STUDIES ON FLORISTIC DIVERSITY IN TAWI WILDLIFE SANCTUARY IN AIZAWL DISTRICT OF MIZORAM

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I, Lallawmkimi hereby declare that the thesis entitled **Studies on Floristic Diversity of Tawi Wildlife Sanctuary in Aizawl District of Mizoram** is a record of work done by me during 2006 to 2011 under the supervision and guidance of Prof. H. Lalramnghinglova Head of Environmental Science Department, 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 by me for any research degree in any other University/Institute.

This is being submitted to the Mizoram University for the degree of Doctor of Philosophy in Environmental Science.

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CONTENTS

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List of Figures **Pages**

List of Tables **Pages**

CHAPTER - 1

CHAPTER - 1

1. INTRODUCTION

1.1. Biodiversity: Concept and definitions

Biodiversity is a basic property of life, which manifests itself at all levels of biological organization from cell to ecosystems and thus includes all types of variability among all living organisms from all sources. The word *'biodiversity'* is an abbreviation of biological diversity. Diversity is a concept, which refers to the range of variations or differences among some set of entities; biological diversity thus refers to variety within the living world. However, the most prevalent usage of the term *'biodiversity'* is a synonym for the *'variety of life'* (Wilson 1988, Harper and Hawksworth 1994, Norse 1994).

'Biological diversity' has a long history of usage in a variety of contexts. The start of its rise in the current sense can be traced to three publications, which appeared in the 1980's. Lovejoy (1980) did not provide a formal definition but used it essentially in the sense of number of species present, and Norse and Mc Manus (1980) employed it to include two related concepts – 'genetic diversity and ecological diversity'. They equated ecological diversity with species richness, *'the number of species in a community of organisms'*. Norse *et al.,* (1986) expanded the usage to refer unequivocally to biological diversity at three levels - genetic (within species), species (species number) and ecological (community) diversity. However, the minutes of the *National Forum* which were published under the title *Biodiversity* in a book edited by Wilson (1988), in effect proper launched the word biodiversity into general use. Consequently, the word *'biodiversity'* first appeared in the *Biological Abstracts* BIOSIS database in 1988 with four references, and since then the concept has been acquiring popularity.

The UN Convention on Biological Diversity (1992) defined biological diversity as " the variability among living organisms from all sources including, *inter alia,* terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within (intraspecific) and between species (interspecific) of an ecosystems" (Anon.1992). The India's 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 of ecosystems" (Anon. 2002). According to Agarwal (2002), 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.

Diversity addresses two distinct aspects *i.e.,* species richness and evenness. Richness refers to the number of species 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

Biodiversity is usually defined in terms of genes, species and ecosystem; corresponding to three fundamental and hierarchically related levels of biological organization. The same is documented as three kinds of biodiversity *i.e.,* genetic diversity, species or taxonomic diversity and ecosystem diversity (McAllister, 1991, Solbrig 1991; Groombridge 1992; Heywood 1994; Norse 1994). However, Harper and Hawksworth (1994) favour the terms referred as genetic, organismal and

ecological diversity. Another classification distinguishes three interdependent sets of attributes: compositional levels (the identity and variety of elements) and structural levels (ecological and evolutionary processes) (Noss 1990). The different types of diversity can be stated as follows:

(a) Genetic diversity

Genetic diversity refers to the variation of genes within species. This cover genetic variation between distinct populations of the same species. Genetic diversity is clearly an important component of biodiversity (Gaston 1996, Mallet 1996).

Gene is a segment of DNA (Deoxyribonucleic acid) in which genetic code is enclosed. These genes are arranged linearly along the DNA and are responsible for various characters exhibited by the individual organism. The DNA of a cell is divided to form chromosomes which are thread like structures. In the living organisms where sexual reproduction takes place, a set of chromosomes each from the two parents is passed on to the offspring during the process of fertilization thus, the genetic differences from the two individuals (parents) are combined to form new combinations, as a result the new individuals with changed characters are formed adding to the diversity of the living world.

The 'fine scale' level of biodiversity is measured in the variety of expressed genes or characters among organisms (Williams *et al.,* 1996). However, as a basic unit for measuring and assessing biodiversity it has previously been dismissed as too difficult and costly to use (Mortiz 1994).

There are many different ways to measure genetic diversity. Genetic Diversity of a population can be assessed by some simple measures.

- **Gene diversity** is the proportion of polymorphic loci across the genome.
- **Heterozygosity** is the mean number of individuals with polymorphic loci.

- **Alleles per locus** are also used to demonstrate variability.

The modern causes for the loss of animal genetic diversity have also been studied and identified (Groom *et al.,*2006) A study conducted by the National Science Foundation in 2007 found that genetic diversity and biodiversity are dependent upon each other - that diversity within a species is necessary to maintain diversity among species, and vice versa.

Genetic diversity plays a very important role in survival and adaptability of a species because when a species's environment changes, slight gene variations are necessary to produce changes in the organism's anatomy that enables it to adapt and survive. A species that has a large degree of genetic diversity among its population will have more variations from which to choose the fit alleles. Increase in genetic diversity is also essential for an organism to evolve. Species that have very little genetic variation are at a great risk. With very little gene variation within the species, healthy reproduction becomes increasingly difficult, and offspring often deal with similar problems to those of inbreeding. The vulnerability of a population to certain types of diseases can also increase with reduction in genetic diversity.

(b) Species diversity

Species diversity refers to the variety of species within a region. It can be defined as a group of interbreeding or potentially inter breeding natural populations that are reproductively isolated from other such groups.

The aspects of species diversity can be measured in a number of ways. Most of these ways can be classified into three groups of measurement: 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

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; Spellerberger 1992).

The biodiversity of a given region is generally assessed in terms of species richness. The species richness describes total number of species found occurring wild or domesticated in the given geographical area. However, the species richness only provides the total number of species and does not reflect the complete picture of the diversity of types of organisms.

The relative abundance of species in various taxonomic groups like micro organisms, cryptogams, angiosperms etc. is only understood by taxic diversity. For example - habitats with equal species diversity (number of species) may not have the same taxic diversity (WRI, IUCN, UNEP, 1992)

(c) Habitat diversity

Habitats can be defined as areas that provide the resource requirements for a discrete phase of a plant or animal's life (Southwood 1981). Andrewartha and Birch (1984) provide a broader context to potential influences on the survival and reproduction and hence, distribution and abundance of organisms *via* their theory of environment with direct and indirect influences on an organism. However, in practice, their physical structure and their constituent vegetative species, especially with respect to dominant species often define habitats (Caley and Schluter 1997). Estimates of habitat diversity are often considered as a foundation of area based management, although it is often difficult to assess habitats quantitatively.

(d) Ecosystem diversity

An ecosystem is defined as a square metre of grassland or of a forest, the edge of a pond, a tide pool, or any large area of nature that has living organisms and non-living substances interacting and exchanging between them. The ecosystem may be:

(a) Aquatic ecosystem – (i) Fresh water ecosystem and (ii) Marine ecosystem.

(b) Terrestrial ecosystem – Forest ecosystem (ii) Desert ecosystem (iii) man made ecosystem.

Ecosystem refers to all the individuals, species, and populations in a spatially defined area, the interactions among them and those between them and the abiotic environment (Likens 1993).

Ecosystem diversity encompasses the broad differences between ecosystem types, and the diversity of habitats and ecological processes occurring within each ecosystem type. It is harder to define ecosystem diversity than species or genetic diversity because the boundaries of communities and ecosystems are more fluid. Since the ecosystem concept is dynamic and thus variable, it can be applied at different scales, though for management purposes it is generally used to group broadly similar assemblages of communities. A key element in the consideration of ecosystems is that in the natural state, ecological processes such as energy flows and water cycles are conserved. 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, and a mangrove swamp ecosystem. Because temperature is an important aspect in shaping ecosystem diversity, it is also used in ecosystem classification (*e.g.,* cold winter deserts, versus warm deserts) (Udvardy 1975).

Broadly speaking, the diversity of an ecosystem is dependent on the physical characteristics of the environment, the diversity of 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).

Ecosystem diversity is generally assessed by the diversity of the component species, relative abundance of various species as well as types of species.

1.3. Patterns of biodiversity

Whittaker (1962, 1975 and 1977) distinguished four levels of inventory diversity that could be estimated at four increasingly larger spatial scales. They are as follows:

(i) Point diversity: On the smallest scale is point diversity of a micro-habitat or sample taken from within a homogenous habitat.

(ii) Alpha diversity: The diversity of this homogenous habitat is termed as alpha diversity, and is directly equivalent to Mc Arthur's (1965) idea of within-habitat

diversity. At a homogeneous site, *i.e.,* for a given landscape ecosystem type or community in a homogeneous site.

(iii) Gamma diversity: The next scale of inventory diversity is gamma diversity, the diversity of a larger unit such as an island or landscape.

(iv) Epsilon diversity: As gamma diversity is defined to be the overall diversity of a group of areas of alpha diversity so epsilon or regional diversity is the total diversity of a group of areas of gamma diversity. Whittaker envisaged epsilon diversity applying to large biogeographic areas.

Alpha (species) diversity is the diversity of species within a particular habitat or community. Beta diversity is a measure of the rate and extent of change in species along a gradient from one habitat to another (or expression of between-habitat diversity). Gamma (Landscape) diversity is dependent on both alpha diversity and beta diversity and is the diversity of species within a geographical area (Spellerberg 1992). To summarise all the above statements, the overall diversity of any given area will be a reflection of the range of habitat it includes and the diversity of the component habitats.

Halffter (1998) has advocated that the diversity be studied at the landscape level because the consequences of human activities (community modification and fragmentation) are most evident at this level. The components of diversity can be characterised by distinguishing them and quantifying the local distribution of species, similarity among local assemblages, and the rate of change in species composition with respect to ecological conditions.

(i) Alpha (α) diversity (*i.e.,* diversity within communities) is measured as the number of species occurring within an area of a given size and the distribution of individuals among the species (Huston 1994). It,

therefore, measures the richness of a potentially interactive assemblage of species. Alpha diversity has two important components: (a) Species richness, *i.e.,* the number of species per unit area, and (b) Species evenness, *i.e.,* 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 *et al.,* 1996). The alpha diversity of any location is a balance between the actions of local biotic and abiotic elements and immigration from other locations (Halffter 1998).

(ii) Beta (β) diversity (*i.e.,* diversity between communities), on the other hand, 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 responses to habitat heterogeneity.

(iii) Gamma (γ) diversity (*i.e.,* total diversity of a region) refers to an overall diversity within a large area and corresponds to the 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.

1.4. Megadiversity Zones

The concept of "megadiversity" involves an estimate of the total number of all the organisms in an ecosystem and means that a place has a larger percentage of living

species in its territory than what would correspond to it if that percentage were proportional to its surface. This 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 mega-diversity emphasizes 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).

On 18 February 2002, the Ministers in charge of the Environment and the delegates of Brazil, China, Colombia, Costa Rica, India, Indonesia, Kenya, Mexico, Peru, South Africa and Venezuela assembled in the Mexican resort town of Cancun. 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 Protocol on 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.

The twelve highest Mega diversity countries of the world are presented in **Table - 1.1**

Table - 1.1 Megadiversity countries of the world

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

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

1.5 Biodiversity hotspots

A **biodiversity hotspot** is a biogeographic region with a significant reservoir of biodiversity that is threatened with destruction.

The concept of biodiversity hotspots was originated by Dr. Norman Myers in two articles in "The Environmentalist" (Myers 1988, 1990), revised after thorough analysis by Myers *et al.,* 1999 in "Hotspots: Earth's Biologically Richest and Most

Endangered Terrestrial Ecoregions" .The hotspots idea was also promoted by Russell Mittermeier in the popular book "Hotspots revisited" (Mittermeier 2004), although this has not been subjected to scientific peer review like the other hotspots analysis.

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, and it has to have lost at least 70% of its primary vegetation (Myers *et al.,* 2000). The existing 25- hotspots of the world have been updated to 34- hotspots with the list of 9 new hotspots in the great range of the Himalayas and the island nation of Japan (Holsinger 2005). These sites support nearly 60% of the world's plant, bird, mammal, reptile, and amphibian species, with a very high share of endemic species. The eight hottest hotspots are shown in Table **1.2**

The biodiversity hotspots have been severely disturbed by various environmental factors, and five important determinants include (i) land use (conversion of 50% of land area to agriculture); (ii) climate change ($4^{o}C$ or 30% change in precipitation); (iii) nitrogen deposition (20 kg/ha/yr; (iv) biotic change (arrival of 200 new species of plant/animal; and, (v) atmospheric CO_2 (2.5 fold increase) by the year 2100 (Sala *et al*., 2000), land use change has been identified as the most severe driver of changes in global diversity.

Table – 1.2. The eight hottest hotspots

Sl. No.	Hotspot	Endemic plants	Endemic plants/ area ratio (species per 100km2)	Remaining primary vegetation as % of original extent
1	Madagascar	9,704	16.4	9.9
2	Philippines	5,832	64.7	3.0
3	Sundaland	15,000	12.0	7.8
4	Brazil's Atlantic Forest	8,000	8.7	7.5
5	Caribbean	7,000	23.5	11.3
6	Indo-Burma	7,000	7.0	4.9
7	Western Ghats/Sri Lanka	2,180	17.5	6.8
8	Eastern Arc and Coastal Forests of Tanzania/Kenya	1,500	75.0	6.7

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

1.6. Community structure and organisation

The concept of community refers to the collection or assemblage of organisms within a particular area at a given time. Community is a generic term of convenience that is used to designate sociological units of any degree of extent and complexity (Cain and Castro 1959). Thus the aggregate of plants over a broad area may be considered a community as well as a local collection of plants associated with a specific site. Beyond the co-occurrence of plants that occupy space and have a spatial boundary, opinions vary as to the 'nature' of the community.

A community is a taxonomic construct, an entity or assemblage defined by the spatial association of organisms – neighbors in the same space. As such, they can be

classified or arranged in many ways depending on purpose. In this regard, the scale at which vegetation is viewed is an important consideration. When viewed at the broad scale of subcontinents and regions, no two units within a subcontinent appear alike. However, if a large and complex area is divided again and again, the scale of differences between units is reduced and the possibility of finding similar communities in limited space is increased. In brief, those whose sample areas that are large will inevitably discover uniqueness; those sample areas that are small, numerous, and in the same vicinity are more apt to discover that essential of classification, acceptable alikeness.

1.6.1. Characteristics of plant community

Like a population, a community too has its own characteristics, which are not shown by its individual component species. These characteristics which have meaning only with reference to community level of organization are as follows -

(a) Species diversity: Each community is made up of much different organisms – plants, animals, microbes, which differ taxonomically from each other. The number of species and population abundance in community also vary greatly.

There are two levels of species diversity: (i) regional diversity of whole nations or parts of continents within which many different communities exist, and (ii) local diversity in a given nation where different communities exist at different latitudes.

(b) Growth form and structure: Community is described in terms of major growth forms as trees, shrubs, herbs, mosses etc. In each growth form as in trees, there may be different kinds of plants as broad - leaved trees, evergreen trees etc. These different growth forms determine the structural pattern of a community. According to the mode of arrangement of the various growth forms, the communities

exhibit: (i) zonation - (horizontal layering) as well as, (ii) stratification-(vertical layering).

Growth forms of plants can be used as the basis of a classification system. Instead of being concerned with the species composition of a plant community, we can use its visible structure as a basis of classification (Beard 1973).

(c) Dominance: In each community all the species are not equally important. There are relatively only a few of these, which determine the nature of the community. These few species exert a major controlling influence on the community. Such species are known as dominants.

(d) Succession: Each community has its own developmental history. It develops as a result of a directional change in it within time.

(e) Trophic structure (self-sufficiency): Nutritionally, each community, a group of autotrophic plants as well as heterotrophic animals, exists as a self - sufficient, perfectly balanced assemblage of organisms.

1.6.2. Composition, structure, origin and development of a community

Each community has its own composition, structure and developmental history.

(a) Composition

Communities may be large which extends over areas of several thousands of square kilometers, as forests, deserts etc. or small such as the groups of microorganisms in such microhabitats as leaf surface, fallen log, litter, soil etc. The number of species and population abundance in communities vary greatly.

In each community there are diverse species. All these species are not equally important but these are only a few overtopping species which by their bulk and

growth modify the habitat and control the growth of other species of the community, thus forming a sort of characteristic nucleus in the community. These species are called the dominants.

(b) Structure

Besides composition and dominance, the communities exhibit a structure or recognizable pattern in the spatial arrangement of their members. Thus structurally, a community may be divided horizontally into 'sub communities', which are units of homogenous life - form and ecological relation. This horizontal division constitutes the zonation in the community. Another aspect of structure is stratification which involves vertical rather than horizontal changes within the community. In each horizontal zone, there may be recognized distinct vertical storey. Sometimes the stratification is very complex where community possesses a number of vertical layers of species, each made up of a characteristic growth form. Stratification in a forest community is most complicated where as many as five vertical subdivisions may be recognized. These vertical subdivisions are: (i) subterranean subdivision, (ii) forest floor, (iii) herbaceous vegetation, (iv) shrubs, and (v) trees. In some tropical rain forests, there may be as many as eight vertical strata. Thus, based upon the light and relative humidity requirements, we find stratification in above ground parts.

(c) Origin and development

A community with its particular environment constitutes an entity which has its origin and development. Communities are never stable, but dynamic, changing more or less regularly over time and space. They are never found permanently in complete balance with their component species or with the physical environment. Environment is always kept on changing over a period of time due to (i) variations in climatic and physiographic factors, and (ii) the activities of the species of the

communities themselves. These influences bring about marked changes in the dominants of the existing community, which is thus sooner or later replaced by another community at the same place. This process continues and successive communities develop one after another over the same area, until the terminal final community again becomes more or less stable for a period of time. This occurrence of relatively definite sequence of communities over a period of time in the same area is known as ecological succession. The authentic studies on succession were started in America by Cowles (1899). Clements (1916) thereafter put forth various principles that governed the process of succession. Clements (1916) while studying plant communities defined succession as 'the natural process by which the same locality becomes successively colonized by different groups or communities of plants.

1.7. Composition and characteristics of soil

The soil is a dynamic layer of surface material which is constantly changing and developing under processes of adjustment to conditions of climate, parent material, topography and vegetation**.** The soil is made up of substances existing in solid, liquid and gaseous states, with colloidal particles of organic and inorganic origin playing an important function in their make up and activity. Ecologically, the soil is the medium for plant growth. It can also be defined as the part of the crust of the earth in which roots of the plant are actually growing. Biologically, soil may be regarded as a weathered outer crust of the earth in which remains and products of decay of living organisms are finely mingled. According to Wadia (1949) "the soil is the topmost layer of the earth's outer crust capping the rocks exposed at the surface. It is a natural body of variable thickness, composed of disintegrated rock material together with variable proportion of organic matter, mostly unconsolidated, generally

differentiated into zones or layers, the lowest of which passes imperceptibly into the parent rock below."

The soil complex can be conveniently regarded as made up of five important systems which are as follows:

1. Mineral particle system
2. The organic matter system
3. The biological system
4. The solution system
5. The atmospheric system.

Formation of soil

The course of development of a soil depends upon the intensity with which active soil formers operate and the possible factors which modify their effects. The active soil formers are climate, comprising moisture relations (precipitation), temperature and wind and biological agencies comprising vegetation and animals and numerous biotic influences exerted by them. The passive factors are the parent rock and topography.

Weathering which is the main process concerned in soil formation is due to active soil forming processes that may be physical, chemical or biological in nature *i.e.,* weathering can be physical, chemical and biological:

(a) Physical Weathering: Physical weathering means breaking up of rocks. This is brought about by a number of climatic factors acting simultaneously but in varying degrees depending on local conditions.

(b) Chemical weathering: The general trend of chemical weathering is the breaking down of complex compounds, mainly through the agency of water containing dissolved carbonic acid and other acidic substances derived from organic matter in the soil. The acid solution contains hydrogen ions which displace the alkali (Sodium and Potassium) and alkaline earths (Calcium and Magnesium) in the silicate minerals. The chief end products are silica, clay, inorganic salts and hydrated oxides. Hydrolysis, hydration, oxidation and reduction are the other chemical processes which occur during weathering.

(c) Biological weathering: This includes biological activity of plants and animals. The processes of humification, nitrification and decay are of fundamental importance in the build up of soil fertility. Due to differences in their requirements, some species also colonise particular types of soil and hence affect the developmental processes in many ways. Animals play a great role as soil transporters, mixers, structure modifiers and occasionally as modifiers of textural and chemical composition.

Soil profile

It is a section of a soil from the surface to the underlying rock. Such a section reveals that the soil has stratified appearance or structure, which is traceable to processes of translocation of the constituent materials which are continuously going

on in it, both mechanically and in solution. Morphology of a soil profile has a significant influence on the development of vegetation. A vertical section of the soil reveals it to have four horizons that are designated as Horizons A, B, C and D. Each horizon is further divisible into sub-horizons. Each horizon is formed as a result of the influence of climate and living organisms. The depth and composition of each horizon varies considerably from place to place e.g. in the forest soil these horizons are thicker than in the grass lands. There is also a change in thickness and composition of horizons with the passage of time as the soil matures and undergoes change Soil profile is influenced by the various aspects of topography. A brief description of these horizons is given below:

Horizon A: It is a superficial layer of the soil that affords vegetation and is also known as the **top** soil. It is rich in organic matter and is comparatively darker in colour and lighter in texture than horizon B. This horizon of soil affords maximum biological activity and can be further sub-classified into five layers:

(i) A_{00}: It is the surface layer of top soil and consists of recently fallen twigs and leaves and other Utter that is largely undecomposed. This sub-horizon may be absent in some soils.

(ii) A_0: It is composed of partially decomposed or matted organic matter and may be absent from some soils. The materials have lost their identity due to the setting in of the process of decay and decomposition.

(iii) A_1: It is a dark layer with high content of organic matter. It has abundant mineral content.

(iv) A_2: It is light coloured zone of maximum eluviation (loss of material) and lacks much of minerals.

(v) A_3: It is a transitional layer to horizon B, but is more like horizon A.

Horizon B: Next to the horizon **A** is the **sub-soil** usually designated as Horizon B**.** It is made up of light brown soil panicles that are fine, dense and compactly arranged. This horizon usually abounds in clay and other organic colloids and serves as reservoir of water. It is a horizon of **illuviation** *i.e.,* redeposition of materials. The biological activities are less and it does not afford plant growth. This horizon is also sub-divided into:

(i) B_1: It is transitional to B but more like B.

(ii) B_2: It shows maximum accumulation of silicate clay mineral or of iron and organic matter.

(iii) B_3: It is transitional to C horizon but more like B.

Horizon C: This horizon is composed of gleyed layers that have accumulated $CaC0_3$ and $CaS0_4$. Plants with long roots send them up to this layer.

Horizon D: This horizon affords no biological activity and consists of parent rock and weathered parent material. Roots cannot reach this zone as they are unable to penetrate the rocks. This zone accumulates water as water table and minerals are deposited on the bed-rock.

Role of plants in soil composition:

The plants play an important role in soil composition. Fallen twigs, leaves, roots, fruit, and wood containing mainly lignified tissues form the main source of humus from the plants. The freshly fallen plant organs, on the soil, constitute litter. Regarding roots, the herbaceous plants contribute a large amount as compared to the trees. This is because the herbaceous plants live only for a season or two and then die. Their roots remain in the soil and contribute to the litter. The litter is attacked by soil micro-organism chiefly bacteria of decay that convert it into humus. The litter largely consists of lignified tissues devoid of starches, sugars and fats; they are mainly cellulose and lignin, and contain small amounts of calcium and nitrogen. Starches, sugars and fats and proteins occur in fine herbaceous litter. The litter undergoes various stages of decay and is ultimately converted into final products by a series of chemical changes like oxidation, reduction, hydrolysis and condensation. Various classes of organic compounds are formed as a result. The carbohydrates in the litter are readily decomposed; sugars and other water solute substances are immediately decomposed into CO_2 or broken down into various acids (oxalic, citric, etc.). Starches and pentosans are also readily consumed. Hemicelluloses are very resistant and persist. The cellulose is decomposed by fungi and bacteria, which use up the nitrogen in the process and the availability of nitrogen determines the speed of this process. Lignins are more resistant and are attacked by some bacteria. Proteins are also easily decomposed into aminoacids and NH_2, the process is known as putrefaction. During this process nitrogen is formed and is used by microbes. Non-protein nitrogenous substances like nucleic acids, alkaloids and amides take more time to decompose.

Soil solutes and their exchange capacity

The soil contains a number of essential elements like calcium, sodium, potassium, iron, aluminium, boron etc. These elements occur in the form of bicarbonates, sulphates, nitrites, nitrates, chlorides and phosphates. They are soluble in water and are called soil solutes. ***So soil solutes are mineral salts in the soil that are usually soluble in water and may be partly organic and partly inorganic compounds.*** The soil solutes occur either as molecules or as positively or negatively charged ions. These salutes come to the soil from three sources - (i) mineral particles of the soil, (ii) decomposition of organic matter, and (iii) from chemical reactions between soil and roots.

The colloidal particles of both clay and the organic matter behave somewhat like acid radicals, and there is interchange on their surface of positive ions such as those of hydrogen and of the bases of potassium, sodium, magnesium, and calcium, the equilibrium position depending on, the relative concentrations. The total capacity of the soil colloids to hold **cations** is termed the **cation exchange capacity,** and is usually expressed in terms of milli-equivalents per 100 grams of soil. The cation exchange material is the repositary of the mineral fertility of the soil as the cations are contained in a form in which they are easily leached out by water and are yet available to plant roots. It is considered that CO_2, excreted by the roots or dissolved in rain water, exchanges its hydrogen for bases from the exchange complex and these combine with liberated acid radicles to form soluble bicarbonates which are absorbed by roots. The base exchange capacity also determines fertiliser application. In fine soils with high exchange capacity large amounts of fertilisers can be added as the nutrient bases will be absorbed. In sandy soils with low exchange capacity, much of

the added nutrients will not be retained by the soil, but leached out before they can be ulilised by the plants. Hence there is the necessity of adding organic matter also at the same time to improve the base exchange capacity of sandy soils.

Calcium is the most abundant base, which except in alkaline soils, is present to the extent of 2-5 times as much as potassium, sodium and magnesium. Soils saturated with bases are either neutral or alkaline, whereas those having excessive exchangeable sodium are strongly alkaline. If the hydrogen ions predominate the soils are acidic. If calcium is leached out most of the other exchangeable bases are also lost and the soils become acidic, particularly if rain water which contains a great deal of dissolved carbon dioxide is the leaching agent. This is due to the fact that calcium is more strongly adsorbed (or has greater replacing power) on the soil colloids than Mg, K and Na.

Flocculation of clay colloid is favoured by strongly adsorbed cations, whereas the easily replaceable ones favour dispersion. Ability to flocculate is one of the necessary conditions for the formation of stable soil. Soils saturated with weakly adsorbed cations of Na are deflocculated or dispersed and have very poor structure. On the other hand hydrogen and calcium cations are strongly adsorbed and give good crumb soil.

The soil solutions are extremely dilute with only 0.05 to 0 2 per cent dissolved solutes (salts), so much so that the latter are almost completely dissociated into their component ions, and adsorption by soil colloids comes freely into play. The osmotic pressure of the soil solution which depends upon the concentration of soluble salt plays a vital role in the process of absorption of nutrients by plants.

Forest trees, like all other terrestrial vegetation, require five primary resources for growth and development: radiant energy, carbon dioxide (CO_2), water (H_2O), mineral nutrients, and a porous medium for physical support. Although plants obtain energy from solar radiation and CO_2 from the atmosphere, the remaining resources are provided by soil. Consequently, soil forms the "foundation" of forest ecosystems in more ways. Plants assimilate nutrients from soil, incorporate them with photosynthetically-fixed C to form living biomass, and eventually return them to soil in dead leaves, roots, branches, and stems (*i.e.*, plant litter). After dead plant material enters the forest floor (O horizons) it is subject to decomposition, a microbially-mediated process that releases organically-bound nutrients into forms that can again be assimilated by plant roots. The uptake of nutrients by plant roots, their incorporation into living tissue, and the release of nutrients during organic matter decomposition cause nutrients to flow or cycle within terrestrial ecosystems. Nutrient cycles are biogeochemical processes, so named because they are controlled by the physiological activities of plants and soil microorganisms, and the geochemical processes in soil that control nutrient supply. The combined influences of climate, topography, biota, and time differentiate geologic materials into soil. As such, soils are diverse as the climates in which they occur, the landforms on which they develop, and the plant life that grows upon and within them.

Biological diversity helps in the formation and maintenance of soil structure and retention of moisture and nutrient levels. The loss of biological diversity through clearing of vegetation has contributed to the salination of soils, leaching of nutrients, laterisation of minerals and accelerated erosion of top soil, reducing the land productivity. Trees, on the other hand, lower the water table and remove the deposited salt from the upper soil horizons. Trees and other vegetation also assist in soil

formation. A significant contribution is the introduction of organic matter through litter formation and the decay and regeneration of tiny fibrous root, both of which facilitate microbial activity. Another contribution is through the effects of root systems, which break-up soil and rock leading to penetration of water. Root systems also bring mineral nutrients to the surface through root uptake. Organic matter formed by the decay of tiny fibrous roots can also bind with minerals, such as iron and aluminium, which can reduce the potential deleterious effects of these minerals on other vegetation (Attiwill and Leeper 1987).

The natural vegetation cover in water catchments helps to maintain hydrological cycles, regulating and stabilizing water runoff, and acting as buffer against extreme events such as flood and drought. The vegetation removal results in siltation of catchment waterways, loss of water yield and quality, and degradation of aquatic habit. Wetlands and forests act as water purifying systems (Read *et al*., 1982). The nutrient supply is affected not only by the types of rocks that give rise to soils, but also by the chemical composition and decomposition rates of leaf litter produced by different types of plants (Hobbie 1992) and by the extent of browsing by herbivores (Pastor *et al.,* 1988). The nutrient supply then determines the relative abundance of conifer and deciduous forest types.

The physico – chemical properties are dependent variables that play important roles in order to understand floristic biodiversity. These are: (i) Soil physical characters like soil colour, soil moisture content, total porosity, bulk density, temperature. (ii) Soil chemical characters like pH, soil organic carbon, total nitrogen, exchangeable potassium and available phosphorous.

1.8. Scope and objectives

Documentation and proper assessment of the status biodiversity is essential and more valuable, in formulating policies and programs for effective management and conservation of biodiversity. The north-eastern region is considered as one of the richest biodiversity centers of the Indian sub-continent with that of Western Ghats. The flora of the Northeast region is remarkably rich and diverse and is known as the 'Cradle of Flowering Plants' (Takhtajan 1969; Rao 1974). About 8000 species of flowering plants (approximately 45% of an estimated 17,500 flowering plants reported in India) occur in this zone. The region is considered as the primary and secondary centers of origin and diversity of about 50 crop plants and about 190 wild relatives. There is an urgent need to determine the status of plant diversity and natural regeneration in north eastern part of India with main emphasis on the natural protected areas.

The research work was an attempt to evaluate the ecological and botanical aspect of plant diversity of Tawi Wildlife Sanctuary. The study focused on the status of floristic diversity and their mutual adjustment with respect to the habitat and life processes. The outcome of the present investigation contributes to the better understanding of the floristic and ecosystem diversity in the sanctuary. The taxonomic works of this area in the light of the revised taxonomic nomenclature of our pioneer works will be the mirror of the vegetation of the area. Keeping the above facts the theme in objective the Tawi Wildlife Sanctuary is selected to evaluate its diversity from ecological point of view. As the wildlife entirely depends on the vegetation and floristic composition of the sanctuary, the present study is hope to be fruitful in developing appropriate strategy for management and conservation of plant diversity.

The aims and objectives of the present study are:

1. Study the status of plant diversity of the sanctuary
2. Determination of the community structure and organization
3. Assessment of the physico-chemical properties of the soil

CHAPTER - 2

CHAPTER – 2

2. REVIEW OF LITERATURE

2.1. An overview

The term biodiversity was used first by wildlife scientist and conservationist Raymond F. Dasmann in a lay book advocating nature conservation. The term was not widely adopted for more than a decade, when in the 1980s. "biodiversity" came into common usage in science and environmental policy. Use of the term by Thomas Lovejoy in the foreword to the book credited with launching the field of conservation biology introduced the term along with "conservation biology" to the scientific community. Until then the term "natural diversity" was used in conservation science circles, including by The Science Division of The Nature Conservancy in an important 1975 study, "The Preservation of Natural Diversity." By the early 1980's The Nature Conservancy's Science program and its head Robert E. Jenkins, Lovejoy, and other leading conservation scientists at the time in America advocated the use of "biological diversity" to embrace the object of biological conservation.

The term's contracted form *biodiversity* may have been coined by W.G. Rosen in 1985 while planning the *National Forum on Biological Diversity* organized by the National Research Council (NRC) which was to be held in 1986, and first appeared in a publication in 1988 when entomologist E. O. Wilson used it as the title of the proceedings of that forum

Since this period both terms and the concept have achieved widespread use among biologists, environmentalists, political leaders, and concerned citizens worldwide. The term is sometimes used to equate to a concern for the natural

environment and nature conservation. This use has coincided with the expansion of concern over extinction observed in the last decades of the 20th century.

"Biodiversity" is often defined as the variety of all forms of life, from genes to species, through to the broad scale of ecosystems (Gaston 1996). The term "Biodiversity" was coined by Walter G Rosen during the organization of the 21 – 24 September 1986 "National Forum on Biodiversity" held in Washington DC (Sarkar and Margules 2002). But the new term arguably has taken on a meaning and import all its own. A symposium in 1986 and the follow-up book *Biodiversity* (Wilson 1988), has heralded the popularity of this concept. 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 seventy-two times, and biological diversity nineteen times". Fifteen years further on, it would be hard to count how many times "biodiversity" is used every day by scientists, policy-makers, and others.

While the history of this term is relatively short, it already has raised important, distinctive, philosophical issues. Some of these are entangled in the very definition of "biodiversity". A challenge is the reconciliation of process-based and elements-based perspectives on biodiversity. Overall, the major issue for biodiversity is how its conservation may be integrated with other needs of society.

Systematic methods for identifying biodiversity priority areas require two separate but interdependent activities; compiling good data on the distribution and abundance patterns of the features to be conserved, the biodiversity surrogates and the development of appropriate procedures for using those data to determine priorities (Williams *et al*., 2002). Biodiversity surrogates might be species, species assemblages

such as vegetation or habitat types, environmental domains or combination of these (Williams *et al.,* 2002). Conservation biology emerged as an identifiable organized discipline in the late 1980s (Sarkar 1998, 2002). The conservation of biodiversity is related in almost all the ways to the maintenance of biological integrity.

The sequel to that first biodiversity book, naturally titled *Biodiversity II* (Reaka-Kudla *et al.,* 1997), documents the rapid rise of the term "biodiversity" in importance and influence. But it also traces the study of aspects of biodiversity back as far as Aristotle. To some extent, biodiversity merely offers a new, emotive, term for some older ideas and programs. In fact, "biodiversity" is now used sometimes to mean "life" or "wilderness" or other conservation values. "Biodiversity" also has served on occasion as a catch-all for "conservation" itself.

The scientific literature illustrates how most any conservation activity might use the label "biodiversity". On the one hand, workers taking advantage of the acknowledged importance of the term have expanded its meaning to capture concerns at a fine scale, such as that focusing on a favourite single species. This focus might be referred to more accurately as one of "biospecifics". At the coarser scale, one important interpretation, discussed below, advocates a primary linkage of biodiversity to the maintenance of ecosystem processes - what might be called the "bio-processes" approach.

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) examined "biodiversity" as one of the current normative concepts in conservation. They concluded that it remains ill-defined, and that distinctions can be made between "functional" and "compositional" perspectives in approaching biodiversity. "Functional" refers to a primarily concern with ecosystem and evolutionary processes, while "compositional" sees organisms as aggregated into populations, species, higher taxa, communities, and other categories. 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. For example, Norton (1994, 2001) points to recent emphasis on structure and process regarding ecological "health" or "integrity" that is seen as going beyond a conventional elements-oriented perspective for biodiversity. One can not aggregate all these different versions of biodiversity. Instead, we are to "describe in ways appropriate given certain purposes" and the choice among these different biodiversity "models" will depend on what values are important to the decision-maker.

This perspective is characterized as "post-positivist" because it recognizes biodiversity as inevitably value laden - there is no one, correct, measure of biodiversity to be discovered but many, each having different values. Roebuck and Phifer (1999) lament what they perceive as current "positivism" in biodiversity conservation, described by them as based variously on processes of verificationism and falsificationism in seeking facts. They argue that biodiversity conservation is

rooted primarily in ethics and we must not continue to back away from values and advocacy.

The idea that the choice of a measure of biodiversity depends on values finds support (Sarkar 2005). He argues that biodiversity operationally amounts to whatever is the valued target of conservation priority setting for different localities.

Biodiversity may be a catch-all for various aspects of conservation, but the fresh perspectives arising from recognition of "biodiversity" suggest possible unifying concepts. Wilson (1988) sees "biodiversity" as corresponding to a dramatic transformation for biologists from a "bits and pieces" approach to a much more holistic approach. Wilson describes this change in perspective as a realization that biological diversity is disappearing and, unlike other threatened things, is irreversible. Ehrenfeld (1988) similarly reinforces this idea of the value of diversity in the aggregate. He argues that diversity previously was never regarded in itself to be in danger, but that biodiversity now is recognised as endangered in its own right. Wrapped up in the term therefore is the idea of a "biodiversity crisis". While the case for such a crisis itself raises debates about measures and definitions (Sarkar 2005), the definition of "biodiversity" sometimes explicitly reflects these links to an extinction crisis. Takacs (1996) reviews cases where the definition of biodiversity is wrapped up in the idea of strategies needed to preserve variation. In accord with this perspective is a shift to a focus on valuing ecosystem processes. This focus arguably will ensure maintenance and ongoing evolution of these systems, and therefore all of biodiversity.

Holistic perspectives on biodiversity have emerged also through another important focus. For Wilson (1988), biodiversity captures the idea of a "frontier of the future", presenting a dazzling prospect of largely unknown variety, with unanticipated

uses. Biodiversity is seen by many as a *symbol* for our lack of knowledge about the components of life's variation, and their importance to humankind (Takacs 1996). These arguments suggest that core biodiversity values might be based more on what we do not know than what we do know. Biodiversity can be viewed as primarily capturing the two-fold challenge of unknown variety, having unknown value.

Anticipated future uses and values of the unknown are captured in the idea of "option values" (World Conservation Union 1980). A species, or other element of biodiversity, has option value when its continued existence retains the possibility of future uses and benefits. Option value corresponds not just for unknown future values of known species, but also to the unknown values of unknown species (or other components of variation). This concept is at the core of biodiversity because it links "variation" and "value". Estimating and quantifying the largely unknown variation that makes up biodiversity is one and the same as quantifying corresponding option values of biodiversity. According to this emphasis, a basic definition of biodiversity might be expanded as: the variety of all forms of life, from the scale of genes through to species and ecosystems so forming a "calculus" - a means for measurement and comparison - of option values.

Focusing on this important aspect of biodiversity does not throw away the other possible "biodiversity" values that might be listed (process-based "resilience" of ecosystems, current commodity values of species, etc.), but facilitates integration of biodiversity's option values with those other values.

Biodiversity is usually defined in terms of genes, species and ecosystem; corresponding to three fundamental and hierarchically related levels of biological organization. The same is documented as three kinds of biodiversity *i.e.,* genetic

diversity, species or taxonomic diversity and ecosystem diversity (Mcallister 1991; Solbrig 1991; Groombridge 1992; Heywood 1994; Norse 1994). However, Harper and Hawksworth (1994) favour the terms referred as genetic, organismal and ecological diversity. Another classification distinguishes three interdependent sets of attributes: compositional levels (the identity and variety of elements) and structural levels (ecological and evolutionary processes) (Noss, 1990).

2.2. Floristic diversity at the global level

Biodiversity as one of the resource-ecosystems of the environment provides basic raw materials, which are primary infrastructures and basic requirement for any economic or other income generating activities. The distribution of plant genetic resources is uneven globally. Out of the 5-50 million species of the world's biota estimated so far, only 1.7 million have been described (Groombridge and Jenkins 2000)

Biodiversity is not uniformly distributed on the planet and, without taking marine ecosystems into account; tropical regions possess most of the terrestrial diversity (about half of the world's species).Of all the countries, only 12 are in the biodiversity belt comprising the tropics and shelter between 50% and 80% of the entire biodiversity in the world. Nevertheless, only seven countries are considered as having great megadiversity: Brazil, Colombia, Mexico, the Democratic Republic of the Congo (formerly Zaire), Madagascar, Indonesia, and Australia.

It is estimated that there exists 5-50 million species on the earth; but there is a fair agreement that there are 12.5 million of species of which only 1.6 million species have been identified so far (Agarwal 2002). Out of the 5-50 million species of the

world's biota estimated so far, only 1.7 million have been described (Groombridge and Jenkins 2000)

Meyer (1986) has estimated that about 50 species are being driven extinction everyday; bulk of them in tropical forests, due to human interference. At present, 3956 species are considered endangered, 3647 vulnerable and 7240 rare (Agarwal 2002).

The report based on the studies carried out by Food and Agriculture (1974), found that the tropical forest is shrinking at the rate of 0.8% each year. If the current rate of deforestation continues, scientists estimated roughly 5-10% of the tropical forest species may face extinction, within next 30 years. The various conservational programs have been launched world over for the management of natural resources.

The diversity of living things is crucial to humanity. More than one out of every ten plant species worldwide is at risk of extinction (IUCN 1997). Of all the estimated 1.7 million known to inhabit the earth, one fourth to one third is likely to become extinct within the next few decades (Spellerberg 1992). According to Myers (1979), these exponential species extinction rates have increased dramatically in the last 50,000 years from one extinction per 1000 years to about 1000 extinction's per year and may reach 40,000 per year until the end of this century, so that one species will be lost every hour.

Nevertheless, species extinction is an integral part of evolution. It is of a subtending character on the one hand and a composite of transformation and speciation on the other hand. (Nixon and Wheeler 1992). The projections for species extinction over the next few decades greatly exceed the formerly documented observations in recent geological history (Wilson 1985). It is estimated that tropical

forests covered approximately 1500 million ha.in pre-agricultural time and that by 1988 the tropical forests had been reduced to about 900 million ha. As per the Current data available, the projecting rate of deforestation with regard to the tropical forests will be reduced to 300 million ha. in the early 21st century (Myers 1991). The US National Science Board (1989) had predicted that as many as 25% or more of the Earth's living species may become extinct within the next quarter century. This threat to species diversity and to the only evidence, that exists with regard to the history of the evolution of life on our planet thereby, imposes an external timetable on the enterprise of making an inventory of our species, and indeed substantial progress and development is required in the next 25 years.

According to the IUCN Red List of Threatened Plants (Walter and Gillett 1998), there are an estimated 2,70,000 known species of vascular plants, which include ferns, fern allies, gymnosperms (including conifers and cycads), and flowering plants. Of these species assessed, 33,798 species, or at least 12.5 per cent of all known vascular plants, are threatened with extinction on a global level. These plants are found in 369 families, and are scattered throughout 200 countries around the globe. Of these, 91 per cent are limited to a single country - which links their potential for extinction to national economic and social conditions. These islands or island groups, which often have high rate of endemicity, face particularly high level of threat to their flora. Indeed, seven of the top ten areas listed according to percentage of threatened flora are islands *viz.,* St. Helena, Mauritius, Seychelles, Jamaica, French Polynesia, Pitcairn and Reunion.

A great number of plant species known to have medicinal value are at risk of disappearing, leaving their human healing potential unfulfilled. For instance, 75 per cent of the species from the *yew* (Taxaceae) family, a source of important cancer-

fighting compounds, are threatened. The *willow* (Onagraceae) family, from which aspirin is derived, has 12 per cent of its species threatened. The *dipterocarps* (Dipterocarpeaceae), a family of trees that includes some valuable timber species in South-east Asia, have 32.5 per cent of their close relatives threatened. With the loss of each species, we lose access to critical genetic material that may have contributed to producing hardier, healthier crops for human and animal consumption. Close relatives and many familiar plants are at risk of extinction. For instance, 14 per cent of the *rose* family, 32 per cent of the *lily* family and 32 per cent of the *iris* family are threatened. Of the evolution of life on our planet thereby, imposes an external timetable on the enterprise of making an inventory of our species, and indeed substantial progress and development is required in the next 25 years.

