucurbitaceae	Choak-a um	NE
30	<i>Uncaria sessilifructus</i> Roxb. / (Rubiaceae) / MZUH001235	Rubiaceae	Ralsamkuai	LC
31	<i>Vallaris solanacea</i> (Roth ex Roem. & Schult.) Kuntze / MZUH001021	Apocynaceae	Theikelki suak	LC
32	<i>Willughbeia edulis</i> Roxb. / MZUH001022	Apocynaceae	Vuakdup	NE

5.1.6 Diversity and Composition of Grasses, canes and palms within NWS

Sixteen species of grasses were identified, spanning the Poaceae and Cyperaceae families, as detailed in **Table 5.14**. Additionally, nine species of canes and palms, categorized under the Arecaceae family, were documented. Notably, among these, *Borassus flabellifer* was classified as Endangered, while *Calamus acanthospathus* and *Calamus erectus* were deemed Vulnerable according to their IUCN status, as outlined in **Table 5.15**. These classifications emphasize the conservation importance of these species and the need to protect their natural habitats to prevent further decline. The presence of these rare and endangered species accentuates the ecological significance of Mizoram and highlights the urgent need for ongoing conservation efforts to preserve its unique biodiversity.

Table 5.14. List of Grasses in NWS with Scientific Names, Family, Local names, IUCN Status.

SN	Scientific Names/ MZUH accession no.	Family	Local Names	IUCN Status
1	<i>Bambusa longispiculata</i> Gamble / MZUH001211	Poaceae	Raw thing	NE
2	<i>Cyperus croceus</i> Vahl / MZUH001093	Cyperaceae	-	LC
3	<i>Cyperus iria</i> L. / MZUH001094	Cyperaceae	-	LC
4	<i>Cyrtococcum oxyphyllum</i> (Hochst. ex Steud.) Stapf / MZUH001212	Poaceae	-	NE
5	<i>Cyrtococcum patens</i> (L.) A.Camus / MZUH001213	Poaceae	-	NE
6	<i>Dendrocalamus longispathus</i> (Kurz) Kurz / MZUH001214	Poaceae	Rawnal	NE
7	<i>Digitaria radicata</i> (J.Presl) Miq. / MZUH001215	Poaceae	Changte	NE
8	<i>Imperata cylindrica</i> (L.) Raeusch. / MZUH001216	Poaceae	Di	NE
9	<i>Melocanna baccifera</i> (Roxb.) Kurz / MZUH001217	Poaceae	Mau tak	NE
10	<i>Oplismenus hirtellus</i> (L.) P.Beauv. / MZUH001218	Poaceae	-	NE
11	<i>Rhynchospora colorata</i> (L.) H.Pfeiff. / MZUH001095	Cyperaceae	Artelubawk	NE
12	<i>Scleria terrestris</i> (L.) Fassett / MZUH001096	Cyperaceae	Thip nem	LC
13	<i>Setaria palmifolia</i> (J.Koenig) Stapf / MZUH001219	Poaceae	hang chikhat	NE

14	<i>Sporobolus diandrus</i> (Retz.) P.Beauv. / MZUH001220	Poaceae	Phul	NE
15	<i>Themeda villosa</i> (Poir.) A.Camus / MZUH001221	Poaceae	Phaiphek	LC
16	<i>Thysanolaena latifolia</i> (Roxb. ex Hornem.) Honda / MZUH001222	Poaceae	Hmunphiah	NE

Table 5.15.List of Canes and Palms in NWS with Scientific names, Family, Local names, RET Status.

SN	Scientific Name	Family	Local Names	IUCN Status
1.	<i>Areca triandra</i> Roxb. ex Buch.-Ham. / MZUH001033	Arecaceae	Uvai	LC
2.	<i>Arenga pinnata</i> (Wurmb) Merr. / MZUH001034	Arecaceae	Thangtung	LC
3.	<i>Borassus flabellifer</i> L. / MZUH001035	Arecaceae	Siallu	EN
4.	<i>Calamus acanthospathus</i> Griff / MZUH001036	Arecaceae	Mit perh	VU
5.	<i>Calamus erectus</i> Roxb. / MZUH001037	Arecaceae	Thilthek	VU
6.	<i>Calamus guruba</i> Buch.-Ham. ex Mart. / MZUH001038	Arecaceae	Thilte	NE
7.	<i>Calamus latifolius</i> Roxb. / MZUH001040	Arecaceae	Hnabhawr	VU
8.	<i>Calamus melanochaetes</i> (Blume) Miq. / MZUH001041	Arecaceae	Raichhawk (Hruizik)	VU
9.	<i>Caryota urens</i> L. / MZUH001390	Arecaceae	Mei-hle	LC
10.	<i>Licuala spinosa</i> Wurmb. / MZUH001042	Arecaceae	Laisua	NE

In summary, herbs exhibited the highest diversity, encompassing 45 families, 103 genera, and 134 species. In contrast, climbers demonstrated the lowest diversity, with only 17 families, 25 genera, and 32 species as shown in **Table 5.16**. Herbs tend to thrive in such environments due to the favorable conditions, such as ample moisture, warmth, and nutrient-rich soil, which promote the growth and diversity of smaller, ground-level plants. Moreover, the forest canopy provides a regulated microclimate that benefits herbaceous plants.

Table 5.16: Angiosperm Composition analysis among Tree, Herbs, Shrubs and Climbers in NWS

Rank	Trees	Herbs	Shrubs	Climbers
Family	40	45	19	17
Genus	76	103	39	25
Species	105	134	43	32

On the other hand, climbers might be more specialized and thus less diverse compared to the more adaptable herbs. The reserved status of the forest may also mean that human disturbances are minimal, allowing a natural balance to persist, further influencing the observed plant diversity patterns.

5.2 RET species

RET species, or "Rare, Endangered, or Threatened" species, refer to those plants or animals that are at risk of extinction due to various factors such as habitat loss, overexploitation, pollution, and climate change. These species play a crucial role in maintaining biodiversity and ecosystem stability. The majority of species classified as RET offer diverse benefits, ranging from medicinal and nutritional value to fulfilling various ecological roles. Sadly, the exploitation of these species for their resources often leads to their extinction.

A total of 25 species are identified under the Rare, Endangered and Threatened (RET) taxa which shows that the NWS still harbours many threatened taxa as well as home to some undescribed taxa (**Table 5.17**). Recently, we described a new species *Parahellenia mizoramensis* from the study site (Lalfakawma *et al.*, 2024). Each part of the forest requires tailored care due to its unique characteristics. Certain plants in the sanctuary under RET category need immediate protection. As seen with *Homalonema aromatica*, outsiders purchase its rhizomes at a lucrative price for gunpowder production, leading to locals extracting them from the sanctuary for profit. As a threatened species, it requires meticulous attention and protection.

Table 5.17. List of threatened (RET) taxa with Scientific name, Family, Local name and RET status.

SN	Scientific Name	Family	Local Names	RET Status
1.	<i>Aerides rosea</i> Lodd. ex Lindl. & Paxton	Orchidaceae	Nauban	VU
2.	<i>Bombax insigne</i> Wall.	Bombacaceae	Pang	CR
3.	<i>Borassus flabellifer</i> L.	Arecaceae	Siallu	EN
4.	<i>Calamus acanthospathus</i> Griff	Arecaceae	Mit perh	VU
5.	<i>Calamus erectus</i> Roxb.	Arecaceae	Thilthek	VU
6.	<i>Calamus latifolius</i> Roxb.	Arecaceae	Hnabhawr	VU
7.	<i>Calamus melanochaetes</i> (Blume) Miq.	Arecaceae	Raichhawk (Hruizik)	VU
8.	<i>Citrus macroptera</i> Montrouz.	Rutaceae	Hatkawra	EN
9.	<i>Dendrobium chrysanthum</i> Wall. ex Lindl.	Orchidaceae	Nauban	EN
10.	<i>Dendrobium devonianum</i> Paxton	Orchidaceae	Lenpatkungmam	EN
11.	<i>Dipterocarpus retusus</i> Blume	Dipterocarpaceae	Thingsen	EN
12.	<i>Dipterocarpus turbinatus</i> C.F. Gaertn.	Dipterocarpaceae	Vailawng	VU
13.	<i>Homalomena aromatica</i> (Spreng.) Schott	Araceae	Anchiri	EN
14.	<i>Kydia calycina</i> Roxb.	Malvaceae	Thalteh	NT
15.	<i>Licuala spinosa</i> Wurm.	Arecaceae	Laisua	EN
16.	<i>Mesua ferrea</i> L.	Clusiaceae	Herhse	EN
17.	<i>Oroxylum indicum</i> Vent	Bignoniaceae	Archangkawm	EN
18.	<i>Parahellenia mizoramensis</i>	Costaceae	ZZR Sumbul	CR
19.	<i>Prunus ceylanica</i> Miq.	Rosaceae	Rahphir	EN
20.	<i>Saurauia punduana</i> Wall.	Actinidiaceae	Tiar	CR
21.	<i>Renanthera imschootiana</i> Rolfe	Orchidaceae	Senhri	EN
22.	<i>Rhynchostylis retusa</i> (L.) Blume	Orchidaceae	Foxtail orchid	EN
23.	<i>Terminalia chebula</i> Retz	Combretaceae	Reraw	NT
24.	<i>Terminalia myriocarpa</i> Van Heurck & Müll.Arg.	Combretaceae	Char	EN
25.	<i>Vanda coerulea</i> Griff. ex Lindl.	Orchidaceae	Lawhlei	EN

Abbreviations: CR=Critically Endangered; EN=Endangered; VU=Vulnerable; NT=Near Threatened;

Also, many invasive alien plants like *Chromolaena odorata*, *Lantana camara*, and *Ageratina adenophora* have started growing in the peripheral parts of the sanctuary as well as the disturbed sites which is another major concern as the encroachment of these invasive alien plants threatens the integrity of the sanctuary's ecosystem. Their presence in the peripheral areas and disturbed sites indicates their ability to spread rapidly and colonize new habitats, outcompeting native flora and altering ecosystem dynamics. The invasion of these species can lead to habitat degradation, loss of biodiversity, and disruption of ecological processes, ultimately compromising the sanctuary's ecological resilience and capacity to support native wildlife. Effective management strategies are urgently needed to control the spread of these invasive species and mitigate their detrimental impacts on the sanctuary's biodiversity and ecosystem health.

5.3 Endemic Species

Endemic plants are those that are native to a specific geographic area and are found nowhere else in the world. These plants often evolve unique characteristics due to the isolation and specific environmental conditions of their habitats. In the case of Mizoram, its unique geographical and climatic conditions have fostered the evolution of several plant species found exclusively within its borders. The diverse topography, ranging from lush valleys to highland areas, coupled with a subtropical climate, creates an ideal environment for these endemic species to thrive. Most of the species under the RET status reported from the study site is found to be endemic to specific regions of northeast India, extended himalayan region and even in the southeast asian region. Also, the dominant herbaceous taxa *Homalomena aromatica* is endemic to northeast india and Eastern Himalayan region (Ronald *et al.*, 2019). Among the species found in the NWS native to Mizoram are *Parahellenia mizoramensis*, *Zingiber mizoramense*, and *Zingiber murlenica*. These plants not only contribute to the region's rich biodiversity but also hold potential cultural and medicinal significance for local communities. Their existence underscores the importance of preserving Mizoram's natural habitats to maintain its ecological heritage and biodiversity.

5.4 Ethnobotanical study within NWS

5.4.1 Demographic profile of informants

A total of 100 informants from 11 ethnic communities that include *Lushai*, *Lai*, *Bru*, *Bawm*, *Zakhai*, *Khumi*, *Pang*, *Mara*, *Paihte*, *Chakma*, and *Matu* tribes residing in the fringe villages of NWS were selected randomly and interviewed (Teklehaymanot and Giday, 2007), with the majority being male and aged between 30 and 85 years (**Table 5.18**). The ethnographic investigation documented numerous applications of plants as recounted by the informants. These encompassed a multifaceted array of purposes: medicinal uses, sustenance, construction materials, handicraft production, fodder for livestock, and the cultivation of fruits. However, the paramount and remarkably diverse utility of the plants resided in their medicinal properties. Regarding the experiential background of traditional practitioners, a significant proportion, accounting for 71% of the informants, boasted a wealth of expertise spanning a minimum of 20 years in the therapeutic application of ethnomedicinal plants for treating individuals. In terms of educational standing, 73 % had just elementary and secondary education, while 18 % were uneducated; 76 % were literate, while the remainder could only communicate by signs and verbal communication. Among the occupations reported, the majority (41%) were involved in agriculture, followed by lumberjacks (24%), herbalists (15%), church leaders (8%), schoolteachers (7%), missionaries (3%), and hunters (2%). This diverse occupation profile reflects the varied livelihood strategies and cultural practices of the local population.

Table 5.18: Demographic Characteristics of Informants in NWS

Variables	Categories	No. of Informants
Gender	Male	83
	Female	17
Occupations	Male Herbalist	11
	Female Herbalist	4
	Church Leader	8
	School Teacher	7
	Agriculturist	41

	Missionaries	3
	Lumberjack	24
	Hunters	2
Religion	Christian	97
Education	Others	3
	Illiterate	24
	Primary	47
Age Group	Secondary	26
	University	9
	30-40	19
	40-50	26
	50-60	23
	60-70	17
	70-80	11
	>80	4

5.4.2 Ethnomedicinal Plants

The majority of medicinal plants collected from NWS were trees, totaling 37 species, as shown in Table 5.12. Herbs were also prevalent, with 35 species, followed by shrubs with 16

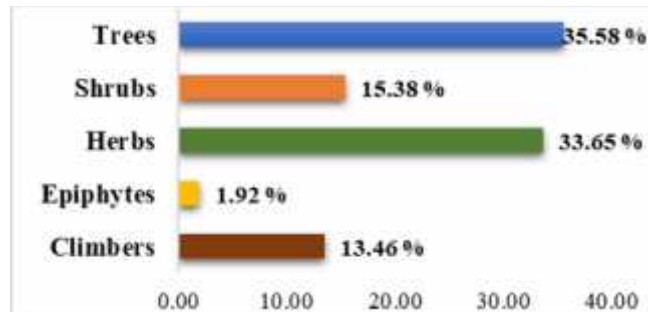


Figure 5.5. Percentage of habit types of ethnomedicinal plants in NWS.

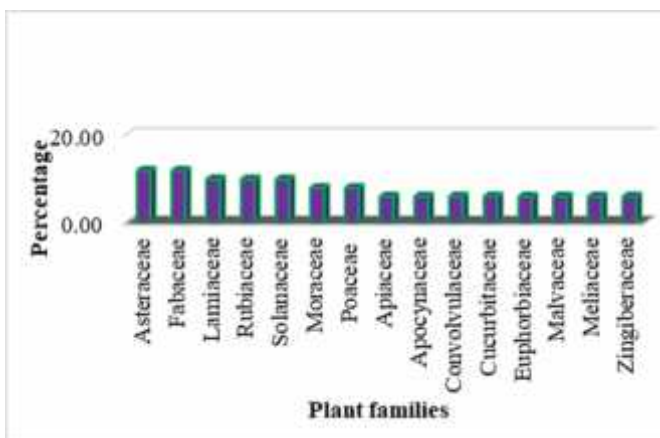


Figure. 5.6 Percentage of ethnomedicinal plant species among the dominant families in NWS

species. Climbers were represented by 14 species, while epiphytes were the least common, with only 2 species identified (see **Figure 5.5**). Comparing these findings with other studies, it is noteworthy that in some research, trees were the

primary plants used for medicinal purposes, similar to the situation in NWS (Ngarivhume *et al.*, 2015), whereas in other studies, herbs were more dominant (Kala *et al.*, 2004). The ethnobotanical survey identified a total of 104 medicinal plant species, distributed across 44 families and 97 genera, as detailed in **Table 5.20**. The families with the highest number of species were Asteraceae and Fabaceae, each with 6 species. They were followed by Lamiaceae, Rubiaceae, and Solanaceae, each with 5 species, among several others. (**Figure 5.6**).

Based on data collected from both semi-structured and structured interviews, a total of 44 health issues were documented and categorized into 13 distinct groups, as outlined in **Table 5.19**. Various diseases and dysfunctions were grouped into specific ailment categories according to the affected bodily systems.

Table 5.19: Ailments categories of the ethnomedicinal plants from NWS, Mizoram

Ailments Category	Medical Terms
Gastro-Intestinal Ailments (GIA)	Diarrhoea, ulcers, piles, indigestion, nausea, vomiting, dysentery, de-worming, constipation, stomach-ache, typhoid, cholera
Dermatological Infection/ Diseases (DID)	Cuts, wounds, boils, burns, ring worm, skin-allergy, chicken pox, measles
Skeleto-Muscular System Disorder (SMSD)	Rheumatism, bone fracture, ligamentous pain, torn ligaments.
Vector Borne Diseases (VBD)	Malaria
Respiratory Disease Syndrome (RSD)	Asthma, pulmonary affliction, bronchitis, tuberculosis
Genito-Urinary Ailments (GUA)	Menstrual disorder, infertility, galactagogue, diuretic, diabetes, and kidney stones
Cell Division Disorder (CDD)	Stomach cancer, lung cancer and other cancer types
General Health (GH)	Fever, headache, cough, tonic
Poisonous Bites (PB)	Snake/insect bite, bee sting and leech bite

Dental Care (DC)	Tooth and gum disorder
Cardiovascular disorder (CVD)	Hypertension, low blood pressure, strokes
Ear Nose Throat (ENT) problem	Tonsillitis, sinusitis, eye & ear related problem
Liver and Spleen Disorder (LSD)	Hepato-protective, jaundice & hepatitis

In this study (**Table 5.7, Figure 5.8**), various plant parts—roots, stem bark, leaves, flowers, fruits, stem juice, and latex—were used in medicinal formulations. Decoction was the most common preparation, though some herbs were consumed raw (Figure 5.8b). Traditional healers predominantly used leaves (41%), followed by bark (13%), fruit (12%), stem (12%), rhizome (9%), roots (8%), flowers (3%), and

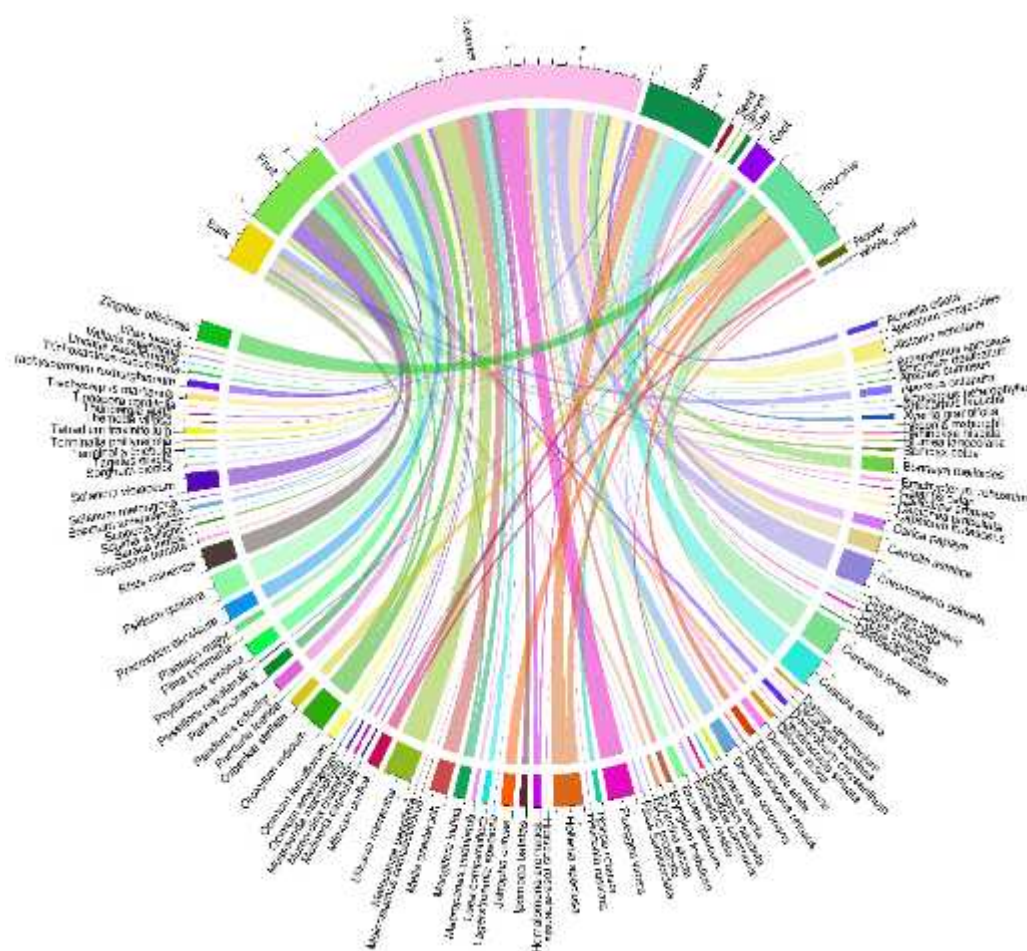


Figure 5.7:Chord diagram of ethnomedicinal plant parts used in NWS

seeds (2%) (Figure 5.8a). Leaves were favored for their ease of collection, availability, and high secondary metabolite content (Kumar *et al.*, 2022).

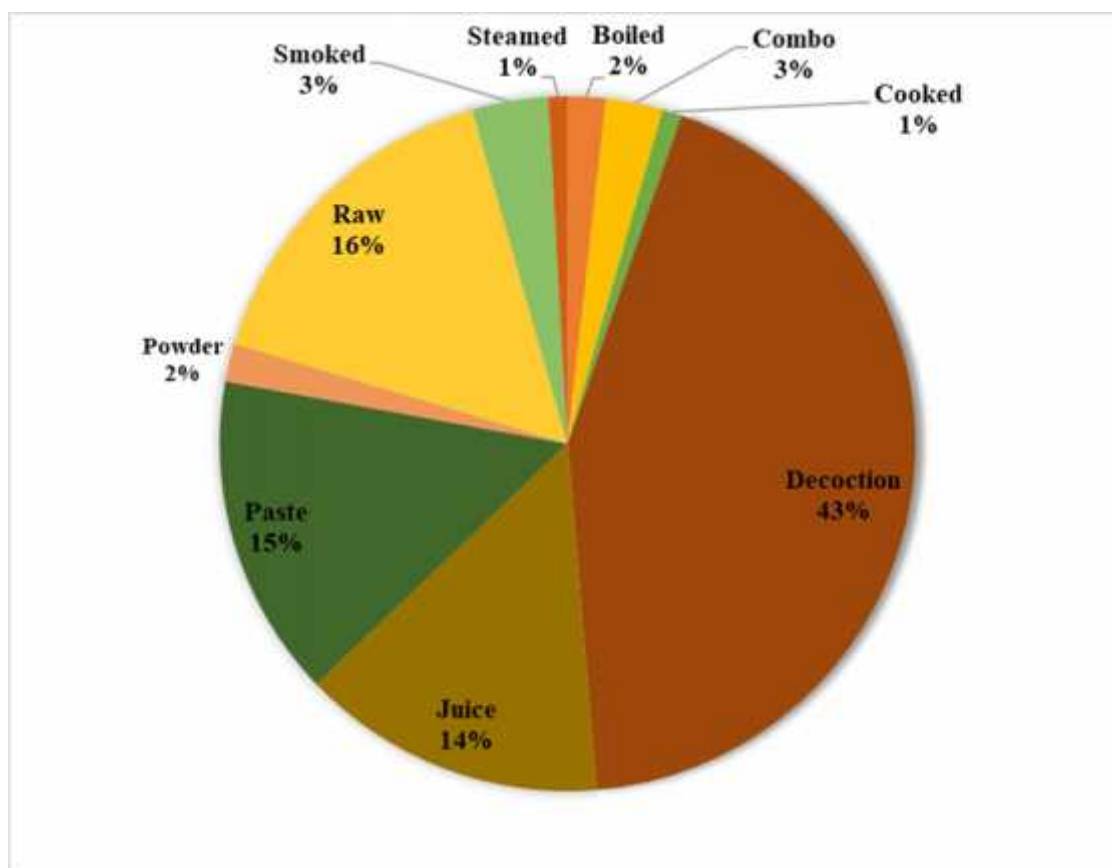


Figure 5.8: Ethnomedicinal plants percentage for their mode of usage in NWS

To identify the most frequently used medicinal plants for treating diseases and assess the consensus among informants in the NWS area regarding plant usage for specific ailments, the following parameters were calculated.

a) Relative Frequency of Citation (RFCs)

This approach involved assessing the RFC values alongside the number of informants who cited these plant species for disease treatment across various locations. The analysis revealed several medicinal plants that were frequently employed, including *Cuscuta reflexa* (0.89), *Curcuma longa* (0.88), *Chromolaena odorata* (0.86), *Mikania micrantha* (0.85), *Flueggea virosa* (0.79), *Oroxylum indicum* (0.68), *Curcuma longa* (0.64), *Mikania micrantha* (0.64), *Rhus chinensis*

Table 5.20: Ethnomedicinal plants of NWS with scientific names, families, voucher nos., local names, habits, part used, folk preparation/formulations, RFC, UV and IUCN status.

