ASSESSMENT OF PLANT DIVERSITY IN DIFFERENT ECOLOGICAL ZONES OF REIEK FOREST IN MAMIT DISTRICT OF MIZORAM

A THESIS

SUBMITTED TO MIZORAM UNIVERSITY IN FULFILLMENT OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN ENVIRONMENTAL SCIENCE

BY

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MIZORAM UNIVERSITY
TANHRIL, AIZAWL
2014

MIZORAM UNIVERSITY

Department of Environmental Science

2014

DECLARATION

I, S.T.Lalzarzovihereby declare that the thesis entitled **Assessment of Plant Diversity in Different Ecological Zones of Reiek Forest in Mamit District of Mizoram** is a record of work done by me during 2008 to 2014 under the supervision and guidance of Dr.Lalnuntluanga, Associate Professor, Department of Environmental Science, Mizoram University. The thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and it has not been submitted to me for any research degree in any other University/ Institute.

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ACKNOWLEDGEMENTS

First and foremost, I offer my sincerest gratitude to my supervisor Dr.Lalnuntluanga, Associate Professor, Department of Environmental Science, Mizoram University, Aizawl, Mizoram for the continuous support of my Ph.D study and research, for his patience, motivation, enthusiasm, and knowledge.

Besides my supervisor, my sincere thanks go to the officials and staff members of Botanical Survey of India, Eastern Circle, Shillong for their help in identification and consultation of herbarium

I would also like to thank Mr. Lalchharliana for his invaluable assistance and cooperation during the field visits

My sincere thanks go to all the faculty and staff members of Environmental Science Department for their assistance and support during the course of study

My sincere thanks go to all my collegues and friends for their support and assistance without which the completion of this study would not have been possible. In particular, I am grateful to Lallawmkimi for her invaluable assistance.

I sincerely thank Mr. Lalhmachhuana, Scientist, MIRSAC who prepared all the maps required for the completion of my thesis.

I am deeply grateful to my family for their assistance, motivation and constant support throughout my period of study

Last but not the least, I thank the Almighty God for granting me health, wisdom and strength to undertake and complete this research

Place : Aizawl

Date : 20th January, 2014 (S.T.LALZARZOVI)

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INTRODUCTION

1.1. Biodiversity : Origin of the word and Definitions

'Biodiversity' is a relatively new compound word, but biological diversity is not. It was first used by Lovejoy (1980), a tropical and conservation biologist and is most commonly used to describe the number of species. Biodiversity refers to the totality of genes, species and ecosystem of a region. The term biodiversity was first defined as including two related concepts- genetic diversity (the amount of genetic variability within species) and ecological diversity (the number of species in a community of organisms) by Norse and McManus (1980).

Rosen(1986),a biologist and senior program officer at the National Research Council brought together prominent scientists from the National Academy of Sciences to host the National Forum on Biodiversity in 1986 in Washington. Hecoined the term 'biodiversity' for the event as a convenient shorthand, a buzzword that would at once encapsulate biologists understanding of a chaotic, diminishing natural world and would raise public awareness about threats to the natural world (Takacs, 1996). Papers from that symposium were published in landmark book 'Biodiversity" edited by Wilson (1988).

Delong(1996) defined biodiversity as, "Biodiversity is an attribute of an area and specially refers to the variety within and among living organisms, assemblages of living organisms, biotic communities and biotic processes, whether naturally occurring or modified by humans. Biodiversity can be measured in terms of genetic diversity and the number of different types of species, assemblages of species, biotic communities and biotic processes, and the amount of *(eg.* abundance, biomass, cover, and rate) and structure of each. It can be observed and measured at any spatial scale ranging from micro sites and habitat patches to the entire biosphere."

The official definition in Article 2 of the ' Convention on Biological Diversity' signed by 156 nations and the European community at the United Nations Conference on the Environment and Development, 'The Earth Summit' in 1992 was "Biodiversity means the variability among living organisms from all sources including, *inter alia*, marine, and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems"(Agarwal, 2002).

The Biological Diversity Act, 2002 defined 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 ecosystem (BDA, 2002)

In other words, biodiversity means the variety and the variability among living organisms and the ecosystem or, in the simplest sense, it may be defined as the sum total of species richness, i.e. the number of species of plants, animals and microorganisms inhabiting a given habitat (Agarwal, 2002). There is no single standard definition for biodiversity.

Diversity addresses two distinct varieties- richness and evenness. Richness refers to the number of units per unit area, and evenness refers to their abundance, dominance or spatial distribution. The focus of biodiversity measurement is typically the species, because they are easily observed and mostly used in the studies of forest ecosystems. (Barnes *et al.,* 1998)

1.2. Types of biodiversity

Biological diversity or biodiversity have been classified into different kinds by different authors. Soulé(1991)documented five kinds of diversity- genes, populations, species, assemblages and whole system at the landscape or ecosystem level. Biodiversity is also organised into three distinct levels or components and all the three levels or components form an intricate web. These three levels are- genetic

diversity, species or taxonomic diversity and ecosystem diversity (McAllister, 1991; Solbrig, 1991; Groombridge, 1992; Heywood, 1994; Norse, 1994). Harper and Hawksworth(1994) and Gaston and Spicer(1998) also proposed three levels of biodiversity, however they classified it as ecological diversity, genetic diversity and organismal diversity.Noss (1990) distinguishes three interdependent sets of attributes i.e. compositional level (the identity and variety of elements) and structural levels(ecological and evolutionary processes).

1.2.1.Genetic Diversity

Genetic diversity is usually thought of as the amount of genetic variability among individuals of a variety, or population of a species (Brown, 1983).It refers to the total number of genetic characteristics in the genetic makeup of a species.

It results from the many genetic differences between individuals and may be manifest in differences in DNA sequence, in biochemical characteristics (e.g. in protein structure or isoenzyme properties), in physiological properties (e.g. abiotic stress resistance or growth rate) or in morphological characters such as flower colour or plant form.(Rao and Hodgkin,2002)

There are four main components of genetic diversity which can be distinguished; the number of different forms (alleles) ultimately found in different populations, their distribution, and the effect they have on performance and the overall distinctness between different populations. The variation that underpins genetic diversity arises from mutation and recombination. Selection, genetic drift and gene flow act on the alleles present in different populations to cause variation in the diversity in them. The selection can be natural or it can be artificial, as is the case with much of the variation present in crop species (Suneson, 1960; Frankel, 1977; Nevo *et al.*, 1984; Brown,1988; Hamrick *et al.*, 1992).

Genetic diversity is appreciated as an essential component of ecosystem resilience and the capacity for species to adapt in changing and challenging environments (Sgro *et al.,* 2011). It helps ensure the survival of species because it is what gives rise to the variation between individuals. This variation may allow a species to change over time andthereby survive changing environmental conditions. A reduction in genetic diversity may make a population more susceptible to diseases. Thus, genetic diversity is essential for a species to evolve and become adapted to changing environment. In recognition of the importance of the genetic componentof biodiversity, the Convention on Biological Diversity has for the first time included consideration of genetic diversity with the Aichi Targets, in the 2010 revised Strategic Plan for Biodiversity (http://www.cbd.int/sp/)

Genetic diversity can be measured using a variety of DNA based and other techniques.However, it has been previously dismissed as too difficult and costly to use as a basic unit for measuring and assessing biodiversity (Mortiz, 1994)

1.2.2. Species Diversity

Species diversity is the variety of species within a habitat or a region. It is a measure of the diversity within an ecological community that incorporates both species richness (the number of species in a community) and the evenness of species' abundances.

Species diversity is the conventionally accepted measures of diversity. .It is the building block for the diversity of higher taxa and for the diversity of ecological associations such as communities and biomes (Kiester, 2001).

To count the number of species, we must define what constitutes a species. Species may be defined by three concepts – the morphological species concept, the biological species concept and the phylogenetic species concept (Laverty *et al*., 2008). The morphological species concept (MSC) is largely outdated

as a theoretical definition but it is still widely used. According to this concept, ‘species are the smallest groups that are consistently and persistently distinct, and distinguishable by ordinary means (Cronquist, 1978).In other words, morphological species concept states that "a species is a community, or a number of related communities, whose distinctive morphological characters are, in the opinion of a competent systematist, sufficiently definite to entitle it, or them, to a specific name" (Regan, 1986). In its simplest form, individuals that look alike and share the same identifying traits belong to the same group. The biological species concept (BSC), as described by Mayr and Ashlock (1991), states that,"a species is a group of interbreeding natural populations that is reproductively isolated from other such groups".The phylogenic species concept is the most complex and recognises more species than the biological species concept. According to the phylogenetic species concept (PSC), as defined by Cracraft (1983), a species, "is the smallest diagnosable cluster of individual organism (that is, the cluster of organisms are identifiably distinct from other clusters) within which there is a parental pattern of ancestry.

Species diversity may be measured by the following three ways- species richness, species abundance and taxonomic or phylogenetic diversity (Magurran, 1988). The measures of species richness count the number of species in a defined area while the species abundance measures the sample of the relative numbers among species. A typical sample may contain several common species, a few less common species and numerous rare species. In effect, the measures of species diversity simplify information on species richness and relative abundance into a single index (Magurran, 1988; Spellerberg, 1991). The relative abundance of species in various taxonomic groups like microorganisms, cryptogams, angiosperms, etc is only understood by taxonomic diversity. For example -Habitats with equal species diversity (number of species) may not have the same taxonomic diversity (WRI-IUCN-UNEP, 1992).

1.2.3. Habitat Diversity

Habitat has been defined in many ways - “Abstraction of the essential physical factors and of the essential co-inhabitant biota, in a locality where individuals of that population regularly live and reproduce” (Udvardy, 1959).“The place where an organism lives, or the place where one would go to find it” (Odum,1971).“The range of environments or communities over which a species occurs” (Whittaker *et al.*,1973).“Plant and animal communities as the characterising elements of the biotic environment,together with abiotic factors (soil, climate, water availability and quality, and others), operating together at a particular scale” (EUNIS, 2009).

The concept of habitat diversity is very difficult to define univocally. Even when there is an agreement on what is meant by habitat, the identification of the spatial scale of analysis must also be considered. A habitat can be a lagoon as well as a salt-marsh, which is contained in a lagoon. However, homogeneous land units identified at the lagoon scale and at the salt-marsh scale are different; meaning that the resulting measures of habitat diversity cannot be compared. For this reason, many habitat classification systems report hierarchical, nested schemes of units which can be recognized at different spatial scales(Tagliapietra and Sigovini, 2010).

The “habitat heterogeneity hypothesis” states that an increase in thenumber of habitats and/or, at a different scale, an increase in their structural complexity leads toan increased species diversity (Simpson, 1949; MacArthur and MacArthur, 1961; MacArthur and Wilson, 1967; Connor and McCoy, 1979). A larger number of (micro) habitats practically mean a largernumber of niches exploitable by different species (Tews *et al.,* 2004). The main problem in using habitat as measures of diversity lies in the complex and variable nature of habitats (Budiansky, 1995)

1.2.4. Ecosystem diversity

Tansley(1935) defined ecosystems as, "The whole system including not only the organism-complex, but also the whole complex of physical factors forming what we call the environment". Any unit that includes all of the organisms (i.e: the "community") in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity, and material cycles (i.e: exchange of materials between living and nonliving parts) within the system is an ecosystem(Odum, 1971). Ecosystem refers to all the individuals, species and population in a spatially defined area, the interactions among them and those between them and the abiotic environment (Likens, 1993). Ecosystems are the largest units generally considered in biodiversity, comprising some amalgam habitats, the species within them and importantly the processes occurring within and between the biotic and abiotic components (Wilcove and Blair, 1995; Christensen*et al*,1996; Noss, 1996). An ecosystem can exist at any scale, for example, from the size of a small tide pool up to the size of the entire biosphere (Laverty*et al*., 2008)

Ecosystem diversity is harder to measure than species or genetic diversity because the "boundaries" of communities - associations of species - and ecosystems are elusive (WRI-IUCN-UNEP, 1992). Nevertheless, as long as a consistent set of criteria is used to define communities and ecosystems, their numbers and distribution can be measured.

Ecosystems are further divorced from genes and species in that they explicitly include abiotic components, being partly determined by soil/parent material and climate (Encyclopedia of Biodiversity, 2001).Ecosystems may be classified according to the dominant type of environment or dominant type of species present; for example, a salt marsh ecosystem, a rocky shore intertidal ecosystem, a mangrove swamp ecosystem. Because temperature is an important aspect inshaping

ecosystem diversity, it is also used in ecosystem classification viz., cold winter deserts versus warm deserts (Udvardy, 1975).

The diversity of an ecosystem is affected by the physical characteristics of an environment. These characteristics include the temperature, precipitation and the topography of the ecosystem. There is a general trend for warm and moist tropical ecosystems to be richer in species than cold temperate ecosystems. Also, the energy flux in the environment significantly affects the ecosystem. An exposed coastline with high wave energy will have a considerably different type of ecosystem than a low-energy environment such as a sheltered salt-marsh. Similarly, an exposed hilltop or mountainside is likely to have stunted vegetation and low species diversity compared to more prolific vegetation and high species diversity found in sheltered valleys (Laverty *et al.,* 2008).

Environmental disturbance on a variety of temporal and spatial scales can affect the species richness and, consequently, the diversity of an ecosystem. For example, river systems in the North Island of New Zealand have been affected by volcanic disturbance several times over the last 25,000 years. Ash-laden floods running down the rivers would have extirpated most of the fish fauna in the rivers, and re-colonization has been possible only by a limited number of diadromous species (*i.e.*, species, like eels and salmons, that migrate between freshwater and seawater at fixed times during their life cycle). Once the disturbed rivers had recovered, the diadromous species would have been able to re-colonize the rivers by dispersal through the sea from other unaffected rivers (McDowall, 1996).

Besides the physical characteristics of the environment, the diversity of an ecosystem is also dependent on the diversity of the species present and the interactions that the species have with each other and with the environment. Therefore, the functional complexity of an ecosystem can be expected to increase with the number and taxonomic diversity of the species present, and the vertical and

horizontal complexity of the physical environment. However, one should note that some ecosystems(such as submarine black smokers, or hot springs) that do not appear to be physically complex and that are not especially rich in species, may be considered to be functional complex. This is because they include species that have remarkable biochemical specializations for surviving in the harsh environment and obtaining their energy from inorganic chemical sources (Rothschild and Mancinelli, 2001). While the physical characteristics of an area will significantly influence the diversity of the species within a community, the organisms can also modify the physical characteristics of the ecosystem (Butler, 1995).

1.2.5. Landscape Diversity

A landscape is a heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout. A landscape is "a mosaic of heterogeneous land forms, vegetation types, and land uses" (Urban *et al.*, 1987). Landscape therefore has a pattern and this pattern consist of repeated habitat components. For example, a landscape may be interspersed with grasslands, meadows, ponds, streams, shrubby areas and forests (Krishnamurthy, 2004).Assemblages of different ecosystems (the physical environments and the species that inhabit them, including humans) create landscapes on earth (Laverty *et al.,* 2008). It involves more than just the kinds of communities and species- it depends on the spatial arrangement of habitats across a large area and on the fluxes of energy, nutrients, disturbances, and organisms across the area (Agrawal, 2002).

The inclusion of landscape as a form of diversity was emphasised by Odum(1996) when he listed the following as one his great ideas in ecology, “An expanded approach to biodiversity should include genetic and landscape diversity, not just species diversity”Although there is no standard definition of the size of a landscape, they are usually on the order of hundreds or thousands of square

kilometres(tens or hundreds of square miles, or tens to hundreds of thousand acre). The landscape level of biodiversity is a relatively new horizon for scientific research due to technological innovations in analyzing satellite images and geographic information systems (GIS) software. The study of landscapes is often closely tied to land use planning and human use of land (Laverty *et al.,* 2008).

Species composition and population viability are often affected by the structure of the landscape; for example, the size, shape and connectivity of individual patches of ecosystems within the landscape (Noss, 1990). Conservation management should be directed at whole landscapes to ensure the survival of species that range widely across different ecosystems viz., jaguars, quetzals, species of plants that have widely dispersed pollen and seeds (Hunter, 2002).

Diversity within and between landscapes depends on local and regional variations in environmental conditions, as well as the species supported by those environments. Landscape diversity is often incorporated into descriptions 'ecoregions'. Ecoregion is a relatively large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions (WWF, 1999). The ecosystems within an ecoregion have certain distinct characters in common (Bailey, 1998).

1.3.Patterns of Biodiversity

1.3.1 Spatial Scale of Biodiversity

Whittaker(1977) was the first to realise that ecological diversity was scale dependent or hierarchical in nature. He distinguished four levels of inventory diversity to help structure this decision. The smallest scale is *point diversity*, the diversity of a micro-habitat or sample taken from within a homogenous habitat. It reflects the diversity at a particular location. The diversity of this homogenous habitat, the second of Whittaker's categories is termed *alpha diversity* (α-diversity). The next scale of

inventory diversity is *gamma diversity*(γ- diversity), the diversity of a larger unit such as an island or landscape. The final scale envisioned by Whittaker (1975)the *epsilon diversity* is the diversity of a large biogeographic region, such as biome.

1.3.2.Differentiation Diversity

Whittaker(1975)devised three levels of differentiation diversity – Pattern diversity, Beta diversity and Delta diversity. *Pattern diversity* is the differentiation diversity between samples takenin a homogeneous habitat and *Beta diversity* is the between- habitat component of diversity. Changes in species composition and abundance that occurs between landscape areas are considered as *Delta diversity.* Of these three types of differentiating diversity, beta diversity is by far the metric most commonly used to examine the degree to which turnover in species composition characterises position along gradients.Another way to think about beta diversity is to view it as measure of the degree of similarity or difference in species composition between sites. In other words, beta diversity examines the degree of species turnover as one moves from habitat to habitat, from community to community, or along any ecological gradient.

Whittaker's(1975) idea was that the total species diversity in a landscape (γ-diversity) is determined by two different things, the mean species diversity in sites or habitats at a more local scale (α-diversity) and the differentiation among those habitats (β-diversity). According to this reasoning, alpha diversity and beta diversity constitute independent components of gamma diversity:

$$\gamma = \alpha \times \beta$$

Halffter (1998) has advocated that the diversity be studied at the landscape level because the consequence of human activities (community modification and fragmentation) is most evident at this level. The components of diversity can be characterised by distinguishing them and quantifying the local distribution of species,

similarly along local assemblages, and the rate of change in species composition with respect to ecological conditions.

a)Alpha diversity(α-diversity): Alpha diversity refers to the diversity within a particular area or ecosystem, and is usually expressed by the number of species in that ecosystem. Alpha diversity has two important components- species richness and species evenness. Species richness is the number of species per unit area while species evenness is the distribution of individuals among the species. Number of species is a function of the size of the area sampled, and may show different patterns at different spatial scales in grassland (Singh,1996).

b)Beta diversity(β-diversity): A comparison of diversity between ecosystems, usually measured as the amount of species change between the ecosystems. It measures the turnover of species between different types of communities or habitats (Whittaker, 1977). The species composition of biological communities often has important effects on ecosystem-level properties (Wardle *et al.,* 1997) and since beta diversity indicates the rate of species change along given habitat or physiognomic gradient, it measures the community response to habitat heterogeneity.

c)Gamma diversity(γ- diversity): It is a measure of the overall diversity for the different ecosystems within a region. Hunter(2002) defines gamma diversity as "geographic-scale species diversity. Cornell(1985) defined it as an overall diversity within a large area. It corresponds to species richness at landscape level (Franklin, 1993). It is the product of the alpha diversity of the communities of a landscape and the degree of beta differentiation among them. According to Whittaker (1977), gamma diversity is the richness in species of a range of habitats in a geographic area (e.g.,a landscape, an island) and it is consequent on the alpha diversity of the individual communities and the range of differentiation or beta diversity among them. Like alpha diversity, it is a quality which simply has magnitude, not direction and can be represented by a single number (a scalar).

1.4. Concept of Megadiversity

The label "Megadiversity" was first introduced at the 1998 Conference on Biodiversity at the Smithsonian Institution in Washington D.C. Similar to the concept of "biodiversity hotspots," the term refers to the number and variation of animal and plant species native to an area. Megadiversity concept stresses the importance of certain countries that have large biological diversity within their borders, many of which are endemic species. It is obvious that organisms are not at the disposal of frontiers but a megadiverse country is one in which a large number of species can be found. The concept of megadiversity emphasises on species richness, threaten species and endemic species, whereas hotspots concept relates to rich endemism and the degree of threat or habitat destruction (Myers *et al.,* 2000).

Some areas in our planet are richer in biodiversity than others. Those areas with a higher density of different species are not necessarily where the environment is best protected –it is rather thanks to the type of ecosystem. Tropical rainforests are the top biodiversity-rich ecosystems: only the Amazon rainforest harbours one out of every ten known species of our planet.Therefore, some countries have a major responsibility to protect this diversity, so the World Conservation Monitoring Centre of the UN Environment Programme (UNEP-WCMC) has been working on this issue since 1988. In fact, seventeen of the world's nearly 200 countries hold over 70% of the earth's biodiversity. These countries are labelled "Megadiverse" by Conservation International and the United Nations Environment Program's World Conservation Monitoring Center. They are Australia, Brazil, China, Colombia, Democratic Republic of the Congo, Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Papua New Guinea, Peru, Philippines, South Africa, United States, and Venezuela.So a megadiversity country is a term used to refer to the world’s top biodiversity-rich countries in the world (Myers *et al .,* 2000).

The Megadiversity concept was created in an attempt to prioritize conservation efforts around the world.This country-based method raises national awareness for biodiversity conservation in nations with high biological diversity, with many species unique to a specific country. This concept complements that of biodiversity hotspots and high-biodiversity wilderness areas to achieve significant coverage of the world's biological resources. The Megadiversity country concept is based on four premises (Mittermeier *et al*., 1997) -

The biodiversity of each and every nation is critically important to that nation's survival, and must be a fundamental component of any national or regional development strategy;

Biodiversity is by no means evenly distributed on our planet, and some countries, especially in the tropics, harbour far greater concentrations of biodiversity than others;

Some of the richest and most diverse nations also have ecosystems that are under the most severe threat;

To achieve maximum impact with limited resources, we must concentrate heavily (but not exclusively) on those countries richest in diversity and endemism and most severely threatened; investment in them should be roughly proportional to their overall contribution to global biodiversity.

The principle criterion is endemism, first at the species level and then at higher taxonomic levels such as genus and family. To qualify as a Megadiverse country, a country must have at least 5000 of the world's plants as endemics (Mittermeier,1988).

On 18th February 2002, the Ministers in charge of the Environment and the delegates of Brazil, China, Colombia, Costa Rica, India, Indonesia , Kenya, Phillipines, Mexico, Peru, South Africa and Venezuela assembled in the Mexican city of Cancún. These countries declared to set up a Group of Like-Minded Megadiverse

Countries as a mechanism for consultation and cooperation so that their interests and priorities related to the preservation and sustainable use of biological diversity could be promoted. They also declared that they would call on those countries that had not become Parties to the Convention on Biological Diversity, the Cartagena Protocol on Biosafety, and the Kyoto Protocolon climate change to become parties to these agreements.

At the same time, they agreed to meet periodically, at the ministerial and expert levels, and decided that upon the conclusion of each annual Ministerial Meeting, the next rotating host country would take on the role of Secretary of the group, to ensure its continuity, the further development of cooperation among these countries and to reach the agreements and objectives set forth herein.

One of the patterns that dictate where extreme biodiversity occurs is the distance from the equator to the poles of the earth. Therefore, most of the Megadiverse countries are found in the tropics: the areas that surround the Earth's equator. The factors that influence biodiversity include temperature, rainfall, soil, and altitude, among others. The warm, moist, stable environments of the ecosystems in tropical rainforests in particular allow flora and fauna to thrive. A country like the United States qualifies mainly due to its size; it is big enough to holds various ecosystems.

Plant and animal habitats are also not distributed evenly within a country, so one may wonder why the nation is the unit of Megadiversity. While somewhat arbitrary, the nation unit is logical in the context of conservation policy; national governments are often the most responsible for conservation practices within the country.

1.5. Biodiversity Hotspots

A biodiversity hotspot is a biogeographic region with a significant reservoir of biodiversity that is under threat from humans. To qualify as a biodiversity hotspot on Myers 2000 edition of the hotspot-map, a region must meet two strict criteria:
it must contain at least 0.5% or 1,500 species of vascular plants as endemics,
it has to have lost at least 70% of its primary vegetation.

Biodiversity hotspots are a method to identify those regions of the world where attention is needed to address biodiversity loss and to guide investments in conservation. First developed by Myers in 1988 to identify tropical forest 'hotspots' characterized both by exceptional levels of plant endemism and by serious levels of habitat loss. Myers subsequently updated the concept in 1990, adding eight hotspots, including four in Mediterranean regions. In the 1999 analysis, published in the book *Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions*, and a year later in the scientific journal *Nature,* 25 biodiversity hotspots were identified (Myers *et al .,* 2000). Perhaps 44% of all vascular plants, and as much as 35% of vertebrate species are confined to the hotspot regions (Kerr and Burkey, 2002). The habitat extent of this land area had been reduced by 87.8% of its original extent, such that this wealth of biodiversity was restricted to only 1.4% of Earth's land surface.

Conservation International adopted Myers' hotspots as its institutional blueprint in 1989, and in 1996, the organization made the decision to undertake a reassessment of the hotspots concept, including an examination of whether key areas had been overlooked. Three years later an extensive global review was undertaken, which introduced quantitative thresholds for the designation of biodiversity hotspots(Myers *et al.,* 2000).

Currently, 34 biodiversity hotspots have been identified, most of which occur in tropical forests(Holsinger, 2005) Between them they contain around 50% of the

world's endemic plant species (150,000species) and 42% of all terrestrial vertebrates(11,980 species), but have lost around 86% of their original habitat (Mittermeier *et al .,* 2004).

Myers *et al.(*2000) considered eight hottest hotspots based on five key factors: numbers of endemics and endemic species/area ratios for both plants and vertebrates, and habitat loss which are listed in Table 1.1

Table1.1 Eight hottest hot spots

Hotspots	Endemic plants	Endemic vertebrates	Endemic plants/area ratio(species per 100 sq km)	Endemic vertebrate/ area ratio(species per 100 sq km)	Remaining primary vegetation as % of original extent	Times appearing in top 10 for each of five factors
Madagascar	9,704	771	16.4	1.3	9.9	5
Phillipines	5,832	518	64.7	5.7	3	5
Sundaland	15,000	701	12.0	0.6	7.8	5
Brazil's Atlantic Forest	8,000	664	8.7	0.6	7.5	4
Caribbean	7,000	779	23.5	2.6	11.3	4
Indo-Burma	7,000	528	7.0	0.5	4.9	3
Western Ghats/Sri Lanka	2,180	355	17.5	2.9	6.8	3
Eastern Arc and Coastal forests of Tanzania/Kenya	1,500	121	75.0	6.1	6.7	3

(Source : Myers *et al .,* 2000)

1.6. Threats to Biodiversity

Deep concern over the rapid loss of biodiversity and the realization that it plays a fundamental role in supporting human life motivated the creation of the Convention on Biological Diversity, a legally binding global treaty. Opened for signature at the Earth Summit Rio de Janeiro in 1992 and came into force in 1993, the Convention arose from an international dialogue begun a decade earlier by the World Commission on Environment and Development (known as the Brundtland Commission). The Convention is holistic, covering all aspects of biodiversity, and was the first international treaty to acknowledge the role of biodiversity in sustainable development. Five main threats to biodiversity are commonly recognized in the programmes of work of the Convention - invasive alien species, climate change, nutrient loading and pollution, habitat change, and overexploitation. Eldredge (2002) also states that the principle threats to biodiversity are habitat loss, invasive species, overexploitation, pollution and global climate change. Behind these direct drivers of biodiversity loss, there are a number of indirect drivers that interact in complex ways to cause human-induced changes in biodiversity. They include demographic, economic, socio-political, cultural, religious, scientific and technological factors, which influence human activities that directly impact on biodiversity.

Habitat loss and fragmentation is considered by conservation biologists to be the primary cause of biodiversity loss. Human settlement, resource extraction and industrial development generally result in small, isolated areas or patches of natural habitat surrounded by developed land (Gascon *et al.*, 1999). Clearance of native vegetation for agriculture, housing, timber and industry, as well as draining wetlands and flooding valleys to form reservoirs, destroys these habitats and all the organisms in them. In addition, this destruction can cause remaining habitats to become

fragmented and so too small for some organisms to persist, or fragments may be too far apart for other organisms to move between.

Invasive alien species are the second greatest threat to biodiversity worldwide. Whether introduced on purpose or accidentally, non-native species can cause severe problems in the ecosystems they invade, from affecting individuals to causing huge changes in ecosystem functioning and the extinction of many species. Virtually all ecosystems worldwide have suffered invasion by the main taxonomic groups. This problem will probably get worse during the next century driven by climate change, and an increase in global trade and tourism. As well as the risks to human health, alien species inflict massive economic costs to agriculture, forestry, fisheries and other human activities. Invasive species can also be native species whose population have expanded dramatically and out-compete, displace or extirpate native species, potentially threatening the structure and function(Hunter, 2002).

Pollution is currently poisoning all forms of life, both on land and in the water, and contributing to climate change. Any chemical in the wrong place or at the wrong concentration can be considered a pollutant. Transport, industry, construction, extraction, power generation and agroforestry all contribute pollutants to the air, land and water. These chemicals can directly affect biodiversity or lead to chemical imbalances in the environment that ultimately kill individuals, species and habitats.
Climate change, brought about by emissions of greenhouse gases when fossil fuels are burnt, is making life uncomfortably hot for some species and uncomfortably cold for others. This can lead to a change in the abundance and distribution of individual species around the globe and will affect the crops we grow, cause a rise in sea levels and problems to many coastal ecosystems. In addition, the climate is becoming more unpredictable and extreme devastating events are becoming more frequent. Global warming is considered to be a major threat to global biodiversity(IPCC, 2002).

Over exploitation by humans causes massive destruction to natural ecosystems. Exploitation of biodiversity occurs for food (e.g. fish), construction (e.g. trees), industrial products (e.g. animal blubber, skins), the pet trade (e.g. reptiles, fish, orchids), fashion (e.g. fur, ivory) and traditional medicines (e.g. rhino horn). Selective removal of an individual species can unbalance ecosystems and all other organisms within them. In addition, the physical removal of one species often harms other (e.g. fishing by-catches). Although habitat loss may be the greatest threat to most species, overharvesting, unsustainable use, and the illegal trade in some species are threatening not only their continued survival but also that of ecosystems and the livelihoods of communities and local economics that depend upon them (Eldregde, 2002).

Although species extinction is an integral part of evolution(Nixon and Wheeler, 1992), the projection for species extinction over the next few decades greatly exceed the formerly documented observations in recent geological history (Wilson, 1985)Only recently have extinctions been recorded and scientists have become alarmed at the high rates of recent extinctions. Most species that become extinct are never scientifically documented. Some scientists estimated that up to half of presently existing species may become extinct by 2100 (Wilson, 2002). According to Spellerberg (1991), of the 1.7 million species known to inhabit the Earth, one fourth to one third is likely to extinct within the next few decades. The exponential species extinction rates have increased dramatically in the last 50,000 years from one extinction per 1000 years to about 1000 extinction per year and may reach 40,000 per year until the end of this century, so that one species will be lost every hour (Myers, 1979). It could be a scary future indeed, with as many as 30 to 50% of all species possibly heading toward extinction by mid-century.

The IUCN has assessed roughly 3% of described species and identified 16,928 species worldwide as being threatened with extinction, or roughly 38% of

those assessed. In its latest four-year endangered species assessment, the IUCN reports that the world won't meet a goal of reversing the extinction trend toward species depletion by 2010(IUCN,2009). Of the more than 300,000 known species of plants, the IUCN has evaluated only 12,914 species, finding that about 68% of evaluated plant species are threatened with extinction.

The loss of biodiversity has immediate and long term effects on human survival. According to Arora(2004), extinction is a major problem because we lose genetic diversity, important links in a species and community stability to interact and withstand stress. Thus we lose important needs of future generations to control disease and human suffering and to manage the environment and also to restore damaged habitat.

1.7.Scope and objectives

Conservation of biodiversity and its proper management is an immediate need as it is both essential for our existence and intrinsically valuable in its own right. Assessing areas of high biodiversity plays a vital role in determining key areas for conservation and establishing conservation priorities. India is a country rich in biological diversity and lies within the Indo-Malaya ecozone and completely houses two of the 34 biodiversity hotspot in the world. One of the two hotspots, i.e. the eastern Himalayas comprises North-east India. The area has long been recognized as a rich centre of primitive flowering plants and is popularly known as the 'Cradle of speciation'. Khoshoo(1992) has reported several vanishing taxa from this region. The plant germplasm resources of this region are getting depleted at an alarming rate due to the species extinction caused by deforestation and other human activities such as hunting and poaching, habitat loss, unplanned introduction of exotics, over-exploitation of plant resources, pollution of soil, water and atmosphere, degrading capacity of organic wastes, oxygen-carbondioxide misbalance and global climatic

change which are being felt in this part as well (Singh *et al .,* 1994; Khoshoo, 1996).Therefore, proper assessment and documentation of the plant diversity of this region is needed to formulate policies and programs for conservation.

The research was carried out to evaluate the ecological and botanical aspect of plant diversity of Reiek forest. An attempt is made to identify endemic, rare, endangered and threatened plant species. The outcome of the research contributes to the better understanding of the floristic and ecosystem diversity in the forest.

The aims and objectives of the present study are:

1. To study plant diversity in the core zone, buffer zone and savannah
2. Screening of rare and threatened species of the study sites.
3. To assess impact of anthropogenic activities on the environment of the study site

CHAPTER-2

CHAPTER -2

REVIEW OF LITERATURE

2.1. An overview

Since ancient times, scholars have simultaneously revered the natural world, attempted to discover in the world a natural order or impose rational order on that world and sought to understand the place of humans in the cosmos based on what they read in the natural world. Worster (1987) and Bowler (1993) offer extensive treatment of pre-20th century attempts by biologists and their intellectual predecessors to understand, categorize and philosophize the natural world. Carolus Linnaeus (1735) classified the riot of life into functional taxonomy, the '*Systema Naturae'.* CharlesDarwinbuilt on Linnaeus's and others ecological and taxonomic groundwork a century later.

In '*A Sand County Almanac',*wildlife ecologist Leopold (1949) proposed a "land ethic" suggesting that all species are intertwined in a complex interrelationship and the diversity of organisms and their interrelationships are crucial for a stable, functional planet.

The earliest reference of biological diversity was attempted by Gerbilskii and Petrunkevitch in 1955 in the context of inter-species variation in behavior and life history (Magurran, 2005). The term 'biological diversity' was first used by conservationist and ecologist Dasmann (1968) in his book, 'A Different Kind of Country'. However, it did not gain popular use until Thomas E. Lovejoy(1980) a conservation biologist, made the fate of tropical forests a public issue and introduced the term to the scientific community a decade later. In 1980 he coined the term "biological diversity" and drew up the first projections of global extinction rates . He conceived the Biological Dynamics of Forest Fragments Project, which defines the

minimum size for national parks and biological reserves. Other workers who followed Lovejoy were Norse *et al*. 1986 and Wilson, 1988

The term 'biodiversity' in its contracted form was coined by Rosen in 1986 while planning the National Forum on Biological Diversity organised by the National Research Council (NRC) held in Washington DC. The forum featured more than 60 leading biologists, economists, agricultural experts, philosophers, representatives of assistance and lending agencies, and other professionals. The word 'Biodiversity' first appeared in publication in 1988 when entomologist Wilson used it as the title of the proceedings of the National Forum on Biological Diversity i.e the follow up book of the symposium. Included in this book are 57 papers presented at the forum.

Since then, biologists promoted the term and the complex worldview it represents. 'Biodiversity' has become a widespread conservation buzzword. Biologists write about it in scientific and popular presses, both exploring its complexity and advocating its protection, environmental groups focus on it in fundraising efforts, conferences convened in its name occur regularly. Lay persons have joined biologist in attempting to shape the planets physical, political and normative environments to make more room.

"Biodiversity" often is defined as the diversity or variety of living forms, from genes and traits, to species, and through to ecosystems. Although biodiversity was a contraction of "biological diversity",the new term arguably has taken on a meaning and import all its own. Ten years later, Takacs (1996) described its ascent this way, "in 1988, biodiversity did not appear as a keyword in Biological Abstracts, and biological diversity appeared once. In 1993, biodiversity appeared 72 times, and biological diversity 19 times". It would be hard to count how many times "biodiversity" is used every day by scientists, policy-makers, and others. In 2013, the continued increase in the use of the keyword "biodiversity" in the scientific literature corresponds to an approximate doubling of the number of biodiversity papers every 5

years. The importance of biodiversity issues regionally and globally also is reflected in the Convention on Biological Diversity's targets for 2020 and in the recent establishment of the Intergovernmental Platform on Biodiversity and Ecosystem Services.

While the history of the term "biodiversity" is relatively short, it raises important and distinctive philosophical issues. Some of these are entangled in the very definition of "biodiversity". The nub of the problem of defining biodiversity is that it is hard to exclude anything from a concept that is taken so easily to mean "everything". Sarkar (2005) has argued that interpreting biodiversity across all biological levels, from genes to ecosystems, amounts to considering all biological entities, so that biodiversity absurdly "becomes all of biology".

Callicott*et al*. (1999) from their examination of biodiversity as one of the current concept in conservation concluded that it remains ill-defined, and that distinctions can be made between "functional" and "compositional" perspectives in approaching biodiversity. "Functional" refers to ecosystem and evolutionary processes, while "compositional" refers to the organisms aggregated into populations, species, higher taxa, communities, and other categories. Callicott*et al.* call for a better integration of these different perspectives,

Norton (1994) has argued that there will never be a single "objective scientific definition" of biodiversity, in the sense of a prescription for how to measure it. In fact, Norton claims that any increase in our understanding of biodiversity will make it less likely that there will be a single objective measure. This biodiversity pluralism is based on an argument that inevitably there are many different "theory bound" versions of biodiversity and many different ways to value it. This perspective is in accord with recognition of functional-compositional perspectives on biodiversity.

2.2. Plant Diversity at the global level.

Biodiversity is not evenly distributed; rather it varies greatly across the globe as well as within regions. Among other factors, the diversity of all living things (biota) depends on temperature, precipitation, altitude, soils, geography and the presence of other species.

Terrestrial biodiversity is up to 25 times greater than ocean biodiversity (Benton, 2001). Generally, there is an increase in biodiversity from the poles to the tropics. Thus localities at lower latitudes have more species than localities at higher latitudes. This is often referred to as the latitudinal gradient in species diversity. Several ecological mechanisms may contribute to the gradient, but the ultimate factor behind many of them is the greater mean temperature at the equator compared to that of the poles (Currie *et al.,* 2004).

Many recently published sources indicate that only about 1.4 million living species of all kinds of organisms have been described. Approximately 750,000 are insects, 41,000 are vertebrates and 2, 50,000 are plants. The remainder consists of a complex array of invertebrates, fungi, algae and microorganisms (Wilson, 1988). However, in 1993, World Conservation Monitoring Centre (WCMC) estimated that there are likely to be 17,980,000 species at the global level, i.e., about 11 times more than the presently known species. This increase is likely to be primarily from the tropics and subtropics (Anon, 1993). Several scientists however consider this to be far below the real picture. According to Groombridge and Jenkins (2000), 5-50 million species of the world's biota is estimated so far out of which only 1.7 million have been described.

Estimates for the number of flowering plants in the world vary from 223,300 (Scotland and Wortley, 2003) through 248,000 (Tangley, 1997), 258 650 (Thorne, 2002, IUCN, 2004), about 270,000 (Groombridge and Jenkins, 2002) to about 315,903 (Kier *et al*., 2009). The latter figure was calculated using range equivalents

of vascular plants for all 90 regions of the world and representing 'a conservative estimate on the number of species of vascular plants known to science today. The IUCN (2004) and Groombridge and Jenkins (2002) estimated that the total flora was about 320,000 species. IUCN (2009) are now using the figures from Thorne (2002) citing the figure of 258,650. There have been 9,932 new species added to the International Plant Names Index (IPNI, 2009) over the past five years .

