ECOLOGICAL STUDIES ON PLANT DIVERSITY AND PRODUCTIVITY OF HERBACEOUS SPECIES IN MIZORAM UNIVERSITY CAMPUS AT TANHRIL, AIZAWL, MIZORAM (N.E. INDIA)

by

LALCHHUANAWMA

THESIS
SUBMITTED IN FULFILMENT OF THE DEGREE OF
DOCTOR OF PHILOSOPHY (Ph.D) IN FOREST ECOLOGY, BIODIVERSITY AND ENVIRONMENTAL SCIENCES

DEPARTMENT
OF
FOREST ECOLOGY, BIODIVERSITY AND ENVIRONMENTAL SCIENCES
MIZORAM UNIVERSITY, AIZAWL.

FEBRUARY 2008

MIZORAM UNIVERSITY

Department of Forest Ecology, Biodiversity and Environmental Sciences

2008

I, Mr. Lalchhuanawma, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of 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 that the thesis has not been submitted by me for any research degree in any University / Institute.

This is being submitted to the Mizoram University for the award of the degree of Doctor of Philosophy in the Department of Forest Ecology, Biodiversity and Environmental Sciences, Mizoram University.

(LALCHHUANAWMA)

(DR. B.P. MISRA)
Reader & Head
Department of Forest Ecology, Biodiversity and Environmental Sciences, Mizoram University.

(PROF. H. LALRAMNGHINGLOVA)
Supervisor & Dean
School of Earth sciences and Natural Resources Management,
Mizoram University.

ACKNOWLEDGMENTS

I am very grateful to my supervisor, Dr. H Lalramnghinglova Professor, Department of Forest Ecology, Biodiversity and Environmental Sciences and Dean, School of Earth Sciences and Natural Resources Management, Mizoram University, Aizawl, for all his support, capable guidance and truly enlightening conversations and helping me to complete this thesis.

I am very thankful to Dr. B.P. Misra Reader & Head, Department of Forest Ecology, Biodiversity and Environmental Sciences, Mizoram university, for all his support and providing all the facilities needed during the course of the research work. I also thank to all the staff of this department for their good cooperation when I was doing my research.

I express my sincere appreciation to Dr. B. Gopichand, Professor and Dr. Lalnundanga Reader & Head, Department of Forestry, Mizoram University for allowing me to use their laboratory facilities during my research work.

I thank Dr. Tawnenga, Dr. U.K. Sahoo, Dr. F Lalnunmawia, Dr. Vanlalhruaii Ralte, Dr. R. Lalfakzuala , Dr. A.S. Devi and Mr. J. Lalbiaknunga for helping me a lot to complete this thesis.

I want to thank Mr. Zomuana, Mr. Vanlalfela Sailo and Mr. R. Lalchhanhima for their assistance in field works and laboratory works.

I am also thankful to my wife, Lalhmachhuani for her patience with me when I was bringing some work home and to tolerate when I was traveling to faraway places in my mind. I would like to thank my parents, my brothers and my sisters for their friendship and full support.

Place: Aizawl.
Date: 25th February, 2008. *(LALCHHUANAWMA)*

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List of abbreviations and symbols

%	: Percentage.
±	: Plus or Minus.
∑	: Sigma; Summation.
≥	: Equal or greater than.
µg	: microgram (s).
^0C	: Degree Celsius.
1 – S	: Index of dissimilarity.
ADP	: Adenosine diphosphate.
AGB	: Above ground biomass.
Al	: Aluminium.
ATP	: Adenosine triphosphate.
BDA	: Biological Diversity Act.
BGB	: Below ground biomass.
C	: Carbon.
C:N	: Carbon/ Nitrogen ratio.
Ca	: Calcium.
CBD	: Convention on Biological Diversity
cd.	: Concentration of dominance.
Champh.	: Chamaephyte (s).
cm	: Centimeter (s).
CO_2	: Carbon dioxide.
Cu	: Copper.
$CuSO_4.5H_2O$	: Copper sulphate pentahydrate.
D	: Simpson index of dominance.
DBH or dbh	: Diameter at breast height (1.5m).
D_{mg}	: Margalef's index of species richness.
DNA	: Deoxyribonucleic acid.
E	: East.
Ed; ed (s).	: Edition; Editor (s) or edited.
Epi.	: Epiphytes.
et al	: et alii: and others.
etc.	: etcetera or cetera; and the others.

Fe	: Ferrum/ Iron
Fig.	: Figure (s).
Flr.	: Flowering period.
Frt.	: Fruiting period.
g	: Gram (s).
Geoph.	: Geophyte (s).
H’	: Shannon index of diversity.
$H_2 SO_4$	: Sulphuric acid.
ha	: hectare (s).
HCl	: Hydrochloric acid.
HD	: Highly disturbed area or site.
hr (s)	: Hour (s).
i.e.	: *id est*; that is.
IIRS	: Indian Institute of Remote Sensing
In	: Logarithm.
Indv (s).	: Individual (s).
IVI	: Important value index.
K	: Potassium.
K_2SO_4	: Potassium sulphate.
L.S.C.	: Lianas, Scandent and Climbers.
L / l	: Liter.
LR	: Lalramnginglova, H.
m	: Meter (s).
M	: Molar/ Molarity or Mizo.
MD	: Mildly disturbed area or site.
Megaph.	: Megaphanerophytes.
Mesoph.	: Mesophanerophytes.
Microph.	: Microphanerophytes.
ml	: Milliliter (s).
mm	: Millimeter (s).
MMLB	: Maximum minus minimum live biomass.
Mn	: Manganese.
msl	: Mean sea level.