2.3. Floristic diversity at the national level

India is a big country with a rich diversity of biotic resources. The rich biodiversity is largely due to a varied physical environment, latitude, longitude, altitude, geology and climate. The geographical area of India is about 3.287million sq.km and its coastline stretches to over 7,500 km. is the second largest country in Asia and seventh in the world. Almost all shades of climate from hot arid in Thar desert to arctic in the Himalaya with all intermediate gradations occur here. The rainfall varies from about 100 mm in Thar desert to over 5,000 mm at Mawsmai in Meghalaya. The diversity spans from the alpine grasslands of Himalayas to coastal mangroves of Sundarbans; from hot deserts of Rajasthan to tropical evergreen and semi evergreen forests of North-east and Western Ghats; 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 ecosystems, and so on. In each of these

ecozones 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 and making India one of the 17 megadiversity centres in the world.

Owing to the above factors, India harbours over 45,000 species of plants though the area of the country is only 2.4 per cent of the world landmass, yet it supports over 11 per cent of all known species of plants. About 28 per cent of total Indian flora is endemic to the country (Sharma and Singh, 2001). Rogers, Panwar and Mathur, 2000 have divided India into 10-biogeographic regions, and Champion and Seth, 1968 classified the forests of India into 16 types. The forest cover in India constitutes 21.02% of its geographical area (SFR 2009). Three mega centers of endemic plants in India are (i) Eastern Himalaya harboring 9,000 species of plants with 3500 endemic species; (ii) Western Ghats possessing 5800 plant species with about 2000 endemics; and (iii) Western Himalayas with 1195 endemic species of plants. The Andaman and Nicobar Islands harbor about 83% endemic species (Nayer 1996) of the world's 18 ‘biodiversity hotspots’ located in the Western Ghats and in the Eastern Himalayas (Myers 1999). The forest cover in these areas is very dense and diverse and of pristine beauty, and incredible biodiversity. It is estimated that there exists 5-50 million species on the earth; but there is a fair agreement that there are 12.5 million of species of which only 1.6 million species have been identified so far (Agarwal 2002). Meyer (1986) has estimated that about 50 species are being driven extinction everyday; bulk of them in tropical forests, due to human interference. At present, 3956 species are considered endangered, 3647 vulnerable and 7240 rare (Agarwal 2002).

There are 17 mega diversity countries, and 34 hotspots of biodiversity in the world. The Western Ghats and North-eastern Himalaya are two centers of mega diversity in India.

At present, there are 14-Biosphere Reserves, 92-National Parks and 500-Wildlife Sanctuaries in the country (MOEF Annual Report 2004). A status report (1989) on the management of National Parks and Sanctuaries gives detailed account of topography (altitude) climate (annual rainfall), vegetation types, water resources (water holes, natural or artificial, perennial or seasonal), Faunal species, floral species, threatened species, forest corridors; forest fires, floods, droughts pollution, cyclones and storms, population within Parks/ Sanctuaries, grazing, extraction of NTFPs, public through fare, tourism, plantations, encroachment, illegal occupation and use; injuring or death to human beings and management aspects (Kothari *et al.,* 1989).

Under the Wildlife Protection Act, 1972, the state Govt. 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. The Biological Diversity Act 2002 provides directives of the CDB's main objectives owing to the sovereignty of the State to use its own biological resources to regulate its bioresources for equitable sustainable use of biodiversity, respect local knowledge, development of biological heritage sites, involvement of local institutions and NGO's.

The country has over 1,15,000 species of plants and animals already identified and described. Out of 45,000 species of the flora, 15,000 species are flowering plants; of which 33% are endemic and located in 26 endemic centers (Singh *et al*., 2002).

2.4. Floristic diversity at the northeast level

The plant resources of Northeast India are enormous and represent a rich, floristic wealth of India. The diversity and richness of forests of Northeast India are influenced by the geography, precipitation, temperature and altitude. The region harbours a large number of endemics and species, more than that found in any other part of the country. According to the Botanical Survey of India, the country has about 17,000 flowering plants, out of which around 8,000 species are found in the Himalayas and about 5,000 species in Northeast India. 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. Forests cover about 54% of the total geographical area of the northeastern region although there are inter-state variations.

Northeast India (comprising the 7 sister states of India - Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura) represents a distinct biogeographic zone, rich in biodiversity, ethnic cultures and folklore traditions. The flora of this region is remarkably rich and diverse and is known as the' Cradle of Flowering Plants' (Takhtajan 1969; Rao 1974). About 8000 species of flowering plants (approximately 45% *of* an estimated 17, 500 flowering plants reported in India) occur in this zone. The region is considered as the primary and secondary centers of origin and diversity of about 50 crop plants and about 190 wild relatives. Important crop plants originated in this zone include Citrus, banana and plantain, mango, rice and several species of legumes, cucurbits, orchids, bamboos and medicinal an aromatic plants. Northeast India (and contiguous areas of Myanmar) is recognized as one among the 25 'global hotspot centers of *biodiversity'* (Myers *et al.,* 2000).

Plants of timber and wood, drugs and medicine, pulpwood, fibre, gums and resin, dyes, tannins, edible fruits, ornamentals, etc. are richly distributed in this region. Due to natural mutation, hybridization and floral evolution, the northeastern region forms the active speciation zone. The plant resources of Northeast India fall under two major categories, *viz.,* agricultural and forest plant resources. Important crops such as rice, tea and jute, maize, cotton, jute, potato, pineapples, oranges, banana, ginger, betel leaves etc. contribute to the agricultural resources. The various forest resources of the region are mostly timber-yielding trees, bamboos, orchids and medicinal plants.

The ecosystem of Northeast India varies from tropical wet evergreen, moist deciduous sub-alpine, alpine forests and grasslands to the numerous freshwater lakes, rivers, swamps and marshy wetlands. A number of sacred groves have been reported from Meghalaya and Manipur States. Hattar *et al*. (2002) (*in* Kotwal & Benerjee, 2002) have described the faunal wealth of NE India. The region is also highly endemic, and the endemism is reported by Chaudhuri and Sarkar (2003). Of the 8,000 reported species of flowering plants from Himalaya, 5,000 species are found in the north-eastern India. 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 the north east India (1 in Meghalaya, 2 in Assam, 1 in Arunachal Pradesh and 1 in Sikkim).

The previous studies have depicted that the forests of north-east India, especially sacred forests are very rich in plant diversity, and mild disturbance supports maximum species richness (Mishra *et al.,* 2004).

In spite of the rich vegetation, flora of this region remains largely unexplored, which hinders the full utilization of the plant resources. A great number of plants species including several unique and irreplaceable varieties are becoming extinct and many more are awaiting a similar fate. The disturbances in the flora of Northeast India could be due to the following reasons (Tandon 2005):

(i) burning of the forests during the pre-monsoon months for the growth of grasses,which is the secondary forest product for cattle rearing/dairy farming,

(ii) burning of the agricultural fields in the form of *Jhum* or shifting cultivation,

(iii) *Bun* cultivation or burning of undergrowth,

(iv) excessive and unmindful collection of the forest by-products *e.g.,* medic'inal herbs and minor non-wood forest products, and

(v) cutting of the dense forests randomly for trade of timber.

2.5. Floristic diversity at the local level

Mizoram has a subtropical humid climate and the temperature varies from 10^0C – 32^0C. The South-west monsoon rains of the Bay of Bengal en route to Mizoram annually with high precipitation ranging from 2500 mm – 3500 mm which favours luxuriant growth of vegetation in the State.

The vegetation and forest type have been analyzed by Champion and Seth 1968, National Remote Sensing Agency (NRSA) 1977, Forest Survey of India (FSI) 1992 and 2009, Indian Institute of Remote Sensing (IIRS) 2003.

Though the forest cover of Mizoram is highest (91.27%) in India (ISFR 2009) it retain 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 NTFP resources.

Out of 25 micro endemic centers identified in India, Mizoram comes under Patkai-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 neighbouring states. So far, 46 endemic species have been reported from Mizoram (Chaudhari and Sarkar 2003). The reason being that floral exploration is not exhaustive, and the faunal investigation is just negligible.

A thorough study of literature has revealed that, botanically Mizoram has not been properly explored with only a few collections made in the past and our knowledge about the flora of Mizoram, in general, is rather inadequate. Mizoram comes under Patkai-Manipur-Lushai Hill (Nayar 1996).

For the first time Gage (1901) recorded 317 species, including 26 species of cryptogams, based on his own collections made from a very small area in Lunglei district during March - April 1899. J. E. Leslie also made some collections in December 1902 and sent them to Calcutta. Some valuable collections made by Mrs. N.E.Parry from 1924 to 1928 (Parry 1932) were sent to Royal Botanic Garden, Calcutta . Rev. W.G.L. Wenger (1926 and 1932), Rev. R.A.Lorrain and his daughter Lorrain Foxall also made some collections from Lunglei, and sent most of them to Kew and some to Calcutta. Based on these collections, Fisher (1938) published 'the Flora of Lushai Hills' enumerates 1360 species including 6 gymnosperms and 155 species of cryptogams. Deb and Dutta (1987) have thrown some light on the

vegetation of Mizoram based on the observation made in Mamit subdivision and west Aizawl. Flora of Mizoram has been published by Singh *et al*., (2002). Sawmliana (2002) has published "Plants of Mizoram". Lalramnghinglova (1997, 2003) has published "Handbook of Common Trees of Mizoram" and "Ethnobotanical Plants of Mizoram" Jha (1997) has published "Natural Resources of Mizoram". Survey of animal diversity on primates was carried out by Mishra *et al.,* (1994); serrow and goral by Shankar Raman *et al.,* 1995; field observation of birds by Robertson (1995 , 1996; ethnozoology by Lalramnghinglova (1999).

Little is known about the biodiversity of Mizoram and no proper scientific research has been carried out so far. According to the IIRS (Indian Institute of Remote Sensing) Dehra Dun report 2002, maximum number of species occurs in the tropical wet evergreen forests followed by sub-tropical broad-leaved hill forests. The evergreen trees form the main part of multi-storied canopy. Dipterocarpus tree species and similar group of trees may project above the general level. Deciduous species are few and never form separate type of forest in Mizoram. Canes, climbers and bamboos are abundant, while herbaceous vegetation and grasses are scarce. Undisturbed patches of tropical evergreen forests occur in Dampa Tiger Reserve and Ngengpui Wildlife Sanctuary. A few patches of pine are confined to the eastern higher altitude in Champhai District. Large tract of bamboo covers almost all the lower valleys and river banks *Arundinaria callosa*, *Sinarundinaria intermedia* etc. occur above 1800 m asl. *Melocana baccifera* dominates the bamboo forests and associated with jhumlands. They occur as pure patches along the river valleys and also form under storey in semi-evergreen forests. Pure pockets of *Bambusa tulda* occur sporadically along riverbanks and clumps of *Dendrocalamus hamiltonii* occur between the elevations from 900 to 1500 m asl. (Anon. 2002). The reported floral wealth of Mizoram constitute:

Flowering plants-2141 species; from 905 genera; and 176 families; Gymnosperms-6 species, Pteridophyte-211 species. Of these, 30 species are endemic (Chaudhuri and Sarkar 2003).

So far, Lalramnghinglova and Lalnunmawia identified 18-20 species of bamboos; Lalnuntluanga identified 13 species of canes.

2.6. Biotic community

A biotic community is any assemblage of populations living in a prescribed area or physical habitat; it is an organized unit to the extent that it has characteristics additional to its individual and population components and functions as a unit through coupled metabolic transformations. It is the living part of the ecosystem, and should remain, a broad term which may be used to designate natural assemblages of various sizes, from the biota of a log to that of a vast forest or ocean. *Major communities* are those which are of sufficient size and completeness of organization that they are relatively independent; that is, they need only to receive sun energy from the outside and are relatively independent of inputs and outputs from adjacent communities. *Minor communities* are those which are more or less dependent on neighboring aggregations. Communities not only have a definite functional unity with characteristic trophic structures and patterns of energy flow but they also have compositional unity in that there is a certain probability that certain species will occur together. However, species are to a large extent replaceable in time and space so that functionally similar communities may have different species compositions.

The community concept is one of the most important principles in ecological thought and in ecological practice. It is important in ecological theory because it emphasizes the fact that diverse organisms usually live together in an orderly manner,

not just haphazardly strewn over the earth as independent beings. The biotic community is constantly changing its appearance (visualize the forest in autumn and in spring), but it has structures and functions which can be studied and described, and which are unique attributes of the group. Victor E. Shelford, a pioneer in the field of biotic community ecology, has defined the community as an "assemblage with unity of taxonomic composition and a relatively uniform appearance." To this we might add: "and with a definite trophic organization and metabolic pattern." Communities may be sharply defined and separated from each other; this would be the case, of course, when the community habitat exhibits abrupt changes, but relatively sharp boundaries may also be the result of community interaction itself. Very frequently, however, communities blend gradually into one another so that there are no sharply defined boundaries. Continuity or discontinuity is largely a function of the steepness of the environmental gradient.

The community concept is important in the practice of ecology because "as the community goes, so goes the organism." Thus, often the best way to "control" a particular organism, whether we wish to encourage or discourage it, is to modify the community, rather than to make a direct attack on the organism. Man's welfare, depends ultimately on the nature of the communities and ecosystems upon which he superimposes his culture.

The structure that results from the distribution of organisms in, and their interaction with, their environment can be called *pattern* (Hutchinson 1953). Many different kinds of arrangements in the standing crop of organisms contribute to *pattern diversity* in the community, as, for example: (1) stratification patterns (vertical layering), (2) zonation patterns (horizontal segregation), (3) activity patterns (periodicity), (4) food-web patterns (network organization in food chains), (5) reproductive patterns

(parent-offspring associations, plant clones, etc.), (6) social patterns (flocks and herds), (7) coactive patterns (resulting from competition, antibiosis, mutualism, etc.), and (8) stochastic patterns (resulting from random forces).

Quantitative measures are employed to describe the structure of plant communities with much ecological precision, qualitative characters such as species richness, life-form spectrum and vertical disposition of species are some of the important parameters to describe community structure. Raunkiaer (1934) described communities of different climatic zones or phytoclimatic zones of the earth on the basis of life-form spectrum or Biological spectrum. Any change in the life-form composition away from its phytoclimatic zone is considered as an indicator of alteration in vegetation either due to biotic or edaphic factors or both. However, in recent years man has abused the natural vegetation so much so that often plant communities do not show their natural structural complexities. Over exploitation of forest resources and overgrazing has resulted in change in the life form composition of plant communities (Reddy *et al*. 2002). Vegetation profile of the component species indicates the phytoclimatic condition of the area and is employed commonly in community structural description through profile diagrams (Ashton and Hall 1992; Chen Wei-Lie 1995; Pignatti 1995; Sahunalu and Dhanmanonda 1995; Unwin 1989; Visalakshi 1995). Similar studies have not been undertaken in the montane humid forests ofnortheast India though several ecological studies have been carried out in the sacred groves of Meghalaya (Barik *et al*. 1992, 1996a, 1996b; Jamir and Pandey 2002, 2003; Rao 1992; Rao *et al*., 1990, 1997; Upadhaya *et al*., 2003).

2.7. PHYSICO – CHEMICAL PROPERTIES OF SOIL

Joffe (1949) and Marbut (1927), two well-known American soil scientists, have defined soil in the following way: "soil is a natural body developed by natural

forces acting on natural materials. It is usually differentiated into horizons of minerals and organic constituents of variable depths which differ from the parent materials in morphology, physical constitutions, chemical properties, composition and biological characterictics."

According to Wadia (1949), "soil is the topmost layer of earth crust capping the rock."It is a natural body of variable thickness, composed of disintegrated rock materials together with variable proportions of organic matters, generraly differentiated into zones or layers and mostly consolidated.

Soils are the resultant of the interactions of several factors - climate, organisms, parent material, and topography (relief) - all acting through time (Jenny, 1941, 1980). These factors affect major: ecosystem processes like primary production, decomposition, and nutrient cycling, which lead to the development of ecosystem properties unique to that soil type, given its previous history. Thus such characteristics as cation-exchange capacity, texture, structure, organic matter status, etc., are the outcomes of the aforementioned processes operating as constrained by the controlling factors.

The physico – chemical properties are dependent variables that play important roles in order to understand floristic biodiversity. These are: (i) Soil physical characters like soil colour, soil moisture content, total porosity, bulk density, temperature. (ii) Soil chemical characters like pH, soil organic carbon, total nitrogen, exchangeable potassium and available phosphorous.

Disturbance in the vegetation, which is a force, often abrupt and predictable, kills or damages the organisms, alters the availability of resources leading to erosional loss of soil and nutrients, and ultimately leads to degradation of land. Its role has been emphasized in many ecosystems such as tropical rainforests (Congdon and Herbohnn

1993), temperate forests (Finzi *et al.,* 2003). Huston (1994) in his theoretical model of diversity variation postulated that 'disturbance' and 'competitive exclusion' are the two fundamental processes controlling diversity in the ecosystem.

Soil texture is the most fundamental attribute os soil fertility. Soil fertility increases with clay content, but high clay – soils are prone to drought in dry areas and to flooding in wet areas (Scholes *et al.,* 1994). Soil structure influences organic matter turnover and soil fertility, and plays a key role in the ability of soil to store organic matter (Balabane 1996).

The moisture content in soils is influenced by the nature of the soil Bhide (1921). Medium black soil has higher amounts of soil moisture than light grey coarse soil. Sandy soils have the lowest amount of soil moisture. Fungi, bacteria and invertebrates (Dighton 1997), rainfall and soil moisture content (Sujatha *et al.,* 2003), and quality of litter in terms of its susceptibility to attack by decomposers are the main factors that affect litter decomposition. A sufficient amount of soil moisture is necessary for efficient growth of plant, excessive irrigation or flooding diminishes the growth, as it destroys the soil texture (Howard and Hole 1918). The amount of moisture in the soil influences transpiration from foliage of plants (Singh and Singh, 1937)

The different reaction in the soil is dependent on the soil pH. The growth and development of plant also depends on the soil pH. Some species can adapt to soil with high pH and some on low pH value, whether the soil pH is neutral (7), acidic (<7) or alkaline (>7), different reactions are either facilitated or inhibited as a result of specific pH requirement, which in turn influences the tree growth and development. Hence, the basic principle is to determine the pH of soil of both open and closed forests to find out the conditions supporting the growth of forests in these two places.

The forms in which inorganic minerals occur and their availability depend on the soil pH (Lucas and Davies, 1961).

Soil pH is probably the most commonly measured soil chemical property and is also one of the more informative. Like the temperature of the human body, soil pH implies certain characteristics that might be associated with a soil. Since pH (the negative log of the hydrogen ion activity in solution) is an inverse, or negative, function, soil pH decreases as hydrogen ion, or acidity, increases in soil solution. Soil pH increases as acidity decreases.

Organic matter content is of prime importance in the development and maintenance of soil fertility both in forest and agricultural lands. Fowler reviewing the work on the subject in India stated that "Organic matter, by affecting the texture of the soil effectively helps the aeration and moisture conservation in soil, thus providing optimum conditions for the micro-organisms to flourish, it affects the reaction of the soil, and the viability of the microflora, especially the nitrifying and denitrifying organisms".

Our knowledge of the relation of soil organic matter with forest growth is mainly from temperate regions of Europe and America. A fairly detailed account is presented by Misra and Puri (1954) in their book. Lately, Hanley has given a complete summary regarding the types of humus present in different types of temperate forests.

In India, Suri (1933) endeavoured to classify some ground flora communities on the basis of the depth of humus in some forests of the northwest Himalayas. Puri and Gupta (1951) found that in conifer forests of Kulu there is an increase in the amount of organic matter and nitrogen in soils with an increase of elevation. The exchangeable calcium was found to be related also to the organic matter content of the surface layers of the soil. Similar relationships were found by Puri (1954) in some mixed oak- laurel forests of the Darjeeling Himalaya. The amount of minerals and nitrogen present in surface layers of the forest soils in the Himalayas

was influenced by calcium and nitrogen content of the tree foliage. Upadhya (1955) has published a preliminary account of his important work on the role of organic matter in the formation of surface soils in deciduous forests of Saugar in M P.

Upadhya (1955) concluded that moisture content, organic matter content, water holding capacity and field capacity of the soil increase with the organic matter. Organic matter generally improves soil texture, physical texture and aggregation of red soils. In soils treated with organic matter pore volume and air capacity increases. Organic matter also increases cation exchange capacity of the soil.

Soil organic matters store nutrients, improve nutrient cycling, increase cation exchange capacity, buffer against rapid change in pH, serve as energy source for micro-organisms, build the soil structure, increase water infiltration and reduce the effects of compaction. Soil degrading processes like erosion, leaching and mineralization have negative impact on organic carbon. Cultivation tends to increase the rate of organic matter loss in soils primarily by accelerated microbial decomposition (Seybold *et al.,* 1999).

The major amount of nitrogen present in the soils is derived from organic matter. Nitrogen content in the soil influences greatly C/N ratio in plants which is related with vegetative and reproductive phases (Dastur and Raut, 1935). The nitrogen content of some forest soils in the Himalayas is, therefore, positively related to the amount of soil organic matter. Mirchandani (1937) discussing the nitrogen status of Indian soils argued that the increase in nitrogen content of Indian soils by leguminous crop is partly due to the addition of organic matter rich in nitrogen.

Dhar (1936-37) suggested that in tropical soils, especially under aerobic conditions, photosynthesis and photooatalysis play important parts in nitrogen fixation. Nitrogen bacteria derive their energy for nitrogen fixation from the oxidation of carbonaceous matter. The

energy liberated by photo-chemical oxidation fixes nitrogen in the presence of suitable catalyst independent of bacterial action.

Sahascrabuddhe (1936-37) found that the bacterial action is mainly responsible for the nitrogen recuperation of soils. The magnitude of fixation depends on moisture and temperature. Blue-green algae have been found to fix nitrogen in rice soils.

Bhaskaran and Subrahmanyam (1937) found that, the mechanism of nitrogen fixation in soils with mixed microflora is different than those in which *Azotobarter* alone are involved.

Dhar, Seshacharyulu and Biswas (1941) discussed some new aspects of Nitrogen fixation and losses in soils.

Aiyar (1937) studied nitrogen status of soils in Burma in relation to climatic conditions, soil pH and carbon content. His data are given fixation in light is always much greater than in the dark, although the number of *Azotobacter* and total bacteria are much less in light than in the dark. The increase in temperature is not responsible for greater nitrogen fixation in sunlight.

Mukherji (1955) stated that electric spark during thunder storm is responsible to some extent in the formation of nitrates in rain-water. He studied occurrences of thunder storms in Silchar, Cherrapunji and Shillong and determined nitrites and nitrates in rain water at Sylhet. From the data presented by him, however there does not seem to be any clear correlation between nitrate formation and thunderstorm.

In some Bombay- Deccan soils Sahascrabuddhe (1937) pointed out that the values of total nitrogen are high during the cold season between November and February. The low temperature in these months does not interfere with the reaction of the soil. The temperature and moisture in this season are favourable for the soil

reactions. Another high figure of total nitrogen is often found in June when the soils are wetted by rains after the heat of summer months. Nitrogen is low in May due to low value of soil moisture content. Sometimes very low figures are obtained in the middle of rainy season due to the loss of nitrates in drainage.

Among the macronutrients, the deficiency of nitrogen and phosphorus adversely affects re-establishment of species on degraded sites (Tyler and Olsson 1993). Nitrogen mineralization is of crucial importance in natural ecosystems where it is a limiting nutrient for plant growth. It has been suggested that N losses from forest ecosystems following tree cutting are caused either by increased N mineralization rates or reduce N uptake by plants after disturbance (Kaye and Hart 1997). Nitrogen availability in the soil-litter interfaces is believed to control the rate of litter decomposition (Prescott 1995, 1996).

The physical factors, which limit plant establishment and survival, include high temperature, moisture stress (Singh *et al.,* 2002), soil particle size, surface instability leading to erosion and compaction (Adams 1998).

CHAPTER - 3

CHAPTER - 3

STUDY AREA

3.1 A brief information about Mizoram

Mizoram is a state of northeastern region located in the eastern border of the country (southern part of north-eastern India) is characterized by hills with sparse to dense forest throughout. The state has a geographical area of 21,081 sq.km and lies between the coordinates of 21° 58' & 24° 35' N Latitude, and 92° 15' & 93° 20' E Longitude, with the tropic of cancer passing through the state at 23° 30' N latitude. The State has a strategic importance because of its proximity to the international boundary with Myanmar to the east and south (404 Km) and Bangladesh to the west (318 Km) as well as with neighboring states like Assam (123 Km), Manipur (95 Km) and Tripura (66 Km) (Anon. 2001).

The State comprises eight districts, namely- Kolasib, Mamit, Aizawl, Champhai, Serchhip, Lunglei, Lawngtlai and Saiha **(Fig. 1).** 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 1382.51 sq 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 (Kamalanagar) respectively. The third autonomous district council resides within Saiha district, *i.e.,* Mara Autonomous District Council (MADC) with it administrative seat located at Saiha town. These autonomous regions are administered in accordance with the provisions of the Sixth Schedule of the Constitution of India.

The total population of Mizoram according to census 2011 is 1,091,014 out of which 552,339 are male and 538,675 are female. The literacy percentage is 91.58% as per statistics collected by Economics & Statistics Dept, Govt. of Mizoram. The main occupation of the people is agriculture.

(a) Physiography

The physiography of Mizoram can be broadly divided into hills and valleys. The hilly terrains (High hills) are undulating with average altitude above 1300 m (msl), Medium hills with altitudes ranging between 500 m and 1300 m and Low hills with altitudes below 500 m above msl with the maximum reaching 2,200 m in Blue Mountains (Phawngpui). The hills run in the north south direction parallel to each other with valleys in between them. Dissected hills and hillocks are dominantiy found in most of the river valleys in the western part of the state.

(b) Geology

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 groups 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.

(c) Drainage

Mizoram is drained by a number of rivers, streams and rivulets of various patterns and lengths. Most of the drainage lines originate in the central part of the state and flow either towards north or south directed by the north-south trending ridges. The valleys are narrow and have been carved out in softer formations. The rivers at various places form deep gorges, and cut across the striking ridges forming water gaps. The upper courses of the rivers are often intervened by waterfalls. As the drainage course is controlled by parallel ranges, the drainage of ephemeral and consequent types show trellis, dendretic as well as parallel drainage patterns.

The northern part is drained by large rivers like Tlawng (with its tributaries - Teirei and Tut), Tuivawl, Tuirial, Langkaih and Tuivai which eventually falls into the Tuiruang river in Cachar plains of Assam. The southern part is drained by much prominent rivers like Chhimtuipui (also known as Kolodyne) with its tributaries - Mat, Tuichang, Tiau and Tuipui whereas river Khawthlangtuipui with its tributaries Kawrpui, Tuichawng, Kau and De drains the south-western part of the state eventually flowing into Bangladesh. These and a few more rivers, forms their respective watersheds in the path they flow giving rise to 25 watersheds in total for the whole of Mizoram.

(d) Climate

Mizoram enjoys a moderate climate owing to its tropical location. It is neither very hot nor too cold throughout the year. The region falls under the direct influence of the south-west monsoon. As such, the region receives an adequate amount of rainfall. The climate is humid tropical, characterized by short winter, long summer with heavy rainfall.

The highest temperature is observed during May, June and July. Thereafter, the onset of monsoon brings down the temperature. The temperature continues to fall with the break of the monsoon rains, and it is minimized in December and January. In autumn, the temperature is usually between 18^0C to 25^0C, while winter temperature records normally between 11^0C to 23^0C and the summer temperature is usually between 21^0C to 31^0C.

It rains heavily from May to September. The average rainfall is 250 cm per annum. The north western portion of the state receives highest rainfall *i.e.,* more than 350 cm per annum. The rainfall also increases southward with increase in humidity. While Aizawl located at $23^0$44'N and $92^0$43'E receives about 208 cm rainfall, Lunglei ($22^0$53'N and $92^0$45'E) records as high as 350 cm.

(e) Soil

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. The soil acidity is high; low in potash and phosphorus. But in an un-eroded soil, the content of Nitrogen is quite high fostered by accumulation of organic matters. The soils in the valleys are heavier as they were brought down by rain water from the high

altitudes. The soils of Mizoram can be classified into three orders of soil taxonomy, viz., Entisols, Inceptisols and Ultisols.

(f) Vegetation/Forest

On the basis of the abstract of Champion (1936) and Champion and Seth (1968), the forests of Mizoram have been broadly divided into 3 (three) categories:

(a) Tropical Wet Evergreen Forest: They are found abundantly in the western and north western parts of the state adjoining Bangladesh, Tripura and Cachar state of Assam. The forests are characterized by tall trees of entirely evergreen variety or nearly so. The soil has moderate water holding capacity. The prominent species in the upper storey are *Dipterocarpus turbinatus, Dipterocarpus macrocarpus, Terminalia myriocarpa, Michelia champaca, Artocarpus chaplasa, Amoora wallichi, Magnifera indica, Terminalia chebula, Terminalia belerica, Podocarpus nerifolia, Duabanga sonneratoides, Protium serratum, Sygygium cumini, Adina cordifolia, Chukrasia tabularis, etc.* The middle storey is dominated by *Mesua ferrae, Dillenia indica*, and bamboo species like *Melocana bambusoides (syn. Melocana baccifera), Bambusa tulda, Dendrocalamus hamiltonii, Dendrocalamus longispathus, etc*.

(b) Tropical Semi-Evergreen Forest: They are found in the central part of the state with moist mixed deciduous forests and occupy comparatively smaller areas along the slopes of higher hills. The dominants include deciduous species but the evergreen species dominate the vegetation. The dominant species are : *Artocarpus chaplasa, Schima wallichi, Duabanga*

sonneratioides, Chukrasia tabularis, Tertrameles nudiflora, Adina cordifolia, Parotium serratum, Salmalia insignis, Michelia champaca, Pheobe sp, Dysoxylum sp, Terminalia myriocarpa, Mangifera indica, Eleocarpus sp, Amoora wallachi, Sterculia sp, Bischofia javanica, Juglans regia, Emblica officinalis, Macaranga denticulata, Gmelina arborea, Gmelina oblongifolia, Albizzia procera, Acrocarpus fraxinifolius, *Mesua ferrea, Sapuim sp, Toona ciliata, Engelhardtia spicata.* The under storey consists of different species of bamboos.

(c) Montane Sub-tropical Pine Forest: This type of forests is found on a higher elevation, mostly confined in the eastern fringe of the region. They are also found in strips of ranges in the western part around W. Bunghmun and isolated in Sangau area in the south. The vegetation of this type is dominated by *Rhododendron, Quercus dealbata, Prunus cerasoides, Myrica nagi, Quercas icana, Emblica officinalis, Rhus javanica, Butea minor Pinus kesiya, Quercus xylocarpa etc*. Other common species of this classification are *Eurya symplocina, Clerodendron, Rubus ellipticus, Derris wallichii* and *Rubus sirmanicus etc.*

3.2. Tawi Wildlife Sanctuary

Tawi Wildlife Sanctuary is selected for the present study. The sanctuary is located in the South eastern part of the Aizawl District, Mizoram (Latitude - $23^0$30'N and Longitude 93^0E), with altitude ranging between 500 m- 1894 m asl. It occupies an area of 35.75 sq. km, and is situated about 101 km, from the state capital Aizawl towards east. The sanctuary was notified as a reserve forest in 1978 vides Government of Mizoram Notification No. FOR. 15-C/74-78/21 dt.29.11.78 and a preliminary notification to declare an area of 35.75 sq.km of this reserve forest as "Tawi Wildlife Sanctuary" has been issued vide Govt. Notification No.B.12012/15/94-FST dt.8/4/1999. The location map is shown in **Fig: 3.1**

Boundary description of Tawi Wildlife Sanctuary:-

North: Crossing above the Khuaimual (Hill ridge) upto the water supply. It then follows Vawmhrawhlui upstream upto Tawizo saddle (Liamkawn).

East: From the saddle (Liamkawn) it goes towards south following Maite approach Road upto the source of Vaiden lui along the foot path.And then, it goes to a small lake above Hruiuai crossing the lake upto Bak puk. It then goes to Riahbuk mual and meets Maite Jeep road. It then goes along the foothills catching Hmuntha road upto the place called Lungmaite.

South: From Lunghnute it follows the foothills of Tawi hill towards north-west direction and then crossed Saza stream and then meets Bengchatlui (stream).

West: From Bengchatlui (stream) source it follows the foothills towards north. It then meets river source of R.Tuikum and then crossing Kawlhawk kah kawn (saddle) and meets Khuailui (stream) the starting point of northern boundary.

3.2.1. Approach road

Fair weather 407 Mini Truck road from Chhingchhip via Hmuntha which is about 20 kms away from Chhingchhip and from Hmuntha village the road links to other villages like Maite, Tawizo, Hualtu by a fair weather jeepable road. From Chhingchhip there is also a fair weather jeepable road which directly links to Hualtu village. There is also another road from Mualpheng via Maite which is a fair weather jeepable road and is approximately 25 kms.This road links to villages like Hualtu, Hmuntha, Keifang, Tawizo by a fair weather jeepable road, it also links to Chhawrtui, Rullam and Puilo villages by footpath.

3.2.2. 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.

The climate of Mizoram is Tropical Monsoon type of climate. So, Tawi Wildlife Sanctuary which is located in Aizawl district, falls under the north-central part of the state enjoys a moderate climate owing to its tropical location. Aizawl district falls under the direct influence of the south west monsoon. As such the area receives an adequate amount of rainfall which is responsible for a humid tropical climate characterized by short winter and long summer with heavy rainfall.

3.2.3. Season

Based on the variation in temperature, rainfall, humidity and other general weather conditions, four different types of season are observed for the district. They are as follows:

(i) The cold or winter season

Winter season starts from the month of December to first half of February. This is the coldest season of the year. During this period rainfall is much less as compare to other seasons, and whatever amount rainfall received is originated from North East Monsoon, generally known as the 'Retreating monsoon'. This season is very pleasant with clear blue sky in the absence of cloud covering and all the people of Mizoram are in festive mood since the most celebrated festival 'Christmas' occurs during this season.

(ii) Spring season

Spring season is the shortest season of the year. It starts from the second half of the February to the first half of March. Temperature is mild during this period and the sky is clear and the Mizo people accustomed to build new houses during this season as there are no weather disturbances during the period.

(iii) Summer season/Rainy season

Summer season or rainy season 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., from second half of March till First half of May is characterized 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 insolation is received during the early part of this season, *i.e.,* April and May.

A study from the daily rainfall records also reveals that the heavy outpour generally starts from the second quarter of May and this heavy outpour is usually subsides in the first quarter of October. Rainfall during May, June, July, August & September *i.e.,* 5 months alone contributed 76 % of the total annual rainfall. This is the season in which the cyclonic rains are often felt. The temperature remains high, but is kept down to a considerable extent by the usual rains.

(iv) Autumn season

Autumn season covers for a period generally starting from the second part of October to November. The season is very pleasant and the summer rain already diminished. This is the season the Mizos are longing for since they have no undone jobs in their paddy fields, just waiting for the ripening of their paddies. People are in festive moods. During this time one of Mizo festivals called 'Mim Kut' was used to be celebrated. But now what we called 'Thalfavang Kut' takes the name instead and is celebrated with joy.

3.2.4. Topography

The Tawi hill range and its surrounding are characterized by many spectacular scraps. These scraps are generally very steep, and made up of hard rock units. The spurs are mainly running in east – west directions. The spurs on the eastern side of the main ridge are relatively long and gentler than the spurs on the western side.

Structural Hills as the name implies, is of structural origin, associated with folding, faulting and other tectonic processes. High structural Hill (above 1200m) is found at the peak of Tawi and Medium structural Hill (500-1200m) is also found below this peak.

3.2.5. Geology and soil

The study area occupies the north-central part of the state and represents a monotonous sequence of argillaceous rocks, which are classified by Geological Survey of India into two formations *viz.*, Middle Bhuban and Upper Bhuban formations. The formations are folded into almost N-S trending anticlines and synclines and affected by longitudinal, oblique and transverse faults of varying magnitudes.

The soil is acidic in nature due to heavy rainfall. It contains a high amount of organic carbon and is high in available nitrogen, low in phosphorus and potassium content. On the basis of rainfall and humidity, the soil moisture is classified as Udic. Classification of soils of the area has been done according to soil taxonomy on the basis of their physico-chemical and morphological properties. The soils found at order level are Entisols, Inceptisols and Ultisols. Under further placement of the soils into lower categories the soils are very deep, dark brown to yellowish red, clay loam to clay, very strongly acid, well drained, hill side slopes, severe to moderate erosion, patchy thin cutans are formed. Loamy skeletal, mixed, hyperthermic.

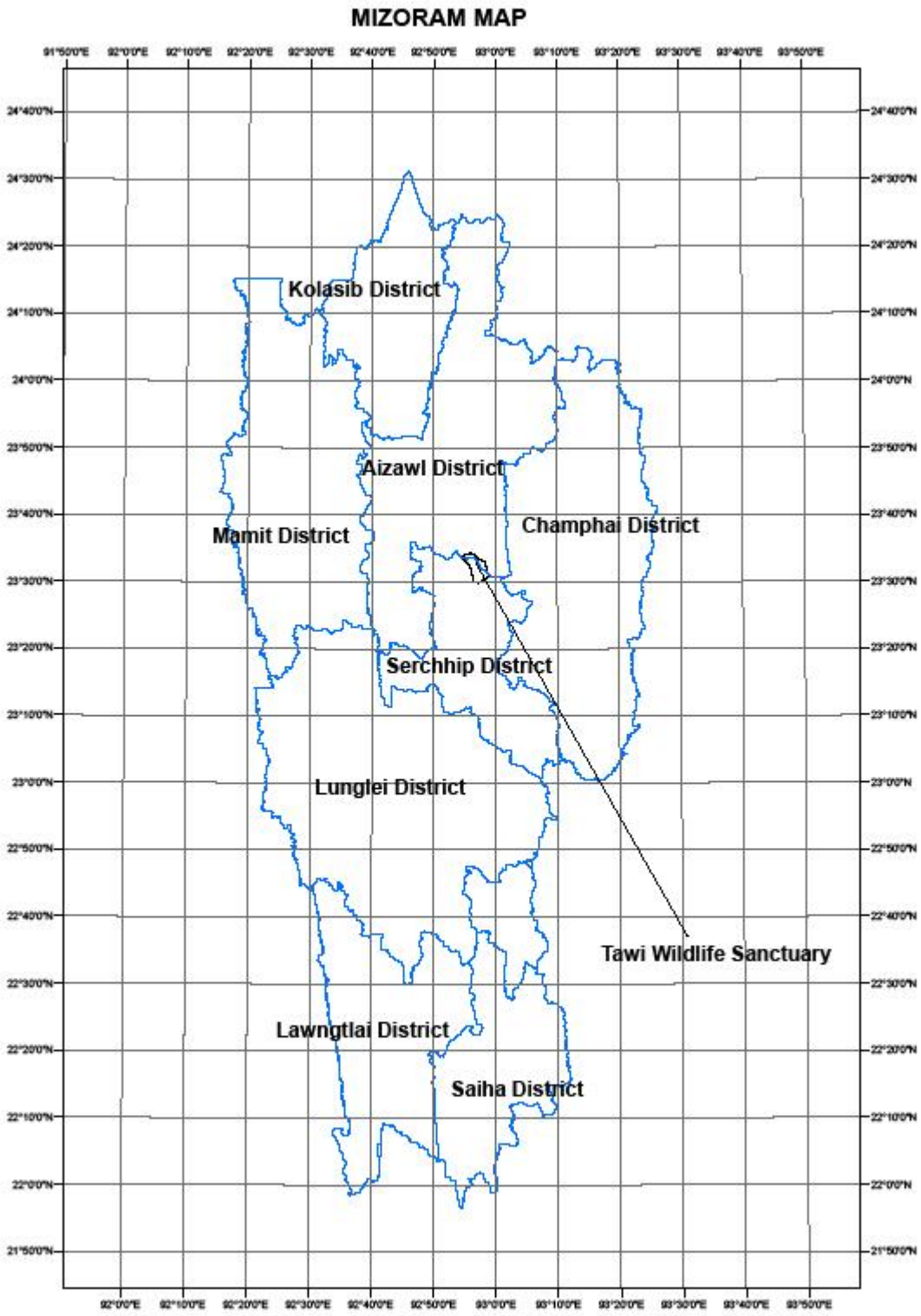

Fig. 3.1. Map of Mizoram

3.2.6. Drainage

The drainage of the study area follows dendritic pattern. Most of the streams within Tawi Wildlife Sanctuary flows towards the western side, while few streams namely - Vaidan lui, Khuai lui and their tributaries flows towards east. The eastern and western streams are separated, within the study area, by a ridge which runs almost along N – S direction.

To the northern periphery of the study area, flows Vawmrawh lui along western direction, draining several small streamlets. Vawmrawh lui is joined by Khuai lui. Other important streams within Tawi Wildlife Sanctuary are Bengchat lui and Saza lui. These two streams drain several streamlets on their way to western side (**Fig. 3.2).**

Streams flowing towards western side are comparatively long, and appear to flow through a rather rugged terrain as compared to streams flowing towards inside of the study area.

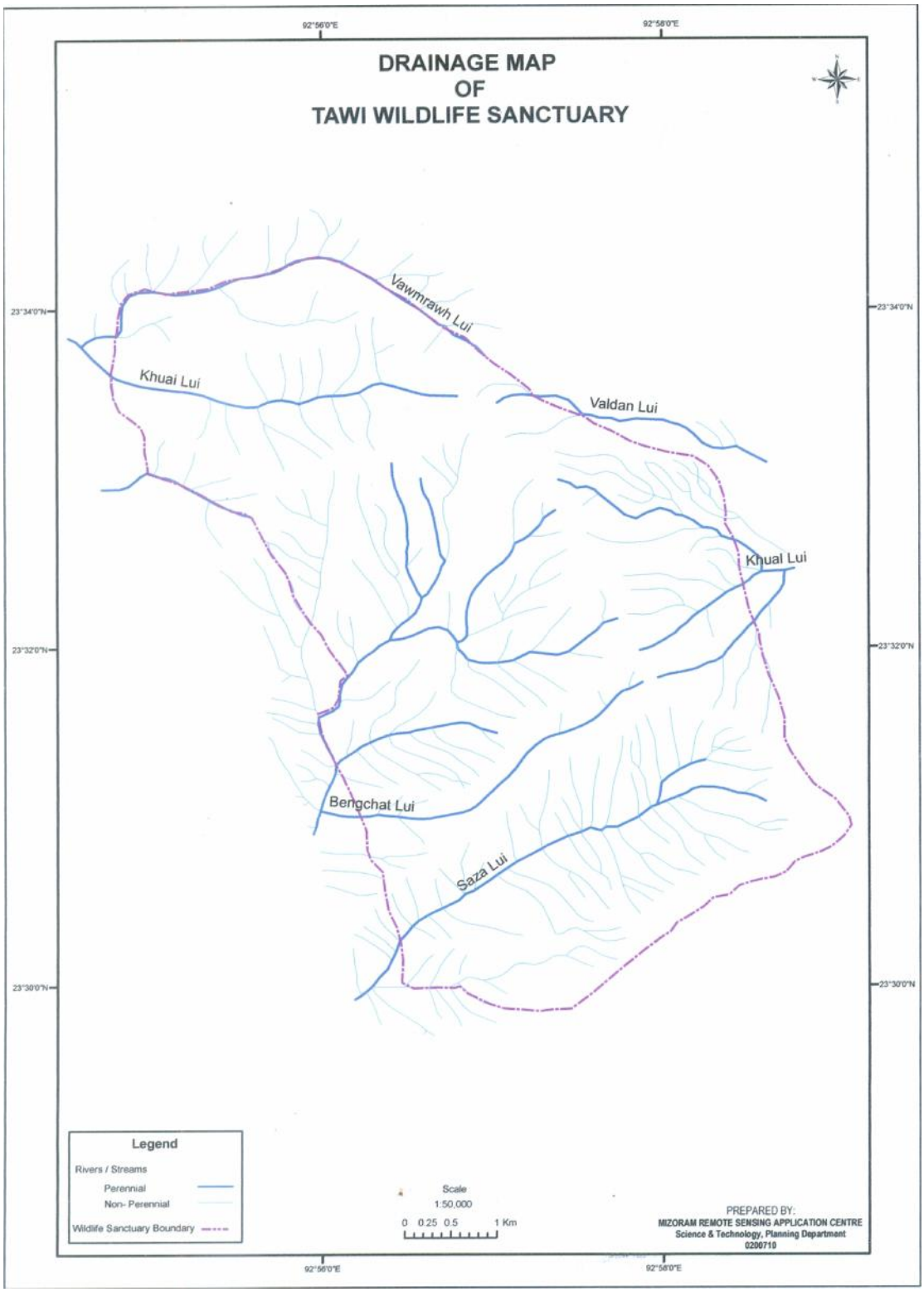

Fig. 3.2 Drainage Map of Tawi Wildlife Sanctuary

3.2.7. Vegetation

The vegetation of the sanctuary falls under the Tropical semi-evergreen and Sub-tropical broadleaved hill forests. The area experiences equable warm climate to chilly winter during November-January at the higher altitude.