Govaerts (2002) estimated that there are 422,127 species of flowering plants based on the first volumes of his World Checklist of Seed Plants, Bramwell (2002) using different methods, estimated a total of 421,968 species. Prance (2001) estimated that there are between 300,000 and 320,000 species, whereas more recently Paton *et al*. (2008) have estimated that there are around 352,000 species in their work for Target 1 of the Global Plant Strategy.

There are a number of contrasting recent estimates for the number of described species of Gymnosperms in the world. Groombridge and Jenkins (2002) gave a figure of 846 while Christopher Earle in The Gymnosperm Database (Earle, 2009) listed 956 species, the IUCN (2009) gives a total of 980 species based on Donaldson (2003), Farjon (2001), Mabberley (1997) and Paton *et al*. (2008) list 1,001 species.

Hill and Stevenson (2004) in their World List of Cycads listed 275 known species of Cycad. The International Plant Names Index (IPNI, 2009) has added another eight species since 2004 making 283 species in total. The World Checklist of Selected Plant Families lists 65 species of Ephedra, 41 species of Gnetum, one species of Welwitschia and one Ginkgo (RBG, 2009). Paton*et al.* (2008) states that there are 630 species of Coniferales. This gives a total of 1,021 species of Gymnosperm.

Ferns and fern allies here have been taken to include the true ferns (Filicinophyta/Polypodiopsida), the club mosses, spike mosses, quillworts

(Lycophyta, Lycopodiophyta/Lycopodiopsida, Selaginellopsida, Isoetopsida), spike horsetails (Sphenophyta/Sphenopsida) and whisk ferns (Psilophyta/Psilopsida) as recognised by various authors. Estimates for the numbers of described taxa include 13,025 from Groombridge and Jenkins (2002), who report 1,000 Lycophyta, 12,000 Filicinophyta, 10 Psilophyta and 15 Sphenophyta. Other estimates include 12 838 in the Checklist of Ferns and Fern Allies (Hassler and Swale, 2002 and IUCN, 2009).

Myers (1986) estimates that about 50 species are being driven to extinction everyday; bulk of them in tropical forests due to human interference. There was a net reduction in the global forest area between 1990 and 2005 of 66.4 million ha, or 1.7 percent. Net forest loss was highest in the tropical climatic domain in both time periods- 5.6 million ha per year between 1990 and 2000 and 9.1 million ha per year between 2000 and 2005. (FAO &JRC, 2012). If the current rate of deforestation continues, scientists estimated roughly 5-10% of the tropical forest species may face extinction within the next 30 years.

Species extinction is an integral part of evolution. However, these exponential species extinction rates have increased dramatically in the last 50,000 years from one extinction per 1000 years to about 1000 extinctions per year and may reach 40,000 per year until the end of this century, so that one species will be lost every hour (Myers, 1979). The most threatened habitat is tropical rainforest. One of the greatest threats facing plants today is the conversion of natural habitats for agriculture or livestock use. Largely as a result of socio-economic difficulties in tropical countries, human-induced extinctions are occurring at perhaps 10^4 times the natural, background rate (May and Tregonning, 1998).

Estimates suggest that tropical forests are being cleared at the rate of 140,000km2 per year or approximately 1.8 % of the remaining forest cover (Myers, 1988; ODA, 1991). The rate of tropical deforestation appears to have accelerated over recent decades. Pearce (1991) notes that during the late 1970s 6,540,000 ha of

closed forests were deforested annually, but that this rose to 14,220,000ha by the late 1980s. As a proportion of the remaining forest, the rate of deforestation rose from 0.6 % in the late 1970s to 1.8–2.1 % in the late 1980s (Pearce, 1991). State of the World's Forests (2005) notes that over the period 1995–2000 about 9,400,000ha of forests were deforested annually across the world. The annual deforestation rate was the highest in Africa (5,300,000ha), followed by South America (3,700,000ha), North and Central America (600,000ha), Asia and Oceania (each 400,000ha). Deforestation and forest degradation are currently more extensive in the tropics than in the rest of the world (WRI, 2005).

Tropical deforestation has disastrous consequences on species and tropical forest ecosystem services. The Millennium Ecosystem Assessment Report notes that current species extinction rates are up to 1000 times higher than the fossils record of less than one species per 1000 mammal species becoming extinct every millennium (WRI, 2005). The projected future extinction rate is more than 10 times higher than the current rate. One estimate suggests that if current deforestation continues at the same rate, approximately one quarter of the world's plant species will be lost over the next 20 years (ODA, 1991).

In 1997, the World Conservation Union (IUCN) Red List of Plants included some 34,000 threatened species (out of 60,000 evaluated). Since then, the IUCN Red Listing criteria have changed, and only around 11,000 species have been evaluated with the new system. However, of those evaluated, some 8,000 species were found to be under threat. Both of these assessments indicate that well over half of all plants evaluated are at risk. According to the latest list published by World Conservation Union i.e IUCN Red List 2012, there are 90 extinct plant species, 31 extinct in the wild, 1,821 critically endangered, 2,655 endangered and 4,914 vulnerable plant species making the total number of threatened species to be 9,390.

2.3. Plant diversity at the national level

India has immense biological diversity which can be attributed to the variety in physiographic and climatic situations resulting in a diversity of ecological habitats. The natural ecosystems range from the cold and high Himalayan regions to the sea coasts and coastal mangroves of Sundarbans; from the wet north-eastern green forests and Western Ghats to the dry north-western arid deserts; from freshwater lacustrine systems of Gangetic plains to Coral reefs of Andaman Sea; from the cold deserts of Ladakh and Lahaul-Spiti to tropical islands ecosystem; with different types of forests, wetlands, islands and the oceans. India consists of fertile river plains and high plateaus and several major rivers, including the Ganges, Brahmaputra and the Indus. The diverse physical features and climatic situations have formed ecological habitats like forests, grasslands, wetlands, coastal and marine ecosystems and desert ecosystems, which harbour and sustained immense biodiversity. In each of these eco-zones, there are hundreds of biotopes, each supporting rich and characteristic floristic and faunistic components. The confluence of three major biogeographical realms viz., Eurasian, Afro-tropical and Indo-Malayan in the Indian region has further enhanced these attributes by enabling the intermingling of floristic elements of these regions. The country is one of the 12 primary centres of origin of cultivated plants and domesticated animals (Vavilov, 1949).

The whole credit of highlighting the regional characteristics of the country's natural vegetation goes to Hooker and Thomson (1855). Clarke (1879) divided this part of Asia into 6 floristic regions: (1) Himalayan region-(a) Eastern Himalaya, and (b) Western Himalaya, (2) Arid region, (3) Malabar region, (4) Coromandel region, (5) Ganga plain, and (6) Assam region. Hooker (1907) identified 8 floristic regions in the British India, these include (1) Eastern Himalaya, (2) Western Himalaya, (3) Indus plain, (4) Ganga plain, (5) Malabar region, (6) Deccan region, (7) Maldive and Sri Lanka, and (8) Burma (not in India). Calder (1937) identified 6 floristic regions in the

country: (1) North-western Himalaya, (2) Eastern Himalaya, (3) Indus Plain, (4) Ganga Plain, (5) Deccan region, and (6) Malabar region. Chatterji (1939) on the basis of certain indigenous plant species in different parts of the country, divided India into 8 main floristic regions- the western Himalayas, the eastern Himalayas, Assam, the Indus plain, the Ganga plain, the Deccan, Malabar and the Andaman.

McNeely *et al*. (1990) estimated that 70% of the world's flowering plants occur in 12 countries, which he designated as the Mega-diversity centres or mega-diversity countries. India is one of the 12 mega-diversity countries. With only 2.4% of the global land area, 11% of the world's biota, so far, has been described from this country. The total number of plant species in India is estimated to be about 45,000 (15,000 flowering plants, 64 gymnosperms, 2,843 bryophytes, 1,012 pteridophytes, 1,940 lichens and 23,000 fungi (Anon, 1994). About 28% of total Indian flora is endemic to the country (Sharma and Singh, 2001).

According to Udvardy (1975) biodiversity exist on earth in 8 broad realms with 193 biogeographical provinces. The richness and diversity of the Indian flora can be appreciated by the fact that as many as 12 biogeographic regions, representing 3 basic biomes and 2 natural realms are recognized in India. Out of the 18 biodiversity hot spots in the world, 2 areas lie in India, namely the Western Ghats and Eastern Himalayas (Chatterjee, 1994). Rodgerset al. (2002) have divided India into 10 biogeographic regions, and Champion and Seth (1968) classified the forests of India into 16 types. According to the India State of Forest Report (2011), the total forest cover in the country is now at 6,92,027 sq km (FSI, 2011). This accounts for 21.05 % of the total geographical area of India.

According to Sharma and Singh (2001) about 28 % of total Indian flora is endemic to the country whereas according to Singh *et al.*(2002) 33 % are endemic. There are three mega centres of endemic plants in India-Eastern Himalayas, Western Ghats and Western Himalayas. Eastern Himalayas harbour 9,000 species

of plants with 3,500 endemic species, Western Ghats harbour 5,800 species of plants with 2,000 endemic species and Western Himalayas possess 1195 endemic species. The Andaman and Nicobar islands harbour about 83 % endemic species (Nayar, 1996). of the world's 18 biodiversity hotspots located in the Western Ghats and in the Eastern Himalayas (Myers *et al .,* 1999).

Under the Wildlife Protection Act, 1972, the state government is empowered to declare any area as a Sanctuary or National Park for the purpose of protecting, propagating or developing wildlife there in or its environment. At present, there are 14 biosphere reserves, 92 national parks and 500-Wildllife sanctuaries in the country.

Jones (1799) perhaps was the earliest British contributor who wrote a memoir 'Botanical observations on selected plant'. Other earlier works include- 'Flora Indica' (Roxburgh, 1832); 'Hand Book of the Indian Flora' (Drury, 1864-69). Hooker (1872-97) published a monumental work 'Flora of British India' in seven volumes which comprise brief descriptions, ordinals, generic and specific of the flowering plants and ferns found within the erstwhile British territories in India including Kashmir and Western Tibet. Banerjee (1980) published Flora & Fauna in Sanskrit literature. Identification of threatened plants of India was carried out by Jain and Rao (1983).

Since then, many scientists and scholars have studied the flora of various states of India such as Flora of Assam (Kanzilal *et al*., 1940); Flora of Tripura State in two volumes (Deb, 1981); Flora of Kashmir Himalayas (Dhar and Kashroo, 1983); Flora of Madhya Pradesh (Roy *et al*., 1992); Flora of Andhra Pradesh in six volumes (Kumar, 1998); Floristic diversity of Assam (Bora and Kumar, 2003); Floristic biodiversity of Barda Hills and its surroundings (Nagar, 2005).

A First Red Data List of Indian plants was brought out as per the assessment of Conservation Assessment and Management Plan (CAMP) workshop held during 1995-1997. At least 10% of the India's recorded wild flora and possibly, a larger fraction of wild fauna are on the threatened list, many of them are on the verge of

extinction. This is not surprising considering the fact that about 50% of India's forest has been lost and 70% of its water polluted (Kothari, 1992)

2.4. Plant diversity at the Northeast level

The Northeast India has a total geographical area of 2,62,179 km^2 (about 8% of the total area of India) and lies between $21^0$34' N to $29^0$50' N latitude and $87^0$32'E to $97^0$52' E longitudes (Mao *et al*., 2009). It represents the transition zone between the Indian, Indo-Malayan and Indo-Chinese biogeographic regions and a meeting place of the Himalayan Mountains and Peninsular India. It was the part of the northward moving 'Deccan Peninsula' that first touched the Asian landmass after the break up of Gondwanaland in the early Tertiary Period (Bhutani, 2008). Northeast India is thus the geographical 'gateway' for much of India's flora and fauna and as a consequence, the region is one of the richest areas of India in biological values (Shankar and Rawat, 2006; Mao *et al .,*2009). It is in this lowland-highland transition zone that the highest diversity of biomes or ecological communities can be found, and species diversities within these communities are also extremely high.

The region is made up of eight states - Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland, Sikkim and Tripura and is endowed with a wide range of physiography and eco-climatic conditions. Together, they represent a distinct biogeographic zone, rich in biodiversity, ethnic cultures and folklore traditions. The diversity and richness of forests of Northeast India are influenced by the geography, precipitation, temperature and altitude. The Northeast India including Eastern Himalaya are positioned in such a way that the region is not only able to capture maximum precipitation and high humidity, which is conducive for flora, but also comes in direct contact with many other floristic regions, so that there is a free migration of flora. The State of Assam has extensive flood plains, while Khangchendzonga in Sikkim stands 8586m tall. Cherrapunjee in the State of

Meghalaya holds the record for the highest rainfall in a single month (9,300mm) as well as the most in a year (26,461mm) in India, while the nearby Mawsynram has the world's highest average rainfall (11,873mm). The forests in the region are extremely diverse in structure and composition and combine tropical and temperate forest types, alpine meadows and cold deserts.

Northeast India forms one of the major regions of tropical forests in India, especially the species-rich tropical rain forests. It accounts for one-fourth of the country's cover but there is a decline of 549 km2 from 2006-2008 (FSI, 2011) The tropical semi-evergreen and moist deciduous forests in the lowlands of this region extend south and west into the subcontinent, and east into Southern China and Southeast Asia. The subtropical forests of the region follow the foothills of the Himalaya to the west; also extend into Southeast China in the east. Himalayan temperate and subalpine zone forests extend from northern Pakistan and adjacent Afghanistan through Northeast India to Southwest China. This region represents an important part of the Indo-Myanmar biodiversity hotspot, one of the 34 global biodiversity hotspots recognized currently (Chatterjee *et al.,* 2006)

In this region 51 different types of forest, which includes tropical moist deciduous forests, tropical semi evergreen forests, tropical wet evergreen forests, subtropical forests, temperate forests and alpine forests. Six important vegetation types out of the nine of India is found in the North Eastern region. More than 8,000 out of 15,000 species (in India) of flowering plants is also found in the North Eastern region, which includes 40 species of gymnosperms, 500 species of pteridophytes, 825 species of orchids, 80 species of rhododendrons, 60 species of bamboo, and 25 species of canes (Dutta and Dutta, 2006; FSI, 2011; Eyzaguirre, 1995). Out of 315 flowering plant families in India more than 200 families are represented in this region (Singh *et al.,*2002). North-east India shares the maximum number of endemic species and other rare plants showing discontinuous distribution. The region is

considered as the primary and secondary centres of origin and diversity of about 50 crop plants and about 190 wild relatives. Important crop plants originated in this zone include citrus, banana, mango, rice and several species of legumes, cucurbits, orchids, bamboos and medicinal and aromatic plants. All these factors have rendered this region as the richest botanical diversity centre in the entire subcontinent-diversity at the community level, at the species level and in endemics. Due to the presence of a large number of primitive and ancient flowering plant in the region it is sometimes known as “The Cradle of Flowering Plants’ (Takhtajan, 1969 and Rao, 1974).

The number of National Parks and Wildlife Sanctuaries present in the region accounts as 12 in Arunachal Pradesh, 81 in Assam, 5 in Meghalaya, 8 in Mizoram, 6 in Sikkim, 4 in Tripura, 2 in Manipur. There are 5 Biosphere Reserves found in this region. A number of sacred grooves have been reported from Meghalaya and Manipur state. The previous studies have depicted that the forests of Northeast India especially sacred forests are very rich in plant diversity, and mild disturbance supports maximum species richness (Mishra *et al .,* 2004).

The primary vegetation in extensive areas of the Northeast India has been disturbed and modified and in some places destroyed by seismic activities, frequent landslides and resultant soil erosion. While these natural causes have contributed only marginally to the change in vegetation type, it is the activity of Man that has led to the irreversible transformation in the landscapes and has resulted in colossal loss of biodiversity in the entire region. Human influences have pushed many species to the brink of extinction and have caused havoc to natural fragile ecosystems. Such devastations to natural ecosystems are witnessed almost everywhere in the region and is a cause of great concern. Northeast India has 64% of the total geographical area under forest cover and it is often quoted that it continues to be a forest surplus region. However, the forest cover is rapidly disappearing from the entire region.

There has been a decrease of about 1800 sq.km in the forest cover between 1991 and 1999 (FSI, 2000). More worrisome still is the fact that the quality of the forest is also deteriorating, with the dense forests (canopy closure of 40% or more) becoming degraded into open forest or scrub. Though there is a succession of several edaphic formations, a vast area of land has already been transformed into barren and unproductive wastelands. This being the case, the statistics of 'more than 64 % of the total geographic area in this region under forest cover' could be misleading. For example, though the forest cover in Manipur extends to 78% of the total geographic area, only 22% of forest area is under dense forest cover and the rest has been converted to open forests. Except in the Brahmaputra and Barak valleys of Assam where substantial areas are under agriculture, little of the land is available for settled cultivation. Hence, shifting agriculture or slash-and-burn agriculture is the major land use in Northeast India and extends over 1.73 million ha (FSI, 1999). Different agencies have come up with different figures concerning the total area under shifting cultivation (jhum) in the region. What is not disputable is that with an ever shortening jhum cycle and other human influences have caused environmental degradation with disastrous consequences.

The vegetation and flora of north-east India has been studied by several workers, such asClarke (1879), Kanjilal *et.al.,(*1934 -40), Bor (1942), Rao (1974), Fischer (1938), Singh (1980), Balakrishnan (1981–1983), Haridasan and Rao (1985 - 87),Khan *et al .,* (1986, 1987),Rao and Hajra (1986),Jamir and Rao (1988) Rao (1992), Barik *et al .,* (1992) and Singh*et al .,*(2002).

The region has high evolutional activity that is evident from the cytogeographic studies on the genera *Rhododendron, Camellia, Magnolia, Buddleia,* etc. However, the whole northeastern region needs to be explored thoroughly so that many more species belonging to both flowering and non-flowering plants could be discovered.

2.5.Plant diversity at the local level

The vegetation and forest types of Mizoram have been analyzed by Champion and Seth (1968), Forest Survey of India (FSI, 2011)and Indian Institute of Remote Sensing (IIRS, 2003). The forest cover is the highest in India covering 79.30 % of its geographical area (FSI, 2011).. However it retains only 84 km^2 of very dense forest which is over 70% of crown density as the forest is being degraded due to the practice of shifting cultivation, logging of woods for timber and harvesting of fuel-wood and extraction of non timber forest resources.

Literature found on the floristic diversity of Mizoram indicates that this area have not been studied adequately with only few collections made in the past and thus our knowledge about the plant diversity of Mizoram is not so much as compared to other states of North East India. Initially, the studies were mainly based on the collection made by army officials, administrators and some missionaries out of their personal interest. The first collection of Mizoram plants was made by Gage (1901); he recorded 317 species including 26 species of Cryptogams based on his collection during 1899 from a small area in Lunglei district. Leslie also made some collections in December, 1902 which she sent to Botanical Survey of India, Calcutta. In addition to this, collections made by Parry from 1924 to 1928 (Parry, 1932) were sent Royal Botanical Garden, Kew and to Indian Botanic Garden, Calcutta. Collections made by Wenger in 1926 and 1932, Lorrain and his daughter Foxall from Lunglei were also sent to Kew and to Calcutta. Based on this collections, In the year 1938, Fischer published 'The Flora of the Lushai Hills', he recorded 1360 species, including 6 species of Gymnosperms and 155 species of Cryptogams. Singh *et al*. (2002) recorded 244 species of orchids under 74 genera from the state. Deb and Dutta (1987) made some observations in Mamit subdivision and west Aizawl. The plant collections of the state have been also made by some other workers like Hooker 1872- 1897 and Kanjilal*et al*., 1934-1940.

Recent workers include Sawmliana (1998-2003); Lalramnghinglova (1997, 2003) ; Jha, 1997. Sawmliana (2003) published The book of Mizoram Plants and recorded about 966 plant species from Mizoram. Lalramnghinglova (1997) published a book “Handbook of Common Trees of Mizoram” and carried out Ethno-botanically important plants in different forest areas and published a book on “Ethno-Medicinal plants of Mizoram” in 2003. Lalramnghinglova (1997) and Lalnunmawia (2003) identified 20 species of bamboos; Jha (1997) published ‘Natural resource management in Mizoram’. Singh *et al*. (2002) published ‘Flora of Mizoram’, Lalnuntluanga (2007) identified 12 species of canes. Out of 25 micro endemic centers identified in India, Mizoram comes under Patkoi- Manipur-Lushai Hill (Nayar, 1996). Despite its phytogenic affinities with Indo-Malaya, Bangladesh, Myanmar, Nepal, Bhutan and some South-East Asian countries, endemics in Mizoram is not so high as compared to the neighboring states. The reason being that floral exploration is not exhaustive and the faunal investigation is just negligible.

The reported floral resources of Mizoram are : Flowering plants -2141 species; genera-905; Family -176; Gymnospersms -6, Pteridophyte -211, Quercus -18; Desmodium – 17; Ficus – 34; Polygonum -20; Begonia -18; Piper – 126; Endemics – 30 species (Chaudhuri and Sarkar, 2003).

According to IIRS (Indian Institute of Remote Sensing), Dehra Dun report 2003, maximum number of species occur in the tropical wet evergreen forests followed by sub-tropical broad-leaved hill forests.

Little is known about the biodiversity of Mizoram and no proper scientific research has been completed as yet. Documentation and proper assessment of the biodiversity is essential and more valuable in a particular region, which will provide the necessary information for formulating policies and programs for its effective management and conservation.

CHAPTER-3

CHAPTER-3

STUDY AREA

3.1.A brief information about Mizoram

Mizoram is a mountainous region which became the 23rd State of the Union in February 1987. It was one of the districts of Assam till 1972 when it became a Union Territory. Sandwiched between Myanmar in the east and south and Bangladesh in the west, Mizoram occupies an area of great strategic importance in the north-eastern corner of India. Flanked by Bangladesh on the west and Myanmar on the east and south, Mizoram have a long international boundary of 722 Kms.

It has an area of 21,081sq.km and lies between coordinates $21^0$58' N to $24^0$35' N latitude and $92^0$15'E to $93^0$20' E longitudes. The tropic of cancer runs through the heart of Mizoram at $23^0$30'N latitude. Two sister states of Manipur and Assam border it on the north while Tripura lies in the north-west.

The State comprises eight districts- Kolasib, Mamit, Aizawl, Champhai, Serchhip, Lunglei, Lawngtlai and Saiha. Geographically speaking, Lunglei covers the largest area district wise with an area of 4538 sq.km while Kolasib district is the smallest with an area of 1382.51sq.km. Lawngtlai district and Saiha district differs from the rest of the other districts in their administrative setup. There are two autonomous district councils within the Lawngtlai district namely the Lai Autonomous District Council (LADC) and the Chakma Autonomous District Council (CADC) with their headquarters at Lawngtlai and Chawngte respectively. The third autonomous district council resides within Saiha district i.e.Mara Autonomous District Council(MADC) with its administrative seat is located at Saiha town. These autonomous regions are administered in accordance with the provisions of the Sixth Schedule of the Constitution of India.

According to 2011 census, the total population of Mizoram is 1,091,014 out of which 552,339 are male and 538,675 are female. The literacy percentage is 91.58 per cent as per statistics of Economic and Statistics Dept, Government of India and is the third highest in the country. Mizos are primarily cultivators and their festivals are much connected with agricultural operations.

a) Physiography

Mizoram is a land of rolling hills, valleys, rivers and lakes. As many as 21 major hills ranges or peaks of different heights run through the length and breadth of the state, with plains scattered here and there. The average height of the hills to the west of the state is about 1,000 metres (3,300 feet). These gradually rise up to 1,300 metres (4,300 feet) to the east. Some areas, however, have higher ranges which go up to a height of over 2,000 metres (6,600 feet). Phawngpui Tlang also known as the Blue Mountain, situated in the south-eastern part of the state, is the highest peak in Mizoram at 2,210 metres (7,250 feet).

b)Drainage

Most of the drainage lines of Mizoram originate in the central part of the state and flow either towards north or south directed by the north-south trending ridges. The largest river in Mizoram is Chhimtuipui also known asKoldoyne (138.46 km in length). It originates in Myanmar, Burma and passes through Lawngtlai and Saiha districts in the Southern Mizoram and lastly enters the Bay of Bengal at Myanmar. The river is in patches and has four tributaries. The western part of the river is drained by Khawthlangtuipui River (128 km in length) and its tributaries. A number of important towns including Chittagong in Bangladesh is situated at the mouth of the river. Before Independence, access to other parts of the country was possible only through the river routes via Cachar in the north, and via Chittagong in the South. Entry through the later was sealed when the Sub-continents was partitioned and ceded to E.Pakistan (now Bangladesh) in 1947.

While many more rivers and streams flow through the hilly ranges of Mizoram, the most important and constructive rivers are the Tlawng also known as Dhaleswari or Katakhal (185.15 in length), Tuirial or Sonai (11.53 in length), Tut and Tuivawl (72.45 in length) which course through the northern territory and ultimately join the Barak River in Assam.

Rivers like Mat (90.16 in length), Tuichang (120.75 in length) and Tuipui (86.94 in length) fall in the southern part of Mizoram. The rivers of Mizoram are the chief source of water for the people of the state. The perpetual rivers of the state nourish the lush green vegetation of Mizoram.

Some of the other main rivers flowing through Mizoram are Tiak (159.39 km in length), Tuichawng (107.87 km in length), Teirei (70.84 km in length), Tuirini (59.57 km in length) and Serlui (56.33 km in length).

c) Climate

The climate in Mizoram is moderate, comfortable in summer and never freezing during winter. During the coolest months (November through February), temperatures typically varies from 7 to 21 °C (45 to 70 °F).. In the warmest months (June through August), it varies from 20 to 29 °C (68 to 84 °F).

The region is influenced by south west monsoon. Storms break out during March-April, just before or around the summer. Pre-monsoon rains are experienced from March to May while regular south-west monsoon commences from June till October. The averages monthly rainfall is 254cms. However, the southern region receives relatively higher rainfall than the northern region. Despite such high rainfall, prolonged dry spells and occasional drought conditions are noticed. Crops are grown mostly rainfed depending upon the monsoon rainfall. Annual rainfall of the State is about 2500mm with 124 numbers of rainy days, but is concentrated between June to September. Except in the month of October and November when rainfall of <200mm and >70mm, respectively is received, there is practically no rainfall (>30mm) in the

subsequent months (December – January). Although the pre-monsoon (February – January) rainfall is more than 700mm, the distribution of rainfall in February and March is scarce (<110mm).

d)Geology

The geology of Mizoram has not been studied in detail due to the rugged inaccessible terrain and thickly covered by vegetation. The hills of Mizoram consist of sandstone and shale of tertiary age, thrown into long folds. The rocks are the continuation of these rocks forming Patkai range and Cachar hills, and probably laid down in delta or estuary of a large river discharged from Himalaya in the tertiary period.

The geology of Mizoram is represented in general by repetitive succession of arenaceous and argillaceous sediments which were later thrown into approximately NNW-SSE trending longitudinal plugging anticlines and synclines. Geologically, two broad groups-Surma and Barail are eminent, where geological formation may be broadly classified under Bokabil, Bhuban and Barail formation.

The rocks of the Surma group are exposed in the western part of the state and exhibit ridge and valley features and trellis drainage pattern. Coupled with the dominance of trend lines, this unit could be separated from the Barail group of rocks which are exposed in the eastern part of the state; showing dendritic drainage pattern and denuded hills oriented in different directions.

In the north- eastern corner along border with Myanmar, rocks show north-linear trend and sub-parallel mountain ranges and valley type of topography. This is due to the alteration of hard stone and soft shale beds, grouped under the Barail group.

e) Soil

The soils of different physiographic units are homogenous in nature so far as the genetical aspect of soil formation is concerned. They are derived mainly from

sandstones, shales and siltstones. The soils of Mizoram can be classified into three orders of soil taxonomy, viz, Entisols, Inceptisols and Ultisols.The narrow valleys usually have the soils order of Entisols and Inceptisols while the hill slopes and ridges covered with vegetations have the soil order of ultisols indicating that physiography and soils have close relationship. The type of soils mostly found at suborder level is Ochrepts and Udults. In the hill terrain the soils are light coloured, highly leached, poor in bases, rich in iron and have low pH value (highly acidic). They are well drained, deep to very deep, moderately rich in organic carbon, low in available phosphate content and medium in available of providing substantial oxygen supply for plant growth and have capacity to retain moisture and maintain its supply throughout the growing season of most of the crops. The soils on the top of barren ridges however, are mostly shallow or underlaid by weathered rock and have a thin solum depth. The valleys flat lands commonly have heavy texture, poorly permeable or poorly drained soils with high ground water table(with one meter depth). They are alluvial and colluvial, most fertile and productive soils. The narrow valleys have light and coarse texture, well drained, well aerated and young soils. The dissected low hills/hillocks however, have soils similar to the soils found in ridges and side slopes of hills. The soils of Mizoram are dominated mainly by loose sedimentary formations. They are generally young, immature and sandy. Derived soils with red, loamy texture is also found with high level of laterite. But in an uneroded soil, the content of nitrogen is quite high fostered by accumulation of organic matters.

f) Vegetation/Forest

Based on past studies as well as from the field observations, Singh *et al*. (2002) described the forest types of the State based mainly on altitude, rainfall and dominant species composition. The classification is as follows:-

i. Tropical Wet Evergreen Forest

ii. Montane sub-tropical Forest

iii. Temperate Forests

iv. Bamboo Forests

v. Quercus Forests

vi. Jhumland.

i. Tropical wet evergreen and semi-evergreen forests:

These forests usually occur below an altitude of 900m and form one of the major forest types of the State with rich species diversity. Patches of these forests can be seen usually on the steep slopes, rocky and steady river banks and areas not suitable for shifting cultivation. The exact distinction between the evergreen and semi-evergreen forests is difficult as they occur in the areas of similar characteristics where rainfall averages between 2,000-2,500mm annually and temperature varies between 20^{o}C to 22^{o}C. Tropical wet evergreen forests are met usually in southern and western part of Mizoram, while semi-evergreen forests occur in northern, north-western and central part of the State.

The tropical wet evergreen forests exhibit clear zonation or canopies consisting of an admixture of numerous species with dense and impenetrable herbaceous undergrowth. Most of the species of the top canopy are evergreen trees with tall boles. Cauliflory is rather common. The middle and lower canopies are dense, evergreen and diverse. Epiphytes and parasites are few. Tree ferns, aroides, palms, ferns, orchids, bryophytes and lichens are fairly common. Lianas are frequent and conspicious, sedges and grasses are common in humid places or along the banks of rivers and rivulets. Species of Musa are also common along the streams on hilly slopes.

In exposed and drier areas, having a thin of soil, deciduous elements along with some evergreen trees are found. Sometimes these are grouped as distinct type, referred as tropical moist deciduous forests. The distinction between the tropical

evergreen forests and tropical moist deciduous forests is difficult as they are found in the small hill ranges.

The third storey of canopy consists of smaller trees and shrubs with maximum floristic diversity.

ii. Montane sub-tropical forests:

These forests are usually found between 900 and 1,500 m altitude in the eastern fringes bordering Chin Hills of Myanmar, and places which are cooler and have less precipitation. Sub-tropical vegetation shows mixed pine forests. The common species of these forests are *Castanopsis purpurella, Duabanga grandiflora, Myristica spp., Phoebe goalparensis, Pinus kesiya, Podocarpus neriifolia, Prunus cerasoides, Quercus acutissima, Q.semiserrata, Schima wallichii,* etc.

iii. Temperate forests:

These forests usually occur above the elevation of 1,600m in areas like Lengteng, Naunuarzo, Pharpak, Thaltlang, Phawngpui reserve forests and display impenetrable virgin primary forests. These forests are not typical temperate forests as found elsewhere in eastern Himalaya. The predominant arboreal elements in the forests are *Pinus kesiya, Actinodaphne microptera, Betula alnoides, Exbucklandia populnea, Elaeocarpus serratus, Dillenia pentagya, Michelia doltsopa, M. Champaca, Garcinia anomala, Schisandra neglecta, Photinia intergrifolia, Litsea salicifolia, Myrica esculenta, Lithocarpus dealbata, Rhododendron arboreum*, etc.

iv. Bamboo forests:

Bamboos usually grow as an under-storey to the tree species in tropical evergreen and sub-tropical mixed-deciduous forests, whereas *Melocanna baccifera* forms dense or pure forests in certain areas in the State. Large tracts of bamboos are seen throughout Mizoram but their distribution is somewhat restricted to about 1,600m and below. They occur mostly between 40m and 1,520m in tropical and sub-tropical areas. Few species occur in temperature areas in Blue Mountain and Mount

Chalfilh. It appears that bamboos have resulted from jhumming system of cultivation (Deb and Dutta, 1987). For practicing jhum cultivation the forests are burnt and tree species are destroyed but the bamboo rhizomes throw out new culms as soon as favourable temperature and seasonal monsoon arrive. Therefore, in abandoned jhumland they are the first colonizer and grow rapidly. Some important associates found growing along with bamboos are *Emblica officinalis, Litsea monopetala, Pterospermum acerifolium, Terminalia myriocarpa, Caryota mitis, Artocartus chama, Duabanga grandiflora, Albizia procera, Gmelina arborea, Syzygium species* (Singh *et al.*,2002).

v. Quercus forests:

These forests are mostly found intermingled in sub-tropical and temperate areas. Pure patches or predominate *Quercus griffithiana* is present near Champhai-Baite hill ranges and its distribution is restricted to other small areas in the eastern part of Mizoram. *Lithocarpus dealbata* is another main species (Singh *et al.*, 2002).

vi. Jhumland:

Jhumlands are very common in Mizoram. They are classified variously as current jhumland, old jhumland and abandoned jhumland. Jhumlands are more prevalent in eastern Mizoram where extensive and intensive jhumming is practiced. Similarly, the areas in western side in Lunglei district towards Bangladesh have also Jhumlands.

On the basis of the abstract of Champion and Seth (1968) the forests of Mizoram have been broadly divided into three categories :

i) Tropical Wet Evergreen Forest

ii) Tropical Semi-Evergreen Forest

iii) Montane Sub- tropical Pine Forest

3.2 Reiek forest

The Reiek forest area is selected for the study area as it has a unique ecosystems and rich biodiversity. It is one of the most attractive epicenters of ecotourism and is easily accessible by road from Aizawl. It is located within Reiek forest range of Aizawl Forest Division.

The area lies between longitude $92^0$37' and $93^0$28'E and latitude $20^0$45' and $22^0$46'N. Reiek village is about 25km away from Aizawl to the west after crossing Tlawng River, the longest river in Mizoram. The area to be selected is about 1000 ha. and surrounded by cliffs on all sides except the northern aspect. The east and west precipices meet at Reiek peak which is 1485 m.s.m. The villages of Reiek and Ailawng are situated in the buffer zone

The Reiek forest had been protected and conserved by the descendants of Sailo Chiefs, particularly Mr.Lalluaia, since the 1890's. The Village Chief prohibited the killing of animals and plants in the forest and introduces whether intentionally or unintentionally, the modern concept of biodiversity conservation a century ago. The forest is believed to be endowed with rich biodiversity although no records have yet been made. But due to increasing land pressure, the forests are depleting and need to be protected and conserved.

Boundary description of Reiek forest

North : The northern boundary starts from the end of YMCA land, the buffer zone goes eastward and meet at Aizawl-Reiek road along the jurisdiction of the Village Supply Reserved Forest.

East : The Eastern boundary starts from the point of Aizawl-Reiek road following the juncture of village supply reserve and gradually deflects eastward and meet at the eastern cliff upto the source of Tuisen Lui (stream)

South : The Southern boundary follows the edge of cliff until it meets with W.Lungdar road at the saddle point

LOCATION MAP OF THE STUDY AREA

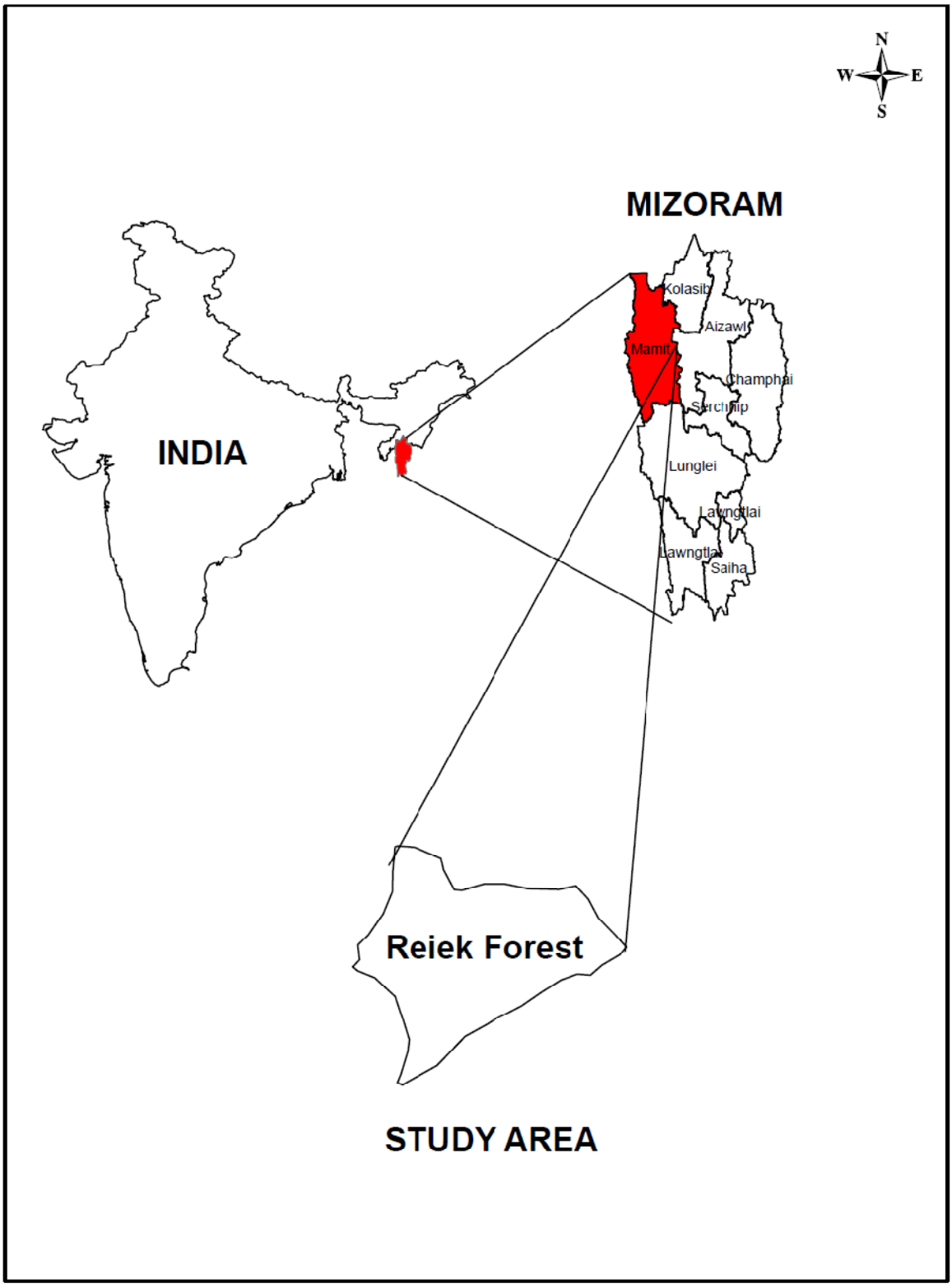


Fig. 3.1

BOUNDARY MAP OF REIEK FOREST

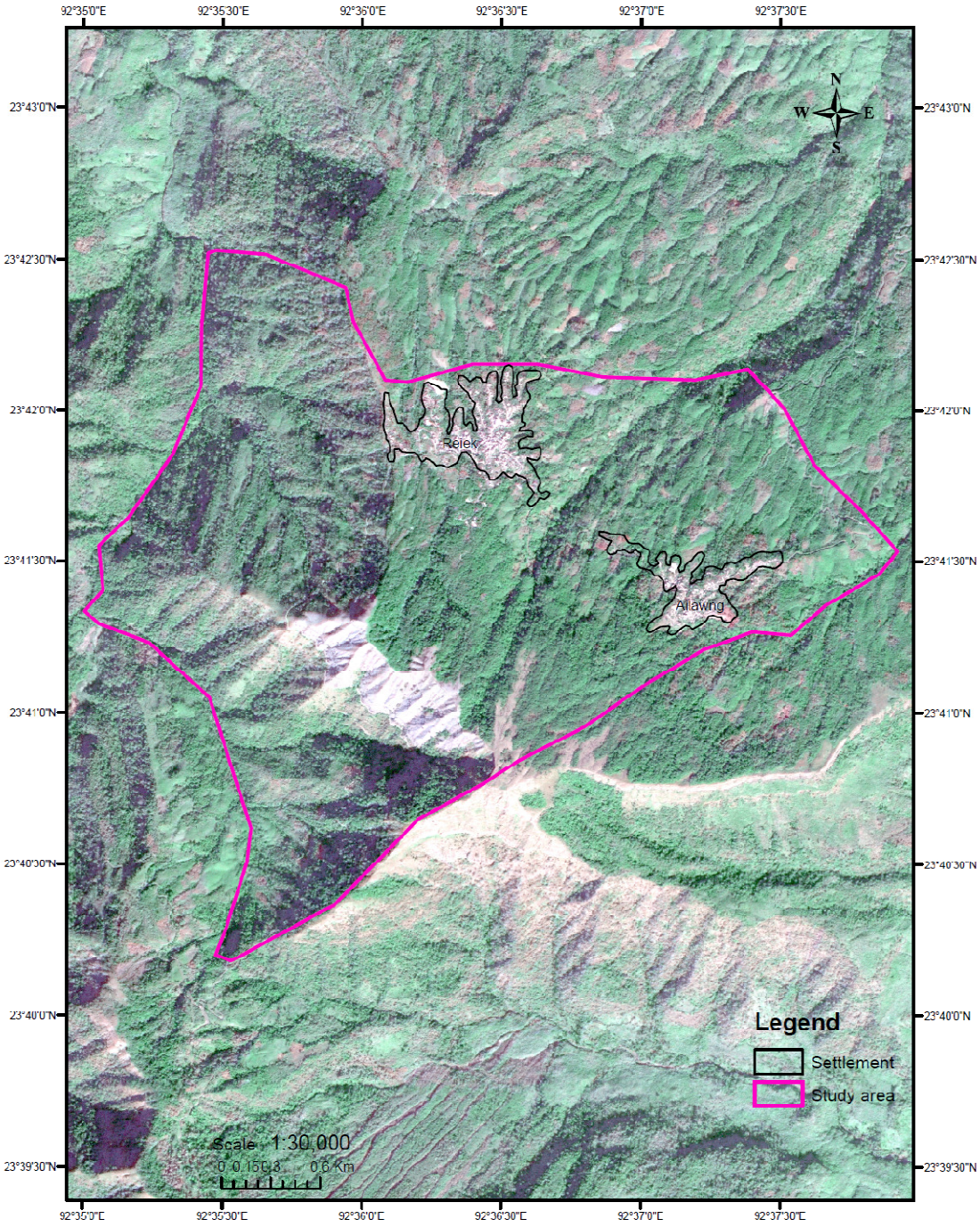


Fig. 3.2

West : The Western boundary follows W.Lungdar-Reiek road and encompass soil and water conservation land and meet at the starting point of YMCA land.