N	: Normal solution (Normality) or North or Total number of individual (s).
N/N_2	: Nitrogen.
$NaHCO_3$	: Sodium bicarbonate.
Nanoph.	: Nanophanerophytes.
NaOH	: Sodium hydroxide.
nm	: Nanometer (s) ; here, used for measuring wavelength.
No. / no.	: Number (s).
NPP	: Net primary production/ Net primary productivity.
NRSA	: National Remote Sensing Agency
P	: Phosphorus.
pH	: Power of hydrogen.
PLB	: Peak live biomass.
PSC	: Peak standing crop.
PWD	: Public Work Department (Government of Mizoram).
r	: Radius.
RNA	: Ribonucleic acid.
Rs.	: Rupees.
S	: Index of similarity or Total number of species.
SMC	: Soil moisture content.
SOC	: Soil organic carbon.
SOM	: Soil organic matter.
SPILB	: Sum of positive increment in live biomass.
SPILDB	: Sum of positive increment in live & dead biomass.
Sq	: Square.
SFR	: State of Forest Report.
Theroph.	: Therophytes.
UD	: Undisturbed area or site.
Vol (s).	: Volume (s).
WHC	: Water holding capacity of soil.
yr (s).	: Year (s).
Zn	: Zinc.
π	: Pi (equivalent to 22/7 or 3.14).

CHAPTER I

INTRODUCTION

INTRODUCTION

1.1 Biodiversity

The term 'biodiversity' which is the short form of 'biological diversity' has a common usage since around the middle of 1980's, reflecting increase awareness, at that time, of the threat to the global biological diversity. The term was coined by Walter G Rosen in 1985 (Wilson, 1988). According to Flint (1991), the value of biodiversity depends on how it is defined. A number of definitions can be found in literature, all saying the same thing in different ways. The following definition as good as any " Biodiversity is the variety and variability among the living organisms and the ecological complexes in which occur. ", " Biodiversity is the degree of nature variety, including both the number and frequency of ecosystem, species or genes assemblage (McNeely, 1988) or " The variability among the living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and ecosystems" (CBD.1992,Art.2 : Agarwal, 2002) . The diversity of plant is important for all animals, herbivores and omnivores. The different nutritional values of fruits and seeds enable a species to get the variety of the chemicals that are necessary for its diet and hence to graze without exhausting the population of a given species (Trivedi, 2000).

The earth has less than 7% cover under forests. The alarming rate of natural resources depletion and loss of forest cover has led to the identification of species rich areas on the earth (Myers, 1988). These areas are popularly called 'hot-spots' of biodiversity. The forest cover is inequitably distributed on the earth's surface and concentrated to 25 hotspots of biodiversity and occupied around 1.4% of the land surface

(Myers, 2001). Many of the hotspots occur in tropical belt; and two of them are in India- Western Ghats and Eastern Himalaya. The biodiversity hotspots of these areas have generally been inhabited by the indigenous tribes (Shankar, 2000).

Physiographically, the Indian mainland may be divided into three distinct regions- the Himalaya, the Indo-gangetic plain and the Peninsular India or the Deccan region. The Himalaya occupying the extreme northern margins of India has a great influence on the climate of the entire region. The great British botanist, Sir J. D. Hooker remarks at one place " The Indian flora is more varied than that of any other country of equal area in the eastern hemisphere, if not on the globe." (Hooker, 1904). It is estimated that about 17,000 vascular plants are accounted for in this region (Singh *et al.*, 2002). India has as many as 5,000 endemic species. The flowering plants of India comprise about 15,000 species and represent 6% of the world's known flowering plants. About 400 families and 2250 genera of flowering plants are known to occur in India in different ecosystems from the humid tropic of Western Ghats to the alpine zone of the Himalayas and from mangroves of tidal Sunderban to the dry desert of Rajasthan (Singh *et al.*, 2002).

The north-east Indian phytosociological region is the most significant one and represents the transition between the Indian, Indo-Malayan, Indo-Chinese phytosociological region as well as a meeting place of Himalayan mountains with that of Peninsular India. Therefore, this region acts as a biogeographically gateway for plant migration. This region is the richest in the biological diversity - diversity at the community level, at the species level and in endemics. The region experiences heavy rainfall, frequent floods and landslides. Much of the rainfall received in the region is through south-west monsoon during June to September. The rainy season is characterized by high humidity favourable for plant

growth. Generally, March to June is said to be the summer season. The winter season comes during December - March, characterised by heavy dew fall and misty night, while in high elevation frost is observed. Thus, the climate within the biogeographic region is highly variable - warm subtropical in foothills, moderate in the mid slopes, cool and temperate type in the high hills (Singh *et al*., 2002). The varied climates and the altitudes have greatly influenced the rich biodiversity in this region. North-East India, which forms the major part of the Himalayas is rich in forest and allied natural resources. About 53 percent of total area of North-East India is under forest cover which is higher than national average of about 20 percent. The area under forest ranges from 39 percent in Assam to 76 percent in Mizoram (Maite and Chakrabarti *in* Datta Ray and Alam, 2002).

North East India is of special significance for biodiversity conservation in the Indian context (Singh *et al*., 1994). But it has less forest cover than it was earlier. Deforestation generates degradation of forests, encroachment of valuable forest lands, illicit felling, interstate boundary disputes and their effect on deforestation, timber trades, shifting cultivation and forest fire are the genuine reasons for the continuous loss of forest cover in North-East India. As a result, the forest of this region is decreasing at a fast rate and has resulted to the ecological problems, like soil erosion, extinction of many ethno-botanical important species and wildlife (Bora & Kumar, 2003).