The year is broadly divided into – summer - late March to May; rainy season- June to October and winter season- November to early March. Maximum temperature ranges between 17^0C to 28^0C and the minimum between 10^0C to 16^0C with the annual rainfall between 2000 and 2500 mm. June and July experience heavy showers.

Tawi Wildlife Sanctuary is rich in diversity so growth of vegetation is luxuriant **(Fig. 3.3).** A great variety of tree species, palms, canes, bamboos, shrubs, herbs, climbers and epiphytes are found growing inside the forest **(Plate 1a).**

The forest is mainly composed of trees like *Persea petiolaris, Syzgium cuminii, Cinnamomum bejolghota, Quercus lineata, Bruinsmia polysperma, Ostodes paniculata, Fagerlindia fasiculata, Macropanax dispermus, Dysoxylum gobara, Glochidion khasicum* etc. The shrubby undergrowth is chiefly composed of *Strobilanthes parryorum, Blumes lanceolara, Clerodendron viscosum, Polygonum chinense, Scleria levis*, etc. Lianas and climbers are represented by *Cayratia obovata, Clementis sikkimensis, Smilex perfoliata, Mellettia pachycarpa* etc.

A large number of species found in the sanctuary have high economic potential and many of these are used by the locals in their daily life. Some of the important species which have medicinal value are *Embelia ribes*, *Hedyotis scandens, Bergenia ciliata, Aechynanthus sikkimensis*, *Costus speciosus etc*. It also harbours many edible plants like *Dysoxylum gobara, Amomum dealbatum* and a great variety of edible *Agaricus spp.* It is also rich in canes and palms species which are of great economic value.

Grassland is a unique type of vegetation found in Tawi Wildlife Sanctuary. Major portion of this grassland area is covered by tall grasses. The common species are *Imperata cylindrica, Cympogon winterianus, Saccharum longisitosum* **(Plate 1b).**

One important thing to be noted while mentioning about the vegetation of Tawi Wildlife Sanctuary is the abundance of a unique bamboo species with thorns at the nodes *Arudinaria callosa* which is endemic to Mizoram.

Within the area of Tawi Wildlife Sanctuary there is a big cave which is not far from Hmuntha village. This cave has attracted many visitors. The main visitors are students from different parts of Mizoram and adventure clubs.

The research work has been started from November 2006 after having permission to take up research work in the sanctuary from the Chief Wildlife Warden, Dept. of Environment & Forest; Government of Mizoram (No. A. 33011/2/99-CWLW/128).

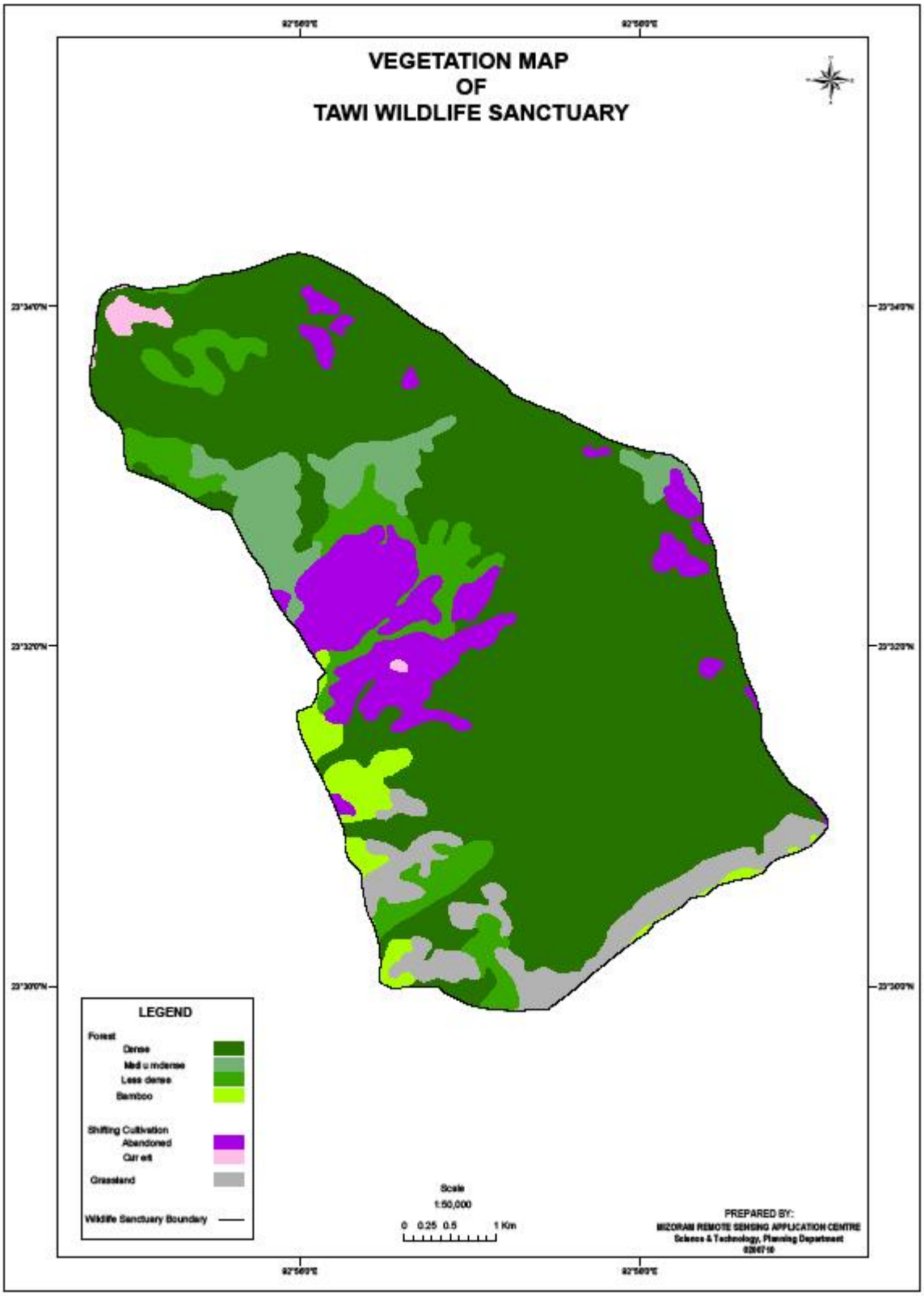

Fig. 3.3. Vegetation Map of Tawi Wildlife Sanctuary

Plate 1

Plate 1a: Forest

Plate 1b: Grassland

CHAPTER - 4

CHAPTER - 4

METHODOLOGY

At the initial stage of the research work *i.e.,* during the month of November 2006, surveying of the study area has been done from different sites of the adjoining 4 villages of the sanctuary, viz, Hmuntha, Maite, Tawizo, Hualtu and Lenchim.

The following methodologies were adopted for the present study.

4.1. Plant community Analysis

a. Quadrate and belt transect method

The forest vegetation was analyzed for trees and herbs. 25 quadrates of $10m^2$ size were laid randomly at 1km intervals for the study of woody species. In each quadrats diameter at breast height (dbh) of trees were measured and recorded. For herbs, $1m^2$ quadrats of five in number were taken randomly in each $10m^2$ quadrats.The vegetation data were quantitatively analyzed for frequency, density and abundance (Curtis and Mc Intosh 1950). The relative values of frequency, density and dominance were determined following Phillips (1959) and were summed up to get Importance Value Index (IVI) of individual species (Curtis 1959). The tree basal area was measured by taking diameter at breast height (dbh). The diversity index was computed by 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 by using Pielou's evenness Index (Pielou 1969) and species richness was calculated by adopting Whittaker's α diversity (Whittaker 1975).

b. 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 (parameters) are taken into consideration. These are then used to express the characteristics of a community. Quantitative characters are analytical characters and are generally expressed in terms of 5-point scale. These include such characters as frequency, density and abundance, cover, basal area etc.

(a) Frequency: Frequency is the number of quadrates (as %) in which species occurs. Thus frequency of each species is calculated as follows:

$$\text{Frequency} = \frac{\text{No. of quadrates in which species occurs}}{\text{Total no. of quadrates sampled}} \times 100$$

(b) Density: Density represents the numerical strength of a species in the community. The number of individuals of the species in any unit area is its density. Density gives an idea of degree of competition. It is calculated by the following formula.

$$\text{Density} = \frac{\text{Total no. of individuals of a species in all quadrates}}{\text{Total no. of quadrates sampled}} \times 100$$

(c) Abundance: This is number of individuals of any species per quadrates of occurrence. It is calculated as follows:

$$\text{Abundance} = \frac{\text{Total no. of individuals of a species in all quadrates}}{\text{Total no. of quadrates in which the species occurred}} \times 100$$

c. Importance Value Index (IVI)

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 = $\frac{\text{No. of quadrats of a species}}{\text{Total number of quadrats of occurrence of all species}} \times 100$

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

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

(d) Basal cover = $\frac{(cbh)}{4n}$

Mean basal cover = Stand basal cover/density

IVI = Relative Frequency + Relative Density + Relative Dominance.

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

Average basal area= πr^2

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

d. Biodiversity indices

The following biodiversity indices were computed for the assessment of plant diversity.

(a) Species richness

Whittaker's α diversity (D) (Whittaker 1975)

$$D = S/\log N$$

Where, S = No. of species in a sample

N = Total number of individuals in the sample.

(b) Species diversity

Shannon and Wiener (1963)

$$H' = \sum Pi \ln Pi.$$

Where, Pi = proportion of each species in the sample.

(c) Evenness index (Pielou 1975)

$$E = H' / \ln S$$

Where, H' = Shannon's index value,

S = Total no. of species.

ln = Bits per individual

(d) Index of Dominance (D) Simpson (1949)

$$D = \sum (ni / N)^2$$

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

N = Total number of individuals.

4.2. Herbarium methodology

A herbarium is defined as a collection of plants that usually have been dried, pressed, preserved on sheets and arranged in accordance with any accepted system of classification for future reference and study. The steps involved in Herbarium methods are as follows:

(a) Plant collection: The twigs of different plant species inside the study area were collected seasonally along with their flowers or fruits. In case of grasses, sedges and other herbs, the whole plant including the underground parts were collected and were prepared in a herbarium for identification by following the works of Jain and Rao (1977) and Womersey (1981).

Photographs of different species were also taken to enrich the study and for easy identification.

(b) Field notes and field numbers: A very important part of the plant collection work is the record of field notes in a field note book. Field books are specially prepared note books for labeling the plants and for recording notes about them in the field. The pages of these note books are specially printed, punched and perforated. The pages are serially numbered and there are six tags or tickets on each page having the same number; these are detachable on lines of perforation, and were tied to the specimens with the thread provided in the punched hole of each tag. Each page has same number marked at seven places one on the page itself and six on the tags or tickets. These tags are for duplicates of same species. Detailed notes like detailed location, habit and growth form, architecture of shoot and root, bark character of trees, nodes and internodes for bamboos, arrangement of leaves, shape of stem, petiole base were entered in the field note book at the time of collection in the field itself. Each specimen was given number before they were put in the polythene bag.

For each species the number were entered in the field note book and a tag bearing that number were attached to the specimens.

(c) Preservation of plants before drying: For longer storage, the specimens are poisoned immediately in the camp or after reaching the village. Poisoning kills the plant and thereby the formation of abscission layer and decay was prevented. The collections are spread out in ordinary old newspapers and bundled up. Each bundle is then placed in a large Polythene bag. 30% paraformaldehyde was prepared by taking 300g of paraformaldehyde in a bottle and filled the bottle with 3000ml luke warm water so as to dissolve the paraformaldehyde powder. The bottle was shaken until the paraformaldehyde was dissolved. This solution was poured over the bundles, so that the bundles just get soaked thoroughly. The bags are then tied airtight. No further change of folders is necessary till reaching the laboratory. On reaching the laboratory, the bundles were opened out; the specimens were exposed to the air to drive away the excess of paraformaldehyde fumes.

(d) Pressing and drying plant specimens: Specimens are pressed in a plant press, 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). The plant press was tightened using straps with buckles. The objective of pressing plants is to extract moisture in the shortest period of time, while preserving the morphological integrity of the plant, and to yield material that can be readily mounted on herbarium paper for long term storage.

In order to fit on a standard herbarium sheet, plant specimens were pressed flat to no more than 1 1 X 1 6 inches. If the specimen were not fit to those dimensions, it was folded 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. Plants specimens were carefully arranged while they are placed in the press to maximize preservation of diagnostic features. Leaves, flowers, and fruits were spread out so that they do not overlap and can be observed from different perspectives. The collection number was clearly written on the outside of the newspaper containing each plant specimen. The plant press was kept tight; this prevents shrinkage and wrinkling of the plant material and yields specimens that are easier to mount securely on herbarium paper. The pressed plants were thoroughly dried prior to storage and mounting. To obtain best results the plant press was kept in an oven and provides steady bottom heat between 95°F and 113°F. A low ambient humidity and good airflow around and through the presses also insures rapid and thorough drying of plant material. As the specimens dry, straps on the press were further tighten to minimize shrinkage and wrinkling.

e) Fumigation: This is done for killing pests and fungal attack on the plant specimens. For this, the specimens were sprayed with a solution of 2% mercuric chloride in 95% alcohol. After this, the specimens were dried in the sun. Simple heating at 110°F (44° C) in an oven with temperature control was also carried out. To prevent damage by insects Naphthalene balls were used as a repellant and were kept in the boxes containing mounted specimens about every three months.

f) Mounting and stitching: Mounting is the process of affixing a dried pressed plant and its label to a sheet of heavy paper. This provides physical support that allows the specimen to be handled and stored with a minimum of damage.

The mounting sheets were made from heavy long-lasting white card sheet in uniform size of 28 x 42 cm (± 1 cm).. Prior to attachment, the specimen and its label are laid out on the paper to allow maximum observation of diagnostic (usually reproductive) features as well as the range of variation in vegetative structures, including both sides of the leaves. Plants are generally positioned in a lifelike arrangement (that is, with roots or lower stem toward the bottom of the sheet and flowers toward the top). After the specimen were pressed, dried and poisoned, on the underside of the plant to be mounted fevicol was applied, it was affixed (along with the collection no.) on a mounting sheet. The mounting sheets with specimens glued with fevicol on them were kept in press for one day for proper sticking and drying Large or bulky items were sewn onto the sheet with a sturdy thread. The objective is to secure the specimen firmly to the mounting paper, while leaving some pieces of the plant loose enough to be removed if necessary.

g) Labelling: A plant specimen is incomplete without label data. Label data is a form of field data and must be accurate. After mounting the specimens on herbarium sheets, each sheet was labeled. A label was pasted on the lower right-hand corner. Herbarium labels are important parts of finished specimens. The standard size of the label is 4" X 2.5".

The labels contained the following data.

(i) Collection No. and Date

(ii) Name of the family

(iii) Name of the genus and species

(iv) Locality of collection

(v) Phenology

(vi) Distribution

(vii) Notes

(viii) Collector's name and number.

4.3. Plant identification: A number of plant specimens were collected during the research work years. Many plants 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, Kanjilal *et al.,* 1991), "A Handbook of Common Trees of Mizoram" (Lalramnghinglova 2003), and Flora of Mizoram Vol.1 (Singh *et al.,* 2001) "Ethno- Medicinal Plants of Mizoram" (Lalramnghinglova.,1997) and "The book of Mizoram Plants" (Sawmliana 2003). During the month of August 2008, critical plants and unconfirmed species were taken to Botanical Survey of India, Eastern Circle, Shillong and were identified and confirmed with the help of Scientists there.

4.4. Community studies: Detailed structural analysis of the forest community was carried out and the following aspects were studied

(i) Stratification: Stratification was studied by drawing profile diagram along belt transect (7.5 m x 100 m). All plants above 5 cm dbh were considered for preparing profile diagram.

(ii) Life-form spectrum: Plant species were grouped into different life forms on the basis of criteria outlined by Raunkiaer (1934).

4.5. Collection and Analysis of Soil Samples: 25 samples of soil from 25 sites of the study area were collected and analyzed seasonally for their physical and chemical properties such as temperature with the help of soil thermometer EUTEC Instruments (Ecoscan Temp 5), soil moisture by oven dry method, bulk density by gravimetric method (Allen *et al.,* 1974) , pH by a digital pH meter (SYSTRONICS-335), Total

Nitrogen Kjeldahl (TKN) was determined by Kjeldahl method (1883), Soil Organic carbon content by rapid titration method (Walkley and Black 1934) exchangeable potassium using flame photometer and available phosphorous using spectrophotometer by Olsen's method (Olsen *et al.,* 1954). The same methodology and parameters is repeated in the following year in the particular seasons as the previous year so as to enrich the research data. The soil samples analyzed during these months were collected during the seasons of pre-monsoon, monsoon and post-monsoon so the data is recorded as per the seasons.

4.5.1. Physical properties of the soil

The physical properties of the soil were determined by the following methods:

a. Soil pH

Procedure:-

10g of freshly collected soil sample were taken in a beaker containing 50ml of distilled water. The soil water mixtures were stirred for 20 minutes on a magnetic stirrer. The solutions were left overnight and the pH readings were taken with the help of pH meter

b. Soil moisture content (Hot air oven method)

Procedure:-

10g of freshly collected soil sample were kept in a hot air oven at 105^{o}C for 24 hours and the oven-dried soil are weighed again.For each sample, three replicates were maintained.

The percentage moisture content is calculated by the following formula,

$$\text{Moisture content (\%)} = \frac{W_1 - W_2}{W_1}$$

Where, W_1 = initial weight

W_2 = final weight

c. Soil temperature

Soil temperature was taken at different sites at different altitudes with the help of soil thermometer EUTEC Instruments (Ecoscan Temp 5). The soil thermometer was inserted 2 inches into the soil and the readings shown on the digital thermometer was recorded.

d. Bulk density

Procedure:-

With the help of hollow cylinder, the known volume of soil was collected from 25 sites in a polythene bag by hammering the core of known volume in the soil. After reaching the laboratory, the collected soils were put on the petriplates separately and kept in the oven at 105^0C for about 28 – 48 hours. Then the weight of the dry soil is taken and recorded.

Then the bulk density is calculated by the following formula,

$$\text{Bulk density} = \frac{\text{Mass}}{\text{Volume}} \text{ g/cm}^3$$

$$= \frac{\text{dry weight of the soil}}{\Pi r^2 h} \text{ g/cm}^3$$

4.5.2. Chemical properties of the soil

The chemical properties were determined by the following methods:

a. Soil organic carbon (Walkey and Black method 1934)

The oven dried soil is ground completely passed to 0.2mm sieve (80-mesh) and 0.5g sample is placed at the bottom of dry 500ml conical flask.10ml of 1N potassium dichromate was added in the conical flask and the flask was swirled gently to disperse the soil in the dichromate solution. The flask is kept on asbestos sheet. 20ml of conc. Sulphuric acid was carefully added from a measuring cylinder and was swirled 2 – 3 times. The flask was allowed to stand for 30 minutes.200ml of distilled water and 10ml of ortho-phosphoric was added to get a sharper end point of titration. After the addition of 1ml diphenylamine indicator, the content was titrated with ferrous ammonium sulfate solution till the colour flashed from blue-violet to green. Simultaneously, a blank is run without soil.

The soil organic carbon content and organic matter was calculated by the following formula,

(a) $$\text{Organic carbon (\%)} = \frac{10\,(B-T)}{B} \times 0.003 \times \frac{100}{S}$$

Where,

B = Volume of ferrous ammonium sulfate solution required for blank titration in ml.

T = Volume of ferrous ammonium sulfate solution required for soil sample in ml.

S = Wt. of soil in gram.

(b) Organic matter (%) = % Organic carbon x 1.724.

b. Total Nitrogen

Procedure:

(i) Digestion.

5g of soil sample was weighed and transfer to the digestion tube.10-15ml of conc. Sulphuric acid (H_2SO_4) was added and 5-7g of catalyst mixture of the sample. The digestion tubes were loaded in the Digester and the digestion block was heated to 410^oC till the sample colour turns colorless or light green colour.

(ii) Distillation:

The main AC power and the Rear side Green colour of the distillation unit was switched on. The distilled water tap was kept in ON condition. The power was switched in control panel. The Digestion tube large (DTL) was taken with digested sample. After the addition of 10ml distilled it was shaken well. The DTL was loaded in Distillation Unit using the slider mechanism. 25ml of 40% Boric acid (plus 3 drops of Methyl red and 3 drops of Bromocresol green) was taken in a 250ml conical flask and kept in the receiver end.

40ml of 40% NaOH was added by using the control panel. The timer was set at 20sec. on the upper button. After the process was over the boric acid turned colourless. After the READY signal was glowing, the tap water inlet was opened for condensation. The required process time was set at 6 minutes for distillation on the lower button. The run key was pressed at the lower button. After the process time was over, steam was automatically cut off and the condensation tap water inlet was closed. The conical flask containing boric acid was taken out from the receiver end and the sample was ready for titration.

(v) Titration.

The solution of Boric acid was titrated against with 0.1N HCl. Or 0.1N H_2SO_4 until the Boric acid turned pink. The burette reading was taken and the percentage of Nitrogen was calculated with the help of the formula.

$$\% \text{ of } N_2 = \frac{14 \text{X Normality of acid X Titrant value X } 100}{\text{Sample weight X } 1000}$$

c. Available Phosphorus (Olsen's Method)

Procedure:

Preparation of extractant:

2.5g of soil and 50ml of extracting solution ($NaHCO_3$) were added in a 250ml conical flask. The flask was shaken for 30minutes with suitable shakers. The suspension was filtered through Whatman filter paper No. 40.Activated carbon (free of phosphorous) was added to obtain a clear filtrate. The flask was again shaken immediately before pouring the suspension into the funnel.

Colour development:

5ml of extract was taken into a 25ml volumetric flask, to which 5ml of Dickman's and Bray's was added drop by drop with constant shaking till the effervescence due to CO_2 evolution ceases. The neck of the flask was washed down and the contents were diluted to about 22ml (Acidification to be checked, pH5.0; if less acidify with 5N H_2SO_4 to pH 5.0)**.** Then 1ml of dilute $SnCl_2$ was added and volume was made up to mark. The colour was stable for 24 hours and maximum intensity was obtained in 10 minutes. (660nm) ($SnCl_2$: 2.5g in 100ml glycerol heat in water bath for mixture)

***Preparation of standard curve*:**

For preparation of standard curve different concentration of phosphorus (1,2,3,4,5 and 10ml of 2ppm phosphorus solution) were taken in 25ml volumetric flask. The standard concentration of phosphorus was prepared in the range of 0.08ug/ml to 0.80ug/ml (Spectophotometer 660nm).

The curve was plotted taking the colorimeter reading on the vertical axis and the amount of phosphorus (in ugP/ml) in the horizontal axis.

Calculation:

$$\text{Olsen's phosphorus (Kg/ha)} = RxV/vx1Sx\ (2.24x10^6/10^6)$$

$$= Rx\ (50/5)\ x\ (1/2.5)x2.24$$

$$= ugPx8.96$$

Where, V = Total volume of extractant (50ml)

v = Volume of aliquot taken for analysis (5ml)

S = Wt. of soil (2.5g)

R = Wt. of the aliquot in ug (from standard)

d. Exchangeable Potassium

Procedure:

(Extraction as suggested by Ghosh et al., 1983)

5g of soil was shaken with 25ml of neutral normal ammonium acetate solution (soil extract = 1:5) for 5 minutes and was filtered immediately through a dry filter paper (Whatman filter paper No. 1).The first few ml of the filtrate was rejected. The potassium concentration was determined in the extract by flame photometer by using K filter.

Preparation of standard curve:

Prepare 10 to 60 ppm K solutions was prepared from the stock solution by adding ammonium acetate solution. After attaching the appropriate filter, gas and air pressure in the flame photometer were also adjusted. The reading was adjusted to zero for the blank in flame photometer. The readings at the different conc. for K solution were noted. The readings were plotted against the concentrations.

Calculation:

1) Available potassium (mg of K/g of soil)

$$= \frac{A \times V}{W \times 100}$$

2) Available K (Kg/ha)

$$= R \times \frac{V}{W} \times \frac{2.24 \times 10^6}{10^6}$$

$$= \text{ppm of K} \times 11.2$$

Where, A = K content of soil extract from standard curve, mg/L

V = Volume of the soil extract ml.

W = weight of air-dried sample taken for extraction in g (5g)

R = ppm of K in the extractant.

4.6. Socio - economic study: Socio-economic study was also conducted in the village communities in and around the study area. The methods of Participatory Rural Appraisal (PRA) were conducted in each village. Informations were gathered from each village through personal/group interviewing from the people of different categories like farmers, Village council members, Govt. employees and personal

communications. Demography, educational/ institutional and social welfare services are presented in **Table – 4.1, 4.2, 4.3.**

Table – 4.1. Demographic & Occupation Data

Name of the village	No. of Household	Population			BPL Family	Occupation					
		Male	Female	Total		Cultivators	Piggery	Poultry	Industry	Govt. Servant	Business
Hmuntha	120	550	400	750	45	110	50	120	-	10	3
Maite	157	475	499	971	45	140	80	150	-	12	7
Tawizo	80	199	182	381	71	72	46	48	-	8	2
Hualtu	162	550	401	951	60	162	120	150	1	12	4
Lenchim	73	165	200	365	20	59	53	64	2	8	

Table – 4.2. Educational and Local Institutional Level

Name of the Village	Educational Level				Local Institutional Level								VC House
	P.G.	Graduate	10+2	CL-X	H/S		M/S		P/S		Anganwadi		
						Teachers/ Students		Teachers/ Students		Teachers/ Students		Teachers/ Students	
Hmuntha	-	15	10	35	1(Govt aided)	5/30	1 (Govt)	6/65	1(Govt.)	5/70	2	4/60	1
Maite	-	11	6	30	1(Pvt.)	4/35	1 (Govt)	16/62	1(Govt.)	4/106	2	4/50	1
Tawizo	-	7	5	12	-	-	1 (Govt)	6/20	1(Govt.)	2/40	1	2/30	1
Hualtu	-	11	7	23	1(Govt. aided)	4/35	1 (Govt)	4/55	1(Govt.)	4/90	2	4/65	1
Lenchim	-	4	2	4	-	-	1 (Govt)	5/34	1(Govt.)	3/39	1	2/36	1

Table - 4.3. Standard of living and Social Welfare Services

Name of the village	Houses Electrified	Houses with LPG	Houses with Telephone	Houses with Chullah	RCC Building	Tin- Roof Building	Public Waterpoint	Rest House	Road Communication
Hmuntha	120/120	60	11(WLL)	2	-	118	15	-	Fair weather 407 Rd.
Maite	157/157	60	6 (WLL)	3	-	154	14	-	Fair weather Jeepable
Tawizo	78/80	30	5 (WLL)	4	-	76	7	-	Fair weather Jeepable
Hualtu	150/162	100	21(WLL)	6	1	155	17	1	Fair weather Jeepable
Lenchim	73/73	34	9 (WLL)	-	-	73	12	-	Fair weather Jeepable

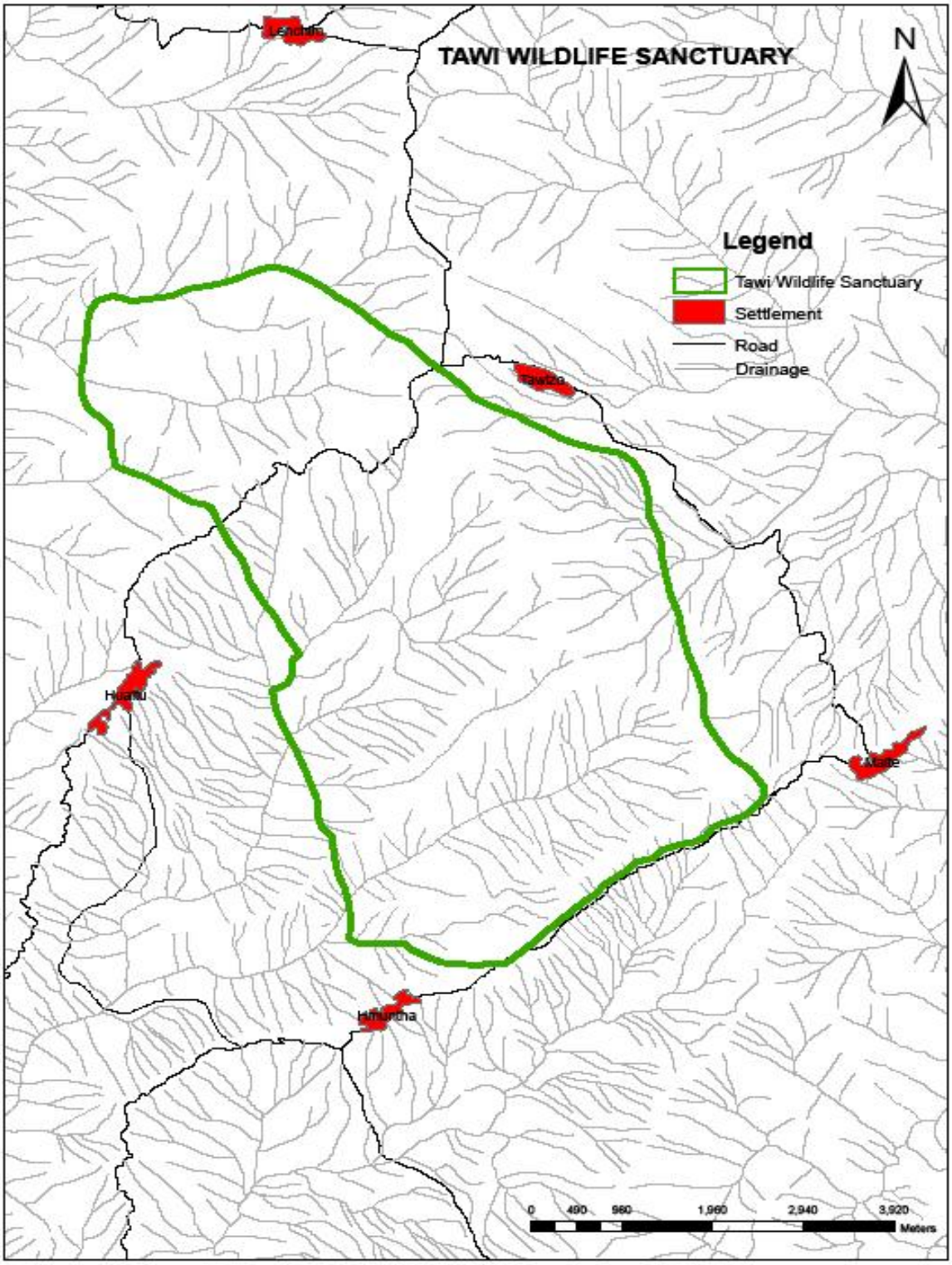

Fig. 4. 1. Adjoining Villages of Tawi Wildlife Sanctuary

CHAPTER - 5

CHAPTER - 5

RESULTS AND DISCUSSION

5.1. Floristic composition

Tawi Wildlife Sanctuary is unique not only because it is a wildlife sanctuary, but also having a rich cover of forest supporting a rich biodiversity. The vegetation is predominantly of forest communities, which are frequently interrupted in buffer zone by scrub jungles and grassland communities. A great variety of tree species, palms, canes bamboos, shrubs, herbs, climbers and epiphytes are found growing inside the forest. The vegetation of the sanctuary falls under the Tropical semi-evergreen and Sub-tropical broadleaved hill forests. The major concentration of forest is found in the hilly portions. Though clear zonation does not exist in the forest, but arbitrarily it can be divided as follows:

(i) Top layer of trees 8 m or above

(ii) Middle layer of trees and shrubs 2 m or < 8 m

(iii) Ground layer of species < 2 m.

(iv) Twiners and climbers

The top layer is dominated by species like *Acrocarpus fraxinifolius, Alseodaphne petiolaris, Amoora chittagonga, Aphanamixis wallichi, Artocarpus chaplasha, Bombax insigne, Bruinsmia polysperma, Persea glaucescens, Cinnamomum bejolghota, Cinnamomum verum, Drimycarpus racemosus, Engelhardtia spicata, Diospyros lanceaefolia, Michelia doltsopa, Nyssa javanica, Phoebe hainesiana, Prunus nepalensis etc, as shown in* **Table - 5.13.** The middle layer consists of trees like *Bridelia monoica, Camellia kissi, Carya laciniosa, Castanopsis indica, Elaeocarpus tectorius, Fagerlindia fasciculata, Garcinia sp.,*

Helicia erratica, Litsea lancifolia, , Macropanax undulatus, Phoebe lanceolata, Prunus jenkinsii, Xantolis hookeri etc. as shown in **Table - 5.14.**

The ground layer or undergrowth consists of a number of seedlings of trees and shrubs. Seedlings of *Calophyllum polyanthum* were found in abundance. Pteridophytes like *Diplazium dilatatum, Leptochilus ellipticus, Polystichum luctuosum* were found in common. Though during monsoon and post monsoon period a number of herbs and undershrubs predominate. Some common species found in this layer were *Artemisia vulgaris, Colquhounia coccinea, Echinacanthus andersonii, Leucosceptrum canum, Perilepta edgeworthiana, Strobilanthes parryorum, Strobilanthes auriculatus, Vernonia volkameriaefolia* etc

Out of 83 families, 51 families are represented by only one genus, in which 47 families are represented by a single genus with a single species. The detailed analysis of dicots and monocots is given in **Table - 5.1.**

A statistical analysis of the flora reveals the occurrence of 237 species under 182 genera belonging to 72 families of angiosperms, 1 family of gymnosperm and 10 families of pteridophytes. The dicotyledons comprise 65 families, 125 genera and 155 species. Out of the 73 families of dicots and monocots, dicots represent 89.04% and monocots represent 10.96%. Out of 167 genera, dicots and monocots genera are 74.85% and 25.15% respectively. Among 237 species, 83 trees (35.02%), 41 herbs (17.3%), 31 shrubs (13.08%), 26 climbers (10.97%), 26 epiphytes (10.97%), 17 grasses (7.17%), 10 canes & palms (4.22%) and 3 saprophytes (1.27%) are represented.

Table: 5.1 Distribution of families, genera and species under dicots and monocots

Category	Dicots		Monocots		Total No
	No.	%	No.	%	
Families	65	89.04	8	10.96	73
Genera	125	74.85	42	25.15	167
Species	155	70.78	64	29.22	219

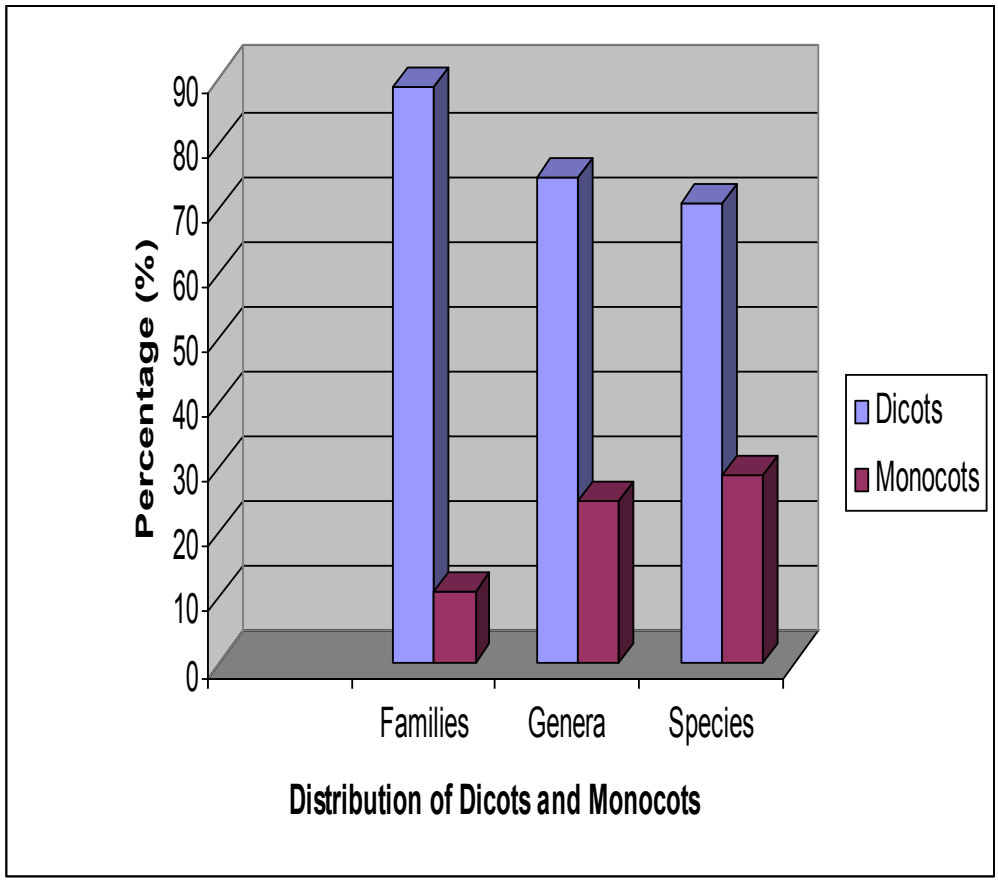

Fig. 5.1. Distribution of dicots and monocots

The data shown in **Table - 5.1**. indicates that the species of dicots outnumber the species of monocots. The ratio of genera to species is 1:1.3 which is rather low in comparison to corresponding ratio for the whole India 1:7 as indicated by Hooker (1904) and conforms to the general feature that the flora of small area is relatively

richer in genera than species. This is in accordance with Good's (1964) observation "the larger the area is the greater will its ecological diversity tend to be and therefore, a greater number of species it will contain". It is also in accordance to the flora of Bhopal 1:1.5 as shown by Ommachan (1960) and 1:1.2 in the flora of Bhimbetka world heritage, Madhya Pradesh shown by Hussain *et al.,* (2010).

Orchidaceae is the most dominant family in the area in respect to number of species (24 sp.), followed by families like Poaceae (17 sp.), Lauraceae (11 sp.), Arecaceae (10 sp.), Euphorbiaceae (9 sp.) and Fabaceae (9 sp). The floristic composition of the sanctuary is similar to the subtropical forest described by Balakrishnan (1981). Apart from the sub tropical species, tropical and temperate species were also present. Some of the tropical species present in the study area are *Elaeocarpus tectorius, Macropanax undulatus, Symplocos cochinchinensis, Schefflera venulosa, Lithocarpus sp, Cyathea spinulosa sp, Pothos scandens etc.* The temperate species include *Lyonia ovalifolia, Clematis sp., Prunus sp., Senecio sp., etc.* (Mani 1974; Rao 1974; Balakrishnan 1981).

An interesting feature of the flora of Tawi Wildlife Sanctuary is its affinity with the flora of Burma- Malayan and South Central China regions. This is evident by the presence of a number of genera and species originating from these regions. The Burma-Malayan species found in the sanctuary are *Engelhardtia spicata, Xantolis hookeri, Cinnamomum spp., Persea spp., Litsea sp., Balanophora dioca etc* .Some pteridophytes including the rare species of *Pteris tricolor* from Yunan south China.

Another important feature of the flora of Tawi WLS is the presence of ancient angiosperms like Ranunculaceae, Anacardiaceae, Berberidaceae, Ebenaceae, Elaeocarpaceae, Magnoliaceae Piperaceae, Lauraceae, Myricaceae, Symplocaceae, and Theaceae.

A large number of shrubs and herbs present in the fringes of the study area also contributed to the high species richness.

The vegetation and flora have much diversity due to a variety of topography. A statistical analysis from IVI calculation of the trees within the wildlife sanctuary reveals the occurrence of 83 tree species; the details of the calculation are given in **Table: 5.2.** Each species are given a rank from the results of IVI calculation. Top ten dominant tree species in respect of species composition in the area are *Callophyllum polyanthum (Sentezel), Engelhardtia spicata (Hnum), Litsea lancifolia (Hnahpawte), Helicia erratica (Sialhma), Ostodes paniculata (Beltur), Alseodaphne petiolaris (Khuangthulh), Michelia doltsopa (Zongiau), Macropanax dispermus (Phuanberh), Diospyros pilosula (Zoruthei) and Fagerlindia fasciculata (Chhawtan).* The natural regeneration of the most dominant species *Callophyllum polyanthum* were found in abundance (**Photo plate - 2).**

Among shrubs, *Strobilanthes parryorum* by has the highest IVI followed by *Strobilanthes anisophyllus, Echinacanthus andersonii, Rhynchotechum ellipticum* and *Strobilanthes auriculatus* details are given in **Table - 5.3.** The most dominant species among herbs is *Dryopteris cochleata* followed by Leptochilus *ellipticus* and *Diplazium dilatatum* details are given in **Table - 5.4.**

The species diversity (Shannon diversity H') was highest among trees (3.86) followed by herbs (3.26) and shrubs (3.14) (**Table - 5.5.)**. In an eastern deciduous forest of North America, Braun (1950) has reported tree species diversity between 1.69 and 3.40. On the other hand tropical forest indicates higher diversity as calculated by Knight (1975) for young (H' = 5.06) and old (H' = 5.40) stands. In the three sacred groves of Jaintia hills, Meghalaya Jamir (2000) obtained a diversity value of 3.738, 4.286, and 4.304 respectively. These figures are close to the values obtained

for Tawi Wildlife Sanctuary. The quantitative analysis of climbers, Epiphytes, Parasites/Saprophytes, Grasses, Canes and Palms are shown in **Table - 5.7, 5.8, 5.9, 5.10 and 5.11** respectively.

During the course of the research work *Kalanchoe roseus* a critically endangered plant which was recorded as endemic only to Manipur and Nagaland and an interesting fern species *Pteris tricolor* were encountered. Both are new records from Mizoram. Critically endangered and endemic species of orchids *Eria lacei, Dendrobium peguanum* are also found from the study area.

The Rare and Threatened plants of the Sanctuary are *Leucomeris decora, Mahonia pycnophylla, Pogostemon plectranthoides, Disporum cantoniense, Ophiopogon dracaenoides, Ophiopogon intermedius, Aeginetia indica, Balanophora dioca* and clumps of *Arundinaria callosa* are found in abundance.

A large number of species found in the sanctuary have high economic and medicinal potential and many of these are used by the locals in their daily life. Some of the important species which have medicinal value are *Hedyotis scandens, Bergenia ciliata, Aechynanthus sikkimensis*, *Costus speciosus*. It also harbours many edible plants like *Dysoxylum gobara, Amomum dealbatum* and a great variety of edible *Agaricus spp.* It is also rich in canes and palms species which are of great economic value.