3.2.1 Climate

The climate of Mizoram as a whole is controlled by its location, physiographic, pressure regime in the North West India and Bay of Bengal, warm and moist maritime tropical air masses from the Bay of Bengal, Local Mountain and valley winds. In addition, the Chin Hills, Arakan Yoma Hill tracts and Chittagong hill tracts also play an important role in shaping the climatic condition of the state. It is a tropical monsoon type of climate so Reiek forest which is located in Mamit district to the west enjoys moderate climate.

The climatic condition is very pleasant and the temperature varies from 8^0C - 22^0C in winter and 20^0C - 28^0C in summer. Rainfall is heavy, the recorded rainfall during 1997 was 2673mm.

3.2.2 Season

There are four different types of season in the area Reiek forest falls under which are as follows :

i) Winter season: Winter season starts from the end of November to the first half of February. It is the coldest season of the year. There may be a little rain brought by the North-east monsoon known as the 'retreating monsoon' but it is drier compared to the other seasons.

ii) Spring season: Spring is the shortest season of the year. It starts from the second half of February to the first half of March. Temperature is mild during this period and the sky is clear. It is probably the best season in Mizoram.

iii) Summer season/ Rainy season: This is the longest season covering about seven months starting from the second half of March till the first half of October. The

early part of this season i.e form the second half of March till First half of May is characterised by bright sunshine and clear sky with little or no cloud till it is disrupted by the coming of Monsoon showers. The months of July, August and September are the warmest months for the whole year but the excruciating temperature condition is quashed by the occurrence of the usual monsoon rains and yet maximum isolation is receive during the early part of this season i.e., April and May. The heavy outpour subsides in the first quarter of October.

iv) Autumn season : This season starts from the second part of October to November. This is the most awaited season of the Mizos as their jobs in the paddy fields are done by this time. The temperature is mild and the summer rain have subsided.

3.2.3 Vegetation

The vegetation falls under tropical semi-evergreen forest or sub-tropical evergreen forest. The areas lying adjacent to Reiek and Ailawng villages are secondary forest and the thick forest in the middle portion is dense primary teepes and the peak is montane sub-tropical scrub type dominated by a mixture of grasses and shrubberies.

3.2.4 Geology and Soil

The soil is composed of silt-loam in the upper portion and stone plates in the peak region and the rest of the area are mostly sandy-loam to black humus top-soils depending on thickness of the vegetation and nature of landscape. Sedimentary rock and stone plates are generally found along the river courses. The stone plates or exposed rock in the upper portion is medium grain sandstone, grey brown in color. (Sailo and Lalmuankimi, 2011)

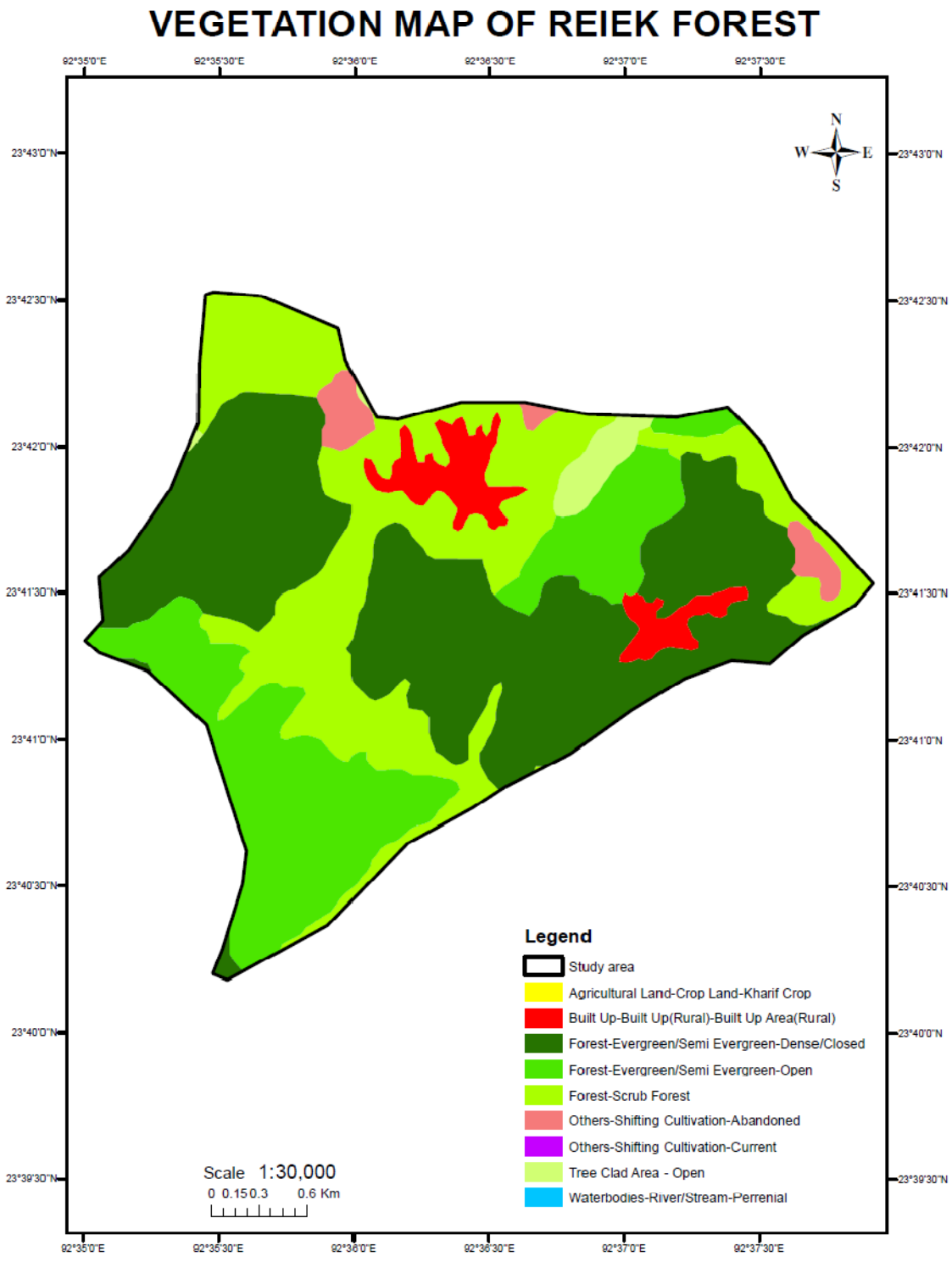

VEGETATION MAP OF REIEK FOREST
92°35'0"E
92°35'30"E
92°36'0"E
92°36'30"E
92°37'0"E
92°37'30"E
23°43'0"N
23°42'30"N
23°42'0"N
23°41'30"N
23°41'0"N
23°40'30"N
23°40'0"N
23°39'30"N
N
W
E
S
Legend
Study area
Agricultural Land-Crop Land-Kharif Crop
Built Up-Built Up(Rural)-Built Up Area(Rural)
Forest-Evergreen/Semi Evergreen-Dense/Closed
Forest-Evergreen/Semi Evergreen-Open
Forest-Scrub Forest
Others-Shifting Cultivation-Abandoned
Others-Shifting Cultivation-Current
Tree Clad Area - Open
Waterbodies-River/Stream-Perrenial
Scale 1:30,000
0 0.15 0.3 0.6 Km

Fig. 3.3

3.2.5 Drainage

All the rivers flow in South-North direction. To the west, on the upper portion of the forest, we find the Tan Lui. Tan Lui joins Dialdawk Lui near ‘Lengte kai’ where it is known as Dialdawk Lui and flows into Tlawng river. Other rivers found in the study area moving from west to east are Khuai Lui, Lungsen Lui, Hranghluanavau Lui, Saikai Lui, Pu Kula Lui, Tuisen Lui and Lunghmul Lui. Saikai Lui have two tributaries namely Diphur kai and Sehpui kai. All these streams are small and ultimately flow into the Tlawng river.

DRAINAGE MAP OF REIEK FOREST

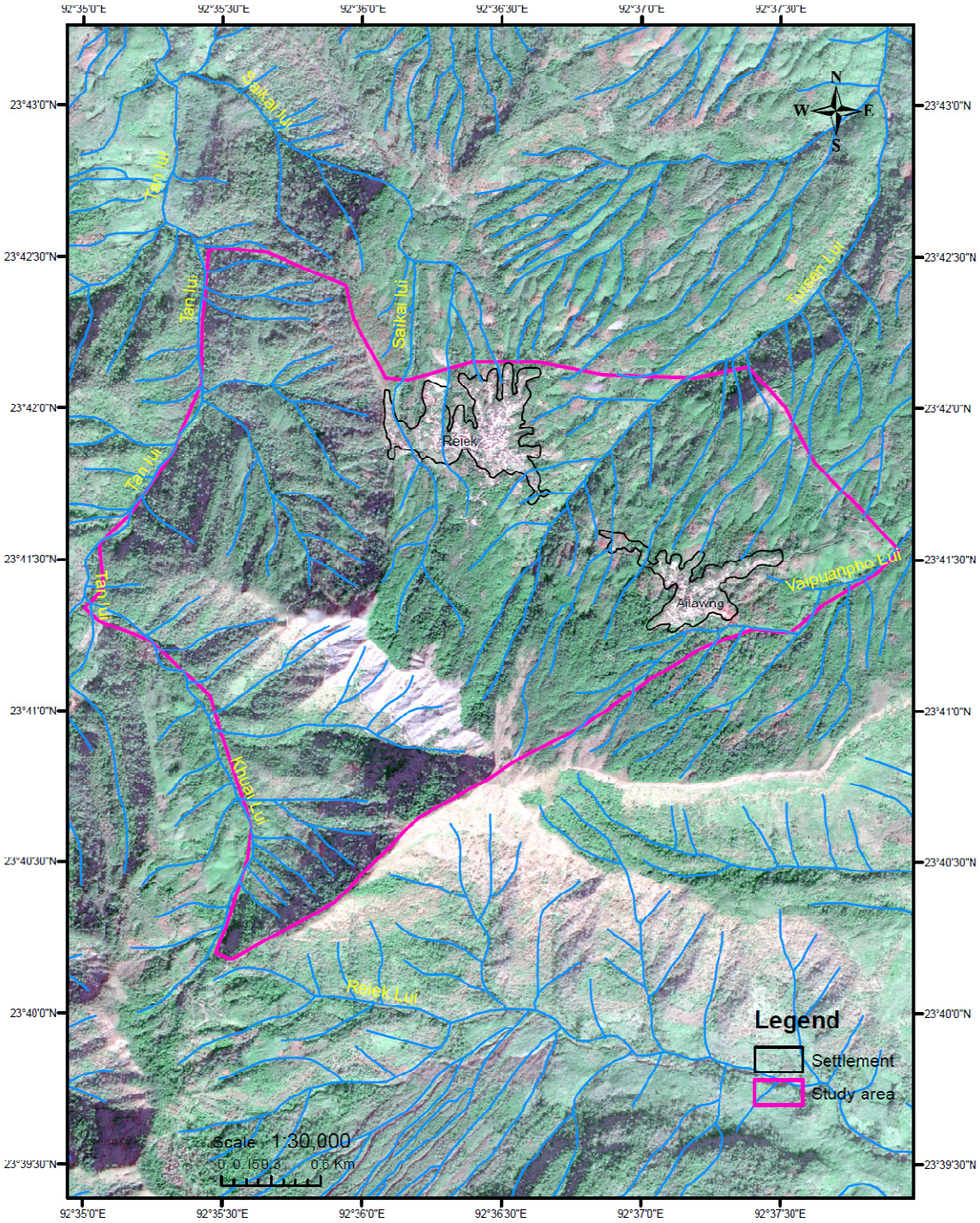


Fig.3.4

CHAPTER-4

CHAPTER- 4

METHODOLOGY

4.1. Demarcation of the study area

The research work was started in November, 2008.: The initial stage of the research work consisted mainly of studying the site i.e Reiek forest and demarcation of the forest into three ecological zones namely the core zone, buffer zone and grassland:-

a) Core zone: The first zone is the Core zone consisting of thick forest areas which are relatively undisturbed. This type of forest is found in the middle portion of the forest.

b) Buffer zone: The buffer zone consists of the forest adjacent to Reiek village and Ailawng village which are mostly secondary forests.

c) Grassland: At the highest elevations, forest disappears and is replaced with mostly grasses and shrubs. This is the grassland zone found near and at the peak of reiek forest

4.2. Socio-economic survey

Socio economic survey is a systematic appraisal of the impacts on a day-to-day quality of life of the local people/communities when the environment is affected by the development or a policy change. Socio-economic survey of the adjacent villages of the study area was carried out by adopting PRA technique.

Participatory Rural Appraisal (PRA) describes a growing family of approaches and methods to enable local people to share, enhance and analyze their knowledge of life and conditions, to plan and to act (Chambers,1994)It is a means of collecting different kind of data, identifying and mobilising intended groups and evoking their participation and also opening ways in which intended groups can participate in

Plate 1

Plate 1 a : Core zone of Reiek forest

Plate 1b : Buffer zone of Reiek forest

Plate 1c : Buffer zone of Reiek forest

Plate 2

Plate 2a : Grassland zone of Reiek forest

Plate 2b : Stone plate in grassland zone of Reiek forest

decision making, project design, execution and monitoring (Mukherjee, 1993).It is a useful methodology to focus attention on people, their livelihoods and inter-relationships with socio-economic and ecological factors (Mukherjee, 1993).

There are several methods of PRA techniques such as village/social mapping, ranking and scoring, seasonal, diagramming and semi-structured interviews. In the present study, interview method was applied where several local people including the Presidents of the Village Councils were interviewed to get information about the socio-economic conditions of their villages

4.3. Plant community Analysis

4.3.1. Quadrate and belt transect method

To study the vegetation, both trees and herbs, quadrats of 10mX10m size were laid at 1km intervals along a transect line in both the core zone and buffer zone for the study of woody species. In these quadrats, diameter at breast height (dbh) of trees were measured and recorded. Within each of these quadrats, 1m X1m quadrats of five in number were taken randomly for herbs. However in the grassland zone, due to the absence of woody species 1m X1m quadrats were taken randomly. The field data was taken into consideration for determining frequency, density, abundance and basal area, the importance value index will be computed for the assessment of plant diversity. The relative values of frequency, density anddominance were determined following Phillips (1959) and the importance value index IVI of individual species was worked out (Curtis, 1959). The diversity index was computed using Shannon-Weiner in formation index (Shannon and Weiner, 1963), concentration of dominance was computed by Simpson's index (Simpson, 1949), species evenness was computed using Pielou's evenness index (Pielou, 1975) and species richness was calculated by adopting Whittaker's α diversity (Whittaker, 1975).

4.3.2. Quantitative analysis

Each community is characterised by its species diversity, growth forms and structure, dominance, successional trend, etc. To study the details of these aspects of any community, a number of characters are taken into consideration.They are then used to express the characteristics of a community. The quantitative characters viz frequency, density and abundance are computed using the following formula

i) Frequency : It refers to the degree of dispersion of individual species in an area and expressed in terms of percentage. It is the number of quadrates in which species occur. It can be calculated by using the formula :

$$\text{Frequency}(\%) = \frac{\text{Number of quadrates in which species occur}}{\text{Total number of quadrates sampled}} \times 100$$

ii) Density : Density is the numerical strength of a species in a community. It is the number of individuals of the species in any unit area. It is calculated by using the following formula

$$\text{Density} = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Total number of quadrates sampled}} \times 100$$

iii) Abundance : This is the number of individuals of any species per quadrates of occurrence. It is calculated using the following formula :

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

4.3.3. Importance Value Index (IVI)

This method yield three quantitative parameters- density, basal area and frequency. In order to express the dominance and ecological success of any species, with a single value, the concept of the importance value index has been used. This index utilizes three characters viz, relative frequency, relative density and relative dominance (Misra, 1968)

The relative value will be measured by the following formulae.

a) Relative frequency = $\frac{\text{No. of occurrence of species}}{\text{No. of occurrence of all species}} \times 100$

b) Relative density = $\frac{\text{No. of individual species}}{\text{No. of individual of all species}} \times 100$

c) Relative dominance = $\frac{\text{Total basal area of species}}{\text{Total basal area of all species}} \times 100$

d) Basal cover = $\frac{(cbh)^2}{4\pi}$

IVI = Relative Frequency + Relative Density + Relative Dominance

We can convert the values of the diameter(cm) at breast height (dbh) (1.5 m above the ground) to basal area (sq.cm) through the following relation :

Average basal area = $\pi r2$

Where $r = \frac{\text{average diameter}}{2}$

4.3.4. Biodiversity Indices

The following biodiversity indices will be employed for the assessment of plant diversity :

i) Species Diversity

Shannon –Wiener diversity index(Shannon, 1949)

$H = -\Sigma (ni / N) \ln(ni / N)$

Where,

ni = Number of individuals of each species in the sample

N = Total number of individuals

ii) Species evenness

Pielou's evenness index (1975)

$E = H'/\ln S$

where,

H' = Shannon's index value

S = Total number of species

iii) Species dominance

Simpson's index of dominance(D)(Simpson, 1949)

$$D = \Sigma \frac{(ni(ni-1))}{(N(N-1))}$$

where,

ni = Number of individuals in the i^{th} species,

N = Total Number of individuals

iv) Species richness

Margalef's index of species richness (1972)

$$D_{mg} = (S-1) / \ln N$$

where,

S = Number of Species

N= Number of individuals

4.4. Profile diagram and stratification

Distinguised stratification or layers of the floristic components was carried out by drawing out profile diagrams. The profile diagram was drawn along belt-transect at 5m x 20m upto 100m depending upon the site.All plants above 5cm dbh were considered for preparing profile diagram. The height of the transect was measured using Abbney level and depending on the tree heights and clearly defined stratifications, different layers of storey was depicted and presented.

4.5. Herbarium Methodology

A herbarium is a store-house of plant specimens collected from far and wide, mounted on appropriate sheets, arranged according to some known system of classification, and kept in pegion-holes of steel or wooden cupboards, usually specially prepared for the purpose (Jain and Rao, 1987). Collected plants specimens will be mounted on herbarium sheets for identification by following the works of Jain

and Rao (1987) and Womersley (1981).The steps followed in the preparation of herbarium are as follows:

a) Collection of plants : According to Jain and Rao(1987) plants should be collected which contain at least flowers or fruits or preferably both . At least three specimen of each plant was collected. In case of grasses, sedges and other herbs, the whole plant including the underground part is collected.

b) Field notes : Field note books are specially prepared note books for labelling the plants and for recording notes about them in the field. The pages of these notebooks are specially printed, punched and perforated according to an almost uniform pattern. One book has hundred leaves, the pages are serially numbered, first book having 1-100, second book 101-200 and so on. The four tags or tickets on each page have the same number; these are detachable on lines of perforation and can be tied to the specimen with the thread provided in the punched hole of each tag. Thus each page has same number marked at five places, one on the page itself and four on the tags. These tags are for duplicates of same species. Detailed notes are entered in the field note book at the time of collection in the field itself which are the vernicular name of the plant, the locality, habitat, description of the plant in brief such as the habit, colour of flowers, fruits, leaves, pubescence, presence of aroma and latex and lastly, the collector's name.

c) Poisoning and preservation of specimens : To prevent the formation of absission layer, poisoning is done in the field immediately after collection. The collection is spread out in in ordinary newspaper and bundled up, each bundle is then placed in a large polythene bag. 10% formalin is poured over the bundles, so that the bundles get soaked thoroughly. Bags are then tied airtight. On reaching the laboratory, the bundles are opened out; the specimens are exposed to the atmosphere to drive away the excess of formalin fumes. Then the specimens are spread out for pressing and drying.

d) Pressing and Drying of specimens : The main objective of pressing is to flatten and dry the specimens while preserving the morphological integrity of the plant and to yield material that can be readily mounted on herbarium paper for long storage. A plant press is used for this purpose which consists of a wooden frame for rigidity, corrugated cardboard ventilators to allow air to flow through the press, blotter paper to absorb moisture and folded newspaper to contain the plant material. In order to fit on a standard herbarium sheet, plant specimens were pressed flat to no more than 11 X 16 inches. If the specimen cannot fit to those dimensions, it was folded like 'V', 'N', 'M' or 'W' or cut into sections. Large fruits or bulbs are cut in half lengthwise or in slices prior to pressing. Each specimen consists of a stem with attached leaves, flowers or fruits. The roots of herbaceous plants were also included. Plant specimens were carefully arranged while they are placed in the press to maximise preservation of diagnostic features. Leaves, flowers and fruits are spread out so that they do not overlap and can be observed from different perspectives. The process of drying is sometimes hastened by placing the press in sun or in drying chambers. When plants are completely dry, they are removed from the press and placed in ordinary newspapers.

e) Fumigation: This is done to kill pest in mounted as well as unmounted duplicate specimens. Specimens were sprayed with a solution of 2% mercuric chloride in 95% alcohol and the specimens were dried in the sun or in an oven by heating at 110^0F. Naphthalene balls were used to prevent damage by insects which were kept in boxes containing mounted specimens.

f) Mounting and Stitching: After fumigation, specimens were mounted on mounting sheets using glue. This is to provide physical support that allows the specimen to be handled and stored with minimum of damage. Mounting sheets are made from heavy long-lasting white card sheet in uniform size of 28X42 cm. Before gluing, the specimen and its label are laid out on the paper to allow maximum observation of

diagnostic features as well as the range of variation in vegetative structures, including both sides of the leaves. Plants are positioned in a lifelike arrangement, with the roots or lower stem toward the bottom of the sheet and flowers toward the top. The specimen is then glued to the mounting paper and kept in press for one day for proper sticking and drying. Large or bulky items were sewn onto the sheet with a sturdy thread to secure the specimen firmly to the mounting paper.

g) Labelling : A herbarium label is prepared which is about 8 X 12 cm in size. The label is fixed on the bottom right hand corner about 1cm away from the edges of the mounting sheet using paste or glue. The label contains the following data

1. Name of the family
2. Name of the genus and species
3. Locality of collection
4. Date of collection and collection number
5. Phenology and distribution
6. Description/remarks/notes
7. Collectors name

4.6. Plant Identification

The plant specimens collected were identified with the help of regional flora, including the books of “Flora of British India Vol 1-7” (Hooker, 1872-1897), “Flora of Assam Vol 1-5” (Kanjilal *et al .,* 1934-1940), “Flora of Mizoram Vol 1” (Singh *et al.,*2002), “A Handbook of Common trees of Mizoram”(Lalramnghinglova, 1997), “Ethno-Medicinal Plants of Mizoram”(Lalramnghinglova, 2003) and “The book of Mizoram Plants” (Sawmliana, 2003). Unidentified specimens were taken to the Botanical Survey of India, Eastern Circle, Shillong, Meghalaya for proper identification and matching of the specimens.

4.7. Screening of rare or threatened species

Screening of rare or threatened species will be done with the help of biodiversity indices, IVI and IUCN criteria, Red Data book of India(Nayar and Sastry, 1987-1990)

4.8. Life form diversity

Plant species were grouped into different life forms on the basis of criteria outlined by Raunkiers (1934) and the life form spectrum has been presented in the form of a graph.

CHAPTER-5

CHAPTER-5

RESULTS AND DISCUSSION

5.1. Diversity of taxa

5.1.1 Family

A total of 92 families were recorded within the study area. Of these, there were 84 families of angiosperms (95.76%), 2 family of gymnosperms (0.71%) and 6 families of pteridophytes(3.53%). The 95.76 % of angiosperms found is comparable to that the findings of Khan *et al.* (1997) who reported that angiosperms constitute about 94% of the total plant species of Meghalaya. Similar values have been reported in Jaintia hills (Jamir and Pandey, 2003)The 48 families of trees encountered within the study site is low compared to the richest tropical forests such as the 91 families reported by Lieberman *et al*. (1996) in Costa Rica, 103 families reported by Vazquezg *et al*. (1998) in tropical Mexico, and Williams *et al*. (1994) reported peak family richness in Cambodia, which has about 54% of the world's total number of families.

The dicotyledons comprised of 72 families and the monocotyledons comprised of 12 families So out of the total angiosperm families, dicotyledons represented 85.71% while monocotyledons represented only 14.29 %. The distribution of monocots and dicots is given in **Table 5.1**. and **Fig 5.2.** The ratio of monocotyledons to dicotyledons was 1:6 for families

The five families with the highest diversity of species (dominant families) although accounting for only 5.43% of total families represented 28.27% of the total species and 26% of genera **(Table 5.6).** The most species rich family wasOrchidaceae (23 species) followed by Poaceae (21 species), Arecaceae (14 species), Rubiaceae (12 species) andAsteraceae (10 species). In contrast to the dominant families, 42 families were represented by only one species each.

In the core zone, there were 80 families present which were distributed as 74 families of angiosperms, 2 family of gymnosperm and 4 families of Pteridophyta. **(Table 5.2)** Among the angiosperms, 62 families were dicotyledons while 12 families were monocotyledons. The most dominant family was Orchidaceae with 22 species and 13 genera. It was followed by Arecaceae with 15 species and 9 genera, Rubiaceae with 12 species and 12 genera and Poaceae with 11 species and 9 genera.

In the buffer zone, there were 74 families present which were distributed as 69 families of angiosperms, 1 family of gymnosperm and 5 families of Pteridophyta. Among the angiosperms, 58 families were dicotyledons while 11 families were monocotyledons. **(Table 5.3)** The most dominant family was Orchidaceae with 19 species and 12 genera, followed by Poaceae with 13species and 11 genera, Lauraceae with 10 species and 7 genera and Arecaceaewith 12 species and 9 genera. A similar trend was observed in the tropical evergreen forest of Tawi wildlife sanctuary in Aizawl district of Mizoram where the families in order of dominance are Orchidaceae, Poaceae, Lauraceae, and Arecaceae (Lallawmkimi, 2011).

In the grassland zone, there were 26 families present which were distributed 24 families of angiosperms and 2 families of Pteridophyta. Among the angiosperms, 20 families were dicotyledons while 4 families were monocotyledons. **(Table 5.4)** The most dominant family was Poaceae with 10 genera and 10 species. This was followed by Asteraceae with 7 genera and 7 species, Cyperaceae with 5 genera and 5 species and Liliaceae with 3 families and 3 species.

5.1.2 .Genera

Plant diversity of Reiek forest was also reflected at the level of genera. A total of 230 genera were recorded within the study area. Out of this, 220 were angiosperms, 2 were gymnosperms and 8 were pteridophytes. Among the

angiosperms, the dicotyledons comprised of 167 genera (75.91%) while the monocotyledons comprised of 53 genera (24.09%) (**Table 5.1**and **Fig 5.2.**) The ratio of monocotyledons to dicotyledons was 1:3.2 for genera..

Within the core zone of the forest,174 genera were found out of which 165 genera were angiosperms, 2 were gymnosperms and 7 were pteridophytes. Out of the angiosperms, 126 genera were dicotyledons while 39 were monocotyledons. **(Table 5.2)**

Within the buffer zone of the forest, 168 genera were found out of which 160 genera were angiosperms, 1 was gymnosperms and 7 were pteridophytes. Out of the angiosperms, 121 genera were dicotyledons while 39 were monocotyledons **(Table 5.3)**.

Within the grassland zone of the forest, 50 genera were found out of which 48 genera were angiosperms and 2 were pteridophytes. Out of the angiosperms,19 genera were dicotyledons while 19 were monocotyledons.**(Table 5.4)**

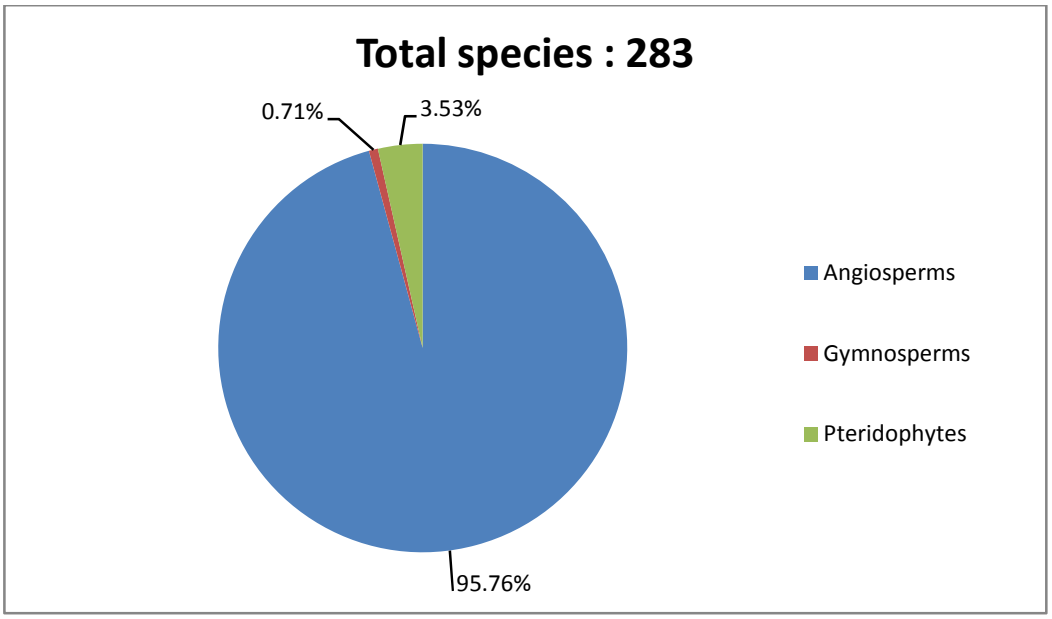
The ratio of genera to species was 1:1.17 which means that almost any one of the species of this site belongs to a different genus . Although this is low when compared to the ratio 1:7 given by Hooker (1904) for whole of India, it is the same as that of Mexican dry tropical forest (Trejo and Drizo, 2002)

5.1.3. Species

A total of 283 plant species were recorded within the study area. The percentage distribution of species is given in **Fig. 5.1**. This was quite high compared to reports by other workers in different tropical forest (Fox *et al*., 1997 (94 species); Mekail *et al.,*1997 (148 species), Kadavul & Parthasarathy, 1999 (89 species); Khera*et al*., 2001 (92 species); Devi & Yadava,.2006(123 species)) . It was comparable to the 200 species reported from tropical wet evergreen forest in and around Namdapha National Park, Northeast India (Nath *et al.,*2005) and 244 species

reported from humid tropical forest in western ghats of Tamil Nadu, India(Swamy *et al*., 2000) and lower than 395 species reported from the sacred groves of Jaintia Hills in northeast India(Jamir and Pandey, 2003)

Fig. 5.1. : Percentage distribution of species in Reiek forest



Out of the total 283 plant species, 271 species were angiosperms , 2 were gymnosperms and 10 were pteridophytes. Among the angiosperms, the dicotyledons comprised of 201 species and the monocotyledons 70 species such that dicotyledons represented 74.17% while monocots represented 25.83%. **(Table 5.1**and **Fig 5.2.).** The ratio of monocotyledons to dicotyledons was 1:2.9 for species.

Within the core zone of the forest, 217 species were recorded out of which 207 were angiosperms, 2 were gymnosperms and 8 were pteridophytes. Out of the angiosperms, 155 species were dicotyledons while 52 species were monocotyledons **(Table 5.2).**

In buffer zone of the forest, 183 species were identified out of which 195 were angiosperms, 1 was gymnosperms and 7 were pteridophytes. Out of the angiosperms, 144 genera were dicotyledons while 51 were monocotyledons**(Table 5.3).**

A total of 51 species were recorded in the grassland out of which 49 were angiosperms and 2 were pteridophytes. Out of the angiosperms, 30 species were dicotyledons while 19 species were monocotyledons**(Table 5.4).**

Of the total 283 plant species recorded, there are 103 species of trees which accounts for 36.4%, 33 species of shrubs accounting for 11.66%, 59 species of herbs accounting for 20.85%, 27 species of climbers/lianas accounting for 9.54%, 15 species of canes and palms accounting for 5.3%, 21 species of grasses accounting for 7.82% and 23 species of epiphytes accounting for 8.13%.

Fig 5.2 Distribution of families, genera and species under dicots and monocots

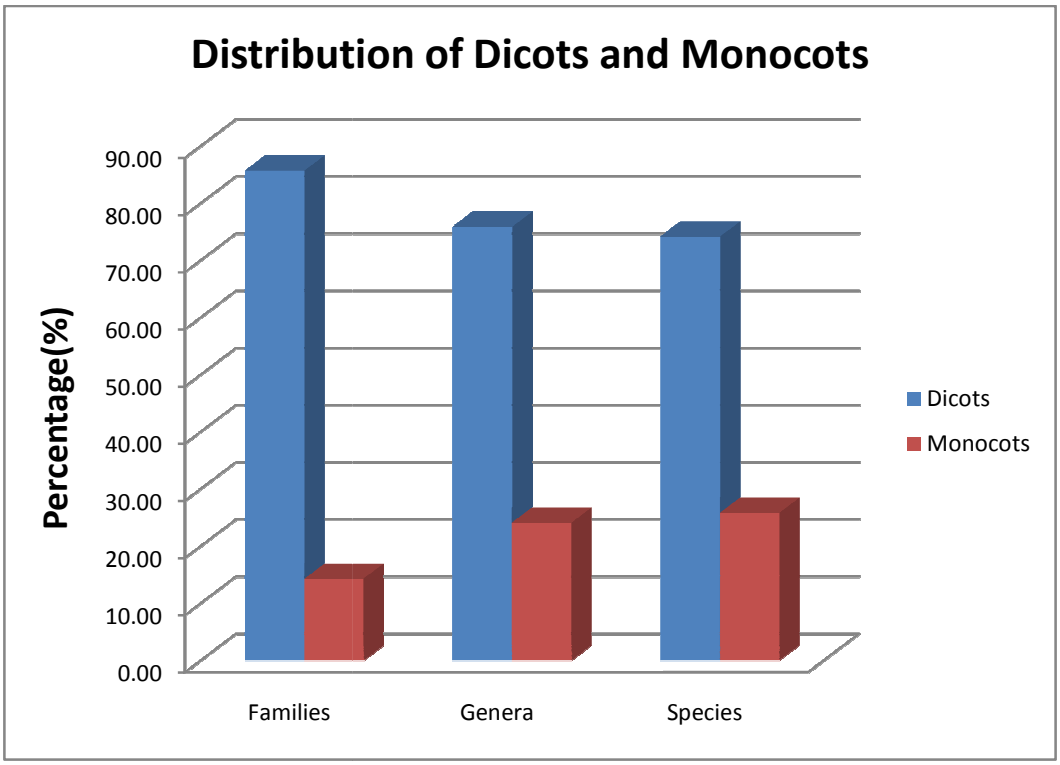


Table 5.1Diversity of taxa in Reiek forest

Categories	Angiosperms					Gymnosperms	Pteridophytes	Total
	Dicots	%	Monocots	%	Total			
Family	72	85.71	12	14.29	84	2	6	92
Genera	167	75.91	53	24.09	220	2	8	230
Species	201	74.17	70	25.83	271	2	10	283

Table 5.2 Taxonomic diversity in the Core zone of Reiek forest

Categories	Angiosperms			Gymnosperms	Pteridophytes	Total
	Dicots	Monocots	Total			
Family	62	12	74	2	4	80
Genera	126	39	165	2	7	174
Species	155	52	207	2	8	217

Table 5.3 Taxonomic diversity in Buffer zone of Reiek forest

Categories	Angiosperms			Gymnosperms	Pteridophytes	Total
	Dicots	Monocots	Total			
Family	58	11	69	1	5	75
Genera	121	39	160	1	7	168
Species	144	51	195	1	7	203

Table 5.4 Taxonomic diversity in Grassland zone of Reiek forest

Categories	Angiosperms			Gymnosperms	Pteridophytes	Total
	Dicots	Monocots	Total			
Family	20	4	24	-	2	26
Genera	19	19	38	-	2	40
Species	30	19	49	-	2	51

Table 5.5 Number of plant families, genera and species in Core, Buffer and Grassland zone of Reiek forest

Zones	Family	Genera	Species
Core zone	80	174	217
Buffer zone	75	168	203
Grassland zone	26	40	51

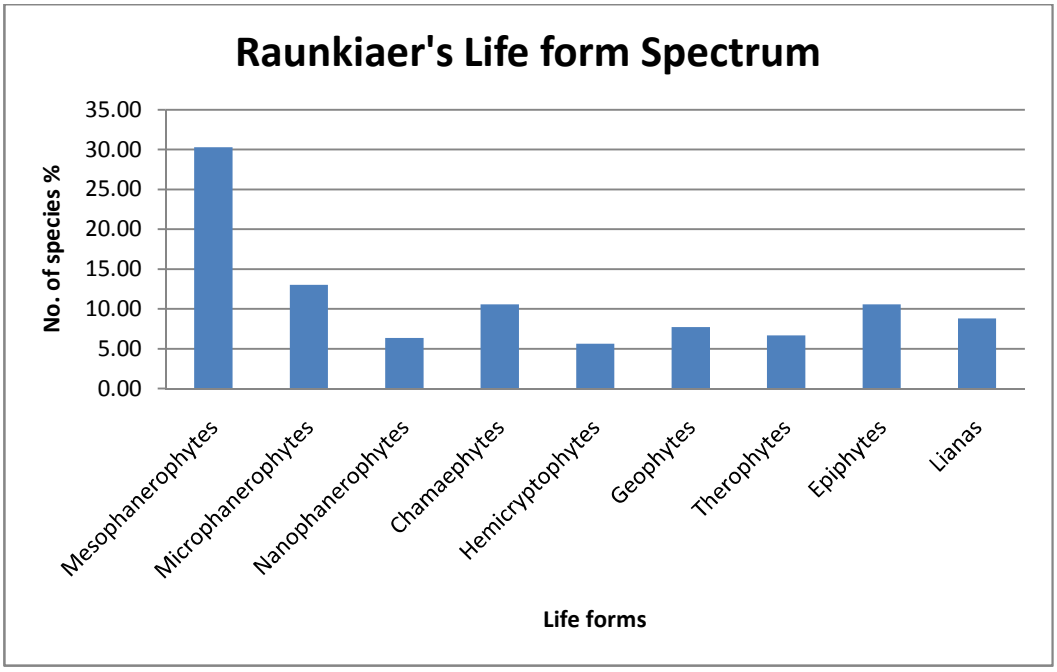
Table: 5.6 Top 5 families ranked according to numbers of species

Name of Family	Species	Percentage of total species
Orchidaceae	23	8.13
Poaceae	21	7.42
Arecaceae	14	4.95
Rubiaceae	12	4.24
Asteraceae	10	3.53
Total	80	28.27

5.2. Diversity of life-form

Life forms of plants in Reiek forest were determined based on the classification of Raunkiaer (1934). All species were classified by life forms (Misra, 1968; Domboise and Ellenberg, 1974) .The existence of a variety of life forms reflects the typically tropical characteristics of the flora of Reiek forest. Phanerophytes were the most dominant life form with about 50% of total plant species in the area. Out of the phanerophytes, Megaphanerophytes i.e trees exceeding 30 m were absent. Mesophenorophytes having 86 species accounted for 30.28% of the total life form, microphenarophytes having 37 species accounted for 13.03%, nanophanerophytes having 18 species accounted for 6.34%, Chamaephytes having 30 species accounted for 10.56%, Hemicryptophytes having 16 species accounted for 5.63%, Cryptophytes or geophytes having 22 species accounted for 7.75 %, Therophytes having 19 species accounted for 6.69% , Epiphytes having 30 species accounted for 10.56% and lianas having 25 species accounted for 8.80% of the total life form**.(Fig 5.3)**

Fig 5.3 Life form spectrum of plants in Reiek forest



The dominance of Phanerophytes is a feature of tropical humid forest life form spectra (Richard, 1996). The life form spectrum of the plant community of Reiek forest reveals that Hemicryptophytes and Therophytes were lower than the normal spectrum of Raunkiaers.According to Cain and Castro (1959) and Shimwell (1971) hemicryptophytes are characteristics of temperate region and therophytes are characteristics of desert climate. The lower percentage of these two life forms can be explained by the tropical moist climate of the study site. According to Cain(1950), therophytes are rare in tropical forest and are found in weed communities and in accordance with this, the therophytes percentage was low in the core region but higher in grassland which was the most disturbed of the three zone. Phanerophytes, Cryptophytes and Epiphytes were higher than normal spectrum while Chamaephytes came the closest to normal spectrum only slightly higher.The abundance of epiphytes is indicative of tropical humid forest as epiphytes are so tightly associated with the wet tropics, that definitions of tropical rain forests frequently include the presence of this growth form (Richards,1952, 1996; Schimper, 1903; Webb, 1959). Lianas are most abundant in tropical forests where the wide array of dimensions, shapes and morphological characters of the trees provides support for them (Clark and Clark 1990). They form an important structural and functional component of tropical rain forests (Hegarty & Caballe 1991).The percentage of lianas was quite high which according to Whitmore (1990) is another characteristic feature of the tropical moist and humid forest.