In warm and wet areas, the biological diversity is high, but decreasing with the decrease in latitudes and altitudes. Therefore, the richest areas on the land undoubtedly are which support tropical moist forests. Tropical forest covers nearly seven percent of the earth's land surface, they sustain more than half of our planet life forms (Myers, 1984). The tropical forests are characterized as highly complex ecosystem which in the

course of uninterrupted evolution over millions of years, have achieved a remarkable balance between plants, animals and the abiotic environment (Richards, 1977). The climax stage of the forest community is mainly attributed by the high level of species diversity. The structure and function of forest ecosystem is determined by the plant component rather than any other living component of the system. Species richness, their dispersion, density and dominance in relation to the co-existing species are major determinant of the community structure (Richards, 1996).

Tropical forest contributes around 69% of earth's biological productivity (Brungi, 1974) which is due to the high rate of carbon and nutrient turnover in soil and contains as much as 40% of carbon stored as terrestrial biomass (Dixon *et al.*, 1994). Tropical forest biomes are diverse, including desert, semi-arid savannas, dry forest, open woodlands, rain forest, mountain forest and coastal mangroves (Trochain, 1980). Champion and Seth (1968) have recognized 16 major forest types comprising 221 minor types in India. Of these, the tropical moist deciduous forest forms the major percentage (37%) of the forest cover in India. Tropical dry deciduous forest forms 28.6% and the remaining ones are scattered in minor percentage (Singh *et al.*, 2002).

In forest ecosystem, the plant component is more important than the other living component of the system for the determination of its structure and function (Richards, 1996). Raunkiaer (1934) proposed a life form system for the description of vegetation on physiognomic basis. This system is ecologically oriented and based primarily on the position of perennating organs or buds from which new shoots or foliage developed after an unfavourable season. He described communities of different

climatic zones on earth on the basis of life form (the sum of the adaptation of the plant to climate) composition.

Tropical forests are disproportionately important in the world carbon budget, representing an estimated 59% of the global carbon pool in forests (Dixon *et al*., 1994). Although they are only 22% of potential vegetation by area (Melillo *et al*., 1993), tropical evergreen and deciduous forests have been estimated to account for 32% (Field *et al*., 1998) to 43% (Melillo *et al*., 1993) of the world's potential terrestrial net primary production (NPP). The net carbon flux between these forests and the atmosphere has been little studied and is currently controversial. Eddy covariance data (Fan *et al*., 1990; Grace *et al*., 1995*a* & *b;* Keller *et al*., 1996) and long-term forest inventory records (Phillips *et al*., 1998) have suggested that mature tropical moist forests are carbon sinks. Other recent studies, however, indicate that reduction in NPP in these forests due to lowered soil moisture (Tian *et al*., 1998) or increased temperature (Kindermann *et al*., 1996) may make them net carbon sources during some years.

1.2 Productivity

Biomass is the term used to describe all the organic matter, produced by photosynthesis that exists on the earth's surface. The source of all energy in biomass is the sun, the biomass acts as a kind of chemical energy store. Biomass estimation is also needed for understanding the structure and dynamic functions of an ecosystem (Ovington, 1962).

Net primary productivity (NPP) is generally understood as the balance between the light energy fixed through photosynthesis and lost through respiration and mortality, representing the net carbon input from the atmosphere to terrestrial vegetation (Mellilo *et al.*, 1993). Net primary

production represents the main energy input of ecosystems (Odum, 1971) and has been proposed as an integrative variable of whole-ecosystem functioning (McNaughton *et al*., 1989). The better understanding of NPP is essential to understand the terrestrial carbon-cycle, biosphere-atmosphere interaction and response of ecosystem function to climate change and CO_2 fertilization (Melillo *et al*., 1993; Luo *et al.*, 2002).

1.3 Physico-chemical properties of soil

Soil plays a fundamental and irreplaceable role in the biosphere because it governs plant productivity of terrestrial ecosystem and allows the completion of the biogeochemical cycle. Soil is a natural mixture of weathered rock fragments and organic matter that has formed at the surface of the earth and is one of the most important ecological factors. Plants depend for their nutrients, water supply, and anchorage upon the soil. It is very complex and dynamic, undergoing continuous changes, and the rates of such changes being influenced by a number of factors in the environment. Soil may affect plants by affecting seed germination, size and erectness of the plant, vigor of the vegetative organs, woodiness of stem, depth of the root system, susceptibility to drought, frost and parasites, number of flowers per plant and the time of flowering, etc. The conservation and improvement of forest utilization have increased the interest in studies addressing the structure and function of forest ecosystems mainly the soil properties (Gallego *et al*., 1993). The present study focused on the physico-chemical properties of soil and mainly the macronutrients.

Soil physical properties play an important role in determining the physical conditions in soil where several biological processes take place (De Vos *et al*., 1994) while its chemical properties determined the quality of a particular soil (Hassink, 1997). Physico-chemical

properties like soil temperature, moisture content, bulk density, water holding capacity, pH, total, organic carbon, total nitrogen and phosphate influence soil microbial population and their activities, and uptake of water and nutrients by roots (Arunachalam et al., 1997). Soil development and plant succession go hand in hand and factors of soil complex such as pH, organic matter and nutrient contents influence community development on degraded and disturbed lands (Aweto, 1981; Pandey and Singh, 1984/ 1985). Nutrient regeneration in soil during revegetation of forest have been studied by Aweto (1981) and Pandey and Singh (1984/ 1985) in the tropical region and by Ramakrishnan and Toky (1981) and Mishra and Ramakrishnan (1983) in the humid sub-tropic of north-east India. They have founded the nutrient level increases with the increase in the age of the jhum-fallows. Studies conducted by Barik et al. (1992) suggest that the micro-environmental conditions especially air temperature and soil moisture regime strongly influence the survival and the growth of tree seedlings on the forest floor after disturbance.