SN	Scientific Names / Family / Voucher No.	Local Names	Habit / Part Used	Folk Preparation / Formulation	RFC	UV	IUCN Status
1	<i>Acmella ciliata</i> (Kunth) Cass./ Asteraceae /MZUH001044	<i>Ansate</i>	Herb / L	Fresh leaves chewed to relieve toothache; juice of crushed leaves used against insect bites and stings	0.14	0.17	NE
2	<i>Ageratum conyzoides</i> L. / Asteraceae / MZUH001046	<i>Vailenhlo</i>	Herb / L, S	Leaves and stem decoction taken orally against Bell's palsy	0.03	0.03	LC
3	<i>Alstonia scholaris</i> (L.) R.Br. /Apocynaceae / MZUH001019	<i>Thuamriat</i>	Tree / L	Leaves decoction used against fever and malaria, with juice taken orally or steamed with vapour	0.39	0.48	NE
4	<i>Amaranthus spinosus</i> L. / (Amaranthaceae) /MZUH001009	<i>Lenhling</i>	Herb / L	Decoction of leaves used against cough	0.04	0.04	LC
5	<i>Amomum dealbatum</i> Roxb. / (Zingiberaceae) / MZUH001369	<i>Aidu</i>	Herb / Fr	Decoction of fruit used for indigestion and flatulence	0.22	0.25	DD
6	<i>Ananas comosus</i> (L.) Merr. / (Bromeliaceae) / MZUH001068	<i>Lakhuih thei</i>	Herb / Fr	Young fruit taken for birth control	0.03	0.03	NE
7	<i>Aporosa octandra</i> (Buch.-Ham. ex D.Don) Vickery / (Euphorbiaceae) / MZUH001106	<i>Chhawntu al</i>	Tree / Bk	Bark decoction used against stomach ache & stomach ulcer	0.21	0.23	LC

8	<i>Artocarpus heterophyllus</i> Lam. / (Moraceae) / MZUH001339	<i>Lamkhuan g</i>	Tree / L	Ash of burnt leaves paste applied on bite marks of dog bite	0.01	0.01	NE
9	<i>Artocarpus lacucha</i> Buch.-Ham. / (Moraceae) / MZUH001181	<i>Theitat</i>	Tree / F (La)	Latex of young fruits applied against boil	0.02	0.02	NE
10	<i>Ayenia grandifolia</i> (DC.) Christenh. & Byng / (Malvaceae) / MZUH001161	<i>Zawng luang hrui</i>	Climber / L, R	Decoction of leaves and roots against headache	0.13	0.13	NE
11	<i>Begonia roxburghii</i> (Miq.) A. DC. / (Begoniaceae) / MZUH001060	<i>Sekhupthur</i>	Herb / Rz	Juice of rhizomes for birth control	0.01	0.01	NE
12	<i>Benincasa hispida</i> (Thunb.) Cogn. / (Cucurbitaceae) / MZUH001093	<i>Mai pawl</i>	Climber / Fr	Fruit consumed against diarrhoea	0.06	0.06	NE
13	<i>Blumea lanceolaria</i> (Roxb.) Druce / (Asteraceae) / MZUH001049	<i>Buarze</i>	Herb / Rz	Juice of rhizomes for birth control	0.02	0.02	LC
14	<i>Bombax ceiba</i> L / (Malvaceae) / MZUH001064	<i>Phunchawng</i>	Tree / Bk	Decoction of bark used for wound healing	0.09	0.09	NE

15	<i>Bonnaya ruelloides</i> (Colsm.) Spreng. / (Linderniaceae) / MZUH001156	<i>Thasuih</i>	Herb / Bk, L	Crushed bark or leaves pasted on against ligamentous pain	0.42	0.42	LC
16	<i>Brachypterum robustum</i> (Roxb. ex DC.) Dalzell & A.Gibson / (Fabaceae) / MZUH001324	<i>Thingkha</i>	Tree / Bk	Decoction of bark against malaria	0.08	0.08	NE
17	<i>Cajanus cajan</i> (L.) Millsp. / (Fabaceae) / MZUH001121	<i>Behliang</i>	Shrub / L, R	Decoction of leaves and roots taken for jaundice	0.03	0.03	NE
18	<i>Callicarpa arborea</i> Roxb. / (Lamiaceae) / MZUH001142	<i>Hnahkiah</i>	Tree / L	Decoction of leaves taken allergy against pork consumption	0.03	0.03	LC
19	<i>Camonea umbellata</i> (L.) A.R.Simões & Staples / (Convolvulaceae) / MZUH001085	<i>Thian-pa</i>	Herb / L	Decoction of leaves taken against jaundice	0.07	0.07	NE
20	<i>Capsicum frutescens</i> L. / (Solanaceae) / MZUH001242	<i>Hmarchate</i>	Shrub / Fr	Paste of crushed fruits applied on bite marks against snake bites	0.02	0.02	LC
21	<i>Carica papaya</i> L. / (Caricaceae) / MZUH001312	<i>Thingfanghma</i>	Tree / L	Decoction of leaves against hypertension, young fruit taken for birth control	0.27	0.31	DD
22	<i>Centella asiatica</i> (L.) Urb. / (Apiaceae) / MZUH001018	<i>Lambak</i>	Herb / L	Decoction of leaves used against stomach ache	0.47	0.47	LC
23	<i>Chromolaena odorata</i> (L.) R.M.King & H.Rob. / (Asteraceae)	<i>Tlangsam</i>	Shrub / L, S	Juice applied on fresh wounds	0.86	0.86	LC

	/MZUH001050						
24	<i>Chukrasia tabularis</i> A.Juss. / (Meliaceae) / MZUH001175	<i>Zawngtei</i>	Tree / Bk, Fr	Juice of Bark & Fruit against diarrhoea	0.04	0.04	NE
25	<i>Cissus repanda</i> var. <i>repanda</i> (Wight & Arn.) Vahl / (Vitaceae) / MZUH001261	<i>Hrui pawl</i>	Climber / L	Leaves chewed to cure toothache	0.03	0.03	NE
26	<i>Citrus sinensis</i> (L.) Osbeck / (Rutaceae) / MZUH001362	<i>Sermam</i>	Tree / Sd	Decoction of seeds used against hypertension	0.07	0.07	NE
27	<i>Cocos nucifera</i> L. / (Arecaceae) / MZUH001371	<i>Coconut</i>	Tree / L, Fr	Leaves are smoked and juice used for 5 mins for earache	0.01	0.01	NE
28	<i>Colocasia esculenta</i> (L.) Schott. / (Araceae) / MZUH001028	<i>Dawl</i>	Herb / S	Stem secretion used to suck out venom of snakes	0.04	0.04	LC
29	<i>Curcuma longa</i> L. / Zingiberaceae) / MZUH001265	<i>Aieng</i>	Herb / Rz	Rhizome & decoction against stomach ache; hypertension; paste of powdered rhizome used for skin care (tonic)	0.88	0.89	NE
30	<i>Cuscuta reflexa</i> Roxb. / (Convolvulaceae) / MZUH001086	<i>Japan hloral</i>	Climber / S	Decoction of stem against jaundice, cholera and diarrhoea	0.89	0.89	LC
31	<i>Datura stramonium</i> L. / (Solanaceae) / MZUH001243	<i>Tawtawrawt par</i>	Herb / Fl	Flowers consumed as pain killer, but toxic in high quantity	0.08	0.08	NE

32	<i>Decalepis khasiana</i> (Kurz) Ionta ex Kambale / (Apocynaceae) / MZUH001020	<i>Thei kelki</i>	Climber / L	Crushed leaves along with honey or sugar consumed to treat cough	0.02	0.02	NE
33	<i>Dendrobium chrysanthum</i> Wall. ex Lindl. / (Orchidaceae) / MZUH001200	<i>Nauban</i>	Epiphyte / Fr	Paste of crushed pod used on sore	0.17	0.17	EN
34	<i>Dendrocide sinuata</i> (Blume) Chew / (Urticaceae) / MZUH001366	<i>Thakpui</i>	Tree / L	Infected person lay down on top of leaves scattered at floor to cure snake bite	0.01	0.01	NE
35	<i>Dillenia indica</i> L. / (Dilleniaceae) / MZUH001098	<i>Kawrthindeng</i>	Tree / Fr	Decoction taken as tonic	0.15	0.15	LC
36	<i>Dimetia scandens</i> (Roxb.) R.J.Wang / (Rubiaceae) / MZUH001227	<i>Kelhnamtur</i>	Shrub / L, S	Decoction of leaves and stem against kidney problem	0.21	0.21	NE
37	<i>Dioscorea alata</i> L. / (Dioscoreaceae) / MZUH001099	<i>Bachhim</i>	Climber / Rz	Decoction of tuber used against cancer	0.22	0.22	NE
38	<i>Dipterocarpus retusus</i> Blume / (Dipterocarpaceae) / MZUH001101	<i>Thingsen</i>	Tree / S	Sap of stem boiled with water taken against infection in urinary tracts	0.07	0.07	EN
39	<i>Drynaria coronans</i> (Wall. ex Mett.) J.Sm. / (Polypodiaceae) / MZUH001223	<i>Awmvel</i>	Epiphyte / L	Decoction of leaves applied externally on infected area to cure shingles	0.43	0.43	NE
40	<i>Duranta erecta</i> L. / (Verbenaceae) / MZUH001259	<i>Kawldai</i>	Shrub / L	Crushed leaves pasted on decaying tooth twice a day	0.13	0.13	LC
41	<i>Elaeagnus caudata</i> Schltld. ex Momiy. /	<i>Sarzuk</i>	Shrub / R	Decoction of roots used for cleaning	0.06	0.06	LC

42	(Elaeagnaceae) / MZUH001104 <i>Elsholtzia communis</i> (Collett & Hemsl.) Diels / (Lamiaceae) / MZUH001144 <i>Embelia vestita</i> Roxb.	<i>Lengser</i>	Herb / L, Fl, S	uterus Whole plant consumed against flatulence	0.08	0.08	NE
43	/ (Myrsinaceae) / MZUH001193 <i>Ensete glaucum</i> (Roxb.) Cheesman / (Musaceae) / MZUH001188	<i>Tling</i>	Shrub / L	Water with decoction of leaves used to bathed for measles	0.13	0.13	LC
44		<i>Saisu</i>	Herb / S	Stem juice used against diarrhoea, dysentery, cholera	0.15	0.25	NE
45	<i>Eryngium foetidum</i> L / (Apiaceae) / MZUH001017 <i>Erythrina stricta</i> Roxb.	<i>Bahkhawr</i>	Herb / L	Decoction of leaves used for asthma & coughing	0.15	0.17	NE
46	/ (Fabaceae) / MZUH001125	<i>Fartuah</i>	Tree / Bk	Juice of bark against stomach ache	0.14	0.14	LC
47	<i>Ficus prostrata</i> (Wall. ex Miq.) Buch.-Ham. ex Miq. / (Moraceae) / MZUH001340	<i>Theitit</i>	Tree / Bk	Bark of stem peeled off and applied on bite marks to cure snake bite	0.04	0.04	LC
48	<i>Ficus semicordata</i> Buch. Ham.ex Sm. / (Moraceae) / MZUH001185	<i>Theipui</i>	Tree / Bk	Decoction of bark used against headache & menstrual cramps	0.07	0.08	LC
49	<i>Flueggea virosa</i> (Roxb. ex Willd.) Royle / (Euphorbiaceae) / MZUH001110	<i>Saisiak</i>	Shrub / L	Decoction of leaves against chicken pox	0.79	0.79	NE
50	<i>Helicia robusta</i> (Roxb.) R.Br. ex Blume / (Proteaceae) /	<i>Sialhma/P asaltakaza</i>	Tree / R	Decoction of root against stomach ache	0.16	0.16	NE

	MZUH001357						
51	<i>Heliconia rostrata</i> Ruiz & Pav. / (Heliconiaceae) / MZUH001139	<i>Changel</i>	Herb / S	Juice collected from stem against used in stomach ache due to allergy	0.02	0.02	NE
52	<i>Hellenia speciosa</i> (J. Koenig) S.R.Dutta / (Costaceae) / MZUH001090	<i>Sumbul</i>	Herb / S, Rz	Decoction of stem against kidney problem; decoction of rhizome against urinary tract, diabetes; stomach ache	0.53	0.87	NE
53	<i>Hibiscus rosa-sinensis</i> L. / (Malvaceae) / MZUH001165	<i>Midum</i> <i>pangpar</i>	Shrub / Fl	Flowers consumed to clear off extra mucus from throat	0.01	0.01	NE
54	<i>Homalomena</i> <i>aromatica</i> (Spreng.) Schott / (Araceae) / MZUH001030	<i>Anchiri</i>	Herb / S, L	Stem juice given against labour pain; decoction of leaves against dysentery	0.19	0.24	NE
55	<i>Ipomoea batatas</i> (L.) Lam. / (Convolvulaceae) / MZUH001089	<i>Kawlbahr</i> <i>a</i>	Herb / L	Leaves juice used for diarrhoea, cholera & dysentery	0.09	0.21	LC
56	<i>Jatropha curcas</i> L. / (Euphorbiaceae) / MZUH001274	<i>Komu</i> / <i>Kangdam</i> <i>dawi</i>	Shrub / Rz	Crushed tuber pasted on burn areas	0.37	0.37	NE
57	<i>Lagerstroemia</i> <i>speciosa</i> (L.) Pers. / (Lythraceae) / MZUH001159	<i>Thlado</i>	Tree / L	Decoction of leaves used to treat kidney ailments & diabetes; decoction of leaves used for weight loss	0.08	0.1	LC
58	<i>Leea compactiflora</i> Kurz / (Vitaceae) / MZUH001155	<i>Kumtintua</i> <i>i</i>	Shrub / L	Leaves covered with paper and smoked for 10-15 minutes and then crush which is then pasted on desired area against	0.19	0.19	NE

				ligamentous pain			
59	<i>Macropanax undulatus</i> (Wall. ex G.Don) Seem. / (Araliaceae) / MZUH001291	<i>Phuanber h</i>	Tree / L, Sh	Young shoots cooked and consumed to cure stomach ache	0.12	0.12	NE
60	<i>Mangifera indica</i> L. / (Anacardiaceae) / MZUH001286	<i>Theihai</i>	Tree / Fr, L	Fruits & young leaves used against digestive disorders like constipation, diarrhoea & dysentery; decoction of bark used against arthritis	0.21	0.36	DD
61	<i>Melia azedarach</i> L. / (Meliaceae) / MZUH001333	<i>Neem suk</i>	Tree / L	Leaves boiled & steamed on vapour against fever & malaria; decoction of leaves for hypertension	0.44	0.53	LC
62	<i>Melocalamus compactiflorus</i> (Kurz) Benth. / (Poaceae) / MZUH001350	<i>Sairil</i>	Tree / S	Juice of stem for regrowth of hair	0.02	0.02	NE
63	<i>Melocanna baccifera</i> (Roxb.) Kurz / (Poaceae) / MZUH001217	<i>Mau</i>	Tree / Bk	Powdered form of bark used against snakes bite and blood clotting	0.02	0.02	NE
64	<i>Mikania micrantha</i> Kunth / (Asteraceae) / MZUH001052	<i>Japan hlo</i>	Climber / L	Crushed leaves pasted on fresh wound to stop bleeding & as antiseptic; decoction of leaves used for diarrhoea	0.85	0.85	NE
65	<i>Mimosa pudica</i> L. / (Fabaceae) / MZUH001129	<i>Hlo nuar</i>	Herb / Fl, R	Decoction of roots against kidney problems; dry flower smoked against	0.27	0.37	NE

				toothache			
66	<i>Molineria capitulata</i> (Lour.) Herb. / (Hypoxidaceae) / MZUH001327	<i>Phaiphak</i>	Herb / Rz	Crushed rhizome pasted on fresh wound as antiseptic	0.05	0.05	LC
67	<i>Momordica charantia</i> L. / (Cucurbitaceae) / MZUH001317	<i>Changkha</i>	Climber / L	Crushed leaves pasted against sore areas	0.08	0.08	NE
68	<i>Mussaenda macrophylla</i> Wall. / (Rubiaceae) / MZUH001231	<i>Vakep</i>	Shrub / L	Crushed leaves pasted against snake bite areas	0.07	0.07	NE
69	<i>Ocimum americanum</i> L. / (Lamiaceae) / MZUH001146	<i>Runhmu</i>	Herb / L	Fresh leaves consumed against fever & headache	0.03	0.04	NE
70	<i>Ocimum tenuiflorum</i> L. / (Lamiaceae) / MZUH001147	<i>Tulsi</i>	Herb / L	Decoction of leaves used to treat asthma, cough & bronchitis	0.23	0.27	LC
71	<i>Oroxylum indicum</i> (L.) Kurz / (Bignoniaceae) / MZUH001062	<i>Archangk awm</i>	Tree / Bk, Fr, L,	Smoked fruit against cancer & diabetes; decoction of bark against chronic liver disease; decoction of fruit & leaves against hypertension	0.68	0.76	NE
72	<i>Osbeckia stellata</i> Buch.-Ham. ex Ker Gawl. / (Melastomataceae) / MZUH001173	<i>Builukham pa</i>	Herb / Rz	Decoction of rhizome against cancer & diabetes	0.23	0.29	LC
73	<i>Paederia foetida</i> L. / (Rubiaceae) / MZUH001233	<i>Vawihuihh rui</i>	Climber / L	Crushed leaves paste on infected area against snake bites	0.02	0.02	LC
74	<i>Pandanus odorifer</i>	<i>Ramlakhui</i>	Shrub /	Decoction of leaves	0.24	0.34	LC

	(Forssk.) Kuntze / (Pandanaceae) / MZUH001205	<i>h</i>	L	used against diarrhoea & dysentery			
75	<i>Parkia timoriana</i> (DC.) Merr. / (Fabaceae) / MZUH001131	<i>Zawngtah</i>	Tree / L	Decoction of leaves used to treat diabetes	0.29	0.29	LC
76	<i>Passiflora napalensis</i> Wall. / (Passifloraceae) / MZUH001206	<i>Nauawium</i> / <i>Nauawimu</i>	Climber / Rz	Decoction of rhizome used against malaria	0.04	0.04	LC
77	<i>Phyllanthus emblica</i> L. / (Phyllanthaceae) / MZUH001346	<i>Sunhlu</i>	Tree / Fr	Crushed fruit mixed with honey as taken as tonic	0.42	0.42	LC
78	<i>Pilea symmeria</i> Wedd. / (Urticaceae) / MZUH001256	<i>Khup - nal</i>	Herb / L	Crushed leaves applied against boil	0.06	0.06	NE
79	<i>Plantago major</i> L. / (Plantaginaceae) / MZUH001209	<i>Kelba-an</i>	Herb / L	Crushed leaves pasted on fresh wound for wound healing	0.19	0.19	NE
80	<i>Prasoxylon excelsum</i> (Spreng.) Mabb. / (Meliaceae) / MZUH001334	<i>Thingthup ui</i>	Tree / L	Decoction of bark used against diarrhoea & dysentery; juice of crushed bark used for wound healing	0.28	0.47	NE
81	<i>Psidium guajava</i> L. / (Myrtaceae) / MZUH001342	<i>Kawlthei</i>	Tree / L	Young leaves consumed against diarrhoea & dysentery	0.54	0.75	LC
82	<i>Rhus chinensis</i> Mill. / (Anacardiaceae) / MZUH001287	<i>Khawmhma</i>	Tree / Fr	Fruits consumed against diarrhoea	0.63	0.63	LC
83	<i>Saprosma ternata</i> (Wall.) Hook.f. / (Rubiaceae) / MZUH001360	<i>Pelhvawm</i>	Tree / Bk	Crushed bark along with garlic against toothache	0.09	0.09	DD

84	<i>Saraca indica</i> L. / (Fabaceae) / MZUH001326	<i>Mualhawih</i>	Tree / Bk	Decoction of bark against menorrhagia	0.01	0.01	LC
85	<i>Schima wallichii</i> Choisy / (Theaceae) / MZUH001250	<i>Khiang-</i>	Tree / Bk	Decoction of bark against stomach ulcer; crushed bark applied on infected area of snake bites	0.07	0.07	LC
86	<i>Scoporia dulcis</i> L. / (Plantaginaceae) / MZUH001210	<i>Perhpawn</i> <i>g chaw/</i> <i>Hlothlum</i>	Herb / L	1 tablespoon decoction of leaves consumed twice a day to reduce blood sugar	0.02	0.02	NE
87	<i>Solanum americanum</i> Mill. / (Solanaceae) / MZUH001244	<i>Anhling</i>	Herb / L, R	Decoction of leaves and root used to treat fever and cough	0.12	0.14	NE
88	<i>Solanum melongena</i> Wall. / (Solanaceae) / MZUH001364	<i>Bawkbaw</i> <i>ng</i>	Herb / Fr	Smoked fruit consumed against typhoid	0.03	0.03	NE
89	<i>Solanum violaceum</i> Ortega / (Solanaceae) / MZUH001245	<i>Tawkte</i>	Herb / Fr	Fruit consumed against hypertension	0.53	0.53	LC
90	<i>Sorghum bicolor</i> (L.) Moench / (Poaceae) / MZUH001351	<i>Chhawchhi</i>	Herb / Sd	Crushed seeds applied on burns	0.08	0.08	LC
91	<i>Tagetes erecta</i> L. / (Asteraceae) / MZUH001053	<i>Derhken</i>	Herb / L	Juice from crushed leaves drop inside ear to cure earache	0.01	0.01	DA
92	<i>Terminalia chebula</i> Retz. / (Combretaceae) / MZUH001080	<i>Reraw</i>	Tree / Bk	Decoction of bark against stomach ache & diarrhoea	0.05	0.07	LC
93	<i>Terminalia</i> <i>phillyreifolia</i> (Van Heurck & Müll.Arg.) Gere & Boatwr. /	<i>Zairum</i>	Tree / Bk	Decoction of bark used against diarrhoea and constipation	0.05	0.05	NE

94	(Combretaceae) / MZUH001314 <i>Tetradium fraxinifolium</i> (Hook.) T.G. Hartley / (Rutaceae) / MZUH001237	<i>Chingit Suak</i>	Tree / Fr	Fruits consumed against dysentery	0.14	0.14	LC
95	<i>Themeda villosa</i> (Poir.) A.Camus / (Poaceae) / MZUH001221	<i>Phaiphek</i>	Grass / L, Rz	Crushed leaves used for treating torn ligaments; crushed rhizome pasted on fresh wound to clot blood and as antiseptic	0.03	0.03	LC
96	<i>Thunbergia alata</i> Bojer ex Sims / (Acanthaceae) / MZUH001003	<i>Zawnga fian</i>	Climber / R	Decoction of root used to treat fever	0.04	0.04	NE
97	<i>Tinospora cordifolia</i> (Willd.) Miers ex Hook.f. & Thomson / (Menispermaceae) / MZUH001179	<i>Hruivankai</i>	Climber / S	Juice from stem used against eye infection	0.02	0.02	NE
98	<i>Trachycarpus martianus</i> (Wall. ex Mart.) H.Wendl. / (Arecaceae) / MZUH001292	<i>Buarpui</i>	Tree / Sp	Sap of the plant is used for wound healing	0.16	0.16	NE
99	<i>Trachyspermum roxburghianum</i> (DC.) H. Wolff / (Apiaceae) / MZUH001288	<i>Pardi</i>	Herb / Bk, R	Leaves and stems used for oral hygiene; leaves and stem used against flatulence, indigestion	0.17	0.23	NE
100	<i>Trichosanthes cucumerina</i> subsp. <i>anguina</i> (L.) Greb.	<i>Berul</i>	Climber / Fr	Steamed fruit used against constipation; fruit is cut open and	0.08	0.08	NE

101	/ (Cucurbitaceae) / MZUH001318	<i>Ralsamku ai</i>	Shrub / L	applied as antidote in snake bites	0.02	0.02	LC
	<i>Uncaria sessilifructus</i> Roxb. / (Rubiaceae) / MZUH001235			Crushed leaves applied in tonsillitis; decoction of roots for stomach ache			
102	<i>Vallaris solanacea</i> (Roth ex Roem. & Schult.) Kuntze / (Apocynaceae) / MZUH001021	<i>Theikelki suak</i>	Climber / R	Decoction of root used for cleaning uterus after childbirth	0.05	0.05	LC
103	<i>Vitex lucens</i> Kirk / (Lamiaceae) / MZUH001149	<i>Thingkhua ilu</i>	Shrub / R	Decoction of root used to promote fertility and as galactagogues	0.06	0.06	LC
104	<i>Zingiber officinale</i> Roscoe / (Zingiberaceae) / MZUH001273	<i>Sawhthing</i>	Herb / Rz	Decoction of rhizome used against cough & cold	0.58	0.58	DD

b) Informant Consensus factor (F_{ic})

To evaluate consensus among NWS area informants on plant use for specific diseases, Fidelity Index (F_{ic}) values were calculated (Heinrich *et al.*, 1998). F_{ic} values ranged from 0.33 to 0.97 (**Table 5.21**), with the highest for Dermatological Infections/Diseases (DID) and Dental Care (DC) (both 0.97), followed by Skeleto-Muscular System Disorder (SMSD) (0.96) and Cardiovascular Disorder (CVD) (0.95). High F_{ic} values for DID and DC are linked to low hygiene standards and activities exposing locals to skin issues and insect bites. The strong consensus on plant use for these conditions contrasts with lower F_{ic} values in other categories, potentially due to limited knowledge sharing and the introduction of modern allopathic drugs. Raising awareness about traditional herbal medicines is essential for preserving this knowledge and promoting sustainable use.