The percentage of therophyte was highest in the grassland zone where 68% of the therophytes were present. Barucha and Dave (1944) have credited high value of therophytes as indicative of man and animals influence in their study of grassland in Bombay. Cain (1950) attributed it to overgrazing resulting in the introduction and spread of weedy grasses. However in the study site, it may be due to biotic interference which was highest in the grassland zone. The

hemicryptophytes percentage was also higher in the grassland zone probably due to altitudinal changes. Saxena *et al.* (1982) stated that hemicryptophytes increase along the major altitudinal gradient (from tropical to alpine) while the phenerophytes decrease in importance.The distribution of plants according to Raunkiaer's life form classification is given in **(Table 5.7)**

Table 5.7Life form spectrum of Reiek forest

Category	No of species	Percentage of species
Mesophanerophytes	86	30.28
Microphanerophytes	37	13.03
Nanophanerophytes	18	6.34
Chamaephytes	30	10.56
Hemicryptophytes	16	5.63
Geophytes	22	7.75
Therophytes	19	6.69
Epiphytes	30	10.56
Lianas	25	8.80

5.3. Plant community analysis

5.3.1 Plant community analysis of Core zone

Within the core zone, 217 species under 174 genera belonging to 80 families were identified.The trees were represented by 91 species, 72 genera and46 families. Among the family, Euphorbiaciea and Fagaceae had the maximum number of species (7 each). Among the tree species, the most dominant species was *Calophyllum polyanthum* having density of 143 individuals per hectare with an IVI of 30. This was followed by *Syzygium cumini* having density of 186 individuals per hectare with an IVI of 20. The third most dominant species was*Quercus leucotrichophora* having density of97 individuals per hectare with IVI of18. The least dominant species was *Calliandra umbrosa* having density of 1 individual per hectare and IVI of 0 .33. This IVI range of 0.33 – 36 is comparable to the IVI range 0.73-44.67 of tree species in tropical deciduous forest of Eastern Ghats (Sahu *et al.,* 2012) (**Table 5.8)**

Shrubs were represented by 20 species, 20 genera and 15 families. Among the families, Rubiaceae was dominant with 3 species. Among shrub species, the most dominant species was*Mallotus albus* with the highest IVI of 31. This wasfollowed by *Amomum dealbatum* with IVI of 26*, Clerodendrum viscosum* and *Elaeagnus pyriformis* with IVI of 23 each*, Lepisanthes senegalensis*with IVI of 21 and *Toddalia asiatica L.* with IVI of20. The species with the lowest rank was*Mycetia longifolia* with IVI of 5 **(Table 5.9).**

Herbs were represented by 36 species, 30 genera and 22 families. Among the families, Zingziberaceae was dominant with 5 families and 4 genera. The species with the highest rank was*Houttuynia cordata* with IVI of 21, followed by *Rhaphidophora decursiva* and *Ophiorrhiza oppositiflora* with IVI of 19 each and*Diplazium maximum* with IVI of 13 **(Table 5.10)**

Climbers were represented by 20 species, 16 genera and 14 families. Fabaceae was the most dominant family with 4 species followed by Passifloraceae, Rubiaceae and Vitaceae with 2 species each.*Smilax lanceaefolia* had the highest density followed by *Clematis siamensis* and *Mikania micrantha*. The species richness of climbers in core zone was comparable to the 26 species reported by Chittibabu and Parthasarathy (2001) from tropical evergreen forest in Eastern ghat and lower than 39 species reported for tropical dry evergreen forests on the Coromandel coast of South India(Reddy and Parthasarathy). The quantitative analysis of climbers is given in **Table 5.11**.

Epiphytes were represented by 24 species, 15 genera and 4 families, Orchidaceae being the most dominant with 21 species and 12 genera. Among the epiphytes, the species with the highest density was *Dendrobium ochreatum.* Grasses were represented by 11 species and 9 genera and the species with the highest density was*Drepanostachyum intermedium* followed by *Pseudostachyum polymorphum* and *Cephalostachyum latifolium*. Canes and palms were represented by 15 species and 9 genera; the species with highest density was Pandanus *odorifer.* The quantitative analysis of epiphytes, grasses and canes and palms are given in **Table 5.12, 5.13,** and **5.14** respectively

The species diversity was the highest amongst trees (4.03) followed by herbs (3.4) and shrubs (2.95).(**Table 5.23).** The diversity index is usually high in tropical forests, which has been reported as 5.06 and 5.40 for young and old stand respectively (Knight, 1975). However, in Indian forests, the reported value is between 0.83 and 4.1 for tropical forests (Parthasarathy *et al*., 1992; Singh *et al*., 1984; Visalakshi, 1995) and between 1.16 and 3.40 for temperate forest (Braun, 1950; Monk, 1967; Pande *et al*., 1996; Singhal *et al*., 1986). The value of diversity index of the present study, therefore, lies within the range reported for tropical forests. The diversity index for trees was lower than those indices recorded by Singh *et al*.(1981)

which was 4.87 and by Giriraji*et al* .(2008) which was 4.89 from their studies in the tropical forest of Western Ghats but higher than indices recorded by others such as 2.95 recorded by Chandrashekara and Ramakrishnan (1994), 3.37 by Ganesh *et al*. (1996), 2.65 by Sundarapandian and Swamy (2000), 2.8 by Swamy *et al*. (2000), 3.32–3.86 by Didita *et al*.(2010) and lastly 2.939 to 3.957 recorded by Rao *et al*. (2011). The diversity of herb species was comparable to that of dry deciduous forest of Western Ghats (3.06) reported by Anitha *et al*. (2009)

Dominance index i.e Simpsons index of dominance (D) revealed that shrub community had the highest dominance index followed by herbs and trees. For tropical forests the average value of dominance was 0.06 (Knight, 1975). In India, the value of dominance in tropical forest reported ranged from 0.21 to 0.92. The value reported in present study corresponded well with the reported range for tropical forest by several workers (Parthasarthy *et al*., 1992; Visalakshi, 1995).Species diversity (H') and dominance were inversely related with each otherin core zone of the study site which is generally the case in established forests (Zobel *et al.,* 1976)

Pielou's evenness index showed that shrubs were the most evenly distributed among the three communities with E value of 0.97. Herbs had a slightly lower E value of 0.96 while trees had the lowest E value of 0.89. These values weresimilar to the those recorded for Western Himalayas (Gairola *et al*., 2011) and Kumaun Himalaya (Kumar and Ram,2005) but lower than the value for Trikuta Hills of Jammu(Sharma *et al*, 1999)

Margalef's index of species richness revealed that trees had the highest species number $D_{mg}$of 13.28 followed by herbs with D_{mg} of 6.84 and shrubs had the lowest species richness with D_{mg} of 3.47. These values were high compared to those reported for temperate forests of western Himalayas which ranged between 0.38-1.16 (Gairola *et al.,*2011) The indices of diversity for trees, shrubs and herbs of core zone are given in **Table 5.23**

Table 5.8 Density, Frequency, Abundance and IVI of tree species of Core zone

Sl No	Name of Species	Density ha^{-1}	Frequ-ency(%)	Abund ance	IVI	Species Rank
1	*Acer laevigatum* Wall .'Thing-khim'	13.33	13.33	1.00	1.48	49
2	*Acronychia pendunculata*(L.)Mi 'Rah-var'	53.33	33.33	1.60	6.19	11
3	*Aglaia spectabilis* (Miq.)S.S.Jain & S.Bennet. 'Sa-ha-tah'	10.00	6.67	1.50	0.83	68
4	*Alangium chinense* (Lour.) Harms 'Ar-sa-rim-nam'	3.33	3.33	1.00	0.33	87
5	*Alphonsea ventricosa* (Roxb.) Hook. f. & Thomson 'Zawng-bal-hla'	33.33	16.67	2.00	2.25	32
6	*Alseodaphne petiolaris* (Meissn.) Hook. f. 'Bul-pui/Khuang-thulh'	46.67	33.33	1.40	5.14	14
7	*Amoora chittagonga* (Miq.) Hiern 'The-hlei-khak'	13.33	6.67	2.00	1.46	50
8	*Anogeissus acuminata* (Roxb. ex DC.) Guillaumin *et al*. 'Zai-rum'	13.33	3.33	4.00	0.82	69
9	*Betula cylindrostachys* Wall. ex Diels 'Hriang-zau'	3.33	3.33	1.00	0.36	81
10	*Bombax insigne* Wall 'Pang'	6.67	6.67	1.00	0.67	73
11	*Calliandra umbrosa* (Wall.)Benth. 'Seng-ma-tawk'	3.33	3.33	1.00	0.33	91
12	*Calophyllum polyanthum* Wall. ex Choisy 'Sen-te-zel'	143.33	66.67	2.15	29.84	2
13	*Camellia kissi* Wallich 'Lal-lai'	20.00	20.00	1.00	2.02	39
14	*Carallia brachiata* (Lour.) Merr. 'Thei-ria'	30.00	30.00	1.00	3.37	24
15	*Castanopsis echinocarpa* Miq. 'Then-ngo'	43.33	20.00	2.17	3.70	22
16	*Castanopsis indica* (Roxb. ex Lindl.) A.DC. 'Se-hawr'	3.33	3.33	1.00	0.33	89
17	*Castanopsis tribuloides* (Sm.) A.DC. 'Thing-sia'	16.67	10.00	1.67	1.29	57
18	*Cephalotaxus griffithii* Hook. f. 'Tu-far'	23.33	20.00	1.17	2.25	31
19	*Cinnamomum glanduliferum* (Wall.) Meisner 'Khiang-zo'	10.00	10.00	1.00	1.11	62
20	*Cinnamomum verum* J.Presl 'Thak-thing'	26.67	10.00	2.67	1.73	45

21	*Coffea khasiana* (Korth.) Hook.f. 'Ngul-ri-thet'	13.33	10.00	1.33	1.10	64
22	*Colona floribunda* (Wall. ex Kurz) Craib 'Hnah-thap'	13.33	6.67	2.00	0.89	67
23	*Croton hookeri* Veitch 'Ba-ken-fung'	43.33	30.00	1.44	3.75	21
24	*Cycas pectinata* Buch.-Ham 'Kawk-pui'	16.67	13.33	1.25	1.44	53
25	*Diospyros lancifolia* Wallich ex Hiern 'Zo-thing-hang'	120.00	36.67	3.27	8.67	8
26	*Drimycarpus racemosus* (Roxb.) Hook.f 'Vawm-bal'.	46.67	30.00	1.56	3.80	20
27	*Dysoxylum gobara* (Buch.-Ham.) Merr. 'Thing-thu-pui'	20.00	16.67	1.20	1.78	44
28	*Elaeocarpus floribundus* Blume 'Thing-lung'	20.00	16.67	1.20	1.85	42
29	*Elaeocarpus rogusus* Roxb. 'Thei-kel-ek'	33.33	30.00	1.11	3.34	25
30	*Elaeocarpus tectorius* (Lour.) Poir. 'Um-khal'	10.00	10.00	1.00	1.16	59
31	*Embelia tsjeriam-cottam* A.DC. 'Rah-sen'	13.33	10.00	1.33	1.11	61
32	*Engelhardtia roxburghiana* Wall. 'Phek-phe'	3.33	3.33	1.00	0.33	83
33	*Engelhardtia spicata* Leschen, ex. Blume 'Hnum'	20.00	10.00	2.00	2.21	35
34	*Eriobotrya bengalensis* (Roxb.) Hook. f. 'Nghal-chhun'	20.00	6.00	1.00	2.24	34
35	*Eurya cerasifolia* (D.Don) Kobuski 'Si-hneh'	133.33	60.00	2.22	9.20	6
36	*Eurya loquaiana* Dun 'Zo-si-hneh'	16.67	10.00	1.67	1.23	58
37	*Ficus benghalensis* L. 'Bung'	3.33	3.33	1.00	0.33	86
38	*Ficus benjamina* L. 'Za-man-hmawng'	3.33	3.33	1.00	0.39	80
39	*Ficus Prostrata* (Wall. ex Miq.) Miq. 'Thei-tit'	13.33	10.00	1.33	1.10	63
40	*Garcinia xanthochymus* Hook. f. ex T. Anderson 'Tuai-ha-bet'	126.67	50.00	2.53	8.87	7
41	*Glochidion khasicum* (Müll.Arg.) Hook.f. 'Thing-pawn-chhia'	16.67	13.33	1.25	1.53	48
42	*Gynocardia odorata* R. Br. 'Sai-thei'	13.33	13.33	1.00	1.36	54

43	*Helicia erratica* Roxb. 'Sial-hma'	83.33	30.00	2.78	6.31	10
44	*Heteropanax fragrans* (Roxb.)Seem 'Chang-khen'	33.33	23.33	1.43	2.95	27
45	*Holigarna longifolia* Buch.-Ham. ex Roxb 'Vawm-bal-hnah-hlai'	60.00	26.67	2.25	4.92	16
46	*Lithocarpus elegans* (Blume) Hatus. ex Soepadmo 'Thing-pui-thing'	6.67	6.67	1.00	0.66	74
47	*Lithocarpus pachyphyllus* (Kurz) Rehder 'Then-sen'	16.67	13.33	1.25	1.44	52
48	*Litsea lancifolia* Roxb. ex Nees 'Hnah-paw-te'	46.67	23.33	2.00	3.39	23
49	*Macaranga indica* Wight 'Khar-duap'	20.00	10.00	2.00	1.90	41
50	*Macropanax undulatus* (Wall. ex G.Don) Seem. 'Phuan-berh'	10.00	10.00	1.00	1.34	56
51	*Magnolia hodgsonii* (Hook.f. & Thomson) H.Keng 'Thing-tum-bu'	6.67	6.67	1.00	0.69	72
52	*Mallotus philippensis* (Lam.) Müll.Arg. 'Bawng-khei'	23.33	20.00	1.17	2.12	37
53	*Mangifera sylvatica* Roxb. 'Hai-fa-vang'	93.33	73.33	1.27	12.61	5
54	*Memecylon celastrinum* Kurz 'Thei-kawr-ak'	53.33	43.33	1.23	5.32	13
55	*Mesua ferrea* L. 'Herh-se'	3.33	3.33	1.00	0.33	88
56	*Michelia champaca* Linn. 'Ngiau'	3.33	3.33	1.00	0.33	84
57	*Musa sylvestris* LA Colla 'Chang-el'	56.67	6.67	8.50	4.02	19
58	*Neolamarckia cadamba* (Roxb.) Bosser 'Ban-phar'	13.33	10.00	1.33	1.11	60
59	*Olea dioica* Roxb. 'Se-vuak'	140.00	56.67	2.47	13.09	4
60	*Olea salicifolia* Wall.ex G.Don 'Thing-thiang'	73.33	40.00	1.83	5.59	12
61	*Ostodes paniculata* Blume ' Bel-tur'	20.00	13.33	1.50	1.56	47
62	*Persea glaucescens* Nees. 'Sa-per bul'	6.67	6.67	1.00	0.70	71
63	*Persea villosa* (Roxb.) Kosterm. 'Bul-bawr'	46.67	20.00	2.33	3.16	26
64	*Phoebe lanceolata* (Nees) Nees 'Bul-fek'	36.67	13.33	2.75	2.24	33

65	*Pithecolobium bigeminum* (L.) Mart. 'Ar-dah-te'	30.00	20.00	1.50	2.43	29
66	*Premna racemosa* Wall. ex Schauer 'Thing-sa-um'	23.33	16.67	1.40	2.13	36
67	*Prunus jenkinsii* Hook.f. & Thomson 'Kei-pui'	23.33	16.67	1.40	1.90	40
68	*Pterospernum semisagittatum* Buch.-Ham. ex Roxb. 'Mu-khau'	6.67	6.67	1.00	0.70	70
69	*Quercus glauca* Thunb.in A.Murray 'Hrum-hriau'	56.67	23.33	2.43	7.74	9
70	*Quercus leucotrichophora* A.Camus 'Then'	96.67	26.67	3.63	17.16	3
71	*Randia wallichii* Hook.f. 'Sa-phut'	20.00	10.00	2.00	1.70	46
72	*Sapium baccatum* Roxb. 'Thing-vawk-pui'	3.33	3.33	1.00	0.53	78
73	*Saraca asoca* (Roxb.) Willd. 'Mual-hawih'	70.00	36.67	1.91	4.85	17
74	*Schima wallichii* (DC.)Korthals 'Khiang'	23.33	13.33	1.75	1.79	43
75	*Securinega virosa* (Roxb. ex Willd.) Baill. 'Sai-siak'	10.00	3.33	3.00	0.56	77
76	*Stephegyne diversifolia* (Wall. ex G.Don)Brandis 'Pual-eng'	10.00	10.00	1.00	1.01	66
77	*Sterculia hamiltonii* (Kuntze) Adelb. 'Tlingi-leh-ngama inchhawlthuaina'	6.67	6.67	1.00	0.66	75
78	*Sterculia villosa* Roxb. 'Khau-pui'	3.33	3.33	1.00	0.34	82
79	*Stereospermum colais* Buch.-Ham. Ex Dillwyn 'Zih-nghal'	33.33	23.33	1.43	4.06	18
80	*Styrax serrulatum*(Roxb) 'Hmar-hleng'	33.33	13.33	2.50	2.11	38
81	*Syzygium claviflorum* (Roxb.) Wall. ex A.M.Cowan & Cowan 'Hmui-fa-rial'	3.33	3.33	1.00	0.33	85
82	*Syzygium cumini* (L.) Skeels 'Len-hmui'	186.67	70.00	2.67	35.98	1
83	*Syzygium fruticosum* DC. 'Hmui-fang-rawng-bel'	10.00	10.00	1.00	1.35	55
84	*Trema orientalis* (L.) Blume 'Bel-phuar'	3.33	3.33	1.00	0.33	90
85	*Ulmus lanceifolia* Roxb. 'Phan'	30.00	13.33	2.25	2.36	30
86	*Vernonia arborea* Buch.-Ham	46.67	13.33	3.50	2.53	28
87	*Vernonia volkameriaefolia* Bedd	10.00	3.33	3.00	0.60	76

	'Khup-al'					
88	*Vitex quinata* (Lour.) F. N. Williams 'Thleng-reng'	20.00	10.00	2.00	1.45	51
89	*Wendlandia grandis* (Hook.f.) Cowan 'Ba-tling'	6.67	3.33	2.00	0.46	79
90	*Wightia speciosissima* (D. Don) Merr 'Chawng-tlai'	53.33	6.67	8.00	4.97	15
91	*Ziziphus incurva* Roxb. 'Hel'	10.00	10.00	1.00	1.01	65

Table 5.9 Density, Frequency, Abundance and IVI of shrub species of Core zone

Sl No	Name of Species	Density ha^{-1}	Frequency (%)	Abundance	IVI	Rank
1	*Amomum dealbatum* Roxb.	66.67	13.33	5.00	31.88	2
2	*Antidesma diandrum* (Roxb.) B.Heyne ex Roth	8.00	8.00	1.00	5.66	14
3	*Blumea lanceolaria* (Roxb.) Druce	40.00	10.00	4.00	16.74	10
4	*Callicarpa dichotoma* (Lour.) K. Koch	6.00	6.00	1.00	4.21	17
5	*Clerodendrum viscosum* Vent	61.33	13.33	4.60	28.83	3
6	*Disporum cantoniense* (Lour.) Merr.	5.33	5.33	1.00	3.73	18
7	*Elaeagnus pyriformis* Hook.	61.33	13.33	4.60	28.83	4
8	*Lasianthus hookeri* C. B. Clarke ex J. D. Hooker	9.33	9.33	1.00	6.64	12
9	*Leea indica* (Burm.f.) Merr	8.67	8.67	1.00	6.15	13
10	*Lepisanthes senegalensis* (Juss. ex Poir.) Leenh.	56.00	12.67	4.42	25.62	5
11	*Maesa indica* (Roxb.) A. DC	48.00	10.00	4.80	20.28	8
12	*Mallotus albus* (Roxb. ex Jack) Müll.Arg	74.67	16.67	4.48	33.51	1
13	*Murraya koenigii* (L.) Spreng	45.33	11.33	4.00	19.75	9
14	*Mycetia longifolia* (Wall.) Kuntze	4.00	4.00	1.00	2.78	20
15	*Randia fasciculata* (Roxb.) DC.	10.00	8.00	1.25	6.09	11
16	*Rauvolfia densiflora* (Wall.) Benth. ex Hook. f.	7.33	7.33	1.00	5.17	16
17	*Rhamnus nepalensis* M. Laws.	48.00	11.33	4.24	20.98	7
18	*Symplocos lancifolia* Siebold et Zucc.	4.67	4.67	1.00	3.25	19
19	*Tabernaemontana divaricata* (L.) R. Br. ex Roem. & Schult.	8.00	8.00	1.00	5.66	15
20	*Toddalia asiatica* L.	56.00	10.00	5.60	24.23	6

Table 5.10 Density, Frequency, Abundance and IVI of herb species of Core zone

Sl No	Name of Species	Density ha^{-1}	Frequency (%)	Abundance	IVI	Rank
1	*Arisaema speciosum* (Wall.) Mart. 'Tel-hawng'	800	6.67	1.20	8.81	14
2	*Asparagus racemosus* Willd	600	6.00	1.00	6.53	18
3	*Begonia dioica* Buch.-Ham. Ex D.Don 'Sekhupthur'	300	2.67	1.00	2.52	32
4	*Blumea alata*(D.Don) DC *'Buar'*	700	6.67	1.10	8.11	16
5	*Cheilocostus lacerus* (Gagnep.) C.D.Specht	300	2.00	1.33	2.23	35
6	*Chlorophytum khasianum* Hook.f 'Kep'	700	7.33	1.00	8.40	15
7	*Commelina benghalensis* Linn. 'Dawng'	300	9.33	1.07	12.31	8
8	*Conyza stricta* Willd .'Bua-rthar-rang'	300	2.67	1.00	2.52	33
9	*Costus speciosus* (J.König) Sm. 'Sum-bul'	400	3.33	1.20	3.72	26
10	*Curculigo crassifolia* (Baker*)* Hook.*f* *'Phai-phak'*	300	2.67	1.00	2.52	34
11	*Curcuma caesia* Roxb. 'Ailaidum'	900	7.33	1.18	9.84	12
12	*Diplazium dilatatum* Blume	400	3.33	1.20	3.72	27
13	*Diplazium maximum* (D.Don) Chatt 'Cha-kawk'	1100	10.00	1.13	14.34	5
14	*Elatostema dissectum* Wedd.	300	2.67	1.25	2.95	30
15	*Elatostema sesquifolium* (Reinw. ex Blume) Hassk.	400	4.00	1.00	4.01	25
16	*Gleichenia linearis* (Burm.f.)C.B.Clarke 'Arthladawn'	1000	9.33	1.07	12.31	9
17	*Gnaphalium luteo-album* Linn	500	3.33	1.40	4.23	24
18	*Hedychium coccineum* Buch.-Ham. ex Sm. 'Ai-chhia'	900	8.00	1.17	10.91	11
19	*Hedychium villosum* Wall. 'Ai-chhia'	1100	8.00	1.33	12.57	6
20	*Houttuynia cordata* Thunb .'Ui-thin-thang'	1500	13.33	1.15	21.94	2
21	*Kalanchoe integra*(Medik.) Kuntze. 'Kangdamdawi'	300	2.00	1.33	2.23	36
22	*Leucas mollissima* Wall 'Va-te-khawi-zu'	500	4.67	1.14	5.36	23
23	*Lycopodium cernuum* Linn	300	3.33	1.00	3.25	28
24	*Lygodium flexuosum* (Linn.)Swartz	300	3.33	1.00	3.25	29
25	*Mimosa pudica* L. 'Hlonuar'	1100	8.00	1.33	12.57	7
26	*Ophiorrhiza mungos* L.	600	4.67	1.29	5.95	19
27	*Ophiorrhiza oppositiflora* Hook.f. 'Lum-suak'	1400	13.33	1.05	19.75	3

28	*Persicaria hydropiper* (L.) Opiz 'Kel-hmar-cha'	300	2.67	1.25	2.95	31
29	*Phaius mishmensis* (Lindl. & Paxton) Rchb.f.	600	4.67	1.29	5.95	20
30	*Plantago major* Linn 'Kel-ba-an'	800	8.00	1.00	9.39	13
31	*Plectranthus coetsa* Buch.-Ham. ex D. Don	1000	9.33	1.07	12.31	10
32	*Polygonatum oppositifolium* (Wall.) Royle 'Le-len'	500	5.33	1.00	5.65	21
33	*Pronephrium lakhimpurense* (Rosenst.) Holtt.	500	5.33	1.00	5.65	22
34	*Pteridium aguilinum* (Linn.) Kuhn.	700	6.67	1.10	8.11	17
35	*Rhaphidophora decursiva* (Roxb.) Schott 'Tu-bal'	1600	14.00	1.14	23.39	1
36	*Scleria terrestris* (L.) Fass 'Thip-nem'	1400	13.33	1.05	19.75	4

Table 5.11 Density, Frequency, and Abundance of climbers in Core zone

Sl No	Name of Species	Density ha^{-1}	Frequency (%)	Abundance
1	*Acacia oxyphylla* Benth 'Khangngo'	2.67	2.00	1.33
2	*Aganope thyrsiflora* (Benth.)Polhill'Hul-hu'	2.00	2.00	1.00
3	*Bauhinia scandens* L. 'Zawng-a-leih-lawn'	1.33	1.33	1.00
4	*Cissampelos pareira* L. 'Khau-chhim'	0.67	0.67	1.00
5	*Clematis siamensis* Drumm. et Craib 'Thla-sik-hrui'	4.67	3.33	1.40
6	*Dioscorea glabra* Roxb.'Hra-kai'	2.00	1.33	1.50
7	*Entada rheedei* Spreng.Subsp.Rheedei 'Kawi'	2.67	2.00	1.33
8	*Ipomoea hederifolia* L 'Ni-pui-par'	2.00	1.33	1.50
9	*Marsdenia formosana* Masam. 'An-kha-te'	0.67	0.67	1.00
10	*Mikania micrantha* Kunth 'Japan-hlo'	4.00	2.67	1.50
11	*Millettia pachycarpa* Benth.'Rulei'	3.33	2.00	1.67
12	*Mucuna gigantea* (Willd.)DC. 'Be-ai-mu-zeh-dum'	0.67	0.67	1.00
13	*Passiflora edulis* Sims'Sap-thei'	2.67	2.67	1.00
14	*Paederia foetida* L. 'Vawih-uih-hrui'	3.33	2.67	1.25
15	*Piper betle* L 'Pan-ruang'	3.33	2.00	1.67
16	*Smilax lanceaefolia* Roxb.'Kaiha'	6.00	3.33	1.80
17	*Tetrastigma dubium* (M. A. Lawson) Planch	2.00	1.33	1.50
18	*Tetrastigma leucostaphylum* (Dennst.) N.P.Balakr. 'Thur-pui'	2.67	2.00	1.33
19	*Trichosanthes quinquangulata* A. Gray 'Cho-ak-a-um'	2.67	1.33	2.00
20	*Uncaria sessilifructus* Roxb.'Ral-sam-kuai'	2.00	1.33	1.50

Table 5.12 Density, Frequency and Abundance of epiphytes in Core zone

Sl No	Name of Species	Density ha^{-1}	Frequency %	Abundance
1	*Aerides odorata* Lour. ' Ngurtinchhing'	4.00	3.33	1.20
2	*Aeschynanthus maculata* Lindl.'Bawlte-hlan-tai'	3.33	2.67	1.25
3	*Bulbophyllum elatum*(Hook.f.)Sm	7.33	6.67	1.10
4	*Bulbophyllum umbellatum* Lindl	4.67	4.67	1.00
5	*Cleistostoma filiforme* (Lindl.)Garay	3.33	3.33	1.00
6	*Cleistostoma racemiferum* (Lindl.)Garay	4.67	4.00	1.17
7	*Coelogyne prolifera* Lindl.	2.00	2.00	1.00
8	*Dendrobium chrysanthum* Lindl.	0.67	0.67	1.00
9	*Dendrobium chrysotoxum* Lindl. 'Banpui par-eng'	6.00	6.00	1.00
10	*Dendrobium densiflorum* Lindl.	4.00	4.00	1.00
11	*Dendrobium formosum* Lindl'Banpui par-var	4.00	3.33	1.20
12	*Dendrobium ochreatum.*Lind'lBanpui par-eng a chhungdum'	10.67	10.00	1.07
13	*Dendrobium parishii*.Reichb.f.	2.67	2.00	1.33
14	*Dendrobium transparens* Wall.Ex Lindl 'Banpui seluphan-mawi	1.33	1.33	1.00
15	*Drynaria coronans (*Wall. ex Mett.) J. Sm. ex T 'Awmvel'	9.33	8.67	1.08
16	*Eria paniculata* Lindl	6.00	5.33	1.13
17	*Eria pannea* Lindl.	4.67	4.67	1.00
18	*Mycaranthes stricta* Lindk.	4.00	4.00	1.00
19	*Oberonia iridifolia*(Roxb.)Lindl	2.67	2.67	1.00
20	*Papolionanthe vandarum* (Rchb.f.)Garay	3.33	3.33	1.00
21	*Pholidota imbricata* Hook	5.33	4.00	1.33
22	*Premna Coriaceae* C.B.Clarke 'Kuam'	8.67	6.67	1.30
23	*Rhynchostylis retusa* (Lindl.)Bl.'Vaihniang'	0.67	0.67	1.00
24	*Vanda coerulea* Griff.ex Lindl.	3.33	3.33	1.00

Table 5.13 Density, Frequency and Abundance of grasses in Core zone

Sl No	Name of Species	Density ha^{-1}	Frequency %	Abundance
1	*Bamboosa khasiana* Munro 'Rawte'	0.80	0.80	1.00
2	*Bamboosa tulda* Roxb 'Rawthing'	1.60	0.80	2.00
3	*Cephalostachyum latifolium* Munro ' Raw-ngal'	4.80	4.80	1.00
4	*Dendrocalamus longispathus* (Kurz) Kurz 'Rawnal'	2.40	2.40	1.00
5	*Dendrocalamus sikkimensis* Gamble ex Oliv.'Raw-mi'	1.60	1.60	1.00
6	*Dinochloa compactiflora* Kurz.Mc Clure 'Sairil'	2.40	1.60	1.50
7	*Drepanostachyum intermedium* (Munro) Keng f.'Lik'	7.20	6.40	1.13
8	*Eulalia trispicata* (Schult.)Henrard 'Thang'	4.80	3.20	1.50
9	*Melocanna baccifera* (Roxb.) Kurz 'Mautak'	3.20	3.20	1.00
10	*Pseudostachyum polymorphum* Munro 'Chal-te'	5.60	4.80	1.17
11	*Themeda villosa* (Poir.) A.Camus 'Phai-phek'	4.00	2.40	1.67

Table- 5.14 Density, Frequency and Abundance of Canes and Palms in Core zone

Sl No	Name of Species	Density ha^{-1}	Frequency %	Abundance
1	*Arenga pinnata* (Wurmb) Merr. 'Thangtung'	4.00	4.00	1.00
2	*Borassus madagascariensi* Bojer ex Jum. & H.Perrier 'Siallu'	4.80	4.00	1.20
3	*Calamus inermis* Griff.'Mitperh'	2.40	1.60	1.50
4	*Calamus khasianus* Kurz 'Mawt'	3.20	2.40	1.33
5	*Calamus erectus* Roxb. 'Thilthek'	1.60	1.60	1.00
6	*Calamus flagellum* Griff. *ex* Mart'Hrui-pui'	4.00	3.20	1.25
7	*Calamus guruba* Buch.-Ham. ex Mart. 'Tairua'	3.20	3.20	1.00
8	*Calamus acanthospathus* Roxb.'Thil-te'	2.40	2.40	1.00
9	*Caryota mitis* Lour.'Meihle'	4.00	3.20	1.25
10	*Caryota urens* L. 'Tum'	3.20	2.40	1.33
11	*Livistona chinensis* (Jacq.) R.Br. ex Mart'Buarpui'	4.80	3.20	1.50
12	*Pandanus odorifer* (Forssk.) Kuntze 'Ram-la-khuih'	8.00	7.20	1.11
13	*Pinanga gracilis* Blume 'Tar-tiang'	1.60	1.60	1.00
14	*Wallichia nana* Griff. 'Lem'	2.40	2.40	1.00
15	*Zalacca secunda* Griff 'Hruitung'	0.80	0.80	1.00

5.3.2.Plant community analysis of Buffer zone

Within the buffer zone, 203 species under 168 genera belonging to 75 families were identified. The buffer zone had more species compared to core zone mainly due to the presence of annual species in the margins.The number of herbaceous species was higher in buffer zone. This may be due to abundant light falling on the forest floor due to broken canopy in the disturbed stands (Bhatnagar, 1966).

Trees were represented by 71 species, 54 genera and 35 families. Lauraceae was the most dominant family with 10 species and 7 genera followed by Fagaceae with 6 species and 3 genera and Euphorbiaceae with 4 families and 4 genera. The most dominant species was*Helicia erratica* having density of 206 individuals per hectare with an IVI of 35. This was followed by*Castanopsis tribuloides* having density of 183 individuals per hectare with an IVI of 29. The third most dominant species was *Eurya cerasifolia* having density of260 individuals per hectare with IVI of21. The least dominant species were*Macropanax undulatus , Elaeocarpus lanceaefolius , Grevillea robusta, Ficus Prostrata, Carallia brachiate, Ficus religiosa, Ficus semicordata, Dysoxylum gobara, Cephalotaxus griffithii* and *Calliandra umbrosa* having density of 1 individual per hectare and IVI of 0 .33. (**Table 5.15**)

Shrubs were represented by 28 species, 28 genera and 21 families. Acanthaceae and Melastomataceae were the most dominant family with 3 species and 3 genera each. This was followed by Apocynaceae, Rubiacieae and Rutaceae with 2 families and 2 genera each. The most dominant species was*Polygonum chinense* withthe highest IVI of 24. This was followed by *Leea indica* withIVI of 19*, Strobilanthes cusia* with IVI of 17*.* The species with the lowest rank was*Rauvolfia densiflora* with IVI of 1.7. **(Table 5.16)**

Within the study area, herbs were represented by 40 species, 35 genera and 26 families. Zingiberaceae was the dominant family with 5 species and 4

genera followed by Araceae and Urticaceae both with 3 species and 2 genera. The species with the highest rank was*Diplazium maximum* with IVI of 21 followed by *Curcuma caesia* with IVI of 20 and *Rhaphidophora decursiva* with IVI of 18 **(Table 5.17)**

Climbers were represented by 19 species, 18 genera and 12 families. Fabaceae is the most dominant family with 5 species followed by Passifloraceae, Rubiaceae and Vitaceae with 2 species each.*Smilax lanceaefolia* had the highest density followed by *Mikania micrantha and Cissus javana* . The quantitative analysis of climbers is given in **Table 5.18.** The species richness of liana taxa was lower in the buffer zone than in core zone which is in accordance with the report from tropical evergreen forest in Eastern ghats.(Chittibabu and Parthasarathy 2001)

Epiphytes were represented by 20 species, 11 genera and 3 families, Orchidaceae being the most dominant with 18 species. The most dominant species was*Aeschynanthus maculate* with IVI of 55 followed by *Dendrobium chrysotoxum* with IVI of 40. **(Table 5.19)** There was a decrease in species abundance from the core zone to the buffer zone. This may be attributed to the higher degree of disturbance in buffer zone. This was consistent with the patterns of forest vegetation in other habitats (Whitmore, 1990; Turner *et al .,* 1994; Hietz *et al .,* 1996).

Grasses were represented by 13 species and 9 genera. The species with the highest density was*Eulalia trispicata* followed by *Pseudostachyum polymorphum* and *Drepanostachyum intermedium*. Canes and palms were represented by 12 species and 9 genera, the species with highest density was *Arenga pinnata followed* by *Pandanus odorifer.* The quantitative analysis of grasses and canes and palms are given in **Table no 5.20**and **5.21**respectively

Many wide spread tropical species tend to be locally abundant in certain areas and relatively rare in others (Hubbell and Foster, 1983). This was exemplified *by Castanopsis tribuloides* and *Helicia erratica* where they were

abundant with IVI of 29.44 and 34.88 respecitively in the buffer zone but have an IVI of only 1.02 and 5.14 in the core zone

The species diversity assessed by Shannon–Weiner index was the highest amongst trees (3.78) followed by herbs (3.5) and shrubs (3.19). This was comparable to the value reported for tree diversity by Zaman*et al.*(2011) for three sites in tropical moist deciduous forest of Bangladesh which were 3.19, 3.48, and 3.11 .The buffer zone had a lower species diversity of trees compared to core zone. This reduction in tree density and Shannon diversity Index from undisturbed to disturbed has been reported by various workers (Rao *et al*., 1990; Bhuyan *et al*., 2003; Mishra *et al.,* 2004;Dutta & Devi, 2013).Basal area and stem density documented in response to disturbances can represent the structure of a forest stand and is also a useful indicator of human impact on a forest stand (Ingram*et al*., 2005).Annuals and short-lived perennials on the other hand are favoured by disturbance which is in agreement with the findings of Raizada *et al*. (1998) which explains the higher diversity for shrubs and herbs in this zone.