The vegetation of some of the hill area comprises of grassland vegetation. The grasses and sedges are chief elements of the grassland vegetation.The common species are *Imperata cylindrica, Cympogon winterianus, Saccharum longisitosum, Artemisia vulgaris, Scleria levis*

Plate 2

Calophyllum polyanthum

Plate 2. Natural regeneration of dominant tree species inside the sanctuary

Table - 5.2. Importance Value Index of tree species

Sl. No	**Name of the plant Species**	Density / Ha [D]	RD	Frq. [%]	RF	Dominance	Rdom	IVI	Species Rank
1	*Acrocarpus fraxinifolius* Wight & Arn *'Nganbawm'* .	4	0.18	4	0.31	1067.93	0.07	0.57	**65**
2	*Alseodaphne petiolaris* Hk.f. *'Khuangthulh'*	68	3.08	32	2.51	87113.73	6.17	11.77	**6**
3	*Amoora chittagonga* (Miq.)Hiern. *'Thehleikhak'*	4	0.18	4	0.31	925.71	0.06	0.56	**66**
4	*Antidesma bunius* (L.) Spreng. *'Tuaitit'*	4	0.18	4	0.31	153.65	0.01	0.50	**78**
5	*Aphanamixis wallichi* R. Br. *'Sahatah'*	16	0.72	12	0.94	366.98	0.02	1.69	**43**
6	*Aphanenthe cuspidata* (Bl.) Planch. *'Theisehret'*	4	0.18	4	0.31	62.22	0.004	0.5	**82**
7	*Aporusa dioica* (Roxb) Muell. Arg *'Chhawntual'*	4	0.18	4	0.31	3634.6	0.25	0.75	**57**
8	*Artocarpus chama* Bauch.-Ham. *'Tatkawng'*	4	0.18	4	0.31	1300.31	0.09	0.58	**62**
9	*Baccauria ramiflora* Lour. *'Pangkai'*	4	0.18	4	0.31	560	0.03	0.53	**71**
10	*Bombax insigne* Wall. *'Pang'*	4	0.18	4	0.31	7142.84	0.50	1.002	**52**
11	*Bruinsmia polysperma* Cl. *'Theipalingkawh'*	28	1.27	24	1.88	30051.84	2.13	5.28	**20**
12	*Calophyllum polyanthum* Wall. *ex.* Choisy *'Sentezel'*	288	13.06	80	6.28	85553.9	6.06	25.42	**1**
13	*Camellia kissi* Wallich. *'Lallai'*	8	0.36	8	0.62	4165.7	0.29	1.28	**47**
14	*Carallia brachiata* (Lour.) Merr *'Theiria'*	4	0.18	4	0.31	285.71	0.02	0.51	**76**

15	*Carya laciniosa* (Michx. f.) G. Don *'Hnumreuh'*	4	0.18	4	0.31	4881.26	0.34	0.84	**54**
16	*Castanopsis tribuloides* (Sm) DC. *'Thingsia'*	28	1.27	20	1.57	60712.7	4.30	7.14	**12**
17	*Castonopsis indica* (Roxb. *ex* Lindl.)A.DC *'Sehawr'*	4	0.18	4	0.31	1142.85	0.08	0.57	**64**
18	*Celtis timorensis* Spanoghe, Linnaea. *'Thinghmarcha'*	24	1.08	12	0.94	14417.11	1.02	3.05	**33**
19	*Cephalotaxus griffithi* Hook.*f.* *'Tufar/Thinglenbuang'*	4	0.18	4	0.31	31.75	0.002	0.49	**83**
20	*Choerospondias axillaris* (Roxb.) Burtt. & Hill. *'Theikuangchawm'*	4	0.18	4	0.31	560	0.039	0.53	**72**
21	*Chukrasia velutina* A.Juss *'Zawngtei'*	4	0.18	4	0.31	12953.62	0.91	1.41	**45**
22	*Cinnamomum bejolghota* Bauch.Ham *'Thakthingsuak'*	68	3.08	28	2.20	11016.15	0.78	6.06	**18**
23	*Persea glaucescens* Nees. *'Saperbul'*	56	2.54	28	2.20	40551.32	2.87	7.61	**11**
24	*Cinnamomum tamala* *'Testpata'*	20	0.90	20	1.57	20992.01	1.48	3.96	**28**
25	*Cinnamomum verum* Presl. *'Thakthing'*	4	0.18	4	0.31	285.71	0.02	0.51	**77**
26	*Diospyros lanceaefolia* Wallich *ex* Hiern. *'Zothinghang'*	28	1.27	28	2.20	8780.82	0.62	4.09	**26**
27	*Diospyros toposia* Ham. *'Zoruthei'*	92	4.17	48	3.77	12273.94	0.87	8.81	**9**
28	*Drimycarpus racemosus* (Roxb.) Hook. *f.* *'Vawmbal'*	48	2.17	24	1.88	41338.52	2.93	7	**13**

29	*Dysoxylum gobara* Bauch.-Ham.Merr. *(Thingthupui)*	68	3.08	28	2.20	10226.21	0.72	6.01	**19**
30	*Elaeocarpus tectorus* (Lour.)Poir *'Kumkhalte/Umkhal'*	4	0.18	4	0.31	560	0.03	0.53	**69**
31	*Engelhardtia spicata 'Hnum'*	88	4	52	4.08	143457.95	10.17	18.25	**2**
32	*Eriobotrya bengalensis* (Roxb.) Hook. f. *'Nghalchhun'*	4	0.18	4	0.31	71.43	0.005	0.50	**80**
33	*Fagerlindia fasciculata* (Roxb.) Tirveng *' Chhawntan'*	84	3.81	44	3.45	9384.98	0.66	7.93	**10**
34	*Ficus geniculata* Kurz. *'Rihnim'*	4	0.18	4	0.31	4571.42	0.32	0.82	**55**
35	*Ficus cunia* Ham. *'Theitit'*	4	0.18	4	0.31	1467.93	0.10	0.6	**59**
36	*Firmiana colorata* Roxb.R.Br. *'Khaukhim'*	4	0.18	4	0.31	825.71	0.05	0.55	**67**
37	*Garcinia sp. 'Hawi'*	4	0.18	4	0.31	24888.83	1.76	2.26	**37**
38	*Garcinia xanthochymus* Hook *.f. ex* T.Anderson *'Tuaihabet'*	4	0.18	4	0.31	71.43	0.005	0.50	**81**
39	*Glochidon khasicum* (Muell.-Arg.)Hk*.f. 'Thingpawnchhia'*	32	1.45	24	1.88	41935.77	2.97	6.31	**15**
40	*Helicia erratica* Hook*. f 'Sialhma'*	112	5.08	72	5.66	32880.56	2.33	13.07	**4**
41	*Heteropanax fragrans* (Roxb.) Seem *'Changkhen'*	4	0.18	4	0.31	1425.08	0.10	0.59	**60**
42	*Ligustrum robustum* (Roxb.) Bl. *'Chawmzil'*	12	0.54	4	0.31	5943.79	0.42	1.28	**49**
43	*Lithocarpus elegans* (Blume) Hatus. *ex* Soepadmo	24	1.08	20	1.57	10762.89	0.76	3.42	**31**

	'Thingpuithing'								
44	*Lithocarpus pachyphylla* (Kurz) Rehder *'Thensen'*	56	2.35	24	1.88	28139.42	2	6.23	**16**
45	*Litsea monopetala* Roxb. Pers. *'Nauthak'*	12	0.54	12	0.94	5453.27	0.38	1.87	**40**
46	*Litsea salicifolia* Nees. *'Par-sen'*	4	0.18	4	0.31	3629.84	0.25	0.75	**58**
47	*Litsea lancifolia* Hook. *f.* *'Hnahpawte'*	112	5.08	60	4.71	54329.75	3.85	13.65	**3**
48	*Lyonia ovalifolia* (Wallich) Drude 'Tlangham'	12	0.54	4	0.31	503.81	0.03	0.89	**53**
49	*Macaranga indica* Wight. *'Hnahkhar'*	32	1.45	8	0.62	5519.79	0.39	2.47	**36**
50	*Phoebe attenuata* Nees. *'Bulbawr'*	12	0.54	12	0.94	32128.17	2.27	3.76	**30**
51	*Macropanax undulatus* Wall. *ex*. G.Don. *'Phuanberh'*	68	3.08	48	3.77	32439.7	2.29	9.15	**8**
52	*Maesa indica* (Roxb.)Wallich. *'Arngeng'*	4	0.18	4	0.31	102.86	0.007	0.503	**79**
53	*Magifera sylvatica* Roxb. *'Haifavang'*	24	1.08	16	1.25	12651.87	0.89	3.24	**32**
54	*Michelia champaca* L. *'Vai Ngiau'*	12	0.54	12	0.94	39894.96	2.82	4.31	**24**
55	*Michelia doltsopa* DC. *Syn*. *'Zongiau'*	56	2.54	36	2.83	74200.81	5.26	10.63	**7**
56	*Myrica esculenta* Bauch.-Ham *'Keifang'*	4	0.18	4	0.31	458.41	0.03	0.52	**74**
57	*Nostolachma khasiana* (Korth.) Deb *et* Lahiri *'Thingsaingal'*	16	0.72	8	0.62	657.22	0.04	1.40	**46**

58	*Nyssa javanica* (Blume) Wanger *'Bulthur'*	12	0.54	4	0.31	4275.22	0.30	1.16	**50**
59	*Olea dioica* Roxb. *'Sevuak'*	4	0.18	4	0.31	1341.27	0.09	0.59	**61**
60	*Olea salicifolia* Wall. *ex* G.Don *'Thingthiang'*	40	1.81	36	2.83	4416.78	0.31	4.95	**21**
61	*Ostodes paniculata* Blume. *'Beltur'*	132	5.98	40	3.14	51553.44	3.65	12.78	**5**
62	*Phoebe hainesiana* Brandis *'Buleng'*	4	0.18	4	0.31	4271.74	0.30	0.79	**56**
63	*Phoebe lanceolata* Nees. *'Bulfek'*	44	1.99	28	2.20	32115.76	2.27	6.47	**14**
64	*Prunus jenkinsii* Hook.*f.* & Thomson *'Keipui'*	20	0.90	16	1.25	30228.5	2.14	4.30	**25**
65	*Prunus nepalensis* Steud. *'Lumler'*	12	0.54	12	0.94	3582.25	0.25	1.74	**42**
66	*Prunus undulata* Bauch.-Ham. *ex* *'Theiarlung'*	32	1.45	20	1.57	13441.39	0.95	3.97	**27**
67	*Quercus dilatata* Lind. *'Thal'*	12	0.54	8	0.62	37904.9	2.68	3.86	**29**
68	*Quercus glauca* Thunb. in A.Murray *'Hrumhriau'*	12	0.54	12	0.94	4982.49	0.35	1.84	**41**
69	*Sapindus mukorossi* Gaertn. *'Hlingsi'*	4	0.18	4	0.31	614.6	0.04	0.53	**68**
70	*Schefflera venulosa* (Wight & Arn.) Harms *'Kelbuh'*	4	0.18	4	0.31	560	0.039	0.53	**70**
71	*Symplocos cochinchinensis* Roxb.	4	0.18	4	0.31	1220.31	0.08	0.58	**63**
72	*Syzygium claviflorum* (Roxb.) Wallich *ex Cowan & Cowan* *'Hmuifarial'*	16	0.72	12	0.94	5039.99	0.35	2.02	**38**

73	*Syzygium cuminii* (L.) Skeels *'Lenhmui'*	32	1.45	32	2.51	31432.46	2.22	6.19	**17**
74	*Syzygium grandis* (Wight) Walp *'Theichhawl'*	8	0.36	4	0.31	17495.83	1.24	1.91	**39**
75	*Terminalia bellirica* (Gaertn.) Roxb *'Thingvandawt'*	12	0.54	12	0.94	45539.47	3.22	4.71	**23**
76	*Terminalia myriocarpa* Heurck et Muell.-Arg. *'Char'*	4	0.18	4	0.31	62864.92	4.45	4.95	**22**
77	*Trema orientalis* (L.) Blume. *'Belphuar'*	4	0.18	4	0.31	411.43	0.02	0.52	**75**
78	*Ulmus lancifolia* Roxb. *'Phan'*	4	0.18	4	0.31	7142.84	0.50	1.002	**51**
79	*Vitex peduncularis* Wall.*ex* Sch. *'Thingkhawilu'*	16	0.72	8	0.62	4308.64	0.30	1.66	**44**
80	*Walsura robusta* Roxb.	4	0.18	4	0.31	533.65	0.03	0.53	**73**
81	*Wendlandia grandis* (Hook.*f.*) Cowan *'Batling'*	12	0.54	8	0.62	1523.81	0.10	1.28	**48**
82	*Wightia speciossima* (D.Don) Merr. *'Chawngtlai'*	24	1.08	12	0.94	11196.71	0.79	2.82	**34**
83	*Xantolis hookeri* **(**C.B.Clarke) P.Royen *'Dozo'*	24	1.08	20	1.57	1565.65	0.11	2.77	**35**

Table - 5.3. Importance Value Index of Shrubs

Sl. No	Name of Species	R. F	R. D	R.dom	IVI	Rank
1	*Ardisia macrocarpa Wall.'Vahritthei'*	1.9	2.07	1.67	5.63	19
2	*Ardisia undulata Cl.*	5.06	6.61	4.09	15.77	9
3	*Artemisia nilagirica(C.B.Clarke) Pamp. 'Sai'*	3.8	3.72	2.35	9.87	11
4	*Blumea lanceolaria (Roxb.) Druce 'Buarze'*	4.43	3.72	0.31	8.46	12
5	*Clerodendrum viscosum Vent.'Phuihnamchhia'*	2.53	2.89	0.49	5.91	18
6	*Colquhounia coccinea Wall., Trans.Linn. Kawihthuangte*	3.8	4.13	0.47	8.4	13
7	*Echinacanthus andersonii*	7.59	8.26	7.34	23.2	3
8	*Girardinia diversifolia (Link.) Fries 'Kangthai'*	1.27	1.24	0.11	2.62	27
9	*Inula cappa Buch.-Ham. ex D. Don. Hmeithaisatul*	1.27	0.83	0.22	2.32	29
10	*Leea compactiflora Kurz 'Kumtintuai'*	1.27	1.24	0.4	2.91	25
11	*Lepionurus sylvestris Blume 'Anpangthuam'*	5.06	1.24	0.9	7.2	16
12	*Leucomeris decora Kurz*	0.63	0.41	0.03	1.07	31
13	*Leucosceptrum canum Sm., Exot.'Kawihthuang'*	4.43	3.31	2.64	10.38	10
14	*Lycianthes laevis (Dunal) Bitter 'Vanian'*	1.9	1.24	0.06	3.2	24
15	*Mahonia pycnophylla (Fedde) Takeda 'Pualeng'*	1.27	1.24	15.96	18.46	7
16	*Melastoma nepalensis Lodd.'Builukham'*	1.27	0.83	0.71	2.81	26
17	*Osbeckia chinensis L.'Builukham'*	2.53	2.48	1.39	6.4	17
18	*Osbeckia crinita Benth. ex C.B.Clarke Builukhampa*	1.9	2.07	0.78	4.74	20
19	*Oxyspora paniculata (D. Don) DC. 'Khampui'*	1.27	1.65	0.49	3.41	23
21	*Pogostemon plectranthoides Desf.*	1.9	2.48	0.11	4.49	21
22	*Polygonum chinense L.*	5.7	2.07	0.25	8.02	14
23	*Psychotria symplocifolia Kurz.'Thingvawihuih'*	1.27	1.65	14.99	17.91	8
24	*Rhynchotechum ellipticum (Wall. ex. D. Dietr) A. DC.'Tiarrep'*	3.16	2.48	16.49	22.13	4
25	*Securinega virosa (Roxb. ex Willd.) Baill. Saisiak*	0.63	0.83	0.34	1.8	30
26	*Strobilanthes anisophyllus T.Anders. 'Ramting'*	7.59	9.92	5.85	23.37	2
20	*Strobilanthes auriculatus Nees. 'Ramting'*	6.96	8.68	3.79	19.43	5
27	*Strobilanthes helictus T. Anders.*	6.33	8.68	4.13	19.14	6
28	*Strobilanthes parryorum T. Anders. 'Ramting-hmul-chi'*	9.49	11.57	5.67	26.73	1
29	*Toddalia asiatica(L.) Lam. 'Nghardai'*	0.63	0.41	2.81	3.86	22
30	*Vaccinum serratum (G. Don) Wight*	0.63	0.41	1.31	2.36	28
31	*Vernonia volkameriaefolia Wall. ex DC. 'Khupal'*	2.53	1.65	3.82	8.01	15

Table - 5.4. Importance Value Index of Herbs

Sl. No.	Name of Species	R. F	R. D	R.dom	IVI	Rank
1	*Abelmoschus moschatus*(L.) Moench. 'Ui chhu me'	0.48	0.57	0.33	1.38	35
2	*Adiantum lunulatum* Burm. f.	1.93	1.71	1.34	4.99	18
3	*Amomum dealbatum* Roxb. 'Aidu'	0.97	0.86	6.03	7.85	13
5	*Asparagus racemosus* Willd. 'Arkebawk'	0.97	0.57	0.11	1.65	32
6	*Asplenium laciniatum* D. Don, Prod.	1.93	1.43	0.82	4.18	22
7	*Bergenia ciliata* (Haw.) Sternb.f. 'Khamdamdawi'	0.97	0.57	1.92	3.45	26
8	*Blechnum orientale* L. Vawmban	0.48	0.29	0.29	1.06	36
9	*Cautleya lutea* (Royle) Hook.f	0.48	0.29	0.26	1.03	38
10	*Corydalis leptocarpa* Hook.f. & Thomson	0.97	0.57	0.39	1.92	31
11	*Costus speciosus* (Koenig) J.E. Sm. 'Sumbul'	1.93	1.71	8.86	12.51	6
12	*Curculigo crassifolia* Hook.f. 'Phaiphek'	1.93	2.00	5.07	9.00	11
13	*Cyathea spinulosa* Wall. ex Hook	0.48	0.29	0.29	1.06	37
14	*Desmodium heterocarpon* (L.) DC.	1.45	1.43	1.28	4.16	23
15	*Desmodium podocarpum* DC.	1.93	1.71	1.75	5.40	15
16	*Didymocarpus cinerea* Wallich. Don 'Sekhupthursuak'	0.48	0.57	0.45	1.50	33
17	*Diplazium dilatatum* Blume	7.73	9.14	9.33	26.21	3
18	*Diplazium maxima* (D. Don) C. Chatt.	2.42	3.43	4.94	10.78	9
19	*Disporum cantoniense* (Lour.) Merr.	2.42	2.57	1.48	6.46	14
20	*Dryopteris cochleata* (Don) C. Chr.	9.18	10.86	11.08	31.12	1
21	*Eulophia spectabilis* (Dennst.) Suresh	0.97	0.57	0.45	1.98	30
22	*Gleichenia linearis* (Burm.f.) C. B. Clarke ' Arthladawn'	6.76	4.86	4.48	16.10	5
23	*Hedychium coccineum* J.E. Sm. 'Aichhia'	1.45	0.86	1.65	3.96	24
24	*Hedychium ellipticum* Buch.-Ham. ex Sm. 'Aibuk'	1.45	1.14	5.27	7.86	12
25	*Impatiens trilobata* Nutt. Sumac	0.97	0.86	0.22	2.04	29
26	*Kalanchoe roseus* Clarke.	0.48	0.29	0.66	1.43	34
27	*Leptochilus ellipticus* (Thunb.) Noot.	8.21	9.43	9.63	27.27	2
28	*Liparis cordifolia* Hook. f.	0.48	0.29	0.22	0.99	39
29	*Lobelia angulata* Forst. 'Choakathi'	0.48	0.86	0.88	2.22	27
30	*Microlepia rhomboidea* (Wall. ex Kunze) Prantl, Arb.	4.35	4.86	2.79	11.99	7
31	*Microlepia strigosa* (Thunb.) Presl, Epim.	3.86	4.57	2.63	11.06	8
32	*Ophiopogon dracaenoides* (Baker) Hook.f.	1.93	2.00	0.80	4.73	21
33	*Ophiopogon intermedius* D.Don, Prodr.	2.42	1.43	1.12	4.96	19
34	*Phaius flavus* (Blume) Lindl.	0.97	0.57	0.58	2.12	28
35	*Polygonum barbatum* L. 'Dawngria'	0.48	0.29	0.14	0.91	40
36	*Polystichum luctuosum* (Kunze) T. Moore	3.86	3.43	1.78	9.07	10
37	*Pteridium aquilinum* (L.) Kuhn. 'Katchat'	6.76	8.00	3.19	17.95	4

38	*Pteris tricolor* Linden	0.48	0.29	0.08	0.85	41
39	*Scleria levis Retzius*. 'Thip'	1.93	2.29	0.74	4.96	20
4	*Scleria levis Retzius*. 'Thip'	1.45	1.14	0.89	3.49	25
40	*Thalictrum punduanum* Wallich. 'Hrat'	2.42	2.29	0.58	5.28	16
41	*Tricholepidium normale* (D.Don) Ching.	8.70	9.14	5.25	23.09	17

Table - 5.5. Biodiversity indices of trees, shrubs and herbs

Sl. No.	DIVERSITY INDEX	Trees	Shrubs	Herbs
1	Species richness α diversity (Whittaker 1975) D=S / log N	30.27	13.00	16.11
2	Species Diversity (H') Shannon and Wiener (1963) H'=∑ Pi ln Pi.	3.86	3.14	3.26
3	Evenness (E) Pielou 1975) E=H' / ln S	0.87	0.91	0.88
4	Index of Dominance (D) Simpson (1949) $D=\sum(ni / N)^2$	0.04	0.052	0.052

Table - 5.6. Representation of different families, its genera, and species in Tawi Wildlife Sanctuary

Name of family	No. of genera	No. of species	Name of family	No. of genera	No. of species
Acantheceae	3	6	Melastomaceae	3	4
Adiantaceae	1	1	Meliaceae	5	5
Amaryllidaceae	1	1	Mimosaceae	1	1
Anacardiaceae	3	3	Moraceae	2	3
Araceae	1	1	Myricaceae	1	1
Araliaceae	3	3	Myrsinaceae	3	4
Arecaceae	5	10	Myrtaceae	1	3
Aristolochiaceae	1	1	Oleaceae	3	4
Aspleniaceae	1	1	Opiliaceae	1	1
Asteraceae	6	7	Orchidaceae	14	24
Balanophoraceae	1	1	Orobanchaceae	1	1
Balsaminaceae	1	1	Passifloraceae	1	1
Berberidaceae	1	1	Piperaceae	2	3
Blechnaceae	1	1	Poaceae	12	17
Bombadaceae	1	1	Polygalaceae	1	1
Caesalpiniaceae	2	2	Polygonaceae	1	2
Campanulaceae	1	1	Polypodiaceae	5	6
Clusiaceae	2	3	Proteaceae	1	1
Combretaceae	2	3	Pteridaceae	1	1
Cornaceae	1	1	Ranunculaceae	2	3
Crassulaceae	1	1	Rhizophoraceae	1	1
Cyatheaceae	1	1	Rosaceae	2	4
Cyperaceae	1	1	Rubiaceae	5	5
Dennstaedtiaceae	1	2	Rutaceae	1	1
Dryopteridaceae	2	2	Sapindaceae	1	1
Ebenaceae	1	2	Sapotaceae	1	1
Elaeorpaceae	1	1	Saxifragaceae	1	1
Ericaceae	1	1	Scrophulariaceae	1	1
Euphorbiaceae	8	9	Solanaceae	1	1
Fabaceae	5	9	Sterculiaceae	1	1
Fumariaceae	1	1	Styraceae	1	1
Gesneriaceae	3	3	Symplocaceae	1	1
Gleicheniaceae	1	1	Taxaceae	1	1
Juglandaceae	1	1	Theaceae	1	1
Lamiaceae	4	4	Ulmaceae	4	4
Lauraceae	5	11	Urticaceae	1	1
Lecythidaceae	1	1	Vaccinaceae	1	1
Liliaceae	4	5	Verbenaceae	1	1
Loranthaceae	1	1	Vitaceae	4	5
Lygodiaceae	1	1	Vittariaceae	1	1
Magnoliaceae	2	3	Zingiberaceae	4	5
Malvaceae	1	1			

Table - 5.7. Frequency, density and abundance of Climbers

Sl. No	Species	Frequency (%)	Density/ ha^{-1}	Abundance
1	*Aristolochia griffithii* Hook. *f*. & Thomson *ex* Duch.	1.6	1.6	100
2	*Bauhinia scandens* L. 'Zawngaleihlawn'	1.6	2.4	150
3	*Bridelia scandens* (Roxb.) Willd. 'Hruiphaktel'	2.4	3.2	133.33
4	*Cayratia japonica* (Thunb.)	4.8	4.8	100
5	*Clematis acuminata* DC. 'Hruipawnro'	3.2	3.2	100
6	*Clematis gouriana*Roxb. *ex* DC 'Rairahmittuitla'	4	5.6	140
7	*Combretum flagrocarpum* C.B. Clarke 'Leihruisen'	2.4	4	166.66
8	*Embelia ribes* Burm.*f.* 'Naufadawntuai'	0.8	1.6	200
9	*Entada rheedei* Spreng. Subsp. *Rheedei* 'Kawi'	1.6	1.6	100
10	*Jasminum arborescens* Roxb.	0.8	0.8	100
11	*Kadsura heteroclita* (Roxb.)Craib. 'Theiarbawm'	1.6	1.6	100
12	*Lygodium flexuosum* (L.) Sw. ' Dawnzempui'	1.6	4	250
13	*Millettia pachycarpa* Benth. 'Rulei'	1.6	1.6	100
14	*Mussaenda glabra* Vahl 'Vakep'	2.4	3.2	133.33
15	*Passiflora nepalensis* Wallich. 'Nauawimuhrui'	3.2	4.8	150
16	*Piper diffusum* Vahl. 'Pawhrual'	2.4	2.4	100
17	*Piper nigrum* L. 'Panruangsuak'	3.2	4	125
18	*Polygala arillata* Bauch.-Ham. *ex* D.Don	1.6	1.6	100
19	*Pothos scandens* L. 'Laikingtairua'	4.8	7.2	150
20	*Senecio scandens* Buch.-Ham. Sai- ek-hlo	2.4	3.2	133.33
21	*Senecio triligulatus* Bauch.-Ham. *ex* D.Don	1.6	2.4	150
22	*Smilax lanceaefolia* Roxb. 'Kaiha'	4	5.6	140
23	*Tetrastigma obovatum* (M. Lawson) 'Puarpeng'	6.4	12	187.5
24	*Tetrastigma rumicispermum* (M. Lawson) 'Hrui-ri-thet'	7.2	13.6	188.88
25	*Thunbergia coccinea* Wall. *ex* D.Don 'Fahrahhrui'	1.6	1.6	100
26	*Vitis tuberculata* (Blume) M. Lawson	3.2	4.8	150

Table - 5.8. Frequency, density and abundance of Epiphytes

Sl. No	Species	Frequency (%)	Density/ ha^{-1}	Abundance
1	*Aeschynanthus sikkimensis* (C.B. Clarke) Stapf 'Bawltehlantai'	4	5.6	140
2	*Bulbophyllum elatum* (Hook.f.) J.J.Sm.	4.8	8.8	183.33
3	*Celogyne nitida* (Wall. *ex* D. Don) Lindl.	5.6	10.4	185.71
4	*Celogyne suaveolens* (Lindl.) Hook *.f.*	1.6	2.4	150
5	*Dendrobium chrysotoxum* Lindl. 'Banpui'	2.4	3.2	133.33
6	*Dendrobium crepidatum* Lindl. & Paxton	3.2	4.8	150
7	*Dendrobium formosum* Roxb. *ex* Lindl. 'Banpui par var'	1.6	2.4	150
8	*Dendrobium infundibulum* Lindl.	0.8	1.6	200
9	*Dendrobium ochreatum* Lindl. 'Banpui par eng chhungdum'	1.6	2.4	150
10	*Dendrobium peguanum* Lindl.	2.4	4	167
11	*Dendrobium primulinum* Lindl., Gard	2.4	4.8	200
12	*Drynaria coronans* (Wall. *ex* Mett.) T. Moore 'Awmvel'	1.6	2.4	150
13	*Eria lacei* Summerh	1.6	2.4	150
14	*Eria vittata* Lindl., J. Proc. Linn. Soc.	0.8	1.6	200
15	*Esmeralda clarkei Rchb.f*., Gard.	1.6	3.2	200
16	*Gastrochilus calceolaris* (Buch.-Ham.*ex*J.E.Sm.)D. Don	0.8	0.8	100
17	*Oberonia iridifolia* (Roxb.) Lindl	1.6	4	250
18	*Oberonia pachyrachis* Rchb. *f. ex* Hook. *f.*	2.4	3.2	133.33
19	*Otochilus porrectus* Lindl., Gen.Sp.	0.8	1.6	200
20	*Panisea uniflora* Lindl.	2.4	2.4	100
21	*Papilionanthe teres* (Roxb.) Schltr.	4.8	5.6	117
22	*Peperomia tetraphylla* (G.Forst.) Hook. & Arn.	0.8	1.6	200
23	*Pholidota articulata* Lindl.	1.6	2.4	150
24	*Pholidota imbricata* Lindl.	1.6	2.4	150
25	*Schefflera venulosa* (Wight & Arn.) Harms'Kelbuh'	0.8	0.8	100
26	*Vittaria flexuosa* Fee	5.6	9.6	171.42

Table - 5.9. Frequency, density and abundance of Parasites/ Saprophytes

Sl. No	Species	Frequency (%)	Density/ ha^{-1}	Abundance
1	*Aeginetia indica* L. 'Sanghar vaibel'	1.6	3.2	3.2
2	*Balanophora dioca* R. Brown *ex* Royle	0.8	0.8	0.8
3	*Scurrula pulverulenta* (Wall.) G. Don 'Thlikthli-ek-bawm'	0.8	1.6	1.6

Table - 5.10. Frequency, density and abundance of Grasses

Sl. No	Species	Frequency (%)	Density/ ha^{-1}	Abundance
1	*Arundinaria callosa* Munro'Phar'	6.4	12	187.5
2	*Bambusa khasiana* Munro 'Rawte'	1.6	2.4	150
3	*Bambusa tulda* Roxb. 'Rawthing'	1.6	2.4	150
4	*Cymbopogon winterianus* Jowitt 'Di lengser'	1.6	3.2	200
5	*Dendrocalamus hamiltonii* Nees & Arn. *ex* Munro 'Phulrua'	4	4.8	120
6	*Dendrocalamus hookeri* 'Munro 'Rawlak'	1.6	1.6	100
7	*Dendrocalamus manipurianus Naithani & Bisht* 'Rawchhechangdam'	0.8	0.8	100
8	*Dendrocalamus strictus* (Roxb.) Nees. 'Tursing'	4	5.6	140
9	*Dinochloa compactiflora* Kurz. Mc Clure 'Sairil'	0.8	1.6	200
10	*Imperata cylindrica* (L.) Raeusch. 'Di'	5.6	8	143
11	*Melocanna baccifera* (Roxb.) Kurz 'Mautak'	1.6	1.6	100
12	*Pseudostachynum polymorphum* Munro 'Chal'	2.4	3.2	133.33
13	*Saccharum longisetosum* (Hackel) Bor 'Luang'	0.8	0.8	100
14	*Schizostachyum capitatum* (Munro) R. Majumdar 'Rawngal'	3.2	5.6	175
15	*Schizostachyum dulloa* (Gamble)Majumdar 'Rawthla'	0.8	0.8	100
16	*Sinarundinaria falcata* (Nees.) Chao & Renvoize 'Lik'	2.4	4	167
17	*Thysanolaena maxima* (Roxb.) Kuntze 'Hmunphiah'	1.6	1.6	100

Table - 5.11. Frequency, density and abundance of Canes and Palms

Sl. No	Species	Frequency (%)	Density/ ha^{-1}	Abundance
1	*Arenga pinnata* (O. Kuntze) Merr. 'Thangtung'	4	4.8	120
2	*Calamus acanthospathus* Griff. 'Thilte'	1.6	2.4	150
3	*Calamus erectus* Roxb. 'Thilthek'	2.4	3.2	133.33
4	*Calamus flagellum*Griff. *ex* Mart. 'Hruipui'	3.2	6.4	200
5	*Calamus gracilis* Roxb. 'Kawrtai'	1.6	4	250
6	*Calamus guruba* Buch.-Ham.*ex* Mart. 'Taite'	3.2	4.8	150
7	*Calamus innermis* Becc., Ann. 'Mitperh'	1.6	2.4	150
8	*Caryota mitis* L. 'Meihle'	2.4	2.4	100
9	*Daemonorops jenkinsianus* (Griff.) Mart. 'Raichhawk'	3.2	5.6	175
10	*Zalacca secunda* Griff. 'Hruitung'	3.2	6.4	200

5.2. Community structure

The profile diagram of Tawi Wildlife Sanctuary drawn along a 7.5 x 100 m transect is shown in **Fig 5.3.** It shows distribution of trees in three distinct layers viz., canopy, sub-canopy and under canopy layers. The canopy layer was composed of 11 trees of 8 species representing 7 families. The average height in this stratum was 19m and the tallest tree was *Nyssa javanica* which was 21m. The species present in this stratum were *Alseodaphne petiolaris, Bruinsmia polysperma, Engelhardia spicata, Calophyllum polyanthum, Diospyros lanceaefolia, Prunus nepalensis, Nyssa javanica, Phoebe hainesiana* . A total of 21 individuals belonging to 8 species were distributed among 7 families were recorded in this layer.

The subcanopy layer was composed of 18 trees belonging to 8 species and 8 families. The mean tree height was 6.5 m and the tallest tree was *Calophyllum polyanthum* which was 7.8 m. The species encountered in this layer were *Calophyllum polyanthum, Garcinia sp., Litsea lancifolia, Olea salicifolia, Ostodes paniculata, Phoebe hainesiana, Syzgium cuminii, Macropanax undulatus.* The undercanopy was composed of shade tolerant small trees and clumps of bamboo. Thirteen trees belonging to 9 species and 7 families and 3clumps of *Arudinaria callosa* were found in this layer. The average tree height in this layer was 5.3 m. *Bridelia monoica, Careya laciniosa, Helicia erratica, Quercus glauca, Quercus lineata, Xantolis hookeri* and *clumps of Chimnobambusa callosa.* Beneath the undercanopy, there were shrubs, herbs and tree seedlings. *Strobilanthes glomeratus, Strobilanthes maculata, Strobilanthes capitatus, Perilepta edgeworthiana* and Pteridophytes like *Diplazium dilatum, Leptochilus ellipticus, Polystichum semifertile* were found in abundance.

All the 237 plant species encountered in the study area were grouped into different life forms on the basis of criteria outlined by Raunkiaer (1934). Megaphanerophyte were absent. The mesophanerophytes with 28.27% was the dominant life form followed by microphanerophyte 20.25%, nanophanerophyte 11.39%, chamaephyte 10.97 %, geophytes 3.38%, therophytes 3.80%, epiphytes 10.97% and climbers 10.97% respectively **(Table – 5.12).**

Table - 5.12. Life form spectrum of Tawi Wildlife Sanctuary

Category	No. of species	% of species
Mesophanerophytes	67	28.27
Microphanerophytes	48	20.25
Nanophanerophytes	27	11.39
Chamaephytes	26	10.97
Geophytes	8	3.38
Therophytes	9	3.80
Epiphytes	26	10.97
Climbers	26	10.97

Dominance of phanerophytes (59.92%) in Tawi Wildlife Sanctuary brings them closer to the tropical forests at Mexico (Vazquezg *et al*., 1998) and Costa Rica (Lieberman *et al*., 1996). High concentrations climbers are another important characteristic feature of the tropical moist and humid forests (Daniels *et al*., 1995; Vazquezg *et al*., 1998) was also observed in the study area. High percentage of epiphytes (10.97%) in the study area is attributed to the year round precipitation and high atmospheric humidity (Benzing 1983; Sugden and Robins 1979). Since the forest

under study was exposed to mild intensity of human disturbance, its effect was noticed by presence of a good number of chamaephytes and therophytes at the forest fringes. In the tropical belt, places with increase in aridity; deforestation and other anthropogenic activities have therophytic or thero–chaemaephytic conditions (Reddy *et al*., 2002).

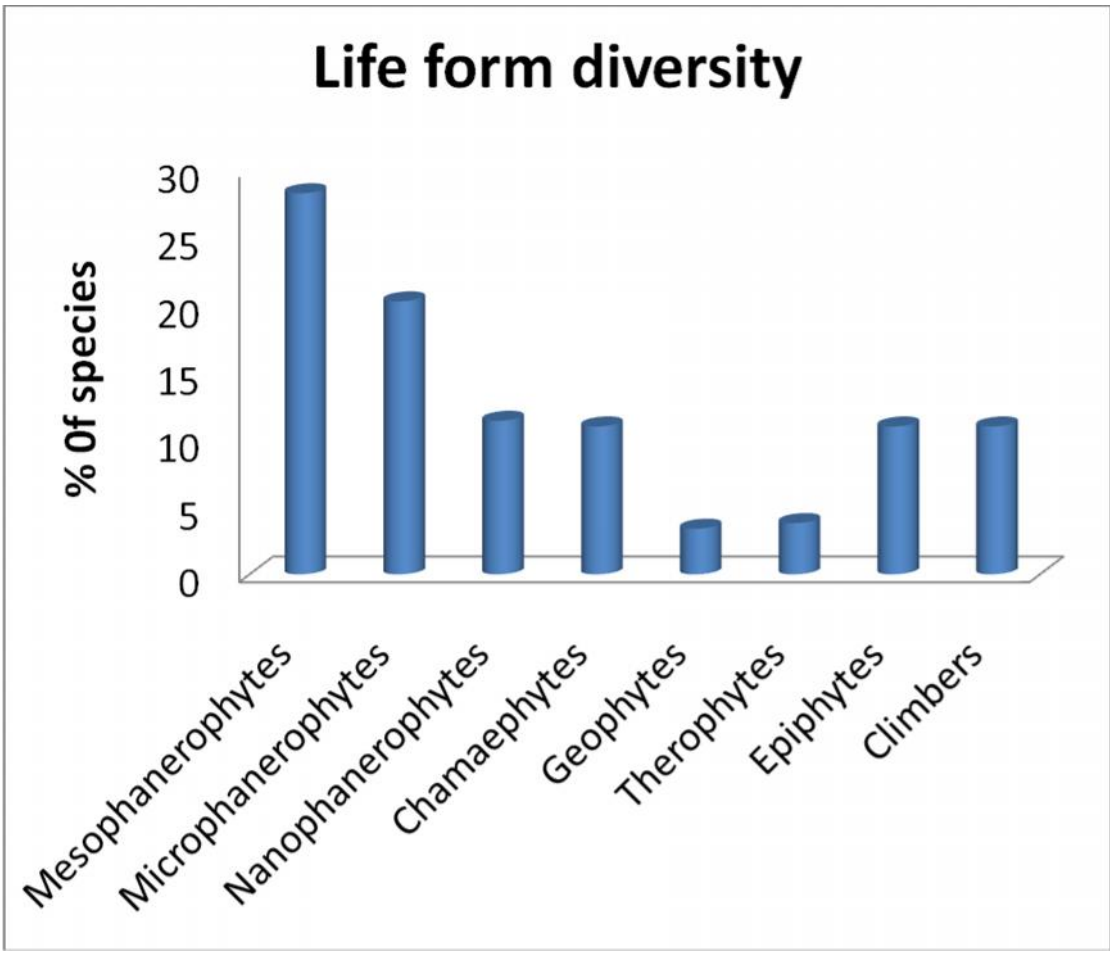

Fig. 5.2. Life form diversity of Tawi wildlife Sanctuary

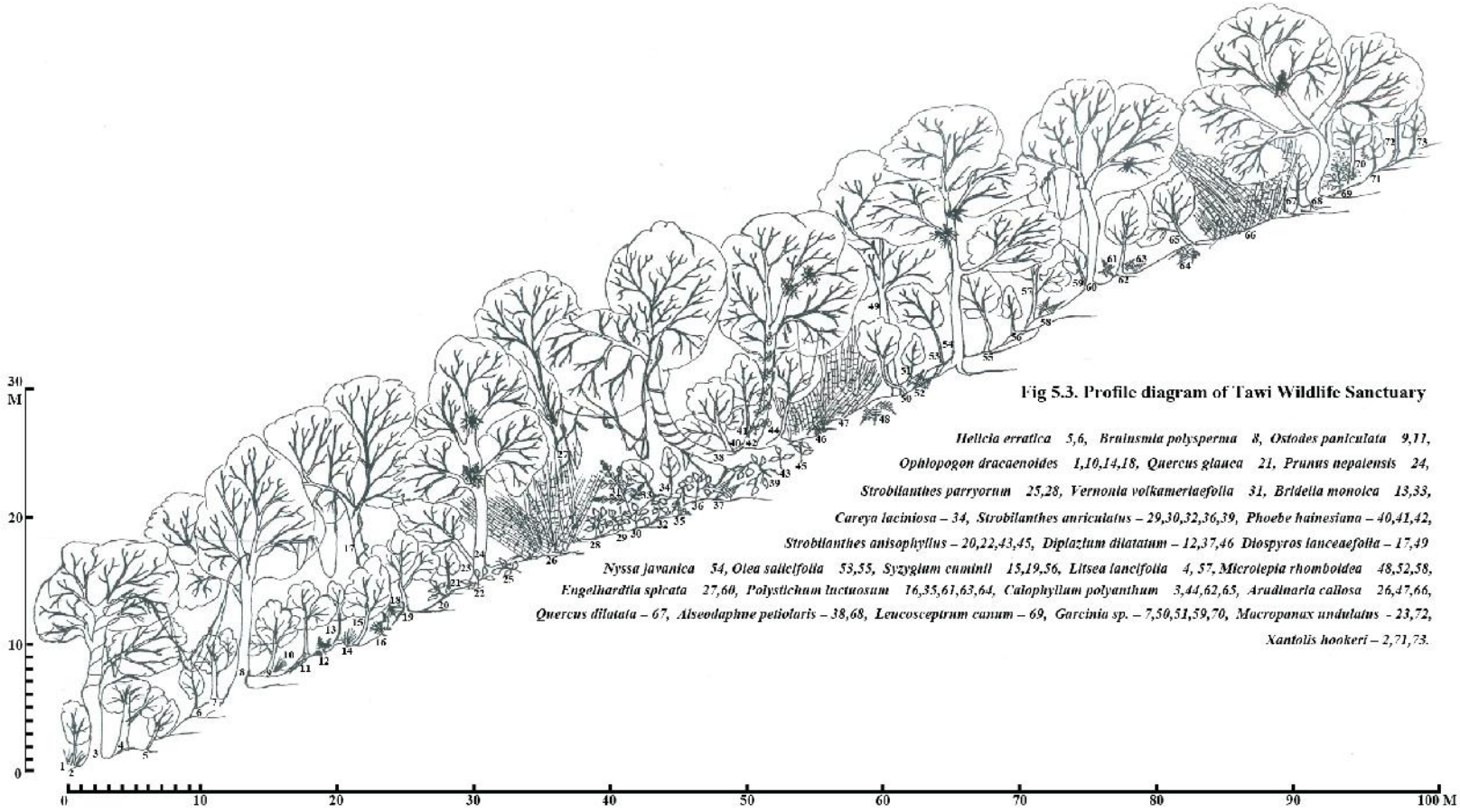

Fig 5.3. Profile diagram of Tawi Wildlife Sanctuary

Helicia erratica 5,6, Bruinsmia polysperma 8, Ostodes paniculata 9,11, Ophiopogon dracaenoides 1,10,14,18, Quercus glauca 21, Prunus nepalensis 24, Strobilanthes parryorum 25,28, Vernonia volkameriaefolia 31, Bridelia monoica 13,33, Careya laciniosa – 34, Strobilanthes auriculatus – 29,30,32,36,39, Phoebe hainesiana – 40,41,42, Strobilanthes anisophyllus – 20,22,43,45, Diplazium dilatatum – 12,37,46 Diospyros lanceaefolia – 17,49 Nyssa javanica 54, Olea salicifolia 53,55, Syzygium cuminii 15,19,56, Litsea lancifolia 4, 57, Microtepia rhomboidea 48,52,58, Engelhardtia spicata 27,60, Polystichum luctuosum 16,35,61,63,64, Calophyllum polyanthum 3,44,62,65, Arudinaria callosa 26,47,66, Quercus dilatata – 67, Alseodaphne petiolaris – 38,68, Leucosceptrum canum – 69, Garcinia sp. – 7,50,51,59,70, Macropanax undulatus - 23,72, Xantolis hookeri – 2,71,73.