Table 5.21: Informant Consensus factor (F_{ic}) as per the ailments category of NWS, Mizoram

Ailments Category	Medical Terms	N_{ur}	N_t	F_{ic}
Gastro-Intestinal Ailments (GIA)	Diarrhoea, ulcers, indigestion, dysentery, de-worming, constipation, flatulence, stomach-ache, typhoid, cholera	614	29	0.95
Dermatological Infection/ Diseases (DID)	Cuts, wounds, boils, burns, allergy, chicken pox, measles, sore	441	20	0.96
Skeleto-Muscular System Disorder (SMSD)	Ligamentous pain, torn ligaments	62	3	0.97
Vector Borne Diseases (VBD)	Malaria	44	4	0.93
Respiratory Disease Syndrome (RSD)	Asthma, bronchitis, postnasal drip	111	7	0.95
Genito-Urinary Ailments (GUA)	Menstrual disorder, infertility, birth control diuretic, diabetes, and kidney stones	212	17	0.92
Cell Division Disorder (CDD)	Stomach cancer, lung cancer and other cancer types	36	3	0.94
General Health (GH)	Fever, headache, cough, tonic, Bell's palsy, weight loss	194	15	0.93
Poisonous Bites (PB)	Snake/insect bites, bee sting and leech bite, dog bite	33	11	0.69
Dental Care (DC)	Tooth and gum disorder, toothache	66	6	0.92
Cardiovascular Disorder (CVD)	Hypertension, low blood pressure, strokes	156	6	0.97
Ear, Nose and Throat Problem (ENT)	Tonsillitis, sinusitis, eye & ear related problem	4	3	0.33
Liver and Spleen Disorder (LSD)	Liver disorder, jaundice	46	4	0.93

c) Fidelity Level (FI)

Fidelity level (FI) indicates the cultural significance of a plant within a community. In ethnobotany, it helps researchers understand the role of plants in traditional healing and cultural practices. In this study, FI values range from 6% to

100% (**Table 5.22**). Notably, 66% of plants have a fidelity level of 100%, while *Carica papaya* for genitourinary ailments has the lowest (**Figure 5.10**). A high FI value suggests consistent use of the same plants for specific ailments, indicating strong consensus among informants (Heinrich *et al.*, 1998). A low FI value indicates diverse use of the same plants for various ailments, reflecting less agreement (Thomas *et al.*, 2009). Documenting fidelity levels is crucial for identifying valuable medicinal plants in traditional healthcare.

Table 5.22: Fidelity level (FI) of the ethnomedicinal plants of NWS, Mizoram

Ailment Category	Fidelity level (%)
Gastro-Intestinal Ailments (GIA)	<i>Amomum dealbatum</i> (100), <i>Aporosa octandra</i> (100), <i>Benincasa hispida</i> (100), <i>Centella asiatica</i> (100), <i>Chukrasia tabularis</i> (100), <i>Curcuma longa</i> (47), <i>Cuscuta reflexa</i> (62), <i>Prasoxylon excelsum</i> (79), <i>Elsholtzia communis</i> (100), <i>Ensete glaucum</i> (100), <i>Erythrina stricta</i> (100), <i>Helicia robusta</i> (100), <i>Hellenia speciosa</i> (13), <i>Homalomena aromatica</i> (100), <i>Ipomoea batatas</i> (100), <i>Macropanax undulatus</i> (100), <i>Mangifera indica</i> (100), <i>Mikania micrantha</i> (12), <i>Pandanus odorifer</i> (100), <i>Psidium guajava</i> (100), <i>Rhus chinensis</i> (100), <i>Schima wallichii</i> (71), <i>Solanum melongena</i> (100), <i>Terminalia chebula</i> (100), <i>Terminalia phillyreifolia</i> (100), <i>Tetradium fraxinifolium</i> (100), <i>Trachyspermum roxburghianum</i> (87), <i>Trichosanthes cucumerina subsp. anguina</i> (75), <i>Uncaria sessilifructus</i> (50)
Dermatological Infection/ Diseases (DID)	<i>Artocarpus lacucha</i> (100), <i>Bombax ceiba</i> (100), <i>Callicarpa arborea</i> (100), <i>Chromolaena odorata</i> (100), <i>Dendrobium chrysanthum</i> (100), <i>Drynaria coronans</i> (100), <i>Prasoxylon excelsum</i> (21), <i>Embelia vestita</i> (100), <i>Flueggea virosa</i> (100), <i>Heliconia rostrata</i> (100), <i>Jatropha curcas</i> (100), <i>Melocanna baccifera</i> (50), <i>Mikania micrantha</i> (88), <i>Molineria capitulata</i> (100), <i>Momordica charantia</i> (100), <i>Pilea symmeria</i> (100), <i>Plantago major</i> (100), <i>Sorghum bicolor</i> (100), <i>Themeda villosa</i> (67), <i>Trachycarpus martianus</i> (100)
Skeleto-Muscular System Disorder (SMSD)	<i>Leea compactiflora</i> (100), <i>Bonnaya ruelloides</i> (100), <i>Themeda villosa</i> (33)
Vector borne diseases	<i>Alstonia scholaris</i> (31), <i>Brachypterum robustum</i> (100), <i>Melia azedarach</i>

(VBD)	(32), <i>Passiflora nepalensis</i>
Respiratory disease syndrome (RSD)	<i>Amaranthus spinosus</i> (100), <i>Eryngium foetidum</i> (100), <i>Hibiscus rosa-sinensis</i> (100), <i>Ocimum tenuiflorum</i> (100), <i>Solanum americanum</i> (14), <i>Decalepis khasiana</i> (100), <i>Zingiber officinale</i> (100)
Genitourinary ailments (GUA)	<i>Ananas comosus</i> (100), <i>Begonia roxburghii</i> (100), <i>Blumea lanceolaria</i> (100), <i>Carica papaya</i> (6), <i>Dipterocarpus retusus</i> (100), <i>Elaeagnus caudata</i> (100), <i>Dimetia scandens</i> (100), <i>Hellenia speciosa</i> (87), <i>Lagerstroemia speciosa</i> (90), <i>Mimosa pudica</i> (24), <i>Oroxylum indicum</i> (18), <i>Osbeckia stellata</i> (72), <i>Parkia timoriana</i> (100), <i>Saraca indica</i> (100), <i>Scoporia dulcis</i> (100), <i>Vallaris solanacea</i> (100), <i>Vitex lucens</i> (100)
Cell division disorder (CDD)	<i>Oroxylum indicum</i> (8), <i>Osbeckia stellata</i> (28)
General Health (GH)	<i>Ageratum conyzoides</i> (100), <i>Alstonia scholaris</i> (69), <i>Ayenia grandifolia</i> (100), <i>Curcuma longa</i> (24), <i>Datura stramonium</i> (100), <i>Dillenia indica</i> (100), <i>Ficus semicordata</i> (100), <i>Lagerstroemia speciosa</i> (10), <i>Melia azedarach</i> (51), <i>Melocalamus compactiflorus</i> (100), <i>Ocimum americanum</i> (100), <i>Phyllanthus emblica</i> (100), <i>Solanum americanum</i> (86), <i>Thunbergia alata</i> (100), <i>Uncaria sessilifructus</i> (50)
Poisonous Bites (PB)	<i>Acmella ciliata</i> (41), <i>Artocarpus heterophyllus</i> (100), <i>Capsicum frutescens</i> (100), <i>Colocasia esculenta</i> (100), <i>Dendrocnide sinuata</i> (100), <i>Ficus prostrata</i> (100), <i>Melocana baccifera</i> (50), <i>Mussaenda macrophylla</i> (100), <i>Paederia foetida</i> (100), <i>Schima wallichii</i> (29), <i>Trichosanthes cucumerina subsp. anguina</i> (25)
Dental Care (DC)	<i>Acmella ciliata</i> (59), <i>Cissus repanda var. repanda</i> (100), <i>Duranta erecta</i> (100), <i>Mimosa pudica</i> (76), <i>Saprosma ternatum</i> (100), <i>Trachyspermum roxburghianum</i> (13),
Cardiovascular Disorder (CVD)	<i>Carica papaya</i> (29), <i>Citrus sinensis</i> (7), <i>Curcuma longa</i> (26), <i>Melia azedarach</i> (9), <i>Oroxylum indicum</i> (32), <i>Solanum violaceum</i> (100)
Ear Nose Throat (ENT) problem	<i>Cocos nucifera</i> (100), <i>Tagetes erecta</i> (100), <i>Tinospora cordifolia</i> (100)
Liver and Spleen Disorder (LSD)	<i>Cajanus cajan</i> (100), <i>Cuscuta reflexa</i> (38), <i>Camonea umbellata</i> (100), <i>Oroxylum indicum</i> (32)

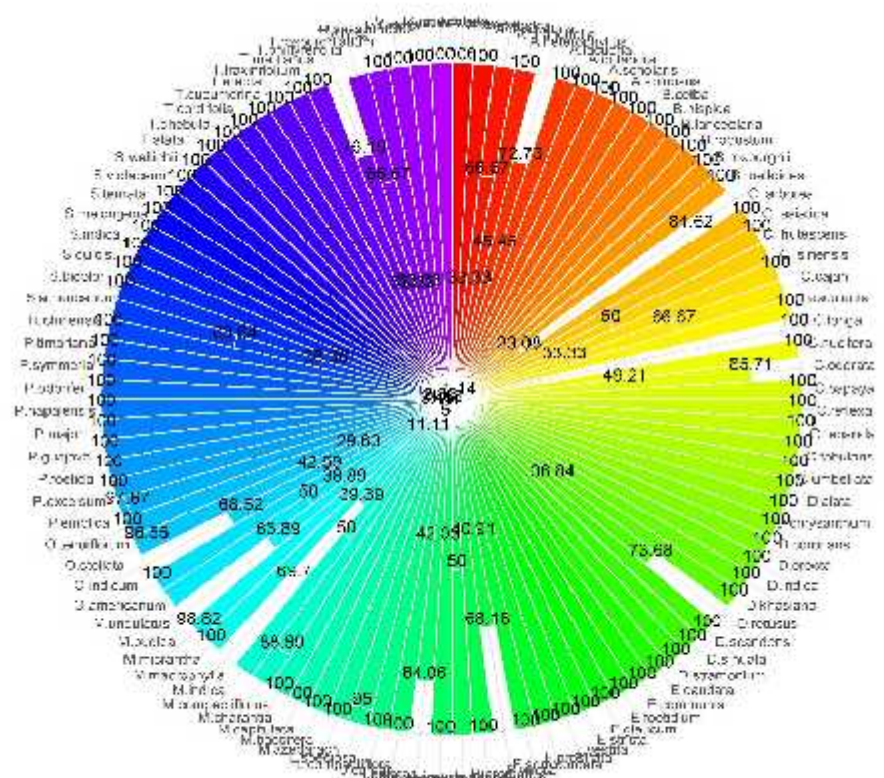


Figure 5.10: Fidelity level (FI) of the ethnomedicinal plants of NWS, Mizoram.

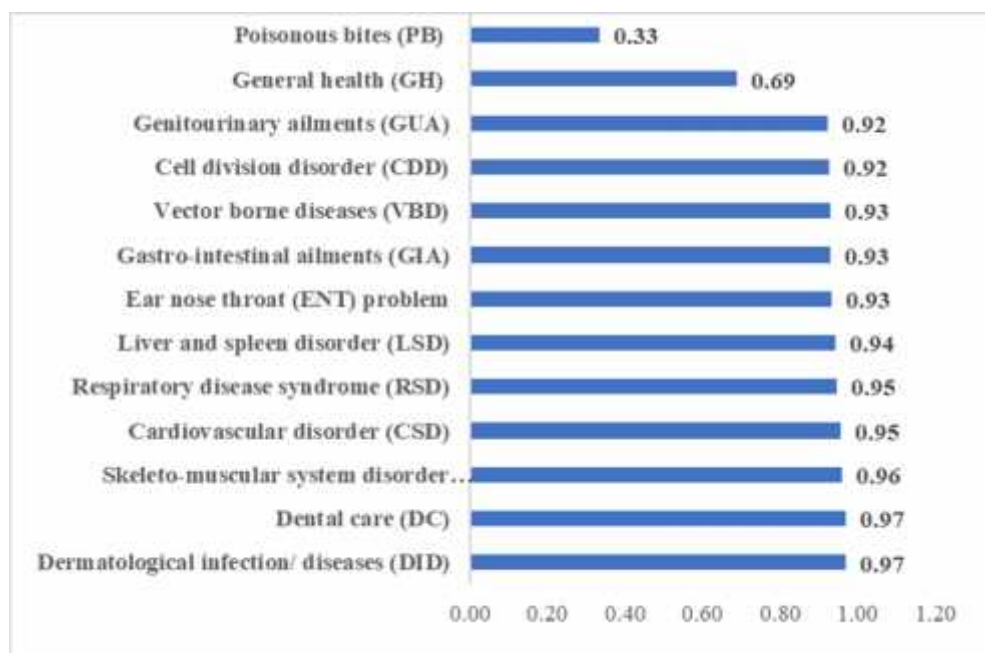


Figure 5.11: Ethnomedicinal plants used against thirteen different

d) Use Value (UV)

During the study, the plants with the highest Use Value (UV) are *Curcuma longa* (0.89) and *Cuscuta reflexa* (0.89), followed by *Hellenia speciosa* (0.87), *Chromolaena odorata* (0.86), *Mikania micrantha* (0.85), *Flueggea virosa* (0.79), *Oroxylum indicum* (0.76), *Psidium guajava* (0.75), and *Rhus chinensis* (0.63) (**Figure 5.11**). Many plants have a UV below 0.1, indicating limited use (Table 5.12). UV data highlights the importance of medicinal plants in a specific region (Hassan *et al.*, 2019). Plants with low UV may still be important but are at higher risk of losing their traditional uses over time (Giday *et al.*, 2009). Documenting and preserving this knowledge is crucial to ensure the continued use of these plants in

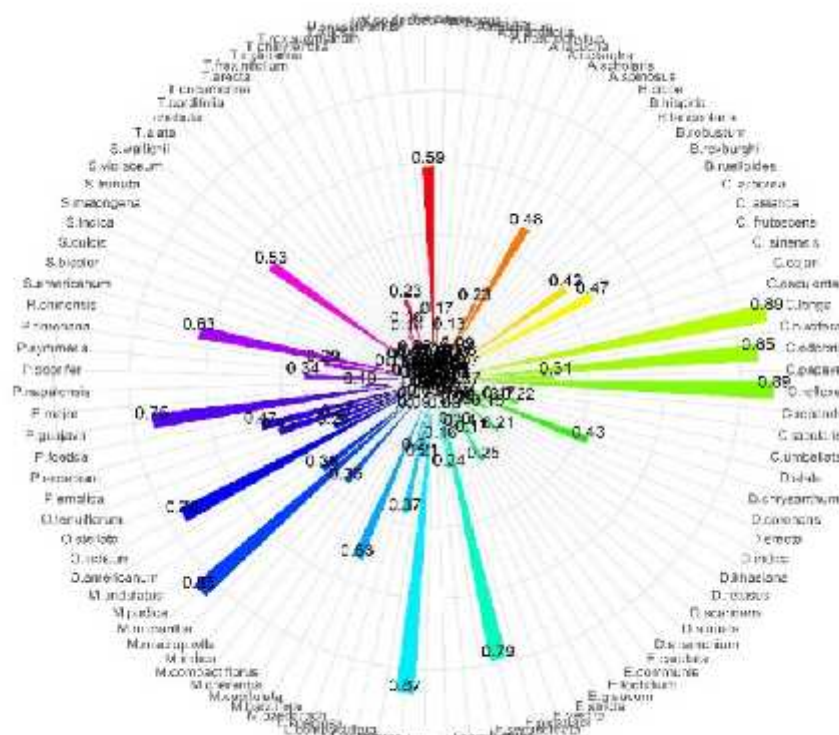


Figure 5.12. Use value (UV) of the ethnomedicinal plants of NWS.

traditional medicine.

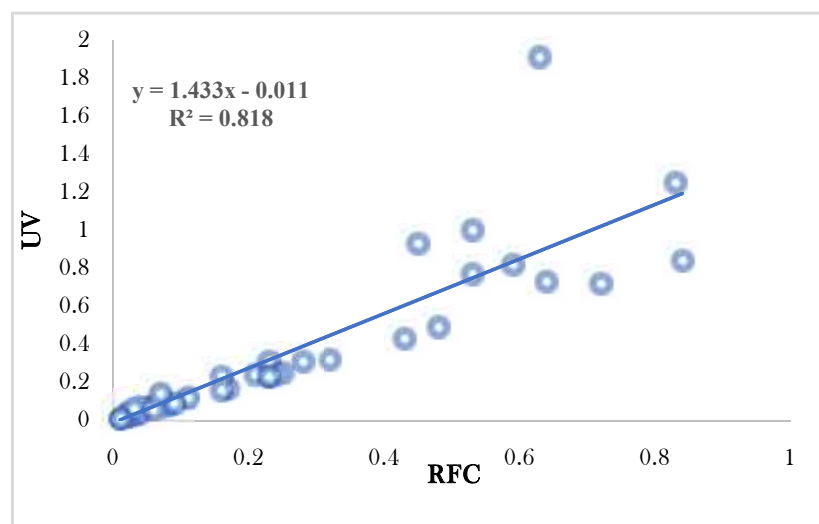


Figure 5.13. Correlation between RFC and UV of the ethnomedicinal plants in

Overall, this study emphasizes the significance of ethnomedicinal plants and the need to conserve traditional knowledge. The findings provide a foundation for further research and conservation efforts.

e) Pearson correlation coefficient

In the present study, the Pearson analysis approach was employed to ascertain the degree and direction of the relationship between UV and RFC variables. At the 0.05 significance level, both UV (1.00) and RFC (0.9) variables displayed a positive correlation, indicating the dependence of these two variables (**Figure 5.12**).

The reliance of rural communities on medicinal plants due to insufficient infrastructure and poor economic conditions further emphasizes the importance of conserving traditional knowledge. Rapid loss of indigenous culture and ethnomedicinal knowledge, driven by globalization and changing lifestyles, poses a significant threat. The study's positive correlation between UV and RFC values indicates that plants with high utility, such as *Curcuma longa*, *Hellenia speciosa*, *Chromolaena odorata*, *Mikania micrantha*, *Flueggea virosa*, *Oroxylum indicum*,

and *Psidium guajava*, are well-known and utilized by local communities. These plants have demonstrated bioactivities in other parts of the world and hold potential for modern pharmacological exploration.

5.4.3 Wild Edible Plants (Vegetables and Fruits)

During the survey, various traditional food recipes prepared by using wild edible vegetables were consumed by the various ethnic communities with the specific ethnic cuisines prepared based on their seasonal availability. In total, 41 species of wild edible vegetables (WEVs) from 20 plant families traditionally used by the ethnic communities for various traditional recipes of cuisines were recorded. The most common type of food recipe is Mizo bai, which can be prepared using different plant species and parts. Leaves are found to be the most commonly used part of a plant which are commonly consumed under wild edible vegetables. The majority of plant species identified in my research belong to the Araceae family, with five species recorded. This is followed by the Amaranthaceae and Begoniaceae families, each represented by four species. Among the wild edibles studied, *Homalomena aromatica* stands out for its diverse applications. Not only can it be cooked as a vegetable, but its rhizome is also collected and sold for the production of gunpowder. This multifunctionality highlights the significant value of some of these plants beyond their nutritional use.

In conclusion, the study highlights the rich plant diversity within the region and the multifaceted roles that wild edibles can play. Understanding these aspects can inform conservation strategies and promote sustainable use of plant resources, contributing to both ecological preservation and local community welfare.