Simpson's index of dominance (D) showed that shrub community had the highest dominance index followed by herbs and trees. The buffer zone had a higher dominance index than the core zone for both herbs and tree species. The dominance index is usually higher in disturbed communities compared to undisturbed communities (Uniyal*et al*., 2010). Magurran (2005) observed that in disturbed communities, due to competition the better adaptive species increase in number to outcompete the others. The family dominance changed from the undisturbed to the disturbed stands, the change being more conspicuous in the highly disturbed stand. A similar result had also been reported by Parthasarathy and Karthikeyan (1997) and Parthasarathy and Sethi (1997) for tropical dry evergreen forest in South India.

Pielou's evenness index showed that shrubs were the most evenly distributed among the three communities with E value of 0.96 while trees had the

lowest value of 0.89. However, this value was higher than the Pielou's evenness of J' = 0.79 found in seasonal forest of southern Brazil(Sühs and Budke, 2011). The evenness value of buffer zone was more or less the same with core zone .

Margalef's index of species richness was the highest for trees with D_{mg} value of 10.58 followed by herbs with D_{mg} of 6.09 and shrubs had the lowest species richness with D_{mg} of 4.03. Species richness was lower in trees for buffer zone compared to core zonebut higher in shrubs. The diversity indices are given in **Table no 5.23**

Table 5.15 Density, Frequency, Abundance and IVI of tree species in Buffer zone

Sl no	Name of Species	Density ha^{-1}	Frequency %	Abundance	IVI	Species Rank
1	*Acer laevigatum* Wall. 'Thing-khim'	13.33	6.67	2.00	1.67	43
2	*Acronychia pendunculata* (L.)Mi 'Rah-var'	86.67	40.00	2.17	9.16	7
3	*Alphonsea ventricosa* (Roxb.) Hook. f. & Thomson 'Zawng-bal-hla'	26.67	10.00	2.67	2.16	38
4	*Alseodaphne petiolaris* (Meissn.) Hook. f. 'Bul-pui/Khuangthulh'	26.67	23.33	1.14	3.44	28
5	*Bruinsmia polysperma* (C.B. Clarke)Steenis 'Thei-pa-ling-kawh'	26.67	16.67	1.60	2.70	35
6	*Calophyllum polyanthum* Wall. ex Choisy 'Sen-te-zel'	36.67	13.33	2.75	6.15	13
7	*Camellia kissi* Wallich 'Lal-lai'	46.67	30.00	1.56	4.30	22
8	*Caralli brachiata* (Lour.) Merr. 'Thei-ria'	3.33	3.33	1.00	0.37	67
9	*Castanopsis indica* (Roxb. ex Lindl.) A.DC. 'Se-hawr'	26.67	6.67	4.00	1.56	47
10	*Castanopsis tribuloides* (Sm.) A.DC. 'Thing-sia'	183.33	56.67	3.24	29.44	2
11	*Celtis timorensis* Span. 'Thing-hmar-cha'	23.33	20.00	1.17	2.61	36
12	*Cephalotaxus griffithii* Hook. f. 'Tu-far'	3.33	3.33	1.00	0.37	71
13	*Cinnamomum glanduliferum* (Wall.) Meisner 'Khiang-zo'	10.00	10.00	1.00	1.24	50
14	*Cinnamomum obtusifolium* (Roxb.) Nees. 'Hnah-zung-thum'	33.33	20.00	1.67	2.99	31
15	*Cinnamomum verum* J.Presl 'Thak-thing'	50.00	26.67	1.88	5.26	16
16	*Croton hookeri* Veitch 'Ba-ken-fung'	10.00	3.33	3.00	0.77	60
17	*Cryptocarya amygdalina* Nees Bauch.Ham 'Thak-thing-suak'	13.33	13.33	1.00	1.60	46
18	*Debregeasia longifolia* (Burm. f.) Wedd. 'Leh-ngo'	33.33	20.00	1.67	3.37	30
19	*Diospyros lancifolia* Wallich ex Hiern 'Zo-thing-hang'	60.00	36.67	1.64	7.22	10
20	*Drimycarpus racemosus* (Roxb.) Hook.f 'Vawm-bal'.	13.33	10.00	1.33	1.39	48
21	*Dysoxylum gobara* (Buch.-Ham.) Merr. 'Thing-thu-pui'	3.33	3.33	1.00	0.37	70
22	*Elaeocarpus floribundus* Blume 'Thing-lung'	83.33	20.00	4.17	7.57	8

23	*Elaeocarpus lanceaefolius* Roxb. 'Kha-ruan'	3.33	3.33	1.00	0.38	64
24	*Elaeocarpus rogusus* Roxb. 'Thei-kel-ek'	26.67	16.67	1.60	2.49	37
25	*Elaeocarpus tectorius* (Lour.) Poir. 'Um-khal'	20.00	13.33	1.50	1.81	41
26	*Embelia tsjeriam-cottam* A.DC. 'Rah-sen'	6.67	6.67	1.00	0.77	61
27	*Engelhardtia roxburghiana* Wall. 'Phek-phe'	10.00	10.00	1.00	1.15	54
28	*Engelhardtia spicata* Leschen, ex. Blume 'Hnum'	23.33	23.33	1.00	2.82	34
29	*Eurya cerasifolia* (D.Don) Kobuski 'Si-hneh'	260.00	63.33	4.11	21.34	3
30	*Eurya loquaiana* Dun 'Zo-si-hneh'	96.67	10.00	9.67	4.83	17
31	*Ficus Prostrata* (Wall. ex Miq.) Miq. 'Thei-tit'	3.33	3.33	1.00	0.37	66
32	*Ficus religiosa* L. 'Hmawng'	3.33	3.33	1.00	0.37	68
33	*Ficus semicordata* Buch.-Ham. ex Sm. 'Thei-pui'	3.33	3.33	1.00	0.37	69
34	*Garcinia xanthochymus* Hook. f. ex T. Anderson 'Tuai-ha-bet'	13.33	6.67	2.00	1.03	58
35	*Glochidion khasicum* (Müll.Arg.) Hook.f. 'Thing-pawn-chhia'	46.67	33.33	1.40	5.80	14
36	*Grevillea robusta* A. Cunn. ex R. Br. 'Silver Oak'	3.33	3.33	1.00	0.38	65
37	*Gynocardia odorata* R. Br. 'Sai-thei'	16.67	6.67	2.50	1.22	52
38	*Helicia erratica* Roxb. 'Sial-hma'	206.67	80.00	2.58	34.88	1
39	*Heteropanax fragrans* (Roxb.)Seem 'Chang-khen'	66.67	36.67	1.82	7.13	11
40	*Lithocarpus elegans* (Blume) Hatus. ex Soepadmo 'Thing-pui-thing'	16.67	13.33	1.25	1.66	44
41	*Lithocarpus pachyphyllus* (Kurz) Rehder 'Then-sen'	66.67	26.67	2.50	5.39	15
42	*Litsea lancifolia* Roxb. ex Nees 'Hnah-paw-te'	46.67	16.67	2.80	4.08	23
43	*Litsea monopetala* (Roxb.) Pers. 'Nau-thak'	10.00	10.00	1.00	1.13	57
44	*Macaranga indica* Wight 'Khar-duap'	6.67	3.33	2.00	0.49	62
45	*Macropanax undulatus* (Wall. ex G.Don) Seem. 'Phuan-berh'	3.33	3.33	1.00	0.43	63
46	*Mangifera sylvatica* Roxb. 'Hai-fa-vang'	20.00	16.67	1.20	2.84	33
47	*Memecylon celastrinum* Kurz 'Thei-kawr-ak'	33.33	33.33	1.00	3.82	24

48	*Olea dioica* Roxb. 'Se-vuak'	100.00	53.33	1.88	10.64	5
49	*Olea salicifolia* Wall.ex G.Don 'Thing-thiang'	43.33	33.33	1.30	4.45	19
50	*Ostodes paniculata* Blume ' Bel-tur'	16.67	10.00	1.67	2.00	39
51	*Persea glaucescens* Nees. 'Sa-per bul'	53.33	26.67	2.00	4.37	21
52	*Persea villosa (Roxb.)* Kosterm. 'Bul-bawr'	30.00	20.00	1.50	3.54	27
53	*Phoebe lanceolata* (Nees) Nees 'Bul-fek'	10.00	10.00	1.00	1.14	55
54	*Pithecolobium bigeminum* (L.) Mart. 'Ar-dah-te'	43.33	23.33	1.86	3.81	25
55	*Premna racemosa* Wall. ex Schauer 'Thing-sa-um'	63.33	30.00	2.11	6.56	12
56	*Prunus jenkinsii* Hook.f. & Thomson 'Kei-pui'	10.00	10.00	1.00	1.20	53
57	*Pterospernum semisagittatum* Buch.-Ham. ex Roxb. 'Mu-khau'	20.00	10.00	2.00	2.00	40
58	*Quercus glauca* Thunb.in A.Murray 'Hrum-hriau'	26.67	16.67	1.60	4.61	18
59	*Quercus leucotrichophora* A.Camus 'Then'	83.33	26.67	3.13	7.46	9
60	*Rhus semialata* Murray. 'Khawm-hma'	10.00	10.00	1.00	1.13	56
61	*Rhus succedanea* (L.) Kuntze 'Chhim-hruk'	40.00	20.00	2.00	3.39	29
62	*Saraca asoca*(Roxb.) Willd. 'Mual-hawih'	16.67	13.33	1.25	1.61	45
63	*Schima wallichii*(DC.)Korthals 'Khiang'	83.33	40.00	2.08	13.27	4
64	*Stephegyne diversifolia* (Wall. ex G.Don)Brandis 'Pual-eng'	6.67	6.67	1.00	0.83	59
65	*Stereospermum colais* Buch.-Ham. Ex Dillwyn 'Zih-nghal'	23.33	10.00	2.33	1.78	42
66	*Styrax serrulatum*(Roxb) 'Hmar-hleng'	43.33	26.67	1.63	3.75	26
67	*Syzygium claviflorum* (Roxb.) Wall. ex A.M.Cowan & Cowan 'Hmui-fa-rial'	13.33	10.00	1.33	1.30	49
68	*Syzygium cumini (L.)* Skeels 'Len-hmui'	76.67	46.67	1.64	9.89	6
69	*Ulmus lanceifolia* Roxb. 'Phan'	23.33	3.33	7.00	1.22	51
70	*Wendlandia grandis*(Hook.f.) Cowan 'Ba-tling'	46.67	26.67	1.75	4.38	20
71	*Ziziphus incurva* Roxb. 'Hel'	26.67	23.33	1.14	2.92	32

Table 5.16 Density, Frequency, Abundance and IVI of shrub species in Buffer zone

Sl No	Name of Species	Density ha^{-1}	Frequency %	Abundance	IVI	Species Rank
1	*Amomum dealbatum* Roxb.'Ai-du'	86.00	16.67	5.16	11.74	15
2	*Blumea lanceolaria* (Roxb.) Druce'Buar-ze'	110.00	30.00	3.67	16.91	6
3	*Chromolaena odorata* (L.) R.M.King & H.Rob.'Tlang-sam'	102.00	20.67	4.94	16.97	5
4	*Clerodendrum viscosum* Vent.'Phui-hnam-chhia'	54.00	14.00	3.86	11.10	17
5	*Disporum cantoniense* (Lour.) Merr.	70.00	20.00	3.50	12.43	13
6	*Elaeagnus pyriformis* Hook.f'Sar-zuk-te'	58.00	19.33	3.00	14.11	7
7	*Ipomoea batatas* (L.) Lam.'Kawl-ba-hra'	44.00	14.00	3.14	12.94	9
8	*Lasianthus hookeri* C. B. Clarke ex J. D. Hooker	6.67	5.33	1.25	3.83	25
9	*Leea indica* (Burm.f.) Merr'Kawl-kar'	90.00	26.00	3.46	19.59	2
10	*Maesa indica* (Roxb.) A. DC.'Ar-ngeng'	6.00	6.00	1.00	2.84	27
11	*Mallotus albus* (Roxb. ex Jack) Müll.Arg	42.00	11.33	3.71	12.74	10
12	*Melastoma nepalensis* Lodd.'Builukham'	50.00	13.33	3.75	12.11	14
13	*Murraya koenigii* (L.) Spreng.'Ar-pa-til'	8.00	7.33	1.09	3.03	26
14	*Mycetia longifolia* (Wall.) Kuntze	10.00	10.00	1.00	3.62	24
15	*Osbeckia chinensis* L.'Builukham'	46.00	14.67	3.14	9.13	18
16	*Osbeckia crinita* Benth. ex Naudin'Builukhampa'	12.00	8.67	1.38	6.07	19
17	*Polygonum chinense* L.'Ta-ham'	116.00	36.67	3.16	25.19	1
18	*Rauvolfia densiflora* (Wall.) Benth. ex Hook. f.	4.00	4.00	1.00	1.26	28
19	*Rhamnus nepalensis* M. Laws.'Sen-tiar'	10.00	9.33	1.07	3.83	23
20	*Rubus buergeri* Miq'Sial-i-nu-chhu'	68.00	20.67	3.29	13.24	8
21	*Strobilanthes cusia* (Nees) Kuntze'Ting'	114.00	13.33	8.55	17.51	3
22	*Strobilanthes discolor* (Nees) T. Anderson'Ram-ting'	92.00	21.33	4.31	16.94	4
23	*Strobilanthes parryorum* T.Anders.'Ram-ting-hmulchi'	70.00	14.00	5.00	12.67	12
24	*Symplocos lancifolia* Siebold et Zucc.	10.67	10.67	1.00	5.08	22
25	*Tabernaemontana divaricata* (L.) R. Br. ex Roem. & Schult.'Par-arsi'	76.00	21.33	3.56	12.98	11
26	*Toddalia asiatica* L.'Nghar-dai'	9.33	9.33	1.00	5.67	20
27	*Viburnum foetidum* Wall'Zothei'	70.00	8.00	8.75	11.22	16
28	*Woodfordia fruticosa* (L.) Kurz'Ai-nawn'	10.00	10.00	1.00	5.25	21

Table 5.17 Density, Frequency, Abundance and IVI of herb species in Buffer zone

Sl No	Name of Species	Density ha^{-1}	Frequency %	Abundance	IVI	Species Rank
1	*Adiantum caudatum* Linn	300	3.33	1.00	1.99	35
2	*Arisaema album* N.E.Br.	300	3.33	1.00	1.99	36
3	*Arisaema speciosum* (Wall.) Mart.'Tel-hawng'	2100	14.00	1.52	17.50	4
4	*Asparagus racemosus* Willd	300	3.33	1.20	2.25	33
5	*Begonia dioica* Buch.-Ham. ex D.Don'Sekhupthur'	500	4.67	1.29	3.49	27
6	*Boenninghausenia albiflora* Reichb.'Ruh-na-dam-dawi'	1500	13.33	1.15	11.88	9
7	*Cheilocostus lacerus* (Gagnep.) C.D.Specht	200	2.00	1.33	1.37	39
8	*Chlorophytum khasianum* Hook.f 'Kep'	800	8.67	1.00	6.01	19
9	*Commelina benghalensis* Linn.'Dawng'	1500	13.33	1.15	11.88	10
10	*Costus speciosus* (J.König) Sm.'Sum-bul'	500	4.67	1.29	3.49	28
11	*Curculigo crassifolia* (Baker) Hook.*f*'Phai-phak'	1200	12.67	1.00	9.69	15
12	*Curcuma caesia* Roxb. 'Ailaidum'	2300	15.33	1.52	19.98	2
13	*Diplazium maximum* (D.Don) Chatt 'Cha-kawk'	2200	20.00	1.13	20.62	1
14	*Elatostema dissectum* Wedd.	1300	12.00	1.17	10.46	13
15	*Elatostema sesquifolium* (Reinw. ex Blume) Hassk.	200	2.67	1.00	1.56	38
16	*Gleichenia linearis* (Burm.f.)C.B.Clarke 'Arthladawn'	1400	11.33	1.29	10.78	12
17	*Gnaphalium luteo-album* Linn	300	4.00	1.00	2.44	31
18	*Hedychium coccineum* Buch.-Ham. ex Sm.'Ai-chhia'	700	8.00	1.00	5.45	20
19	*Hedychium villosum* Wall.'Ai-chhia'	1100	10.00	1.20	8.46	16
20	*Houttuynia cordata* Thunb.'Ui-thin-thang'	300	3.33	1.20	2.25	34
21	*Impatiens laevigata* Wall. ex Hook. f. & Thomson	500	6.00	1.00	3.87	25
22	*Kalanchoe integra* (Medik.) Kuntze. 'Kangdamdawi'	600	6.00	1.11	4.19	24
23	*Lindernia ruellioides* (Colsm.) Pennell 'Thasuih'	700	5.33	1.38	4.33	23
24	*Lycopodium cernuum* Linn	500	5.33	1.00	3.38	29
25	*Lygodium flexuosum* (Linn.)Swartz	500	6.00	1.00	3.87	26
26	*Microlepia rhomboidea* (Wall.ex Kunze) Prantl, Arb.	700	7.33	1.00	4.91	22
27	*Mimosa pudica* L.'Hlonuar'	1500	10.67	1.44	11.11	11
28	*Ophiorrhiza mungos* L.	300	3.33	1.00	1.99	37
29	*Ophiorrhiza oppositiflora* Hook.f. 'Lum-suak'	1500	14.00	1.14	12.61	7
30	*Persicaria hydropiper* (L.) Opiz 'Kel-hmar-cha'	400	4.67	1.00	2.90	30
31	*Phaius mishmensis (Lindl. & Paxton) Rchb.f.*	900	10.00	1.00	7.17	18

32	*Plantago major* Linn 'Kel-ba-an'	1500	14.00	1.14	12.61	8
33	*Plectranthus coetsa* Buch.-Ham. ex D. Don	1100	10.00	1.20	8.46	17
34	*Polygonatum oppositifolium* (Wall.) Royle 'Le-len'	100	2.00	1.00	1.15	40
35	*Polygonum barbatum* L. 'Dawngria'	300	4.00	1.00	2.44	32
36	*Pouzolzia bennettiana* Wight	700	7.33	1.09	5.26	21
37	*Pteridium aguilinum* (Linn.) Kuhn.	1700	14.00	1.24	13.74	6
38	*Rhaphidophora decursiva* (Roxb.) Schott 'Tu-bal'	2100	17.33	1.23	18.47	3
39	*Scleria terrestris* (L.) Fass 'Thip-nem'	1600	16.00	1.04	13.75	5
40	*Torenia violacea* (Azaola ex Blanco) Pennell'Ar-aw-keu'	1300	11.33	1.24	10.27	14

Table 5.18 Density,Frequency and Abundance of Climbers in Buffer zone

Sl No	Name of Species	Density ha^{-1}	Frequency %	Abundance
1	*Acacia oxyphylla* Benth 'Khangngo'	1.33	1.33	1.00
2	*Aganope thyrsiflora* (Benth.)Polhill'Hul-hu'	3.33	3.33	1.00
3	*Caesalpinia cucullata* Roxb. 'Hling-khang'	4.67	2.00	2.33
4	*Cissampelos pareira* L. 'Khau-chhim'	3.33	2.67	1.25
5	*Cissus javana* DC 'Sa-nghar-hmai'	5.33	4.00	1.33
6	*Dioscorea glabra* Roxb.'Hra-kai'	2.67	2.00	1.33
7	*Ipomoea hederifolia* L 'Ni-pui-par'	6.00	3.33	1.80
8	*Marsdenia formosana* Masam. 'An-kha-te'	1.33	1.33	1.00
9	*Mikania micrantha* Kunth 'Japan-hlo'	7.33	5.33	1.38
10	*Mucuna gigantea* (Willd.)DC. 'Be-ai-mu-zeh-dum'	2.00	2.00	1.00
11	*Passiflora edulis* Sims'Sap-thei'	2.67	2.67	1.00
12	*Passiflora nepalensis* Wallich'Nau-awi-mu-hrui'	3.33	2.67	1.25
13	*Paederia foetida* L. 'Vawih-uih-hrui'	4.00	3.33	1.20
14	*Piper betle* L 'Pan-ruang'	3.33	2.00	1.67
15	*Shuteria vestita* var. glabrata (Wight & Arn.)Baker	2.67	2.67	1.00
16	*Smilax lanceaefolia* Roxb.'Kaiha'	10.00	7.33	1.36
17	*Tetrastigma dubium* (M. A. Lawson) Planch	0.67	0.67	1.00
18	*Trichosanthes quinquangulata* A. Gray 'Cho-ak-a-um'	4.67	4.00	1.17
19	*Uncaria sessilifructus* Roxb.'Ral-sam-kuai'	2.00	1.33	1.50

Table-5.19 Density,Frequency and Abundance of Epiphytes in Buffer zone

Sl No	Name of Species	Density ha^{-1}	Frequency %	Abundance
1	*Aerides odorata* Lour. ' Ngurtinchhing'	6.00	6.00	1.00
2	*Aeschynanthus maculata* Lindl.'Bawlte-hlan-tai'	16.00	14.00	1.14
3	*Bulbophyllum elatum* (Hook.f.)Sm	5.33	4.67	1.14
4	*Bulbophyllum khasianum* Griff	4.00	3.33	1.20
5	*Bulbophyllum umbellatum* Lindl	4.67	4.67	1.00
6	*Cleistostoma filiforme* (Lindl.)Garay	2.67	2.67	1.00
7	*Cleistostoma racemiferum* (Lindl.)Garay	5.33	5.33	1.00
8	*Coelogyne prolifera* Lindl.	7.33	6.00	1.22
9	*Dendrobium chrysotoxum* Lindl. 'Banpui par-eng'	12.67	12.67	1.00
10	*Dendrobium formosum* Lindl'Banpui par-var	4.00	4.00	1.00
11	*Dendrobium ochreatum*.Lind'lBanpui par-eng a chhungdum'	8.67	7.33	1.18
12	*Dendrobium parishii*.Reichb.f.	1.33	1.33	1.00
13	*Dendrobium transparensWall*.Ex Lindl 'Banpui seluphan-mawi	3.33	2.67	1.25
14	*Eria paniculata* Lindl	10.00	10.00	1.00
15	*Mycaranthes stricta* Lindk.	2.00	2.00	1.00
16	*Papolionanthe vandarum* (Rchb.f.)Garay	3.33	3.33	1.00
17	*Pholidota imbricata* Hook	2.00	2.00	1.00
18	*Premna Coriaceae* C.B.Clarke 'Kuam'	10.00	8.00	1.25
19	*Rhynchostylis retusa* (Lindl.)Bl.'Vaihniang'	2.67	2.00	1.33
20	*Vanda coerulea* Griff.ex Lindl.	2.00	2.00	1.00

Table-5.20 Density,Frequency and Abundance of Grasses in Buffer zone

Sl No	Name of Species	Density ha^{-1}	Frequency %	Abundance
1	*Bamboosa khasiana* Munro 'Rawte'	4.00	3.20	1.25
2	*Bamboosa tulda* Roxb 'Rawthing'	4.80	4.80	1.00
3	*Cephalostachyum latifolium* Munro ' Raw-ngal'	3.20	1.60	2.00
4	*Dendrocalamus hamiltonii* Nees & Arn.ex Munro 'Phulrua'	2.40	2.40	1.00
5	*Dendrocalamus sikkimensis* Gamble ex Oliv.'Raw-mi'	1.60	1.60	1.00
6	*Drepanostachyum intermedium* (Munro) Keng f.'Lik'	9.60	7.20	1.33
7	*Erianthus longisetosus* Anderss. ex Benth'Luang'	8.00	5.60	1.43
8	*Eulalia trispicata* (Schult.)Henrard 'Thang'	15.20	12.80	1.19
9	*Melocanna baccifera* (Roxb.) Kurz 'Mautak'	2.40	2.40	1.00
10	*Pseudostachyum polymorphum* Munro 'Chal-te'	12.00	8.80	1.36
11	*Schizostachyum dulloa* (Gamble) Majumdar 'Rawthla'	1.60	1.60	1.00
12	*Themeda villosa* (Poir.) A.Camus 'Phai-phek'	4.80	4.00	1.20
13	*Thysanolaena maxima* (Roxb.) Kuntze'Hmun-phiah'	3.20	3.20	1.00

Table-5.21 Density,Frequency and Abundance of Canes and Palms in Buffer zone

Sl No	Name of Species	Density ha^{-1}	Frequency %	Abundance
1	*Arenga pinnata* (Wurmb) Merr. 'Thangtung'	7.20	7.20	1.00
2	*Borassus madagascariensi* Bojer ex Jum. & H.Perrier 'Siallu'	3.20	2.40	1.33
3	*Calamus inermis* Griff.'Mitperh'	4.00	4.00	1.00
4	*Calamus erectus* Roxb. 'Thilthek'	6.40	5.60	1.14
5	*Calamus flagellum* Griff. *ex* Mart'Hrui-pui'	3.20	2.40	1.33
6	*Calamus acanthospathuss* Roxb.'Thil-te'	1.60	1.60	1.00
7	*Caryota urens* L. 'Tum'	4.80	4.00	1.20
8	*Livistona chinensis* (Jacq.) R.Br. ex Mart'Buarpui'	4.00	3.20	1.25
9	*Pandanus odorifer* (Forssk.) Kuntze 'Ram-la-khuih'	8.80	6.40	1.38
10	*Pinanga gracilis* Blume 'Tar-tiang'	2.40	1.60	1.50
11	*Wallichia nana* Griff. 'Lem'	3.20	2.40	1.33
12	*Zalacca secunda* Griff 'Hruitung'	4.80	3.20	1.50

5.3.3. Grassland

A total of 51 species under 50 genera belonging to 26 families were found in the grassland of Reiek forest.

Shrubs were represented by 6 species, 5 genera and 4 families. The most dominant species was *Vibrunum foetidum* followed by *Osbeckia crinita* and *Polygonum chinense*. Herbs were represented by 29 species, 29 genera and 17 families. The most dominant herb species was *Scleria levis* followed by *Ageratum conyzoides* and *Carex cruciate*. Climbers were represented by 6 species, 6 genera and 5 families, the most abundant species being *Porana racemosa* followed by *Smilax glabra* and *Passiflora nepalensis* .Grasses are represented by 10 species and 10 genera, the dominant species was*Eulalia trispicata* followed by *Imperata cylindrical* and *Cynodon dactylon*.

Eulalia trispicata had the highest IVI of 48 and was the most dominant species. This is followed by *Imperata cylindrical* with IVI of 47, *Cynodon dactylon* with IVI of 14, *Erianthus longisetosus* with IVI of 13 and *Scleria terrestris* with IVI of 12

The grassland of Reiek forest appeared to be as species rich as some temperate Asian grasslands. Zhang (1998) reported a total richness of 60 species from Mongolian steppe. It was also more or less similar the findings in sub-alpine grasslands in trans-Himalayan region of Manang, central Nepal consisting of 59 species from Ice Lake and and 50 species from Yak Kharka (Bhatt& Lekhak, 2009)

The Shannon –Weiner diversity index showed a value of 3.4 . This was higher than the value (2.21) reported for tropical grassland at Berhampur (Misra &Misra, 1981). It was more or less similar to the value (3.3) reported for Montane meadow of the Kyrgyz Republic in Central Asia (Taft*et al.,* 2011) The reason for high diversity appeared to be because the study was carried out during rainy season which ensured the presence of annuals and ephemerals. The grassland was the most disturbed zone which also ensures higher diversity (Raizada *et al*., 1998)

. Simpson's index of dominance (D) was 0.05 which was similar to the value reported for Montane meadow of the Kyrgyz Republic in Central Asia (Taft *et al.,* 2011). Pielou's evenness index value of 0.87 was the same as the evenness index of ecotone grassland of Yanchi County in northwest China (Li *et al,*.2007). Margalef's index of species richness yielded a value of 7.37. The diversity indice for grassland is given in **Table 5.22**

Table 5.22 Density, Frequency, Abundance and IVI in Grassland zone

Sl No	Name of species	Density ha^{-1}	Frequency	Abundance	IVI	Species Rank
1	*Ageratum conyzoides* L.'Vai-len-hlo'	20400	60	3.40	7.37	8
2	*Alectra indica* Benth	12200	25	4.88	3.50	26
3	*Allium tuberosum* Rottler ex Spreng'Kham-pu-run'	3500	32	1.09	2.04	36
4	*Bidens pilosa* L.'Vawk-pui-thal'	11200	76	1.47	5.64	13
5	*Blumea alata*(D.Don) DC'Buar'	12000	53	2.26	4.76	20
6	*Boenninghausenia albiflora* Reichb.'Ruh-na-dam-dawi'	17500	55	3.18	6.28	11
7	*Bupleurum tenue* Buch.-Ham. ex D. Don	5400	32	1.69	2.38	33
8	*Butea minor* Buch.-Ham. ex Baker'Thual-thu'	3000	18	1.67	1.30	45
9	*Carex cruciata* var. rafflesiana (Boott) Noot.	19200	53	3.62	6.68	9
10	*Centella asiatica* L.'Lam-bak'	18000	38	4.74	5.63	14
11	*Chlorophytum khasianum* Hook.f'Kep'	3500	32	1.09	2.04	37
12	*Commelina benghalensis* Linn.'Dawng'	6600	25	2.64	2.28	35
13	*Conyza stricta* Willd.'Buartharrang'	3000	18	1.67	1.30	46
14	*Cynodon dactylon* Pers'Phai-tual- hnim'	38400	58	6.62	14.08	3
15	*Cyperus rotundus*.Linn	13500	62	2.18	5.54	16
16	*Dichrocephala integrifolia* (L.f.) Kuntze'Vawk-eka-tum-tual'	6400	35	1.83	2.71	29
17	*Diplazium maximum* (D.Don) Chatt 'Cha-kawk'	3200	18	1.78	1.34	44
18	*Erianthus longisetosus* Anderss. ex Benth 'Luang'	35400	62	5.71	12.95	4
19	*Eulalia trispicata* (Schult.)Henrard 'Thang'	88600	92	9.63	48.40	1
20	*Gleichenia linearis (Burm.f.)C.B.Clarke* 'Arthladawn'	5500	31	1.77	2.35	34
21	*Gnaphalium luteo-album* Linn	4900	18	2.72	1.63	42
22	*Imperata cylindrical* (L.) Raeusch'Di'	87500	86	10.17	47.19	2
23	*Ipomoea hederifolia* L 'Ni-pui-par'	700	6	1.17	0.38	51
24	*Kylinga brevifolia* Rottb.	15400	74	2.08	6.59	10
25	*Leucas mollissima* Wall'Va-te-khawi-zu'	3200	23	1.39	1.57	43
26	*Lycopodium cernuum* Linn	1500	12	1.25	0.78	49
27	*Melastoma nepalensis* Lodd.'Builukham'	4800	25	1.92	1.94	38
28	*Oplismenus burmanii* Beauv.	15400	55	2.80	5.71	12
29	*Osbeckia chinensis* Linn.'Builukham'	7600	39	1.95	3.13	28
30	*Osbeckia crinita* Benth. ex C.B.Clarke'Builukhampa'	15000	52	2.88	5.46	17
31	*Paspalum compactum* Roth.	13800	35	3.94	4.36	24
32	*Passiflora nepalensis* Wall.'Nau-awi-mu-hrui'	3500	29	1.21	1.90	39
33	*Plantago major* Linn'Kel-ba-an'	9800	35	2.80	3.41	27
34	*Polygonum chinense* L'Ta-ham'	14200	55	2.58	5.39	18
35	*Porana racemosa* Roxb.	5100	36	1.42	2.51	31
36	*Pouzolzia bennettiana* Wight	10200	55	1.85	4.43	23
37	*Pteridium aguilinum* (Linn.) Kuhn.	4100	23	1.78	1.72	41

38	*Saccharum arundinaceum* Retz'Rai-ruang'	12700	48	2.65	4.69	21
39	*Scleria levis* Retz.	12500	69	1.81	5.62	15
40	*Scleria terrestris* (L.) Fassett 'Thip-nem'	27900	96	2.91	11.57	5
41	*Setaria glauca* Beauv.	24400	88	2.77	9.96	6
42	*Smilax glabra* Roxb'Tluang-ngil'	4600	41	1.12	2.65	30
43	*Solanum khasianum* Clarke 'At-hlo-hling'	2500	18	1.39	1.22	47
44	*Spilenthes calva* Wight'An-ka-sa-kirlo'	8700	20	4.35	2.47	32
45	*Tetrastigma leucostaphylum* (Dennst.) N.P.Balakr. 'Thur-pui'	1200	8	1.50	0.55	50
46	*Themeda villosa* (Poir.) A.Camus'Phai-phek'	12400	45	2.76	4.48	22
47	*Thunbergia glandiflora* Roxb'Zawng-a-fian'	2400	15	1.60	1.06	48
48	*Thysanolaena maxima* (Roxb.) Kuntze'Hmun-phiah'	26400	42	6.29	8.50	7
49	*Torenia violacea* (Azaola ex Blanco) Pennell'Ar-aw-keu'	4500	22	2.05	1.75	40
50	*Urena lobata* Linn 'Se-hnap'	5800	55	1.05	3.53	25
51	*Vibrunum foetidum* Wall'Zothei'	16400	40	4.10	5.27	19

Table 5.23 Indices of diversity for Core zone, Buffer zone and Grassland zone of Reiek forest

Sl.No	Indices	Core zone			Buffer zone			Grassland zone
		Trees	Shrubs	Herbs	Trees	Shrubs	Herbs	
1	**Shannon Diversity index (H') (Shannon, 1949) $H = -\Sigma (ni / N) \ln (ni / N)$**	4.03	2.92	3.40	3.78	3.19	3.50	3.44
2	**Evenness index(Pielou's index) (Pielou, 1975) $E = H'/\ln S$**	0.89	0.97	0.95	0.89	0.96	0.95	0.87
3	**Margalef's index of species richness (Margalef, 1975) $D_{mg} = (S-1) / \ln N$**	13.28	3.30	6.84	10.58	4.03	6.09	7.37
4	**Simpson's index of Dominance (D) (Simpson, 1949) $D = \Sigma \frac{(ni(ni-1))}{(N(N-1))}$**	0.02	0.05	0.03	0.03	0.04	0.03	0.04

5.4 Plant Community structure-Stratification of forest

Forest plant communities often consist of a number of strata such as canopy, sub canopy, shrubsand herbs depending on the type of forest. (Cain, 1934; Smith, 1973) However, the boundaries between these strata are not always clearly defined (Popma *et al*., 1988). Stratification is one of the characteristic features of tropical forest ecosystem and has been studied from various points of view. The profile diagram approach used in this study is the best known qualitative method (Davis & Richards, 1933, 1934; Halle *et al*., 1978; Richards,1983). Profile diagram was drawn along a 5x70m transect shown in **Fig 5.4.** The profile diagram showed that the forest in both the core zone and buffer zone was composed of three layers – the top canopy which ranged from 15m to 30m, the middle canopy which ranged from 5m to 15m and the undercanopy layer below 5m.

In the core zone, the dominant tree species in the top canopy were *Syzygium cumini, Calophyllum polyanthum, Quercus leucotrichophora, Mangifera sylvatica* and *Quercus glauca* .The highest tree recorded in the profile was for *Calophyllum polyanthum* which reached a height of 24 m. The average height in the top canopy was 20m and they were more or less continuous. The dominant species in middle canopy were*Olea dioica, Eurya cerasifolia, Garcinia xanthochymus,Acronychia pendunculata* and*Helicia erratica .* The average height of trees in this layer was 8m. The undercanopy was composed of shrubs, herbs and saplings and seedlings of trees. There was abundance of species like *Mallotus albus,Amomum dealbatum*, Rhaphidophora*decursiva, Houttuynia cordata* and *Ophiorrhiza oppositiflora* (**Fig. 5.4**).

In the buffer zone, the dominant tree species in the top canopy were *Castanopsis tribuloides, Syzygium cumini, Schima wallichii, Elaeocarpus floribundus* and *Quercus leucotrichophora*. The highest tree recorded in the profile was*Alseodaphne petiolaris* which reached a height of 23 m. The average height of

the trees in the top canopy was the same as that of core zone (20m). They were not as continuous as that of the core zone. In the middle canopy, the dominant species were *Helicia erratica,Eurya cerasifolia, Olea dioica, Acronychia pendunculata* and *Premna racemosa.*The average height of tree was also the same as that of core zone (8m) . The undercanopy comprised of an abundance of shrubs, herbs, grasses, seedlings and saplings of trees which was more diverse than that of core zone. *Polygonum chinense, Strobilanthes cusia, Strobilanthes discolour, Diplazium maximum*and *Arisaema speciosum* were abundant in this layer.(**Fig. 5.5**)

The two layer of trees found in Reiek forest was similar to that found in mixed forest of British Guinea (Davis and Richards, 1933), Mora forest andCarapa -Eschweilera forest in Trinidad(Beard, 1946),oak/hemlock forest, Massachusetts, USA (Halle *et al.,*1978) and mixed mesophytic cove forest in Virginia, USA (Oosterhuis *et al.,* 1982). There were no tall emergents found in the study site. Herbs were the most species rich life form in the understorey.