Mechanical composition of soil, refer to the distribution of ultimate particles such as sand, silt and clay and not to aggregates present in the soil. Soil particles are classified quantitatively according to size and qualitatively according to shape, density and composition. However, the classification based on size of soil particles is most commonly used. Soil fertility is greatly influenced by texture of soil. The production of plant is lower in clay soil than in sandy soil in arid areas, but higher in the wet soil. Soil fertility increases with the increase in clay content, but high clay-soils are prone to drought in dry areas and to flooding in wet areas (Scholes *et al* ., 1994). Productivity of areas due to the interacting effects of clay on soil water and nutrient status. The clay content has a controlling influence on the soil water retention (Scholes, 1990). However, it is negatively related to the mineralization of nitrogen (Cote *et al.,* 2000). 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).

pH is the most important single property identifying the nature of soil. The pH of the solution has been defined as the negative logarithm of the hydrogen ion activity which in very dilute solutions can be expressed as concentration, in gram mole per liter. Soil pH value is a measure of the hydrogen ion activity of the soil water system and expresses the acidity and alkanity of soil. Soil pH influences the solubility of nutrients, microbial activity and physical condition of the soil. It affects the activity of micro-organisms responsible for breaking down organic matter and most chemical transformation in the soil. Soil pH thus affects the availability of several plant nutrients. In natural systems, the pH of soil is affected by the mineralogy, climate and weathering. The rate of soil acidification may be considerably increased by anthropogenic sulphur and nitrogen emission, since soil acidification is intimately connected with the cycling and transformation of carbon, nitrogen and sulphur species. Due to various human activities, the soil acidification rate has been increased particularly since World War II (Nilsson, 2004). Up to now, soil acidification has mainly been considered a problem of the industrialized countries of Europe and North America, but the problem of high sulphur and nitrogen emission is rapidly spreading to other part of the World such as southeast Asia (Kuylenstierna *et al.*, 1995). While, alkali soils contain an excess of exchangeable sodium and have sodium carbonate. Under conditions of excess salt, the soil pH is seldom higher than 8.5 and the clay particles remain flocculated as the concentration of the salt in the soil solution is lowered during rainfall (some of the exchangeable sodium hydrolyses and forms sodium hydroxide). This may change to sodium carbonate upon

reaction with carbon dioxide and absorbed (from the soil, air and atmosphere) and the soil may become strongly alkaline (pH above 8.5) (Keren, 2004).

Water plays a very significant role in soil-plant growth relationship. It forms major part of plant itself, essential for physiological activities, acts as a solvent and nutrient carrier and maintains turgidity of the plants. In fact, water is a regulator of physical, chemical and biological activities in the soil. It is the medium in which most transport of elements and particles occur within the ecosystem, for example, to the root surface and across its boundaries (Scholes *et al.*, 1994). The major source of soil water is rainfall. Most of the water which falls during rainfall is lost as run-off and some are lost during evaporation. Soil moisture is an important property of soil. Water content of soil is related to its texture and structure and also with the magnitude of such physical forces as capillary attraction, cohesion and adhesion. The size of the mineral particles and their shape and number of the pores spaces are important in the amount of water retained by the soil. Sand which are coarse-textured with larger particles can hold water only loosely due to bigger pore spaces. The water in such soil generally runs down rapidly reaching to deeper layers. Thus the sand soils are well drained. Clay soil, with much proportion of colloidal fraction as humus, etc. can retain much water. Silts like clays are also able to retain much water. Loam, which are a mixture of silt and sand and/ or clay, are supposed as best soil for plant growth, as such being rich in nutrients have proper aeration and hold fairly large amount of water (Sharma, 1997). Ecosystem biogeochemistry is strongly influenced by plant species acting in concern with abiotic factors (Hobbie, 1992). As a result, changes in vegetation composition can produce substantial changes in carbon and nitrogen dynamics and accelerate or constrain future changes (Chapin, 1993; Hooper and Vitousek, 1997; Tilman *et al.*, 1997). In arid and semiarid regions, trees and shrubs

affect the spatial distribution and cycling of nutrients by altering soil structure, microbial biomass, soil moisture, and microclimate and by concentrating organic matter beneath their canopies (Binkley and Giardina, 1998; Schlesinger and Pilmanis, 1998).

Soil organic matter is an accumulation of dead plant matter, partially decayed and partially re-synthesised plant and animal residues. Freshly fallen leaves and dying roots rapidly decomposed and the residues become part of soil humus - some portion of which remain in the soil for a very long period. The chemical composition of entire plant residue varies widely among plant species. The nature of soil organic matter in a range of forest soil is effected by tree species and soil physio-chemical condition The organic component on a dry weight basis comprise 5 - 30 % of water soluble, simple sugars, amino acids, and aliphatic acid; 10 - 50 % cellulose; 10 - 30 % hemicellulose; 5 - 30 % lignin; 1 - 8 % fats, waxes, oils, and rasins; and 1 -20 % protein (Reddy, Feijtel and Patrick, 1986). Soil organic C is the largest C reservoir in many terrestrial ecosystems including grasslands, savannas, boreal forests, tundra, some temperate forests, and cultivated systems, comprising as much as 98% of ecosystem C stocks in some systems (Schlesinger, 1977). Globally, the amount of C stored in soil is equal to the amount stored in vegetation and in the atmosphere combined (Schimel, 1995). A substantial portion of C fixed by vegetation is transferred to the soil annually (Raich and Nadelhoffer, 1989), a portion of which is refractory material with long turnover times (Falloon and Smith, 2000; Paul *et al*., 1997); the rest decomposes relatively rapidly and recedes to the atmosphere as CO_2. Soil organic matter act to store nutrients, improve nutrient cycling, build the soil structure, increase water infiltration, reduce soil compaction, increase the cation-exchange capacity, buffer against rapid change in soil pH,

serve as energy source for microorganisms and increase in the absorption of Cu, Mn and Zn in the soil (Borah *et al*., 1992).