Table 5.22: Wild Edible Vegetables in NWS with Scientific Name, Family and Local Name

SN	Scientific Name	Family	Local Name
	<i>Achyranthes aspera</i> L. / MZUH001005	Amaranthaceae	Ui hlo

2.	<i>Acmella ciliata</i> (Kunth) Cass./ MZUH001044	Asteraceae	Ansate
3.	<i>Aglaonema hookerianum</i> Schott / MZUH001023	Araceae	Tubal
4.	<i>Alpinia malaccensis</i> (Burm.f.) Roscoe / MZUH001263	Zingiberaceae	Aichal / Du pawl
5.	<i>Alpinia malaccensis</i> C.Presl / MZUH001263	Zingiberaceae	Aichal / Du pawl
6.	<i>Alternanthera philoxeroides</i> (Mart.) Griseb. / MZUH001006	Amaranthaceae	Nghateril thau chi
7.	<i>Alternanthera sessilis</i> (L.) DC. / MZUH001007	Amaranthaceae	Nghateril thau chi
8.	<i>Amaranthus viridis</i> All. / MZUH001008	Amaranthaceae	Lenhling hling nei lo
9.	<i>Amorphophallus bulbifer</i> (Schott) Blume / MZUH001024	Araceae	Telhawng nu
10.	<i>Amorphophallus napalensis</i> (Wall.) Bogner et Mayo./ MZUH001025	Araceae	Telhawng pa
11.	<i>Areca triandra</i> Roxb. ex Buch.-Ham. / MZUH001033	Arecaceae	Uvai
12.	<i>Bambusa longispiculata</i> Gamble / MZUH001211	Poaceae	Raw thing
13.	<i>Begonia annulata</i> K.Koch/ MZUH001057	Begoniaceae	Sekhupthur
14.	<i>Begonia dioica</i> Buch.-Ham. ex. D.Don / MZUH001058	Begoniaceae	Sekhupthur
15.	<i>Begonia roxburghii</i> (Miq.) A.DC. / MZUH001060	Begoniaceae	Sekhupthur
16.	<i>Bidens pilosa</i> L./ MZUH001048	Asteraceae	Vawkpui thal
17.	<i>Cajanus cajan</i> (L.) Huth /MZUH001121	Fabaceae	Behliang
18.	<i>Calamus latifolius</i> Roxb. /MZUH001040	Arecaceae	Hnabhawr
19.	<i>Calamus melanochaetes</i> (Blume)Miq./ MZUH001041	Arecaceae	Raichhawk (Hruizik)
20.	<i>Centella asiatica</i> (L.) Urb /MZUH001018	Apiaceae	Lambak
21.	<i>Colocasia esculenta</i> (L.) Schott / MZUH001028	Araceae	Dawl
22.	<i>Crassocephalum crepidioides</i> f. luteum (Steen.) Belcher / MZUH001051	Asteraceae	Buar thau
23.	<i>Dendrocalamus longispathus</i> (Kurz) Kurz / MZUH001214	Poaceae	Rawnal
24.	<i>Drymaria cordata</i> Willd. ex Schult. /MZUH001074	Caryophyllaceae	Changkalrit
25.	<i>Dysoxylum excelsum</i> Blume /MZUH001176	Meliaceae	Thingthupui
26.	<i>Ensete glaucum</i> (Roxb.) Cheesman / MZUH001188	Musaceae	Saisu

27.	<i>Etlingera linguiformis</i> (Roxb.) R.M.Sm. /MZUH001266	Zingiberaceae	
28.	<i>Eurya japonica</i> Thunb. /MZUH001248	Theaceae	Sihneh
29.	<i>Homalomena aromatica</i> (Spreng.) Schott / MZUH001030	Araceae	Anchiri
30.	<i>Ipomoea batatas</i> (L.) Lam. /MZUH001089	Convolvulaceae	Kawlbahra
31.	<i>Macropanax dispermus</i> Kuntze /MZUH001032	Araliaceae	Phuanberh
32.	<i>Melocanna baccifera</i> (Roxb.) Kurz /MZUH001217	Poaceae	Mau
33.	<i>Musa ornata</i> Roxb./MZUH001190	Musaceae	Chang vandawt
34.	<i>Oroxylum indicum</i> Vent / MZUH001062	Bignoniaceae	Archangkawm
35.	<i>Parkia timoriana</i> (DC.) Merr. / MZUH001131	Fabaceae	Zawngtah
36.	<i>Phrynium pubinerve</i> Blume/ MZUH001167	Marantaceae	Hnahthialnu
37.	<i>Senegalia pennata</i> (L.) Maslin / MZUH001335	Fabaceae	Khanghu
38.	<i>Sesamum indicum</i> L./ MZUH001207	Pedaliaceae	Chhibung
39.	<i>Solanum americanum</i> Mill. /MZUH001244	Solanaceae	Anhling
40.	<i>Solanum violaceum</i> Ortega / MZUH001245	Solanaceae	Tawkte
41.	<i>Tacca integrifolia</i> Ker Gawl./ MZUH001207	Dioscoreaceae	Thialkha

Additionally, in the present study, a total of 22 species of wild edible fruits from 14 different families among the documented plants. These fruits are primarily consumed fresh, though some are also enjoyed as juice. Moreover, several of these fruits serve as excellent ingredients in various vegetable dishes, enhancing their flavor and nutritional value. This diversity is crucial for maintaining nutritional balance and food security within these communities. As globalization and changing lifestyles threaten traditional dietary practices, preserving this culinary knowledge is vital for sustaining the health and well-being of local populations.

Table 5.23: Wild Edible Fruits in NWS with Scientific Name, Family and Local Name

SN	Scientific Name	Family	Local Name
----	-----------------	--------	------------

1	<i>Antidesma bunius</i> (L.) Spreng. /MZUH001105	Euphorbiaceae	Tuaitit
2	<i>Artocarpus lacucha</i> Buch.-Ham. / MZUH001181	Moraceae	Theitat
3	<i>Baccaurea ramiflora</i> Lour. /MZUH001107	Euphorbiaceae	Pangkai
4	<i>Citrus macroptera</i> Montrouz. /MZUH001236	Rutaceae	Hatkawra
5	<i>Cyathocalyx martabanicus</i> Hook.f. & Thomson / MZUH001015	Annonaceae	Hreirawt
6	<i>Dillenia indica</i> Blanco /MZUH001098	Dilleniaceae	Kawrthindeng
7	<i>Elaeagnus caudata</i> Schltdl. ex Momiy. / MZUH001104	Elaegnaceae	<i>Sarzuk</i>
8	<i>Embelia vestita</i> Roxb. / MZUH001193	Myrsinaceae	<i>Tling</i>
9	<i>Ficus semicordata</i> Buch.-Ham. ex Sm. / MZUH001185	Moraceae	Theipui
10	<i>Ficus variegata</i> Blume /MZUH001186	Moraceae	Chhohe
11	<i>Garcinia lanceifolia</i> Roxb /MZUH001075	Clusiaceae	Chengkek
12	<i>Garcinia pedunculata</i> Roxb. /MZUH001076	Clusiaceae	Vawmva
13	<i>Garcinia xanthochymus</i> Hook.f. /MZUH001077	Clusiaceae	Tuaihabet
14	<i>Mangifera sylvatica</i> Roxb. /MZUH001011	Anacardiaceae	Ramtheihai
15	<i>Memecylon celastrinum</i> Kurz /MZUH001170	Melastomataceae	Theikawrak
16	<i>Morus macroura</i> Miq. /MZUH001187	Moraceae	Lungli
17	<i>Neolamarckia cadamba</i> (Roxb.) Bosser /MZUH001232	Rubiaceae	Thingbanphar
18	<i>Palaquium polyanthum</i> Engl. /MZUH001238	Sapotaceae	Hnaibung
19	<i>Protium serratum</i> Engl. /MZUH001072	Burseraceae	Bil
20	<i>Sarcosperma griffithii</i> Hook.f. / MZUH001239	Sapotaceae	Theikhawkham
21	<i>Spondias pinnata</i> (L.f.) Kurz /MZUH001013	Anacardiaceae	Tawitaw
22	<i>Terminalia chebula</i> Retz /MZUH001080	Combretaceae	Reraw

5.4.4 Timber Yielding Plants

Out of 25 timber-yielding families, 16 are represented, with Burseraceae and Meliaceae having the most species at three each. Following these are Dipterocarpaceae, Fabaceae, Lythraceae, Moraceae, and Sapotaceae, each with two

species. The residents of the villages around NWS frequently cut down trees to sell the wood, leading to the depletion of high-quality timber around the sanctuary. Moreover, the most dominant tree species, *Dipterocarpus retusus*, is also an excellent timber-yielding plant. Protecting these valuable timber resources from overexploitation is crucial. Implementing strict conservation measures can help ensure the long-term availability of these resources, thereby supporting both local economies and forest ecosystems.

Table 5.24: Timber yielding plants in NWS with Scientific Name, Family and Local Name.

Sl. No.	Scientific Name	Family	Local Name
1	<i>Acrocarpus fraxinifolius</i> Wight & Arn /MZUH001117	Fabaceae	Nganbawm
2	<i>Albizia odoratissima</i> (L.f.) Benth. /MZUH001119	Fabaceae	Thingri
3	<i>Artocarpus chama</i> Buch.-Ham. / MZUH001338	Moraceae	Tatkawng
4	<i>Calophyllum polyanthum</i> Wall. exChoisy /MZUH001073	Calophyllaceae	Sentezel
5	<i>Canarium bengalense</i> Roxb. /MZUH001069	Burseraceae	Berawchal
6	<i>Chisocheton cumingianus</i> Harms /MZUH001174	Meliaceae	Lawngtlaibantlo
7	<i>Chukrasia tabularis</i> Wight & Arn. /MZUH001175	Meliaceae	Zawngtei
8	<i>Dipterocarpus retusus</i> Blume /MZUH001101	Dipterocarpaceae	Thingsen
9	<i>Dipterocarpus turbinatus</i> C.F. Gaertn. / MZUH001102	Dipterocarpaceae	Vailawng
10	<i>Duabanga grandiflora</i> Walp. /MZUH001158	Lythraceae	Zuang
11	<i>Dysoxylum gotadhora</i> (Buch.- Ham.) Mabb. / MZUH001177	Meliaceae	Sahatah
12	<i>Garuga floribunda</i> Decne. /MZUH001070	Burseraceae	Tuairam
13	<i>Garuga pinnata</i> Roxb. / MZUH001071	Burseraceae	Bungbutuairam
14	<i>Gmelina arborea</i> Roxb. ex Sm./ MZUH001145	Lamiaceae	Thlanvawng
15	<i>Haldina cordifolia</i> (Roxb.) Ridsdale / MZUH001228	Rubiaceae	Lungkhup

16	<i>Horsfieldia amygdalina</i> (Wall.) Warb./MZUH001191	Myristicaceae	Sialtuai
17	<i>Langerstroemia speciosa</i> (L.) Pers. / MZUH001159	Lythraceae	Thlado
18	<i>Magnolia champaca</i> (L.) Baill. Ex Pierre/ MZUH001160	Magnoliaceae	Ngiau
19	<i>Mallotus nudiflorus</i> (L.) Kulju & Welzen/ MZUH001113	Euphorbiaceae	Phaithing
20	<i>Morus macroura</i> Miq. /MZUH001187	Moraceae	Lungli
21	<i>Palaquium polyanthum</i> Engl. /MZUH001238	Sapotaceae	Hnaibung
22	<i>Phoebe attenuata</i> (Nees) Nees /MZUH001153	Lauraceae	Bul
23	<i>Sarcosperma griffithii</i> Hook.f. / MZUH001239	Sapotaceae	Theikhawkham
24	<i>Terminalia myriocarpa</i> Van Heurck & Müll.Arg. / MZUH001081	Combretaceae	Char
25	<i>Tetrameles nudiflora</i> R. Br. /MZUH001097	Datisceae	Thingdawl

5.4.5 Firewood and Charcoal yielding Plants

Among the 105 tree species recorded in the study, 56 species belonging to 27 families have been identified as particularly suitable for firewood and producing high-quality charcoal. While any tree twigs can be used for firewood, the species listed in the accompanying table stand out for their exceptional durability and quality. The Euphorbiaceae family leads with the highest number of species suitable for these purposes, contributing six species. Following closely are the Fabaceae and Rubiaceae families, each providing five species. These families are noted for their excellent firewood and charcoal properties, making them valuable resources for the local communities.

The identification of these species is crucial as it helps in managing and utilizing forest resources more sustainably. By focusing on the most durable and high-quality options, efforts can be made to ensure that these resources are used efficiently, helping to preserve other tree species and maintain ecological balance.

This information can also guide local practices in firewood collection and charcoal production, promoting the use of the best-suited species and potentially reducing the pressure on less suitable ones.

Table 5.25: Plants used for Firewood and making Charcoal in NWS with Scientific Name, Family and Local Name.

SN	Scientific Name	Family	Local Name
1	<i>Albizia chinensis</i> (Osbeck.) Merr./MZUH001118	Fabaceae	Vang
2	<i>Albizia odoratissima</i> (L.f.) Benth./MZUH001119	Fabaceae	Thingri
3	<i>Albizia procera</i> (Roxb.) Benth. /MZUH001120	Fabaceae	Kangtek
4	<i>Balakata baccata</i> (Roxb.) Esser/MZUH001108	Euphorbiaceae	Thingvawkpui
5	<i>Callicarpa arborea</i> Roxb./MZUH001142	Lamiaceae	Hnahkiah
6	<i>Canarium bengalense</i> Roxb./MZUH001069	Burseraceae	Berawchal
7	<i>Cassia javanica</i> L. /MZUH001123	Fabaceae	Makpazangkan
8	<i>Castanopsis tribuloides</i> A.DC./MZUH001135	Fagaceae	Thingsia
9	<i>Catunaregam spinosa</i> (Thunb.) Tirveng. /MZUH001226	Rubiaceae	Sazuk Thei
10	<i>Chisocheton cumingianus</i> Harms /MZUH001174	Meliaceae	Lawngtlaibantl
11	<i>Chukrasia tabularis</i> Wight & Arn./MZUH001174	Meliaceae	Zawngtei
12	<i>Cordia fragrantissima</i> Kurz /MZUH001066	Boraginaceae	Muk
13	<i>Dillenia indica</i> Blanco /MZUH001098	Dilleniaceae	Kawrthindeng
14	<i>Dipterocarpus retusus</i> Blume /MZUH001101	Dipterocarpaceae	Thingsen
15	<i>Dipterocarpus turbinatus</i> C.F. Gaertn. /MZUH001102	Dipterocarpaceae	Vailawng
16	<i>Drimycarpus racemosus</i> Hook.f. /MZUH001010	Anacardiaceae	Vawmbal hnah
17	<i>Duabanga grandiflora</i> Walp. /MZUH001158	Lythraceae	Zuang
18	<i>Ficus fistulosa</i> Reinw. Ex Blume /MZUH001182	Moraceae	Theibate/Theib
19	<i>Ficus religiosa</i> L. /MZUH001183	Moraceae	Hmawng
20	<i>Ficus semicordata</i> Buch.-Ham. ex Sm. /MZUH001185	Moraceae	Theipui
21	<i>Garcinia xanthochymus</i> Hook.f. /MZUH001077	Clusiaceae	Tuaihabet
22	<i>Garuga pinnata</i> Roxb. /MZUH001071	Burseraceae	Bungbutuairam
23	<i>Grewia laevigata</i> Vahl /MZUH001163	Malvaceae	Varita bel kang
24	<i>Homalium ceylanicum</i> (Gardner) Benth. /MZUH001137	Flacourtiaceae	Thinglung
25	<i>Hydnocarpus kurzii</i> (King) Warb. /MZUH001138	Flacourtiaceae	Khawitur
26	<i>Ixora nigricans</i> Zoll. ex Miq. /MZUH001229	Rubiaceae	Thingkhim
27	<i>Ixora subsessilis</i> Wall. /MZUH001230	Rubiaceae	Thingsaingal
28	<i>Knema linifolia</i> (Roxb.) Warb. /MZUH001192	Myristicaceae	Thingthi
29	<i>Langerstroemia speciosa</i> (L.) Pers. /MZUH001159	Lythraceae	Thlado
30	<i>Lithocarpus dealbatus</i> Rehder /MZUH001136	Fagaceae	Fah
31	<i>Macaranga denticulata</i> Müll.Arg./MZUH001111	Euphorbiaceae	Hnahkhar pa
32	<i>Macaranga peltata</i> Boiv. ex Baill./MZUH00112	Euphorbiaceae	Hnahkhar nu
33	<i>Magnolia champaca</i> (L.) Baill. Ex Pierre /MZUH001160	Magnoliaceae	Ngiau

34	<i>Mallotus nudiflorus</i> (L.) Kulju & Welzen / MZUH001113	Euphorbiaceae	Phaithing
35	<i>Mallotus roxburghianus</i> Müll.Arg. / MZUH001114	Euphorbiaceae	Zawngtenawhl
36	<i>Memecylon celastrinum</i> Kurz / MZUH001170	Melastomataceae	Theikawrak
37	<i>Mesua ferrea</i> L. / MZUH001078	Clusiaceae	Herhse
38	<i>Neolamarckia cadamba</i> (Roxb.) Bosser / MZUH001232	Rubiaceae	Thingbanphar
39	<i>Ostodes paniculata</i> Blume / MZUH001115	Euphorbiaceae	Bel tur
40	<i>Palaquium polyanthum</i> Engl. / MZUH001238	Sapotaceae	Hnaibung
41	<i>Parkia timoriana</i> (DC.) Merr. / MZUH001131	Fabaceae	Zawngtah
42	<i>Pavetta indica</i> L. / MZUH001234	Rubiaceae	Thainu rual
43	<i>Polyalthiajenkinsii</i> (Hook.f. & Thomson) Hook.f. & Thomson / MZUH001016	Annonaceae	Zathu
44	<i>Prunus ceylanica</i> Miq. / MZUH001225	Rosaceae	Rahphir
45	<i>Pterospermum acerifolium</i> (L.) Wild. / MZUH001246	Sterculiaceae	Siksil
46	<i>Saurauia punduana</i> Wall. / MZUH001004	Actinidiaceae	Tiar
47	<i>Schima khasiana</i> Dyer / MZUH001249	Theaceae	Khiang zo
48	<i>Schima wallichii</i> (DC.) Korth. / MZUH001250	Theaceae	Khiang
49	<i>Semecarpus anacardium</i> L.f. / MZUH001012	Anacardiaceae	Vawmbal hnahhlai
50	<i>Spondias pinnata</i> (L.f.) Kurz / MZUH001013	Anacardiaceae	Tawitaw
51	<i>Syzygium cumini</i> L. / MZUH001194	Myrtaceae	Lenhmui
52	<i>Syzygium diospyrifolium</i> (Wall. Ex Duthie) / MZUH001195	Myrtaceae	Hnunthlum
53	<i>Syzygium ramosissimum</i> (Blume) N.P.Balakr. / MZUH001196196	Myrtaceae	Hmuivar
54	<i>Terminalia myriocarpa</i> Van Heurck & Müll.Arg. / MZUH001081	Combretaceae	Char
55	<i>Toona ciliata</i> M. Roem. / MZUH001178	Meliaceae	Teipui
56	<i>Vitex peduncularis</i> Wall. / MZUH001150	Lamiaceae	Thingkhawilu

5.4.6 Fodder

14 species from 8 different families are utilized as fodder by various ethnic groups, highlighting their importance in traditional livestock feeding practices. The predominance of the Amaranthaceae family in providing fodder highlights the importance of preserving these plant species to support sustainable livestock practices.

Table 5.26: Plants used as Fodder in NWS with Scientific Name, Family and Local Name.

Sl. No.	Scientific Name	Family	Local Name
1	<i>Achyranthes aspera</i> L. / MZUH001005	Amaranthaceae	Ui hlo

2	<i>Achyranthes aspera</i> L. / MZUH001005	Amaranthaceae	Ui hlo
3	<i>Alternanthera philoxeroides</i> (Mart.) Griseb. / MZUH001006	Amaranthaceae	Nghateril thau chi
4	<i>Cyanotis cristata</i> (L.) D.Don / MZUH001082	Commelinaceae	Vawmkur
5	<i>Acrocarpus fraxinifolius</i> Wight & Arn / MZUH001117	Fabaceae	Nganbawm
6	<i>Albizia procera</i> (Roxb.) Benth. / MZUH001120	Fabaceae	Kangtek
7	<i>Amaranthus spinosus</i> L. / MZUH001009	<i>Amaranthaceae</i>	<i>Lenhling</i>
8	<i>Bombax ceiba</i> L. / MZUH001064	Bombacaceae	Phunchawng
9	<i>Bombax insigne</i> Wall. / MZUH001065	Bombacaceae	Pang
10	<i>Haldina cordifolia</i> (Roxb.) Ridsdale / MZUH001228	Rubiaceae	Lungkhup
11	<i>Heliconia rostrata</i> Ruiz & Pav. / MZUH001139	<i>Heliconiaceae</i>	<i>Changel</i>
12	<i>Ipomoea batatas</i> (L.) Lam. / MZUH001089	Convolvulaceae	<i>Kawlbahra</i>
13	<i>Musa balbisiana</i> Colla / MZUH001189	Musaceae	Changthir
14	<i>Pouzolzia rugulosa</i> (Wedd.) Acharya & Kravtsova / MZUH001367	Urticaceae	Lenlang

5.4.7 Other Uses

Apart from the uses documented in the previous tables, many plant species are primarily utilized as food ingredients. In Mizo culture, a prevalent method of fish capture involves using the juice of plants like *Albizia procera* and *Diospyros pilosiuscula* for poisoning. While other plants are also employed for this purpose, these two are specifically found within the sanctuary's vicinity. Moreover, the leaves of certain plants such as *Calamus melanochaetes* find extensive use in roofing houses within villages where expensive construction materials are beyond reach. Additionally, the rhizome of *Homalomena aromatica* holds significance for its role in gunpowder production, further illustrating the multifaceted utility of plant species within the region (Table 5.27).

Table 5.27: Other Uses of Plants in NWS with Scientific Name, Family and Local Name

SN	Scientific Name	Family	Local Name	Uses
----	-----------------	--------	------------	------

1	<i>Albizia procera</i> (Roxb.) Benth. / MZUH001120	Fabaceae	Kangtek	Fish Poisoning
2	<i>Amomum dealbatum</i> Roxb. / MZUH001369	Zingiberaceae	Aidu	For making rope
3	<i>Amomum maximum</i> Roxb. / MZUH001264	Zingiberaceae	Aidu	For making rope
4	<i>Bombax ceiba</i> L. / MZUH001064	Bombacaceae	Phunchawng	Cotton for pillows and cushions
5	<i>Bombax insigne</i> Wall. / MZUH001065	Bombacaceae	Pang	Cotton for pillows and cushions
6	<i>Borassus flabellifer</i> L. / MZUH001035	Arecaceae	Siallu	Roof top
7	<i>Calamas latifolius</i> Roxb. / MZUH001040	Arecaceae	Hnabhawr	Handicraft
8	<i>Calamus melanochaetes</i> (Blume) Miq. / MZUH001041	Arecaceae	Raichhawk (Hruizik)	Roof top
9	<i>Curcuma longa</i> L. / MZUH001265	Zingiberaceae	Aieng	Food Ingredient
10	<i>Diospyros pilosiuscula</i> G. Don / MZUH001103	Ebenaceae	Ruthei	Fish Poisoning
11	<i>Elsholtzia communis</i> (Collett & Hemsl.) Diels / MZUH001144	Lamiaceae	Lengser	Food Ingredient
12	<i>Gossypium arboreum</i> L. / MZUH001162	Malvaceae	La	Cotton
13	<i>Hibiscus macrophyllus</i> Roxb/ MZUH001164	Malvaceae	Vaiza	Bark fibre for making rope
14	<i>Homalomena aromatica</i> (Spreng.) Schott / MZUH001030	Araceae	Anchiri	Gun Powder
15	<i>Imperata cylindrica</i> (L.) Raeusch. / MZUH001216	Poaceae	Di	Roof top
16	<i>Melocanna baccifera</i> (Roxb.) Kurz / MZUH001217	Poaceae	Mau	Building Houses & Handicrafts
17	<i>Ocimum americanum</i> L. / MZUH001146	Lamiaceae	Runhmu	Food Ingredient
18	<i>Ocimum tenuiflorum</i> L. / MZUH001147	Lamiaceae	Tulsi	Food Ingredient
19	<i>Thysanolaena latifolia</i> (Roxb. ex Hornem.) Honda / MZUH001222	Poaceae	Hmunphiah	Used for making brooms
20	<i>Zingiber officinale</i> Roscoe / MZUH001273	Zingiberaceae	Sawhthing	Food Ingredient

The study sheds light on the innovative uses of plants in everyday activities. Traditional practices, such as using *Albizia procera* and *Diospyros pilosiuscula* for fish poisoning or *Calamus melanochaetes* for roofing, demonstrate the ingenuity of

local communities in harnessing natural resources. These practices are deeply embedded in cultural traditions and provide practical solutions to everyday challenges. Preserving this knowledge is crucial for maintaining the cultural heritage and resilience of these communities.