Table - 5.13. TREES (TOP CANOPY), STATUS AND USES

Sl. No:	Plants/Floral Diversity	Family	Uses	Status
1	*Acrocarpus fraxinifolius* Wight & Arn. 'Nganbawm'	Caesalpiniaceae	Wood moderately hard used for planking, flo-oring, shingles. It is also used for furnitures, tea boxes, packing cases. The timber is odourless so it is suita-ble for fruit packing cases.Fruit eaten by birds.	Infrequent
2	*Alseodaphne petiolaris* Hk.f. 'Khuangthulh'	Lauraceae	Wood used for building, furniture and firewood	Common
3	*Amoora chittagonga* (Miq.)Hiern. 'Thehleikhak'	Meliaceae	Wood hard, used for house posts, firewood etc.Fruits eaten by squirrels, pigeons.	Rare
4	*Aphanamixis wallichi* R. Br. 'Sahatah'	Meliaceae	Used as firewood.	Infrequent
5	*Artocarpus chama* Bauch.-Ham. 'Tatkawng'	Moraceae	Wood for furniture and fuel. Fruits edible, pulp eaten by human beings and animals; leaves as fodder. Decoction of bark in diarrhea	Infrequent
6	*Bombax insigne* Wall. 'Pang'	Bombadaceae	Match boxes, splints, drums, cheap furniture etc.The bark is crus-hed with *Mangifera indica* and then boiled. The water is taken as an	Infrequent

			effective remedy against dysentery.	
7	*Bruinsmia polysperma* Cl. 'Theipalingkawh'	Styraceae	Wood as firewood; leaves as fodder; pulp of fruit edible.	Common
8	*Calophyllum polyanthum* Wall. *ex.* Choisy 'Sentezel'	Guttiferae	Wood red brown, moderately hard, elastic, used for bridges, railway sleepers, building construction, firewood, etc. Fruits eaten by wild animals like civets etc.	Common
9	*Cinnamomum bejolghota* Bauch.Ham 'Thakthingsuak'	Lauraceae	Decoction of bark in dyspepsia and liver problems.	Common
10	*Cinnamomum verum* Presl. 'Thakthing'	Lauraceae	Wood as low grade board wood. Bark for vomiting and as spices.	Frequent
11	*Diospyros lanceaefolia* Wallich *ex* Hiern. 'Zothinghang'	Ebenaceae	Wood grey or yellow, used for firewood, and the pole for temporary building, fence posts etc.	Common
12	*Drimycarpus racemosus* (Roxb.) Hook. *f.* 'Vawmbal'	Anacardiaceae	Wood used for constr-uction of houses, boats canoes etc. Drupes eayen by bears, palm civets, squirrels etc.	Frequent
13	*Engelhardtia spicata* Lechen *ex* Blume. 'Hnum'	Juglandaceae	Timber is used for tea-boxes and packing cases. Bark as fish poison; resin in medicine.	Common
14	*Ficus geniculata* Kurz. 'Rihnim'	Moraceae	Fruits are edible and leaves are shady.	Infrequent

15	*Mangifera sylvatica* Roxb. 'Haifavang'	Anacardiaceae	Fruits edible. Wood used for packing cases etc.	Frequent
16	*Michelia champaca* L. 'Vai-Ngiau'	Magnoliaceae	Timber widely used for house building, furniture and miscellaneous purposes. Roots as purgative; bark as astringent, expectorant, febrifuge and stimulant; leaves with honey given in colic; flowers oil for opthal-mia and gout; flowers and fruits as antispa-smodic, tonic, stomachic, carminative, in renal diseases, nausea, fever etc; seeds and fruits applied externally for healing cracks in feet.	Frequent
17	*Michelia doltsopa* DC. *Syn*. 'Zo-Ngiau'	Magnoliaceae	Timber durable and suitable for furniture and planking; leaves as fodder; fruits eaten by birds.	Common
18	*Nyssa javanica* (Blume) Wanger 'Bul-thur'	Cornaceae	Wood used for house construction; fruits ea-ten by wild animals and birds.	Frequent
19	*Persea glaucescens* Nees. 'Saperbul'	Lauraceae	The timber is durable, used for furniture, boat building etc. The fruits are eaten by bears, hornbills, imperial pige-	Common

			ons, etc.	
20	*Phoebe hainesiana* Brandis ‘Bul-eng’	Lauraceae	Wood yellow, used for furniture, planking, building, motorbodies, plywood etc.The fruits are eaten by bears, momkeys, hornbills, pigeons, etc.	Frequent
21	*Prunus nepalensis* Steud. ‘Lumler’	Rosaceae	Wood as fuelwood, fruits eaten by man, barking deer and birds.	Frequent
22	*Sapindus mukorossi* Gaertn. ‘Hlingsi’	Sapindaceae	Wood light yellow, used for fuelwood and charcoal making. Leaves as fodder. Fruits as expectorant, fish poison; also as substitute for soap.	Rare
23	*Syzygium cuminii* (L.) Skeels ‘Lenhmui’	Myrtaceae	Wood reddish grey, moderately hard, durable under water, used for plywood, gunstocks, toolhandles,posts, rafters, door frames and panels, firewood etc.Fruits eaten by man, monkeys ,hoolock gibbon, bears, palm civets, giant squirrels, jackals and birds Fruit pulp in stomachic and as diuretic.	Common
24	*Terminalia bellirica.* (Gaertn.) Roxb.	Combretaceae	Construction purposes, Fruits as astringent,	Frequent

	'Thingvandawt'		laxative, tonic in diarrh-oea, dyspepsia, leprosy and headache.	
25	*Terminalia myriocarpa* Heurck et Muell.-Arg. 'Char'	Combretaceae	Wood used for construction, furniture and plywood. Bark as cardiac stimulant and diuretic.	Infrequent
26	*Ulmus lancifolia* Roxb. 'Phan'	Ulmaceae	Wood hard and used for implements, house build-ing etc. Leaves as cattle fodder.	Infrequent
27	*Wightia speciosissima* (D.Don) Merr. 'Chawngtlai'	Scrophulariaceae	Wood white, soft, light, does not wrap, used for ceiling, partition wall etc. Nectar of the flowers is sucked by birdslike leafbirds, bulbuls, dron-gos,spiderhunters,sunbir-ds etc.	Common

Table - 5.14. TREES (MIDDLE CANOPY) STATUS AND USES

Sl. No:	Plants/Floral Diversity	Family	Uses	Status
1	*Antidesma bunius* (L.) Spreng. 'Tuaitit'	Euphorbiaceae	Wood red, hard, used for firewood. Fruits eaten by man and birds. Leaves antidote to snake poison and in syphilis.	Infrequent
2	*Aphananthe cuspidata* (Bl.) Planch. 'Theisehret'	Ulmaceae	Wood hard, red brown, used for planking, rafters, firewood and charcoal. Leaves as fodder; fruits eaten by man, wild animals and birds.	Infrequent
3	*Aporosa dioica* (Roxb) Muell. Arg 'Chhawntual'	Euphorbiaceae	Wood for house posts and fuel; bark medici-nal. Capsule eaten by birds.	Infrequent
4	*Baccaurea ramiflora* Lour. 'Pangkai'	Euphorbiaceae	Wood is hard and used for house-posts. Fruits edible; bark dust as purgative.	Infrequent
5	*Bridelia monoica* Lour. Merr. *Syn* 'Phaktel'	Euphorbiaceae	Wood suitable for carts and wheels, tool-hands and bark used for tanning.	Infrequent
6	*Camellia kissi* Wallich. 'Lallai'	Theaceae	Leaves used as substitute for tea. Oil cake used to stupefy fish.	Infrequent
7	*Carallia brachiata*	Rhizophoraceae	Wood good for	Infrequent

	(Lour.) Merr. 'Theiria'		furniture, fruits edible and used for ulcers. Bark for itch.	
8	*Carya laciniosa* (Michx. f.) G. Don 'Hnumreuh'	Lecythidaceae	Wood hard, elastic, used for house building, firewood etc. Kernel of the seed is eaten by man and wild animals like bear, wild pig, barking deer, squirrels, etc.	Infrequent
9	*Castanopsis indica* (Roxb. *ex* Lindl.)A. DC. 'Sehawr'	Fagaceae	Wood light greyish brown, hard, used for building, furniture, axe handles, firewood etc. The leaves are used for cigarettes, and the nuts are eaten by man, wild pig, bear, squirrels etc.	Frequent
10	*Castanopsis tribuloides* (Sm) DC. 'Thingsia'	Fagaceae	Firewood and the whitish kernel of nuts edible.	Common
11	*Celtis timorensis* Spanoghe, Linnaea. 'Thinghmarcha'	Ulmaceae	Wood hard, unpleasant scent, used for medicine, tool handles, firewood etc. Fruits eaten by birds.	Frequent
12	*Cephalotaxus griffithii* Hook.*f*. 'Thinglenbuang'	Taxaceae	Wood light brown used for building, furniture, fuelwood etc.	Rare
13	*Choerospondias axillaris* (Roxb.) Burtt. & Hill. 'Theikuangchawm'	Anacardiaceae	Wood greyish white, used for house building, tea boxes etc.Ripe	Frequent

			fruit eaten by man, wild animals like monkeys, squirrels, barking deer, serow, wild pig, etc. and birds like wreathed hornbill etc.	
14	*Chukrasia tabularis* A.Juss. 'Zawngtei'	Meliaceae	Wood hard, used for construction purposes, high class furniture, paneling, plywood etc. Bark as astringent, juice of fruits in dys-entery, diarrhoea, infl-atulant and indigestion.	Frequent
15	*Cinnamomum tamala* Fr. Nees. 'Tespata'	Lauraceae	Wood as firewood. Leaves as condiment, colic and diarrohea.	Common
16	*Diospyros toposia* Ham. ' Ruthei'	Ebenaceae	Fruits for poisoning fish; seeds edible. Fresh gums from stems for toothache.	Common
17	*Dysoxylum gobara* Bauch.-Ham.Merr. 'Thingthupui'	Meliaceae	Wood used as fire wo-od, young leaves, sho-ots and flowers as vegetables. Decoction of leaves and buds in diarrohea and dysente-ry.	Common
18	*Elaeocarpus tectorius* (Lour.)Poir	Elaeocarpaceae	Wood for construction purposes, posts and	Infrequent

	‘ Umkhal/Kumkhal’		firewood.	
19	*Eriobotrya bengalensis* (Roxb.) Hook. f. ‘Nghalchhun’	Rosaceae	It is said to be suitable for shuttles. Wood is used as firewood.	Infrequent
20	*Fagerlindia fasciculata* (Roxb.) Tirveng. ‘Chhawntan’	Rubiaceae	Leaves applied externally on sores.	Common
21	*Ficus cunia* Ham. ‘Theitit’	Moraceae	Fruits edible; leaves fodder, receptacles eaten by man and squirrels.	Infrequent
22	*Firmiana colorata* Roxb.R.Br. ‘Khaukhim’	Stercullariaceae	Bark fibre is used for cordage; bark boiled with Citrus limon and the water is taken for tonsillitis; plants for cholera; leaves as fodder; seeds eaten by man, hornbills and squirrels; nectar of flower sucked by birds like sunbirds, drongos, bulbuls, leaf birds etc.	Infrequent
23	*Garcinia sp.* ‘Hawi’	Clusiaceae		Frequent
24	*Garcinia xanthochymus* Hook*.f. ex* T.Anderson ‘Tuaihabet’	Clusiaceae	Fruits used as cooling, cholagogue, emollient, antiscorbutic and demulcent.	Infrequent
25	*Glochidion khasicum* (Muell.-Arg.)Hk*.f.* ‘Thingpawnchhia’	Euphorbiaceae	Wood as firewood and seeds eaten by birds.	Common
26	*Helicia erratica*	Proteaceae	Wood used for fire-	Common

	Hook. *f.* 'Sialhma'		wood. Decoction of the bark is used in colic; fruits eaten by barking deer.	
27	*Heteropanax fragrans* (Roxb.) Seem. 'Changkhen'	Araliaceae	Young leaves eaten as vegetable and as cattle fodder. Fruits eaten by birds and flowers also sucked by drongos, leaf birds, sunbirds etc.	Infrequent
28	*Ligustrum robustum* (Roxb.) Bl. 'Chawmzil'	Oleaceae	Fuelwood and fruits are eaten by birds.	Rare
29	*Lithocarpus elegans* (Blume) Hatus. *ex* Soepadmo 'Thingpuithing'	Fagaceae	Wood red, very hard, used for building, rice pestle, firewood, cha-rcoal; and the sapling aspendant for scrorc-hing off the bristles of pigs killed. The fruits are eaten by wild pig, porcupine, squirrels etc.	Infrequent
30	*Lithocarpus pachyphylla* (Kurz) Rehder 'Thensen/Thil'	Fagaceae	Wood grey, durable, used for planking shingles, firewood etc. Bark and acorns are used as astringent. Acorns devoured by wild animals like wild boar, etc.	Frequent
31	*Litsea lancifolia* Hook. *f.* 'Hnahpawte'	Lauraceae	Wood for firewood and charcoal.	Common
32	*Litsea monopetala*	Lauraceae	Wood olive grey, soft,	Frequent

	Roxb. Pers. 'Nauthak'		not durable, used for firewood. Muga silk worms are reared on the leaves. Bark as astringent, in diarrhoea and loss of memory; fruits eaten by bears and birds.	
33	*Litsea salicifolia* Nees. 'Parsen'	Lauraceae	Wood for firewood. Also used as phytope-sticide, traditionally by various tribes of Assam (Phukan & Ka-lita 2005) .Bark pounded and mixed with water is applied on bone fracture and tightly tied with a piece of cloth to set right the bone; bark paste is also adminis-tered twice daily against boils and abscesses; ripe fruits are eaten (Srivastava 2010)	Infrequent
34	*Lyonia ovalifolia* (Wallich) Drude 'Tlangham'	Ericaceae	Wood light reddish brown, soft, used for gun powder, firewood and charcoal. Young twigs poisonous to goats, insects, and infusion in skin diseases.	Infrequent

35	*Macaranga indica* Wight. 'Hnahkhar'	Euphorbiaceae	Wood soft, occasionally used as firewood. The gum is applied to sores; fruits eaten by wild animals and birds.	Frequent
36	*Macropanax undulatus* Wall. *ex*. G.Don. 'Phuanberh'	Araliaceae	Wood as firewood.	Common
37	*Maesa indica* (Roxb.)Wallich. 'Arngeng'	Myrsinaceae	Fuelwood. Roots in syphilis; leaves as fish poison; berries as anthelmintic.	Frequent
38	*Myrica esculenta* Bauch.-Ham 'Keifang'	Myricaceae	Wood used for firewood; fruits eaten by man and birds; leaves as fodder; bark as astringent, carminative and antiseptic; also used in asthma, cough, cold and headache.	Frequent
39	*Nostolachma khasiana* (Korth.) Deb *et* Lahiri 'Thingsaingal'	Rubiaceae	Used for living fence posts; drupes are eaten by birds.	Frequent
40	*Olea dioica* Roxb. 'Sevuak'	Oleaceae	Wood used for tool handles, firewood and charcoal. Bark used as febrifuge; fruits eaten by birds and wild animals.	Infrequent
41	*Olea salicifolia* Wall. *ex* G.Don	Oleaceae	Wood as firewood; fruits eaten by birds.	Common

	'Thingthiang'			
42	*Ostodes paniculata* Blume. 'Beltur'	Euphorbiaceae	Wood used for planking and gum used in paper manufacturing; leaves as fodder and to poison fish Seeds used as purgative.	Common
43	*Phoebe attenuata* Nees. 'Bul-bawr'	Lauraceae	Valuable timber excellent for cabinet making and also used for construction of house. A medium quality fuelwood. Fruits eaten by bears, pigeons, bulbuls, barbets etc.	Frequent
44	*Phoebe lanceolata* Nees. 'Bul-fek'	Lauraceae	Fuelwood, house post, leaves for cattle fodder	Frequent
45	*Prunus jenkinsii* Hook.f. & Thomson 'Keipui'	Rosaceae	Wood used for firewood, rice pestles etc.Leaves for cattle fodder; fruits eaten by man, barking deer, serrow, squirrels etc.	Frequent
46	*Prunus undulata* Bauch.-Ham. *ex* 'Theiarlung'	Rosaceae	Leaves for cattle fodder; fruits eaten by man, monkeys, bears, barking deer, squirrels and birds.	Common
47	*Quercus dilatata* Lind. 'Thal'	Fagaceae	Wood as firewood and construction purposes.	Infrequent
48	*Quercus glauca* Thunb. in A.Murray	Fagaceae	Wood grey or greyish brown, very hard used	Frequent

	'Hrumhriau'		for tool handles, fire-wood and charcoal; fruits eaten by wild boar, bear and barking deer.	
49	*Symplocos cochinchinensis* Roxb. 'Van-va-thing	Symplocaceae	The wood is of a clear red colour and close-grained, it is used for house posts and furni-ture and bark is used for dyeing. Bark is collected for medicine.	Infrequent
50	*Syzygium claviflorum* (Roxb.) Wallich *ex Cowan & Cowan* 'Hmuifarial'	Myrtaceae	Wood used for firewood; fruit eaten by man, bears and birds.	Infrequent
51	*Syzygium grande* (Wight) Walp . 'Theichhawl'	Myrtaceae	Wood red, hard, used for firewood and cha-rcoal; fruits eaten by man, bears monkeys, hoolock gibbon and birds.	Frequent
52	*Trema orientalis* (L.) Blume. 'Belphuar'	Ulmaceae	Wood light reddish grey, soft, used for fuelwood, charcoal, making gun powder; leaves as fodder and bark yield a strong fibre. Plant juice in epilepsy.	Infrequent
53	*Vitex peduncularis*	Verbenaceae	Wood is very good	Frequent

	Wall.*ex* Sch. 'Thingkhawilu'		charcoal and also used as posts, beams, oil-mill pestle, yokes and charcoal. Stem bark boiled in water and is used for patients suffering from malarial fever and black fever.Bark is also used as an external application to relieve pain in the chest.	
54	*Walsura robusta* Roxb.	Meliaceae	Wood light red, very hard, used for firewood and charcoal. The fruits are eaten by children and squirrels.	Rare
55	*Wendlandia grandis* (Hook.*f*.) Cowan 'Batling'	Rubiaceae	Wood reddish yellow, soft used for gun powder, charcoal, firewood etc. The pole is also used for fencing post. Flowers are also eaten.	Frequent
56	*Xantolis hookeri* (C.B.Clarke) P.Royen 'Dozo'	Sapotaceae	Wood pale-brown, moderately hard, used for posts, firewood etc. The fruits are eaten by man, cattle, barking deer etc. Leaves are also lopped for cattle fodder.	Frequent

Table - 5.15. SHRUBS STATUS AND USES.

Sl. No	**Plants/Floral Diversity**	**Family**	**Uses**	**Status**
1	*Ardisia macrocarpa* Wall. 'Vahritthei'	Myrsinaceae	Fruitseaten by children and birds also planted as ornamental purposes.	Frequent
2	*Ardisia undulata* Cl.	Myrsinaceae	NA	Frequent
3	*Artemisia nilagirica* (C.B.Clarke) Pamp. 'Sai'	Asteraceae	Plants as antispasmo-dic, anthelmintic and in stomach problem; root as tonic and antispasmodic; leaves and flowering twig in asthma, diseases of brain etc.; decoction of leaves in malaria and intestinal worms.	Frequent
4	*Blumea lanceolaria* (Roxb.) Druce 'Buarze'	Asteraceae	Juice of leaves applied to cure wounds and chronic ulcers and also on animal sores to kill worms; leaf infusion for dysentery, suspension of boiled leaves to cure bronchitis, asthma, cancer and liver ailments.	Infrequent
5	*Clerodendrum viscosum* Vent.	Verbenaceae	Roots or leaves boiled water are used	Frequent

	'Phuihnamchhia'		for bath in case of scabies and other skin diseases, and also for washing hair to eliminate scurf. The fruits are eaten by birds like bulbils, etc.	
6	*Colquhounia coccinea* Wall., Trans.Linn. 'Kawihthuangte'	Lamiaceae	Nectar of the flower is sweet and sucked by children and birds.	Frequent
7	*Echinacanthus andersonii*	Acantheceae	Ramting	Frequent
8	*Girardinia diversifolia* (Link.) Fries 'Kangthai'	Urticaceae	Fibre is used for making ropes, twine and a coarse cloth like gunny; leaves for headache, swollen joints; ad-ecoction for fever, also as fodder. Root paste against food allergy.	Infrequent
9	*Inula cappa* Buch.-Ham. *ex* D. Don. 'Hmeithaisatul'	Asteraceae	Decoction of roots for epilepsy and rheumatism.	Infrequent
10	*Leea compactiflora* Kurz 'Kumtintuai'	Vitaceae	Young leaves as vegetable; decoct-ion of the tender leaves for stomach troubles; fruits eaten by birds.	Infrequent
11	*Lepionurus sylvestris*	Opiliaceae	Decoction of leaves	Common

	Blume 'Anpangthuam'		for throat pain.	
12	*Leucomeris decora* Kurz	Asteraceae	NA	Rare
13	*Leucosceptrum canum* Sm., Exot. 'Kawihthuang'	Lamiaceae	Root decoction and root juice is taken in malaria (Hynniewta & Kumar 2008)	Infrequent
14	*Lycianthes laevis* (Dunal) Bitter 'Vanian'	Solanaceae	Leaves eaten as vegetable.	Infrequent
15	*Mahonia pycnophylla* (Fedde) Takeda 'Pualeng'	Berberidaceae	Berries as diuretic and dysentery.	Rare
16	*Melastoma nepalensis* Lodd. 'Builukham'	Melastomaceae	Fruits eaten by man and birds.	Frequent
17	*Osbeckia chinensis* L. 'Builukham'	Melastomaceae	Decoction of roots is useful in disease of kidney, dysuria, stomach complaints, dysentery and for expelling thread worms from the body.	Infrequent
18	*Osbeckia crinita* Benth. *ex* C.B.Clarke 'Builukhampa'	Melastomaceae	Decoction of the leaves is used for toothache.	Infrequent
19	*Oxyspora paniculata* (D. Don) DC. 'Khampui'	Melastomaceae	Root paste in heart, stomach, kidney problems and in bleeding of nose.	Frequent
20	*Strobilanthes auriculatus* Nees. 'Ramting'	Acanthaceae	Pounded leaves rubbed on the bodyduring tempera-	Frequent

			ture falls of intermittent fever.	
21	*Pogostemon plectranthoides* Desf.	Lamiaceae	Widely in modern perfumery and modern scented industrial products such as paper towels, laundry detergents, and air fresheners; oil and scent used to induce relaxation, insect repellent, hair conditioner; Chin-ese uses the herb to treat headaches, colds, nausea, diarrohea, and abdominal pain.	Rare
22	*Polygonum chinense* L.	Polygonaceae	Plant juice as tonic.	Frequent
23	*Psychotria symplocifolia* Kurz. 'Thingvawihuih'	Rubiaceae	Wood used for firew-ood.The bark, leaves, ripe fruits are chewed as a remedy for sore gums. The fruits are eaten by birds like barbets, laughing thr-ush, bulbuls etc.	Infrequent
24	*Rhynchotechum ellipticum* (Wall. *ex*. D. Dietr) A. DC. 'Tiarrep'	Gesneraceae	Leaves eaten as veget-able and also for pig are feed; fruit edible. Decoction of the leaves is used in treatment of cancer.	Frequent

25	*Securinega virosa* (Roxb. *ex* Willd.) Baill. 'Saisiak'	Euphorbiaceae	Leaves boiled with water and used for bathing children suffering from scabies and measles; leaves juice with tobacco leaves used as vermifuge.	Infrequent
26	*Strobilanthes anisophyllus* T.Anders. 'Ramting'	Acantheceae	NA	Frequent
27	*Strobilanthes helictus* T. Anders.	Acantheceae	NA	Infrequent
28	*Strobilanthes parryorum* T. Anders. 'Ramting-hmul-chi'	Acanthaceae	NA	Frequent
29	*Toddalia asiatica* (L.) Lam. 'Nghardai'	Rutaceae	Plants as febrifuge and bark as tonic. Berries eaten by children.	Infrequent
30	*Vaccinum serratum* (G. Don) Wight	Vaccinaceae	NA	Infrequent
31	*Vernonia volkameriaefolia* Wall. *ex* DC. 'Khupal'	Asteraceae	Wood is used for firewood and lopped for cattle fodder.	Frequent

Table - 5.16. HERBS STATUS AND USES

Sl. No:	**Plants/Floral Diversity**	**Family**	**Uses**	**Status**
1	*Abelmoschus manihot/moschatus* (L.) Moench. 'Ui chhu me'	Malvaceae	Leaf and root paste as a poultice for sprain and inflama-tions.	Infrequent
2	*Adiantum lunulatum* Burm. *f*.	Adiantaceae	Root for strangury and fever due to elephantiasis; plant is used in dysentery, blood diseases, ulce-rs, erysipelas, burning sensations, epileptic fit.	Frequent
3	*Amomum dealbatum* Roxb. 'Aidu'	Zingiberaceae	Roots and buds are eaten as vegetable. Fruits eaten by man and wild animals. Plant also used to cure enlargement of liver.	Frequent
4	*Anisochilus pallidus* Wall., Pl. Asiat. 'Lengser – suak.	Lamiaceae	Juice of the plant is applied externally to sore of baby's navel.	Frequent
5	*Asparagus racemosus* Willd. 'Arkebawk'	Liliaceae	Roots as refrigerant, demulcent, diuretic, antispasmodic, galac-togogue, in dysent-ery, diarrohea and inveterinary medici-ne.	Frequent

6	*Asplenium laciniatum* D. Don, Prod.	Aspleniaceae	About 10 g of fresh root paste along with 100 ml of cow urine is taken orally in empty stomach once in the morning for fifteen days to have relief from leucorr-hoea (Rout *et al*., 2009)	Infrequent
7	*Bergenia ciliata* (Haw.) Sternb.f. 'Khamdamdawi'	Saxifragaceae	Plant paste externally on boil and orally for dissolving stones in the kidney; roots as tonic,in fever, pulmo-nary trouble, and in diarrohea.	Infrequent
8	*Blechnum orientale* L. Vawmban	Blechnaceae	Hot decoction of pin-nae is applied extern-ally over abscess to liberate pus and also for its antiseptic acti-on. Fresh decoction is applied once a day till abscess dries up. (Shil & Dutta, 2009).	Infrequent

			The leaf juice, 2-3 drops, is put as ear drops in case of seve-re pain. Rhizome is used to cure the intestinal wounds. Fresh fronds are used as poultice for boils and also used for urinary bladder complaints. (Rout *et al*., 2009)	
9	*Cautleya lutea* (Royle) Hook.*f*	Zingiberaceae	NA	Infrequent
10	*Corydalis leptocarpa* Hook.*f*. & Thomson	Fumariaceae	NA	Infrequent
11	*Costus speciosus* (Koenig) J.E. Sm. 'Sumbul'	Zingiberaceae	Roots as astringent, purgative, depurat-ive, stimulant, tonic, anthelmintic and in snake bite.	Frequent
12	*Curculigo crassifolia* Hook .*f*. 'Phaiphek'	Amaryllidaceae	Juice of tuber in stomachache.	Frequent
13	*Cyathea spinulosa* Wall. *ex* Hook	Cyatheaceae	Soft pith and roots are used in the preparation of local drinks. Fronds are	Infrequent

			used as fodder as well as thatching the huts.	
14	*Desmodium heterocarpon* (L.) DC.	Fabaceae	As a cover crop for erosion and weed control in tropical tree plantations and restoration of degraded soils.	Frequent
15	*Desmodium podocarpum* DC.	Fabaceae	Used for treatment of febrile diseases,cough and bleeding wounds for its analgesic, anti-inflammatory and anti- pyretic agent.	Frequent
16	*Didymocarpus cinerea* Wallich. Don	Gesneriaceae	Sekhupthursuak	Infrequent
17	*Diplazium dilatatum* Blume	Polypodiaceae	Used as diuretic in the renal system (Baltrushes, N. 2006)	Frequent
18	*Diplazium maxima* (D. Don) C. Chatt.	Polypodiaceae	Tender leaves are eaten as vegetable.	Frequent
19	*Disporum cantoniense* (Lour.) Merr.	Liliaceae	NA	Rare
20	*Dryopteris cochleata* (Don) C. Chr.	Dryopteridaceae	Used in mental disorder. Filtered water extract of rhizome is given to The unconscious persons suffering from epilepsy. (Srivastava 2007).	Frequent

			Rhizomes used in leprosy, antifungal, swellings, ulcers & pains. (Perumal, 2010).	
21	*Eulophia spectabilis* (Dennst.) Suresh	Orchidaceae	Tubers used as an effective remedy for treating tumours, bronchitis, scrofulous gland of neck and as a vermifuge.	Rare
22	*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). The rhizomes are used as a source of edible starch by Australian aborigines,	Frequent

			and its leaves are woven into matting in parts of Malaysia.	
23	*Hedychium coccineum* J.E. Sm. 'Aichhia'	Zingiberaceae	Rhizome paste for bee sting and also applied to anus against pin-worms.	Infrequent
24	*Hedychium ellipticum* Buch.-Ham. *ex* Sm. 'Aibuk'	Zingiberaceae	NA	Infrequent
25	*Impatiens trilobata* Nutt. Sumac	Balsaminaceae	NA	Frequent
26	*Kalanchoe roseus* Clarke.	Crassulaceae	Used as an antidote in snake bites.	Rare
27	*Leptochilus ellipticus* (Thunb.) Noot.	Polypodiaceae	NA	Rare
28	*Liparis cordifolia* Hook. *f.*	Orchidaceae	NA	Rare
29	*Lobelia angulata* Forst. 'Choakathi'	Campanulaceae	Leaves in dysentery, diarrhoea, ulcers, night blindness.	Infrequent
30	*Microlepia rhomboidea* (Wall. *ex* Kunze) Prantl, Arb.	Dennstaedtiaceae	NA	Frequent
31	*Microlepia strigosa* (Thunb.) Presl, Epim.	Dennstaedtiaceae	Young fronds are cooked as vegetables	Common
32	*Ophiopogon dracaenoides* (Baker) Hook.*f.*	Liliaceae	NA	Rare

33	*Ophiopogon intermedius* D.Don, Prodr.	Liliaceae	NA	Rare
34	*Phaius flavus* (Blume) Lindl.	Orchidaceae	NA	Infrequent
35	*Polygonum barbatum* L. 'Dawngria'	Polygonaceae	Seeds for colic	Infrequent
36	*Polystichum luctuosum* (Kunze) T. Moore	Dryopteridaceae	NA	Infrequent
37	*Pteridium aquilinum* (L.) Kuhn. 'Katchat'	Polypodiaceae	Decoction of rhizome and fronds is taken orally at bedtime in the treatment of worms. The infusion of plant is used to relieve stomach cramps and increases urine flow. Decoction of rhizome drunk as herbal health tea (Rout *et al*., 2009). Rhizome and fruits in chronic visceral and spleen probl-ems.	Frequent
38	*Pteris tricolor* Linden	Pteridaceae	NA	Rare
39	*Scleria levis* Retzius.	Cyperaceae	Young leaves and	Common

	'Thip'		inflorescence are used for Rhino fodder (Gosh & Das 2007)	
40	*Thalictrum punduanum* Wallich. 'Hrat'	Ranunculaceae	NA	Frequent
41	*Tricholepidium normale* (D.Don) Ching.	Polypodiaceae	NA	Infrequent

Table - 5.17. CLIMBERS STATUS AND USES

Sl. No:	Plants/Floral Diversity	Family	Uses	Status
1	*Aristolochia griffithii* Hook. *f*. & Thomson *ex* Duch.	Aristolochiaceae	NA	Infrequent
2	*Bauhinia scandens* L. 'Zawngaleihlawn'	Caesalpiniaceae	Bark used for making ropes.	Infrequent
3	*Bridelia scandens* (Roxb.) Willd. 'Hruiphaktel'	Euphorbiaceae	Fruits eaten by children and birds and also used for pop gun ammunitions.	Infrequent
4	*Cayratia japonica* (Thunb.)	Vitaceae	NA	Rare
5	*Clematis acuminata* DC. 'Hruipawnro'	Ranunculaceae	NA	Frequent
6	*Clematis gouriana* Roxb. *ex* DC 'Rairahmittuitla'	Ranunculaceae	Leaves applied to bruised skin cause vesication.	Frequent
7	*Combretum flagrocarpum*	Combretaceae	Leaf juice on cuts and wounds to stop	Frequent

	C.B. Clarke 'Leihruisen'		bleeding.	
8	*Embelia ribes* Burm.*f.* 'Naufadawntuai'	Myrsinaceae	Roots for cough and diarrhoea; decoction of dried fruits for fever, heart problems and skin diseases.	Infrequent
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.	Infrequent
10	*Jasminum arborescens* Roxb.	Oleaceae	The leaves are astrin-gent and stomachic. Juice of leaves, with pepper, garlic and other stimulants, is used as an emetic in obstruction of the bronchial tubes due to viscid phlegm. (Bhaghat K. *et al.,* 2010)	Rare
11	*Kadsura heteroclita* (Roxb.) Craib. 'Theiarbawm'	Magnoliaceae	Fruits eaten by man, squirrels, rats, torto-ise, kalij pheasant, peacock pheasant barbets etc.	Infrequent

12	*Lygodium flexuosum* (L.) Sw. ‘ Dawnzempui’	Lygodiaceae	Infusion of leaves used for treating female infertility. Paste is applied to fix fractured bones. Powdered root 2 g mixed with 1g *Piper nigrum* and 100 ml of water are orally administered twice a day for 3 days to check dysentery. Rhizome boiled with mustard oil is locally applied to carbuncle and in the treatment ofr heumatism, spr-ains, scabies and ulcers. Aqueous rhi-zome extract is used for treatment of gonorrhea. About one teaspoonful of plant juice is given twice a day to relieve fever	

			(Rout *et., al* 2009)	
13	*Millettia pachycarpa* Benth. 'Rulei'	Fabaceae	Roots in scabies and skin diseases; pods and roots are also used to poison fish.	Frequent
14	*Mussaenda glabra* Vahl 'Vakep'	Rubiaceae	Roots and leaves in cough; flowers in asthma, fevers and dropsy.Young leaves eaten as salads.	Frequent
15	*Passiflora nepalensis* Wallich. 'Nauawimuhrui'	Passifloraceae	Ripef ruit edible; young leaves as vegetable; decoction of root is used in malaria and juice of the crushed leaves as purgative.	Frequent
16	*Piper diffusum* Vahl. 'Pawhrual'	Piperaceae	Leaves in stomacha-che.	Frequent
17	*Piper nigrum* L. 'Panruangsuak'	Piperaceae	Fruits used as spice, condiment and medicine.	Common
18	*Polygala arillata* Bauch.-Ham. *ex* D.Don	Polygalaceae	Roots for headache, as purgative and febrifuge.	Rare
19	*Pothos scandens* L. 'Laikingtairua'	Araceae	Stems in snake bite and small pox; also good for asthma.	Frequent
20	*Senecio scandens* Buch.-Ham. Sai- ek-hlo	Asteraceae	Decoction of the leaves is used against stomach troubles, cancer etc. Juice of the leaves is applied	Frequent

			to chronic ulcers.	
21	*Senecio triligulatus* Bauch.-Ham. *ex* D.Don	Asteraceae	NA	Infrequent
22	*Smilax lanceaefolia* Roxb. 'Kaiha'	Liliaceae	Roots for rheumatism.	Frequent
23	*Tetrastigma obovatum* (M. Lawson) 'Puarpeng'	Vitaceae	NA	Frequent
24	*Tetrastigma rumicispermum* (M. Lawson) 'Hruirithet'	Vitaceae	NA	Frequent
25	*Thunbergia coccinea* Wall. *ex* D.Don 'Fahrahhrui'	Acanthaceae	Stem tied around neck of cattle to expel sore-worms.	Infrequent
26	*Vitis tuberculata* (Blume) M. Lawson	Vitaceae	NA	Infrequent

Table - 5.18. EPIPHYTES STATUS AND USES

Sl. No	Plants/Floral Diversity	Family	Uses	Status
1	*Aeschynanthus sikkimensis* (C.B. Clarke) Stapf 'Bawltehlantai'	Gesneriaceae	Decoction of root for fever; flowers in throat pain.	Frequent
2	*Bulbophyllum elatum* (Hook.f.) J.J.Sm.	Orchidaceae	NA	Infrequent
3	*Celogyne nitida* (Wall. *ex* D. Don) Lindl.	Orchidaceae	NA	Infrequent
4	*Celogyne suaveolens* (Lindl.) Hook *.f.*	Orchidaceae	NA	Infrequent

5	*Dendrobium chrysotoxum* Lindl. 'Banpui'	Orchidaceae	Anti tumerous and anti cancerous substances are extracted from it.	Infrequent
6	*Dendrobium crepidatum* Lindl. & Paxton	Orchidaceae	Used as anticeptic in cuts and wounds.	Infrequent
7	*Dendrobium formosum* Roxb. *ex* Lindl. 'Banpui par var'	Orchidaceae	NA	Rare
8	*Dendrobium infundibulum* Lindl.	Orchidaceae	NA	Infrequent
9	*Dendrobium ochreatum* Lindl. 'Banpui par eng chhungdum'	Orchidaceae	NA	Infrequent
10	*Dendrobium peguanum* Lindl.	Orchidaceae	NA	Infrequent
11	*Dendrobium primulinum* Lindl., Gard	Orchidaceae	Ornamental	
12	*Drynaria coronans* (Wall. *ex* Mett.) T. Moore 'Awmvel'	Polypodiaceae	Rhizome used in stomach and tooth problem.	Infrequent
13	*Eria lacei* Summerh	Orchidaceae	NA	Rare
14	*Eria vittta* Lindl., J. Proc. Linn. Soc.	Orchidaceae	NA	Infrequent
15	*Esmeralda clarkei* Rchb.*f*., Gard.	Orchidaceae	NA	Rare
16	*Gastrochilus calceolaris* (Buch.-Ham.*ex*J.E.Sm.) D. Don	Orchidaceae	NA	Infrequent
17	*Oberonia iridifolia*	Orchidaceae	NA	Infrequent

	(Roxb.) Lindl			
18	*Oberonia pachyrachis* Rchb. *f. ex* Hook. *f.*	Orchidaceae	NA	Infrequent
19	*Otochilus porrectus* Lindl., Gen.Sp.	Orchidaceae	NA	Infrequent
20	*Panisea uniflora* Lindl.	Orchidaceae	NA	Infrequent
21	*Papilionanthe teres* (Roxb.) Schltr.	Orchidaceae	Ornamental.	Infrequent
22	*Peperomia tetraphylla* (G.Forst.) Hook. & Arn.	Piperaceae	NA	Rare
23	*Pholidota articulata* Lindl.	Orchidaceae	NA	Infrequent
24	*Pholidota imbricata* Lindl.	Orchidaceae	Pseudo-bulbs anthelmintic solution in water used for navel pain; paste used as poultice for finger abscess; whole plant as tonic and bulb for rheumatism.	Infrequent
25	*Schefflera venulosa* (Wight & Arn.) Harms 'Kelbuh'	Araliaceae	Fruit juice is applied on sprains and also eaten by birds.	Infrequent
26	*Vittaria flexuosa* Fee	Vittariaceae	NA	Infrequent

Table - 5.19. PARASITES/SAPROPHYTES STATUS AND USES

Sl. No	Plants/Floral Diversity	Family	Uses	Status
1	*Aeginetia indica* L. 'Sanghar vaibel'	Orobanchaceae	Juice of roots, tubers and rhizome used externally in mumps.	Rare
2.	*Balanophora dioca* R. Brown *ex* Royle	Balanophoraceae	Antioxidant phytochemicals and glucosides, hypoglycemic effects.(Lau *et al*., 2003), (Ho *et al.*, 2010) Juice from fleshy root stock yields gum which is used for catching birds in Arunachal Pradesh (Srivastava 2010)	Rare
3.	*Scurrula pulverulenta* (Wall.) G. Don 'Thlikthli-ek-bawm'	Loranthaceae		Frequent

Table - 5.20. GRASSES STATUS AND USES

Sl. No	Plants / Floral Diversity	Family	Local Name	Status
1	*Arundinaria callosa* Munro 'Phar'	Poaceae	Culms used for fencing and tying purposes; young shoots as vegetables.	Common
2	*Bambusa khasiana* Munro 'Rawte'	Poaceae	The culms are used in building and for basket work; young shoots eaten as vegetable.	Frequent
3	*Bambusa tulda* Roxb. 'Rawthing'	Poaceae	Young shoots as vegetable; frayed outer skin is applied to stop bleeding.	Common
4	*Cymbopogon winterianus* Jowitt 'Di lengser'	Poaceae	Essential oils used in perfumery & for insect repellents.Also used to control soil erosion.	Frequent
5	*Dendrocalamus hamiltonii* Nees & Arn. *ex* Munro 'Phulrua'	Poaceae	The culm is used for temporary building, mats, baskets, gutters, water vessels, fuel and paper making. Young shoots as vegetables; fruits eaten in time of femine and also for low blood pressure.	Common
6	*Dendrocalamus hookeri* Munro 'Rawlak'	Poaceae	The culm is used for building, construction, baskets, water buckets etc.	Frequent
7	*Dendrocalamus manipurianus Naithani & Bisht* 'Rawchhechangdam'	Poaceae	Construction purposes	Frequent

8	*Dendrocalamus strictus* (Roxb.) Nees. 'Tursing'	Poaceae	The culm is used in paper mills, for building rafter, roofing, flooring, walling, scaffolding, tent poles, matting, basket maki-ng etc. Young shoots as vegetable; leaves as fodder. Silicious matter as tonic and astringent; leaves ecbolics to animals.	Frequent
9	*Dinochloa compactiflora* Kurz. Mc Clure 'Sairil'	Poaceae	Used for making baskets, hats etc. Juice of the stem is taken for influenza, curing dandruff, falling hair and baldness.	Frequent
10	*Imperata cylindrica* (L.) Raeusch. 'Di'	Poaceae	Commonly used for thatching grass. Roots for intestinal worms.	Common
11	*Melocanna baccifera* (Roxb.) Kurz 'Mautak'	Poaceae	The culm is used for building, paper pulp, house walls, thatching, mats, baskets etc. Tender shoots as vegetable; glossy surface of the stem is scraped and the powder is applied to new cuts; fruits eaten by cattle and wild animals.	Common
12	*Pseudostachynum polymorphum* Munro 'Chal'	Poaceae	The culm is used for making baskets, mats, umbrella handles, wal-king sticks and tying purposes; young shoots as	Frequent

			vegetable.	
13	*Saccharum longisetosum* (Hackel) Bor 'Luang'	Poaceae	Young leaves are good for cattle fodder.	Infrequent
14	*Schizostachyum capitatum* (Munro) R. Majumdar 'Rawngal'	Poaceae	The culm is used for making baskets, mizo hats, blow guns, tying fences etc. Leaves used for fodder and also good for stomachache.	Common
15	*Schizostachyum dulloa* (Gamble)Majumdar 'Rawthla'	Poaceae	The culm is used for making baskets, mats, mizo looms, ceiling, partition walls, hut's purlins etc; young shoots as vegetable; glutinous rice is also cooked in the joints.	Infrequent
16	*Sinarundinaria falcata* (Nees.) Chao & Renvoize 'Lik'	Poaceae	Used for fish rods and hedge plant.	Common
17	*Thysanolaena maxima* (Roxb.) Kuntze 'Hmunphiah'	Poaceae	The flower panicles are used for making brooms; leaves for cattle fodder; young shoots are eaten by monkeys, langur, por-cupine, tortoise and squirrels.	Infrequent

Table - 5.21. CANES AND PALMS STATUS AND USES

Sl. No	Plants / Floral Diversity	Family	Uses	Status
1	*Arenga pinnata* (O. Kuntze) Merr. 'Thangtung'	Arecaceae	Roots used in stomachic and in bronchitis; outer fleshy layer of fruit used as fish poison; young shoots eaten raw.	Common
2	*Calamus acanthospathus* Griff. 'Thilte'	Arecaceae	The cane is used for chair making, walking sticks, baskets, containers, handles of umbrellas, etc. and also as a substitute for ropes and cables in suspension bridges; tender pith of the upper part of the stem is eaten as vegetable; fruits used as purgative and also curing chronic stomach-ulcer; fruits eaten by man, monkeys, squirrels etc.	Infrequent
3	*Calamus erectus* Roxb. 'Thilthek'	Arecaceae	Young shoot eaten as vegetable.	Infrequent
4	*Calamus flagellum* Griff. *ex* Mart. 'Hruipui'	Arecaceae	The cane is used for chairs, baskets, containers, etc. The top shoots are eaten as vegetable; fruits eaten by man, monkeys, langur, squirrels etc.	Infrequent
5	*Calamus gracilis* Roxb. 'Kawrtai'	Arecaceae	Handicrafts and young shoots are edible.	Common

6	*Calamus guruba* Buch.-Ham.*ex* Mart. 'Taite/Tairua'	Arecaceae	The cane is used for making baskets etc.	Frequent
7	*Calamus inermis* Becc., Ann. 'Mitperh'	Arecaceae	Handicrafts and furniture (Haridasan *et al*., 2002)	Infrequent
8	*Caryota mitis* L. 'Meihle'	Arecaceae	Starch rich food. White fleshy part edible. Fibre used in the manufacture of brushes and brooms. Nuts applied externally on head in case of hemicrania.	Frequent
9	*Daemonorops jenkinsianus* (Griff.) Mart. 'Raichhawk'	Arecaceae	The cane is used for making baskets, umbrella handles etc. Shoots eaten as vegetable; fruits eaten by man, monkeys, langur, squirrels, etc.	Frequent
10	*Zalacca secunda* Griff. 'Hruitung'	Arecaceae	Leaves for roofing; seeds edible. (Sarmah, 2010)	Frequent

Plate 3

Plate 3a: *Engelhardtia spicata* (Roxb.) Bl.

Plate 3b: *Xantolis hookeri* (C.B. Clarke) P. royen

Plate 3c: *Quercus dilatata* Lind.

Plate 3d: *Helicia erratica* Hook *.f.*

Plate 3e: *Ligustrum robustum* (Roxb.) Bl.