Nitrogen is primarily stored in the form of storage proteins, amino acids and nitrate (Millard, 1988; Chapin *et al*., 1990). It is an essential nutrient and is viewed as a central element because of its role in substances such as protein and nucleic acids that form living material. It is a part of all essential constituents of cells: chlorophyll that is essential for photosynthesis, the nucleic acids, DNA and RNA in which the pattern of plant growth and development are encoded, the protein which include the enzymes that catalyze all the biochemical processes, the cell walls that hold cells together. It has significance in environmental and health problems (Benbi and Richter, 2004). In soil, complex nitrogenous compounds present in dead plant and animal tissues are broken down into number of simpler compounds, most of the nitrogen, being released in the form of ammonia and this process is known as ammonification (Devi, 2002). The plant demand for nitrogen is met by the N uptake from soil after the restoring of positive carbon balance of the whole plant (Clement *et al.,* 1978). The ability of plants to take up and assimilate inorganic nitrogen is reduced or stopped both in early spring and after defoliation (Clement *et al.,* 1978; Ourry *et al.,* 1990; Thornton and Millard, 1993). The major parts less than 90% of the soil nitrogen exist as 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 mineralisable nitrogen are considered to be quite satisfactory as index of nitrogen available in soil. Generally, in soil testing laboratory, organic carbon is used to indicate the status of available nitrogen.

Phosphorus (P) is a naturally occurring element in the environment that can be found in soils as well as in water and all living organisms. Soil P exists in inorganic and organic forms. Each form is a continuum of many P compounds, existing in equilibrium with each other and ranging from solution P (taken up by plants) to very stable or unavailable compounds (the most typical). Inorganic P is usually associated with aluminum (Al), iron (Fe), and calcium (Ca) compounds of varying solubility and availability to plants. Organic phosphorus compounds range from readily available undecomposed plant residues and microbes within the soil to stable compounds that have become part of soil organic matter. Biological processes in the soil, such as microbial activity, tend to control the mineralization and immobilization of organic phosphorus. Phosphorus has many important functions in plants, the primary one being the storage and transfer of energy through the plant. Adenosine diphosphate (ADP) and adenosine triphosphate (ATP) are high-energy phosphate compounds that control most processes in plants including photosynthesis, respiration, protein and nucleic acid synthesis, and nutrient transport through the plant cells. In most soil, the phosphorus content of surface horizons is greater and gradually decline with increasing depth was reported by Singh *et al.* (1995) in forest ecosystem at Holongapara, Jorhat (Assam).

Potassium is one of the major plant nutrients, which largely determines soil fertility. According to plant availability it is divided into potassium present in soil solution, in exchangeable form, as well as non-replaceable and present in soil crystal lattice (Barber, 1984; Mengel and Kirkby, 1987). It plays a dominant role in the maintenance of plant turgor, stomatal movement, cell expansion, cation - anion balance, pH, phloem transport, protein synthesis, and the activation of many enzymes. Soil with different climatic regimes, mineralogy, and texture may contain very different amounts of

total Potassium. In Temperate, neutral soils may contain up to about 3.6% or about 140 t ha^{-1} in the top 30 cm of soil (Lowton, 1955), whereas in wet, humid tropics levels can be as low as 0.05% or about 0.6 t ha^{-1} (Phetchawee *et al*,. 1985). Generally, only a very small proportion of the amount of potassium in soils is exchangeable or in solution and is thus readily available to crops.

1.4 Scope and objectives

1.4.1 Scope

The study area of the present work is the Mizoram University permanent campus near Tanhril village in the western part of Aizawl city. Formerly, the land belongs to and lies within the jurisdiction of Tanhril Village Authority. Tanhril village was established in 1881 and the name of the village is named after the name of their first local chief 'Tanhrila'. During that time, the main occupation of the people were jhuming agriculture and hunting animals. The common tree species were- *Aporusa octandra, Castanopsis tribuloides, Schima wallichii,* etc. In 1900's, the area was fully covered with primary vegetation and dense forests till the late of 1960's. But due to changes in land use, the area gradually became degraded by way of converting it into agricultural purposes and human activities. The impact of anthropogenic activity on the landmass and its biodiversity gradually start regaining of the ecological restoration since the signing of Memorandum of Understanding on segregation of land for Mizoram University between Tanhril Village Council Authority and the Government of Mizoram on 18th September 1984. The existence of Mizoram University is on 2nd July 2001 by the Mizoram University Act, 2000 which appeared in the Gazette of India (Extraordinary) on 25th April, 2000 as a Central University, has enormously enhanced the rejuvenation of herbaceous plants and shrubs in its natural habitat and ecosystem. Nevertheless, it is anticipated that, someday, the verdant vegetation cover of the area will become vanishing and many of them

will be blotted out of their natural habitats owing to the campus development and infrastructural set ups. Many changes will take place in due course of time. Before such things happen, it is felt that plant diversity and community within the campus should be properly studied, analyzed and documented as an essential asset to the first information material assistance for the future research and reference. Hence, the study was taken up to meet the challenge of the day at its initial stage of development.

1.4.2 Objectives

The present study focused on the following points-

(1) Assessment of plant diversity of the study area.

(2) Evaluation of the structure and composition of three stands (undisturbed, mildly disturbed and highly disturbed areas).

(3) Estimation of productivity of herbaceous species from the three stands.