The rich ethnobotanical knowledge embedded in the use of these plants underscores their cultural and ecological significance. Preserving this knowledge is not merely an academic endeavor but a practical necessity for safeguarding invaluable practices that have sustained communities for generations. This study highlights the need for a holistic approach to conservation that respects traditional ecological knowledge while promoting sustainable resource management.

5.4.8 Conservation of ethnobotanically useful plant species and indigenous knowledge

The study of Ngengpui Wildlife Sanctuary (NWS) in Mizoram, India, underscores the critical importance of conserving its rich and diverse forest ecosystem. The sanctuary is home to several ethnomedicinal plants, some of which are classified as threatened, such as *Dipterocarpus retusus* and *Dendrobium chrysanthum*. These species are crucial for traditional medicinal practices and the well-being of local communities. Their endangered status highlights the urgent need for comprehensive conservation efforts to prevent further decline and safeguard these valuable resources.

One of the significant findings is that 55.9% of the ethnomedicinal plants used in the region have not yet been evaluated under the IUCN Red List. This lack of evaluation indicates that many potentially threatened species may be overlooked in conservation strategies. It is imperative to conduct further research to determine the status of these plants and prioritize conservation efforts accordingly. Protecting these plants is not only vital for biodiversity but also for preserving the traditional medicinal practices and knowledge that have sustained local communities for generations. Biodiversity loss in NWS is driven by several factors, including habitat destruction due to invasive alien plant species (IAPS), unsustainable exploitation by

indigenous communities, and forest fires resulting from honey collection. Addressing these issues is crucial for maintaining the sanctuary's ecological balance. Sustainable methods of honey collection and forest resource management must be implemented to prevent further damage.

The flora of NWS is integral to the daily lives of fringe village communities, providing a wide range of resources beyond medicinal applications. Plants in this region serve as essential remedies for ailments, provide timber for construction, offer vegetables and fruits for nutrition, and supply fuelwood for energy. This comprehensive utility of plants underscores the necessity of preserving both the flora and the traditional knowledge associated with their uses.

Medicinal plants like *Curcuma longa* and *Cuscuta reflexa*, with high Use Values, play a significant role in traditional healing practices. These plants are indispensable for treating numerous health conditions and maintaining the well-being of the local population. However, the erosion of ethnobotanical knowledge poses a threat to these traditional practices, as younger generations may not inherit the same depth of understanding about these natural remedies. Documenting and conserving this knowledge is crucial to ensure these plants continue to be used effectively in traditional medicine. Beyond their medicinal value, many plants in NWS serve as vital food sources. The study documented 41 species of wild edible vegetables (WEVs) used in traditional recipes, particularly Mizo bai. Additionally, 22 species of fruits from 14 families were recorded, enhancing the local diet's diversity and nutritional balance. This variety of food sources not only enriches the diet but also ensures the nutritional well-being of the local population.

Timber-yielding plants are also significant in NWS, with 25 families identified as sources of timber. The depletion of high-quality timber due to frequent tree cutting is a concern, particularly for species like *Dipterocarpus retusus*. Protecting these valuable timber resources is essential for sustainable forest management and maintaining ecological balance. The outcome of this research can guide local practices in firewood collection and charcoal production, promoting the use of the best-suited species and reducing pressure on less suitable ones.

Homalomena aromatica is significant for gunpowder production, highlighting the multifaceted utility of plant species in the region. The rich tapestry of traditional knowledge embedded in the use of these plants underscores their cultural and ecological significance. Preserving this knowledge is essential for safeguarding invaluable practices that have sustained communities for generations. Efforts to document and transmit this knowledge must be prioritized to ensure its continuity and relevance in contemporary contexts.

Recognizing the intricate interplay between human societies and their natural environments underscores the importance of sustainable management practices. By understanding how local communities depend on forest resources, we gain insights into the complex dynamics shaping human-environment relationships. The ethnobotanical wealth of NWS offers a compelling narrative of human ingenuity and resilience in harnessing natural resources. Acknowledging and preserving this knowledge honors the interconnectedness between culture, biodiversity, and sustainable livelihoods. Holistic conservation approaches that protect biodiversity while respecting traditional ecological knowledge are essential for fostering a sustainable future. The findings of this study provide a foundation for further research on these plants' potential medicinal properties and inform conservation efforts to preserve traditional knowledge and the natural resources supporting it.

CHAPTER 6

6. SUMMARY AND CONCLUSION

6.1 Summary

Ngengpui Wildlife Sanctuary (NWS) is a protected area located in Mizoram, India and is known for its unique ecosystems and rich biodiversity. The sanctuary is home to a variety of flora and fauna including several RET or threatened taxa. The present study was undertaken in the sanctuary focusing on the diversity of angiosperms, their ethnobotanical significance, finding the endemic and threatened taxa and exploration of new taxa and new records. The study catalogued a total of 353 angiosperm species from 91 families that are categorized into trees, herbs, shrubs, climbers, orchids, grasses and palms. Additionally, a new species *Parahellenia mizoramensis*, was discovered during the study with even the genus *Parahellenia* reported as a new generic record for India.

For the present study, six distinct forest areas in NWS namely Hmunnuam, Ngengpui, Diltlang, Saizawh east, Khawmawi, and Bungtlang south forests, falling under Tropical Wet Evergreen and Semi-Evergreen Forest types, were selected for the assessment of diversity, structure, and composition of the angiosperms particularly trees, herbs and shrubs. Using a stratified random sampling approach with 250 plots covering 0.01 hectares each, the research identified 2,545 individual trees representing 105 woody species from 40 families and 85 genera. The most dominant tree species was *Dipterocarpus retusus* with the highest Importance Value Index (6.63%). The Hmunnuam forests had the highest Shannon diversity index (4.42), Bungtlang south forests had the highest stem density (1350 individuals/hectare), and Khawmawi forests displayed the greatest mean stem diameter (76.4cm) at 1.3 meters height. The study also revealed a reverse J-shaped distribution of tree diameters across the six forests, indicating uneven-agedness. And highlighting the diversity of trees in size class distribution within the NWS. Also, the sanctuary is still home to some of the threatened taxa which are

categorized under different categories of IUCN Red List including the most dominant tree *Dipterocarpus retusus* under the endangered (EN) category.

The herbs were distributed among 45 families, with the Asteraceae (20 sp.) representing the maximum number of species followed by Zingiberaceae (13 sp.), Amaranthaceae (9 sp.) followed by the Araceae (8 sp.) and Begoniaceae (6 sp.). *Homalomena aromatica* represents the herbaceous plant with the highest number of IVI (7.68) showing its dominance in the study site among the herbs showing the appropriate condition for their growth as an understorey plant. During the study, six species of *Begonia* was found showing the richness of species in the genus among the herbaceous plants. Many of these *Begonia* species was found to be endemic to northeast India and Eastern Himalayas. Within the NWS, 43 shrub species under 39 genera from 19 families were identified with the maximum representation from the family Fabaceae with nine (9) species. However, a major concern is the emergence of the dominant shrub species *Chromolaena odorata* ranking first in the Importance Value Index (24.57). The Orchidaceae family is represented by 13 species from 9 genera which are all epiphytic species except for *Spathoglottis pubescens*, which is a ground orchid. A total of 32 climber species under 25 genera in 17 families were recorded from the present study as climbers are quite diverse and abundant component of tropical forest which compete with the trees for light space and nutrients. climbing plant species were also documented. The family Convolvulaceae has the highest number of species (5) in the climbers. Sixteen (16) grass species from the Poaceae and Cyperaceae families were identified. Ten (10) species of canes and palms from the Arecaceae family were also documented. Among these, *Borassus flabellifer* was classified as endangered (EN), and both *Calamus acanthospathus* and *Calamus erectus* were listed as vulnerable (VU) according to their conservation status.

Studying of the angiosperm diversity NWS is crucial as the study could provide insights into the ecosystem health of the sanctuary by identifying and documenting the diverse life forms in the sanctuary, identifying the dominant taxa as well the RET taxa that will help in development of effective conservation

strategies to protect the unique flora within the NWS. Also, by providing a comprehensive understanding of forest diversity, composition, and structure, the study aids in the formulation of conservation and sustainable management strategies. This is particularly important for the protection of 25 identified RET species like *Bombax insigne*, *Dipterocarpus turbinatus*, *D. retusus*, *Prunus ceylanica*, and *Saurauia punduana* among the trees and *Aerides rosea*, *Renanthera imschootiana* among orchids etc. Among them, three species—*Bombax insigne*, *Saurauia punduana*, and the newly discovered *Parahellenia mizoramensis*—are categorized as critically endangered (CR), while 14 species are listed as endangered (EN), six species are classified as vulnerable (VU) and two are near threatened (NT). While exploring the angiosperm diversity in NWS, we could also collect a unique taxa from Costaceae family which was not described previously. After detailed study, we could describe the species *Parahellenia mizoramensis* as new to science with even the genera as new record for India. Overall, the study enhances our knowledge of the sanctuary's ecosystems and supports efforts to adapt conservation strategies in the face of changing environmental conditions. The research contributes valuable information for the development of effective forest management plans in the sanctuary.

Ethnobotanical study was carried out in the villages surrounding Ngengpui Wildlife Sanctuary (NWS). The study aimed to document and analyzed the traditional medicinal knowledge, forest-derived food, and various ethnobotanical practices among communities belonging to different tribes namely Lushai, Lai, Bru, Bawm, Zakhai, Khumi, Pang, Mara, Paihte, Chakma, and Matu tribes. For ethnomedicinal study, the collected data were quantitatively analyzed using several parameters, including relative frequency of citation (RFC), fidelity level (FI), informant consensus factor (Fic), and use value (UV). In the area, a total of 210 plant species were identified as having significant connections to the local inhabitants. Among these, 104 species were utilized for ethnomedicines, 41 species served as wild edible vegetables, 22 as wild edible fruits, 25 as timber yield plants, 56 tree species were utilized for firewood and charcoal production, 14 as fodder, and 20 for various other purposes.

Among the 104 ethnomedicinal plant species from 44 families, with trees constituting the highest proportion (35.58%), followed by herbs (33.65%). Leaves were the most commonly used plant part (41%), followed by bark (13%) and fruit (12%). These plants were utilized to treat 44 different ailments categorized into 13 groups. The fidelity level (Fl) ranged from 6% to 100%, and the informant consensus factor (Fic) varied from 0.33 to 0.97 across the study region. Highly cited medicinal plants with significant RFC values included *Chromolaena odorata* (0.86), *Flueggea virosa* (0.79), *Oroxylum indicum* (0.68), *Curcuma longa* (0.64), *Mikania micrantha* (0.64), and *Rhus chinensis* (0.63). These species were widely recognized by a large number of informants in the study.

Based on the extensive array of plant uses scrutinized, particularly in terms of medicinal applications, it becomes evident that the flora within the NWS region serves pivotal roles for the fringe villages. Beyond their medicinal significance, these plants fulfill a spectrum of diverse needs: some serve as timber for construction purposes, others contribute as vital sources of wild edible vegetables and fruits, while yet others are valued for their efficacy as fuelwood. It is imperative to meticulously document these multifaceted uses, given the gradual erosion of ethnobotanical knowledge among succeeding generations. Our findings underscore the enduring disparity between urban and rural lifestyles, highlighting the profound reliance of village communities on forest resources for myriad necessities. Moreover, the rich tapestry of traditional knowledge embedded within the utilization of these plants underscores their cultural and ecological significance. Preserving this knowledge is not merely an academic pursuit but also a means of safeguarding invaluable practices that have sustained communities for generations. As such, efforts to document and transmit this knowledge must be prioritized to ensure its continuity and relevance in contemporary contexts.

6.2 Significant findings

The research on the floristic diversity of angiosperm in Ngengpui Wildlife Sanctuary of Mizoram made several findings including its ethnobotanical significance:

- a) **High Species Diversity:** NWS hosts a remarkable diversity of angiosperms taxa from different life forms, highlighting its importance of floral richness in the region. A total of 353 angiosperm species from 273 genera from 91 families could be documented showing the rich diversity of flowering plants inside the sanctuary.
- b) **Dipterocarp dominant forest:** Among the two species of Dipterocarpaceae family, *D. retusus* emerged as the dominant tree species in the sanctuary, indicating their ecological significance and potential role as key structural components of the forest ecosystem. The Dipterocarp forest are known for their rich biodiversity which are vital for carbon sequestration, providing habitat for numerous plants and animal species and understanding the health of ecosystem.
- c) **Discovery of New Species:** During the research study, a previously unknown taxa *Parahellenia mizoramensis* (DOI: 10.1016/j.japb.2023.11.007) belonging to the family Costaceae has been discovered from the sanctuary. This finding underscores the significance of ongoing biodiversity exploration efforts and contributes to our understanding of the intricate web of life within this ecosystem. Also, the sanctuary serves as a reservoir of undiscovered biodiversity and the need for continued exploration and conservation efforts.
- d) **Endemic and RET taxa:** The present research identified many endemic and rare angiosperm species unique to the sanctuary, emphasizing its value for the preservation of regionally significant plant diversity. It was found that numerous taxa are facing threats to their survival, with a total of 25 species identified as threatened. These findings highlight the urgent need for conservation measures to protect the biodiversity of the region. In Ngengpui

Wildlife Sanctuary (NWS), several species native to Mizoram have been identified, including *Parahellenia mizoramensis*, *Zingiber mizoramense*, and *Zingiber murlenica*. These species represent unique components of Mizoram's biodiversity and contribute to the rich ecological tapestry of the sanctuary.

- e) **Invasive Alien Species:** The study also documented the presence of invasive alien angiosperm species within the sanctuary which can affect the diversity of many native taxa suggesting the change the original habitat inside the sanctuary. These invasive alien plants that include *Chromolaena odorata*, *Ageratina riparia*, *A. adenophora*, *Mikania micrantha*, *Lantana camara* etc. which are well known for their aggressive invasive characters could potentially challenge the native plant communities and ecosystem dynamics in the sanctuary which are home to many RET and endemic taxa.
- f) **Ecological Significance:** Understanding the floristic diversity of angiosperms from different life forms in Ngengpui Wildlife Sanctuary is essential for assessing its ecological significance, including its role in providing habitat, food sources and ecosystem services for wildlife population.
- g) **Ethnobotanical Significance:** The indigenous communities residing near the sanctuary rely on angiosperm species for various traditional uses including medicinal, culinary, ritual, economic purposes. A total of 210 species were found to be ethnobotanically useful with many of these plants play a crucial role in the livelihoods, cultural practices, and traditional knowledge systems of local communities. Understanding and conserving these ethnobotanical resources are essential for promoting sustainable development, preserving cultural heritage, and fostering biodiversity conservation in the state.
- h) **Conservation Implications:** All the findings have significant implications for conservation management as many endemic as well as RET taxa are

identified from the sanctuary, highlighting the importance of protecting them as well as the diverse angiosperm flora of NWS and addressing threats such as habitat loss, invasive species, and climate change.

6.3 Conclusion

The extensive study could address the knowledge gap in forest structure and composition within the Ngengpui Wildlife Sanctuary in Mizoram, northeast India. It has yielded crucial insights with significant implications for conservation and sustainable forest management. The six focused areas fall under Tropical Wet Evergreen and Semi-Evergreen Forest types, providing a thorough understanding of the ecosystems in this protected area. The variation in forest structure metrics through study on tree diversity composition across different areas, such as stem density and mean stem diameter, underscores the heterogeneity of these ecosystems. The reverse J-shaped distribution of tree diameters highlights the uneven-agedness within the forests, emphasizing the significance of integrating regeneration dynamics in management strategies. Differences observed in the characteristics among the six forests, such as the highest Shannon diversity index in Hmunnuam (HN) forests and unique structural features in Bungtlang south (BS) and Khawmawi (KM) forests, emphasize the necessity for customized management approaches.

The angiosperm diversity in Ngengpui Wildlife sanctuary represents a diverse array of trees, herbs, shrubs, climbers, epiphytes, grasses and the palms and canes. Among the tree species, *Dipterocarpus retusus* represents the dominant species, *Homalomena aromatica* in herbs, *Chromolaena odorata* in shrubs respectively. The remarkable richness of tree diversity with a total report of 353 species within NWS not only enhances the ecological integrity of the sanctuary but also supports a wide array of flora and fauna, including endemic and threatened taxa making it a critical area for wildlife conservation. Forest in NWS is a dipterocarp dominant forest with both the two species *Dipterocarpus retusus* and *D. turbinatus* reported from the study sites which are categorized under threatened category of IUCN Red List due to

severe threats from logging due to the timber potential and land use changes. Dipterocarps play a critical role in numerous regions where they thrive offering essential ecosystem services and they rank among the most highly coveted timber species in both South and Southeast Asia. So, by recognizing and preserving the tree species including various threatened taxa within the NWS, we can ensure the continued health of this vital ecosystem, safeguarding its biodiversity for future generations.

The presence of diverse herbaceous plants including many endemic monocots, shrubs, climbers, bamboos, palms and epiphytes which are characteristic of any tropical forest underscores the ecological resilience and importance of preserving its habitats. Each of these plant groups plays a unique role in the ecosystem, contributing to nutrient cycling, soil stabilization and microclimate regulation. The identification of the unique assemblages and distribution patterns across different habitats and life forms in NWS is imperative to implement holistic conservation strategies. However, another major concern during the study was the presence of many IAPS that could pose a significant threat to the native biodiversity and ecological integrity of many such protected forest. So, early detections and measures to identify these IAPS before successful invasion are critical for protecting these vulnerable ecosystems.

The discovery of *Parahellenia mizoramensis* as novel addition of taxa to science from NWS serves as a reminder of the importance of biodiversity conservation and underscore the need for continued scientific inquiry and protection of natural habitats. Also, the rich biodiversity present in the sanctuary suggests that there may be numerous other undiscovered species awaiting identification. The taxa from Zingiberaceae family *Z. mizoramensis* and *Z. murlenica* are found endemic to Mizoram although there are many taxa endemic to northeast region including *Renanthera imschootiana*, *Globba spathulata*, *Globba wardii* and *Homalomena aromatica*. The documentation of endemic and threatened species, including *Bombax insigne*, *Dipterocarpus turbinatus*, *D. retusus*, *Prunus ceylanica*, and *Saurauia punduana*, underscores the conservation significance of Ngengpui

Wildlife Sanctuary (include more). The diverse range of habitats provides a crucial breeding ground for many species, contributing to regional biodiversity conservation efforts.

The ethnobotanical studies conducted on various indigenous communities residing in fringe villages of NWS highlights the importance of preserving not only the biodiversity of the sanctuary, but also the traditional knowledge and practices of the local communities. Many plant species identified through the present study have been found to have medicinal, edible resources and various other uses showing the multifaceted contributions to human well-being and livelihoods. The ethnobotanical studies emphasize the interconnectedness of these indigenous communities with nature and shows the importance of integrating local knowledge and practices into conservation efforts. In promoting sustainable practices, the documentation and quantitative analysis of local plant uses serve as a foundational resource. The ethnobotanical study not only sheds light on the intricate relationship between people and nature but also advocates for a harmonious coexistence that recognizes the value of traditional wisdom in the pursuit of conservation and sustainable management practices. This information provides a roadmap for conservation strategies that integrate traditional knowledge, ensuring the continued well-being of local communities while safeguarding the delicate ecological balance of Ngengpui Wildlife Sanctuary.

The ethnobotanical wealth of the NWS region offers a compelling narrative of human ingenuity and resilience. By documenting and preserving the traditional uses of plants, we honor the profound interconnectedness between culture, biodiversity, and sustainable livelihoods. The findings of this study provide a foundation for further research on the medicinal properties of these plants and inform conservation efforts aimed at preserving both traditional knowledge and the natural resources that support it. Sustainable management practices that integrate traditional knowledge with modern conservation strategies are essential for fostering a balanced and resilient ecosystem. This approach not only protects biodiversity but also ensures the well-being and cultural integrity of local

communities, creating a sustainable future that honors the past. The documentation and quantitative analysis of local plant uses in NWS represent a crucial step in evaluating the useful plants and promoting sustainable utilization of indigenous practices associated with these plants. The findings emphasize the importance of preserving traditional knowledge and biodiversity while addressing the conservation needs of endangered ethnobotanically important plant species in the region.



A. Acmella ciliata



Amorphophallus napalensis



Begonia roxburghii



Boehmeria nivea



Canna indica



Cyclocodon axillaris



Floscopa scandens



Impatiens tripetala



Sonerila maculata



Staurogyne argentea



Torenia crustacea



Torenia violacea

Photoplate 1: Herbs



Albizia chinensis



Alstonia scholaris



Dillenia indica



Dipterocarpus retusus



Duabanga grandiflora



Lagerstroemia speciosa



Macaranga peltata



Mesua ferrea



Mallotus nudiflorus



Palaquium polyanthum



Schinus molle



Terminalia myriocarpa

Photoplate 2: Trees



A. *Calamus latifolius*



B. *Calamus melanochaetes*



C. *Licuala spinosa*



D. *Cymbidium aloifolium*



E. *Liparis viridiflora*



F. *Rhynchosyllis retusa*



G. *Callicarpa arborea*



H. *Engelhardia spicata*



I. *Magnolia champaka*



J. *Aeginetia indica*



K. *Homalomena aromatica*



L. *Musa ornata*

Photoplate 3: A – C: Canes, D-F : Orchids, G-I : Trees, J-I : Herbs.



Brachiaria decumbens



Cortaderia selloana



Cyperus croceus



Cyperus iria



Cyrtococcum oxyphyllum



Cyrtococcum patens



Digitaria radicata



Melocanna baccifera



Oplismenus hirtellus



Setaria palmifolia



Sporobolus diander



Thysanotlaena latifolia

Photoplate 4: Grasses



Aristolochia sp.



Entada phaseoloides



Ipomoea cairica



Mikania micrantha



Parderia foetida



Persicaria chinensis



Piper betle



Piper longum



Pueraria lobata



Rhaphidophora decursiva



Thunbergia grandiflora



Uncaria sessilifructus

Photoplate 5: Climbers



Abelmoschus moschatus



Chromolaena odorata



Clerodendrum infortunatum



Duranta erecta



Lantana camara



Mussaenda macrophylla



Osbeckia stellata



Oreocnide integrifolia



Pavetta indica



Sarcochlamys pulcherrima



Sida acuta



Solanum torvum

Photoplate 6: Shrubs



A. *Alpinia conchigera*



B. *Alpinia malaccensis*



C. *Curcuma longa*



D. *Etlingera linguiformis*



E. *Globba orixensis*



F. *Hedychium coccineum*



G. *Hedychium greenii*



H. *Hedychium stenopetalum*



I. *Zingiber mizoramensis*



J. *Zingiber murlenica*



K. *Chellocostus speciosus*



L. *Parahellenia mizoramensis*

Photoplate 7: A-J: Zingiberaceae, K & I: Costaceae

Appendices

Appendix 1

Questionnaires on Ethnobotanical Data Collection of NWS

- Informants' detail

Name/Hming:

☐ Gender : Male ☐ / Female

Age/kum :

☐ Community/Hnam Hming : Hmar ☐ / Paihte

- Data on ethnobotanical importance of wild plants

Local name of plant/Thlai hming :

Habit of plant/Nihphung :

Mode of consumption/ Chawh me hasiam dan:

Part used as food :

Season of availability/a awm hun : 1) Whole year/ kum tluan in

2) From to (Month)

Medicinal value (If any)/ Damdawi atan ahmanna:

.....