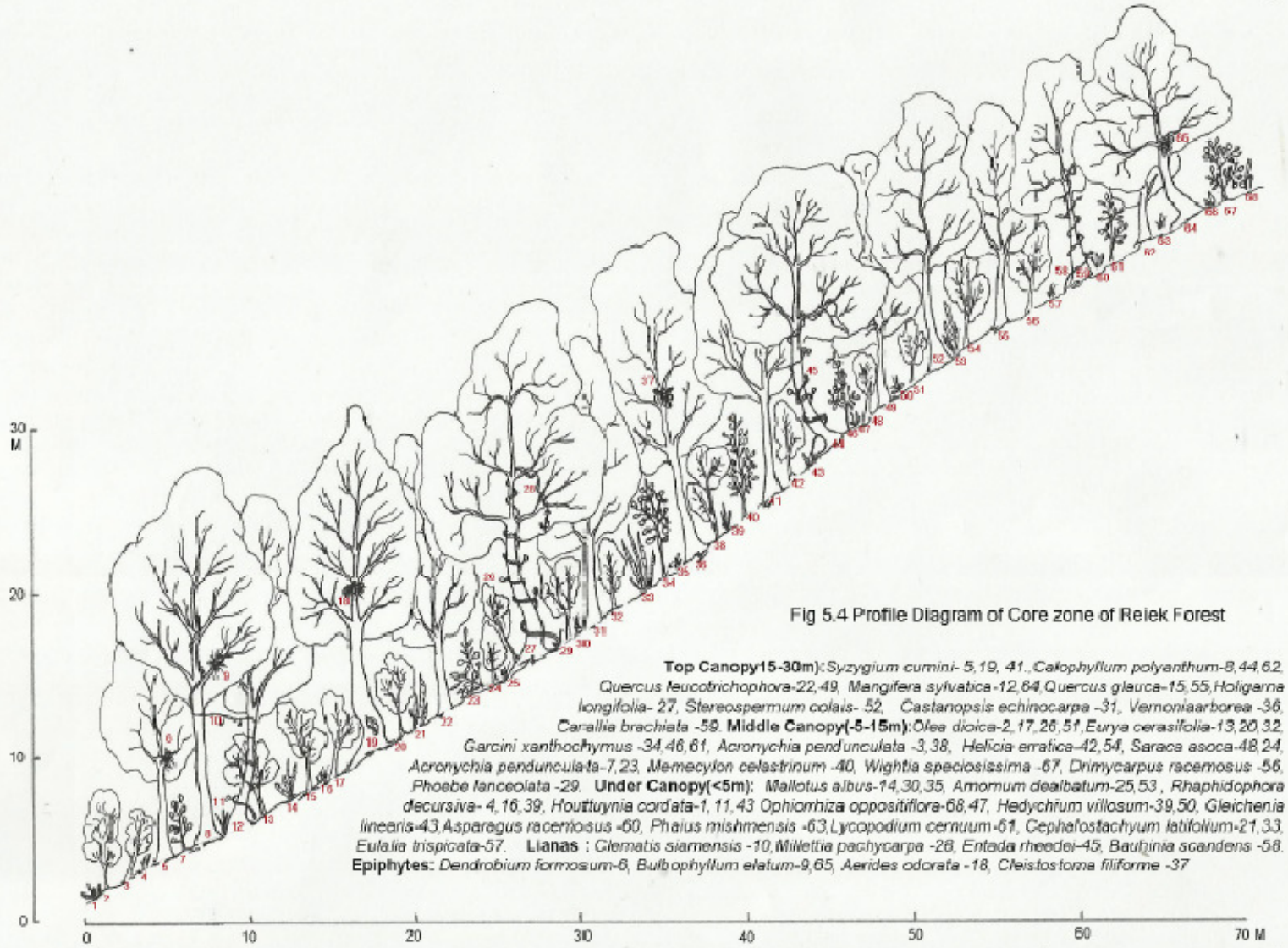


Fig 5.4 Profile Diagram of Core zone of Relek Forest

Top Canopy(15-30m): *Syzygium cumini- 5,19, 41., Calophyllum polyanthum-8,44,62, Quercus leucotrichophora-22,49, Mangifera sylvatica-12,64,Quercus glauca-15,55,Holigarna longifolia- 27, Stereospermum colais- 52, Castanopsis echinocarpa -31, Vernoniaarborea -36, Camellia brachiata -59.* **Middle Canopy(-5-15m):** *Olea dioica-2,17,26,51,Eurya cerasifolia-13,20,32, Garcini xanthochymus -34,46,61, Acronychia pedunculata -3,38, Helicia erratica-42,54, Saraca asoca-48,24, Acronychia pedunculata-7,23, Memecylon celastrinum -40, Wightia speciosissima -67, Drimycarpus racemosus -56, Phoebe lanceolata -29.* **Under Canopy(<5m):** *Mallotus albus-14,30,35, Amomum dealbatum-25,53 , Rhaphidophora decursiva- 4,16,39, Houttuynia cordata-1, 11,43 Ophiorhiza oppositiflora-68,47, Hedychium villosum-39,50, Gleichenia linearis-43,Asparagus racemosus -60, Phalus mishimensis -63,Lycopodium cernuum-61, Cephalostachyum latifolium-21,33, Eulalia trispicata-57.* **Lianas** *: Clematis siamensis -10,Millettia pachycarpa -26, Entada rheedei-45, Bauhinia scandens -58.*
Epiphytes: *Dendrobium formosum-6, Bulbophyllum elatum-9,65, Aerides odorata -18, Cleistostoma filiforme -37*

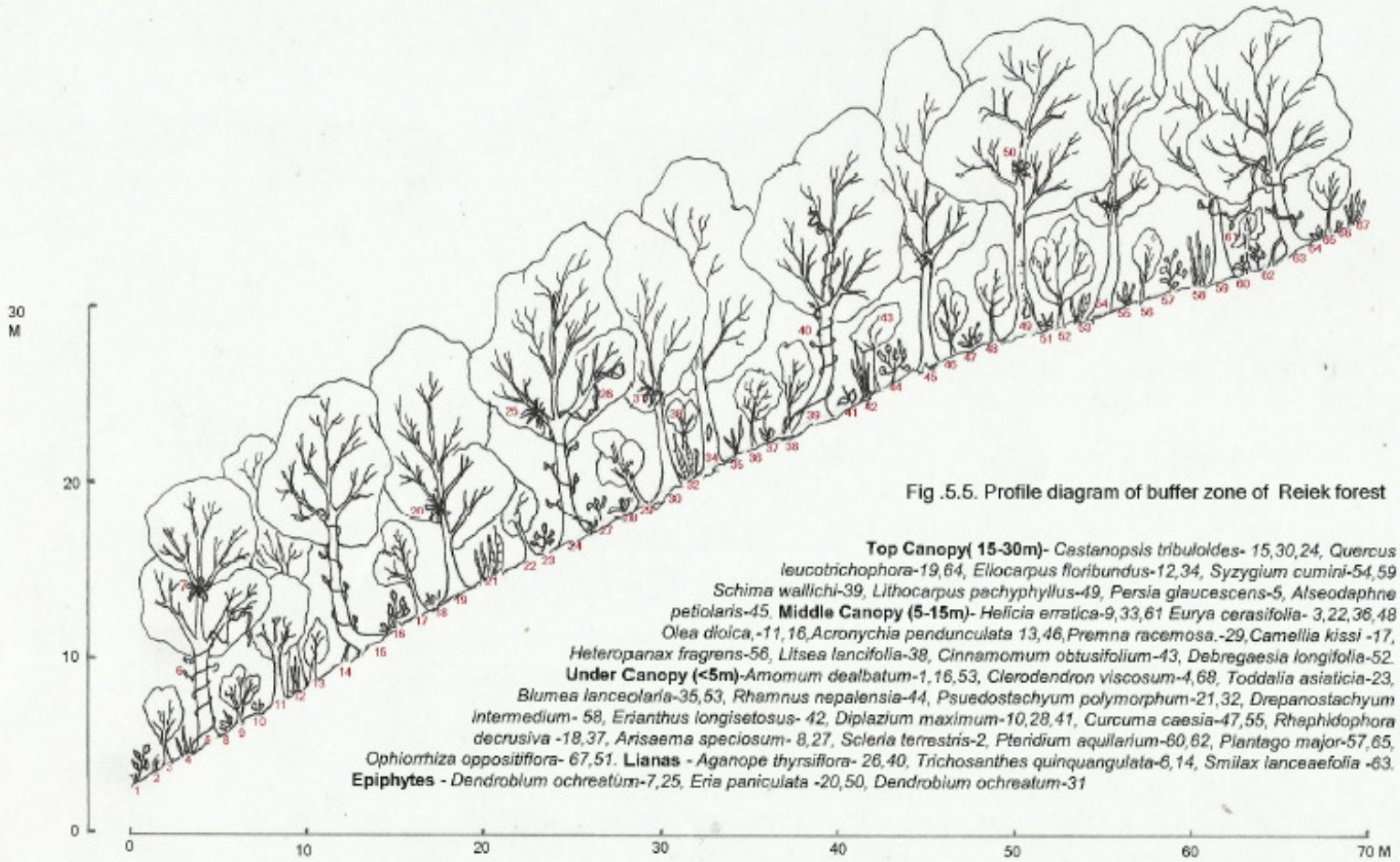


Fig .5.5. Profile diagram of buffer zone of Reiek forest

Top Canopy(15-30m)- *Castanopsis tribuloides- 15,30,24, Quercus leucotrichophora-19,64, Ellocarpus floribundus-12,34, Syzygium cumini-54,59 Schima wallichi-39, Lithocarpus pachyphyllus-49, Persia glaucescens-5, Alseodaphne petiolaris-45.* **Middle Canopy (5-15m)-** *Helicia erratica-9,33,61 Eurya cerasifolia- 3,22,36,48 Olea dioica,-11,16,Acronychia pendunculata 13,46,Premna racemosa.-29,Camellia kissi -17, Heteropanax fragrens-56, Litsea lancifolia-38, Cinnamomum obtusifolium-43, Debregaesia longifolia-52.* **Under Canopy (<5m)-***Amomum dealbatum-1,16,53, Clerodendron viscosum-4,68, Toddalia asiaticia-23, Blumea lanceolaria-35,53, Rhamnus nepalensia-44, Psuedostachyum polymorphum-21,32, Drepanostachyum intermedium- 58, Erianthus longisetosus- 42, Diplazium maximum-10,28,41, Curcuma caesia-47,55, Rhaphidophora decrusiva -18,37, Arisaema speciosum- 8,27, Scleria terrestris-2, Pteridium aquilarium-60,62, Plantago major-57,65, Ophiorrhiza oppositiflora- 67,51.* **Lianas** *- Aganope thyrsiflora- 26,40, Trichosanthes quinquangulata-6,14, Smilax lanceaefolia -63.*
Epiphytes *- Dendrobium ochreatum-7,25, Eria paniculata -20,50, Dendrobium ochreatum-31*

5.5. Conservation status: Rare and threatened species

The conservation status of all the plant species have been assesed with the help of IUCN Red List of Threatened species. Out of the 283 species identified, only 17 have been assessed by the IUCN out of which only one is endangered i.e *Borassus madagascariens*. 2 species have been identified as vulnerable which are *Eleocarpus rogusus* and *Saraca asoca.* 1 species *Amomum dealbatum* is placed under Data Deficient. 13 species have been placed under Least concern which is the lowest risk. These species are *Calamus tenuis, Aglaia spectabilis, Engelhardia spicata, Mangifera sylvatica, Woodfordia fructicosa, Centella asiatica, Commelina benghalensis, Cyperus rotundus, Kyllinga brevifolia, Lindernia ruellioides, Mimosa pudica, Persicaria hydropiper, Scleria terrestris.*

The plants were also screened using the Red Data Book of Indian plants(Nayar and Sastry,1987-1990) published by Botanical Survey of India. None of the species were listed in the three volumes

Based on the Importance Value Index, the species with less than IVI value lower than 1 and represented by only one individual in the sampled area have been classified as rare species. In the buffer zone, a total of 9 rare species are found which are *Cephalotaxus griffithii, Dysoxylum gobara, Ficus semicordata, Ficusreligiosa, Carallia brachiate, Ficus Prostrata, Grevillea robusta, Elaeocarpus lanceaefolius, and Macropanaxundulatus.* In the core zone, 13 rare species are found which are *Calliandra umbrosa, Castanopsis indica, Trema orientalis, Mesua ferrea, Alangium chinense, Ficus benghalensis, Syzygium claviflorumachys, Ficus benjamina* and *Sapium baccatum***.**

Table 5.24 Trees- Uses, zone where species occur and IUCN status

(C= Core zone, B=Buffer zone, G = Grassland zone, NE= Not Evaluated, LC= Least Concern, Vu= Vulnerable, En = Endangered, DD= Data Deficient)

Sl no	Name of Species	Family	Uses	Zone where species occur	IUCN Status
1	*Acer laevigatum* Wall. 'Thing-khim'	Aceraceae	Wood hard, used for building, furniture, fence post, firewood and charcoal. Decoction of leaves used in sprain and broken bone.	C, B	NE
2	*Acronychia pendunculata* (L.)Miq 'Rah-var'	Rutaceae	Wood used for firewood, leaves and bark are used in medicine	C,B	NE
3	*Aglaia spectabilis* (Miq.)S.S.Jain & S.Bennet. 'Sa-ha-tah'	Meliaceae	Wood used as firewood	C	LC
4	*Alangium chinense* (Lour.) Harms 'Ar-sa-rim-nam'	Alangiaceae	Wood elastic, used for firewood. Fruit eaten by birds	C	NE
5	*Alphonsea ventricosa* (Roxb.) Hook. f. & Thomson 'Zawng-bal-hla'	Annonaceae	Wood elastic, used for boat building, native bows, posts, poles, firewood etc. Fruit eaten by man, wild animals and birds	C,B	NE
6	*Alseodaphne petiolaris* (Meissn.) Hook. f. 'Bul-pui/Khuang-thulh'	Lauraceae	Wood grey or reddish brown, used for building, furniture, firewood, etc. Fruit eaten by birds and wild animals	C,B	NE
7	*Amoora chittagonga* (Miq.) Hiern 'The-hlei-khak'	Meliaceae	Wood hard, used for house post, firewood etc. Fruit eaten by birds and wild animals	C	NE
8	*Anogeissus acuminata* (Roxb. ex DC.) Guillaumin *et al*. 'Zai-rum'	Combretaceae	Wood hard, used for house posts, tool handles, fuel and charcoal. Decoction of bark is used in diarrhoea and also applied in measles, chicken-pox, sprains and burns. Leaves are cooked in water and water is taken as a remedy for high blood pressure. Fruit and flower eaten by birds	C	NE
9	*Betula*	Betulaceae	Wood red, hard, used for	C	NE

	*cylindrostachys*Wall. ex Diels 'Hriang-zau'		building, furniture, firewood and charcoal		
10	*Bombax insigne* Wall 'Pang'	Bombacaceae	Wood is used for making match-boxes, splints, drums, cheap furniture. Leaves are used as fodder. Fruit and seed eaten by birds and rodents. Flower nectar sucked by birds and flower eaten by wild animals	C	NE
11	*Bruinsmia polysperma* (C.B. Clarke)Steenis 'Thei-pa-ling-kawh'	Styracaceae	Wood used for firewood. Leaves as fodder. Pulp of fruit edible	B	NE
12	*Calliandra umbrosa* (Wall.)Benth. 'Seng-ma-tawk'	Mimosaceae	Wood elastic, can be used for firewood, etc. Nectar of the flower is sucked by birds	C	NE
13	*Calophyllum polyanthum*Wall. ex Choisy 'Sen-te-zel'	Guttiferae	Wood red brown, quite hard and used for construction of bridges, railway sleepers, buildings and for firewood. Fruit eaten by wild animals	C, B	NE
14	*Camellia kissi* Wallich 'Lal-lai'	Theaceae	Wood used for fence posts, tool handles and firewood. Leaves can be used as a substitute for tea, oil cake is used for poisoning fish	C,B	NE
15	*Carallia brachiata* (Lour.) Merr. 'Thei-ria'	Rhizophoraceae	Wood red, hard, used for furniture, picture frames, pestle, panelling, firewood, etc. Leaves lopped for fodder. Fruit eaten by man, wild animals and birds	C, B	NE
16	*Castanopsis echinocarpa*Miq. 'Then-ngo'	Fagaceae	Wood used for firewood. Nut eaten by man, animals and birds	C	NE
17	*Castanopsis indica* (Roxb. ex Lindl.) A.DC. 'Se-hawr'	Fagaceae	Wood hard, used for building, furniture, axe handle, firewood, etc. Leaves are used for cigarette. Nut eaten by man, wild animals and birds	C, B	NE
18	*Castanopsis tribuloides* (Sm.)	Fagaceae	Wood used for house-post, firewood and charcoal. Nut	C, B	NE

	A.DC. 'Thing-sia'		eaten by man, animals and birds. Juice of stem used to treat children mouth infection.		
19	*Celtis timorensis Span.* 'Thing-hmar-cha'	Ulmaceae	Wood hard, unpleasant scent, used for medicine, tool handles, firewood, etc. Fruits eaten by birds.	B	NE
20	*Cephalotaxus griffithii* Hook. f. 'Tu-far'	Cephalotaxaceae	Wood light brown, used for building, furniture	C, B	NE
21	*Cinnamomum glanduliferum* (Wall.) Meisner 'Khiang-zo'	Lauraceae	Wood is scented, durable, used for furniture, boxes, house building, posts, firewood, etc. Decoction of bark is useful for pneumonia, bronchitis. Bark used for poisoning fish. Fruit eaten by wild animals and birds	C, B	NE
22	*Cinnamomum obtusifolium* (Roxb.) Nees. 'Hnah-zung-thum'	Lauraceae	Wood reddish-grey, shining, used for planking, tea boxes, firewood and charcoal. Aromatic leaves used as food flavouring and the bark in medicine. Fruit eaten by bears and birds.	B	NE
23	*Cinnamomum verum* J.Presl 'Thak-thing'	Lauraceae	Wood used for firewood, the bark as spice or condiment, leaves used for flavouring food and oil extracted from bark is used in perfumes. Decoction of bark is used in cancer, diarrhoea and vomiting. Fruits eaten by birds.	C, B	NE
24	*Coffea khasiana* (Korth.) Hook.f. 'Ngul-ri-thet'	Rubiaceae	Used as live fence, posts and drupes are eaten by birds.	C	NE
25	*Colona floribunda* (Wall. ex Kurz) Craib 'Hnah-thap'	Tiliaceae	Wood used for firewood	C	NE
26	*Croton hookeri Veitch* *'Ba-ken-fung'*	Euphorbiaceae	Wood used for firewood. Decoction of leaves is used for black water fever and applied externally for sprains and sinew-ache. Fruit eaten by birds	C, B	NE

27	*Cryptocarya amygdalina* Nees Bauch.Ham 'Thak-thing-suak'	Lauraceae	Wood light brown, moderately hard, used for tea-boxes etc.	B	NE
28	*Cycas pectinata Buch.-Ham* 'Kawk-pui'	Cycadaceae	Yields a coarse sago that is eaten with the fruit (Negi)	C	Vu
29	*Debregeasia longifolia* (Burm. f.) Wedd. 'Leh-ngo'	Urticaceae	Tender leaves are eaten cooked as vegetable, often cooked with fish or meat. Pounded leaves are applied on burns. Fibre is used for cordage and leaves for pig-feed. Fruits are eaten by man and birds.	B	NE
30	*Diospyros lancifolia* Wallich *ex* Hiern 'Zo-thing-hang'	Ebenaceae	Wood grey or yellow, used for firewood, the pole for temporary building, fence post, etc	C, B	NE
31	*Drimycarpus racemosus* (Roxb.) Hook.f. 'Vawm-bal'.	Anacardiaceae	Wood yellowish grey, used for building boats, canoes, etc. The drupes are eaten by wild animals.	C, B	NE
32	*Dysoxylum gobara* (Buch.-Ham.) Merr. 'Thing-thu-pui'	Meliaceae	Wood used as fire wood, young leaves, shoots and flowers as vegetables. Decoction of leaves and buds in used in diarrhoea and dysentery	C, B	NE
33	*Elaeocarpus floribundus* Blume 'Thing-lung'	Tiliaceae	Wood is heavy, used for building, pestle, firewood etc. Fruit is eaten cooked or pickled.	C, B	NE
34	*Elaeocarpus lanceaefolius* Roxb. 'Kha-ruan'	Tiliaceae	Wood brown, used for tea boxes, house building, firewood and charcoal. Kernel of seed is edible. Fruit eaten by man and animal. Flower necter sucked by birds	B	NE
35	*Elaeocarpus rugosus* Roxb. 'Thei-kel-ek'	Tiliaceae	Wood light brown, soft, used for tea-boxes, firewood, etc. Fruit eaten by man and birds	C, B	Vu
36	*Elaeocarpus tectorius* (Lour.) Poir. 'Um-khal'	Tiliaceae	Wood white, used for firewood. Kernel of the seed is edible. Fruit eaten by man, cattle, wild animals and birds	C, B	NE

37	*Embelia tsjeriam-cottam* A.DC. 'Rah-sen'	Myrsinaceae	Wood used for firewood. Bark, leaves and fruits are used in medicine. Fruit eaten by birds	C, B	NE
38	*Engelhardtia roxburghiana*Wall. 'Phek-phe'	Juglandaceae	Wood light red, moderately hard, used for house building, tea boxes, carving and firewood. Bark is used to poison fish	C, B	NE
39	*Engelhardtia spicata* Leschen, *ex*. Blume 'Hnum'	Juglandaceae	Wood used for house building, tea-boxes, packing cases, carvings, etc. Bark is medicinal, also used for fish poisoning and tanning. Leaves used for fodder	C, B	LC
40	*Eriobotrya bengalensis* (Roxb.) Hook. f. 'Nghal-chhun'	Rosaceae	Wood used for firewood and charcoal. Leaves used as fodder. Fruit eaten by wild animals	C	NE
41	*Eurya cerasifolia* (D.Don)Kobuski 'Si-hneh'	Pentaphylacaceae	Wood used for firewood and charcoal, tender leaves are eaten cooked with rice or meat, fruit eaten by birds	C, B	NE
42	*Eurya loquaiana* Dunn 'Zo-si-hneh'	Pentaphylacaceae	Leaves are medicinal	C, B	NE
43	*Ficus benghalensis* L. 'Bung'	Moraceae	Wood used for well curbs etc. Bark and aerial roots used for making coarse ropes. Leaves used for fodder. Infusion of bark used in diabetes. Juice of stem is applied externally for rheumatism, toothache and bruises. Fruit eaten by man, wild animals and birds.	C	NE
44	*Ficus benjamina* L. 'Za-man-hmawng'	Moraceae	Wood soft, used for firewood. Decoction of leaves mixed with oil is applied to ulcer. Fruit eaten by wild animals and birds.	C	NE
45	*Ficus Prostrata* (Wall. ex Miq.) Miq. 'Thei-tit'	Moraceae	Wood is used for firewood. Juice of the root is given in snake bite. Leaves are used as fodder. Fruits are eaten by man and wild animals.	C,B	NE

46	*Ficus religiosa* L. 'Hmawng'	Moraceae	Wood durable under water, used for fuel and charcoal. Bark, fruit and leaves are used in medicine. Leaves and twigs lopped for fodder. Fruit eaten by wild animals and birds.	B	NE
47	*Ficus semicordata* Buch.-Ham. ex Sm. 'Thei-pui'	Moraceae	Wood used for mortars, firewood etc. Bark fibre is used for making ropes. Leaves are used as fodder. White latex is applied on boils. The root, bark and fruits are used in medicine. Fruits are eaten by man, wild animals and birds	B	NE
48	*Garcinia xanthochymus* Hook. f. ex T. Anderson'Tuai-ha-bet'	Guttiferae	Wood used for firewood. Bark uses as dye. Fruit is edible, used in medicine. Seeds are eaten by porcupine	C, B	NE
49	*Glochidion khasicum (*Müll.Arg.) Hook.*f.* 'Thing-pawn-chhia'	Euphorbiaceae	Wood used for firewood. Fruit eaten by birds	C, B	NE
50	*Grevillea robusta* A. Cunn. ex R. Br. 'Silver Oak'	Proteaceae	Wood light reddish brown, hard, used for furniture, flooring, tool handles, firewood etc. Nectar of flower sucked by birds	B	NE
51	*Gynocardia odorata* R. Br. 'Sai-thei'	Flacourtiaceae	Wood hard. Used for planking, post and firewood. Bark and fruit pulp used for poisoning fish. Fruit is useful in bronchitis, ulcers, skin diseases, small tumors, leprosy, diabetes, gonorrhoea, fever and piles. Fruit is eaten by wild animals	C, B	NE
52	*Helicia erratica* Roxb. 'Sial-hma'	Proteaceae	Wood used for firewood. Decoction of the bark is used in colic and stomach ache treatment and for strengthening the function of uterus	C, B	NE
53	*Heteropanax fragrans*(Roxb.)Seem	Araliaceae	Young leaves eaten as vegetable and cattle fodder. Eri silkworm also	C, B	NE

	'Chang-khen'		feed on leaves. Fruit and flower eaten by birds		
54	*Holigarna longifolia* Buch.-Ham. ex Roxb 'Vawm-bal-hnah-hlai'	Anacardiaceae	Wood light grey, used for making small boats. The juice from stem used as varnish. Bark and fruit are medicinal. Fruit eaten by wild animals.	C	NE
55	*Lithocarpus elegans* (Blume) Hatus. ex Soepadmo 'Thing-pui-thing'	Fagaceae	Wood red, very hard, used for building, rice pestle, firewood, charcoal. Fruit eaten by wild pigs, porcupine, squirrel, etc	C, B	NE
56	*Lithocarpus pachyphyllus*(Kurz) Rehder 'Then-sen'	Fagaceae	Wood grey, durable used for planking shingles, firewood, etc. Bark and acorns are used as astringent. Acor devoured by wild animals like wild boar, etc	C, B	NE
57	*Litsea lancifolia* Roxb. ex Nees 'Hnah-paw-te'	Lauraceae	Wood used for firewood	C, B	NE
58	*Litsea monopetala* (Roxb.) Pers. *'Nauthak'*	Lauraceae	Wood olive grey, soft, not durable, used for firewood. Muga silkworms are reared on the leaves. Bark is used in medicine and leaves for fodder	B	NE
59	*Macaranga indica* Wight 'Khar-duap'	Euphorbiaceae	Wood greyish red, soft, can be used as firewood. Gum is applied to sores. Fruits eaten by wild animals and birds	C, B	NE
60	*Macropanax undulatus* (Wall. ex G.Don) Seem. 'Phuan-berh'	Araliaceae	Wood is used as firewood	C, B	NE
61	*Magnolia hodgsonii* (Hook.f. & Thomson) H.Keng 'Thing-tum-bu'	Magnoliaceae	Wood is soft, grey and used for handles of knives, firewood etc. Fruit eaten by birds and squirrels	C	NE
62	*Mallotus philippensis* (Lam.) Müll.Arg. 'Bawng-khei'	Euphorbiaceae	Wood hard, used for bobbins, firewood and charcoal. Crimson powder which covers fruit is used for dyeing silk. Decoction of the bark/leaves is recommended for diarrhea, dysentery,	C	NE

			diabetes. Glands and hairs on the fruit are useful in scabies, ringworm and other skin diseases. Leaves eaten by sheep and goat, fruit by birds.		
63	*Mangifera sylvatica* Roxb. *'Hai-fa-vang'*	Anacardiaceae	Wood hard, used for cheap furniture, boat building, planking, tea-boxes, packing cases, door and window-frames. Fruit is eaten by man and wild animals.	C, B	LC
64	*Memecylon celastrinum*Kurz 'Thei-kawr-ak'	Melastomataceae	Wood is used for tool handles. Fruit eaten by man, wild animals and birds	C, B	NE
65	*Mesua ferrea*Linn. 'Herhse'	Guttiferae	Wood very hard, used for railway sleepers, bridges, posts, tool handles gunstock, rice pestle, firewood and charcoal. Bark, flower, unripe fruit and seed oil are medicinal. Seed eaten by wild animals	C	NE
66	*Michelia champaca* Linn. 'Ngiau'	Magnoliaceae	Wood durable, used for furniture, house building, panelling, drums, plywood, firewood, etc. Leaves used as fodder. Bark, roots, leaves, flowers and fruits are used in medicine. Fruit eaten by birds and wild animals	C	NE
67	*Musa sylvestris* LA Colla 'Chang-el'	Musaceae	The bud, flower and pith of stem are eaten as vegetable. Leaves used for fodder. Pith of stem is used for expelling intestinal round worms from the body and externally for bites of snake, centipede and large spider. Juice of stem is used for diarrhoea and dysentery. Fruit eaten by birds and wild animals	C	NE
68	*Neolamarckia cadamba* (Roxb.) Bosser 'Ban-phar'	Rubiaceae	Wood used for planks, furniture, boxes, matches, plywood, pulpwood, firewood etc and leaves	C	NE

			lopped for fodder. Spirit is distilled fromm flowers. Bark and leaves are medicinal. Fruit eaten by man, wild animals and birds.		
69	*Olea dioica Roxb.* 'Se-vuak'	Oleaceae	Wood used for tool-handles, firewood and charcoal. Bark used as febrifuge. Fruit eaten by birds and wild animals	C, B	NE
70	*Olea salicifolia* Wall.*ex* G.Don 'Thing-thiang'	Oleaceae	Wood is used for firewood. Fruit eaten by birds	C, B	NE
71	*Ostodes paniculata* Blume ' Bel-tur'	Euphorbiaceae	Wood used for firewood. Gum is used in manufacturing paper. Leaves are used as fodder and fruit to poison fish. Seeds are used as purgative and eaten by birds and animals.	C, B	NE
72	*Persea glaucescens* Nees. 'Sa-per-bul'	Lauraceae	Timber is durable, used for furniture, boat building, etc. Fruit eaten by birds and wild animals	C, B	NE
73	*Persea villosa* (Roxb.) Kosterm. 'Bul-bawr'	Lauraceae	Wood yellowish brown, moderately hard, used for house construction, posts, etc. Fruit eaten by birds	C, B	NE
74	*Phoebe lanceolata* (Nees) Nees 'Bul-fek'	Lauraceae	Wood used for firewood. Leaves for cattle fodder. Fruit eaten by bird	C, B	NE
75	*Pithecolobium bigeminum* (L.) Mart. 'Ar-dah-te'	Mimosaceae	Wood is used for planking, battens, etc. Bark is used for poisoning fish. Leaves and seeds are used medicinally	C, B	NE
76	*Premna racemosa* Wall. ex Schauer 'Thing-sa-um'	Lamiaceae	Wood used for firewood. Fruits are eaten by birds	C, B	NE
77	*Prunus jenkinsii*Hook.f. & Thomson 'Kei-pui'	Rosaceae	Wood is used for firewood, rice-pestles, etc. Leaves used as fodder. Fruit eaten by man and wild animals	C, B	NE
78	*Pterospernum semisagittatum* Buch.-Ham. ex Roxb. 'Mu-khau'	Sterculiaceae	Wood reddish –grey, used for tool-handles and firewood	C, B	NE
79	*Quercus*	Fagaceae	Wood grey or greyish-	C, B	NE

	*glauca*Thunb.in A.Murray 'Hrum-hriau'		brown, very hard, used for tool handles, firewood and charcoal. Fruit eaten by wild animals.		
80	*Quercus leucotrichophora* A.Camus 'Then'	Fagaceae	Wood reddish brown, very hard, used for house building, tool handles firewood and charcoal. Leaves are lopped for fodder. Acorn eaten by birds and wild animals	C, B	NE
81	*Randia wallichii* Hook.f. 'Sa-phut'	Rubiaceae	Wood used for building, firewood, charcoal etc. Fruit eaten by man, squirrel and birds.	C	NE
82	*Rhus semialata* Murray. 'Khawm-hma'	Anacardiaceae	Wood used for fence post and gunpowder charcoal. Decoction of fruit used in colic and diarrhoea. Leaves are boiled and water is used for bath in measles. Fruit eaten by man, birds and squirrels.	B	NE
83	*Rhus succedanea* (L.) Kuntze 'Chhim-hruk'	Anacardiaceae	Wood used for house post, gun stock and firewood. Lacquer varnish is obtained by tapping the bark, wax of seed is made into candles. The thorn-like excrescences on the branches are used in medicine. Fruit eaten by birds	B	NE
84	*Sapium baccatum* Roxb. 'Thing-vawk-pui'	Euphorbiaceae	Wood grey, soft, used for plywood, packing cases, firewood etc. Fruit eaten by man, wild animals and birds	C	NE
85	*Saraca asoca* (Roxb.) Willd. 'Mual-hawih'	Fabaceae	Wood soft, used for tool handles, ploughs and shafts. Tender leaves are eaten cooked as vegetable. The bark, flowers, seed used in medicine. Fruit eaten by wild animals and nectar of flower sucked by birds	C, B	Vu
86	*Schima wallichii (*DC.)Korthals 'Khiang'	Theaceae	Wood used for house-building, firewood. Bark used for poisoning fish	C, B	NE
87	*Securinega virosa*	Euphorbiaceae	Wood durable, used for	C	NE

	(Roxb. ex Willd.) Baill. 'Sai-siak'		agricultural implements, fence, posts. Bark is used for poisoning fish. Decoction of leaves is used for bath in case of measles, chicken pox, scabies and skin itching. Fruit are eaten by birds		
88	*Stephegyne diversifolia (*Wall. ex G.Don)Brandis 'Pual-eng'	Rubiaceae	Wood yellowish brown, moderately hard, used for house-building, firewood, etc	C, B	NE
89	*Sterculia hamiltonii* (Kuntze) Adelb. 'Tlingi-leh-ngama-inchhawlthuaina'	Sterculiaceae	Tender fruit eaten cooked like beans and mature seeds are eaten fried or roasted. Bark is used for making fibre.	C	NE
90	*Sterculia villosa* Roxb. 'Khau-pui'	Malvaceae	Wood greyish-brown, very soft, used for drums and paper pulp. Seeds are eaten roasted or fried. Bark yields strong fibre. Decoction of bark used in cholera, dysentery, diarrhoea and tonsillitis. Fruit eaten by birds and wild animals. Flower nectar sucked by birds.	C	NE
91	*Stereospermum colais* Buch.-Ham. Ex Dillwyn 'Zih-nghal'	Bignoniaceae	Wood used for building, house post, mortars, beams, planking, furniture, firewood, etc. Leaves used for fodder, remedy for colic. Fruit eaten by birds	C, B	NE
92	*Styrax serrulatum*(Roxb) 'Hmar-hleng'	Styracaceae	Wood used for firewood. yields balsamic resin. Leaves lopped for fodder. Fruit eaten by birds	C, B	NE
93	*Syzygium claviflorum* (Roxb.) Wall. ex A.M.Cowan & Cowan 'Hmui-fa-rial'	Myrtaceae	Wood used for firewood. Fruit eaten by man, bear and birds	C,B	NE
94	*Syzygium cumini (L.) Skeels* 'Len-hmui'	Myrtaceae	Wood used for plywood, gunstock, tool handles, posts, rafters, door frames and panels, firewood, etc. Seed is use in treatment of diabetes, bark in treatment of sore-throat,	C, B	NE

			bronchitis, asthma, ulcers and chronic dysentery. Fruit eaten by man, wild animals and birds		
95	*Syzygium fruticosum* DC. 'Hmui-fang-rawng-bel'	Myrtaceae	Juice of the tender leaves with rice water is taken in blood dysentery	C	NE
96	*Trema orientalis* (L.) Blume 'Bel-phuar'	Ulmaceae	Wood light reddish grey, soft used for making gun powder charcoal. Bark yields strong fibre. Leaves lopped for fodder. Plant used in epilepsy. Fruit eaten by birds and wild animals	C	NE
97	*Ulmus lanceifolia* Roxb. 'Phan'	Ulmaceae	Wood hard and used for implements, house building, etc. Leaves are used as fodder	C, B	NE
98	*Vernonia arborea* Buch.-Ham	Asteraceae	Timber is used as firewood or for light indoor construction. Mixture of leaves is used to make a tonic for women after childbirth.	C	NE
99	*Vernonia volkameriaefolia* Bedd 'Khup-al'	Compositae	Wood is used for firewood. Leaves are lopped for fodder.	C	NE
100	*Vitex quinata* (Lour.) F. N. Williams 'Thleng-reng'	Verbenaceae	Wood yellow, used for firewood. The fruit is eaten by palm civets and birds	C	NE
101	*Wendlandia grandis* (Hook.*f*.) Cowan 'Ba-tling'	Rubiaceae	Wood reddish yellow, soft used for gun powder, charcoal, firewood, etc. The pole is also used for fencing post. Flowers edible	C, B	NE
102	*Wightia speciosissima* (D. Don) Merr 'Chawng-tlai'	Scrophulariaceae	Wood white, soft, used for ceiling, partition wall, etc. Nectar of flower is sucked by birds	C	NE
103	*Ziziphus incurva*Roxb. 'Hel'	Rhamnaceae	Wood reddish, hard. Used for firewood. Fruit eaten by birds.	C, B	NE

Table 5.25 Shrubs- Uses, Zone where species occur and IUCN status

(C= Core zone, B=Buffer zone, G = Grassland zone, NE= Not Evaluated, LC= Least Concern, Vu= Vulnerable, En = Endangered, DD= Data Deficient)

Sl.no	Name of species	Family	Uses	Zone where species occur	IUCN status
1	*Amomum dealbatum* Roxb. 'Ai-du'	Zingiberaceae	Roots and bids are eaten as vegetable. Fruit sweet, eaten by man and wild animals. Plant is also prescribed for enlargement of liver	C, B	DD
2	*Antidesma diandrum* (Roxb.) B.Heyne ex Roth	Euphorbiaceae	Leaves used in sores, dropsy, muscular pain, dysentery , pneumonia and intercoastal neuralgia	C	NE
3	*Blumea lanceolaria* (Roxb.) Druce 'Buar-ze'	Asteraceae	Tender leaves are cooked as vegetable. Leaves are recommended for stomach ulcer, indigestion, asthma, T.B., chronic dysentery. The juice of the leaves is applied externally to scabies, skin diseases, sores, dandruff.	C, B	NE
4	*Butea minor*Buch.-Ham. ex Baker 'Thual-thu'	Papilionaceae	Seeds are given as purgative and vermifuge	G	NE
5	*Callicarpa dichotoma* (Lour.) K. Koch	Lamiaceae	-	C	NE
6	*Chromolaena odorata* (L.) R.M.King & H.Rob. 'Tlang-sam'	Compositae	Juice of the leaves is applied to new cuts. Plant is also used as fish poison	B	NE
7	*Clerodendrum viscosum* Vent. 'Phui-hnam-chhia'	Verbenaceae	Leaves are tonic and used in malaria, scorpion sting and snake-bite. The roots or leaves are boiled and water is used for bath in case of scabies and other skin disease	C, B	NE
8	*Disporum cantoniense* (Lour.) Merr.	Liliaceae	The juice of the roots is used in the treatment of fevers.Tender leaves and young shoots are cooked. Used as a vegetable	C, B	NE
9	*Elaeagnus pyriformis* Hook.f 'Sar-zuk-te'	Elaeagnaceae	Decoction of root is given to women after giving birth to expel pieces of retained	C, B	NE

			placeta. Ripe fruit eaten by man and birds. Nectar of flower is sucked by birds		
10	*Ipomoea batatas* (L.) Lam. 'Kawl-ba-hra'	Convolvulaceae	Root is sweet, stops diarrhoea. Leaves are eaten cooked as vegetable and used against diarrhoea, dysentery, stomach-ache, digestive troubles and food poisoning. The tubers are eaten by man and wild animals. Leaves are browsed by barking deer and used to feed pigs	B	NE
11	*Lasianthus hookeri* C. B. Clarke ex J. D. Hooker	Rubiaceae	-	C, B	NE
12	*Leea indica* (Burm.f.) Merr 'Kawl-kar'	Vitaceae	Leaves are used as vegetable. Root is medicinal. Ripe fruit eaten by man and birds	C, B	NE
13	*Lepisanthes senegalensis* (Juss. ex Poir.) Leenh. 'Zu-til'	Sapindaceae	Wood tough, used for tool handles. Ripe fruit eaten by man and birds	C	NE
14	*Maesa indica* (Roxb.) A. DC. 'Ar-ngeng'	Primulaceae	The tender leaves are used in curries and colic. The leaves and fruits are used for poisoning fish. Berries eaten by children and birds	C, B	NE
15	*Mallotus albus* (Roxb. ex Jack) Müll.Arg	Euphorbiaceae	Wood may be used for construction purpose	C, B	NE
16	*Melastoma nepalensis* Lodd. 'Builukham'	Melastomataceae	Fruit eaten by man and bird	B, G	NE
17	*Murraya koenigii* (L.) Spreng. 'Ar-pa-til'	Rutaceae	Wood hard, durable, used for agricultural implements. Leaves are used for flavouring curries. Leaves and roots are medicinal. Fruit eaten by birds	C, B	NE
18	*Mycetia longifolia* (Wall.) Kuntze	Rubiaceae	Leaves are cooked and eaten as vegetable in Arunachal pradesh	C, B	NE
19	*Osbeckia chinensis* L. 'Builukham'	Melastomtaceae	Decoction of roots is useful in diseases of kidney, dysuria, stomach complaints, dysentery and	B, G	NE

			for expelling thread worms from the body		
20	*Osbeckia crinite* Benth. ex Naudin 'Builukhampa'	Melastomataceae	Decoction of the leaves is used for toothache	B, G	NE
21	*Polygonum chinense* L. 'Ta-ham'	Polygonaceae	Tender leaves are eaten cooked as vegetable or for pig feed. Stalk used for rubbing warts. Young leaves eaten by barking deer	B, G	NE
22	*Randia fasciculata* (Roxb.) DC.	Rubiaceae	-	C	NE
23	*Rauvolfia densiflora* (Wall.) Benth. ex Hook. f.	Apocynaceae	The root is used to reduce blood pressure	C, B	NE
24	*Rhamnus nepalensis* M. Laws. 'Sen-tiar'	Rhamnaceae	Fruit is said to be medicinal. Berries are eaten by birds	C, B	NE
25	*Rubus buergeri* Miq 'Sial-i-nu-chhu'	Rosaceae	Leaves and fruits are medicinal. Fruit is eaten by man and birds	B	NE
26	*Strobilanthes cusia* (Nees) Kuntze 'Ting	Acanthaceae	The leaves yield blue dye. Leaves are also used in medicine	B	NE
27	*Strobilanthes discolor* (Nees) T. Anderson 'Ram-ting'	Acanthaceae	Leaves used to treat intestinal worm	B	NE
28	*Strobilanthes parryorum* T.Anders. 'Ram-ting-hmulchi'	Acanthaceae	-	B	NE
29	*Symplocos lancifolia* Siebold et Zucc.	Symplocaceae	Leaves have anti-bacterial properties	C,B	NE
30	*Tabernaemontana divaricata* (L.) R. Br. ex Roem. & Schult. 'Par-arsi'	Apocynaceae	Leaves are eaten cooked as vegetables. Red pulp around the seed is used as dye. Milky juice is prescribed in eye disease, the root bark for mouth sores, toothache, scorpion sting and epilepsy. The juice of bark is used to treat convulsion	C, B	NE
31	*Toddalia asiatica* L. 'Nghar-dai'	Rutaceae	Berries edible. Bark of root is used in fever and fresh	C, B	NE

			leaves in stomach complaints. The root bark yields a yellow dye.		
32	*Viburnum foetidum* Wall 'Zothei'	*Caprifoliaceae*	Fruit eaten by humans and birds	B, G	NE
33	*Woodfordia fruticosa* (L.) Kurz 'Ai-nawn'	*Lythraceae*	Wood hard, suitable for axe handle and firewood. Flowers are used for dying silk and the bark in medicine	B	LC