Plate 3f: *Myrica esculenta* Bauch.-Ham

Plate 4

Plate 4a: ***Leucoceptrum canum*** **Sm., Exot**

Plate 4b: ***Colquhounia coccinea*** **Wall., Trans.Linn**

Plate 4c: ***Disporum cantoniense*** **(Lour.) Merr**

Plate 4d: ***Polystichum luctuosum*** **(Kunze) T. Moore**

Plate 4e: ***Asplenium laciniatum*** **D. Don, Prod.**

Plate 4f: ***Leptochilus ellipticus*** **(Thunb.) Noot.**

Plate 5

Plate 5a: ***Dinochloa compactiflora***

Plate 5b: ***Melocanna baccifera***

Plate 5c: ***Bambusa tulda***

Plate 5d: ***Dendrocalamus hamiltonii***

Plate 5e: ***Schizostachyum capitatum***

Plate 5f: ***Calamus flagellum***

Plate 6

Plate 6a: ***Kadsura heteroclita***

Plate 6b: ***Eria vittata***

Plate 6c: ***Peperomia tetraphylla***

Plate 6d: ***Aeschynanthus sikkimensis***

Plate 6e: ***Vittaria flexuosa***

Plate 6f: ***Polygala arillata***

Plate 7

Plate 7a: ***Esmeralda clarkei***

Plate 7b: ***Dendrobium chrysotoxum***

Plate 7c: ***Celogyne nitida***

Plate 7d: ***Eulophia spectabilis***

Plate 7e: ***Panisea uniflora***

Plate 7f: ***Dendrobium infundibulum***

Plate 8

Plate 8a: ***Balanophora dioca***

Plate 8b: ***Eria lacei***

Plate 8c: ***Pteris tricolor***

Plate 8d: ***Kalanchoe roseus***

Plate 8e: ***Arudinaria callosa***

Plate 8f: ***Dendrobium peguanum***

5.3. Soil Analysis

Results of Soil Analysis

The results of the physico-chemical analysis of soil after taking the average calculation, it has been found that during the 2 years of seasonal analysis temperature is the highest in July 2008 *i.e.,* 15.42^{0}C and lowest in January 2007 which is 11.26^{0}C.Temperature decreases as we ascend to higher altitude. Also, due to the presence of thick canopy cover which blocks the sunlight, the temperature of the closed forest decreases. Bulk density was highest in the month of July 2008 *i.e.,* 1.30g/cm^3 and lowest in the month of April 2007 which was 0.66g/cm^3.

Soil moisture content was high during the rainy season and was recorded highest during the month of July 2008 *i.e.,* 19.43% and lowest in January 2007 which was 6.86%. The soil moisture content were found to be lower during the winter season in the surface soil layer which could be the result of higher evapotranspiration from the soil and plant surfaces and percolation and infiltration of water to the lower depths (Tiwari *et al.,* 1992).

The pH results revealed that all the samples analyzed from Tawi Wildlife Sanctuary are acidic in nature. pH is highest in April 2007 which is 6.13 and lowest in July 2008 which is only 4.5 on an average on all the 25 sites. The pH was higher during the dry winter season and lower during rainy season. Since acidic reaction of the soil is due to presence of exchangeable Al^{+3} and intensive leaching of bases (Fitzpatrick 2003), drop in the pH during rainy season could be the result of excessive leaching of basic cations by rainwater (Wild 1996). The high acidity of the forest soil is due to the accumulation of organic acids from the decaying of vegetation and decomposition of different types of litters on the forest floor. The acidity of the soil

may also be due to the fact that the broad leaf might be acidic in nature. The microorganisms present in the forest soil may also contribute Carbon dioxide to the soil thus increasing its acidity.

Soil organic matter and Organic carbon content was found to be high throughout the year. It is recorded highest in the month of November 2008 which was 5.49% and lowest in January 2007 which was 4.22%. Greater accumulation of organic carbon in the surface layer is due to slow microbial decomposition of litter in acidic soils as reported by Nayak and Srivastava (1995) from humid sub-tropical soils under shifting cultivation in northeast India.

Nitrogen analysis showed that nitrogen was highest in the month of July 2007 which was 1.01% and lowest in January 2007 which was 0.73%. Deka (1981) reported lower values of nitrogen during dry winter period. Similar results were also obtained at the present sudy sites as well.

Potassium was highest during November 2007 which accounts for 492.13 Kg/ha and lowest in April 2008 which was 260.467 Kg/ha. There is a great fluctuation in the soil exchangeable potassium content, as it is easily leached from living and decomposing plant tissues compared to other nutrients.

Available phosphorus was very low throughout the year and it ranged between 0.77 Kg/ha to 2.75 Kg/ha. It was found to be higher during winter and lower during rainy season. Greater input of phosphorus through litter during winter and spring seasons in the 7, 13 and 16 years old forest regrowth has been reported by Arunachalam *et al.,* (1998) in humid subtropical region.

Table - 5.22. Seasonal variation of Temperature

Sample No	2007				2008			
	Jan. (^{0}C)	April (^{0}C)	July (^{0}C)	Nov. (^{0}C)	Jan. (^{0}C)	April (^{0}C)	July (^{0}C)	Nov. (^{0}C)
1	13	16	16.5	14	13.5	17	17	14.5
2	13.5	16.5	16	13.5	13	16.5	17	14
3	13	15	15.5	14	13	16.5	16.5	14
4	12	16.5	15.5	14	12	16	16.5	13.5
5	12.5	16	16	13	12	16	16	13.5
6	11	16	14.5	13.5	11	16	16	14
7	11	15	14.5	14	11.5	15.5	15	14
8	10.5	15	14	13.5	11.5	15.5	15	13
9	10.5	14	14	13.5	11	16	15	13
10	10	15	14	12.5	12	15	14.5	13.5
11	10	15	14	12.5	11	15	14.5	11.5
12	11	15.5	13.5	12	10	15	15	11.5
13	11.5	14	13.5	12	10	14.5	15	11
14	10.5	14.5	13	11.5	10	14.5	14	12
15	10	14	13	11	10.5	13.5	14	12.5
16	11	14	13.5	11	11.5	13.5	14.5	12
17	10	14.5	14	11.5	11.5	15.5	14.5	12.5
18	10	13.5	14.5	12	11	15.5	15	13
19	11	13.5	15	12	11	15	15	13
20	11	14	15	12.5	12	15	16	13.5
21	11.5	14	15	13	12	15	16.5	13
22	12	15	14.5	13	12.5	14.5	16	13.5
23	12	15	14	12.5	12.5	14.5	15.5	13.4
24	11	15	15	13	13	15	15.5	14
25	12	15.5	15.5	14	13	16.5	16	14
Mean	11.26	14.88	14.54	12.71	11.63	15.3	15.42	13.1

Table - 5.23. Seasonal variation of Moisture Content

	2007 Moisture Content (%)				2008 Moisture Content (%)			
Sample No:	Jan.	April	July	Nov.	Jan.	April	July	Nov.
1	0.25	0.36	0.45	0.34	0.27	0.55	0.72	0.55
2	0.23	0.29	0.41	0.35	0.29	0.57	0.68	0.61
3	0.2	0.45	0.41	0.39	0.29	0.73	0.88	0.68
4	0.25	0.40	0.53	0.38	0.33	0.69	0.89	0.69
5	0.32	0.46	0.52	0.38	0.48	0.73	0.91	0.72
6	0.28	0.47	0.56	0.34	0.42	0.71	0.85	0.43
7	0.29	0.39	0.53	0.3	0.38	0.77	0.74	0.45
8	0.29	0.46	0.54	0.29	0.34	0.81	0.86	0.51
9	0.34	0.49	0.49	0.33	0.52	0.88	0.91	0.58
10	0.34	0.43	0.47	0.29	0.51	0.86	0.78	0.55
11	0.28	0.46	0.53	0.32	0.36	0.95	0.89	0.32
12	0.32	0.54	0.43	0.36	0.41	0.79	0.79	0.48
13	0.31	0.38	0.38	0.36	0.48	0.73	0.74	0.66
14	0.35	0.51	0.56	0.2	0.46	0.84	0.95	0.38
15	0.33	0.36	0.50	0.3	0.52	0.68	0.64	0.57
16	0.28	0.43	0.39	0.23	0.34	0.77	0.58	0.48
17	0.23	0.45	0.45	0.26	0.28	0.79	0.86	0.54
18	0.32	0.46	0.42	0.23	0.35	0.82	0.73	0.47
19	0.22	0.48	0.4	0.3	0.29	0.79	0.62	0.52
20	0.23	0.50	0.56	0.3	0.26	0.85	0.95	0.61
21	0.23	0.45	0.31	0.24	0.31	0.81	0.67	0.49
22	0.23	0.47	0.43	0.17	0.32	0.65	0.58	0.21
23	0.28	0.41	0.38	0.3	0.43	0.69	0.77	0.42
24	0.23	0.34	0.35	0.33	0.39	0.71	0.76	0.56
25	0.23	0.39	0.30	0.16	0.46	0.75	0.68	0.24
Mean	6.86	10.83	11.3	7.45	9.49	18.92	19.43	12.72

Table - 5.24. Seasonal variation of Bulk Density

Sample No:	Jan-07	April-07	July-07	Nov-07	Jan-08	April-08	July-08	Nov-08
	Bulk Density (g/cm^3)	**Bulk Density (g/cm^3)**	**Bulk Density (g/cm^3)**	**Bulk Density (g/cm^3)**	**Bulk Density (g/cm^3)**	**Bulk Density (g/cm^3)**	**Bulk Density (g/cm^3)**	**Bulk Density (g/cm^3)**
1	0.33	0.81	0.97	0.5	0.88	0.98	1.06	0.76
2	0.55	0.79	1.45	0.49	0.92	0.81	1.51	0.79
3	0.35	0.66	0.99	0.58	0.85	0.75	1.06	0.71
4	0.36	0.62	1.43	1.06	0.55	0.74	1.64	1.23
5	0.54	0.53	1.57	0.31	0.82	0.61	1.71	0.66
6	0.67	0.54	1.15	1.15	0.98	0.74	1.68	1.31
7	0.61	0.51	1.33	0.56	0.90	0.87	1.58	0.85
8	0.56	0.65	0.96	0.77	0.66	0.71	1.05	0.96
9	0.6	0.52	0.93	0.32	0.76	0.72	1.02	0.58
10	0.75	0.49	0.88	1.06	0.88	0.77	0.98	1.17
11	0.6	0.52	1.32	0.88	0.86	0.76	1.45	1.13
12	0.47	0.51	1.24	0.44	0.65	0.59	1.33	0.64
13	0.59	0.49	1.17	1.06	0.73	0.64	1.28	1.28
14	0.77	0.55	0.83	0.36	0.96	0.72	0.99	0.62
15	0.88	0.51	0.86	1.31	0.99	0.67	0.96	1.55
16	0.83	0.74	0.85	1.05	1.08	0.82	0.96	1.29
17	1	0.56	0.96	1.07	1.45	0.89	1.16	1.18
18	0.72	0.6	1.09	0.95	0.94	0.75	1.07	1.18
19	0.7	0.76	1.11	0.85	0.89	0.83	1.22	1.03
20	0.67	1	1.83	0.63	0.96	0.69	1.43	0.86
21	0.83	0.96	1.26	1.04	1.14	1.09	1.53	1.17
22	1.11	0.9	1.3	0.77	1.65	0.98	1.47	0.93
23	0.58	0.68	1.2	0.87	0.86	0.78	1.35	0.97
24	0.97	0.87	1.83	0.98	1.08	0.96	1.89	1.07
25	1.04	0.94	1.7	1.07	1.32	1.01	1.11	1.22
Mean	0.68	0.66	1.20	0.80	0.95	0.79	1.30	1.00

pH:

pH is defined as the negative logarithm of the hydrogen ion ($H^{+)}$ concentration to the base 10. Hence, the acidity is expressed as a power of the reciprocal of the hydrogen ion concentration (Kimmins 1987).

Table - 5.25. Seasonal variation of pH

Sample No:	2007				2008			
	Jan.	April	July	Nov.	Jan.	April	July	Nov.
1	5.51	5.69	5.76	7.44	4.95	5.12	5.22	5.81
2	5.93	5.97	5.42	6.33	5.67	4.68	5.99	5.39
3	5.12	4.81	5.48	6.35	6.21	5.14	4.63	5.49
4	5.53	5.51	4.73	6.34	4.85	4.66	3.93	4.88
5	5.31	5.28	5.13	4.95	4.97	3.98	3.97	5.18
6	5.56	5.57	5.11	6.93	4.87	3.74	3.85	5.09
7	5.48	5.41	5.34	6.06	4.83	4.96	4.12	5.31
8	5.43	5.37	4.97	5.87	5.06	4.17	4.1	5.01
9	5.31	5.05	5.53	5.84	4.99	4.92	4.46	5.55
10	5.04	4.84	5.73	5.78	4.6	4.18	4.11	5.68
11	5.91	5.87	4.85	5.65	5.47	4.07	4.09	4.87
12	5.46	5.43	4.77	4.65	4.73	4.88	4.32	4.86
13	4.96	4.89	5.55	5.87	4.27	5.17	5.08	5.51
14	5.32	5.37	4.69	5.88	5.52	5.11	4.73	4.6
15	5.14	5.05	6.2	6.04	4.69	4.94	4.42	5.71
16	5.05	4.76	4.81	5.8	5.2	4.91	4.89	5.61
17	5.07	4.99	4.91	5.74	4.8	4.88	4.37	5.41
18	5.03	5.06	4.87	5.9	4.88	4.78	4.64	5.08
19	5.11	5.15	6.25	5.83	4.88	4.16	3.92	5.92
20	5.09	5.15	4.99	6.21	4.91	4.99	4.79	5.16
21	6.06	6.18	5.17	6.55	4.62	4.83	4.66	5.2
22	7.03	7.11	4.34	6.72	5.02	5.14	5.02	4.78
23	7.01	6.92	6.45	6.81	4.92	4.68	4.39	6.08
24	6.94	6.83	4.96	6.76	4.88	4.56	4.48	4.72
25	6.51	6.54	5.87	7	4.83	4.55	4.34	5.91
Mean	5.6	5.56	5.28	6.13	4.98	4.69	4.5	5.31

Organic carbon:

Organic carbon is contained in the soil organic fraction, which consists of cells of microorganism, plants and animals residues at various stages of decomposition, stable humus synthesized from residues, and highly carbonized compounds such as charcoal, graphite and coal.

Organic matter (humus) in the soil gets oxidized by Chromic acid (Potassium dichromate plus concentrated Sulphuric acid) utilizing the heat of dilution of Sulphuric acid. The unreacted dichromate is determines by Black titration with Ferrous ammonium sulfate (redox titration)

Table - 5.26. Seasonal variation Organic matter and organic carbon content 2007

Sample No:	Jan-07 0rganic carbon (%)	Jan-07 Organic matter (%)	April-07 0rganic carbon (%)	April-07 Organic matter (%)	July-07 0rganic carbon (%)	July-07 Organic matter (%)	Nov-07 0rganic carbon (%)	Nov-07 Organic matter (%)
1	5.42	9.35	5.31	9.15	5.19	8.95	5.85	10.08
2	5.27	9.08	5.07	8.74	5.37	9.26	5.52	9.51
3	5.56	9.59	4.77	8.22	4.92	8.48	5.88	10.13
4	5.79	9.98	5.01	8.64	4.53	7.8	5.58	9.61
5	5.07	8.74	3.3	5.69	4.32	7.45	5.73	9.87
6	4.86	8.37	4.71	8.12	4.77	8.22	5.76	9.93
7	5.52	8.52	5.07	8.74	4.92	8.48	4.32	7.45
8	5.58	9.61	5.1	8.79	5.28	9.1	5.07	8.74
9	5.85	10.08	4.14	7.14	4.47	7.7	4.92	8.48
10	2.79	4.8	4.95	8.53	4.98	8.59	5.37	9.26
11	4.44	7.65	5.49	9.46	5.07	8.74	5.13	8.84
12	5.13	8.84	4.74	8.17	4.5	7.76	5.55	9.57
13	5.67	9.78	4.65	8.01	5.1	8.79	5.82	10.03
14	4.14	7.13	5.07	8.74	5.37	9.26	5.64	9.72
15	4.29	7.4	4.65	8.01	5.13	8.84	5.31	9.15
16	2.46	4.24	5.64	9.72	5.01	8.64	5.19	8.94
17	3.33	5.74	5.61	9.67	5.28	9.1	5.76	9.93
18	2.28	3.93	5.58	9.62	5.22	9	5.88	10.13
19	4.32	7.44	5.04	8.69	4.92	8.48	5.31	9.15
20	4.65	8.01	4.92	8.48	4.98	8.59	5.13	8.84
21	2.07	3.57	4.17	7.19	5.16	8.9	5.7	9.82
22	3.12	5.38	4.5	7.75	5.19	8.95	5.67	9.78
23	4.44	7.65	5.34	9.2	4.98	8.59	5.37	9.26
24	2.43	4.18	4.92	8.48	5.13	8.84	5.82	10.03
25	0.96	1.66	5.37	9.26	5.16	8.9	5.79	9.98
Mean	4.22	7.33	4.93	8.49	5	8.61	5.48	9.45

Table - 5.27. Seasonal variation Organic matter and organic carbon content 2008

Sample No:	Jan-08	Jan-08	April-08	April-08	July-08	July-08	Nov-08	Nov-08
	0rganic carbon (%)	Organic matter (%)	0rganic carbon (%)	Organic matter (%)	0rganic carbon (%)	Organic matter (%)	0rganic carbon (%)	Organic matter (%)
1	5.64	9.72	5.37	9.26	5.31	9.15	5.88	10.14
2	5.28	9.1	5.1	8.79	5.13	8.84	5.64	9.72
3	5.46	9.41	4.92	8.48	4.95	8.53	5.91	10.19
4	5.82	10.03	5.22	9	4.71	8.12	5.64	9.72
5	5.13	8.84	4.17	7.19	4.47	7.71	5.79	9.98
6	5.07	8.74	5.31	9.16	4.53	7.8	5.73	9.88
7	5.22	9	5.22	9	4.98	8.56	4.38	7.55
8	5.52	9.51	5.16	8.9	5.16	8.9	5.22	9
9	5.73	9.88	4.29	7.4	4.68	8.07	5.13	8.84
10	3.18	5.48	4.89	8.43	5.1	8.79	5.49	9.46
11	4.08	7.03	5.34	9.2	5.19	8.94	5.28	9.1
12	4.53	7.8	4.98	8.59	5.43	9.36	5.31	9.15
13	2.82	4.86	4.56	7.86	5.16	8.9	5.67	9.78
14	3.84	6.62	5.13	8.84	5.52	9.51	5.49	9.46
15	2.82	4.86	4.68	8.06	5.28	9.1	5.37	9.26
16	4.44	7.65	5.43	9.36	5.07	8.74	5.28	9.1
17	4.47	7.7	5.73	9.88	5.37	9.26	5.64	9.72
18	2.52	4.34	5.67	9.78	5.64	9.72	5.76	9.93
19	3.42	5.9	5.19	8.95	5.07	8.74	5.19	8.95
20	4.53	7.8	5.07	8.74	5.13	8.84	5.16	8.9
21	2.88	4.97	4.26	7.34	5.58	9.62	5.61	9.67
22	3.15	5.43	4.59	7.91	5.37	9.26	5.58	9.61
23	3.96	6.82	5.37	9.26	5.22	9	5.31	9.15
24	4.47	7.7	4.89	8.43	5.43	9.36	5.91	10.19
25	3.06	5.26	5.4	9.3	5.37	9.26	5.82	10.03
Mean	4.28	7.38	5.04	8.68	5.15	8.88	5.49	9.46

Nitrogen:

The major parts less than (90%) of the soil Nitrogen exist as a complex combination in the organic matter function. It becomes available to crops after breaking down to simpler forms followed by mineralization. Hence, easily oxidizable organic carbon and mineralizable Nitrogen are considered to be quiet satisfactory as index of Nitrogen available in soil.

Generally in soil testing laboratory, organic carbon is used to know the status of available Nitrogen. In soil, Nitrogen generally occurred in the form of organic compound, Ammonium and Nitrates. The ammonia is liberated after digestion and distillation using Kjeldahl Method and the ammonia is determined by titration and serves as an index of the available Nitrogen status

Table - 5.28. Seasonal variation of Total Nitrogen content

Sample No:	Jan-07	April-07	July-07	Nov-07	Jan-08	April-08	July-08	Nov-08
	Total N_2 (%)	**Total N_2 (%)**	**Total N_2 (%)**	**Total N_2 (%)**	**Total N_2 (%)**	**Total N_2 (%)**	**Total N_2 (%)**	**Total N_2 (%)**
1	0.81	0.81	1.06	0.9	0.84	0.72	0.95	0.87
2	0.73	0.5	1	0.87	0.78	0.53	0.9	0.59
3	0.59	0.7	0.87	0.72	0.67	0.67	0.81	0.64
4	0.76	0.25	1.14	0.95	0.87	0.78	0.95	0.81
5	0.78	1.09	1.18	1	0.95	1.06	1.06	0.81
6	0.81	1.12	1.2	1.06	0.9	1.09	0.9	0.84
7	0.67	0.25	1.03	0.78	0.81	0.14	0.95	0.64
8	0.62	0.98	1.14	0.81	0.7	0.87	1.09	0.7
9	0.7	1.09	1.26	0.78	0.64	0.98	1.18	0.77
10	0.76	0.81	1.29	0.84	0.81	0.78	1.2	0.78
11	0.84	0.78	1.15	1.06	1	0.72	0.9	0.9
12	0.9	0.87	1.04	0.87	0.78	0.81	0.98	0.92
13	0.7	0.92	0.87	0.78	0.59	0.9	0.78	0.64
14	0.87	0.76	1	0.92	0.87	0.67	0.98	0.81
15	0.78	0.73	0.9	0.95	0.9	0.62	0.87	0.87
16	0.9	0.9	1.09	1.03	0.98	0.81	1.06	0.98
17	0.72	1.15	1.18	0.89	0.98	1.04	1.12	0.78
18	0.78	1.18	1.09	0.95	0.7	1.06	1.14	0.87
19	0.56	1.2	0.92	0.75	0.73	0.87	0.95	0.57
20	0.61	1.26	0.84	0.7	0.59	1.15	0.87	0.64
21	0.81	1	0.81	0.61	0.53	0.95	0.78	0.84
22	0.59	0.98	0.87	0.72	0.64	0.92	0.84	0.53
23	0.62	0.5	0.78	0.81	0.73	0.59	0.7	0.67
24	0.7	0.76	0.87	0.76	0.67	0.7	0.78	0.76
25	0.64	0.95	0.81	0.7	0.59	0.67	0.72	0.7
Mean	0.73	0.86	1.01	0.85	0.77	0.8	0.94	0.76

Potassium:

Exchangeable K is the major sources of K to plants. It is present in relatively large quantities in most soils, averaging about 1.9%. The various forms of K in soils can be classified on the basis of availability in three general groups.

Unavailable	-	90 – 98% of the total soil K
Slowly available	-	1 – 10%
Readily available	-	0.1 – 2%

A relatively small portion of total K in soils is exchangeable (approximately 1%) Exchangeable K ranges from <100 to 2000ppm 0r more compared with total K value in order of 1 to 2 %.

Table - 5.29. Seasonal variation of Exchangeable Potassium

Sample No:	Jan-07	April-07	July-07	Nov-07	Jan-08	April-08	July-08	Nov-08
	K (Kg/ha)	**K (Kg/ha)**	**K (Kg/ha)**	**K (Kg/ha)**	**K (Kg/ha)**	**K (Kg/ha)**	**K (Kg/ha)**	**K (Kg/ha)**
1	274.4	257.6	520.8	392	257.6	247.52	471.52	358.4
2	280	280	369.6	442.4	274.4	249.76	347.2	408.8
3	319.2	280	257.6	420	285.6	240.8	224	364
4	358.4	336	336	392	369.6	319.2	313.6	347.2
5	291.2	240.8	352.8	520.8	302.4	229.6	235.2	476
6	274.4	257.6	408.8	560	257.6	246.4	212.8	504
7	257.6	224	420	520.8	291.2	201.6	224	459.2
8	324.8	280	408.8	481.6	280	218.4	218.4	431.2
9	313.6	308	280	520.8	308	280	257.6	470.4
10	218.4	201.6	392	616	224	196	201.6	571.2
11	364	336	420	481.6	386.4	319.2	218.4	448
12	268.8	240.8	369.6	392	190.4	263.2	207.2	403.2
13	207.2	224	392	593.6	240.8	240.8	369.6	470.4
14	268.8	280	481.6	420	274.4	274.4	470.4	425.6
15	240.8	224	520.8	442.4	224	218.4	448	386.4
16	369.6	336	240.8	481.6	347.2	308	235.2	431.2
17	313.6	308	308	481.6	291.2	291.2	257.6	436.8
18	246.4	240.8	224	520.8	235.2	246.4	228.48	470.4
19	280	257.6	240.8	504	263.2	229.6	217.28	464.8
20	296.8	308	224	632.8	240.8	274.4	211.68	588
21	431.2	520.8	420	520.8	352.8	453.6	377.44	408.8
22	291.2	257.6	408.8	392	246.4	268.8	383.04	347.2
23	263.2	201.6	392	593.6	218.4	212.8	353.92	520.8
24	330.4	280	408.8	632.8	207.2	263.2	356.16	599.2
25	240.8	224	336	347.2	196	218.4	313.6	464.8
Mean	292.99	276.19	365.34	492.13	270.59	260.467	294.157	450.24

Table - 5.30. Seasonal variation of Available Phosphorus

Sample No:	Jan-07	April-07	July-07	Nov-07	Jan-08	April-08	July-08	Nov-08
	P (Kg/ha)	**P (Kg/ha)**	**P (Kg/ha)**	**P (Kg/ha)**	**P (Kg/ha)**	**P (Kg/ha)**	**P (Kg/ha)**	**P (Kg/ha)**
1	1.34	1.16	0.44	1.43	1.16	2.78	0.71	1.16
2	1.07	0.89	0.44	1.07	1.98	4.06	0.35	0.98
3	1.07	0.26	0.53	2.27	0.98	4.48	0.53	3.16
4	1.43	0.89	0.35	4.16	1.07	4.06	0.98	2.37
5	0.26	0.62	0.53	2.06	2.16	3.16	0.62	3.27
6	0.26	0.71	0.71	1.98	1.8	1.37	0.53	4.06
7	0.44	1.34	0.53	1.16	2.68	1.07	0.44	0.98
8	0.44	1.25	0.26	1.34	0.71	2.18	0.35	1.07
9	0.26	0.53	0.08	1.07	0.44	1.16	0.53	0.98
10	0.26	1.61	0.26	1.98	2.27	1.07	0.44	4.06
11	0.35	1.61	0.26	3.06	2.68	1.34	0.17	3.27
12	0.44	1.25	0.35	3.06	3.16	1.16	0.26	3.16
13	0.98	0.80	0.17	1.98	0.89	2.27	0.35	4.06
14	1.16	0.71	0.44	2.68	0.98	1.98	0.35	4.48
15	1.43	0.89	3.22	3.16	1.07	1.07	0.98	3.27
16	0.71	0.35	2.50	3.27	5.37	1.25	1.52	2.16
17	1.16	0.53	1.25	4.06	4.06	1.16	1.16	3.16
18	1.43	0.71	0.98	1.98	3.06	1.16	7.16	4.06
19	0.71	0.89	1.07	1.98	1.07	4.06	0.98	0.89
20	1.16	1.52	1.25	1.07	1.25	1.34	1.07	0.98
21	1.34	1.07	1.16	4.06	1.16	0.98	8.06	3.27
22	1.25	0.89	0.71	2.16	1.07	4.06	0.62	3.27
23	0.89	1.16	0.44	4.06	0.98	1.98	0.53	3.16
24	1.16	0.53	0.53	1.89	1.89	1.07	0.44	4.16
25	0.98	1.16	0.80	3.16	4.06	2.29	0.71	3.37
Mean	0.87	0.93	0.77	2.40	1.92	2.10	1.19	2.75

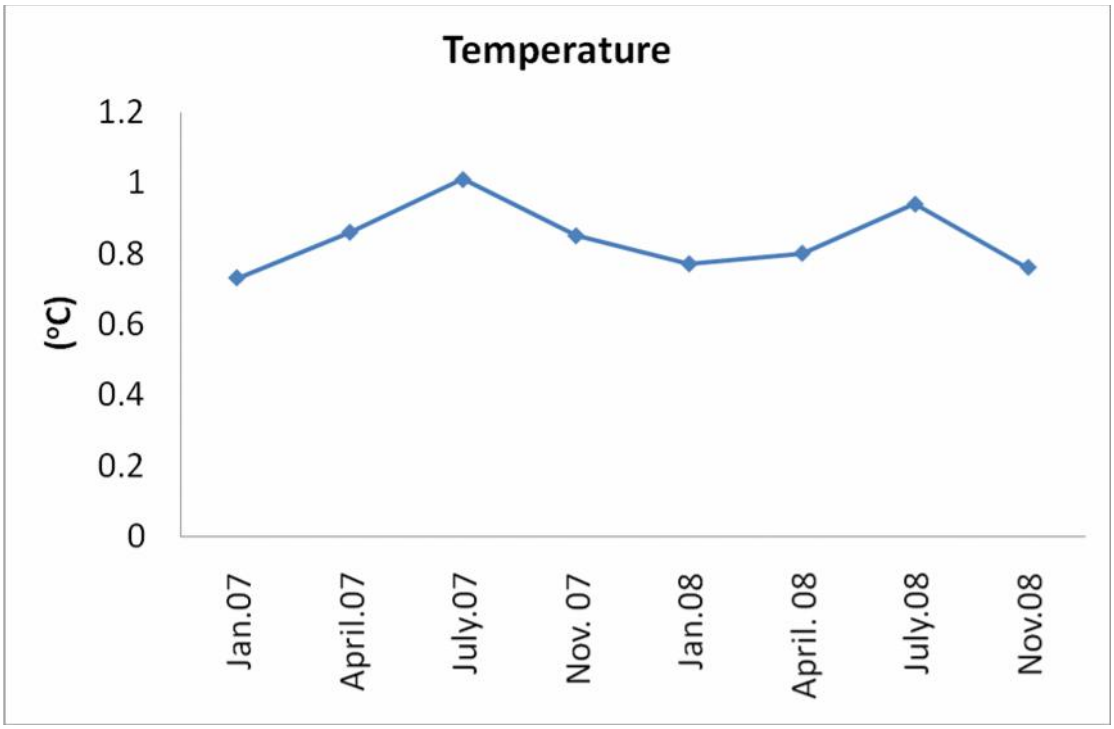

Fig. 5.4. **Mean seasonal variation of temperature of the study area**

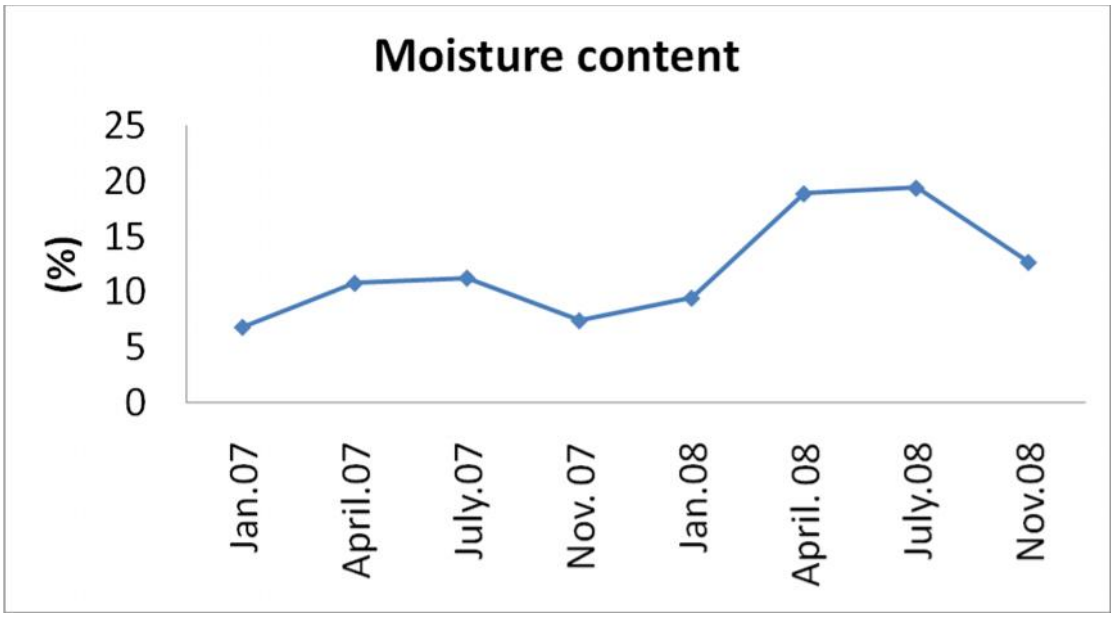

Fig. 5.5. **Mean seasonal variation of moisture content of the study area**

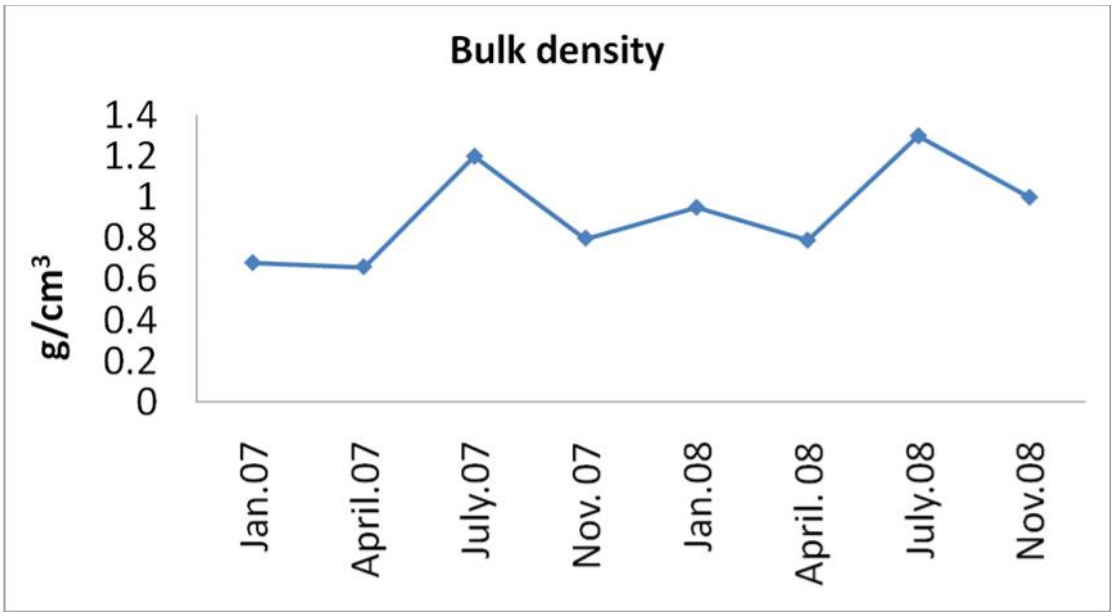

Fig. 5.6. **Mean seasonal variation of bulk density of the study area**

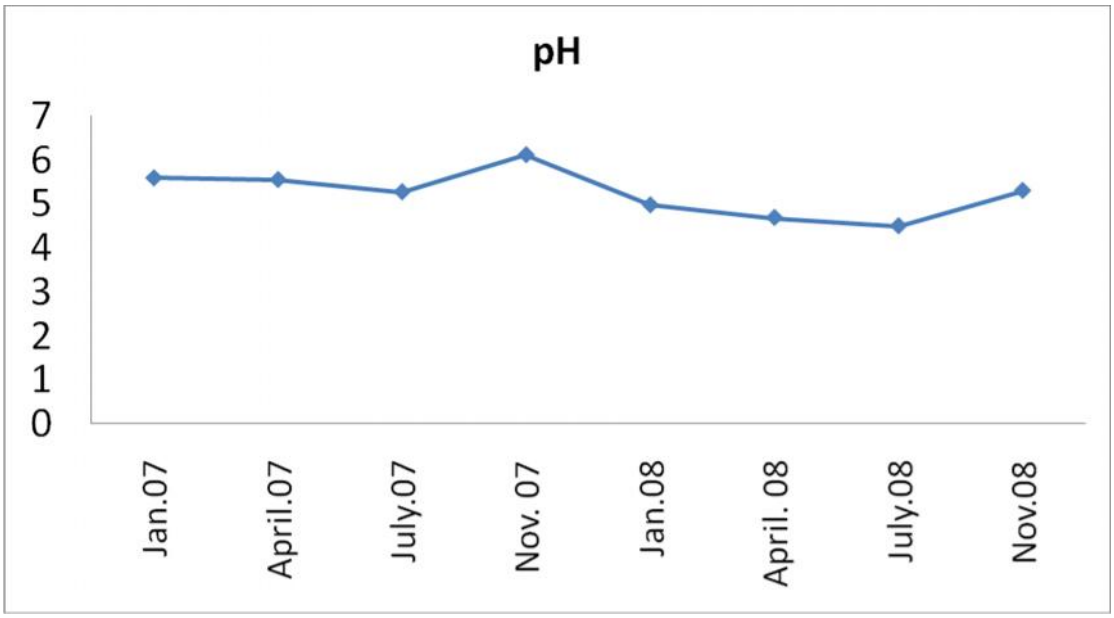

Fig. 5.7. **Mean seasonal variation of pH of the study area**

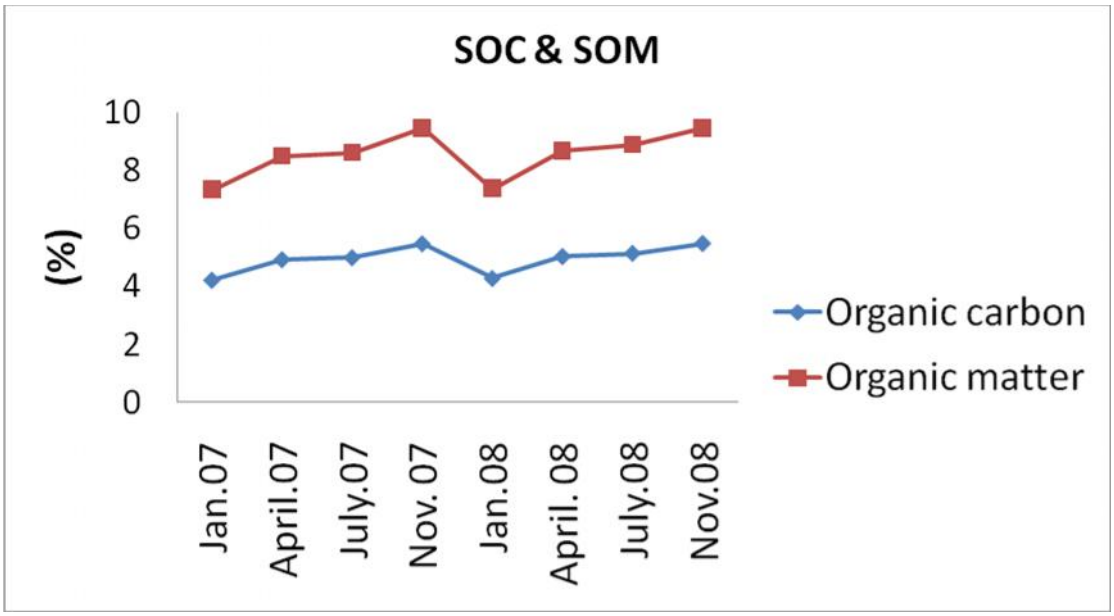

Fig. 5.8. **Mean seasonal variation of SOC and SOM of the study area**

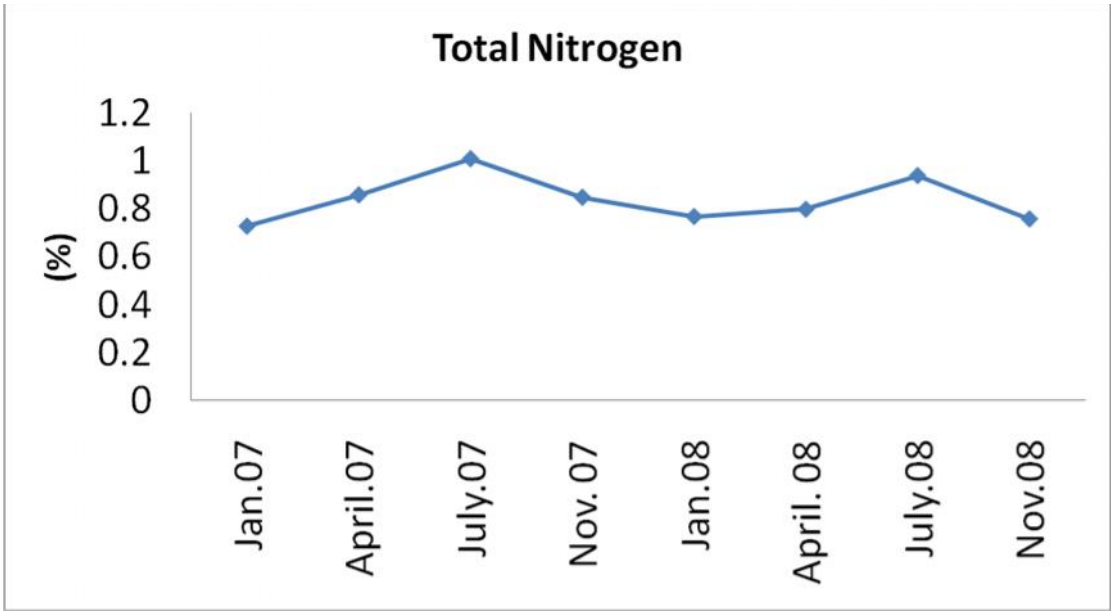

Fig. 5.9. **Mean seasonal variation of total nitrogen content of the study area**

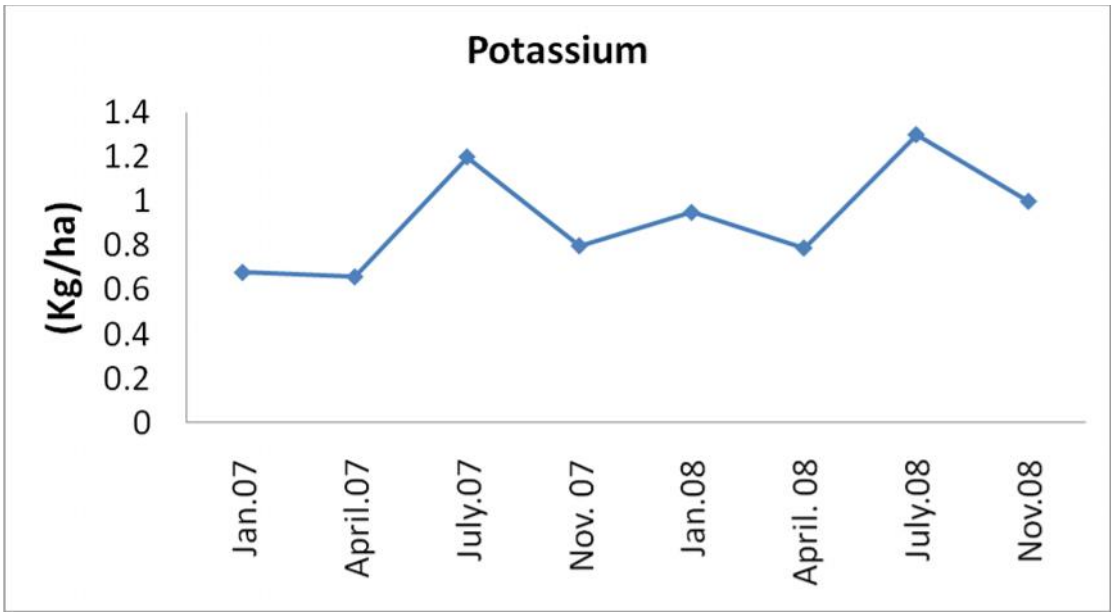

Fig. 5.10. Mean seasonal variation of exchangeable potassium

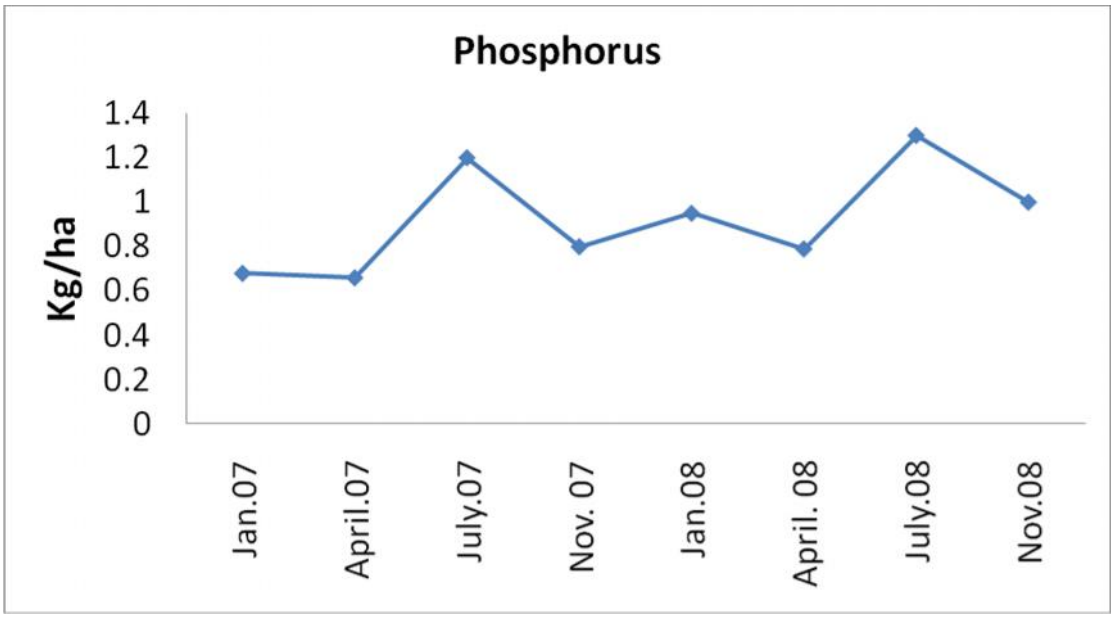

Fig. 5.11. Mean seasonal variation of available phosphorus of the study area

5.4. Socio- econonomic status

The general profile that is the demographic and occupation data of the 5 villages as already been shown in **Table - 4.1.** Among the 5 villages Maite has the highest population which has 971 inhabitants and Lenchim has the lowest population which has only 365 inhabitants. 92% of the families are depending on jhum farming in the 5 villages and the rest 8% are engaged in Govt., small business and cottage industries.