Use report for other disease treatment (Natna dang a hmanna):

.....

I hereby give my full consent and willingly accepted to participate in this study and declare that the information provided by me during the course of interview was true and accurate to the best of my knowledge.

Appendix 2

Questionnaires on Multipurpose uses of wild flora from Ngengpui Wildlife Sanctuary, Mizoram.

- Informants' detail

Name/Hming :

Gender : Male ☐ / Female ☐

Age/kum :

- Data on multipurpose plant species (DMR)

Trees/Thingming	Vegetable / Chawhmeh	Firewood/ Tuahting	Fodder/ Ranchaw	Fruit / Thei	Timber / Damdawi

I hereby give my full consent and willingly accepted to participate in this study and declare that the information provided by me during the course of interview was true and accurate to the best of my knowledge.

References

- Agarwal, S. K. (2002). International Cooperation on Biodiversity. In: *Biodiversity Conservation*. Rohini Books, Jaipur, pp: 79-11.
- Agrawal, K. C. (2002). *Global Biodiversity (Conservation, Indigenous Rights and Biopiracy)*. Nidhi publishers (India), Bikaner, pp: 1-75.
- Aiba, Shin-ichiro and Kitayama, Kanehiro. (1999). Structure, composition and species diversity in an altitude-substrate matrix of rain forest tree communities on Mount Kinabalu, Borneo. *Plant Ecology*, **140**: 139–157.
- Alexiades, M.N. (1996). Selected Guidelines for Ethnobotanical Research: A Field Manual. The New York Botanical Garden, New York, pp: 99-133.
- Ali, A.I. and Das, I., (2003). Tribal situation in northeast India. *Studies of Tribes and Tribals*, **1**(2): 141-148.
- Andrade-Cetto, A. (2009). Ethnobotanical study of the medicinal plants from Tlanchinol, Hidalgo, México. *Journal of ethnopharmacology*, **122**(1), 163-171. <https://doi.org/10.1016/j.jep.2008.12.008>
- Andrewartha, H.G. and Birch, L.C. (1984). *The Ecological Web*. University of Chicago Press, Chicago.
- Anon. (1978). *Tropical Forest Ecosystems: A State-of-Knowledge Report*. UNESCO, Paris, France.
- Anon. (1990). *Ethnobiology in India. A status report*: MoEF, New Delhi, pp: 1- 68.
- Anon. (2009). *India State of Forest Report*. (2009). Forest Survey of India, Ministry of Environmental & Forests, Govt. of India, Dehradun, India.
- Anon. (2011) *State Forest Report*. (2011). Published by Forest Survey of India, Dehradun, pp: 187.

- Anon. (2015). *India State of Forest Report*. (2015). Forest Survey of India, Ministry of Environmental & Forests, Govt. of India, Dehradun, India, pp: 34- 44.
- Arora, R.K. (1995). Himalayan Resources, Diversity and Conservation, *In*: U. Dhar (ed.), *Himalayan Biodiversity*. Gyanodaya, Prakashan. Nainital, 2:39-55.
- Balick, M. J. and Cox, P. A. (1996). *Plants, people, and culture: the science of ethnobotany*. Scientific American Library.
- Balmford, A., G.J. Gaston, S. Blyth, A. James and V. Kapos (2003), ‘Global variation in conservation costs, conservation benefits, and unmet conservation needs’, *Proceedings of the National Academy of Sciences of the U.S.A.*, **100**(3): 1046–50.
- Bansal, M., Morley, R.J., Nagaraju, S.K., Dutta, S., Mishra, A.K., Selveraj, J., Kumar, S., Niyolia, D., Harish, S.M., Abdelrahim, O.B. and Hasan, S.E., (2022). Southeast Asian Dipterocarp origin and diversification driven by Africa-India floristic interchange. *Science*, **375**(6579): 455-460.
- Barbhuiya, P.A., Laskar, A.M., Mazumdar, H., Dutta, P.P., Pathak, M.P., Dey, B.K. and Sen, S., (2022). Ethnomedicinal Practices and Traditional Medicinal Plants of Barak Valley, Assam: a systematic review. *Journal of Pharmacopuncture*, **25**(3): 149.
- Barik, S. K., Pandey, H. N., Tripathi, R. S. and Rao, P. (1992). Micro-environmental variability and species diversity in tree fall gaps in subtropical broad-leaves forest. *Vegetation*, **103**: 31-40.
- Barnes, B. V., Zak, D. R., Denton, S. R. and Spurr, S. H. (1998). *Forest Ecology* (4th Edition) John Wiley & Sons, Inc. USA, pp: 588-611.

- Bhagwat, S.A. and Willis, K.J. (2008) Agroforestry as a solution to the oil-palm debate. *Conservation Biology*, **22**: 1368-1369.
- Bhatt, A. and Bankoti, N.S. (2016). Analysis of forest vegetation in Pithoragarh Kumaun Himalayas, Uttarakhand, India. *International Journal of Current Microbiology and Applied Sciences*, **5**(2): 784-793.
- Bhutia, Y., Gudasalamani, R., Ganesan, R. and Saha, S., (2019). Assessing forest structure and composition along the altitudinal gradient in the state of Sikkim, Eastern Himalayas, India. *Forests*, **10**: 633. <https://doi.org/10.3390/f10080633>
- Borah, N. and Garkoti, S.C., (2011). Tree species composition, diversity and regeneration patterns in undisturbed forests of Barak Valley, South Assam, India. *Int. j. Ecol.* **37**, 131 – 141. <http://dx.doi.org/10.13140/RG.2.1.1808.6563>
- Brooks, T.M., Mittermeier, R.A., Da Fonseca, G.A., Gerlach, J., Hoffmann, M., Lamoreux, J.F., Mittermeier, C.G., Pilgrim, J.D. and Rodrigues, A.S. (2006). Global biodiversity conservation priorities. *Science*, **313**(5783): 58-61.
- Brooks, T.M., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B., Rylands, A.B., Konstant, W.R., Flick, P., Pilgrim, J.D., Oldfield, S., Magin, G. and Hilton-Taylor, C. (2002) Habitat loss and extinction in the hotspots of biodiversity. *Conservation Biology*, **16**:909–923
- Champion H. G. and S. K. Seth (1968). *A Revised Survey of Forest Types of India*. FRI, Dehradun, pp: 404.

- Chandra, J., Rawat, V.S., Rawat, Y.S. and Ram, J. (2010). Vegetational diversity along an altitudinal range in Garhwal Himalaya. *International Journal of Biodiversity and Conservation*, **2**:14-18.
- Chatterjee, S. (2008). Biodiversity conservation issues of Northeast India. *International Forestry Review*, **10**(2):315-324.
- Chaturvedi, R.K., Gopalakrishnan, R., Jayaraman, M., Bala, G., Joshi, N.V., Sukumar, R. and Ravindranath, N.H. (2011). Impact of climate change on Indian forests: a dynamic vegetation modeling approach. *Mitigation and Adaptation Strategies for Global Change*, **16**:119-142.
- Chaudhuri, A. B. (1993). *Tree and the Environment: An Indian Scenario*, Ashish Publishing House, 8/81, Punjabi Bagh, New Delhi- 110026, pp: 592.
- Clifford, H. T. and Stephenson, W. (1975). *An Introduction to Numerical Classification*, Academic Press, London.
- Cotton, C.M. (1996). *Ethnobotany: Principles and Applications*. Chichester. John.Wiley & Sons, pp: 242-348.
- Curtis, J.T. and McIntosh, R.P., (1950). The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*. **31**: 434-55.
<https://doi.org/10.2307/1931497>
- Dashman, R. F. (1986). *A different kind of country*, Mac Milan Company, New York.
- Deb, D.B. and Dutta, R.M. (1987). A contribution to the flora of Mizoram. *Journal of Economic and Taxonomic Botany*, **10**(1):21-61.
- Devi, L.S. and Yadava, P.S. (2006). Floristic diversity assessment and vegetation analysis of tropical semi evergreen forest of Manipur, north east India. *Tropical Ecology*, **47**(1): 89-98.

- Dhillion, S.S., Svarstad, H., Amundsen, C. and Bugge, H.C. (2002). Bio prospecting: effects on environment and development. *AMBIO* **31** (6): 491–493.
- Dutta, B.K. and Dutta, P.K., (2005). Potential of ethnobotanical studies in North East India: An overview. *Indian Journal of Traditional Knowledge*, **4**(1):7-14.
- Ellu, G. and Obua, J. (2005). Tree condition and natural regeneration in disturbed sites of Bwindi impenetrable forest national park, South Western Uganda. *Tropical Ecology*, **46**:99-111.
- Elredge, N. (Ed.) (2002). *Life on earth: An Encyclopedia of Biodiversity, Ecology and Evolution*, Vol. 1 (A-G). ABC-CLIO Inc. Santa Barbara, California.
- Fischer, C. E. C. (1938). *The Flora of the Lushai Hills*. Firma KLM, Pvt. Ltd. Culcutta.
- Gage, A. T. (1899). *A Botanical tour in the south Lushai Hills*. Periodic Expert Book Agency, Delhi.
- Gaston, K.J. (1996). *Biodiversity: A Biology of numbers and difference*, Oxford: Blackwell.
- Geist, H. J. and Lambin, E. F. (2002). Proximate causes and underlying driving forces of tropical deforestation. *BioScience*, **52**:143-150.
- Gentry, A. H. (1988). Changes in plant community diversity and floristic composition on environment and geographical gradients. *Annals of the Missouri Botanical Garden*, **75**:1-34.
- Giday, M., Asfaw, Z., Woldu, Z., & Teklehaymanot, T. (2009). Medicinal plant knowledge of the Bench ethnic group of Ethiopia: an ethnobotanical investigation. *Journal of Ethnobiology and Ethnomedicine*, **5**(1): 1-10. <https://doi.org/10.1186/1746-4269-5-34>.

- Greig-Smith, P. (1957). *Quantitative Plant Ecology*, 2nd edition. Butterworth, London.
- Groombridge, B. (Ed.). (1992). *Global Biodiversity: Status of the Earth's Living Resources*. Chapman and Hall, London.
- Hare, M. A., Lantagne, D. O., Murphy, P. G. and Checo, H. (1997). Structure and tree species composition in a sub-tropical dry forest in the Dominican Republic; comparison with a dry forest Puerto Rico. *Tropical Ecology*, **38**(1):1-17.
- Harper, J.L. and Hawksworth, D.I. (1994). Biodiversity: Measurement and estimation- preface. *Philosophical Transactions of the Royal Society of London Series B*, **345**:5-12.
- Harshberger, J.W. (1896). The purposes of ethno-botany. *Botanical gazette*, **21**(3): 146-154.
- Hart, K.H. and Cox, P.A. (2000). A cladistic approach to comparative ethnobotany: Dye plants of the the southwestern United States. *Journal of Ethnobiology*, **20**(2): 303-325.
- Hassan, N., Din, M. U., Shuaib, M., Ul-Hassan, F., Zhu, Y., Chen, Y., ... and Iqbal, A. (2019). Quantitative analysis of medicinal plants consumption in the highest mountainous region of Bahrain Valley, Northern Pakistan. *Ukrainian Journal of Ecology*, **9**(1):35-49.
<https://doi.org/10.1016/j.chnaes.2020.09.003>
- Hawksworth, D.L. (1996). *Biodiversity: measurement and estimation*. Springer, pp: 6.

- Hazarika, T.K., Lalramchuana and Nautiyal, B.P. (2012), Studies on wild edible fruits of Mizoram India used as ethnomedicine, *Genetic Resources and Crop Evolution*, **59**: 1767-1776.
- Heinrich, M., Ankli, A., Frei, B., Weimann, C. and Sticher, O. (1998). Medicinal plants in Mexico: Healers' consensus and cultural importance. *Social Science & Medicine*, **47**(11): 1859-1871. [https://doi.org/10.1016/S0277-9536\(98\)00181-6](https://doi.org/10.1016/S0277-9536(98)00181-6)
- Heywood V. H. (Ed.) (1994). The measurement of Biodiversity and the politics of implementation *In*: Forey, P.L., Humphries, C.J. and Vane-Wright, R.I. (Eds.). *Systematics and Conservation Evaluation*, Claderon Press. Oxford. pp:15-21.
- Holsinger, K.E. (2005). Global biodiversity patterns. [http: creative common. Org/lincenses/by ncsa/2.5](http://creativecommons.org/licenses/by-ncsa/2.5).
- Hooker, J.D. (1872-1897). *The Flora of the British India*, Vol. 1-7. London.
- Hore, D.K. (2005). Rice diversity collection, conservation and management in northeastern India. *Genetic Resources and Crop Evolution*, **52**:1129-1140.
- Huang, W., Pohjonen, V., Johansson, S., Nashanda, M., Katigula, M.I.L. and Luukkanen, O. (2003). Species diversity, forest structure and species composition in Tanzanian tropical forests. *Forest Ecology and management*, **173**(1-3): 11-24.
- Huang, W., Pohjonen, V., Johansson, S., Nashanda, M., Katigula, M. I. L., & Luukkanen, O. (2003). Species diversity, forest structure and species composition in Tanzanian tropical forests. *Forest Ecology and Management*, **173**: 11-24.

- Hubbell, S. P. and Foster, R. B. (1992). Short term dynamics of a neo-tropical forest: change within limits. *Bioscience*, **42**:822-828.
- Hubbell, S. P. and Foster, R.B. (1983). Diversity of canopy trees in a neotropical forest and implications for conservation: Sutton, S. L., Whitmore, T. C. and Chadwick, A. C. (eds). *Tropical rain forest: Ecology and Management*. Blackwell scientific Publishers, Oxford, pp: 25-41.
- Hubbell, S.P. (1979). Tree Distribution, Abundance and Diversity in a Tropical Dry Forest. *Science*, **203**(4387): 1299.
- ISFR. (2021). India State of Forest Report 2021. Forest Survey of India. Ministry of Environment, Forest and Climate Change, Government of India, Dehradun, India
- IUCN Standards and Petitions Committee. (2022). *Guidelines for using the IUCN Red List Categories and Criteria*. Version 15. Prepared by the Standards and Petitions Committee. Downloadable from <https://www.iucnredlist.org/documents/RedListGuidelines.pdf>.
- IUCN. (1996). 1996 Red List of Threatened Animals. IUCN, Gland, Switzerland, pp: 448.
- Jain, S.K. and Rao, R.R. (1977). Handbook of Field and Herbarium Methods. Today and tomorrow's Printers & Publishers, New Delhi.
- Jhala, Y.V., Gopal, R. and Qureshi, Q., (2008). Status of tigers, co-predators, and prey in India, p:164
- Kala, C. P., Farooquee, N. A. and Dhar, U. (2004). Prioritization of medicinal plants on the basis of available knowledge, existing practices and use value status

- in Uttaranchal, India. *Biodiversity & Conservation*, **13**:453-469.
[10.1023/B:BIOC.00000006511.67354.7f](https://doi.org/10.1023/B:BIOC.00000006511.67354.7f)
- Kalita, G. J., Rout, S., Mishra, R. K. and Sarma, P. (2015). Traditionally used medicinal Plants of Bajali Sub-division, Barpeta District, Assam. *Journal of Medicinal Plants*, **3**(2): 08-17.
- Kanjilal, U.N., Kanjilal, P.C., Das, A., De, R. N. and Bor, N. L. (1934-1940). *Flora of Assam.*, Vols. 1-5. Govt. Press, Shillong.
- Kayani, S., Ahmad, M., Sultana, S., Shinwari, Z.K., Zafar, M., Yaseen, G., Hussain, M. and Bibi, T., (2015). Ethnobotany of medicinal plants among the communities of Alpine and Sub-alpine regions of Pakistan. *Journal of ethnopharmacology*, **164**: 186-202.
- Kayani, S., Ahmad, M., Zafar, M., Sultana, S., Khan, M. P. Z., Ashraf, M. A., ... and Yaseen, G. (2014). Ethnobotanical uses of medicinal plants for respiratory disorders among the inhabitants of Gallies–Abbottabad, Northern Pakistan. *Journal of ethnopharmacology*, **156**:47-60.
<https://doi.org/10.1016/j.jep.2014.08.005>
- Kershaw, K.A. (1973). Quantitative and Dynamic Plant Ecology, 2nd edition. ELBS and Edward Arnold (publ.) Ltd. London, p: 308.
- Kharkwal, G. and Singh, Y. (2010). Structure and composition of vegetation in subtropical forest of Kumaun Himalaya. *African Journal of Plant Science*, **4**(4):116-121, April 2010.
- Kiester, A. R. (2001). Species Diversity, Overview. In *Encyclopaedia of Biodiversity*, Vol. 5. Academic Press, NY, p: 442.

- Kindt, R. and Coe, R., (2005). BiodiversityR: A package for community ecology and metapopulation dynamics in R. <http://www.ucl.ac.uk/~rkindt/biodiversityR/index.html>
- Kress, W. J., Prince, L. M., Williams, K. J. and Hahn, W. J. (2002). The phylogeny and a new classification of the gingers (Zingiberaceae): evidence from molecular data. *American Journal of Botany*, **89**(11): 1682-1696.
- Krishnamurthy, K.V. (2004). An advanced text book on Biodiversity Principles and Practice. Oxford and IBH Publishing, pp:1-3.
- Krishnaswamy, J., Bawa, K.S., Ganeshaiah, K.N. and Kiran, M.C., (2009). Quantifying and mapping biodiversity and ecosystem services: Utility of a multi-season NDVI based Mahalanobis distance surrogate. *Remote Sensing of Environment*, **113**(4): 857-867.
- Kumar, A., Marcot, B.G. and Saxena, A., (2006). Tree species diversity and distribution patterns in tropical forests of Garo Hills. *Current Science*, **91**: 1370-1381.
- Kumar, M and Bhatt, V. (2006). Plant Biodiversity and Conservation of Forests in Foot Hills of Garhwal Himalaya. *Lyonia*, **11**(2):43-59.
- Kumar, S., Saini, R., Suthar, P., Kumar, V. and Sharma, R. (2022). Plant secondary metabolites: Their food and therapeutic importance. In *Plant Secondary Metabolites: Physico-Chemical Properties and Therapeutic Applications*. Singapore: Springer Nature Singapore, pp: 371-413 [10.1007/978-981-16-4779-6_12](https://doi.org/10.1007/978-981-16-4779-6_12)

- Kumar, V., Dhaliwal, R.K., Singh, C. and Kaur, M. (2015). Impact of climate change on Faunal and Floral Diversity in Different Geographical Regions of Punjab. *Indian Journal of Forestry*, **38**(4):303-308.
- Kumaraguru, A., Brinda, T. and Sateesh, N. (2016). Diversity of vegetation in the tail end of eastern Ghats, Tiruchirappalli Forest division, Tamil Nadu, India. *Indian Forester*, **142**(4): 324-335.
- Kunwar, R. M. and Bussmann, R. W. (2008). Ethnobotany in the nepal himalaya. *Journal of Ethnobiology and Ethnomedicine*, **4**(1): 24.
- Lalawmpuii, G. (2019). Assessment of tree diversity and distribution pattern in Lengteng Wildlife Sanctuary of Mizoram, India. Ph.D. Thesis. Mizoram University, Aizawl.
- Lalbiaknunga, J. (2012). Ecological Studies on plant diversity of Thorang Sanctuary. Ph.D. Thesis. Dept. of Environmental Science, Mizoram University, Aizawl, pp: 1-160.
- Lalfakawma, Khomdram S.D. and Yumkham S. D., (2023). A new generic record of Indian Costaceae with the discovery of new species *Parahellenia mizoramensis* from Northeast India. *Journal of Asia-Pacific Biodiversity*, <https://doi.org/10.1016/j.japb.2023.11.007>
- Lalfakzuala, R., Lalramnghinglova, H. and Kayang, H. (2007). Ethnobotanical usages of plants in western Mizoram, *Indian Journal of Natural Product and Resources*, **6** (3): 486.
- Lallawmkimi (2010). *Floristic studies of Tawi Wildlife Sanctuary in Aizawl District of Mizoram*. Ph.D. Thesis. Mizoram University, Aizawl.

- Lalnunmawia, F. (2003). *Comparative study on growth and productivity of three bamboo species grown with ginger crop*. Ph.D. Thesis. Mizoram University, Aizawl.
- Lalnuntluanga (2007). *Study on taxonomy, distribution and utilization of Canes/Rattans in Mizoram*. Ph.D Thesis. Dept. of Environmental Science, Mizoram University, Aizawl.
- Lalramnghinglova H. (2002) Ethnobotanical study on the edible plants of Mizoram, *Ethnobotany*, **14**: 23-33.
- Lalramnghinglova, H. and Jha, L. K. (1998). Ethnomedicinal plants among the hill tribes of Mizoram. *Prospects of Medicinal plants*: 67-86.
- Lalramnghinglova. H. (1999). Ethnobotanical and agroecological studies on genetic resources of food plants in Mizoram State. *Journal of Economic and Taxonomic Botany*, **23**(2): 637.
- Lalramnghinglova, H. (1997). *Handbook of Common Trees of Mizoram*. K. Lalhluna, Zarkawt, Aizawl.
- Lalramnghinglova, H. (2003). *Ethno-Medicinal Plants of Mizoram*. Bishen Singh Mahendra Pal Singh, Dehra Dun, p:328.
- Lalramnghinglova, H. (2011). Technical Report. Biodiversity exploration in the Protected Area (Murlen National Park) of Mizoram, 108p. (UGC project).
- Lalramnghinglova, H. (2016). *A guide to herbarium methods*. Lengchhawn Press, Aizawl, Mizoram, India, p: 110.
- Lalramnghinglova, H. and Lalchhuanawma (2010). *Plants of Mizoram University Campus, Aizawl, Mizoram*. p: 256.

- Lalramnghinglova, H. and Lalnunmawia, F. (2011). *Forest resources of Mizoram*, Dept. of Environmental Science and RCNAEB, NEHU, Shillong, pp: 1-345.
- Lalthanzara, H., Sailo, L., Solanki, G.S. and Ramanujam, S.N. (2014). Galliformes and their conservation issues in Mizoram, India. *CIBtech Journal of Zoology*, **3**(1): 42.
- Leonti, M. (2022). The relevance of quantitative ethnobotanical indices for ethnopharmacology and ethnobotany. *Journal of Ethnopharmacology*, **288**:115008.
- Likens, G.E. (1993). Human accelerated environmental change: An ecologist's view. *The Bulletin of the Ecological Society of America*, **74**: 331.
- Lovejoy, T.E. (1980). Changes in Biological diversity. In: G.O. Barney (ed.) *The global 2000 report to the president, Vol 2* (the technical report), Harmonds- worth: Penguin Books, pp: 327-332.
- Ly, V., Nanthavong, K., Pooma, R., Luu, H.T., Nguyen, H.N., Vu, V.D., Hoang, V.S., Khou, E. and Newman, M.F. (2017). *Dipterocarpus retusus*. *The IUCN Red List of Threatened Species* 2017: e.T32400A2817693. <https://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T32400A2817693.en>.
- Lyngdoh, A.W., Kumara, H.N., Karunakaran, P.V. and Babu, S., (2019). A review on status of mammals in Meghalaya, India. *Journal of Threatened Taxa*, **11**(15): 14955-14970.
- Mac Arthur, R. and Connell, J. (1966). *The Biology of Populations*. New York: John Wiley and Sons.