(4) Analysis of physico-chemical characteristics of the soil.

CHAPTER II

LITERATURE REVIEW

LITERATURE REVIEW

2.1 Plant diversity in the world

The term biodiversity encompasses a broad spectrum of biotic scales, from genetic variation within species to biome distribution on the planet (Wilson and Willes, 1992; Gaston, 1996; Purvis and Hector, 2000; Mooney 2002). The introduction of the term biological diversity is not a new, which roses some twenty years ago (Lovejoy, 1980 a; b; Wilson and Peter, 1988; Reid and Miller, 1989; McNeely *et al.*, 1990; Chauvet and Oliver, 1993), but the origins of the concept go far back in time. Palmer (1995) stated that species diversity appears to be the most straight forward concept of the components of biodiversity than the other two components namely the genetic diversity and community diversity. According to Magurran (2004) the earliest reference of biological diversity was attempted by Gerbilskii and Petrunkevitch in 1955 in the context of inter-species variation in behavior and life history, and, followed by Lovejoy 1980b, Norse *et al.* 1986, Wilson, 1988.

A large number of studies have been carried out all over the world on various aspects of biodiversity. Hubbell and Foster (1983, 1992) and Johnston and Gilman (1995) conducted plant diversity studies in Panama and Guyana, respectively. Proctor *et al*. (1983, 1988) and Manokaran and Kochummen (1990) also carried out studies in the tropical moist forests of Malayasia. Cao Zhang (1997) reported the tree species composition in a seasonal rain forest in China. Lawesson, *et al.* (1998) investigated the floristic richness of different size, age and disturbances and have analyzed the relationship between species richness and forest area in Danish Beech forest. Burel, *et al.* (1998) compared the biodiversity in contrasted landscape units

within a small region. Connell (1978) studied diversity in tropical rain forests and coral reefs. Tanner (1977) carried out quantitative characterization of floristic and other ecological attributes in four montane rain forests of Jamaica. Similar studies have been carried out by Tackaberry and Kellman (1996) in Venezuela. Cao and Zhang (1997) investigated tree species diversity of Tropical forests vegetation in Xishuangbanna (South West China).Hare, *et al*. (1997) studied the structure and tree species composition in a sub-tropical dry forest in Dominican Republic; and he compared with a dry forest of Puerto Rico. Stapanian, *et al.* (1997) assessed regional pattern of local diversity of trees influenced by anthropozenies disturbances. Valencia *et al*. (1994) have reported a record number of 307 tree species (≥ 10 cm dbh) in one hectare plot of *Terra firme* forest in Amazonian Equator. Gentry (1988) reported 300 species (≥ 10cm dbh) from a one hectare plot of a Yanomono forest, Peru and, Bongers et al. (1988) in Mexico, recorded 292 tree species from one hectare plot.

2.2 Plant diversity in India

Biodiversity hotspots are defined as areas featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat (Myers *et al.,* 2000). Recently, 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). India is among the leading hotspots in terms of endemics. The determining criteria for a hotspot is that an area must contain at least 0.5% or 1,500 of the world's 300,000 plant species and 27,298 vertebrates (including mammals, birds, reptiles and amphibians) as endemics, and the remaining primary vegetation is less than 30% of its extent area (Sala *et al.,* 2000).

The Biological Diversity Act, 2002 states that biological diversity is 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 (BDA, 2002).

Champion and Seth (1968) classified the forests of India into 16 types. The forest cover in India constitutes 20.64% of its geographical area (SFR, 2003). 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 (Mayer, 1996). The vegetation and forest types have been analyzed by Champion and Seth (1968), National Remote Sensing Agency (NRSA, 1979) *in* Anon (1979), Forest Survey of India (SFR) (Anon, 2003), and Indian Institute of Remote Sensing (IIRS) (2003).

In India there are a number of ecological studies on floristic and biodiversity. Ghate, *et al.* (1997) assessed the plant diversity in western Ghat, while Jhosi and Suresh (1997) have carried out diversity analysis in Nilgiri Biosphere Reserve. Adhikari, *et al.* (1991) investigated the species composition and diversity in high altitude forest of Kumaon region in Western Himalayan. Ramakhrisna and his associates (Singh & Mudgal, 1998; Saxsena & Singh, 1982) initiated ecological studies on the forest of Meghalaya in the 1980's. Further studies on forest ecosystem of north east India were carried out by Singh (1980), Khan, *et al.* (1986: 1987); Barik *et al.*(1992), Rao, (1992), Rao and Hajra (1986), Rao *et al*. (1990). Barik, *et al.* (1992) studies

the species diversity in the sub-tropical forest of Meghalaya. Ganesh, *et al.* (1996) studied plant diversity in mid-elevation evergreen forest of Western Ghats.

Takhtajan (1969) considered northeast India as "The *cradle of ancient angiosperms*" due to the presence of a large number of primitive and ancient flowering plant in the region.

2.3 Plant diversity in Mizoram

The literature indicates that the plant diversity of Mizoram is not adequately studied as compared to other states of North East India. The initial studies were mainly based on the collection made by army officials, administrators and some missionaries out of their personal interest. The first collection of Mizoram plants was made by Col. A.T. Gage in the year of 1899; he recorded 317 species including 26 species of Cryptogams. The plant collections of the state have been also made by some workers (Hooker 1872- 1897; Gage 1899a & b; Kanjilal *et al*., 1934-1940; Deb & Dutta 1987; Parry 1932; Fischer, 1938a & b; Lorrain, 1940; and recent workers include Sawmliana, 1998-2003; Lalramnghinglova 1997, 2003; Singh *et al*., 2002). Lalramnghinglova (1997) published a book "Handbook of Common Trees of Mizoram" and carried out Ethno-botanically important plants in different forest areas and published a book on "Ethno-Medicinal plants of Mizoram" in 2003. Sawmliana (2003) recorded about 966 plant species from Mizoram. Lalramnghinglova (1997) and Lalnunmawia (2003) identified 20 species of bamboos; Lalnuntluanga (2007) identified 12 species of canes from Mizoram.