Table 5.26 Herbs- Uses, zone where species occur and IUCN status

(C= Core zone, B=Buffer zone, G = Grassland zone, NE= Not Evaluated, LC= Least Concern, Vu= Vulnerable, En = Endangered, DD= Data Deficient)

Sl. no	Name of Species	Family	Uses	Zone where species occur	IUCN Status
1	*Adiantum caudatum* Linn	Adiantaceae	Fronds used for decoration	B	NE
2	*Ageratum conyzoides* L. 'Vai-len-hlo'	Asteraceae	Juice of the roots and leaves are useful as application in skin diseases, opthalmia and fresh cuts	G	NE
3	*Alectra indica* Benth	Scrophulariaceae	-	G	NE
4	*Allium tuberosum* Rottler ex Spreng 'Kham-pu-run'	Liliaceae	Leaves and the stalks of the flowers are used as a flavoring in cooking	G	NE
5	*Arisaema album* N.E.Br.	Araceae	-	B	NE
6	*Arisaema speciosum* (Wall.) Mart. 'Tel-hawng'	Araceae	The corm is cooked with ashes in water and eaten as vegetable	C, B	NE
7	*Asparagus racemosus* Willd.	Asparagaceae	Roots used as a uterine tonic, as a galactogogue (to improve breast milk), in hyperacidity, and as a general health tonic.	C, B	NE
8	*Begonia dioica* Buch. -Ham. ex D.Don 'Sekhupthur'	Begoniaceae	Stem and leaves are eaten to treat diarrhoea and dysentery. Juice of the stem or petiole is applied to rash or sore which is caused by juice of some poisonous tree	C, B	NE
9	*Bidens pilosa* L. 'Vawk-pui-thal'	Asteraceae	Plant is used medicinally. Leaves are cooked for pig feed and eaten by cattle and horses	G	NE
10	*Blumea alata* (D.Don) DC 'Buar'	Asteraceae	Leaves may be used as mosquito repellent	C, G	NE
11	*Boenninghausenia albiflora* Reichb. 'Ruh-na-dam-dawi'	Rutaceae	Decoction of the plant is used externally for rheumatism, sprains and also bath for patients suffering from chicken pox	B, G	NE
12	*Bupleurum tenue* Buch.-Ham. ex D. Don	Apiaceae	-	G	NE
13	*Carex cruciata*	Cyperaceae	-	G	NE

	var. Rafflesiana (Boo tt) Noot.				
14	*Centella asiatica* L. 'Lam-bak'	Umbelliferae	The stalk and leaves are used as curry and for fodder. Plant is used in diabetes, stomachache, dysentery, diarrhoea, high blood pressure, skin diseases, etc	G	LC
15	*Cheilocostus lacerus* (Gagnep.) C.D.Specht	Zingiberaceae	-	C, B	NE
16	*Chlorophytum khasianum* Hook.f 'Kep'	Liliaceae	The leaves are eaten cooked or fried as vegetables	C, B, G	NE
17	*Commelina benghalensis* Linn. 'Dawng'	Commelinaceae	Whole plant is medicinal	C, B, G	LC
18	*Conyza stricta* Willd. 'Buar-thar-rang'	Asteraceae	-	C, G	NE
19	*Costus speciosus* (J.König) Sm. 'Sum-bul'	Zingiberaceae	Juice of the crushed roots is useful in diseases of kidney, dysuria, fever, bronchitis, rheumatism, indigestion and juice of the stem for ear-aches	C, B	NE
20	*Curculigo crassifolia* (Baker*)* Hook.*f* 'Phai-phak'	Hypoxidaceae	Juice of the crushed tuber is used in stomachache and tender white petiole for liver problems	C, B	NE
21	*Curcuma caesia* Roxb. *'Ailaidum'*	Zingiberaceae	The roots are used for stomachache, dysentery, jaundice, asthma, measles and food allergy or food poisoning	C, B	NE
22	*Cyperus rotundus.*Linn	Cyperaceae	Roots are medicinal	G	LC
23	*Dichrocephala integrifolia* (L.f.) Kuntze 'Vawk-eka-tum-tual'	Asteraceae	Decoction of flower buds is diuretic. The tender shoots are used for insect bites and stings. Leaves are eaten by rabbit and rat.	G	NE
24	*Diplazium dilatatum* Blume	Polypodiaceae	Used as diuretic in the renal system.	C	NE
25	*Diplazium maximum* (D.Don) Chatt 'Cha-kawk'	Polypodiaceae	Tender leaves eaten as vegetable	C, B	NE
26	*Elatostema dissectum* Wedd.	Urticaceae	Young leaves cooked	C, B	NE
27	*Elatostema sesquifolium* (Reinw.	Urticaceae	-	C, B	NE

	ex Blume) Hassk.				
28	*Gleichenia linearis* (Burm.f.)C.B.Clarke 'Arthladawn'	Gleicheniaceae	Applied externally into wounds in East Britain (Srivastava 2007) Extract of whole plant administered internally to little children suffering from convulsion after which a cold bath is given to reduce high body temperature (Rout *et al .,* 2009)	C, B	NE
29	*Gnaphalium luteo-album* Linn	Asteraceae	Whole plant is medicinal	C, B, G	NE
30	*Hedychium coccineum* Buch.-Ham. ex Sm. 'Ai-chhia'	Zingiberaceae	Rhizome paste for bee sting and also applied to anus against pin worms	C, B	NE
31	*Hedychium villosum* Wall. 'Ai-chhia'	Zingiberaceae	Used in treatment of pain and inflammation	C, B	NE
32	*Houttuynia cordata* Thunb. 'Ui-thin-thang'	Saururaceae	The whole plant is eaten raw or cooked as vegetable	C, B	NE
33	*Impatiens laevigata* Wall. ex Hook. f. & Thomson	Balsaminaceae	-	B	NE
34	*Kalanchoe integra* (Medik.) Kuntze. 'Kangdamdawi'	Crassulaceae	Juice of leaves is applied on burns	C, B	NE
35	*Kyllinga brevifolia* Rottb.	Cyperaceae	-	G	LC
36	*Leucas mollissima* Wall 'Va-te-khawi-zu'	Lamiaceae	-	C, G	NE
37	*Lindernia ruellioides* (Colsm.) Pennell 'Thasuih'	Linderniaceae	Applied externally for worms in the skin. Whole plant is used as poultice for cramps, rheumatism, sciatica, wounds and also internally for eye problems	B	LC
38	*Lycopodium cernuum* Linn	Lycopodiaceae	Decoction of stem is used in stomach pain	C, B	NE
39	*Lygodium flexuosum* (Linn.)Swartz	Lycopodiaceae	The fresh root boiled with mustard oil is applied to sprain	C, B	NE
40	*Microlepia rhomboidea* (Wall.*ex* Kunze) Prantl, Arb.	Dennstaedtiaceae	-	B	LC
41	*Mimosa pudica* L. 'Hlonuar'	Mimosaceae	The root is resolvent, alterative, useful in diseases arising from	C, B	LC

			corrupted blood and bile, piles, jaundice, leprosy, ulcers, smallpox. Decoction of roots and leaves used in diseases of liver and kidney		
42	*Ophiorrhiza mungos* L.	Rubiaceae	Decoction of root is used to cure all toxic elements in the body, for snakebites	C, B	NE
43	*Ophiorrhiza oppositiflora* Hook.f. 'Lum-suak'	Rubiaceae	Fruit is used as dye	C, B	NE
44	*Persicaria hydropiper* (L.) Opiz 'Kel-hmar-cha'	Polygonaceae	Plant is medicinal. The leaves including stem are used for poisoning fish	C, B	LC
45	*Phaius mishmensis (*Lindl. & Paxton) Rchb.f.	Orchidaceae	-	C, B	NE
46	*Plantago major* Linn 'Kel-ba-an'	Plantaginaceae	Plant is useful in rheumatism and griping pain of bowels. Leaves are used as chutney or eaten cooked as vegetable. Decoction of the whole plant is used in malarial fever, diabetes and tuberculosis. Juice of the leaves is used externally for wounds, boils, chronic ulcers, sprains, bee or wasp-sting	C, B, G	NE
47	*Plectranthus coetsa* Buch.-Ham. Ex D. Don	Lamiaceae	Chemicals isolated from the plant have possible use in leukemia treatment	C, B	NE
48	*Polygonatum oppositifolium* (Wall.) Royle 'Le-len'	Liliaceae	-	C, B	NE
49	*Polygonum barbatum* L. 'Dawngria'	Polygonaceae	Seed for cholic	B	LC
50	*Pouzolzia bennettiana* Wight	Urticaceae	Young parts eaten as vegetable	B, G	NE
51	*Pronephrium lakhimpurense* (Rosenst.) Holtt.	Thelypteridaceae	-	C	NE
52	*Pteridium aquilinum* (Linn.) Kuhn.	Polypodiaceae	Decoction of rhizome and fronds taken orally at bedtime in treatment of worms. The infusion of plant is used to relieve stomach cramps and	C, B	NE

			increase urine flow. Fronds used for decoration		
53	*Rhaphidophora decursiva* (Roxb.) Schott 'Tu-bal'	Araceae	The stem and stalk are eaten cooked as a vegetable	C, B	NE
54	*Scleria levis* Retz.	Cyperaceae	-	G	NE
55	*Scleria terrestris* (L.) Fass 'Thip-nem'	Cyperaceae	-	C, B, G	LC
56	*Solanum khasianum* Clarke 'At-hlo-hling'	Solanaceae	Roots and fruit are used in medicine	G	NE
57	*Spilanthes calva* DC 'An-ka-sa-kirlo'	Asteraceae	Leaves with stem are used as vegetable. Flowers are chewed to relieve toothache. Plant is sometimes administered to women after childbirth. Plant is also used for feeding pigs	G	NE
58	*Torenia violacea* (Azaola ex Blanco) Pennell 'Ar-aw-keu'	Linderniaceae	The plant is used to treat chronic dysentary	B, G	NE
59	*Urena lobata* Linn 'Se-hnap'	Malvaceae	Bark yields a strong white fibre. Infusion of the tender leaves is used for diarrhoea and dysentery. Roots are diuretic and used as an external remedy for rheumatism	G	NE

Table 5.27 Climbers- Uses, zone where species occur and IUCN status

(C= Core zone, B=Buffer zone, G = Grassland zone, NE= Not Evaluated, LC= Least Concern, Vu= Vulnerable, En = Endangered, DD= Data Deficient)

Sl no.	Name of species	Family	Uses	Zone where species occur	IUCN status
1	*Acacia oxyphylla* Benth 'Khangngo'	Fabaceae	The bark is used as fish poison.	C, B	NE
2	*Aganope thyrsiflora* (Benth.) Polhill 'Hul-hu'	Fabaceae	Wood used for firewood. Young leaves are eaten as vegetable. Decoction of fruit is used against stomachache and dysentery	C, B	NE
3	*Bauhinia Scandens* L. 'Zawng-a-leih-lawn'	Fabaceae	Bark is used for making rope	C	NE
4	*Caesalpinia cucullata* Roxb. 'Hling-khang'	Fabaceae	-	B	NE
5	*Cissampelos pareira* L. 'Khau-chhim'	Menispermaceae	Stem is used for tying beams, rafter, etc of native houses. Juice of pounded roots is prescribed for cholera, diarrhoea, dysentery, fever, stomach ulcer, dyspepsia and urinary troubles	C, B	NE
6	*Cissus javana* DC 'Sa-nghar-hmai'	Vitaceae	Decoction of leaves and stem taken for stomachace. Juice of leaves applied to itching sores	B	NE
7	*Clematis siamensis* Drumm. et Craib 'Thla-sik-hrui'	Ranunculaceae	Leaves of fresh stem if bruised and applied to skin cause vesication	C	NE
8	*Dioscorea glabra* Roxb. 'Hra-kai'	Dioscoreaceae	Tubers are eaten cooked or fried as a vegetable	C, B	NE
9	*Entada rheedei* Spreng.Subsp.Rheedei 'Kawi'	Mimosaceae	Stem, bark and seeds poisonous; seeds as fish poison, tonic anti-periodic, emetic. Stem used as emetic, wood bark in ulcers	C	NE
10	*Ipomoea hederifolia*L. 'Ni-pui-par'	Convolvulaceae	Root is sweet, fattening, stops diarrhoea, dysentery, stomachache, digestive troubles and food	C, B, G	NE

			poisoning. Tubers are eaten by man, wild animals. Leaves are browsed by barking deer and used for feeding pigs		
11	*Marsdenia formosana* Masam. 'An-kha-te'	Apocynaceae	Young stem and leaves are eaten cooked as vegetable	C, B	NE
12	*Mikania micrantha* Kunth 'Japan-hlo'	Asteraceae	Leaves are locally used for pigs feed. Juice of the crushed leaves is used in fever, stomachache, diarrhoea, dysentery and also applied to fresh cuts.	C, B	NE
13	*Millettia pachycarpa* Benth. 'Rulei'	Papilionaceae	Roots used in scabies and skin diseases. The roots and pods are used to poison fish	C	NE
14	*Mucuna gigantea* (Willd.)DC. 'Be-ai-mu-zeh-dum'	Fabaceae	Seed used as bait for setting traps. Leaves browsed by barking deer	C, B	NE
15	*Passiflora edulis* Sims 'Sap-thei'	Passifloraceae	Ripe fruit is useful for jaundice and liver problems. Fruit eaten by man and animals	C, B	NE
16	*Passiflora nepalensis* Wallich 'Nau-awi-mu-hrui'	Passifloraceae	Ripe fruit edible, young leaves as vegetable, decoction of root is used in malaria and juice of the crushed leaves as purgative	B, G	NE
17	*Paederia foetida* L. 'Vawih-uih-hrui'	Rubiaceae	Whole plant is regarded as a medicine for rheumatic affections, in which it is administered both internally and externally. Juice of the crushed leaves is used for diarrhoea and dysentery. Stem and leaves are chewed for relief in tooth-ache	C, B	NE
18	*Piper betle* L 'Pan-ruang'	Piperaceae	Leaves improve appetite, tonic to the brain, heart, liver, strengthen teeth, lessen thirst, clears the throat. The juice of leaves is dropped into the eye in night blindness	C, B	NE
19	*Porana racemosa* Wall.	Convolvulaceae	-	G	NE
20	*Shuteria vestita var. glabrata* (Wight &	Fabaceae	Plant is medicinal	B	NE

	Arn.)Baker				
21	*Smilax glabra* Roxb. 'Tluang-ngil'	Liliaceae	Rhizome is medicinal	G	NE
22	*Smilax lanceaefolia* Roxb. 'Kaiha'	Liliaceae	Pieces of the stem are used for cleaning teeth. Roots used in rheumatism	C, B	NE
23	*Tetrastigma dubium* (M. A. Lawson) Planch	Vitaceae	-	C, B	NE
24	*Tetrastigma leucostaphylum* (Dennst.) N.P.Balakr. 'Thur-pui'	Vitaceae	Leaves are medicinal	C, G	NE
25	*Thunbergia grandiflora* Roxb 'Zawng-a-fian '	Acanthaceae	Juice of leaves is used for diabetes, eye diseases and new cuts. Leaves are good for fodder	G	NE
26	*Trichosanthes quinquangulata* A. Gray 'Cho-ak-a-um'	Cucurbitaceae	The fruit is useful in asthma, earache and ozoena. Fruit are eaten by wild animals and birds	C, B	NE
27	*Uncaria sessilifructus*Roxb. 'Ral-sam-kuai'	Rubiaceae	Decoction of root bark or young leaves are used as a cure for menstrual complaints, sore-throat and rheumatism	C, B	NE

Table 5.28 Epiphytes- Uses, zone where species occurand IUCN status

(C= Core zone, B=Buffer zone, G = Grassland zone, NE= Not Evaluated, LC= Least Concern, Vu= Vulnerable, En = Endangered, DD= Data Deficient)

Sl.no	Name of species	Family	Uses	Zone where species occur	IUCN Status
1	*Aerides odorata* Lour. 'Ngurtinchhing'	Orchidaceae	-	C, B	NE
2	*Aeschynanthus maculata* Lindl. 'Bawlte-hlan-tai'	Gesneriaceae	Flower is edible. Root bulbs are used as a substitute for coffee. Infusion of bark is applied to inflammatory diseases of the glands and the flowers are taken for diseases of throat. The flowers are sucked by birds	C, B	NE
3	*Bulbophyllum elatum*(Hook.f.)Sm	Orchidaceae	-	C, B	NE
4	*Bulbophyllum khasianum* Griff	Orchidaceae	-	B	NE
5	*Bulbophyllum umbellatum* Lindl	Orchidaceae	-	C, B	NE
6	*Cleistostoma filiforme* (Lindl.)Garay	Orchidaceae	-	C, B	NE
7	*Cleistostoma racemiferum*(Lindl.)Garay	Orchidaceae	-	C, B	NE
8	*Coelogyne prolifera* Lindl.	Orchidaceae	-	C, B	NE
9	*Dendrobium chrysanthum* Lindl.	Orchidaceae	Ornamental	C	NE
10	*Dendrobium chrysotoxum* Lindl. 'Banpui par-eng'	Orchidaceae	Ornamental	C, B	NE
11	*Dendrobium densiflorum* Lindl.	Orchidaceae	Ornamental	C	NE
12	*Dendrobium formosum* Lindl'Banpui par-var	Orchidaceae	-	C, B	NE
13	*Dendrobium ochreatum.*Lind'lBanpui par-eng a chhungdum'	Orchidaceae	-	C, B	NE
14	*Dendrobium parishii.*Reichb.f.	Orchidaceae	-	C, B	NE
15	*Dendrobium*	Orchidaceae	-	C, B	NE

	*transparens*Wall.Ex Lindl 'Banpui seluphan-mawi				
16	*Drynaria coronans* (Wall. ex Mett.) J. Sm. ex T 'Awmvel'	Polypodiaceae	Rhizome used in stomach and tooth problem	C	NE
17	*Eria paniculata* Lindl	Orchidaceae	-	C, B	NE
18	*Eria pannea* Lindl.	Orchidaceae	-	C	NE
19	*Mycaranthes stricta* Lindk.	Orchidaceae	-	C, B	NE
20	*Oberonia iridifolia*(Roxb.)Lindl	Orchidaceae	-	C	NE
21	*Papolionanthe vandarum (*Rchb.f.)Garay	Orchidaceae	-	C, B	NE
22	*Pholidota imbricata* Hook	Orchidaceae	-	C, B	NE
23	*Premna Coriaceae* C.B.Clarke 'Kuam'	Verbenaceae	Leaves lopped for fodder. Fruit eaten by bird	C,B	NE
24	*Rhynchostylis retusa* (Lindl.)Bl.'Vaihniang'	Orchidaceae	-	C,B	NE
25	*Vanda coerulea* Griff.ex Lindl.	Orchidaceae	Ornamental	C,B	NE

Table 5.29 Grasses- Uses, zone where species occur and IUCN status

(C= Core zone, B=Buffer zone, G = Grassland zone, NE= Not Evaluated, LC= Least Concern, Vu= Vulnerable, En = Endangered, DD= Data Deficient)

Sl no	Name of species	Family	Uses	Zone where species occur	IUCN status
1	*Bamboosa khasiana* Munro 'Rawte'	Poaceae	Culms used in building and basket making. Young shoot eaten as vegetable	C, B	NE
2	*Bamboosa tulda* Roxb 'Rawthing'	Poaceae	Young shoot eaten as vegetable. Frayed outer skin is applied to wounds to stop bleeding	C, B	NE
3	*Cephalostachyum latifolium* Munro ' Raw-ngal'	Poaceae	Culm is used for making baskets, mizo hat, blow guns, tying fences, etc. Leaves are used as fodder. Fruit are eaten by wild animals and birds	C, B	NE
4	*Cynodon dactylon* L. Pers 'Phai-tual- hnim'	Poaceae	Fodder grass. Good for lawn grass and soil stabiliser. Whole plant is medicinal	G	NE
5	*Dendrocalamus hamiltonii* Nees & Arn.ex Munro 'Phulrua'	Poaceae	Culms used for mats, baskets, gutters, buildings, fuel, paper, water vessels. Young shoot eaten as vegetable. Fruit eaten in times of famine and for lowering blood pressure	B	NE
6	*Dendrocalamus longispathus* (Kurz) Kurz 'Rawnal'	Poaceae	Culms used for paper pulp, basket, building, etc. Young shoots are eaten cooked as vegetable and also eaten by monkeys. Seed eaten by Red junglefowls.	C	NE
7	*Dendrocalamus sikkimensis* Gamble ex Oliv. 'Raw-mi'	Poaceae	The culm is used for construction purposes, flooring, etc.Seeds eaten by wild animals and birds	C, B	NE
8	*Dinochloa compactiflora* Kurz.Mc Clure 'Sairil'	Poaceae	Culms used for making basket, hats, etc. Juice of stem is used for influenza, dandruff, falling hair and baldness	C	NE
9	*Drepanostachyum intermedium* (Munro) Keng f. 'Lik'	Poaceae	Used for fish rods and hedge plant	C, B	NE
10	*Erianthus longisetosus*	Poaceae	Young leaves used as fodder	B, G	NE

	Anderss. ex Benth 'Luang'				
11	*Eulalia trispicata* (Schult.)Henrard 'Thang'	Poaceae	Used for thatching root. Roots are used for expelling thread-worms and other worms from the body	C, B, G	NE
12	*Imperata cylindrica* (L.) Raeusch 'Di'	Poaceae	Used as a thatching grass. Roots are used to treat intestinal worms	G	NE
13	*Melocanna baccifera* (Roxb.) Kurz 'Mautak'	Poaceae	Culms used for paper, mats, baskets, building, thatching, etc. Young shoots are eaten as vegetable. Glossy surface of stem is scraped and applied to wounds to stop bleeding. Fruit eaten by cattle and wild animals	C, B	NE
14	*Oplismenus burmannii* Beauv.	Poaceae	Uses as fodder. Used as antidotes (venomous stings, bites, etc.); in cutaneous, subcutaneous parasitic infection;in eye treatments; as stimulants/depressants; pain-killers	G	NE
15	*Paspalum compactum* Roth.	Poaceae	Excellent fodder grass much relished by cattle, grain eaten as cereal, flour used to make bread or porridge, used for lawn making	G	NE
16	*Pseudostachyum polymorphum* Munro 'Chal-te'	Poaceae	Culm is suitable for baskets, mats, umbrella handles, walking stick and tying purposes. The young shoots are also used as a vegetable	C, B	NE
17	*Saccharum arundinaceum* Retz 'Rai-ruang'	Poaceae	Roots are medicinal	G	NE
18	*Schizostachyum dulloa (*Gamble) Majumdar 'Rawthla'	Poaceae	Culms used for making baskets, mats, mizo loom, building, ec. Young shoot eaten as vegetable.	B	NE
19	*Setaria glauca* (L.) P.Beauv	Poaceae	-	G	NE
20	*Themeda villosa (Poir.)* A.Camus 'Phai-phek'	Poaceae	-	C, B, G	NE
21	*Thysanolaena maxima* (Roxb.) Kuntze 'Hmun-phiah'	Poaceae	For making broom, roots are medicinal	B, G	NE

Table 5.30 Canes and Palms - Uses, zone where species occur and IUCN status

(C= Core zone, B=Buffer zone, G = Grassland zone, NE= Not Evaluated, LC= Least Concern, Vu= Vulnerable, En = Endangered, DD= Data Deficient)

Sl no	Name of species	Family	Uses	Zone where species occur	IUCN Status
1	*Arenga pinnata* (Wurmb) Merr. 'Thang-tung'	Arecaceae	Young shoots eaten as vegetable, roots used in stomach problems and bronchitis, outer fleshy layer of fruit is used to poison fish	C, B	NE
2	*Borassus madagascariensi*s Bojer ex Jum. & H.Perrier 'Sial-lu'	Arecaceae	Outer hard wood is used in house post, rafters. Tapped for toddy. Pulp, unripe seeds and young seedlings are edible. Leaves are used for thatching, mats, hats, fans, etc.	C, B	En
3	*Calamus inermis* Griff. 'Mit-perh'	Arecaceae	Cane is used to make chair, walking stick, containers, etc. Tender pith is used as vegetable. Fruit is used as purgative and for curing chronic stomach ulcer. Fruit eaten by man, monkey, squirrel	C, B	NE
4	*Calamus khasianus* Kurz 'Mawt'	Arecaceae	Cane is used for baskets, container, handles of umbrella, etc and used for tying	C	NE
5	*Calamus erectus* Roxb. 'Thil-thek'	Arecaceae	Young fleshy part eaten as vegetable	C, B	NE
6	*Calamus flagellum* Griff. *ex* Mart 'Hrui-pui'	Arecaceae	Cane is used for chairs, baskets, hats, containers, etc. Top shoot are eaten cooked as vegetable. Fruit eaten by man and wild animals	C, B	NE
7	*Calamus guruba* Buch.-Ham. ex Mart. 'Tai-rua'	Arecaceae	Cane is used for making baskets	C	NE
8	*Calamus acanthospathus* Roxb. 'Thil-te'	Arecaceae	Used for making baskets, mats, furniture, chair seats, etc. The fruit is eaten and tender shoots eaten as vegetable. Top shoot are boiled and water taken for	C, B	LC

			dysentery. Leaves also eaten by buffalo		
9	*Caryota mitis* Lour.'Mei-hle'	Arecaceae	Wood is used in making Mizo loom. Tender pith of upper part of palm is eaten as vegetable. Fruit eaten by wild animals and leaves as fodder	C	NE
10	*Caryota urens* L. 'Tum'	Arecaceae	The wood has many domestic uses, fibre is used for making rope, brush, broom, basket, etc.The young stem is cooked as vegetable. Seedlings used as fodder	C, B	NE
11	*Livistona chinensis*(Jacq.) R.Br. ex Mart 'Buar-pui'	Arecaceae	Leaves used for making fan, leafstalk fibre for rope. Young shoot eaten as vegetable	C, B	NE
12	*Pandanus odorifer* (Forssk.) Kuntze 'Ram-la-khuih'	Pandanaceae	Fruit used to comb cotton yarn. Seed are edible. Fibre obtained from leaves is used for nets, sacks and brushes. Leaves are useful in leprosy, small-pox, syphilis, scabies, heat of body, pain, leucoderma, diseases of the heart and brain	C, B	NE
13	*Pinanga gracilis* Blume 'Tar-tiang'	Arecaceae	Fruit is chewed like betel nut. Leaves are used in roofing native huts	C, B	NE
14	*Wallichia nana* Griff. 'Lem'	Arecaceae	Leaves sometimes used for thatching jhum huts	C, B	NE
15	*Zalacca secunda* Griff 'Hrui-tung'	Arecaceae	Leaves used to thatch jhum huts, seeds are edible	C, B	NE

Plate 3

Plate 3a : *Disporum cantoniense* (Lour.) Merr.

Plate 3b :*Callicarpa dichotoma* (Lour.) K. Koch

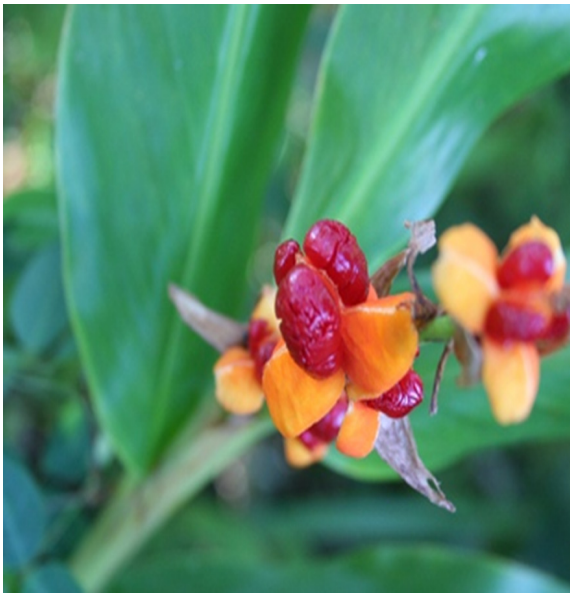


Plate 3c : *Hedychium coccineum* Buch.-Ham. ex Sm

Plate 3d :*Viburnum foetidum* Wall

Plate 4

Plate 4a :*Dendrobium densiflorum* Lindl

Plate 4b :*Phaius mishmensis* (Lindl. & Paxton)

Plate 4c : *Dendrobium chrysotoxum* Lindl.

Plate 4d : *Ophiorrhiza oppositiflora* Hook.f.

Plate 5

Plate 5a : *Acronychia pendunculata*(L.) Miq

Plate 5b : *Randia wallichii* Hook.f.

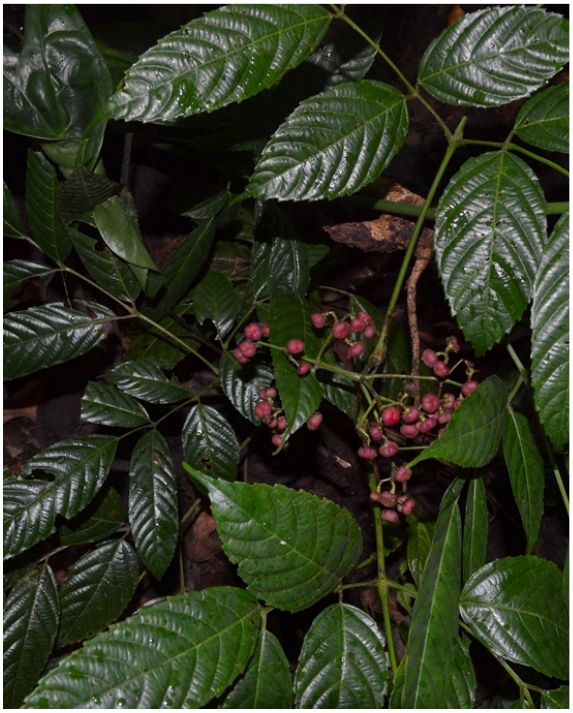


Plate 5c : *Leea indica* (Burm.f.) Merr

Plate 5d : *Eurya cerasifolia* (D.Don)Kobuski

Plate 6

Plate 6a :*Osbeckia crinita* Benth. ex C.B.Clarke

Plate 6b :*Boenninghausenia albiflora* Reichb.

Plate 6c :*Butea minor* Buch.-Ham. ex Baker

Plate 6d :*Torenia violacea* (Azaola ex Blanco) Pennell

Plate 7

Plate 7a : *Arisaema speciosum* (Wall.) Mart.

Plate 7b :*Cissus javana DC*

Plate 7c :*Bauhinia scandens L.*

Plate 7d :*Urena lobata* Linn

Plate 8a : *Pseudostachyum polymorphum* Munro

Plate 8b : *Dendrocalamus sikkimensis* Gamble

Plate 8c:*Carex cruciata var. rafflesiana* (Boott) Noot

Plate 8d : *Bupleurum tenue* Buch.-Ham. ex D. Don

5.6. Socio-Economic Status

The demographic and occupation data of the adjoining villages i.e Reiek village and Ailawng village has been given in **Table 5.31**.Reiek village had a higher population of 1690 while Ailawng village had a population of 712. The main source of livelihood in both the villages was jhum cultivation practised by 53% of the household. While pig was reared in almost all the households, it was not the main source of livelihood but used mainly as a supplement. There were no industry to speak of in Ailawng village whereas there was one industry i.e Turmeric processing plant in Reiek village. Other sources of livelihood included poultry farming, government services, working as daily labourers and small businesses.

As seen in **Table 5.32**,the two villages were under the guidance of their own Village council. The local institutional level was only upto the High School level with 1 Govt. High School, 1 Govt. Middle School, 2 Govt. Primary School and 7 Anganwadis in Reiek village. In Ailawng village,there was 1 privately run High School, 1 Govt. Middle School, 2 Govt. Primary School and 4 Anganwadis.

The Standard of living and social welfare services is given in **Table5.33**. All the houses in Reiek village were electrified whereas in Ailawng, there were still 10 households with no electricity. 75% of the household in Reiek village and 63% of the household in Ailawng village had LPG connection while the rest still depend on fuel wood for cooking. Even amongst the household with LPG connection, fuelwood is still used to supplement cooking fuel due to the poor supply of LPG cylinders. As Reiek village is a tourist spot, there was a government run Tourist lodge as well as a privately run one but there was no rest house in Ailawng. The road condition was not very good with only the main roads metalled while the side roads were all katcha roads.

1. Agriculture : Compared to other villages in Mizoram, the number of households depending on agriculture for sustenance was low but still accounted for more than half of the total households. Jhum farming was practiced by all the farmers. Paddy was the main crop grown in all the farms with a mixture of seasonal vegetables. Vegetables provided a source

of sustenance for many of these farmers with their produce being sold in the local markets. Some of the main vegetables grown include *Oryza sativa, Brassica juncea, Phaseolus vulgaris, Solanum melongena, Vignia unguiculata, Momordica charantia, Zea mays, Cucurbita maxima, Benincasa hispida, Sechium edule, Eryngium foetidum, Solanum anguivi, Coriandrum sativum, Abelmoschus esculentus, and Trichosanthes angiuna.* The list of vegetables grown is given in **Table 5.34.**

2. Cultivated Fruit trees and Fruit trees found in the wild : 26 species of fruit crops were cultivated by the people living in Reiek and Ailawng villages while 41 species of fruit trees were found to grow wild in and around the two villages. Some of the fruit trees such as*Garcinia cowa,Averrhoa carambola, Phyllanthus acidus, Passiflora edulis* and *Eleagnus caudata* have been mentioned by Rai *et al.*(2005) as underutilised horticultural crops which have the potential to be enhanced to a greater extent through publicity. The cultivated fruit trees are given in **Table 5.35**.Some of the major fruit trees grown were*Prunus domestica, Psidium guajava, Artocarpus heterophyllus, Citrus limon, Tamarindus indica,Musa paradisiaca, Citrus grandis* and *Mangifera indica.* The fruit trees found in the wild are given in **Table 5.36**. The common trees include *Protium serratum, Pyrus pashia,Mangifera sylvatica,Syzygium cumini,Prunus jenkinsii,Rhus semialata,Baccaurea ramiflora, Ficus semicordata, Antidesma bunius* and*Bruinsmia polysperma.* Some of the nut trees growing in the wild include *Juglans regia,* and *Castanopsis tribuloides*

3. Livestock: Only 17% of the total households in both the villages practiced poultry farming and used it as the main source of livelihood. Piggery was very popular with 76% of the households rearing at least one pig. However, piggery was usually practised not as a means of livelihood but as a supplement to some other main livelihood. Pigfeed were cooked using firewood collected from the forest increasing pressure on nearby forest. Cattles were owned by only a few household.

4. Timber and fuel wood : As 98% of the houses in the two villages were constructed using timber, consumption of timber was high. Other uses of timber included

furniture making and handles of tools. 35 species of trees were felled for timber and the list of timber species used in the two villages are given in **Table 5.37**.The common timber species were *Alseodaphne petiolaris , Persea villosa, Terminalia myriocarpa, Michelia champaca, Mesua ferrea, Cinnamomum obtusifolium,Betula cylindrostachys, Schima wallichii, Cinnamomum glanduliferum,Bischofia javanica, Syzygium cumini, Macropanax undulatus,Stephegyne diversifolia, Terminalia chebula, Aglaia spectabilis, Persea glaucescens, Calophyllum polyanthum, Bruinsmia polysperma, Tetrameles nudiflora, Celtis timorensis, Castanopsis tribuloides, Gmelina arborea and Drimycarpus racemosus.*

According to Indian State Forest Report (2011), in India 853.88 million persons use fuelwood as a source of energy for cooking out of which 199.63 million (23.38%) use fuelwood collected from forests. The total amount of fuelwood used in the country every year was estimated to be 216.4 million tonnes out of which 58.75 million tonnes come from forest. In the North eastern region of India where the study site is located 3.8 million tonnes of fuelwood is used every year from forest. And as per the result of Household Consumer Expenditure Survey carried out by the conducted by NSSO in the year 2007-2008, over 77 % of households in rural area continue to depend on fuelwood for cooking. Within the villages encompassed by the study site, only 30% of households depended solely on fuelwood as a source of energy for cooking which was low compared to the findings of NSSO. Howevers, due to poor availibility of LPG cylinders, many of the households with LPG connection supplement it with fuelwood to meet their daily energy need. Wood is either directly burned in chullahs or they are made into charcoal. The production of charcoal is a source of livelihood for some of the poorer families. 34 species of trees used as fuelwood are listed in **Table 5.38**. The common fuelwood species were *Elaeocarpus lanceaefolius,Schima wallichii, Engelhardtia roxburghiana, Macropanax undulatus, Ailanthus integrifolia, Ervatamia coronaria,Persea glaucescens, Ficus rigida,Olea dioica, Eurya cerasifolia, Emblica officinalis, Cinnamomum verum, Quercus leucotrichophora, Heritiera acuminata, Dysoxylum alliaria.*

4. Medicinal plants : According to the WHO,over 80% of the world's population relies on traditional forms of medicine, largely plant based to meet primary health care needs (Attisso, 1983). Approximately 3000 plants species are known to have medicinal properties in India (Prakasha *et al*, 2010) . The use of the herbal remedy is not only cost effective but also safe and almost free from serious side effects(Mohd Mazid *et al.,* 2012) .There were 34 species of medicinal plants used by the local people which is listed in **Table 5.39.** The plant parts used include leaves, tubers, roots, shoots, rhizomes, fruit, seed, bark, flowers and the whole plant. They were prepared using various methods such as decoction, juice, powder, etc. They were used for treating a wide range of diseases from fever, cough and headache to stomach problems, skin diseases, etc. The medicinal plants used included*Curcuma longa, Curcuma caesia, Solanum surattense,Blumea lanceolaria, Euphorbia royleana, Albizzia myriophylla, Aporusa octandra, Colocasia esculenta, Erythrina stricta, Mimosa pudica, Mikania micratha, Kalanchoe integra, Psidium guajava, Osbeckia chinensis, Rhus semialata, Hedyotis scandens, Ricinus communis, Helicia robusta, Uncaria sessilifructus, Aeginetia indica, Securinega virosa, Elaeagnus caudata, Begonia dioica, Costus speciosus, Dendrocnide sinuata, Lindernia ruellioides, Prunus undulata, Picrasma javanica, Castanopsis tribuloides, Eupatorium odoratium, Smilax glabra, Alstonia scholaris, Thunbergia grandiflora,Macaranga denticulata.*

5.Edible plants : About one billion people in the world use wild foods (mostly from plants) on a daily basis (Abermound, 2009). Ethno botanical investigations on Wild edible plants suggest that more than 7,000 species have been used for food in human history (Grivetti and Ogle, 2000) . In certain countries like China, India, Thailand and Bangladesh hundreds of wild edible plants are still consumed along with domesticated species (Mazhar *et* al, 2007).In India 600 wild edible plants species have been documented (Rathore , 2009)

39 species of wild edible plants were collected by the people living in Reiek village and Ailawng village and is given in **Table 5.40**. Out of these, the parts consumed includethe whole plant in 5 species namely *Spilanthes acmella, Lepionurus sylvestris,Glinus*

oppositifolia, Diplazium maxima and *Centella asiatica*, the leaves and twigs of 8 species namely *Marsdenia maculata, Marsdenia formosana, Zanthoxylum rhetsa, Acacia pennata,Curanga amara, Gnetum gnemon, Clerodendrum colebrookianum, Eurya cerasifolia and Dysoxylum gobar,* the stem pith and tender shoots of 11 species namely *Livistona chinensis, Calamus flagellum, Zalacca secunda, Calamus andamanicus, Caryota mitis, Calamus acanthospathus, Borassus flabellifer, Arisaema speciosum, Arenga pinnata, Calamus tenuis* and *Pogostemon benghalense* , the fruit of 3 species namely *Trevesia palmata, Hodgsonia macrocarpa* and *Musa sp*. the bark of *Cinnamomum verum,* the seed of*Glycine max* and the rhizome of *Arisaema speciosum.* 5 species of mushroom were collected and the tender shoots of bamboos like *Dendrocalamus longispathus, Bambusa tulda,Melocanna baccifera* and *Dendrocalamus hamiltonii*were also collected and eaten as vegetable or sold in the local market.