- Magurran, A.E. (1998). Ecological diversity and its measurements. Croom Helm Limited, London, pp: 7-167.
- Malsawmsanga, A. (2011). Studies on Plant Diversity of Phawngpui National Park. Ph.D. Thesis. Dept. of Environmental Science, Mizoram University, Aizawl, pp: 1-189.
- Mao, A.A. and Hynniewta, T.M., (2000). Floristic diversity of North East India. *Journal of the Assam Science Society*, **41**(4): 255-266.
- Martin, G.J. (1995). Ethnobotany: a Methods Manual, Chapman & Hall, London.
- Mathur, A. and Joshi, H. (2015). Important timber (wood) plant species found in tarai region of Kumaun, Uttarakhand. *Indian Journal of Forestry*, **38**(3):227-230.
- Mayaux, P., Holmgren, P., Achard, F., Eva, H., Stibig, H., and Branthomm, A. (2005). Tropical forest cover change in the 1990s and options for the future monitoring. *Philosophical Transactions of Royal Society: Biological Sciences*, **360**:373- 384.
- Mc. Allister, D. (1991) Estimating the pharmaceutical value of forests, Canadian and tropical. *Canadian Biodiversity*, **1**: 16-25.
- McNeely, J.A., Miller, K.R., Mittermeier, R.A. and Werner, T.B. (1990). *Conserving the World's Biological diversity*. IUCN, Gland; WRI, CI, WWF-US, and the World Bank, Washington D.C.
- Mishra, B. P. and Jeeva, S. (2008). Plant diversity and community attributes of woody plants in two climax subtropical humid forests of Meghalaya, Northeast India. *Applied Ecology and Environmental Research*, **10**(4): 417-436.

- Mishra, B.P., Tripathi, R.S., Tripathi, O.P. and Pandey, H. N. (2004). Effect of anthropogenic disturbance on plant diversity and community structure of a sacred grove in Meghalaya, north-east India. *Biodiversity & Conservation*, **13**:421-436.
- Misra, R. (1968). Ecology Workbook. Oxford & IBH Publishing. Co. New Delhi, pp: 175- 180.
- Mittermeier, R.A., Gil, P.R., Hoffmann, M., Pilgrim, J., Brooks, T., Mittermeier, C.G., Lamoreux, J. and da Fonseca, G.A.B. (2004). Hotspots revisited. Cemex: Mexico City, Mexico.
- Mueller-Dombois, D. and Ellenberg, H., (1974). Aims and Methods in Vegetation Ecology. John Wiley & Sons, New York.
- Murthy, I. K., Bhat, S., Sathyanarayan, V., Patgar, S., Beerappa, M., Bhat, P.R., Ravindranath, N.H., Khalid, M.A., Prashant, M., Iyer, S., Bebbber, D.M. and Saxena, R. (2016). Vegetation structure and composition of tropical evergreen and deciduous forests in Uttara Kannada District, Western Ghats under different disturbance regimes. *Tropical Ecology*, **57**(1):77-88.
- Myers N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B. and Kent, J. (2000) Biodiversity hotspotsfor conservation priorities. *Nature* **403**:853–858.
- Myers, N. (1979) *The Sinking Ark*. New York. Pregamon.
- Myers, N. (1988). Threatened biotas: 'hotspot' in tropical forests. *The Environmentalist*, **8**(3): 187-208.
- Myers, N. (1990). The biodiversity challenge: expanded Tiotspots' analysis. *The Environmentalist*, **10**: 243-256.

- Myers, N., Lovett, J.C. and Burgess, N.D. (1999). Eastern Arc Mountains and coastal forests. In R.A. Mittermeier, N. Myers, P. Robles Gil & C.G. Mittermeier.
- Myers, N., Mittermeier, R.A., Mittermeier, C.G, da Fonseca, Y.A.B. and Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, **403**(6772): 853-858.
- Nayar, M.P. and Sastry, A.R.K. (1987). *Red data book of Indian plants*. Vol. 1. Calcutta: Botanical Survey of India, p:367.
- Ndah, N.R., Andrew, E.E. and Bechem, E. (2013). Species composition, diversity and distribution in a disturbed Takamanda Rainforest. *African Journal of Plant Science*, **7**(12):576-585.
- Ngarivhume, T., van't Klooster, C. I., de Jong, J. T. and Van der Westhuizen, J. H. (2015). Medicinal plants used by traditional healers for the treatment of malaria in the Chipinge district in Zimbabwe. *Journal of Ethnopharmacology*, **159**:224-237.
<https://doi.org/10.1016/j.jep.2014.11.011>
- Nohro, S. and Jayakumar, S. (2020). Tree species diversity and composition of the Pala Wetland Reserve Forest, Mizoram, Indo-Burma hotspot, India. *Biocatalysis and Agricultural Biotechnology*, **23**(1): 6.
<https://doi.org/10.1016/j.bcab.2019.101474>
- Norse, E.A. (1994). Global marine biological diversity: a strategy for building conservation into decision making. Island Press, Washington.
- Noss, R.F. 1990. Indicators for monitoring Biodiversity: A Hierarchical Approach. *Conservation Biology*, **4** (4): 355-364.

- Odum, E. P. (1971). *Fundamentals of Ecology*. (3rded.) W.B. Saunders Co., Philadelphia. USA. p: 574.
- Oksanen, J., Blanchet, F.G., Kindt, R., Legendre, P., Minchin, P.R., O'Hara, R.B., Simpson, G.L., Solymos, P., Stevens, M.H.H., Wagner, H., (2022). *vegan: Community Ecology Package*. R package version 2.6-1. <https://CRAN.R-project.org/package=vegan>
- Ramachandra, T. V. and Nagarathna, A. V. (2003). Biodiversity Characterization at Landscape Level in North-East India using Satellite Remote Sensing and Geographical Information System, <http://wgbis.ces.iisc.ernet.in/energy/water/paper/>
- Parry, N. E. (1932). *The Lakheres* (Appendix VII) Firma KLM Pvt. Ltd. Calcutta.
- Pfoze N.L. (2012) *Ethnobotanical Studies and Phytochemical Analysis of Selected Medicinal Plants of Senapati District, Manipur*, Ph.D. Dissertation, North Eastern Hill University, Shillong.
- Phillips, O., Gentry, A. H., Reynel, C., Wilkin, P. and Gálvez- Durand B, C. (1994). Quantitative ethnobotany and Amazonian conservation. *Conservation Biology*, **8**(1): 225-248. <https://doi.org/10.1046/j.1523-1739.1994.08010225.x>
- Pielou, E. C. (1969). *An introduction to Mathematical Ecology*. Wiley, New York.
- Proctor, J., Anderson, J.M., Chai, P. and Valack, H.W. (1983). Ecological studies of four contrasting lowland rain forest types of GunungMulu National Park, Sarawak. I. Forest environment, structure and floristics. *Journal of Ecology*, **71**:327-260.

- Puri, G.S., Meher-Homji, V.A., Gupta, R.K. and Puri, S. (1990). *Forest Ecology*, **Vol. I & II**. Oxford & IBH Publishing Co., Pvt. Ltd. New Delhi.
- Ralte, L. and Singh, Y. T. (2024). Ethnobotanical survey of medicinal plants used by various ethnic tribes of Mizoram, India. *PlosOne*, **19**(5):16-23.
- Ramya, R. (2022). GC-MS analysis of bioactive compounds in ethanolic leaf extract of *Hellenia speciosa* (J. Koenig) SR Dutta. *Applied Biochemistry and Biotechnology*, **194**(1): 176-186. 10.1007/s12010-021-03742-2
- Rana, D. and Kapoor, K.S. (2015). Assessment of floristic diversity of Shimla water catchment sanctuary, Himachal Pradesh. *Indian Forester*, **141**(12): 1244-1247.
- Rao, A. S. and Verma, D. M. (1982). *Cyperaceae of North East India*. B.S.I. Howrah.
- Rao, P., Barik, S. K., Pandey, H. N. and Tripathi, R. S. (1990). Community composition and tree population structure in a sub-tropical broad-leaved forest along a disturbance gradient. *Vegetatio*, **88**:151-162.
- Rao, R. R. and Hajra, P.K. (1986). Floristic diversity of Eastern Himalaya in a conservation perspective. *Proceedings of India Academy of Sciences (Animal/Plant Science) Supplement*, pp: 103-125.
- Ravindranath, N.H., Joshi, N.V., Sukumar, R. and Saxena, A. (2006). Impact of climate change on forest in India. *Current Science*, **90**:354-361.
- Rezende, V. L. de Miranda, P. L. S., Meyer, M., Linhares, L.C., de Oliveira-Filho, A.T. and Eisenlohr, P.V. (2015). Tree species composition and richness along altitudinal gradients as a tool for conservation decisions: the case of

- Atlantic semi deciduous forest. *Biodiversity and Conservation*, **24**:2149–2163.
- Richardson, J. A. (1958). The effect of temperature on the growth of plants on pit heaps, *Journal of Ecology*, **40**: 537-546.
- Ronald, K., Gajurel, P. R., and Singh, B. (2019). Assessment of eco-diversity status of *Homalomena aromatica* (Spreng.) Schott and its habitat in tropical forest of Indian Eastern Himalaya. *Plant Science Today*, **6**(2):71-83.
- Rothschild, L.J. and Mancinelli, R.L. (2001). Life in extreme environments. *Nature*, **409**: 1092 - 1101.
- Saikia, P., Kumar, A. and Khan, M. L. (2016). Biodiversity status and climate change scenario in Northeast India. *Climate Change Challenge (3C) and Social-Economic-Ecological Interface-Building: Exploring Potential Adaptation Strategies for Bio-resource Conservation and Livelihood Development*, pp: 107-120.
- Sakya, S. R. and Baina, A. M. S. (1998). Natural vegetation of Chandragiri region. *Ecoprint*, **5**:51-55.
- Sala, O.E., Chapin, I.F.S., Armesto, J.J., Berlow, E., Bloomfield, J., Dirzo, R., Huber Sanwald, E., Huenneke, L.F., Jackson, R.B., Kinzig, A., Leemans, R., Lodge, D.H., Mooney, H.A., Oesterheld, M., Leroy Poff, N., Sykes, M.T., Walker, B.H., Walker, M. and Wall, D.H., (2000). Global biodiversity scenarios for the year 2100. *Science*, **287** (5459): 1770–1774.
- Sawmliana, M., (2013). The book of Mizoram plants. Published by P. Zakhuma, Aizawl, Mizoram. Loisbet offset, Chanmari Aizawl.

- Saxena, A. K., Singh, S.P. and Singh, J.S. (1984). Population structure of forests of Kumaun Himalaya: Implications for management. *Journal Environmental Management*, **190**:307-324.
- Shannon, C. E and Wiener, W. (1963). *The Mathematical theory of communication*. University of Illinois Press, Urbana.
- Singh, J. S., Singh, S. P. and Gupta. S. R. (2010). *Ecology Environment and Resources Conservation*, Anamaya Publishers, New Delhi, pp: 5178-553.
- Singh, J., Rajasekaran, A., Niegi, A.K. and Vijender Pal Panwar. (2016). Wild edible plant diversity in *Pinusgerardiana* Wall.ex D. Don Forest of Kinnaur District, Himachal Pradesh, India. *Indian Journal of Forestry*, **39**(1):13-20.
- Singh, J.S. and Yadav, P.S. (1974). Seasonal variation in composition, plant biomass and Net primary productivity of Tropical grassland at Kurukshetra, India. *Ecological Monographs*, **44**:351-375.
- Singh, M. P., Singh, B. S. and Dey, S. (2002). *Flora of Mizoram*. Vol. I, shiva Offset Press, Dehra Dun, India.
- Singh, N.P. and Singh, K.P., eds., (1997). Floristic diversity and conservation strategies in India. Botanical Survey of India, Calcutta.
- Singh, O.P., De, S.K. and Cajee, L. (2016). State of environment report of Mizoram. Department of Environment, Forests and Climate Change, Government of Mizoram.
- Singh, R., Rai, Ishwari D., Rawat, Gopal S., Goraya, Gurinder S. and Jalal, J. S. (2015). Additions to the Flora of Green Himalayan National Park, Western Himalaya. *Journal of Indian Forestry*, **38**(4): 375-381.

- Singh, S.K., Kumar, S.K., Aier, B., Kanduri, V.P. and Ahirwar, S. (2012). Plant community characteristics and soil status in different land use systems in Dimapur district, Nagaland, India. *Leoene Pr. Badaw.* **73**: 305-312. <http://dx.doi.org/10.2478/v10111-012-0029-x>
- Sinha, G.P., Singh, D.K. and Singh, K.P., (2012). Flora of Mizoram, Volume 2: Campanulaceae – Salicaceae. Botanical Survey of India, Calcutta.
- Sobuj, N A. and Rahman, M, (2011). Assessment of plant diversity in Khadimnagar National Park of Bangladesh. *International Journal of Environmental Science*, **2**(1):79-99.
- Solbring, O.T. (1991). The origin and function of biodiversity. *Environment*, **2**(1):79-99.
- Southwood, T.R.E. (1981). Ecological aspects of insect migration, in: Aidley, D.J. (ed.). Animal Migration. Cambridge University Press, Cambridge, pp: 197-208.
- Spellberg, I. F. (1991). *Monitoring Ecological Change*. Cambridge: Cambridge University Press.
- Stapanian, M. C., Casell, D. L., and Cline, S. P. (1997). Regional pattern of local diversity of trees association with anthropogenic disturbance. *Forest Ecology and Management*, **93**:33-44.
- Sunil C, Somashekar, R. K. and Chikkarangappa, N. B. (2016). Diversity and Composition of riparian vegetation scrod forest and agroecosystem landscapes of river Cauvery, southern India. *Tropical Ecology*, **57**(2): 343-354.

- Swamy, P. S., Sundarapandian, S. M., Chandrasekar, P. and Chandrasekaran, S. (2000). Plant species diversity and tree population structure of a humid tropical forest in Tamil Nadu, India. *Biodiversity and Conservation*, **9**: 1634-1699.
- Swarts, N. D. and Dixon, K. W. (2009). Terrestrial orchid conservation in the age of extinction. *Annals of botany*, **104**(3): 543-556.
- Takhtajan, A. (1969). *Flowering Plants, Origin and Dispersal*. Edinburgh.
- Tapsell, L. C., Hemphill, I., Cobiac, L., Sullivan, D. R., Fenech, M., Patch, C. S., ... and Inge, K. E. (2006). Health benefits of herbs and spices: the past, the present, the future. *Medical Journal of Australia*, **185** (4): S1-S24.
- Teklehaymanot, T. and Giday, M. (2010). Ethnobotanical study of wild edible plants of Kara and Kwego semi-pastoralist people in Lower Omo River Valley, Debub Omo Zone, SNNPR, Ethiopia. *Journal of Ethnobiology and ethnomedicine*, **6**(1): 23.
- Teklehaymanot, T. and Giday, M. (2007). Ethnobotanical study of medicinal plants used by people in Zegie Peninsula, Northwestern Ethiopia. *Journal of Ethnobiology and Ethnomedicine*, **3**(1): 1-11.
<https://doi.org/10.1186/1746-4269-3-12>
- Thangliankhup, K., Lalfakawma, Gouda, S. and Khomdram, S. D. (2023). Ethnomedicinal plants of Kuki-Chin tribes in Kaihlam wildlife sanctuary of Manipur, India. *Acta Ecologica Sinica*, **43**(4): 628-643.
<https://doi.org/10.1016/j.chnaes.2022.07.011>
- Thomas, E., Vandebroek, I., Sanca, S. and Van Damme, P. (2009). Cultural significance of medicinal plant families and species among Quechua

- farmers in Apillapampa, Bolivia. *Journal of Ethnopharmacology*, **122**(1): 60-67. <https://doi.org/10.1016/j.jep.2008.11.021>
- Trivedi, P.C. and Sharma, N., (2011). *Text book of Ethnobotany*. Pointer publishers.
- Trotter, R. T. and Logan, M. H. (2019). Informant consensus: a new approach for identifying potentially effective medicinal plants. In *Plants in indigenous medicine & diet*, pp: 91-112
- Tynsong, H. and Tiwari, B.K., (2010). Plant diversity in the homegardens and their significance in the livelihoods of war khasi community of Meghalaya, North-east India. *Biodiversity Journal*, **1**: 1-11. <https://doi.org/10.1080/09766901.2010.11884713>
- Valencia, R., Balslev, H. and Pazy Mino, C.G. (1994). High tree alpha diversity in Amazonian Ecuador. *Biodiversity and Conservation*, **3**:21-28.
- Vanchhawng, L. and Lalramnghinglova, H., (2016). Notes on the genus *Hedychium* J. Koen.(Zingiberaceae) in Mizoram, northeast India. *International Journal of Waste Resources*, **6**(3):1-6.
- Vavilov, N. I. (1926). Studies on the origin of cultivated plants. *Trudy po Prikladnoi Botanike, Genetike i Seleksii*, **16**: 139– 248
- Verma, D., Singh, S. K., Kholia, B. S., Sinha, B. K., and Pandey, S. (2013). Pteridophytes of Ngengpui Wildlife Sanctuary, Mizoram, India. *Kenean Journal of Science*, **2**:3-12.
- Verma, R. K. and Kapoor, K. S. (2016). Assessment of Vegetation Along an Altitudinal Gradient in Khajrot Beat of Kala top Wildlife Sanctuary of District Chamba, Himachal Pradesh. *Indian Journal of Forestry*, **39**(1):1-8.

- Vetaas, O.R., (2000). The effect of environmental factors on the regeneration of *Quercus semecarpifolia* Sm. in Central Himalaya, Nepal. *Plant Ecology*, **146**: 137–144. <http://dx.doi.org/10.1023/A:1009860227886>
- Vijayakumar, S., Yabesh, J. M., Prabhu, S., Manikandan, R. and Muralidharan, B. (2015). Quantitative ethnomedicinal study of plants used in the Nelliampathy hills of Kerala, India. *Journal of ethnopharmacology*, **161**: 238-254. <https://doi.org/10.1016/j.jep.2014.12.006>
- Walter, K.S. and Gillet, H.J. (eds.). (1998). *1997 IUCN Red List of Threatened Plants*. Compiled by the World Conservation Monitoring Centre, IUCN-The World Conservation Union, Gland, Switzerland and Cambridge, UK. p:862.
- Wang, W., Yu, H., Li, T., Li, L., Zhang, G., Liu, Z., ... and Zhang, Y. (2017). Comparative proteomics analyses of pollination response in endangered orchid species *Dendrobium chrysanthum*. *International Journal of Molecular Sciences*, **18**(12): 2496. <https://doi.org/10.3390/ijms18122496>
- Whitmore, T.C. (1984). *Tropical rain forests of the Far East* (2nd edition). Oxford University Press, Oxford.
- Whittaker, R. H. (1977). Evolution of species diversity in land communities. *Evolutionary Biology*, **10**:1-67.
- Whittaker, R.H. (1975). *Communities and Ecosystems* (2nd edn.). Macmillan Pub. Co. New York, p: 385.
- Wickham, H., (2016). *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York. ISBN 978-3-319-24277-4. <https://ggplot2.tidyverse.org/>

- Williams, P.H., Humphries, C.J., Vane-Wright, R. and Gaston, K.J. (1996). Values in biodiversity, ecological services and consensus. *Trends in Ecology and Evolution*, **11**:385.
- Wilson, E.O. (1988). BioDiversity. National Academy Press.
- Womersley, J.S. (1981). Plant collection and herbarium development- A manual. FAO, Rome, p: 337.
- Zemedu, A. (1997). Indigenous African food crops and useful plants: Survey of indigenous food crops, their preparations and home gardens. *Nairobi: The United Nation University institute for natural resources in Africa*.
- Zent, E. L. and Zent, S. (2004). Floristic composition, structure, and diversity of four forest plots in the Sierra Maigualida, Venezuelan Guayana. *Biodiversity and Conservation*, **13**: 2453–2484.
- Zhang M., Kang X., Meng J. and Zhang L. (2015). Distribution Patterns and Associations of Dominant Tree Species in a Mixed Coniferous-Broadleaf Forest in the Changbai Mountains. *Journal of Mountain Science*, **12**(3): 659-670.
- Zote, S., Lalramnghinglova, H. and Deori, C. (2009). *Dendrobium salaccense* (Blume) Lindl. (Orchidaceae) from Mizoram: A new record for India. *Journal of the Orchid Society of India*, **23**: 91 – 92.

BIO-DATA

LALFAKAWMA

Contact:+919233015767

E-Mail:fakasteim28@gmail.com

PERSONAL DETAILS

Father'sName: C. Lalchhuanmawia

Mother's Name: Vanlalpari

DateOfBirth: 18.09.91

Gender: Male

Marital Status: Married

Nationality: Indian

Languages Known: English & Mizo

Permanent Address: C-142, ITI Veng, Aizawl

Present Address: C-142, ITI Veng, Aizawl

Qualification	Passing Year	University/ Institution	Percentage/ Grade	Division
HSLC	2008	St. Pauls HSS	72	First
HSSLC	2010	St. Pauls HSS	60	First
BSc	2013	Pachhunga University	72	First
MSc	2015	Mizoram University	76.02	Distinction

List of Publications

1. **Lalfakawma**, Khomdram, S. D., & Yumkham, S. D. (2024). A new generic record of Indian Costaceae with the discovery of new species *Parahellenia mizoramensis* from Northeast India. *Journal of Asia-Pacific Biodiversity*, **17(2)**: 284-289. <https://doi.org/10.1016/j.japb.2023.11.007>
2. Thangliankhup, K., **Lalfakawma**, Gouda, S., & Khomdram, S. D. (2023). Ethnomedicinal plants of Kuki-Chin tribes in Kaihlam wildlife sanctuary of Manipur, India. *Acta Ecologica Sinica*, **43(4)**: 628-643. <https://doi.org/10.1016/j.chnaes.2022.07.011>



Contents lists available at ScienceDirect

Journal of Asia-Pacific Biodiversity

journal homepage: <http://www.elsevier.com/locate/japb>

Original Article

A new generic record of Indian Costaceae with the discovery of new species *Parahellenia mizoramensis* from Northeast IndiaLalfakawma^a, Sandhyarani Devi Khomdrum^{a,*}, Sanatombi Devi Yumkham^b^a Department of Botany, Mizoram University, Aizawl 796004, Mizoram, India^b Plant Physiology Laboratory, Center of Advanced Studies in Life Sciences, Manipal University, Channarayana 796003, India

ARTICLE INFO

Article history:

Received 13 September 2023

Received in revised form

20 November 2023

Accepted 22 November 2023

Available online 1 December 2023

Keywords:

Costaceae

India-Northeast

Mizoram

*Parahellenia mizoramensis**Parahellenia mizoramensis**Parahellenia mizoramensis*

ABSTRACT

Parahellenia mizoramensis sp. nov. from Costaceae is described and illustrated as a new species from Northeast India (Mizoram) and represents the only existing species under the genus from India. It differs from its closest species *Parahellenia tonkinensis* (Gagnep.) Juan Chen, N.H. Xia, L.Y. Zeng, S. Jin Zeng, and *Parahellenia yunnanensis* S. Jin Zeng, N.H. Xia, L.Y. Zeng, and Juan Chen by the size and shape of axillary buds, wider bracts, longer calyx and corolla lobes, crenulate margin of labellum, prominent overhanging of labellum margin to form trumpet-shaped, presence of bright red streaks in anther crest, and shape of dorsal appendage in stigma. The newly described species is provisionally assessed as Critically Endangered (CR) based on the available data as per the International Union for Conservation of Nature (IUCN) Red List Categories and Criteria.