Some species of sedges and grasses were worked out for the state by some workers (Rao & Verma 1982; Shukla 1995). J.E. Leslie also made some valuable collection in 1920 and

deposited in Botanical Survey of India, Calcutta. Mrs. N.E. Parry also made some collection between 1924 and 1929 from Lunglei district. Most of her collections were sent to Royal Botanical Garden, Kew and to Indian Botanic Garden, Calcutta. In the year 1938, Fischer published 'The Flora of the Lushai Hills', he recorded 1360 species, including 6 species of Gymnosperms and 155 species of Cryptogams. Singh *et al.* (1990) recorded 244 species of orchids under 74 genera from the state (in Singh *et al*., 2002).

Out of 25 micro endemic centers identified in India, Mizoram comes under Patkoi-Manipur-Lushai Hill (Mayer, 1996). Despite its phytogenic affinities with Indo-Malaya, Bangladesh, Myanmar, Nepal, Bhutan and some South-East Asian countries, endemics in Mizoram is not so high as compared to the neighboring states. The reason being that floral exploration is not exhaustive and the faunal investigation is just negligible.

2.4 Plant community structure

One of the key goals of ecology is to explain the distribution and abundance of the species (Harte *et al*., 1999; Kunnin *et al*., 2000). Diversity of a community can be assessed by the proportional species abundance data either by using statistical sampling theory (Fischer et al., 1943; Preston, 1948; 1962) or by a variety of nonparametric measures (Simpson, 1949; Shannon, 1963). Due to the complex nature and lack of theoretical justification for statistical sampling theory, the nonparametric measures have a gained, a great deal of popularity in the recent past (Magurran, 1988a & b; Krebs, 1989).

If the relative abundance of species in a particular plant or animal group in a given community is some how measured, there will be some common species, and some rare species and many species of varying degree of rareness (May, 1975). The concept of dominance, that is, the idea that certain species so pervade the ecosystem that they exert a powerful on the occurrence of other species is one of the oldest concepts in ecology. McNaughton and Wolf (1970) opined that dominance is an expression of ecological inequalities arising out of different exploitation strategies.

The growth form or life-form composition of a community is the manifestation of the adaptation of its component species to the climatic condition of the area. Raunkiaer (1934) described plant communities in terms of life form composition. He divided the plants of the world into five (5) major life-forms, and prepared *life-form spectrum* or "*Biological spectrum"* and concluded that biological spectrum varies with latitude and altitude. Raunkiaer's work culminated in identification of four major plant climate zones on the land. The tropical zone was called as *Phanerophyte* climate, Sub-tropical zone as *Therophyte* climate, Temperate zone as *Hemicryptophyte* and Cold zone or Artic zone as Chamaephyte climate. High percentage of Phanerophyte in the flora of tropics has been supported by Lieberman *et al.* (1996). Richards (1996) used the word '*Synusiae'* to describe a group of plants having similar life-form which play similar role in the community to which they belong. He categorized synusiae of a community into two broad categories, *viz.,* autotrophic and heterotrophic.

2.5 Biomass and Productivity

Estimation of biomass is essential in determining the distribution of flow of material in an ecosystem (Anderson, 1971). Biomass study is static while its dynamics include the study of growth, productivity and turnover, and may be characterised by monitoring the changes in biomass over a period of interval (Santantonio *et al*., 1979).

Ovington *et al*. (1963) compared biomass and productivity of different ecosystem. Such as Prairie ecosystem, Savanna ecosystem and Oakwood ecosystem with that of intensely managed maize field. Gupta & Singh, (1982) found that the peak aboveground biomass in the tropical grassland around Kurukshetra ranged from 424-1921 g m^{-1} in November. Productivity of an ecosystem is strongly regulated by the botanical composition rather than by rainfall pattern (Bourlier and Headley, 1970; Singh and Joshi, 1979).

2.6. Soil and plant relationship

Soil and vegetation has a complex interrelationship. Soil properties influence the vegetation and *vice versa*. Selective absorption of nutrients by different tree species and their capacity to return these to the soil brings about changes in the soil properties (Rawat, 2005).

Recently, soil degradation is one of the serious environmental problems in the world (Middleton and Thomas, 1992). Especially, soil degradation proceeds rapidly in arid and semi-arid region, resulting in desertification in these areas. It is estimated that most of desertification has been caused by human activity (Koizumi *et al*., 2000), and the desertification in grazing lands is widely accelerated by overgrazing (Dregne *et al*., 1991; Kadomura, 1996).

Soil texture and density are important for soil water and air conditions (Landon, 1984). Soil texture is the most fundamental attribute of soil fertility. Soil fertility increases with clay content, but high clay-soil are prone to drought in dry areas and to flooding in wet areas. Clay soils lowered the production of plant than sandy soil in arid areas; the plant production is higher in wet areas due to the interacting effect of clay on soil water and nutrient status. Clay content has a controlling influence on the soil water retention (Scholes, 1990). Moreover, it is negatively related to the mineralization of nitrogen (Cote *et al.* 2000). The structure of soil influences organic matter turnover and fertility of soil and plays an important key role in the ability of soil to store organic matter (Balabane, 1996).