In the adjoining villages of Tawi Wildlife Sanctuary *viz.,* Hmuntha, Maite, Tawizo Hualtu and Lenchim all the inhabitants are Mizo. Each village is under the rule of 1 Village Council. As seen in **Table - 4.2** the local institutional level is still backward, there is only 1 Govt. primary School, 1 Govt. Middle School in each of the villages ,1 High School (Govt. aided) in Hmuntha and Hualtu and 1 Private High School in Maite. So, setting up of at least a Higher Secondary School is in great need.

No industry has been set up so far in all of the villages except there is two cottage industry (Furniture Workshop) in Lenchim and one in Hualtu. **Table - 4.3** represents the standard of living and social welfare services. All the houses in Hmuntha, Maite and Lenchim are electrified. Only 2 houses are not electrified out of 80 houses in Tawizo and 12 houses are not electrified out of 162 houses in Hmuntha. Apart from Tawizo and Lenchim more than half of the families have LPG connection as the Environment & Forest Dept. had distributed LPG connection under the programme of Forest Development Agency. But the use of firewood is still popular even among the LPG holder families because of the poor condition of roads; transportation is a big hindrance as it is difficult to replace the cylinder once it is used up. So, it is clear that majority of the families are still depending on fuelwood for

cooking. Regarding the water supply, there are many water points in all of the four villages so scarcity of water is not a problem accept during the very dry seasons. The people living in these villages are hard working so their socio-economic conditions are not very low comparing to many villages in Mizoram.

Biodiversity is essential for human survival and economic well being and also for the ecosystem function and stability (Singh 2002). In India, habitat destruction, over exploitation, pollution and species introduction are identified as major causes of biodiversity loss.

1. Agriculture

Majority of the people *i.e.,* 92% of the surrounding 5 villages depend on agriculture and related activities connected to land. The vegetables were grown using seeds produced from the previous season. All cultural operations were manual and seeds were line sown. Agriculture is practiced for sustenance. The agriculture production system in the region is mostly monocropped and at a subsistence level. The cropping pattern in the region is characterized by predominance of rice as the food crop. The productivity of total vegetables in Mizoram which is only 2.0 MT/Ha (IHD 2005) is quite low as compared to the national average productivity. Vegetables, besides providing nutritional security, are also major source of income especially for small and marginal farmers. The vegetable crops, apart from higher productivity and high value produce, provide more food per unit time and area can improve the economic condition of the growers as compared to cereal crops. Hence, they are becoming a potential commodity to provide economic security to the resource poor farmers of the country. Newly developed short duration varieties crops like cabbage, tomato, capsicum, pea, french bean, etc. fit in the fold. The scope for horizontal

expansion of area is very much limited for want of suitable land and thus the only option available is to increase the productivity. (Rai, N. *et al*., 2008). The common agricultural crops grown in the adjoining 5 villages are shown in **Table – 5.37**. Some of the common crops are *Oryza collina, Allium hookeri, Brassica juncea, Capsicum annum, Colocasia esculenta, Cucumis melo, Cucumis sativus, Cucurbita maxima, Glycine max, Manihot esculenta, Sorghum cernuum, Trichosanthes angiuna, Vignia unguiculata, Zea mays, Zingiber officinale.*

The crops, which are neither grown commercially on large scale nor traded widely, may be termed as underutilized horticultural crops (UUHC). These crops are cultivated, traded and consumed locally.The popularity of these horticultural crops varies from crop to crop and locality to locality, which however, can be enhanced to a greater extent through publicity. The underutilized horticultural crops (UUHC) have many merits. These are easier to grow and hardy in nature, producing a crop even under adverse soil and climatic conditions. Most of them are very rich sources of vitamins, minerals, and other nutrients such as carbohydrates, proteins and fats. Moreover, these are cheap and readily available. The horticultural crops are contributing 3.14% of the total geographical area of the North East region. The region is one of the richest reservoirs of genetic variability and diversity of different horticultural crops, which exist in plant types, morphological and physiological variations, reactions to diseases and pests, adaptability and distribution. (Rai, N. *et al.,* 2005). There are 28 species of fruit plants found in the surrounding five villages. These fruit plants fall under underutilized horticultural crops (UUHC). These are *Annona squamosa, Artocarpus heterophyllus, Carallia brachiata, Citrus grandis, Citrus macroptera, Elaeagnus caudate, Myrica esculenta, Prunus domestica, Prunus persica, Psidium guajava, Pyrus communis, Rubus accuminatus, Protium serratum,*

Garcinia lanceaefolia, Embelia vestita, Cyathocalyx martabanicus, Emblica officinalis, Haematocarpus thomsoni, Euphoria longan, Baccaurea ramiflora, Garcinia sopsopia, Pentanura khasiana, Prunus undulata, Prunus jenkinsii. The detailed local name, family, common name and place of occurrence are listed in **Table - 5.39.**

From the above result, it shows that the study area is rich in plant diversity and has a large number of underutilized horticultural crops. So for the development of these crops domestication of potential wild species through homestead cultivation should be encouraged for avoiding over-exploitation from natural sources. Supports are required in terms of multiplication of planting materials and their distribution besides providing market access through marketing network for perishables. Rapid expansion of infrastructure facilities with priority on market development, transport and communication needs to be done. At the very onset, there is a necessity to make the farming community aware about the nutritional importance of unexploited horticultural crops, *i.e.,* fruits, vegetables and medicinal plants. (Sharma 2003). For this, use of mass media like radio, TV, newspaper and other printed literature can play an effective role in creating awareness among the farmers. For proper exploitation and better economic returns from underutilized horticultural crops emphasis should be given on developing processing units in this area. It would also provide employment opportunities to the villagers.

2. Livestock

Regarding the livestock, animal rearing in the 5 villages is dominated by piggery and poultry. 59% of the villagers are engaged in poultry and 90% of the families in the 5 villages are also engaged in poultry. Cattles are owned by few families and none

of the villagers was having large cattle herd size. Veterinary services are not available from the veterinary dispensaries of Mizoram state Govt. to all the farmers.

3. Timber and fuel wood

There is only one cement concrete house in Hualtu. 97% of the houses in the 5 villages are wooden houses with tin-roofs and the rest are wooden houses with thatched-roofs. Construction of these wooden houses and their regular maintenance under the prevalent climatic conditions consumed timber species. 18 timber species are recorded from the 5 villages; their details can be seen in **Table - 5.31.** These timber species includes *Acrocarpus fraxinifolius, Alseodaphne petiolaris, Artocarpus chaplasha, Artocarpus heterophyllus, Bombax insigne, Calophyllum polyanthum, Cephalotaxus griffithii, Choerospondias axillaris, Chukrasia velutina, Cinnamomum tamala, Duabanga grandiflora, Mangifera indica, Michelia champaca, Michelia doltsopa, Phoebe lanceolata, Garunga floribunda, Terminalia bellirica, Terminalia myriocarpa.*

As discussed earlier in the standard of living, half of the households have LPG connection the use of firewood is still popular even among the LPG holder families because of the poor condition of roads; transportation is a big hindrance as it is difficult to replace the cylinder once it is used up. So, majority of the families are still depending on fuelwood for cooking. Besides these, large amount of fuel wood are extracted for making charcoal which are sold to the cities and provides an important source of income for the poor villagers. 23 fuel wood are recorded from the adjoining 5 villages of Tawi Wildlife Sanctuary as listed in **Table - 5.32.** The fuel wood species are *Albizzia procera, Callicarpa arborea, Castanopsis echinocarpa, Castanopsis indica, Castanopsis tribuloides, Derris robusta, Eleocarpus lanceaefolius, Eriobotrya bengalensis, Eurya cerasifolia, Glochidion velutinum, Lithocarpus dealbata,*

Lithocarpus pachyphylla, Litsea lancifolia, Macaranga indica, Lithocarpus elegans, Quercus glauca, Quercus helferiana, Quercus leucotrichophora, Quercus dilatata , Quercus polystachya, Schima wallichii, Syzygium cuminii, Wendlendia grandis.

4. Medicinal Plants

Medicinal and aromatic plants play a very important role in the life support systems and well being of mankind. They are local inheritance of worldwide importance (Purohit, 2004)

The plant parts used for different purposes were bark, flower, fruit, leaf, root, rhizome, tuber, seed, shoot etc. and in some case the whole plant is utilized. The medicinal plant species were utilized to treat diseases like fever, headache, cough, intestinal pain, stomachache, skin diseases etc. Some plant species were also used as tonic, astringent, antidote etc. The preparation methods include decoction, juice, root powder and leave extract.

The present study area has high number of commercially exploitable medicinal species; 22 species are recorded as listed in **Table - 5.33** which are *Aporusa octandra, Bergenia ciliata, Blumea lanceolaria, Cassia nodosa, Centella asiatica, Costus speciosus, Dillenia pentagyna, Embelia ribes, Haldinia cordifolia, Hedyotis scandens, Helicia robusta, Lepionurus sylvestris, Lindernia ruellioides, Mimosa pudica, Oroxylum indicum, Osbeckia chinensis, Phyllanthus urinaria, Securinega virosa, Senecio scandens, Smilax glabra, Vitex peduncularis, Zanonia indica.*

Harvesting medicinal plants can have a positive or negative impact on the conservation of biodiversity (Bhattarrai 1996). The area contains highly valuable medicinal plants, which have good market demand and they are illegally digged from the forests and sold. It has been known that people from Burma used to come to the

villages looking for orchids which were collected by the villagers and sell to these people. Though local people do not have much scientific knowledge on sustainable harvesting of these resources, they are familiar with with habitat specificity and phenology of plants. Due to poverty in the present area, people are compelled to over harvest resources for commercial purpose.

Medicinal plants local available are utilized by people because of their belief in these plants and ease of their accessibility. Therefore, for conservation of over exploited medicinal and other commercially important plant species in the study area, it is mandatory to prepare their inventory and study habitats, distribution, indigenous use and their current status.

5. Edible Plants

It also harbours many edible plants **(Table - 5.34)** which includes *Dysoxylum gobara, Amomum dealbatum, Gynura bicolor, Amaranthus spinosus, Marsdenia formosana, Acacia pennata, Lepionurus sylvestris, Crotolaria tetragona, Musa spp., Parkia timoriana, Trevesia palmata* and a great variety of edible *Agaricus spp.* Besides these fresh bamboo shoots like *Bambusa tulda, Dendrocalamus hamiltonii, Dendrocalamus longispathus, Melocanna baccifera* were collected for daily subsistence.

Since the people living in and around the sanctuary depends on forest sources as sources of their livelihood and it is being recognized that no legal provision can be effective unless local communities are involved in planning and monitoring conservation programs. Hence the local communities should be involved by the Forest Department in conservation programs launched by them.

6. Bamboos, Canes and Palms

The study area is also rich in canes and palms species which are of great economic value. As listed in **Table - 5.36.** 14 species of bamboos are recorded which are *Bambusa khasiana, Bambusa tulda, Arudinaria collosa, Dendrocalamus hamiltonii, Dendrocalamus hookeri, Dendrocalamus manipurianus, Dendrocalamus strictus, Dinochloa compactiflora, Melocanna baccifera, Pseudostachynum polymorphum, Schizostachyum capitatum, Dendrocalamus longispathus, Schizostachyum dulloa, Sinarundinaria falcata.* Besides bamboos a great variety of canes and palms listed in **Table - 5.35**. are also present which includes *Arenga pinnata, Calamus acanthospathus, Calamus erectus, Calamus flagellum, Calamus gracilis, Calamus guruba, Calamus tenuis, Calamus khasianus, Caryota mitis, Caryota urens, Zalacca secunda.*

Bamboos, canes and palms are commercial multipurpose species that has tremendous potential of production. Bamboo based industries and usage of bamboo and canes products are innumerable. It is also very highly economic species.

From the above discussion it is clear that the day to day need of forest resources has increased the pressure on forest trees and shrubs and herbs to a great extent. Futhermore, the over-exploitation of species for fuel, timber for house construction, medicine, food (wild edibles) may lead to the extinction of species from the area. Therefore, there is a need to develop adequate strategy and action plan for the conservation and manangement of habitats and species so that sustainable utilization of the species could be ensured.

Table - 5.31. Timber species

Sl. No	Local Name	Botanical Name	Family	Common/English Name	Place of occurrence
1	Nganbawm	*Acrocarpus fraxinifolius*	Caesalpiniaceae	Mundani	HM,M,HU,T,L
2	Khuangthulh	*Alseodaphne petiolaris*	Lauraceae	-	M, HU, T
3	Tatkawng	*Artocarpus chaplasha*	Moraceae	Chaplash	HM,HU,T,L
4	Lamkhuang	*Artocarpus heterophyllus*	Moraceae	Jack fruit tree	HM
5	Pang	*Bombax insigne*	Bombadaceae	Didu	HM, M, HU, T, L
6	Sentezel	*Calophyllum polyanthum*	Guttiferae	Poon	HM, M, HU, T
7	Tufar	*Cephalotaxus griffithii*	Taxaceae	Plum-yew	HM
8	Theikuangchawm	*Choerospondias axillaris*	Anacardiaceae	Labshi	M, T
9	Zawngtei	*Chukrasia velutina*	Meliaceae	Chuckrassy	M, T
10	Tespata	*Cinnamomum tamala*	Lauraceae	-	M
11	Zuang	*Duabanga grandiflora*	Lythraceae	Lampati	HM, M, HU,T, L
12	Theihai	*Mangifera indica*	Anacardiaceae	-	HM
13	Ngiau	*Michelia champaca*	Magnoliaceae	Golden champa	HM, M, HU, T, L
14	Zongiau	*Michelia doltsopa*	Magnoliaceae	-	M, HU, T,
15	Bul	*Phoebe lanceolata*	Lauraceae	-	HM, M, HU, T,L
16	Tuairam	*Garunga floribunda*	Burseraceae	-	L
17	Thingvandawt	*Terminalia bellirica*	Combretaceae	-	M, HU,T,
18	Char	*Terminalia myriocarpa*	Combretaceae	-	HM, M, H, T, L

Table - 5.32. Fuelwood species

Sl. No	Local Name	Botanical Name	Family	Common/English Name	Place of occurrence
1	Kangtek	*Albizzia procera*	Mimosaceae	White siris	HM, HU
2	Hnahkiah	*Callicarpa arborea*	Verbenaceae	-	HM
3	Thenngo	*Castanopsis echinocarpa*	Fagaceae	-	HU
4	Sehawr	*Castanopsis indica*	Fagaceae	Chestnut	HM,T
5	Thingsia	*Castanopsis tribuloides*	Fagaceae	-	HM,HU
6	Thingkha	*Derris robusta*	Papilionaceae	-	M, T, L
7	Kharuan	*Eleocarpus lanceaefolius*	Tiliaceae	-	M
8	Nghalchhun	*Eriobotrya bengalensis*	Rosaceae	-	M, T
9	Sihneh	*Eurya cerasifolia*	Theaceae	-	HM,M,HU
10	Thingpawnchhia	*Glochidion khasicum*	Euphorbiaceae	-	M, T
11	Fah	*Lithocarpus dealbata*	Fagaceae	-	HM, M, HU,T, L
12	Thensen	*Lithocarpus pachyphylla*	Fagaceae	-	HU
13	Hnahpawte	*Litsea lancifolia*	Lauraceae	-	M,T
14	Hnahkhar	*Macaranga indica*	Euphorbiaceae	-	HM, M, HU, T, L
15	Thingpuithing	*Lithocarpus elegans*	Fagaceae	-	M, T
16	Hrumhriau	*Quercus glauca*	Fagaceae	-	M, T
17	Hlai	*Quercus helferiana*	Fagaceae	-	HM, M, HU, T
18	Then	*Quercus leucotrichophora*	Fagaceae	Ban oak	M, T

19	Thal	*Quercus dilatata*	Fagaceae	Indian oak	M, T
20	Thil	*Quercus polystachya*	Fagaceae	-	HM, M, HU, T, L
21	Khiang	*Schima wallichii*	Theaceae	Needle wood	HM, M, T, L
22	Lenhmui	*Syzygium cuminii*	Myrtaceae	-	M, T
23	Batling	*Wendlendia grandis*	Rubiaceae	-	M, HU, T

Table - 5.33. Medicinal Plants

Sl. No	Local Name	Botanical Name	Family	Common/ English Name	Place of occurrence
1	Chhawntual	*Aporusa octandra*	Euphorbiaceae	-	HU, T
2	Khamdamdawi	*Bergenia ciliata*	Saxifragaceae	Stone crusher plant	HM, M, HU, T
3	Buarze	*Blumea lanceolaria*	Compositae	-	HM, M, HU, T
4	Makpazangkang	*Cassia nodosa*	Caesalpinaceae	Pink&white shower	M
5	Lambak	*Centella asiatica*	Umbelliferae	Indian pennyworth	HM, M, HU, T
6	Sumbul	*Costus speciosus*	Zingiberaceae	Kew	HM, M, HU, T
7	Kaihzawl	*Dillenia pentagyna*	Dilleniaceae	Dillenia or Karmal	HU, T, L
8	Naufadawntuai	*Embelia ribes*	Myrsinaceae	Bidang	HU, M
9	Lungkhup	*Haldinia cordifolia*	Rubiaceae	Haldu	M, T
10	Kelhnamtur	*Hedyotis scandens*	Rubiaceae	-	HM, M, HU,T, L
11	Pasaltakaza	*Helicia robusta*	Proteaceae	-	HM, M, HU, T, L
12	Anpangthuam	*Lepionurus sylvestris*	Olacaceae	-	HU
13	Thasuih	*Lindernia ruellioides*	Scrophulariaceae	-	HM, M, HU, T, L

14	Hlonuar	*Mimosa pudica*	Mimosaceae	Touch me not	HU
15	Archangkawm	*Oroxylum indicum*	Bignoniaceae	Trumpet flower	M, T
16	Builukhampa	*Osbeckia chinensis*	Melastomaceae	-	M
17	Mitthi sunhlu	*Phyllanthus urinaria*	phorbiaceae	-	HM, M, HU, T
18	Saisiak	*Securinega virosa*	Euphorbiaceae	-	HM, M, HU, T
19	Saiekhlo	*Senecio scandens*	Compositae	-	T, L
20	Tluangngil	*Smilax glabra*	Liliaceae	-	HU, L
21	Thingkhawilu	*Vitex peduncularis*	Verbenaceae	-	M, T
22	Lalruanga dawibur	*Zanonia indica*	Cucurbitaceae	Cart-track plant	HM, M, HU

Table - 5.34 Edible Plants

Sl. No	Local Name	Botanical Name	Family	Common/English Name	Place of occurrence
1	Changelpa	*Agaricus sp.*	Agaricaceae	-	M, T, L
2	Luangpa	*Agaricus sp.*	Agaricaceae	-	HM, M, HU, T, L
3	Maupa	*Agaricus sp.*	Agaricaceae	-	HM, M, HU, T, L
4	Pa-ar-dang	*Agaricus sp.*	Agaricaceae	-	HM, M, HU, T
5	Pachang	*Agaricus sp.*	Agaricaceae	-	HM, M, HU, T,L
6	Papar	*Agaricus sp.*	Agaricaceae	-	HM, L
7	Pasawntlung	*Agaricus sp.*	Agaricaceae	-	HM, M, HU, T, L
8	Pasi	*Agaricus sp.*	Agaricaceae	-	HM, M, HU, T, L
9	Pauithin	*Agaricus sp.*	Agaricaceae	-	HM, N, HU, T
10	Aidu	*Amomum dealbatum*	Zingiberaceae	-	HM, M, HU, T, L
11	Rawthing	*Bambusa tulda*	Poaceae	Bamboo shoot	HM, M, HU, T, L

12	Hruipui	*Calamus flagellum*	Arecaceae	-	HM, M, L
13	Tum	*Caryota urens*	Arecaceae	-	HM, M, L
14	Phulrua	*Dendrocalamus hamiltonii*	Poaceae	Bamboo shoot	HM, M, HU, T, L
15	Rawnal	*Dendrocalamus longispathus*	Poaceae	Bamboo shoot	HM, M HU, T, L
16	Thingthupui	*Dysoxylum gobara*	Meliaceae	-	HM, M, HU, T, L
17	Tlangnal	*Gynura bicolor*	Compositae	-	M, T
18	Mautak	*Melocanna baccifera*	Poaceae	Bamboo shoot	HM, M, HU, T, L
19	Lenhling	*Amaranthus spinosus*	Amaranthaceae	Prickly amaranth	HU, T
20	Ankhapui	*Marsdenia formosana*	Asclepiadaceae	-	HU, L
21	Khanghu	*Acacia pennata*	Mimosaceae		HM, M, HU, T, L
22	Anpangthuam	*Lepionurus sylvestris*	Olacaceae	-	HM,HU
23	Tumthang	*Crotolaria tetragona*	Papilionaceae	-	HU,HM
24	Tumbu	*Musa sp.*	Musaceae	-	HM, M, HU, T, L
25	Zawngtah	*Parkia timoriana*	Mimozaceae		HM, M, HU, T, L
26	Kawhtebel	*Trevesia palmata*	Araliaceae	-	HM, M, HU, T, L

Table - 5.35. Canes and Palms

Sl. No	Local Name	Botanical Name	Family	Common/English Name	Place of occurrence
1	Thangtung	*Arenga pinnata*	Arecaceae	Malay Sago Palm	HM, M, HU, T, L
2	Thilte	*Calamus acanthospathus*	Arecaceae	-	M, HU, T, L
3	Thilthek	*Calamus erectus*	Arecaceae	-	HM, M, HU, T
4	Hruipui	*Calamus flagellum*	Arecaceae	-	HM, M, HU, T, L

5	Kawrtai	*Calamus gracilis*	Arecaceae	-	HM, M, HU, T, L
6	Taite/Tairua	*Calamus guruba*	Arecaceae	Sundi bet	M, HU, T
7	Changdam	*Calamus tenuis*	Arecaceae	-	HU, T, L
8	Mawt	*Calamus khasianus*	Arecaceae	-	HM, M, HU, T, L
9	Meihle	*Caryota mitis*	Arecaceae	-	M, T
10	Tum	*Caryota urens*	Arecaceae	-	HU, L
11	Hruitung	*Zalacca secunda*	Arecaceae	-	M, HU, T, L

Table - 5.36. Bamboos

Sl. No	Local Name	Botanical Name	Family	Place of occurrence
1	Rawte	*Bambusa khasiana*	Poaceae	HM, M, HU, T
2	Rawthing	*Bambusa tulda*	Poaceae	HM, M, HU, T, L
3	Phar	*Arudinaria collosa*	Poaceae	HM, M, HU, T, L
4	Phulrua	*Dendrocalamus hamiltonii*	Poaceae	HM, M, HU, T, L
5	Rawlak	*Dendrocalamus hookeri*	Poaceae	HM, M, HU, T
6	Rawchhechang	*Dendrocalamus manipurianus*	Poaceae	M, T
7	Tursing	*Dendrocalamus strictus*	Poaceae	M
8	Sairil	*Dinochloa compactiflora*	Poaceae	HM, M, HU, T, L
9	Mautak	*Melocanna baccifera*	Poaceae	HM, M, HU, T, L
10	Chal	*Pseudostachynum polymorphum*	Poaceae	HM, M, HU, T, L
11	Rawngal	*Schizostachyum capitatum*	Poaceae	HM, M, HU, T, L

12	Rawnal	*Dendrocalamus longispathus*	Poacaea	HM, M
13	Rawthla	*Schizostachyum dulloa*	Poaceae	HU, L
14	Lik	*Sinarundinaria falcata*	Poaceae	M, HU, T

Table - 5.37. Agricultural crops

Sl. No	Local Name	Botanical Name	Family	Common/ English Name	Place of occurrence
1	Bawrhsaiabe	*Abelmoschus esculentus*	Malvaceae	Lady's finger	M, L
2	Mizo purun	*Allium hookeri*	Liliaceae	-	HM, M, HU, T
3	Maipawl	*Benincasa hispida*	Cucurbitaceae	Ash pumpkin	M
4	Zikhlum	*Brassica capitata*	Cruciferae	Cabbage	HM, L
5	Brokoli	*Brassica italica*	Cruciferae	Brocolli	HM, M
6	Antam	*Brassica juncea*	Cruciferae	Indian mustard	HM, M, HU, T
7	Hmarcha	*Capsicum annum*	Solanaceae	Chilli	HM, M, HU, T
8	Coffee	*Coffea arabica*	Rubiaceae	Coffee	HM, M, T
9	Bal	*Colocasia esculenta*	Aracaceae	Toro	HM, M, HU,T
10	Hmazil	*Cucumis melo*	Cucurbitaceae	Sweet melon	HM, M, HU, T, L
11	Fanghma	*Cucumis sativus*	Cucurbitaceae	Cucumber	HM, M, HU, T, L
12	Mai	*Cucurbita maxima*	Cucurbitaceae	Pumpkin	HM, M, HU, T, L
13	Bekang	*Glycine max*	Papilionaceae	Soyabean	HM, M, HU
14	Kawlbahra	*Ipomoea batatas*	Convolvulaceae	Sweet potato	M
15	Tomato	*Lycopersicon esculentum*	Solanaceae	Tomato	M

16	Pangbal	*Manihot esculenta*	Euphorbiaceae	Tapioca	HM, M, HU, T
17	Changkha	*Momordica charantia*	Cucurbitaceae	Bitter gourd	M
18	Vaihlo	*Nicotiana tabacum*	Solanaceae	Tobacco plant	HU
19	Buh	*Oryza collina*	Oryzeae	Paddy	HM, M, HU, T, L
20	Bepuipawr	*Psophocarpus tetragonolobus*	Papilionaceae	Winged bean	M
21	Alu	*Solanum tuberosum*	Solanaceae	Potato	HM, M, HU
22	Chhawhchhi	*Sorghum cernuum*	Graminae	White durra	HM, M, HU, T, L
23	Berul	*Trichosanthes angiuna*	Cucurbitaceae	Snake gourd	HM, M, HU, T
24	Tung	*Vernicia montana*	Euphorbiaceae	China wood oil tree	HM, HU, T
25	Behlawi	*Vignia unguiculata*	Papilionaceae	Cow pea	HM, M, HU, T, L
26	Vaimim	*Zea mays*	Gramineae	Maize	HM, M, HU, T, L
27	Sawhthing	*Zingiber officinale*	Zingiberaceae	Ginger plant	M, HU, T

Table - 5.38. Horticultural crops

Sl. No	Local Name	Botanical Name	Family	Common/English Name	Place of occurrence
1	Lakhuihthei	*Ananas comosus*	Bromeliaceae	Pineapple	HM, M, HU, T, L
2	Serthlum	*Citrus reticulata*	Rutaceae	Orange	HM, M, HU, T, L
3	Balhla	*Musa paradisiaca*	Musaceae	Banana	HM, M ,HU, T, L
4	Sapthei	*Passiflora edulis*	Passifloraceae	Passion fruit	HM, M, HU, T, L
5	Fu	*Saccharum officinarum*	Gramineae	Sugarcane	HM, M, HU, T, L
6	Grape	*Vitis vinifera*	Ampelidaceae	Grape	M

Table - 5.39. Fruit Plants

Sl. No	Local Name	Botanical Name	Family	Common/English Name	Place of occurrence
1	Theiarbawm	*Annona squamosa*	Annonaceae	Castard apple	M, HU, T
2	Lamkhuang	*Artocarpus heterophyllus*	Moraceae	Jack fruit tree	M, L
3	Theiria	*Carallia brachiata*	Rhizophoraceae	-	HM, M, T
4	Sertawk	*Citrus grandis*	Rutaceae	Shaddock	HM, M, HU, T, L
5	Hatkora	*Citrus macroptera*	Rutaceae	-	HM, M, T
6	Sisu	*Citrus sp.*	Rutaceae		M, L
7	Zammir	*Citrus sp.*	Rutaceae		M
8	Sarzuk	*Elaeagnus caudata*	Elaeagnaceae	Sarzuk	HM, M, HU, T, L
9	Theihai	*Mangifera indica*	Anacardiaceae	Mango tree	HM, M, HU, T, L
10	Keifang	*Myrica esculenta*	Myricaceae	Box myrtle	HM, M, HU T
11	Japan Theite	*Prunus domestica*	Rosaceae	Plum tree	HM, M, T
12	Theitehmul	*Prunus persica*	Rosaceae	Peach	HM, M, T
13	Kawlthei	*Psidium guajava*	Myrtaceae	Guava	HM, M, HU, T, L
14	Per-thei	*Pyrus communis*	Rosaceae	Pear tree	M
15	Theihmu	*Rubus accuminatus*	Rosaceae	-	HM, M, T
16	Bil thei	*Protium serratum*	Burseraceae	Indian Red Pear	HU
17	Chengkek	*Garcinia lanceaefolia*	Guttiferae	-	HU, T
18	Tling	*Embelia vestita*	Myrsinaceae	-	HU
19	Hreirawt	*Cyathocalyx martabanicus*	Annonaceae	-	HU

20	Sunhlu	*Emblica officinalis*	Euphorbiaceae	Amla	HM, M, HU, T, L
21	Theichhungsen	*Haematocarpus thomsoni*	Menispermaceae	-	HU, T
22	Theifeimung	*Euphoria longan*	Sapindaceae	Lichi	HU
23	Pangkai	*Baccaurea ramiflora*	Euphorbiaceae	Lutqua	HU, T
24	Vawmva	*Garcinia sopsopia*	Guttiferae	-	HU
25	Theikelki	*Pentanura khasiana*	Asclepadiaceae		HU
26	Theiarlung	*Prunus undulata*	Rosaceae	-	HU, T
27	Keipui	*Prunus jenkinsii*	Rosaceae	-	HU, T

- **HM** = Hmuntha, **M** = Maite, **HU** = Hualtu, **T** = Tawizo, **L** = Lenchim

CHAPTER - 6

CHAPTER - 6

SUMMARY AND CONCLUSIONS

6.1.Summary

Tawi Wildlife Sanctuary which is located in the South eastern part of the Aizawl District of Mizoram (Latitude-$23^0$30'N and Longitude 93^0E) with altitude ranging between 500m- 1854m asl. It occupies an area of 35.75 sq.km at a distance of about 101 km from the State capital Aizawl towards the east. The sanctuary was notified as as "Tawi Wildlife Sanctuary" vide Govt. Notification No.B.12012/15/94-FST dt.8/4/1999. The area is 35.75 sq. km. The vegetation of the sanctuary falls under the Tropical semi-evergreen and Sub-tropical broadleaved hill forests. Maximum temperature ranges between 17^0C to 28^0C and the minimum between 10^0C to 16^0C with the annual rainfall between 2000 and 2500 mm.

Majority of the people (*i.e.,,* 92%) of the surrounding 5 villages depend on agriculture and related activities connected to land.

The research findings of the study are an outcome of the research works undertaken during the period from July 2006 to April 2010. A statistical analysis of the flora reveals the occurrence of 237 species under 182 genera belonging to 72 families of angiosperms, 1 family of gymnosperm and 10 families of pteridophytes. The dicotyledons comprise 65 families, 125 genera and 155 species. Each species is provided with an upto date nomenclature, vernacular name and uses. Soil physical properties such as pH, temperature, soil moisture, bulk density and chemical properties such as Total Nitrogen (TKN) , Soil Organic carbon content, exchangeable potassium and available phosphorous were also analyzed. Detailed analysis of the

adjoining 5 villages of the Sanctuary was also enumerated. The thesis contains six chapters as follows.

First chapter deals with introduction of biodiversity, types and patterns of biodiversity, megadiversity zones and hotspots, community structure and organization, composition and characteristics of soil, scope and objectives.

Second chapter deals with review of literature at the global level, national level, northeast level and at the local level.

Third chapter deals with the study area. Land use/ land cover map and drainage map of Tawi Wildlife sanctuary are also provided.

Fourth chapter deals with materials and methods for plant community analysis, soil analysis and socio- economic study.

Fifth chapter deals with results and discussion which is the most important part of the present investigation. The important findings of the study are summarized under:

1. A statistical analysis of the flora reveals the occurrence of 237 species under 182 genera belonging to 72 families of angiosperms, 1 family of gymnosperm and 10 families of pteridophytes. The dicotyledons comprise 65 families, 125 genera and 155 species.
2. Out of the 73 families of dicots and monocots, dicots represent 89.04% and monocots represent 10.96%. Out of 167 genera, dicots and monocots genera are 74.85% and 25.15% respectively.
3. Among 237 species, 83 trees (35.02%), 41 herbs (17.3%), 31 shrubs (13.08%), 26 climbers (10.97%), 26 epiphytes (10.97%), 17 grasses (7.17%), 10 canes & palms (4.22%) and 3 saprophytes (1.27%) are represented.

4. Orchidaceae are the most dominant family in the area in respect to number of species (24 sp.), followed by families like Poaceae (17 sp.), Lauraceae (11 sp.), Arecaceae (10 sp.), Euphorbiaceae (9 sp.) and Fabaceae (9 sp).
5. Ten dominant tree species in respect of species composition in the area are *Callophyllum polyanthum (Sentezel), Engelhardtia spicata (Hnum), Litsea lancifolia (Hnahpawte), Helicia erratica (Sialhma), Ostodes paniculata (Beltur), Alseodaphne petiolaris (Khuangthulh), Michelia doltsopa (Zongiau), Macropanax dispermus (Phuanberh), Diospyros pilosula (Zoruthei) and Fagerlindia fasciculata (Chhawtan).*
6. During the course of the present studies *Kalanchoe roseus* a critically endangered plant which is endemic only to Manipur and Nagaland and an interesting fern species *Pteris tricolor* were encountered. Both are new records from Mizoram critically endangered and endemic species of orchids *Eria lacei, Dendrobium peguanum* are also found from the study area.
7. Soil temperature is the highest in July 2008 (15.42^0C) and lowest in January 2007 (11.26^0C).
8. Bulk density was highest in the month of July 2008 (1.30g/cm^3) and lowest in the month of April 2007 (0.66g/cm^3).
9. Soil moisture content was high during the rainy season and was recorded highest during the month of July 2008 (19.43%) and lowest in April 2007 which (6.86%).
10. The soil was acidic (pH = 4.5 – 6.13) in nature at all sites. Lowest pH (4.5) was recorded in January 2007.

11. Organic carbon content was found highest (5.49%) in November 2008 and the minimum value (4.22%) was recorded in January 2007.
12. Nitrogen was highest in the month of July 2007 (1.01%) and lowest in April 2007 (0.73%).
13. Potassium was highest during November 2007 (492.13 Kg/ha) and lowest in April 2008 (260.467 Kg/ha).
14. The available phosphorus was very low throughout the year and it ranged between 0.77 Kg/ha to 2.75 Kg/ha.
15. In the adjoining 5 villages Maite has the highest population (971 inhabitants) and Lenchim has the lowest population (365 inhabitants).
16. 92% of the families are depending on jhum farming in the 5 villages and the rest 8% are engaged in Govt., small business and cottage industries.
17. The common agricultural crops are *Oryza collina, Allium hookeri, Brassica juncea, Capsicum annum, Colocasia esculenta, Cucumis melo, Cucumis sativus, Cucurbita maxima, Glycine max, Manihot esculenta, Sorghum cernuum, Trichosanthes angiuna, Vignia unguiculata, Zea mays, Zingiber officinale.*
18. In the study of horticultural crops 28 species of fruit plants are found in the surrounding five villages. These fruit plants fall under underutilized horticultural crops (UUHC). These are *Annona squamosa, Artocarpus heterophyllus, Carallia brachiata, Citrus grandis, Citrus macroptera, Elaeagnus caudata, Myrica esculenta, Prunus domestica, Prunus persica, Psidium guajava, Pyrus communis, Rubus accuminatus, Protium serratum, Garcinia lanceaefolia etc.*

19. Animal rearing in the 5 villages is dominated by piggery (59%) and poultry (90%).
20. In the adjoining 5 villages 18 timber species are recorded . These timber species includes *Acrocarpus fraxinifolius, Alseodaphne petiolaris, Artocarpus chama, Artocarpus heterophyllus, Bombax insigne, Calophyllum polyanthum, Cephalotaxus griffithii, Choerospondias axillaris, Chukrasia velutina, Cinnamomum tamala, Duabanga grandiflora, Mangifera indica, Michelia champaca, Michelia doltsopa, Phoebe lanceolata, Garunga floribunda, Terminalia bellirica, Terminalia myriocarpa.*
21. Twenty three fuel wood species are recorded which are *Albizzia procera, Callicarpa arborea, Castanopsis echinocarpa, Castanopsis indica, Castanopsis tribuloides, Derris robusta, Eleocarpus lanceaefolius, Eriobotrya bengalensis, Eurya cerasifolia, Glochidion velutinum, Lithocarpus dealbata, Lithocarpus pachyphylla, Litsea lancifolia, Macaranga indica, Quercus brevipetiolata, Quercus glauca, Quercus helferiana, Quercus leucotrichophora, Quercus lineata , Quercus polystachya, Schima wallichii, Syzygium cuminii, Wendlendia grandis.*
22. The sanctuary has high number of commercially exploitable medicinal species. 22 species are recorded which are *Aporusa octandra, Bergenia ciliata, Blumea lanceolaria, Cassia nodosa, Centella asiatica, Costus speciosus, Dillenia pentagyna, Embelia ribes, Haldinia cordifolia, Hedyotis scandens, Helicia robusta, Lepionurus sylvestris, Lindernia ruellioides, Mimosa pudica, Oroxylum indicum, Osbeckia chinensis,*

Phyllanthus urinaria, Securinega virosa, Senecio scandens, Smilax glabra, Vitex peduncularis, Zanonia indica.

23. Edible plants includes *Dysoxylum gobara, Amomum dealbatum, Gynura bicolor, Amaranthus spinosus, Marsdenia formosana, Acacia pennata, Lepionurus sylvestris, Crotolaria tetragona, Musa spp., Parkia timoriana, Trevesia palmata* and a great variety of edible *Agaricus spp.* Besides these fresh bamboo shoots like *Bambusa longispiculata, Dendrocalamus hamiltonii, Calamus flagellum, Dendrocalamus longispathus, Melocanna baccifera* were collected for daily subsistence.
24. Fourteen species of bamboos are recorded which are *Bambusa khasiana, Bambusa longispiculata, Arudinaria collosa, Dendrocalamus hamiltonii, Dendrocalamus hookeri, Dendrocalamus manipurianus., Dendrocalamus strictus, Dinochloa compactiflora, Melocanna baccifera, Pseudostachynum polymorphum, Schizostachyum capitatum, Dendrocalamus longispathus, Schizostachyum dulloa, Sinarundinaria intermedia.*
25. Ten species of canes and palms are encountered which includes *Arenga pinnata, Calamus acanthospathus, Calamus erectus, Calamus flagellum, Calamus gracilis, Calamus guruba, Calamus inermis, Calamus khasianus, Caryota mitis, Caryota urens, Zalacca secunda.*

Sixth chapter deals with the summary and conclusion of the whole text.

The work is supplemented with exhaustive references.

6.2. Conclusions

Tawi Wildlife Sanctuary is a very important protected area. As revealed from the research studies the forest is an evergreen forest which is dominated by evergreen tree species. The area is rich in plant diversity harbouring rare, endangered and endemic species. Anthropogenic disturbances, over exploitation, habitat destruction, forest fragmentation, frequent forest fires and encroachments from the people living in the adjoining villages of the Sanctuary are the threat for the flora and fauna.

Frequent land slides and forest fires have also led to depletion of fragile habitats.

Timber logging inside the sanctuary and agricultural encroachments need to be checked.

The human population pressure and activities are the main causes and decline of endemic and threatened species. Another cause for concern is lack of proper inventory of ecologically sensitive sites of endemic species. This calls for better conservation planning and site specific action plans so as to restore the special habitats and threatened plant populations. Endemic species once lost is an irretrievable loss for the region or nation. It is the primary responsibility of the people and the state to protect and conserve their own endemic biological resources.

Threatened, endangered and endemic species may soon become extinct from its natural habitat unless effective conservation measures are taken up by the State Government and the rich floral diversity of the sanctuary may not be able to withstand the burgeoning anthropogenic pressures.

Preserving the natural dynamics of ecosystems is vital to protecting biodiversity. Biodiversity is worthy of protection because it maintains ecosystem stability and productivity (Worm *et al.,* 2006). Ecosystems with high biological

diversity have more complex interspecific interactions and greater intraspecific variability. This makes them less prone to collapse and more stable during environmental fluctuations and other stochastic events (Loreau *et al.,* 2001). At the same time, biologically diverse ecosystems are more productive, making them better providers of goods and services important in the lives of all species, including humans.

However, a critical assessment of biodiversity is prerequisite for effective management of any protected area. As a precursor for such plan, the present study provides baseline data on vegetation and floral diversity of Tawi Wildlife Sanctuary.

A detailed study of the socio economic conditions of the adjoining villages revealed that the socio-economic condition is not very bad. The most important issue of agricultural development is related to marketing and transport. Transport situation in the area is so bad that any casual visitor can confirm that it is almost impossible to modernize agriculture with the existing infrastructural support. For this reason, encroachment from the surrounding villagers is frequent inside the sanctuary as the forest is rich in flora and fauna. Maintenance and construction of approach roads to the villages is a burning issue for the upliftment and development of this area so that encroachment and anthropogenic disturbances inside the sanctuary may be lessened if the socio-infrastructural conditions could be develop in a better way which in turn would result into a safer conservation of the sanctuary.

SUGGESTIONS AND RECOMMENDATIONS FOR TAWI WILDLIFE SANCTUARY

1. **Awareness training and involvement of local people**: To create awareness training among the local people about the conservation and sustainable utilization of forest resources and involve them in forest management. The pre-requisite for any ecological restoration work is mass movement of people's participation. Though the forest department is working for the protection of the sanctuary, their service is hampered by not people participatory, lack of local people's confidence, limited staff and resources and lower salutary returns to local communities.
2. **Establishment of commercial farms**: Establishment of commercial farms for medicinal and other economic important plants to prevent over-exploitation and also encouragement for cultivation of well known and less known economic potential plants to check their destructions from their natural habitats.
3. **Conservation of RET & E plants**: Strict and appropriate legislative mechanism for sustenance of rare, threatened and endemic species.
4. **Regular census and monitoring**: Subsequent re-census and monitoring will provide additional data on forest composition and diversity changes due to various disturbance regimes, which will be useful in forest management and conservation efforts.
5. **Control of fire:** Appropriate steps should be taken up for fire control. It must be understood that forest fire can cause massive losses of valuable gene pool and it takes several years to recover environmental losses. One of the biggest threats to the biodiversity of Tawi Wildlife Sanctuary is the forest fire in the

grassland area. The tall grasses get burnt easily during the dry season which encourages forest fire in the area. Forest fire mainly starts from uncared throwing of burning cigarette butts or matches by visitors to the sanctuary. Laws of no entry in the forest for collection of non-wood forest produce should be imposed during the higher fire risk days. Employment of fire watcher at least during the drier months of the year might prove very effective for the control of fire within the sanctuary. Any kind of human interference in the core area of sanctuary should be strictly prohibited. Illegal felling of trees for timber and collection of canes inside the Tawi Wildlife Sanctuary continue to be a problem inspite of strict protection.