6. Bamboos, Canes and Palms : 13 species of bamboo have been recorded which were used by the local people of the study site namely *Pseudostachynum polymorphum, Sinarundinaria falcata, Melocanna baccifera, Dendrocalamus hamiltonii, Dendrocalamus hookeri, Dendrocalamus sikkimensis, Dendrocalamus longispathus, Schizostachyum capitatum, Bambusa khasiana, Bambusa tulda, Schizostachyum dulloa, Dinochloa compactiflora* and *Bambusa oliveriana.* The list of

bamboo species is given in **Table 5.41**. The cane and palm species are given in Table 5.42 and includes 12 species namely *Livistona chinensis, Calamus flagellum, Zalacca secunda, Calamus andamanicus, Caryota mitis, Calamus acanthospathus, Borassus flabellifer, Calamus guruba, Arenga pinnata, Calamus tenuis, Calamus erectus* and *Caryota urens.*

Bamboos were collected for various purposes such as construction of houses, fence,handicraft, agarbati stick, etc and the tender shoots were eaten as well. The cane and palms were used for thatching, furniture, handicrafts, etc and the tender shoots and pith were eaten.

It can be seen from the socio economic discussion that the local people were still depending on the forest to supply their daily sustenance requirement. To supply this need, there was increased pressure on the forest for items such as timber, fuelwood, edible plants, medicine, bamboos and cane. Overexploitation of the forest can have a disastrous effect on the biodiversity of the forest and may even lead to extinction of certain species. Therefore, there is a need to ensure the forest is used in a sustainable manner.

Table 5.31Demographic and Occupation Data

Name of Village	No. of House hold	Population			BPL family	Occupation					
		Male	Female	Total		Cultivators	Piggery	Poultry	Industry	Govt. Servant	Business
Reiek	419	816	874	1690	120	244	317	86	1	128	12
Ailawng	160	350	362	712	32	65	124	10	nil	6	10

Table 5.32Education and Local Institutional level

Name of Village	Educational Level				Local Institutional level								VC House
	PG	Grad	12	10	High School		Middle School		Primary School		Anganwadi		
					No.	Teacher/ Students	No.	Teacher/ Students	No.	Teacher/ Students	No.	Teacher/ Students	
Reiek	9	33	54	71	1 Govt	8/16	1 Govt	10/73	2 Govt	5/27 5/91	7	7/84	1
									3 Private	7/37 4/35 6/73			
Ailawng	4	10	44	52	1 Private	7/23	1 Govt	6/46	1 Govt	4/52	4	1/79	1

Table 5.33Standard of Living and Social Welfare Services

Name of Village	House Electrified	House with LPG	House with telephone	House with Chullah	RCC Building	Tin Roof building	Rest House	Road Communication
Reiek	All	300	170	Nil	4	415	1 Govt 1 Private	Metal/ Katcha Road
Ailawng	150	100	Nil	2	7	151	Nil	Metal/ Katcha Road

Table 5.34 Agricultural crops

Sl	Local Name	Botanical Name	Family	Common/English name	Place of
1	Aieng	*Curcuma longa*	Zingziberaceae	Turmeric plant	A,R
2	Alu	*Solanum tuberosum*	Solanaceae	Potato	A,R
3	Ankasa	*Spilanthes acmella*	Compositae	-	A,R
4	Antam	*Brassica juncea*	Cruciferae	Indian mustard	A,R
5	Bahkhawr	*Eryngium foetidum*	Umbelliferae	Wild coriander	A,R
6	Bahra	*Ipomoea batatas*	Convolvulaceae	Sweet potato	A,R
7	Bal	*Colocasia esculenta*	Aracaceae	Toro	A,R
8	Bawkbawn	*Solanum melongena*	Solanaceae	Brinjal/Egg plant	A,R
9	Bawrhsaiabe	*Abelmoschus esculentus*	Malvaceae	Lady's finger	A,R
10	Bean	*Phaseolus vulgaris*	Papilionaceae	French bean	A,R
11	Behlawi	*Vignia unguiculata*	Papilionaceae	Cow pea	A,R
12	Behliang	*Cajanus cajan*	Papilionaceae	Lentil/Pegion pea	A,R
13	Bekang	*Glycine max*	Papilionaceae	-	A,R
14	Bepui	*Lablab purpureus*	Papilionaceae	Hyacinth bean	A,R
15	Bepuithlanei	*Psopocarpus tetragonolobus*	Papilionaceae	Winged bean	A,R
16	Berul	*Trichosanthes angiuna*	Cucurbitaceae	Snake gourd	A,R
17	Brocolli	*Brassica italica*	Cruciferae	Brocolli	A,R
18	Buh	Oryza collina	Oryzeae	Paddy	A,R
19	Carrot	*Daucus carota*	Umbelliferae	Carrot	A,R
20	Changkha	*Momordica charantia*	Cucurbitaceae	Bitter gourd	A,R
21	Dawnfawh	*Citrullus lanatus*	Cucurbitaceae	Water melon	A,R
22	Dhania	*Coriandrum sativum*	Apiaceae	Coriander /cilantro	A,R
23	Fanghma	*Cucumis sativus*	Cucurbitaceae	Cucumber	A,R
24	Fangra	*Canavalia ensiformis*	Papilionaceae	Broad or sword bean	A,R
25	Hmarchate	*Capsicum minimum*	Solanaceae	Chilli	A,R
26	Hmarchapui	*Capsicum frutescens*	Solanaceae	Sweet/Hot long pepper	A,R
27	Hmazil	*Cucumis melo*	Cucurbitaceae	Sweet melon	A,R
28	Iskut	*Sechium edule*	Cucurbitaceae	Chayote	A,R
29	Lengser	*Elsholtzia communis*	Labiatae	-	A,R
30	Lettuce	*Lactuca sativa*	Asteraceae	Lettuce	A,R
31	Mai	*Cucurbita maxima*	Cucurbitaceae	Pumpkin	A,R
32	Maipawl	*Benincasa hispida*	Cucurbitaceae	Ash pumpkin	A,R
33	Maitamtawk	*Momordica mixta*	Cucurbitaceae	-	A,R
34	Mizopurun	*Allium hookeri*	Liliaceae	-	A,R
35	Motorchana	*Pisum sativum*	Papilionaceae	Green or field pea	A,R
36	Pangbal	*Manihot esculenta*	Euphorbiaceae	Topiaca	A,R
37	Pardi	*Trachyspermum roxburghianum*	Umbelliferae		A,R
38	Samtawk	*Solanum anguivi*	Solanacee	Indian nightshade	A,R
39	Sawhthing	*Zingiber officinale*	Zingziberaceae	Ginger plant	A,R
40	Tomato	*Lycopersicon esculentum*	Solanaceae	Tomato	A,R
41	Um-ei	*Lagenaria siceraria*	Cucurbitaceae	Bottle gourd	A,R
42	Vaimim	*Zea mays*	Graminae	Maize	A,R
43	Zawngtur	*Pueraria montana*	Papilionaceae		A,R

Table 5.35 Cultivated fruit trees

Sl no	Local Name	Botanical Name	Family	Common/English name	Place of Occurrence
1	Apple	*Malus pumila*	Rosaceae	Apple	A
2	Balhla	*Musa paradisiaca*	Musaceae	Banana	A,R
3	Butterfruit	*Persea americana*	Lauraceae	Avocado	A,R
4	Grape	*Vitis vinifera*	Ampelidaceae	Grape	A,R
5	Hatkora	*Citrus macroptera*	Rutaceae	-	A,R
6	Japan theite	*Prunus domestica*	Rosaceae	Plum tree	A,R
7	Kawlsunhlu	*Phyllanthus acidus*	Euphorbiaceae	Star aonla	A,R
8	Kawlthei	*Psidium guajava*	Myrtaceae	Guava	A,R
9	Lakhuihthei	*Ananas comosus*	Bromeliaceae	Pineapple	A,R
10	Lamkhuang	*Artocarpus heterophyllus*	Moraceae	Jackfruit	A,R
11	Nimbu	*Citrus limon*	Rutaceae	Lemon	A,R
12	Per-thing	*Pyrus communis*	Rosaceae	Pear tree	A,R
13	Sapthei	*Passiflora edulis*	Passifloraceae	Passion fruit	A,R
14	Serfang	*Citrus sp.*	Rutaceae	-	A,R
15	Sermam	*Citrus sp.*	Rutaceae	-	A,R
16	Serpui	*Citrus sp.*	Rutaceae	-	A,R
17	Sertawk	*Citrus grandis*	Rutaceae	Shaddock	A,R
18	Serthlum	*Citrus reticulata*	Rutaceae	Orange	A,R
19	Sisu	*Citrus sp.*	Rutaceae	-	A,R
20	Tengtere	*Tamarindus indica*	Caesalpinaceae	Tamarind	A,R
21	Theichhungsen	*Haematocarpus thomsoni*	Menispermaceae	-	A,R
22	Theifeihmu	*Euphoria longan*	Sapindaceae	Litchi	A,R
23	Theihai	*Mangifera indica*	Anacardiaceae	Mango	A,R
24	Theiherawt	*Averrhoa carambola*	Oxalidaceae	Carambola tree	A,R
25	Theiria	*Carallia brachiata*	Rhizophoraceae	-	A,R
26	Zammir	*Citrus sp.*	Rutaceae	-	A,R

Table 5.36 Fruit trees found in the wild

Sl no	Local Name	Botanical Name	Family	Common/English name	Place of Occurrence
1	Bil	*Protium serratum*	Burseraceae	Indian red pear	A,R
2	Chalthei	*Pyrus pashia*	Rosaceae	Wild pear	A,R
3	Chengkek	*Garcinia cowa*	Guttiferae	-	A,R
4	Haifavang	*Mangifera sylvatica*	Anacardiaceae	-	A,R
5	Hel	*Ziziphus incurva*	Rhamnaceae	-	A,R
6	Hmuifang	*Syzygium praecoxum*	Myrtaceae	-	A,R
7	Hmuipui	*Syzygium cumini*	Myrtaceae	-	A,R
8	Hreirawt	*Cyathocalyx martabanicus*	Annonaceae	-	A,R
9	Kawrthindeng	*Dillenia indica*	Dillaniaceae	Elephant apple	A,R
10	Keipui	*Prunus jenkinsii*	Rosaceae	-	A,R
11	Khawkherh	*Juglans regia*	Juglandaceae	Walnut	A,R
12	Khawmhma	*Rhus semialata*	Anacardiaceae	-	A,R
13	Lumler	*Prunus nepalensis*	Rosaceae	-	A,R
14	Pangkai	*Baccaurea ramiflora*	Euphorbiaceae	Lutqua	A,R
15	Hmuifarial	*Syzygium claviflorum*	Myrtaceae	-	A,R
16	Raithei	*Aglaia edulis*	Meliaceae	-	A,R
17	Sarzuk	*Eleagnus caudata*	Eleagnaceae	-	A,R
18	Sunhlu	*Emblica officinalis*	Euphorbiaceae	Gooseberry/Amla	A,R
19	Tawitaw	*Spondias pinnata*	Anacardiaceae	Hog plum tree/Amra	A,R
20	Tat-kawng	*Artocarpus chama*	Moraceae	Chaplash	A,R
21	Tatte	*Artocarpus nitidus*	Moraceae	-	A,R
22	Theiarlung	*Prunus undulata*	Rosaceae	-	A,R
23	Theichhawl	*Syzygium grandis*	Myrtaceae	-	A,R
24	Theichhungsen	*Haematocarpus thomsoni*	Menispermaceae	-	A,R
25	Theihmu	*Rubus accuminatus*	Rosaceae	-	A,R
26	Theikelki	*Pentanura khasiana*	Asclepadiaceae	-	A,R
27	Theikhuangchawm	*Choerospondias axillaris*	Anacardiaceae	Labshi	A,R
28	Theikum	*Diospyros malabarica*	Ebenaceae	Riber ebony	A,R
29	Theipabuan	*Chrysophyllum lanceolatum*	Sapotaceae	Star apple	A,R
30	Theipalingkawh	*Bruinsmia polysperma*	Styracaceae	-	A,R
31	Theipui	*Ficus semicordata*	Moraceae	-	A,R
32	Theisawntlung	*Stixis suaveolens*	Capparidaceae	-	A,R
33	Theisehret	*Aphananthe cuspidata*	Ulmaceae	-	A,R
34	Theitat	*Artocarpus lacucha*	Moraceae	-	A,R
35	Thingsemim	*Castanopsis tribuloides*	Fagaceae	Chestnut	A,R
36	Tling	*Embelia vestita*	Myrsinaceae	-	A,R
37	Tuaihabet	*Garcinia xanthochymus*	Guttiferae	-	A,R
38	Tuaitit	*Antidesma bunius*	Euphorbiaceae	Chinese laurel	A,R
39	Vawmva	*Garcinia sopsopia*	Guttiferae	-	A,R
40	Vuakdup	*Willughbeia edulis*	Apocynaceae	Lata-am	A,R
41	Zawngbalhla	*Alphonsea ventricosa*	Annonaceae	-	A,R

Table 5.37 Timber species

Sl no	Local Name	Botanical Name	Family	Common/English name	Place of Occurrence
1	Buanchum	*Pachylarnax pleiocarpa*	Magnoliaceae	-	A
2	Bulpui	*Alseodaphne petiolaris*	Lauraceae	-	A, R
3	Bulbawr	*Persea villosa*	Lauraceae	-	R
4	Char	*Terminalia myriocarpa*	Combretaceae	Hollock	R
5	Nganbawm	*Artocarpus fraxinifolius*	Caesalpiniaceae	Mundani or Shingle tree	R
6	Ngiau	*Michelia champaca Linn.*	Magnoliaceae	Champak	A, R
7	Herhse	*Mesua ferrea*	Guttiferae	Iron-wood tree	A
9	Hnahzungthum	*Cinnamomum obtusifolium*	Lauraceae	Patichanda	A
10	Hriangzau	*Betula cylindrostachys*	Betulaceae	Low level Darjeeling birch,Saur	A
11	Kangtek	*Albizzia procera*	Mimosaceae	White Siris	A
12	Khiang	*Schima wallichii*	Theaceae	Needlewood	A, R
13	Khiangzo	*Cinnamomum glanduliferum*	Lauraceae	-	A
14	Khuangthli	*Bischofia javanica*	Euphorbiaceae	Bishop wood, Uriam	A,R
15	Lenhmui	*Syzygium cumini*	Myrtaceae	Blackplum, Blackberry, Jamun	A
16	Pang	*Bombax insigne Wall*	Bombadaceae	Didu	A
17	Phuanberh	*Macropanax undulatus*	Araliaceae	-	A
18	Pualeng	*Stephegyne diversifolia*	Rubiaceae	-	R
19	Reraw	*Terminalia chebula*	Combretaceae	Chebulic myrobalan	A
20	Sahatah	*Aglaia spectabilis*	Meliaceae	Aglaia, Amari	R
21	Saper bul	*Persea glaucescens Nees.*	Lauraceae	Rohu	A, R
22	Sentezel	*Calophyllum polyanthum*	Guttiferae	Poon	A
23	Tatkawng	*Artocarpus chama*	Moraceae	Chaplash	A, R
24	Theikhuangchawm	*Choerospondias axillaris*	Anacardiaceae	Labshi	R
25	Theipalingkawh	*Bruinsmia polysperma*	Styracaceae	-	A
26	Thingdawl	*Tetrameles nudiflora*	Datiscaceae	Maina	A, R
27	Thinghmarcha	*Celtis timorensis Span.*	Ulmaceae	-	R
28	Thingsaiphaw	*Heritiera acuminata*	Sterculiaceae	-	A
29	Thingsia	*Castanopsis tribuloides*	Fagaceae	Chestnut	A,R
30	Thingvandawt	*Terminalia bellirica*	Combretaceae	Belleric myrobalan	A, R
31	Thingvawkpui	*Sapium baccatum*	Euphorbiaceae	Seleng	A
32	Thlanvawng	*Gmelina arborea*	Verbenaceae	Gmelina, Gamari	R
33	Tualram	*Terminalia crenulata*	Combretaceae	Laurel	R
34	Vawmbal	*Drimycarpus racemosus*	Anacardiaceae	Telsur	A
35	Zuang	*Duabanga grandiflora*	Lythraceae	Lampati	R

Table 5.38 Fuelwood species

Sl No	Local name	Botanical name	Family	Common/English name	Place of occurrence
1	Banphar	*Neolamarckia cadamba*	Rubiaceae	Kadam	A
2	Batling	*Wendlandia grandis*	Rubiaceae	-	A
3	Bulpui	*Alseodaphne petiolaris*	Lauraceae	-	A,R
4	Chawmzil	*Ligustrum robustum*	Oleaceae	-	A,R
5	Fah	Lithocarpus dealbata	Fagaceae	-	A
6	Hel	*Ziziphus incurva*	Rhamnaceae	-	A,R
7	Hmuipui/lenhmui	*Syzygium cumini*	Myrtaceae	Blackplum, Blackberry, Jamun	A,R
8	Hnahzungthum	*Cinnamomum obtusifolium*	Lauraceae	False cinnamon	A
9	Kharuan	*Elaeocarpus lanceaefolius*	Tiliaceae	Needlewood	A,R
10	Khiang	*Schima wallichii*	Theaceae	-	A,R
11	Phekphe	*Engelhardtia roxburghiana*	Juglandaceae	-	A
12	Phuanberh	*Macropanax undulatus*	Araliaceae	-	A
13	Phuanberhpui	*Ailanthus integrifolia*	Simarubaceae	-	A
14	Rahvar/Par-arsi	*Ervatamia coronaria*	Apocynaceae	-	A,R
15	Saperbul	*Persea glaucescens*	Lauraceae	Rohu	R
16	Sehsen	*Ficus rigida*	Moraceae	-	A,R
17	Sevuak	*Olea dioica*	Oleaceae	Indian Olive, Karamba	A,R
18	Sihneh	*Eurya cerasifolia*	Pentaphylacaceae	-	A,R
19	Sunhlu	*Emblica officinalis*	Euphorbiaceae	Emblic myrobalan, amla	A
20	Thakthing	*Cinnamomum verum*	Lauraceae	True cinnamon, Dalchini	A,R
21	Theikawrak	*Memecylon celastrinum*	Melastomataceae	-	A
22	Theikum	*Diospyros malabarica*	Ebenaceae	Riber ebony, Tunka	A
23	Theipabuan	*Chrysophyllum lanceolatum*	Sapotaceae	Star apple	A
24	Theipalingkawh	*Bruinsmia polysperma*	Styracaceae	-	A
25	Then	*Quercus leucotrichophora*	Fagaceae	Grey oak, Ban oak	A,R
26	Thenngo	*Castanopsis echinocarpa*	Fagaceae	-	A
27	Thensen	*Lithocarpus pachyphyllus*	Fagaceae	-	A
28	Thingpawnchhia	*Glochidion khasicum*	Euphorbiaceae	-	R
29	Thingsaiphaw	*Heritiera acuminata*	Sterculiaceae	-	A,R
30	Thingsaphu	*Dysoxylum alliaria*	Meliaceae	-	A,R
31	Thingsia	*Castanopsis tribuloides*	Fagaceae	Chestnut	R
32	Tiar	*Saurauia punduana*	Saurauiaceae	-	R
33	Vawmbuh	*Castanopsis lanceaefolia*	Fagaceae	-	A
34	Zothinghang	*Diospyros lancifolia*	Ebenaceae	-	A

Table 5.39 Medicinal species

Sl no	Local Name	Botanical Name	Family	Common/English name	Place of Occurrence
1	Aieng	*Curcuma longa*	Zingziberaceae	Turmeric plant	A,R
2	Ailaidum	*Curcuma caesia*	Zingziberaceae	Black zedoary	A,R
3	At-hlo	*Solanum surattense*	Solanaceae	Yellow-berried nightshade	A
4	Buarze	*Blumea lanceolaria*	Compositae	-	R
5	Chawng	*Euphorbia royleana*	Euphorbiaceae	Danda thor	A,R
6	Chawhmathlum	*Albizzia myriophylla*	Mimosaceae	-	A
7	Chhawntual	*Aporusa octandra*	Euphorbiaceae	-	A,R
8	Dawl	*Colocasia esculenta*	Araceae	Taro	A,R
9	Fartuah	*Erythrina stricta*	Papilionaceae	-	A
10	Hlonuar	*Mimosa pudica*	Mmosaceae	Touch-me-not	A,R
11	Japanhlo	*Mikania micratha*	Compositae	-	A,R
12	Kangdamdawi	*Kalanchoe integra*	Crassulaceae	-	A,R
13	Kawlthei	*Psidium guajava*	Myrtaceae	Guava	A,R
14	Khampa	*Osbeckia chinensis*	Melastomaceae	-	A,R
15	Khawmhma	*Rhus semialata*	Anacardiaceae	-	A,R
16	Laikingtuibur	*Hedyotis scandens*	Rubiaceae	-	A
17	Mutih	*Ricinus communis*	Euphorbiaceae	Castor-oil plant	R
18	Pasaltakaza	*Helicia robusta*	Proteaceae	-	A
19	Ralsamkuai	*Uncaria sessilifructus*	Rubiaceae	-	R
20	Sangharvaibel	*Aeginetia indica*	Orobanchaceae	Forest ghost flower	A,R
21	Saisiak	*Securinega virosa*	Euphorbiaceae	-	A,R
22	Sarzuk	*Elaeagnus caudata*	Elaeagnaceae	-	A,R
23	Sekhupthur	*Begonia dioica*	Begoniaceae	-	A,R
24	Sumbul	*Costus speciosus*	Zingziberaceae	Kew	A,R
25	Thakpui	*Dendrocnide sinuata*	Urticaceae	-	R
26	Thasuih	*Lindernia ruellioides*	Scrophulariaceae	-	A,R
27	Theiarlung	*Prunus undulata*	Rosaceae	-	R
28	Thingdamdawi	*Picrasma javanica*	Simarubaceae	-	A,R
29	Thingsia	*Castanopsis tribuloides*	Fagaceae	Chestnut	A,R
30	Tlangsam	*Eupatorium odoratium*	Compositae	Common floss flower	A,R
31	Tluangngil	*Smilax glabra*	Liliaceae	-	A,R
32	Thuamriat	*Alstonia scholaris*	Apocynaceae	Scholar or Devil tree	A
33	Vako/ Zawngafian	*Thunbergia grandiflora*	Acanthaceae	Sky flower/Blue trumpet vine	A
34	Zawngtenawhlung	*Macaranga denticulata*	Euphorbiaceae	-	R

Table 5.40 Edible species

Sl no	Local Name	Botanical Name	Family	Common/English name	Place of Occurrence
1	Ankasa	*Spilanthes acmella*	Compositae	-	A,R
2	Ankhapui	*Marsdenia maculata*	Asclepiadaceae	-	A,R
3	Ankhate	*Marsdenia formosana*	Asclepiadaceae	-	A,R
4	Anpangthuam	*Lepionurus sylvestris*	Olacaceae	-	A,R
5	Bakhate	*Glinus oppositifolia*	Aizoaceae	-	A,R
6	Bekang	*Glycine max*	Papilionaceae	Soyabean	A,R
7	Buarpui	*Livistona chinensis*	Arecaceae	Chinese fan palm	R
8	Chakawk	*Diplazium maxima*	Polypodiaceae	-	A,R
9	Changelpa	*Agaricus sp.*	Agaricaceae	-	A,R
10	Chingit	*Zanthoxylum rhetsa*	Rutaceae	Mullilam	A,R
11	Hruipui	*Calamus flagellum*	Arecaceae	Kadam bet	A,R
12	Hruitung	*Zalacca secunda*	Arecaceae	-	A,R
13	Kawhtebel	*Trevesia palmata*	Araliaceae	-	A,R
14	Khanghu	*Acacia pennata*	Mimosaceae	-	A,R
15	Khatual	*Curanga amara*	Scrophulariaceae	-	A,R
16	Khaum	*Hodgsonia macrocarpa*	Cucurbitaceae	-	A,R
17	Lambak	*Centella asiatica*	Umbelliferae	Indian pennywort	A,R
18	Luangpa	*Agaricus sp.*	Agaricaceae	-	A,R
19	Maupa	*Agaricus sp.*	Agaricaceae	-	A,R
20	Mautak	*Melocanna baccifera*	Poaceae	-	A,R
21	Mawt	*Calamus andamanicus*	Arecaceae	-	A,R
22	Meihle	*Caryota mitis*	Arecaceae	-	R
23	Mitperh	*Calamus acanthospathus*	Arecaceae	-	A,R
24	Pasi	*Agaricus sp.*	Agaricaceae	-	A,R
25	Pasuntlung	*Agaricus sp.*	Agaricaceae	-	A,R
26	Pelh	*Gnetum gnemon*	Gnetaceae	-	A,R
27	Phuihnam	*Clerodendrum colebrookianum*	Verbenaceae	-	A,R
28	Phulrua	*Dendrocalamus hamiltonii*	Poaceae	-	A,R
29	Rawnal	*Dendrocalamus longispathus*	Poaceae	-	A,R
30	Rawthing	*Bambusa tulda*	Poaceae	Tulda	A,R
31	Sakhichildiah	*Pogostemon elsholtziodes*	Lamiaceae	-	A
32	Siallu	*Borassus flabellifer*	Arecaceae	Palmyra or Toddy palm	A,R
33	Sihneh	*Eurya cerasifolia*	Theaceae	-	A,R
34	Telhawng	*Arisaema speciosum*	Araceae	Snake or cobra plant	A,R
35	Thakthing	*Cinnamomum verum*	Lauraceae	True cinnamon, Dalchini	A,R
36	Thangtung	*Arenga pinnata*	Arecaceae	Malay sago palm	A
37	Thilte	*Calamus tenuis*	Arecaceae	Jali or Jalla bet	A,R
38	Thingthupui	*Dysoxylum gobara*	Meliaceae	-	A,R
39	Tumbu	*Musa sp.*	Musaceae	-	A,R

Table 5.41 Bamboo species

Sl no	Local Name	Botanical Name	Family	Common/English name	Place of Occurrence
1	Chalte	*Pseudostachynum polymorphum*	Poaceae	-	A,R
2	Lik	*Sinarundinaria falcata*	Poaceae	-	A,R
3	Mautak	*Melocanna baccifera*	Poaceae	-	A,R
4	Phulrua	*Dendrocalamus hamiltonii*	Poaceae	-	A,R
5	Rawlak	*Dendrocalamus hookeri*	Poaceae	-	A,R
6	Rawmi	*Dendrocalamus sikkimensis*	Poaceae	-	A,R
7	Rawnal	*Dendrocalamus longispathus*	Poaceae	-	A,R
8	Rawngal	*Schizostachyum capitatum*	Poaceae	-	A,R
9	Rawte	*Bambusa khasiana*	Poaceae	-	A,R
10	Rawthing	*Bambusa tulda*	Poaceae	Tulda	A,R
11	Rawthla	*Schizostachyum dulloa*	Poaceae	-	A,R
12	Sairil	*Dinochloa compactiflora*	Poaceae	-	A,R
13	Talan	*Bambusa oliveriana*	Poaceae	-	A,R

Table 5.42 Canes and Palms

Sl no	Local Name	Botanical Name	Family	Common/English name	Place of Occurrence
1	Buarpui	*Livistona chinensis*	Arecaceae	Chinese fan palm	R
2	Hruipui	*Calamus flagellum*	Arecaceae	Kadam bet	A,R
3	Hruitung	*Zalacca secunda*	Arecaceae	-	A,R
4	Mawt	*Calamus andamanicus*	Arecaceae	-	A,R
5	Meihle	*Caryota mitis*	Arecaceae	-	R
6	Mitperh	*Calamus acanthospathus*	Arecaceae	-	A,R
7	Siallu	*Borassus flabellifer*	Arecaceae	Palmyra or Toddy palm	A,R
8	Tairua	*Calamus guruba*	Arecaceae	Sundi bet	A,R
9	Thangtung	*Arenga pinnata*	Arecaceae	Malay sago palm	A
10	Thilte	*Calamus tenuis*	Arecaceae	Jali or Jalla bet	A,R
11	Thilthek	*Calamus erectus*	Arecaceae	-	A,R
12	Tum	*Caryota urens*	Arecaceae	Fishtail palm	A,R

- A= Ailawng village, R = Reiek village

CHAPTER-6

CHAPTER 6

SUMMARY AND CONCLUSION

6.1. Summary

The study site Reiek forest is located between longitude $92^0$37' and $93^0$28'E and latitude $20^0$45' and $22^0$46'N in the north west of Mizoram in Mamit district. It occupies an area of 10 sq.km and is 25 kms away from Aizawl, the capital of Mizoram. The highest point is the peak of Reiek mountain which is 1485m asl. The forest can be classified as tropical semi-evergreen forest. The temperature ranges between 8^0C - 22^0C in winter and 20^0C - 28^0C in summer.. Rainfall is heavy; the recorded rainfall during 1997 was 2673mm. The soil is composed of silt-loam in the upper portion and stone plates in the peak region and the rest of the area are mostly sandy-loam to black humus top-soils The study site does not enclose any major stream but is marked by the presence of small seasonal brook which all flow into Tlawng river.

The research was conducted for a period of 5 years starting from November 2008. The study site have been divided into three zones- the core zone which is the undisturbed site, the buffer zone which is the moderate to highly disturbed site and the grassland zone found in the higher altitude.

The thesis consist of six chapters which are as follows:

The first chapter is the introduction which consist of the origin of the word and definition of biodiversity, types and patterns of biodiversity; concept of megadiversity and hotspots; the definition, structure and classification of plant community; threats to biodiversity and lastly scope and objectives.

The second chapter is the review of literature and has been classified at the global level, national level, northeast level and local level.

The third chapter deals with the study area, its location and boundaries, the climate, season, vegetation, geology and soil and drainage.

The fourth chapter is concerned with the research methodology followed in this study for the analysis of plant communities and for socio economic study.

The fifth chapter deals with the result and discussion. The main findings of the study are summarized below.

The total of 283 plant species were recorded in the study site belonging to 230 genera and 92 families. Of the 92 families, there were 84 families of angiosperms, 2 families of gymnosperms and 6 families of pteridophytes. The dicotyledons comprised of 72 families, 167 genera and 201 species. The monocotyledons comprised of 12 families, 53 genera and 70 species.

Raunkiaer's life form of plants revealed thatPhanerophytes were the most dominant life (50%) followed by Chamaephytes (10.56%), Epiphytes (10.56%), Lianas (8.80%) Cryptophytes or geophytes (7.75%), Therophytes (6.69%) and Hemicryptophytes (5.63%). Megaphanerophytes were absent in the study area.

Within the core zone, 217 species under 174 genera belonging to 80 familieswere identified. Within the buffer zone, 203 species under 168 genera belonging to 75 families were identified. A total of 51 species under 50 genera belonging to 26 families are found in the grassland

Within the families, the five most dominant ones in their order of dominance were Orchidaceae , Arecaceae , Rubiaceae , Poaceae and Euphorbiaceae in the core zone, Orchidaceae, Poaceae, Arecaceae, Lauraceae and Rubiaceae in the buffer zone and Poaceae, Asteraceae, Cyperaceae, Liliaceae and Melastomaceae in the grassland zone

In the core zone, the most dominant tree species was *Calophyllum polyanthum having* IVI of 30, the most dominant shrub species was *Mallotus albus*with IVI of 31 and the most dominant herb species was *Houttuynia cordata* with

IVI of 21. Among climber, *Smilax lanceaefolia* had the most density. Among epiphytes, the species with the highest density was *Dendrobium ochreatum. Drepanostachyum intermedium* had the highest density among grasses and *Pandanus odorifer* had the highest density among canes and palms.

In the Buffer zone, the most dominant tree species was *Helicia erratica* having IVI of 35, the most dominant shrub species was *Polygonum chinense* with IVI of 24 and the most dominant herb species was *Diplaziummaximum* with IVI of 21. The species which had the highest density were *Smilax lanceaefolia* among climbers, *Aeschynanthus maculate* among epiphytes, *Eulalia trispicata* among grasses and *Arenga pinnata* among canes and palms.

The grassland zones was marked by the absence of trees. The most dominant shrub species was *Vibrunum foetidum* , the most dominant herb species was *Scleria levis*, the most dominant climber was *Porana racemosa* and the most dominant grass species was *Eulalia trispicata.* Within the grassland zone, *Eulalia trispicata* has the highest IVI of 48. This is followed by *Imperata cylindrical* with IVI of 47 , *Cynodon dactylon* with IVI of 14, *Erianthus longisetosus* with IVI of 13 and *Scleria terrestris* with IVI of 12 which shows the dominance of grass species.

The biodiversity indices for core zone revealed that species diversity was high ranging from H'= 2.92 to 4.03 Margalef's index of species richness D_{mg} ranged from 3.3 to 13.28 with the highest value for tree species. Simpson's dominance index (D) was low ranging from 0.02 to 0.03 with higher dominance among shrub species. The Pielou's index of evenness (E) ranged from 0.89 to 0.97 . In the buffer zone, the species diversity index H' ranged from 3.19 to 3.78 with trees showing the maximum diversity. Margalef's index of species richness D_{mg} ranged from 4.03 to 10.58. Simpson's dominance index (D) ranged from 0.03 to 0.04. The Pielou's index of evenness (E) ranged from 0.89 to 0.96. For the grassland zone, the species diversity H' = 3.44, Margalef's index of species richness D_{mg} = 7.37, Simpson's Dominance

index = 0.04 and Pielou's index of evenness (E) =0.87. The core zone showed a higher diversity for tree species compared to buffer zone while buffer zone showed higher diversity for herbs. The shrub diversity was almost the same in the buffer and core zones.

Stratification of the floristic components was distinguished by drawing profile diagram which shows that there are 3 layers or stratification found in Reiek forest- the top canopy, middle canopy and under canopy. The top canopy and middle canopy were dominated by tree species while the under canopy was dominated by shrubs and herbaceous species.

The conservation status of each plant species were checked against Red Data book of Indian plants(Nayarand Sastry, 1987-1990. and IUCN Red List of Threatened species which showed that only 17 species have been assessed so far and out of that *Borassus madagascariens* was classified as vulnerable while Eleocarpus *rogusus* and *Saraca asoca* were endanged. The rest of the species have been placed under data deficient or least concern

There are two adjoining villages- Reiek village with a population of 1690 and Ailawng village with a population of 712. More than half of the total population depend on agriculture as the main source of livelihood. Animal rearing was dominated by piggery with 76% of the households rearing at least one pig. This was followed by poultry practiced by 17 % of the households

Of the 43 species of crop cultivated, the main crop grown was *Oryza sativa.* This was supplemented by crops like *Brassica juncea, Phaseolus vulgaris, Solanum melongena, Vignia unguiculata, Momordica charantia, Zea mays,Cucurbita maxima, Benincasa hispida, Sechium edule,Eryngium foetidum,Solanum anguivi,Coriandrum sativum, Abelmoschus esculentus, Trichosanthes angiuna.*

23 species of fruit were cultivated under horticulture while 41 fruit trees have been recorded in the wild. Some of the major fruit trees grown were *Prunus*

domestica,Psidium guajava,Artocarpus heterophyllus, Citrus limon,Tamarindus indica,Musa paradisiaca,Citrus grandis and *Mangifera indica.* The common fruit trees found in the wild include *Protium serratum, Pyrus pashia,Mangifera sylvatica,Syzygium cumini,Prunus jenkinsii,Rhus semialata,Baccaurea ramiflora, Ficus semicordata, Antidesma bunius ,Bruinsmia polysperma.* Some of the nut trees growing in the wild include *Juglans regia* and *Castanopsis tribuloides*

35 timber species have been recorded. The common timber species were *Alseodaphne petiolaris, Persea villosa, Terminalia myriocarpa, Michelia champaca, Mesua ferrea, Cinnamomumobtusifolium, Betula cylindrostachys, Schima wallichii,, Cinnamomum glanduliferum ,Bischofia javanica, Syzygium cumini, Macropanax undulatus*

34 fuelwood species have been recorded and the common fuelwood species were *Elaeocarpus lanceaefolius, Schima wallichii, Engelhardtia roxburghiana, Macropanax undulatus, Ailanthus integrifolia, Ervatamia coronaria,Persea glaucescens, Ficus rigida,Olea dioica, Eurya cerasifolia, Emblica officinalis, Cinnamomum verum, Quercus leucotrichophora, Heritiera acuminata, Dysoxylum alliaria.*

Medicinal plants used by the local people consist of 34 species. The medicinal plants used included *Curcuma longa, Curcuma caesia, Solanum surattense, Blumea lanceolaria, Euphorbia royleana, Albizzia myriophylla, Aporusa octandra, Colocasia esculenta, Erythrina stricta, Mimosa pudica, Mikania micratha, Kalanchoe integra, Psidium guajava, Osbeckia chinensis, Rhus semialataand Hedyotis scandens*

39 edible plants species were collected from the forest by the local people. This included *Spilanthes acmella, Lepionurus sylvestris,Glinus oppositifolia, Diplazium maxima, Marsdenia formosana, Zanthoxylum rhetsa, Acacia pennata, Livistona chinensis, Calamus flagellum, Zalacca secunda*and *Calamus andamanicus.*

13 species of bamboo have been recorded which were used by the local people of the study site namely *Pseudostachynum polymorphum, Sinarundinaria falcata, Melocanna baccifera, Dendrocalamus hamiltonii, Dendrocalamus hookeri, Dendrocalamus sikkimensis, Dendrocalamus longispathus, Schizostachyum capitatum, Bambusa khasiana, Bambusa tulda, Schizostachyum dulloa, Dinochloa compactiflora* and *Bambusa oliveriana*

Canes and palms included 12 species namely *Livistona chinensis, Calamus flagellum, Zalacca secunda, Calamus andamanicus, Caryota mitis, Calamus acanthospathus, Borassus flabellifer, Calamus guruba, Arenga pinnata, Calamus tenuis, Calamus erectus* and *Caryota urens.*

The sixth chapter deals with summary and conclusion of the findings in the study site.

The work is supplemented by exhaustive references.

6.2. Conclusion

From the present study, it can be concluded that Reiek forest in Mamit district of Mizoram has a rich plant diversity consisting of high taxonomic diversity of species, genera and family. The factor contributing to this are favourable climatic conditions of the area, its geographic proximity to the species-rich eastern Himalayas, Burma and the Malayan peninsula and its prolonged protection. The forest is tropical in nature and resembles closely the tropical forest of Western and Eastern Ghats in plant community structure. It is dominated by evergreen tree species and thus may be classified as an evergreen or semi-evergreen forest.

Qualitative and quantitative biodiversity data of Reiek forest will be useful in future forest management and conservation. The whole study area although protected jointly by the village councils of Reiek and Ailawng village and the Young Mizo Association of the two villages, is still not free from encroachment which is the

main threat to the rich biodiversity of the area. In order to maintain the complexity of this forest and its species diversity, an economically and ecologically sound management plan is desirable with minimum disturbance to the forest ecosystem. A formal conservation action is needed from the Government so as to ensure its protection.Long-term research on the forest and forest management practices must be given priority for the protection, conservation, and perpetuation of this forest. It is hoped that for such a plan, the present study will provide the required baseline data on the structure and floral diversity of Reiek forest.

Subalpine and alpine grassland species are disappearing at an alarming rates worldwide, reducing annually by 1–4% of their current area (Laurence, 1999) Proper management is needed to prevent the grassland from turning into brushland and to prevent soil erosion. The anthropogenic disturbance and uncontrolled fire has paved the way for alien plant invasion threatening the endemic species.

Reiek forest with its rich biodiversity needs to be conserved as a genetic reservoir of wild species.

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