© 2023 National Science Museum of Korea (NSMK) and Korea National Arboretum (KNA), Publishing Services by Elsevier. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

The family Costaceae Nakai is characterized by sometimes branched aerial shoots with spiral phyllotaxy, tubular leaf sheaths and a petaloid labellum formed by the fusion of five sterile stamens (Kirschner and Ritschhausner 1990; Wu and Larsen 2000). The members of the family are pantropical in distribution, with many taxa confined to the New World tropics and Africa, while some species are confined to Asia (Maas 1979; Specht and Stevenson 2006; Maas-van de Kamer et al. 2016). Currently, the family is reported to have eight genera with the recent recognition of *Parahellenia* N.H. Xia, Juan Chen, L.Y. Zeng, and S. Jin Zeng by Chen et al. (2022), and the other seven genera, which include *Chamaecostus* C.D. Specht and D.W. Stey, *Cosmus* L., *Dimerocostus* Kuntze, *Hellenia* Reitz., *Monocostus* K. Schum., *Paracostus* C.D. Specht, and *Tapeinochloa* Mic. The newly recognized genus *Parahellenia* was separated from one of the Asian clade *Hellenia* based on molecular and morphological evidence. This *Parahellenia* clade is based on autapomorphies and is also supported by morphological evidence like lateral inflorescences, the presence of solitary axillary bud at each

node, lax imbricate bracts, long and slender floral tubes fused more than halfway with the style base, a large funnel-shaped labellum, and a bilamellate stigma with two equal lobes as compared to terminal inflorescences, 1–5 axillary buds, and a horizontally flattened labellum in *Hellenia* (Chen et al. 2022).

The genus *Parahellenia* has eight known species: *Parahellenia Lourensis* (A.D. Poulsen), N.H. Xia, Juan Chen, and S. Jin Zeng (2022, 395); *Parahellenia candida* (Skorck.) Bohmova and H.D. Tran, N.H. Xia and Juan Chen (2023, 73); *Parahellenia globosa* (Blume) N.H. Xia, Juan Chen, and S. Jin Zeng (2022, 396); *Parahellenia malpensis* Juan Chen, L.Y. Zeng, S. Jin Zeng & N.H. Xia (2022, 396); *Parahellenia tonkinensis* (Gagnep.) Juan Chen, N.H. Xia, L.Y. Zeng and S. Jin Zeng (2022, 396); *Parahellenia bongdayii* Juan Chen, V.C. Nguyen, K.S. Nguyen and N.H. Xia (2023, 73); *Parahellenia yunnanensis* S. Jin Zeng, N.H. Xia, L.Y. Zeng, and Juan Chen (2022, 396). The genus was previously known to be distributed in southern China, Indonesia, Malaysia, Thailand, and Vietnam. Recently, the distribution was extended to the Tanintharyi region of Myanmar with the report of *P. taikienensis* (mentioned as *Chamaecostus tonkinensis* (Gagnep.) Skorck.) by Nagahama et al. (2023). The present finding thus extends the distribution of the genus to the northeastern part of India.

During one of the field explorations in Ngazun Wildlife Sanctuary in Lawngtlai District of Mizoram (India), the first author collected a member of the Costaceae that was different from the

* Corresponding author. ORCID: 0000-0002-4884-9637.

E-mail address: sandhyarani.khomdrum@gmail.com (S.D. Khomdrum).

Peer review under responsibility of National Science Museum of Korea (NSMK) and Korea National Arboretum (KNA).

<https://doi.org/10.1016/j.japb.2023.11.007>ISSN 2473-894X/ISSN 2473-8944/© 2023 National Science Museum of Korea (NSMK) and Korea National Arboretum (KNA), Publishing Services by Elsevier. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).



Ethnomedicinal plants of Kuki-Chin tribes in Kaihlam wildlife sanctuary of Manipur, India

K. Thangliankhup^a, Lalfakawma^a, Sushanto Gouda^b, Sandhyarani Devi Khomdram^a  

Show more 

 Add to Mendeley  Share  Cite

<https://doi.org/10.1016/j.chnaes.2022.07.011> 

[Get rights and content](#) 

Abstract

Background

The undocumented indigenous knowledge of Kuki-Chin tribes within the fringe villages of Kaihlam Wildlife Sanctuary (KWLS) is vanishing without a trace, therefore preserving the valuable assets is critical for future generations.

Methods

Ethnomedicinal information was collected from 84 informants from Kuki-Chin tribes (*Paite, Thadou, Hmar, Gangte, Simte, Vaiphei* and *Zo*) and quantitatively analyzed using ICF (Informant consensus factor), FL (Fidelity level), UV (Use value) and RFC (Relative frequency of citation).

List of Presentations

1. Presented paper on A noteworthy collection and identification of Interesting Plants in Mizoram at The National Conference on Emerging Trends in Environmental Research organized by Department of Environmental Science, Pachhunga University College, Aizawl from 31st October – 2nd November, 2019.
2. Presented paper on Plants used in preparation of ‘Bai’ : A Mizo traditional food of Mizoram, India at the National Seminar on Biodiversity and Utilization of Natural Resources with reference to Northeast India (BCUNRNEI) organized by Department of Botany, Mizoram University, Aizawl from 30th – 31st march, 2017.
3. Presented paper on Critical notes on Three Carnivorous Plants with a new addition to state carnivorous flora *Utricularia recta* P. Taylor (Lentibulariaceae) from Reiek Tlang, Mizoram at the International Conference on Chemistry & Environmental Sustainability (ICCES-2019) organized by Department of Chemistry, Mizora University from 19nd – 22nd February, 2019.

Conferences/Seminars/Workshops Attended

1. Participated in One Day Awareness Programme cum Workshop on Invasive Alien Plnts in Himalayas: Status, Ecological Ipact and Management (Mizoram & Tripura Chapter), organized by Botanical Survey of India in collaboration with Department of Botany, Mizoram University, Aizawl on 26th April, 2019 under National Mission for Himalayan Studies.
2. Participated on One day National Workshop on IPR and Plant Protection with special reference to NE India, jointly organised by Department of Botany, Mizoram university and Department of Horticulture. Government of Mizoram.
3. Participated in Webinar (31st August, 2020) organized by the department of Botany, Mizoram University, Aizawl on the topic entitled ‘ Technological Advancements for Application in forest exploration.

PARTICULARS OF THE CANDIDATE

NAME OF CANDIDATE	: Lalfakawma
DEGREE	: Ph.D.
DEPARTMENT	: Botany
TITLE OF THESIS	: Floristic diversity of angiosperms in Ngengpui Wildlife Sanctuary, Mizoram
DATE OF ADMISSION	: 26.05.2016
APPROVAL OF RESEARCH PROPOSAL	
1. DRC	: 24.04.2017
2. BOS	: 01.05.2017
3. SCHOOL BOARD	: 26.05.2017
MZU REGISTRATION NO	: 3512 of 2010-11
REGISTRATION NO. & DATE	: MZU/Ph.D./1016 of 26/05/2017
EXTENSION (IF ANY)	: 16-2/MZU(Acad)/21/179-182 (2 years)

Head

Department of Botany

ABSTRACT
FLORISTIC DIVERSITY OF ANGIOSPERMS IN NGENGPUI
WILDLIFE SANCTUARY, MIZORAM

AN ABSTRACT SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

LALFAKAWMA

MZU REGISTRATION No. 3512 of 2010-11

Ph. D. REGN NO. MZU/Ph.D. /1016 of 26.05.2017



DEPARTMENT OF BOTANY
SCHOOL OF LIFE SCIENCES
MAY, 2024

ABSTRACT
FLORISTIC DIVERSITY OF ANGIOSPERMS IN
NGENGPUI WILDLIFE SANCTUARY, MIZORAM

BY
Lalfakawma
Department of Botany
Supervisor: Dr. Khomdram Sandhyarani Devi

Submitted
In partial fulfillment of the requirement of the Degree of Doctor of Philosophy in Botany
of Mizoram University, Aizawl.

ABSTRACT

Ngengpui Wildlife Sanctuary (NWS) is a protected area located in Mizoram, India and is known for its unique ecosystems and rich biodiversity. The sanctuary is home to a variety of flora and fauna including several RET or threatened taxa. The present study was undertaken in the sanctuary focusing on the diversity of angiosperms, their ethnobotanical significance, finding the endemic and threatened taxa and exploration of new taxa and new records. The study catalogued a total of 353 angiosperm species from 91 families that are categorized into trees, herbs, shrubs, climbers, orchids, grasses and palms. Additionally, a new species *Parahellenia mizoramensis*, was discovered during the study with even the genus *Parahellenia* reported as a new generic record for India.

For the present study, six distinct forest areas in NWS namely Hmunnuam, Ngengpui, Diltlang, Saizawh east, Khawmawi, and Bungtlang south forests, falling under Tropical Wet Evergreen and Semi-Evergreen Forest types, were selected for the assessment of diversity, structure, and composition of the angiosperms particularly trees, herbs and shrubs. Using a stratified random sampling approach with 250 plots covering 0.01 hectares each, the research identified 2,545 individual trees representing 105 woody species from 40 families and 85 genera. The most dominant tree species was *Dipterocarpus retusus* with the highest Importance Value Index (6.63%). The Hmunnuam forests had the highest Shannon diversity index (4.42), Bungtlang south forests had the highest stem density (1350 individuals/hectare), and Khawmawi forests displayed the greatest mean stem diameter (76.4cm) at 1.3 meters height. The study also revealed a reverse J-shaped distribution of tree diameters across the six forests, indicating uneven-agedness. And highlighting the diversity of trees in size class distribution within the NWS. Also, the sanctuary is still home to some of the threatened taxa which are categorized under different categories of IUCN Red List including the most dominant tree *Dipterocarpus retusus* under the endangered (EN) category.

The herbs were distributed among 45 families, with the Asteraceae (20 sp.) representing the maximum number of species followed by Zingiberaceae (13 sp.),

Amaranthaceae (9 sp.) followed by the Araceae (8 sp.) and Begoniaceae (6 sp.). *Homalomena aromatica* represents the herbaceous plant with the highest number of IVI (7.68) showing its dominance in the study site among the herbs showing the appropriate condition for their growth as an understorey plant. During the study, six species of *Begonia* was found showing the richness of species in the genus among the herbaceous plants. Many of these *Begonia* species was found to be endemic to northeast India and Eastern Himalayas. Within the NWS, 43 shrub species under 39 genera from 19 families were identified with the maximum representation from the family Fabaceae with nine (9) species. However, a major concern is the emergence of the dominant shrub species *Chromolaena odorata* ranking first in the Importance Value Index (24.57). The Orchidaceae family is represented by 13 species from 9 genera which are all epiphytic species except for *Spathoglottis pubescens*, which is a ground orchid. A total of 32 climber species under 25 genera in 17 families were recorded from the present study as climbers are quite diverse and abundant component of tropical forest which compete with the trees for light space and nutrients. climbing plant species were also documented. The family Convolvulaceae has the highest number of species (5) in the climbers. Sixteen (16) grass species from the Poaceae and Cyperaceae families were identified. Ten (10) species of canes and palms from the Arecaceae family were also documented. Among these, *Borassus flabellifer* was classified as endangered (EN), and both *Calamus acanthospathus* and *Calamus erectus* were listed as vulnerable (VU) according to their conservation status.

Studying of the angiosperm diversity NWS is crucial as the study could provide insights into the ecosystem health of the sanctuary by identifying and documenting the diverse life forms in the sanctuary, identifying the dominant taxa as well the RET taxa that will help in development of effective conservation strategies to protect the unique flora within the NWS. Also, by providing a comprehensive understanding of forest diversity, composition, and structure, the study aids in the formulation of conservation and sustainable management strategies. This is particularly important for the protection of 25 identified RET species like *Bombax insigne*, *Dipterocarpus turbinatus*, *D. retusus*, *Prunus*

ceylanica, and *Saurauia punduana* among the trees and *Aerides rosea*, *Renanthera imschootiana* among orchids etc. Among them, three species—*Bombax insigne*, *Saurauia punduana*, and the newly discovered *Parahellenia mizoramensis*—are categorized as critically endangered (CR), while 14 species are listed as endangered (EN), six species are classified as vulnerable (VU) and two are near threatened (NT). While exploring the angiosperm diversity in NWS, we could also collect a unique taxa from Costaceae family which was not described previously. After detailed study, we could the described the species *Parahellenia mizoramensis* as new to science with even the genera of the species as new record for India. Overall, the study enhances our knowledge of the sanctuary's ecosystems and supports efforts to adapt conservation strategies in the face of changing environmental conditions. The research contributes valuable information for the development of effective forest management plans in the sanctuary.

Ethnobotanical study was carried out in the villages surrounding Ngengpui Wildlife Sanctuary (NWS). The study aimed to document and analyzed the traditional medicinal knowledge, forest-derived food, and various ethnobotanical practices among communities belonging to different tribes namely Lushai, Lai, Bru, Bawm, Zakhai, Khumi, Pang, Mara, Paihte, Chakma, and Matu tribes. For ethnomedicinal study, the collected data were quantitatively analyzed using several parameters, including relative frequency of citation (RFC), fidelity level (FI), informant consensus factor (Fic), and use value (UV). In the area, a total of 210 plant species were identified as having significant connections to the local inhabitants. Among these, 104 species were utilized for ethnomedicines, 41 species served as wild edible vegetables, 22 as wild edible fruits, 25 as timber yield plants, 56 tree species were utilized for firewood and charcoal production, 14 as fodder, and 20 for various other purposes.

Among the 104 ethnomedicinal plant species from 44 families, with trees constituting the highest proportion (35.58%), followed by herbs (33.65%). Leaves were the most commonly used plant part (41%), followed by bark (13%) and fruit (12%). These plants were utilized to treat 44 different ailments categorized into 13

groups. The fidelity level (F_l) ranged from 6% to 100%, and the informant consensus factor (F_{ic}) varied from 0.33 to 0.97 across the study region. Highly cited medicinal plants with significant RFC values included *Chromolaena odorata* (0.86), *Flueggea virosa* (0.79), *Oroxylum indicum* (0.68), *Curcuma longa* (0.64), *Mikania micrantha* (0.64), and *Rhus chinensis* (0.63). These species were widely recognized by a large number of informants in the study.

Based on the extensive array of plant uses scrutinized, particularly in terms of medicinal applications, it becomes evident that the flora within the NWS region serves pivotal roles for the fringe villages. Beyond their medicinal significance, these plants fulfill a spectrum of diverse needs: some serve as timber for construction purposes, others contribute as vital sources of wild edible vegetables and fruits, while yet others are valued for their efficacy as fuelwood. It is imperative to meticulously document these multifaceted uses, given the gradual erosion of ethnobotanical knowledge among succeeding generations. Our findings underscore the enduring disparity between urban and rural lifestyles, highlighting the profound reliance of village communities on forest resources for myriad necessities. Moreover, the rich tapestry of traditional knowledge embedded within the utilization of these plants underscores their cultural and ecological significance. Preserving this knowledge is not merely an academic pursuit but also a means of safeguarding invaluable practices that have sustained communities for generations. As such, efforts to document and transmit this knowledge must be prioritized to ensure its continuity and relevance in contemporary contexts.

6.2 Significant findings

The research on the floristic diversity of angiosperm in Ngengpui Wildlife Sanctuary of Mizoram made several findings including its ethnobotanical significance:

- a) High Species Diversity:** NWS hosts a remarkable diversity of angiosperms taxa from different life forms, highlighting its importance of floral richness

in the region. A total of 353 angiosperm species from 273 genera from 91 families could be documented showing the rich diversity of flowering plants inside the sanctuary.

- b) Dipterocarp dominant forest:** Among the two species of Dipterocarpaceae family, *D. retusus* emerged as the dominant tree species in the sanctuary, indicating their ecological significance and potential role as key structural components of the forest ecosystem. The Dipterocarp forest are known for their rich biodiversity which are vital for carbon sequestration, providing habitat for numerous plants and animal species and understanding the health of ecosystem.
- c) Discovery of New Species:** During the research study, a previously unknown taxa *Parahellenia mizoramensis* (DOI: 10.1016/j.japb.2023.11.007) belonging to the family Costaceae has been discovered from the sanctuary. This finding underscores the significance of ongoing biodiversity exploration efforts and contributes to our understanding of the intricate web of life within this ecosystem. Also, the sanctuary serves as a reservoir of undiscovered biodiversity and the need for continued exploration and conservation efforts.
- d) Endemic and RET taxa:** The present research identified many endemic and rare angiosperm species unique to the sanctuary, emphasizing its value for the preservation of regionally significant plant diversity. It was found that numerous taxa are facing threats to their survival, with a total of 25 species identified as threatened. These findings highlight the urgent need for conservation measures to protect the biodiversity of the region. In Ngengpui Wildlife Sanctuary (NWS), several species native to Mizoram have been identified, including *Parahellenia mizoramensis*, *Zingiber mizoramense*, and *Zingiber murlenica*. These species represent unique components of Mizoram's biodiversity and contribute to the rich ecological tapestry of the sanctuary.

- e) **Invasive Alien Species:** The study also documented the presence of invasive alien angiosperm species within the sanctuary which can affect the diversity of many native taxa suggesting the change the original habitat inside the sanctuary. These invasive alien plants that include *Chromolaena odorata*, *Ageratina riparia*, *A. adenophora*, *Mikania micrantha*, *Lantana camara* etc. which are well known for their aggressive invasive characters could potentially challenge the native plant communities and ecosystem dynamics in the sanctuary which are home to many RET and endemic taxa.
- f) **Ecological Significance:** Understanding the floristic diversity of angiosperms from different life forms in Ngengpui Wildlife Sanctuary is essential for assessing its ecological significance, including its role in providing habitat, food sources and ecosystem services for wildlife population.
- g) **Ethnobotanical Significance:** The indigenous communities residing near the sanctuary rely on angiosperm species for various traditional uses including medicinal, culinary, ritual, economic purposes. A total of 210 species were found to be ethnobotanically useful with many of these plants play a crucial role in the livelihoods, cultural practices, and traditional knowledge systems of local communities. Understanding and conserving these ethnobotanical resources are essential for promoting sustainable development, preserving cultural heritage, and fostering biodiversity conservation in the state.
- h) **Conservation Implications:** All the findings have significant implications for conservation management as many endemic as well as RET taxa are identified from the sanctuary, highlighting the importance of protecting them as well as the diverse angiosperm flora of NWS and addressing threats such as habitat loss, invasive species, and climate change.

6.3 Conclusion

The extensive study could address the knowledge gap in forest structure and composition within the Ngengpui Wildlife Sanctuary in Mizoram, northeast India. It has yielded crucial insights with significant implications for conservation and sustainable forest management. The six focused areas fall under Tropical Wet Evergreen and Semi-Evergreen Forest types, providing a thorough understanding of the ecosystems in this protected area. The variation in forest structure metrics through study on tree diversity composition across different areas, such as stem density and mean stem diameter, underscores the heterogeneity of these ecosystems. The reverse J-shaped distribution of tree diameters highlights the uneven-agedness within the forests, emphasizing the significance of integrating regeneration dynamics in management strategies. Differences observed in the characteristics among the six forests, such as the highest Shannon diversity index in Hmunnuam (HN) forests and unique structural features in Bungtlang south (BS) and Khawmawi (KM) forests, emphasize the necessity for customized management approaches.

The angiosperm diversity in Ngengpui Wildlife sanctuary represents a diverse array of trees, herbs, shrubs, climbers, epiphytes, grasses and the palms and canes. Among the tree species, *Dipterocarpus retusus* represents the dominant species, *Homalomena aromatica* in herbs, *Chromolaena odorata* in shrubs respectively. The remarkable richness of tree diversity with a total report of 353 species within NWS not only enhances the ecological integrity of the sanctuary but also supports a wide array of flora and fauna, including endemic and threatened taxa making it a critical area for wildlife conservation. Forest in NWS is a dipterocarp dominant forest with both the two species *Dipterocarpus retusus* and *D. turbinatus* reported from the study sites which are categorized under threatened category of IUCN Red List due to severe threats from logging due to the timber potential and land use changes. Dipterocarps play a critical role in numerous regions where they thrive offering essential ecosystem services and they rank among the most highly coveted timber species in both South and Southeast Asia. So, by recognizing and preserving the tree species including various threatened taxa within the NWS, we can ensure the

continued health of this vital ecosystem, safeguarding its biodiversity for future generations.

The presence of diverse herbaceous plants including many endemic monocots, shrubs, climbers, bamboos, palms and epiphytes which are characteristic of any tropical forest underscores the ecological resilience and importance of preserving its habitats. Each of these plant groups plays a unique role in the ecosystem, contributing to nutrient cycling, soil stabilization and microclimate regulation. The identification of the unique assemblages and distribution patterns across different habitats and life forms in NWS is imperative to implement holistic conservation strategies. However, another major concern during the study was the presence of many IAPS that could pose a significant threat to the native biodiversity and ecological integrity of many such protected forest. So, early detections and measures to identify these IAPS before successful invasion are critical for protecting these vulnerable ecosystems.

The discovery of *Parahellenia mizoramensis* as novel addition of taxa to science from NWS serves as a reminder of the importance of biodiversity conservation and underscore the need for continued scientific inquiry and protection of natural habitats. Also, the rich biodiversity present in the sanctuary suggests that there may be numerous other undiscovered species awaiting identification. The taxa from Zingiberaceae family *Z. mizoramensis* and *Z. murlenica* are found endemic to Mizoram although there are many taxa endemic to northeast region including.... The documentation of endemic and threatened species, including *Bombax insigne*, *Dipterocarpus turbinatus*, *D. retusus*, *Prunus ceylanica*, and *Saurauia punduana*, underscores the conservation significance of Ngengpui Wildlife Sanctuary (include more). The diverse range of habitats provides a crucial breeding ground for many species, contributing to regional biodiversity conservation efforts.

The ethnobotanical studies conducted on various indigenous communities residing in fringe villages of NWs highlights the importance of preserving not only the biodiversity of the sanctuary, but also the traditional knowledge and practices of the local communities. Many plant species identified through the present study have been found to have medicinal, edible resources and various other uses showing the

multifaceted contributions to human well-being and livelihoods. The ethnobotanical studies emphasize the interconnectedness of these indigenous communities with nature and shows the importance of integrating local knowledge and practices into conservation efforts. In promoting sustainable practices, the documentation and quantitative analysis of local plant uses serve as a foundational resource. The ethnobotanical study not only sheds light on the intricate relationship between people and nature but also advocates for a harmonious coexistence that recognizes the value of traditional wisdom in the pursuit of conservation and sustainable management practices. This information provides a roadmap for conservation strategies that integrate traditional knowledge, ensuring the continued well-being of local communities while safeguarding the delicate ecological balance of Ngengpui Wildlife Sanctuary.

The ethnobotanical wealth of the NWS region offers a compelling narrative of human ingenuity and resilience. By documenting and preserving the traditional uses of plants, we honor the profound interconnectedness between culture, biodiversity, and sustainable livelihoods. The findings of this study provide a foundation for further research on the medicinal properties of these plants and inform conservation efforts aimed at preserving both traditional knowledge and the natural resources that support it. Sustainable management practices that integrate traditional knowledge with modern conservation strategies are essential for fostering a balanced and resilient ecosystem. This approach not only protects biodiversity but also ensures the well-being and cultural integrity of local communities, creating a sustainable future that honors the past. The documentation and quantitative analysis of local plant uses in NWS represent a crucial step in evaluating the useful plants and promoting sustainable utilization of indigenous practices associated with these plants. The findings emphasize the importance of preserving traditional knowledge and biodiversity while addressing the conservation needs of endangered ethnobotanically important plant species in the region.