6. **Construction of approach roads**: Despite the Government's constant efforts to provide alternate arrangements through forest development agency programmes, this forest is experiencing destruction because of the frequent visits of people from nearby villages for their daily requirement of fuel, fruits, bamboo, canes and other non-timber forest produce. This has resulted in the fragmentation of the forest, thereby causing damage to both plant and animal diversity. So maintenance and construction of approach roads to the adjoining villages is a burning issue for the growth and development of the socio-economic condition of this area so as to minimize encroachments from the surrounding villages.

References

Adams, P.W. 1998. *Soil Compaction of Woodland Properties*, Oregon State University, Kerr Administration, Corvallis, OR.

Agarwal, K.C. *Global Biodiversity*. 2002. Nidhi Publishers (India) Bikaner, 406 p.

Aiyar, S.P. 1937. The nitrogen status of the soils of Burma, *Proc. Nat. Inst. Sci, Ind.,* 3:259-269.

Allen, S. E., et al. 1974. *Chemical Analysis of Ecological Materials*. John Wiley and Sons, New York.

Andrewartha, H.G. and Birch, L.C. 1984. *The Ecological Web.* University of Chicago Press, Chicago.

Anon. 2009. *India State of Forest Report* (Ministry of Environment & Forests), Govt. of India, Kaulagarh Road, Dehradun India.

Anon. 2002. *Biodiversity characterization at Landscape level in North-Eastern India using Satellite Remote Sensing and GIS*, IIRS, Dehradun, p296.
anthropogenic disturbance on plant diversity and community structure of a sacred groove.

Anon. 1992. *Convention on Biological Diversity*, RIO.

Arunachalam A., Maithani K., Pandey H.N. and Tripathi R.S. 1998. Fine litter and nutrient dynamics during forest regrowth in humid sub-tropics of north-eastern India. *Forest Ecology and Management* 110:209-219.

Ashton, P.S. & P. Hall. 1992. Comparison of structure among mixed dipterocarp forest of north-western Borneo. *Journal of Ecology* 80: 459-481.

Attiwill, PM. And Leeper, G.W. 1987. Forest *soils and nutrient cycles.* Melbourne University Press, Melbourne.

Balabane M. 1996. Turnover of clay associated organic nitrogen in the different aggregate size classes of a cultivated silty loam. *European Journal of Soil Science* 47: 285-291.

Balakrishnan N.P. 1981–1983. *Flora of Jowai and Vicinity, Meghalaya*.Vols. 1-2. Botanical Survey of India, Howrah, India.

Baltrushes N. 2006. *Medical Ethnobotany, Phytochemistry, and Bioactivity of the Ferns of Moorea, French Polynesia*, p 25.

Barik, S.K., H.N. Pandey, R.S. Tripathi & P. Rao. 1992. Micro-environmental variability and species diversity in tree fall gaps in a sub-tropical broad leaved forest. *Vegetation* 103: 31-40.

Barik, S.K., P. Rao, R.S. Tripathi & H.N. Pandey. 1996a. Dynamics of tree seedling population in a humid subtropical forest of northeast India as related to disturbances. *Canadian Journal of Forest Research* 26: 584-589.

Barik, S.K., H.N. Pandey, R.S. Tripathi & P. Rao. 1996b.Tree regeneration in a subtropical humid forest: effect of cultural disturbances on seed production, dispersal and germination. *Journal of Applied Ecology* 33: 1551-1560.

Barnes, B.V. Zak, D.R., Denton, S.R. and Spurr, S.H. 1998. *Forest Ecology* (4th Ed.). John Wiley & Sons, Inc. USA, pp. 588-611, 255-278, 362-386.

Beard, J.S. 1973. *The physiognomic approach. In Ordination and Classification of Communities, ed. R.H. Whittaker*, pp 355- 386. Dr. W. junk publishers, The Hague.

Benzing, D.H. 1983. Vascular epiphytes: a survey withspecial reference to their interactions with other organisms. pp. 11-23. *In*: S.L. Sutton, T.C.Whitmore & A.C. Chadwick (eds.) *Tropical Rain Forest*, *Ecology and Management*. Blackwell Scientific Publications, Oxford.

Bhaghat, K. Prashith TR. , Raghavendra HL.,Swarnalatha SP., Preethi HR & Surabhi K.S. 2010. In Vitro Antioxidant and anthelmintic activity of extracts of *Jasminum arborescens*. *International Journal of Drug Development & Research Jan-March 2010 Vol. 2 Issue 1,* p. 90.

Bhaskaran, T.R. and V. Subrahmanyan 1937. Some new aspects of the mechanism of nitrogen fixation in the soil, *Proc. Nat. Inst. Sci*., 3:163-174

Bhattarai, N.K. 1996. Biodiversity: People Interface in Nepal. In: Medicinal Plants for Forest Conservation and Health Care. Non-wood Forest Product Series. *Biol.* 10:1-67.

Bhide, R.K. 1921. Drought resisting plants in the Deccan, Journ. Ind. Bot. Soc., 2:27-43.

Biological Diversity Act. 2002. National Biodiversity Authority, India, pp 1 - 29

Bor, N.L. 1991. *Flora of Assam Vol 5.*Allied Book Centre, Dehradun, India.

Braun, E.L. 1950. *The Ecology of the Forest of Eastern North America, Their Development, Composition, and Distribution. Deciduous Forests of Eastern North America*. Mc Graw Hill, New York: Blakiston.

Butler, D.R. 1995. *Zoogeomorphology*. Cambridge, U.K. : Cambridge University Press.

Cain SA, De Oliveria Castro GM. 1959. *Manual of Vegetation Analysis*. Harper & Brothers, New York.

Caley, M. J. and Schluter, D. 1997. The relationship between local and regional diversity. *Ecology.* Jan; *78(1),* 70-80.

Callicott, J. B., Crowder, L. B. and Mumford, K., 1999. "Current normative concepts in conservation", *Conservation Biology*, 13: 22-35.

Champion, H.G. and S.K. Seth, 1968. *A revised survey of the forest types of India.* Manager of Publications, Delhi, p. 245.

Chaudhuri, A.B. and Sarkar, D.D. 2003. *Megadiversity conservation*. Daya Publishing House, Delhi. pp 1-272

Chen, Wei-Lie. 1995. Subtropical montane deciduous forests in southern China. pp. 317-323. *In*: E.O. Box, R.K. Peet, T. Masuzawa, I. Yamada, K. Fujiwara & P.F. Maycock (eds.) *Vegetation Science in Forestry*. Kluwer Academic Publishers, Dordretch, Netherlands.

Chowdhery, H.J. and Murti S.K. 2000. *Plant Diversity and conservation in India*. Bishen Singh Mahendra Pal Singh, 23-A, Connaught Place, Dehradun 248001. pp 3-5

Clements, F.E. 1916. *Plant succession: analysis of the development of vegetation*. Publ. Carnegie Inst., Wash., 242: 1-512

Congdon R.A. and Herbohn J.L. 1993. Ecosystem dynamics of disturbed and undisturbed sites in north Queensland wet tropical rain forest. I. Floristic composition, climate and soil chemistry. *Journal of Tropical Ecology* 9: 349 - 363.

Connell J. H. Hughes T. P., Wallace C.C., Tanner J.E., Harms K.E. and Kerr A.M. 2004. A long term study of competition and diversity of corals. *Ecological Monographs* 74: 179-129.

Cornell, H.V. 1985. Local and regional richness of cynipine gall wasps on California oaks. *Ecology* 66:1247-1260.

Cote L., Brown S., Pare D., Fyler J. and Bauhus J. 200. Dynamics of carbon and nitrogen mineralization in relation to stand type, stand age and soil structure in the boreal mixed wood. Soil Biology and Biochemistry 32: 1079-1090.

Cowles, H.C. (1890) The ecological relations of the vegetation of the sand dunes of Lake Michigan. *Botanical Gazette*, 27, 95-117, 167-202, 281-308, 361-91.

Curtis, J.J. 1959. *The vegetation of Wisconsin: An ordination of Plant communities.* University of Wisconsin Press, Madison, p 65.

Curtis, J.J. and R.P. Mcintosh. 1950. *Ecology,* 31: 434-455. Knight, D.H. 1975. *Ecol. Monogr.,* 45: 259-284.

Dasmann, R. F. 1968. *A Different Kind of Country*. Mac Millan Company, New York.

Daniels, R.J.R., M. Gadgil & N.V. Joshi. 1995. Impact ofhuman extraction on tropical humid forests in the western ghats in Uttara Kannada, South India. *Journal of Applied Ecology* 32: 866-874.

Dastur, R.H. and Raut M.R. 1935. Carbohydrate nitrogen ratio of the shoots of some Tropical trees, *Journ. Ind. Bot. Soc*. 14:269-289

Deb, D.B. and Dutta R. M. 1987. A contribution to the Flora of Mizoram. *J. Econ. Tax. Bot.* 10(1): 21-61.

Deka, H.K. 1981. *Studies on soil microbial populations of jhum fallows of different ages*, Ph.D. Thesis, North-Eastern Hill University, Shillong, India

Department of Environment & forest, Govt. of Mizoram. 2001 *Statistical abstract.*

Dhar, N.R. 1936. Paper on the problem of nitrogen supply to the Indian soil held by the *Royal Asiatic Society of Bengal*. 1937. Presidential Address, *Nat. Acad. Sci. Ind.*

Dhar, N.R., Seshacharyulu E.V. and Biswas N.N. 1941. New aspects of nitrogen fixation and loss in soil, *Proc. Nat. Inst. Sci, Ind*., 7:115-131.

Dighton J. 1997. Nutrient cycling by saprotrophic fungi in terrestrial habitats. In: *The Mycota IV: environmental and microbial relationships (D.T. Wicklow and B.E. Soderstrom eds.),* Springer, Berlin Heidelberg New York, pp. 271-279.

Directorate of Economics & Statistics, Govt. of Mizoram. 2001.*Mizoram at a Glance,*

Directorate of Economics & Statistics, Govt. of Mizoram. 2008. *Statistical handbook of Mizoram.*

Edward O.W., Frances M.P. 1988. *Biodiversity*, National Academy Press, online edition

Ehrenfeld, D.1988. "Why put a value on biodiversity?" in E.O. Wilson (ed), *Biodiversity*, Washington, DC: National Academy Press.

FAO. 1974. *Logging and Log Transport in Tropical High Forest,* Rome.

Finzi A.C., van Breeman N. and Canha C.D. 1998. Canopy tree-soil interactions within temperate forest: species effects on soil carbon and nitrogen. *Ecological Applications* 8: 440-446.

Fischer, C. E. C. 1938. *The Flora of Lushai Hills*. Periodical Expert Book Agency, Delhi – 32.

Fitzpatrick, R.N., Powell B., Mc Kenzie N.J., Marchmedt D.J., Schoknecht N. and Jacquier D.N. 2003. Demands on Soil Classification in Australia. In: *Soil Classification: A global Reference (H. Eswaran, T. Rice, R. Ahrens and B.A. Stewart eds.),* CRC Press, LLC Boco Raton, F.L., pp. 77-100.

Franklin, J F. 1993. Preserving biodiversity: Species, ecosystems or landscapes. *Ecol.* Appl. 3: 202 – 205.

Gage, A.T.1901 *A Botanical tour in the South Lushai Hillls*. Firma KLM Pvt. Ltd. Calcutta.

Gaston, K.J.1996 *Biodiversity: A Biology of numbers and difference*, Oxford: Blackwell.

Genetic Diversity. 2008." National Biological Information Infrastructure. NBII. 16 Mar. *www.nbii.gov*

Global Biodiversity Assessment.1995. *UNEP, Annex 6, Glossary*. ISBN 0-521 56481-6, used as source by "Biodiversity", Glossary of terms related to the CBD, Belgian Clearing-House Mechanism. Retrieved 2006-04-26.

Good, R. 1964. (3rd ed.) *The Geography of The Flowering plants.* Logmans, Green and Co ltd, London. 1964. P. 518.

Gosh C. and Das A. P. 2007. Rhino-Fodders in Jaldapara Wildlife Sanctuary in Duars ofWest Bengal, India. *Our Nature* 5:14 – 20, p 18.

Groom, M.J., Meffe, G.K. and Carroll, C.R. 2006. *Principles of Conservation Biology (3rd ed.)*. Sunderland, MA: Sinauer Associates. Website with additional information: http://www.sinauer.com/groom/

Groombridge, B. Jenkins M.D., 2000. Global Biodiversity: Earth's living resource in the 21st century. WCMC. Cambridge: World Conservation Press.

Groombridge, B. 1992. *Global Biodiversity: Status of the Earth's Living Resources.* Compiled by the World Conservation Monitoring Centre. Chapman & Hall, London, p. 594.

Halffter, G. 1998. A strategy for measuring landscape biodiversity. *Biology International* 36: 3 – 17.

Haridasan, K., Sarmah A., Hegde S.N., Bhuyan LR. 2002. Field manual for propagation and plantation of canes in Arunachal Pradesh. *State Forests Research Institute (SFRI) Information Bulletin No. 15.* SFRI, Itanagar, India.

Harper, J.L. and Hawksworth, D.I., 1994. Biodiversity: Measurement and estimation-preface. Philosophical Transactions of the Royal Society of London Series B, 345:5-12.

Henry O.J. (1958) *The study of plant communities*. W.H. Freeman and Company. pp17-31.

Heywood, V.H. 1994. The measurement of biodiversity and the politics of implementation. In: Forey, P.L., C.J. Humphries & R.I. Vane-Wright P.L. Forey, C.J. Humphries & R.I. Vane-Wright (ed.) *Systematics and conservation evaluation.* Systematics Association special Vol. No. 50. Oxford: Clarenden Press, London, p. 15-22.

Ho S.T., Tung Y.T., Cheng K.C. & Wu J.H. 2010. Screening, determination and quantification of major antioxidants from *Balanophora laxiflora* flowers. *Food Chemistry* 122: 584-588

Hobbie, S.E. 1992. *Effects of plant species on nutrient cycling.* Trends in Ecology and Evolution 7:336-339.

Holsinger, K.E. 2005. Global biodiversity patterns. http: creative common. Org/lincenses/by ncsa/2.5

Hooker, J.D. (1904). *A sketch of Flora of British India*. London.

Hooker, J. D. 1872- 1897. *The Flora of British India*, London. 7 vols.

Howard, A. and Hole, R.S. 1918. Recent investigations on soil aeration, *Journ, Proc. Asia, Soc, Beng.,* 14: xeix – ci.

Hussain, T., Datt, B., Chaudhary, L.B., Asthana, A. and Agnihotri., P. 2010. Floristic diversity of Bhimbetka World Heritage site (Madhya Pradesh) – an overview. *Indian Forester*, p 216.

Huston M.A. 1994. *Biological diversity: the coexistence of the species on changing landscapes*. Cambridge University Press, Cambridge.

Hutchinson, G. E., 1953. The concept of pattern in ecology. *Proc. Acad. natn. Sci.* Philadelphia 105: 1-12.

Hynniewta & Kumar Y. 2008. Herbal remedies among the khasi traditional healers and village folks in Meghalaya. *Indian Journal of Traditional Knowledge Vol. 7(4*), p. 583.

Indian Horticulture Database, 2005. NHB Ministry of Agric. GOI.Institute of Vegetable Research, Jakhini, Varanasi-221305. U.P., India and ICAR Research Complex for NEH Region, Umiam, Meghalaya-793103, India.

IUCN. 1996. *1996 Red List of Threatened Animals.* IUCN, Gland, Switzerland. 448pp.

Jain, S.K. and Rao, R.R. 1977. *Handbook of Field and Herbarium Methods*. Today and tomorrow's Printers & Publishers, New Delhi.

Jamir, S.A. 2000. *Studies on Plant Biodiversity,Community Structure and Population Behaviour of Dominant Tree Species in some Sacred Groves of Jaintia Hills, Meghalaya*. Ph.D. Thesis. North-Eastern Hill University, Shillong, Meghalaya.

Jamir, S.A. & H.N. Pandey. 2002. Status of biodiversity in the sacred groves of Jaintia hills, Meghalaya. *The Indian Forester* 128: 738-744.

Jamir, S.A. & H.N. Pandey. 2003. Vascular plant diversity in the sacred groves of Jaintia hills in northeast India. *Biodiversity and Conservation* 12:1497-1510.

Jenny, H. (1941). *Factors of Soil Formation*. Mc Graw Hill, NY.

Jenny, H. (1980). "The soil resource: origin and behavior." *Ecological Studies* 37 Springer-Verlag, New York.

Jha, L.K. 1997. *Natural Resource Management: Mizoram*. A.P.H. Publishing Corporation, New Delhi – 110002.

Joffe, J.S. 1949. *The ABC of Soils*. Pedology Publications, New Brunswick; New Jersey.

Kanjilal, U. N.; Kanjilal, P.C..,De, R.N.,Das (1991) *Flora of Assam Vol 1-4.*Allied Book Centre, Dehradun, India.

Karlson R.H. and Hurd L.E. 1993. Disturbance, coral reef communities and changing ecological paradigms. *Coral Reefs* 12:117-125.

Kaye J.P. and Hart S.C. 1997. Raising of N-mineralization increases the availability of nitrogen typically leading to greater N-uptake by plants. *Trends in Ecology and Evolution* 12: 139-142.

Kholia B. S. 2010. *Ferns and Fern- allies of Sikkim A Pictorial Handbook Part – 1* Sikkim State Biodiversity Board & Botanical Survey of India.

Kimmins. 1987. Chemical properties of soil. *Forest Ecology* 11, p.295 and Porosity: The distribution of Space in soils & Bulk density: The mass of soil per Unit Volume. *Forest Ecology* 11, pp.288-289

Kjeldahl, J. 1883. A new method for the determination of nitrogen in organic matter. *Z. Anal. Chem.* 22:366.

Knight, D.H. 1975. A phytosociological analysis of species rich tropical forest on Barro Colorado Island, Panama; *Ecol. Monograph*. 45: 259 – 289.

Kothari , A. 1989, *Management of national parks and sanctuaries in India: a status report,* Indian Institute of Public Administration, New Delhi

Kotwal, P.C. and S. Banerjee 2002. Biodiversity Conservation in Managed Forests and Protected Areas. *Agrobios*, India.

Lalnunmawia, F. 2003. Ph.D. Thesis. Comparative study on growth and preoductivity of three bamboo species grown with ginger crop. (unpublished) Mizoram University, Mizoram.

Lalnuntluanga, 2007. Ph.D. Thesis. Study on taxonomy, distribution and utilization of Canes/Rattan in Mizoram (unpublished) Mizoram University, Mizoram.

Lalramnghinglova, H. 1999. Ethnobiology in Mizoram State: folklore medico-zoology, *Bull Indian Inst Hist Med*, Hyderabad, 29(1999) pp123-148.

Lalramnghinglova, H. 1997. *A handbook of Common Trees of Mizoram*, p 100.

Lalramnghinglova, H.2003. *Ethno-Medicinal Plants of Mizoram* Bishen Singh Mahendra Pal Singh, Dehra Dun. p 328

Lau K.M., Li N.H. & Hu S.Y. 2003. A new species of *Balanophora* (Balanophoraceae) from Hong Kong. *Harvard Papers in Botany* 7(2):439 - 441

Lavorel S., Touzard B., Lebreton J.D., Clement B. 1998. Identifying functional groups for response to disturbance in abandoned pasture. *Acta Oecologica* 19: 227-240.

Lieberman D., Lieberman M., Peralta R. and Hartshorn G.S. 1996. Tropical forest structure and composition on a large scale altitudinal gradient in Costa Rica. *Journal of Ecology* 84: 137–152.

Likens, G.E. 1993. Human accelerated environmental change: An ecologist's view. Bull. *Ecol. Soc*. Am. 74: 331

Loreau M, Naeem S, Inchausti P, Bengtsson J, Grime J, Hector A, Hooper D, Houston M, Raffaelli D, Schmid B, Tilman D, Wardle D. 2001. Biodiversity and Ecosystem Functioning: Current Knowledge and Future Challenges. *Science* 294(5543): 804-808.

Lovejoy, T.E. 1980. Changes in Biological diversity. In: G.O.Barney (ed.) *The global 2000 report to the president, Vol 2* (the technical report), Harmonds- worth: Penguin Books, pp. 327-332.

Lovejoy, T.E. 1980. Foreword. In: M.E. Soule & B.A. Wilox (ed.). *Conservation Biology and evolutionary-ecological prespective.* Sunderland, Massachusetts: Sinauer Associates. pp. 5-6.

Lucas, R.E. and Davies, J.F. 1961. Relationship between pH values of organic soils and availabilities of 12 plant nutrients. *Soil science* 92. pp. 177 - 182.

Mac Arthur, R. and J. Connell, 1966. *The Biology of Populations.* New York: John Wiley and Sons.

Magurran, A.E. 1998. *Ecological diversity and its measurements*. Croom Helm Limited, London, pp. 7-167.

Maiti, S.K. 2003. *Handbook of Methods in environmental studies*: vol-II: Oxford book Company, Natraj Nagar, Imliwala Phatak, Jaipur, India

Mallet, J. 1996. The generics of biological diversity: from varieties to species, pp. 13-53 in: Gaston, K.J (ed.) *Biodiversity: A Biology of Numbers and Difference.* Blackwell, Oxford.

Mani M.S. 1974. *The flora. In: Mani M.S. (ed.), Ecology and Biogeography in India.* W. JunkPublishers, The Hague, the Netherlands, pp. 159–177.

McAllister, D. 1991. Estimating the pharmaceutical value of forests, Canadian and tropical. *Canadian Biodiversity* 1: 16-25.

Marbut, C. F. 1927. A Scheme for Soil Classification, Proc. First Int. Cong. *Soil Science Com. V.*

Margalef, R. 1972. Homage to Evelyn Hutchinson, or why there is an upper limit to diversity. *Trans. Connect. Acsd. Arts Sci*. 44:211-35.

Meyer S.E. 1986. *The ecology of gypsophile endemism in the Eastern Mojave desert. Ecology* 67:1303-1313.

Mirchandani, T.J. 1937. Nitrogen status of the Indian soils. *Proc. Nat, Inst. Sci. Ind.,*3:185-189.

Mishra, B.P., Tripathi, R.S., Tripathi, O.P. and Pandey, H.N .2004. Effect of anthropogenic disturbance on plant diversity and community structure of a sacred grove in Meghalaya, north-east India. *Biodiversity & Conservation*. 13: 421 - 436.

Mishra, C., Raman, T.R.S., & Johnsingh, A.J.T.1994 'Survey of primates, serow, and goral in Mizoram.' *WII,* Dehradun. 36 p.

Misra, R. 1968. *Ecology Workbook*. Oxford & IBH Publishing. Co. New Delhi: 175-180.

Misra, R. And G.S. Puri 1954. *Indian manual of plant ecology*, English Book Depot, Dehradun and Poona.

Mittermeier, R.A., Gil, P.R., Hoffmann, M., Pilgrim, J., Brooks, T., Mittermeier, C.G., Lamoreux, J., da Fonseca, G.A.B. 2004 *Hotspots revisited*. Cemex: Mexico City, Mexico.

Mittermeier, R.A., P. Gil, P.R., and C.G. Mittermeier 1997. Megadiversity: Earth's biologically wealthiest nations. Mexico, CEMEX, 501p.

Moorthy, B. Rama, Desai S.V. and Raychaudhari S.P. 1952. Potassium fixation in soils with special reference to India, Ind. *Journ. Agri, Sci*., 22:49-61

Moritz, C. 1994. Defining "Evolutionary significant Units" for conservation. *TREE.* 9 : 373-375.

Mudgal V and Hajra P.K. 1999. *Floristic diversity and Conservation in India Vol: III* Botanical Survey of India, p. 1218.

Mukherjee, A.K.1955. Thunderstorm and fixation of nitrogen in rain *Ind. Journ. Meteor. Geophy*., 6:57 - 60.

Muller, D. and Ellenberg,E.1974. *Aims and methods of vegetation ecology*: 67-80, 139-147, 211-230, and 449 – 465.

Myers, N.: 1991, 'Deforestation Rates, Present and Future', *Climatic Change.*

Myers, N. 1988. Threatened biotas: 'hotspot' in tropical forests. *The Environmentalist* 8(3): 187-208.

Myers, N. 1990. The Biodiversity challenge: expanded Tiotspots' analysis. *The Environmentalist* 10: 243-256.

Myers, N., Mittermeier, R.A., Mittermeier, C.G, da Fonseca, Y.A.B. and Kent, J. 2000. Biodiversity hotspots for conservation priorities. *Nature vol. 403*

Myers, N., Lovett, J.C. & Burgess, N.D. 1999. Eastern Arc Mountains and coastal forests. In R.A. Mittermeier, N. Myers, P. Robles Gil & C.G. Mittermeier.

(Eds.), *Hotspots*. pp. 204–217. Mexico City, México: CEMEX.

Myers, N. 1979. *The Sinking Ark: A New Look at the Problem of Disappearing Species.* Pergamon Press, Oxford.

Nagar, P.S. 2005. *Floristic Biodiversity of Barda Hills and its surroundings*, Scientific Publishers, Jodhpur, pp. 1-16.

Nayak, D.C. and Srivastava R. 1995. Soils of shifting cultivated areas in Arunachal Pradesh and their suitability for land use planning. *Journal of India Society of Soil Science* 43:246-251.

Nayar, M.P. 1996. *Hot Spots of Endemic Plants of India*, Nepal and Bhutan. Tropical Botanical Garden and Research Institute, Palode, Thiruvanthapuram

Nichols, 1996. "Relating Extractable Soil Phosphorus to Phosphorus Losses in Runoff," *Soil Sci. Soc. Am. J.* 60:855-859.

Nixon, K.C. & Wheeler, Q.D. 1992. Extinction and the origin of species. In: M. J. Novacek and Q.D. Wheeler (eds.) *Extinction and phylogeny.* Columbia University Press, New York. p. 119-43.

Norse, E.A., Rosenbaum, K.L. and Wilconee, D.S. 1986. Conserving biological diversity in our national forests. Washington D.C. The Wilderven Society of acipenserines and their reproduction in the low regions of rivers with biological flow. *Systematic Zoo*., 4: 81-99.

Norse, E.A. and McManus, R.E. 1980. Ecology and Living Resources: Biological Diversity. In: *Environmental Quality 1980: The Eleventh Annual Report of the Council on Environmental Quality,* pp. 31-80. Council on Environmental Quality, Washington, DC.

Norse, E.A. (ed.) 1994. *Global marine biological diversity: a strategy for building conservation into decision making*. Island Press, Washington.

Norton, B. G. 1994. "On what we should save: the role of cultures in determining conservation targets," in P. Forey, et al. (eds), *Systematics and conservation evaluation*.

Norton, B. G., 2001. "Conservation biology and environmental values: can there be a universal earth ethic," in C. Potvin, et al. (eds), *Protecting biological diversity: roles and responsibilities*, Montreal: McGill-Queen's University Press.

Noss, R.F. 1990. "Indicators for monitoring Biodiversity: A Hierarchial Approach." *Conser. Biol.* 4 (4): 355-364

Nyle, C.B. 2005. *The nature and properties of soil*. Pearson Education (Singapore) Pvt. Ltd., Indian Branch, Delhi. pp 18-26, 152-165, 608-651.

Odum Eugene P. 1996. *Fundamentals of Ecology* Natraj Publishers Dehradun. pp 140-156.

Olsen, S.R., C.V. Cole, F.S. Watanabe, and L.A. Dean. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *U.S. Dep. of Agric. Circ. 939.*

Oommachan, M. 1960. *The Flora of Bhopal*. (M.P.), J.K. Jain Brothers, Bhopal.

Parry, N.E. 1932. *The Lakhers* (Appendix VII). Firma KLM Private Limited Calcutta.

Pastor, J., Naiman R.J., Dewey B. & Mclnnes P. 1988. Moose, microbes, and the boreal forest. *Bioscience* 38:770-777.

Perumal, G. 2010. Ethnomedicinal Use of Pteridophyte from Kolli Hills, Namakkal District, Tamil Nadu, India *Ethnobotanical Leaflets* 14: 161-72.

Phillips, E.A. 1959. *Methods of vegetation study. Henry* Holt and Co. Inc., USA, 707p.

Phukan, S., Kalita M.C. 2005. Phytopesticidal and repellent efficiency of *Litsea salicifolia* (Lauraceae) against *Aedes aegypti* and *Culex quinquefasciatus*. *Indian J Exp Biol.* 43(5):472.

Pielou, E.C. 1969. *An introduction to Mathematical ecology*. Wiley, New York.

Pignatti, S. 1995. Land use and human influences in the evergreen broad leaved forest regions of East Asia, the Mediterranean and Australia. pp. 199-210. *In*: E.O. Box, R.K. Peet, T. Masuzawa, I. Yamada, K. Fujiwara & P.F. Maycock (eds.) *Vegetation Science in Forestry*. Kluwer Academic Publisher, Dordrecht, Netherlands.

Prabhat Kumar Rai and Lalramnghinglova H. 2010. *Journal of Medicinal Plants Research Vol. 4(13),* pp. 1306 – 1307.

Presscott C.E. 1995. Does nitrogen availability control rates of litter decomposition on forest? *Plant and Soil* 168: 83-88.

Puri, G.S. 1954. Soil climate of some Indian forests, *Journ, Ind. Bot. Soc.,* 33: 394-416

Puri, G.S. and Gupta A.C. 1951. The Himalayan conifers 11. The ecology of humus in conifers forests of the Kulu Himalayas, *Ind. For.,* 77: (1, 2): 55-63, 124129.

Purohit, S.S. and S.P. Vyas .2004. Medicinal Plant Cultivation: A Scientific Approach. *Agrobois*, India.

Pushpangadan .P and Narayanan Nair K. 2005. Medicinal Plant Wealth of Meghalaya: Its Conservation, Sustainable Use and IPR Issues *Biodiversity: Status and Prospects.*

Rai N., Yadav D.S., Rai A.B., Rai M., Yadav R.K. and Sanwal S.K. 2008. Indian Institute of Vegetable Research, Jakhini, Varanasi-221305. U.P., India and ICAR Research Complex for NEH Region, Umiam, Meghalaya-793103, India.

Raman, T.R.S., Mishra, C. and Johnsingh, A.J.T. 1995. Survey of primates in Mizoram, North-east India. *Primate Conservation*. 16**:**59-62.

Rao, A.S. 1974. Vegetation and phytogeography of Assam, Burma: In: Mani, M.S. (ed.) *Ecology and Biogeography of India.* The Hague, pp. 204 - 246.

Rao, P., S.K. Barik, H.N. Pandey & R.S. Tripathi. 1990. Community composition and tree population structure in a subtropical broad leaved forest along a disturbance gradient. *Vegetation* 88: 151-162.

Rao, P. 1992. *Ecology of Gap Phase Regeneration in a Subtropical Broadleaved Climax Forest of Meghalaya*. Ph.D. Thesis. North-Eastern Hill University, Shillong, India.

Rao, P., S.K. Barik, H.N. Pandey & R.S. Tripathi. 1997. Tree seedling germination establishment in tree fall gaps and understory in a subtropical forest of northeast India. *Australian Journal of Ecology* 22: 136-145.

Raunkiaer, C. 1934. *The Life Forms of Plants and Statistical Plant Geography*. Clarendon Press,Oxford, England.

Read, Sturgess and Associates. 1982. Evaluation of Economic Values of Wood and Water for the Thompson Catchment (Report).

Reaka-Kudla, M. L., Wilson, D. E. and Wilson, E. O. (eds), 1997. *Biodiversity II: Understanding and Protecting Our Biological Resources*, Joseph Henry Press.

Reddy, K.N., C.H. Jadhav, S. Reddy & V.S. Raju. 2002. Life forms and biological spectrum of Marriguda Reserve Forest, Khammam District, Andhra Pradesh. *The Indian Forester* 128: 151-156.

Report on National Land Use Land Cover Mapping, Mizoram. 2009. Mizoram Remote Sensing application Center, Science & Technology Dept., Aizawl, Mizoram.

Robertson, A. 1995 and 1996. *Report on field trip to Mizoram*. List of birds species observed, pp. 1-20.

Roebuck, P. and Phifer, P. 1999. "The persistence of positivism in conservation biology", *Conservation Biology*, 13: 444 - 446.

Rodgers W. A., Panwar, H.S. and Mathur, V.B. 2002. *Wildlife Protected Area Network in India: A Review (Executive Summary)*. Wildlife Institute of India, Dehradun

Rothschild, L.J. and R.L. Mancinelli. 2001. Life in extreme environments. *Nature*, 409, 1092 - 1101.

Rout S. D., Panda T. and Mishra N. 2009. Ethnomedicinal studies on some pteridophytes of Similipal Biosphere Reserve, Orissa, India *Int. J. Med. Med. Sci*. pp 194-195.

Roy, P.S. & S. Tomar. 2000. Biodiversity characterization at landscape level using geospatial modelling technique. *Biological Conservation* 95(1): 95-109.

Sahascrabuddhe, D. L. 1936. Symposium on the problem of nitrogen supply to the Indian soil, *Roy. Asia. Soc. of Beng*. 1937. Fluctuations, recuperation and fixation of nitrogen in the soils of western India, *Proc. Nat. Inst. Sci., Ind*., 3:139-147

Sahunalu, P. and P. Dhanmanonda. 1995. Structure and dynamics of dry dipterocarp forest, Sakaerat, North- Eastern Thailand. pp. 465-494. *In*: E.O. Box, R.K. Peet, T. Masuzawa, I. Yamada, K. Fujiwara & P.F. Maycock (eds.) *Vegetation Science in Forestry.* Kluwer Academic Publications, Dordretch,Netherlands.

Sala, OE, FS Chapin III, JJ Armesto, R Berlow, J Bloomfield, R Dirzo, E Huber-Sanwald, LF Huenneke, RB Jackson, A Kinzig, R Leemans, D Lodge, HA Mooney, M Oesterheld, NL Poff, MT Sykes, BH Walker, M Walker, DH

Wall 2000. Global biodiversity scenarios for the year 2100. *Science* 287:1770-1774

Sarkar, S. 2005. *Biodiversity and Environmental Philosophy: An Introduction*, (Cambridge Studies in Philosophy and Biology), New York: Cambridge

Sarkar, S. and Margules, C. R. 2002. "Operationalizing biodiversity for conservation planning", *Journal of Biosciences*, 27: 299-308.

Sarkar, S. 1998 *Genetics and reductionism* New York: Cambridge University Press

Sarker, S.K. & Hossain Enayet A.B.M. 2009. Pteridophytes of greater Mymensingh District of Bangladesh used as vegetables and medicines. *Bangladesh Association of Plant Taxonomists*

Sarmah, R. 2010. Commonly used non- timber forest products (NTFPS) by the Lisu tribe in Changlang District of Arunachal Pradesh, India. *Sibcoltejo Vol. 05:* 68-77.

Sawmliana, M. 2003. *The Book of Mizoram Plants* by P.Zakhuma, Chanmari West, Aizawl. p277.

Scholes R.J. 1990. The influence of soil fertility on the ecology of Southern African dries Savannas. *Journal of Biogeography* 17: 415-419.

Scholes R.J., Dalal R. and Singer S. 1994. Soil Physics and Fertility the effects of water, temperature and texture. In: *The Biological Management of Tropical Soil Fertility (P.L. Woomer and M.J. Swift eds.),* John Wiley and Sons Publications, U. K., pp. 117-136.

Seybold C.A., Herrick J.E. and Brejda J.J. 1999. Soil resilience: A fundamental component of soil quality. Soil Science 165: 224-234.

Shannon, C.E., and Weiner, W. 1963. *The mathematical theory of communication*. Urbana Univ. Illinois Press.

Sharma, P.D. 1999. *Ecology and Environment* Rastogi Publications, Meerut, India, pp. 173-178.

Sharma, D.V. 2003. *Transfer of technology for increasing the scope of unexploited horticultural crops*. Winter School on "Exploitation of Underutilized Horticultural crops. 5-25th November, Department of Horticulture, College of Agriculture, MPUAT, Rajasthan, 313-320 pp.

Sharma, J.R. and D.K. Singh 2001. Status of Plant Diversity in India : An overview. In: Roy, P.S., S. Singh and A.G. Toxopeus (eds.) *Biodiversity and Environment,* pp. 69-105. IIRS, Dehra Dun.

Sharpley, A. N., Daniel T. C. and Edwards .D. R. 1993. "Phosphorus Movement in the Landscape,"*J. Prod. Agric.*, Vol. 6, No. 4.

Shil S. and Choudhury Dutta M. 2009. Ethnomedicinal Importance of Pteridophytes used by Reang tribe of Tripura, North East India *Ethnobotanical Leaflets* 13: 634-43.

Shukla R.S. and Chandel P.S. 2009. *A text book of Plant Ecology* S. Chand & Company Ltd. New Delhi.pp 427-429.

Simpson, E.H. 1949. *Measurement of diversity. Nature*, 163:688.

Singh, B.N. and R.B. Singh 1937. The role of leaf water content, soil moisture and plant age on transpiration of crop plants, *Joum, Ind. Bot. Soc.*, 16 : 63-80.

Singh A.N., Raghubashi A.S. and Singh J.S. 2002. Plantations as a tool fir mine spoil restoration. *Current Science* 82: 1436-1441

Singh N.P. and Singh D.K. 2001. *Floristic Diversity and conservation strategies in India Vol. IV*. Botanical Survey of India.pp 1631-1632.

Singh N.P. and Singh D.K. 2002. *Floristic diversity and conservation in India Vol: V* Botanical Survey of India p 2355

Singh, J.S. 2002. The biodiversity crisis: a multifaceted review. *Current Science*, 82: 638-647.

Singh, J.S. 1996. Biodiversity and ecosystem function. *In:* Ramakrishnan, P. S., Das, A.K., and Saxena, K. G. (eds). Conserving Biodiversity for Sustainable Development. *Indian National Science Academy*, New Delhi. pp. 118-129.

Singh, N.P., Singh, K.P. and Singh, D.K. 2002. *Flora of Mizoram Vol-I*. Botanical Survey of India, Kolkata, 845 p.

Soil temperature protocol. 2005. *Globe*.

Solbrig, O.T. 1991. Biodiversity: Scientific Issues and Collaborative Research Proposals. *MAB Digest - 9*. UNESCO.

Sood, S. K., Negi C.J., Lakhanpal T. N. 2006. *Orchidaceae and Mankind*, Deep Publications, New Delhi -110063.

Soule M.E. and Wilcox B.A.1980. *Conservation Biology: An Evolutionary Ecological Perspective*. Sinauer Associates. Sunderland, Massachusetts.

Southwood, T.R.E. 1981. Ecological aspects of insect migration, pp. 197-208 in: Aidley, D.J. (ed.). *Animal Migration.* Cambridge University Press, Cambridge.

Spellerberger. I.F. 1992. *Evaluation, and Assessment for Conservation.* Chapman, and Hall, London, p.259.

Srivastava K. 2007. Importance of Ferns in Human Medicine *Ethnobotanical Leaflets 11: 231-234.* p 2.

Srivastava, R.C. & Nyshi Community 2010. *Indian Journal of TraditionalKnowledge*. Vol.9 (1) pp 27, 31.

Srivastava. 2007. Importance of Ferns in Human Medicine Kamini *Ethnobotanical Leaflets 11: 231-234* .

SRSC, Aizawl 2006. *Natural Resources Mapping of Mizoram Using remote Sensing & GIS*, Aizawl District. State Remote Sensing Centre, Science, Technology and Environment, Aizawl.

Subrahmanyam, N.S. 2005. *Modern Plant Taxonomy*, Vikas Publishing House, New Delhi.pp 197-199.

Sugden, A.M. & R.J. Robins. 1979. Aspects of the ecology of vascular epiphytes in Columbian cloud forest. 1. The distribution of the epiphytic flora. *Biotropica* 11: 173-188

Sujatha M.P., Jose A.I. and Sankar S. 2003. Leaf litter decomposition and nutrient release in reed bamboo (*Ochlandra travancorica*). *Journal of Bamboo and Rattan* 2: 65-78.

Suri, P.N. 1933. A study in the ecology and silviculture of the Himalayan spruce (*Picea morinda*) and silver fir (*Abies pindrow*) with special reference to works in progress in Kulu, *Proc. Punj. For. Conf. Lahore*.

Takacs, D., 1996. *The idea of biodiversity: philosophies of paradise*, Baltimore: The Johns Hopkins University Press.

Takhtajan, A. 1969. *Flowering Plants, Origin and Dispersal* (Translation by Jeffery), Edinburgh.

Tandon, P. and Kumaria S. 2005. Prospects of Plant Conservation Biotechnology in India with Special Reference to Northeastern Region *Biodiversity: Status and Prospects.*

Tessie M., Vivier J-P., Quin A., Gloaguen J-C. & Lefeuvre J.C. 2003. Vegetation dynamics and plant species interactions under grazed and ungrazed conditions in western European salt marsh. *Journal of Ecology* 24:103-111.

Tiwari S.C., Tiwari B.K. and Mishra R.R. 1992. Variation in some physico-chemical properties of pineapple orchard soils of north-eastern India. Journal of Indian Soil Science Society 40: 204-208.

Tyler G. and Olsson P. 1993. The calcifuges behavior *Viscaria vulgaris. Journal of Vegetational Science* 4: 29 - 36.

Udvardy, M.D.F. 1975. *A classification of the biogeographical provinces of the world.* (Occasional Paper no. 18). Gland, Switzerland: International Union for the Conservation of Nature and Natural Resources.University of IIinois Press, Urbana: 117p.

Unwin, G.L. 1989. Structure and composition of the abrupt rainforest boundary in the Herberton highland, North Queensland. *Australian Journal of Botany* 37: 413-428.

Upadhya, S. 1955. Soil formation under forest cover, *Bull. Bot. Soc. Univ. Saugar*, 7:3-13.

Upadhaya, K., H.N. Pandey, P.S. Law & R.S. Tripathi. 2003. Tree diversity in sacred groves of the Jaintia hills in Meghalaya, northeast India. *Biodiversity and Conservation* 12: 583-597.

Vazquezg J., Antonio G. and Givnish J. 1998. Altitudinal gradients in tropical forests composition, structure and diversity in the Sierra de Manantan. *Journal of Ecology* 86: 999–1020.

Visalakshi, N. 1995. Vegetation analysis of two tropical dry evergreen forests in Southern India. *Tropical Ecology* 36: 117-127.

Wadia, D.N. 1949. Presidential address, 14th *Annual General Meeting of Ind. Soc. Soil, Sci* 1948.

Walkley, A. and I. A. Black. 1934. *An Examination of Degtjareff Method for Determining Soil Organic Matter and a Proposed Modification of the Chromic Acid Titration Method*. Soil Sci. 37:29-37.

Walter, K.S. and Gillett, H.J. [eds] 1998. *1997 IUCN Red List of Threatened Plants.* Compiled by the World Conservation Monitoring Centre. IUCN - The World Conservation Union, Gland, Switzerland and Cambridge, UK. lxiv + 862pp.

Wardle, A.D., Zackrisson, O., Hornberg, G., and Gallet, C. 1997. The influence of island area on ecosystem properties. *Science*, N.Y. 277:1296-1299.

Whittaker, R.H. 1975. Communities and Ecosystems (2nd edn.). Macmillan Pub. Co.New York, p. 385.

Whittaker, R. H. 1977. Evolution of species diversity in land communities. *Evol. Biol.* 10:1-67.

Wild, A. 1996 *Soils and the environment: An introduction*, Cambridge University Press.

Williams, P.H., Humphries, C.J., Vane-Wright, R., and Gaston, K.J. 1996. Values in biodiversity, ecological services and consensus. *Trends in Ecology and Evolution.* 11, 385

Williams, P.H., Margules, C.R. and Hilbert, D.W. 2002. Data requirements and data sources for biodiversity priority area selection*; J. Biosci*. (Suppl 2)27:327–338

Wilson, E.O. 1985. The biological diversity crisis *Biosciences* 35: 700-706.

Wilson, E.O. 1988. Editors Forward. In *Biodiversity* (ed. E.O.Wilson), National Academy Press, Washington, D.C. p. 5-7.

Womersley, J.S. 1981. *Plant collection and herbarium development- A manual.* FAO, Rome, p. 337.

World Conservation Union, 1980. *World conservation strategy: living resource conservation for sustainable development*, Gland: IUCN- UNEP-WWF. www.nature.com. pp. 853 - 858.

Worm B, Barbier EB, Beaumont N, Duffy JE, Folke C, Halpen BS, Jackson JBC, Lotze HK, Micheli F, Palumbi SR, Sala E, Selkoe KA, Stachowicz JJ, Watson R. 2006. Impacts of Biodiversity Loss on Ocean Ecosystem Services. *Science*. 314(3): 787-790.

WRI/UNEP/IUCN. 1992. *Global Biodiversity Strategy: Guidelines for Action to Save, Study and Use Earth's Biotic Wealth Sustainably and Equitably*. WRI. Washington.