The temperature of soil is one of the most important factors for the growth of plant particularly that of the surface layers by its effect during germination (Richardson, 1958). The single most powerful control on the rate of chemical and biological processes in the soil is the soil water content. It is the medium in which most transport of elements and particles occurs within the ecosystem e.g., to the root surface and across its boundaries (Scholes *et al*., 1994). According to Singh and Datta (1987) the hill soils of Mizoram are acidic and conformed with several other works (Toky and Ramakrishnan, 1981; Andresse and Koopmans, 1984; Okigbo, 1984; Kumada *et al.,* 1985). pH characterizes soil acidity and is strongly correlated with base saturation, organic carbon, total nitrogen and cation exchange capacity (CEC) that are important parameters to characterize soil fertility for plant production (Landon, 1984).

Soil organic C is the largest C reservoir in many terrestrial ecosystems including grasslands, savannas, boreal forests, tundra, some temperate forests, and cultivated systems, comprising as much as 98% of ecosystem C stocks in some systems (Schlesinger, 1977). Globally, the amount of C stored in soil is equal to the amount stored in vegetation and in the atmosphere combined (Schimel, 1995). A substantial portion of C fixed by vegetation is transferred to the soil annually (Raich and Nadelhoffer, 1989), a portion of which is refractory material with long turnover times (Falloon and Smith, 2000; Paul *et al*., 1997); the rest decomposes relatively rapidly and is returned to the atmosphere as CO_2. Thus soil C is a large, relatively dynamic component of terrestrial C stocks.

Soil organic matter is an important determinant of the cation exchange capacity of soils, particularly in coarse texture soils and so called 'low activity' clay soils. It also plays an important role in retention of non-ionic organic compounds and pesticides in soils (Chiou, 1990). According to Russell (1980) the 'soil organic matter consists of a whole series product which range from undecayed plant and animal tissues through ephemeral products of decomposition to fairly stable amorphous brown to black material bearing no trace of anatomical structure of the material from which it was derive'. It is this latter, amorphous material that Russell (1980) terms 'humus'. Similarly, Schnitzer (1991) defined soil organic matter as the sum total of all organic-carbon containing substances in the soils which consist of 'a mixture of plant and animal residues in various stages of decomposition, of substances synthesized microbiologically and/or chemically from the breakdown products and of the bodies of live and dead microorganisms and small animals and their decomposing products'. Major environmental controls of organic matter decomposition in soil are moisture status, soil temperature, oxygen supply, clay content and

mineralogy (Alexander, 1977; Eijsackers and Zehnder, 1990; Anderson and Flanagan, 1990). Cultivation tends to increase the rate of organic matter loss in soils primarily by accelerating microbial decomposition (Seybold *et al*., 1999). Soil organic matter increases the absorption of Zn, Cu and Mn in soil (Borah *et al*., 1992). Organic matter is responsible for most desirable soil structure, increases soil porosity, impervious water and air, reduces soil erosion by wind and water and it is the reservoir of nitrogen. The nature of soil organic matter in a range of forest soils has been affected by tree species and soil physico-chemical condition (Howard *et al*., 1997).

Ecosystem biogeochemistry may be strongly influenced by plant species acting in concern with abiotic factors (Hobbie, 1992). As a result, changes in vegetation composition can produce substantial changes in carbon and nitrogen dynamics and accelerate or constrain future changes (Chapin, 1993; Hooper and Vitousek, 1997; Tilman *et al*., 1997). In arid and semiarid regions, trees and shrubs affect the spatial distribution and cycling of nutrients by altering soil structure, microbial biomass, soil moisture, and microclimate and by concentrating organic matter beneath their canopies (Binkley and Giardina, 1998; Schlesinger and Pilmanis, 1998). The result is the formation of ‘‘fertile islands’’ (Pauker and Seastedt [1996] for contrasting processes in alpine tree islands). This phenomenon has been widely described in cold desert scrub (e.g., Burke *et al*., 1989), hot desert scrub (Schlesinger *et al*., 1990; Kieft *et al*., 1998), temperate woodlands (Padien and Lajtha ,1992), and tropical (Scholes and Archer, 1994) and temperate savannas (McPherson, 1997).

The ability of plants to take up and assimilate inorganic nitrogen is lowered or stopped both in early spring and after defoliation (Clement *et al.,* 1978; Ourry *et al.,* 1990; Thornton and Millard, 1993). The plant demand for nitrogen is met by the N uptake from soil after the restoring of positive carbon balance of the whole plant (Clement *et al.,* 1978). Thus, the availability and mobilization of nitrogen reserves must be considered as an important factor in survival and competitive ability of perennial plants. Nitrogen is primarily stored as storage proteins, free amino acids and nitrate ions (Millard, 1988, Chapin *et al.,* 1990). However, it is not a much suitable nitrogen source for growth when the rate of photosynthesis is limited because reduction and assimilation of nitrate have a high requirement for the energy and carbon skeletons. Many plant species accumulate amino acids and amides in their vegetative tissues in large quantities (Millard, 1988). The content of these compounds in perennating organs usually rise in late autumn and remains high until late spring (Volenec *et al*., 1996). The marked increase in amino acid content in autumn is closely connected with remobilization of N from senescing plant parts (Millard, 1988) but may also reflect the temporary higher availability of N in soil. The composition of free amino acid pool varies considerably during the growing season. High levels of glutamine, asparagine, arginine and alanine usually accumulate in below-ground organs before the winter dormancy (Rosnitschek-Schimmel, 1985a & b; Nordin and Näsholm, 1997). These compounds possess low C to N ratio and thus minimizes the requirement of carbon skeletons for N storage. Nitrogen stored in form of free amino acids may contribute up to 20 % to present total N in over-wintering organs (Nordin and Näsholm, 1997). Vegetative storage proteins may also serve as a mobilizable nitrogen reserve. Convincing evidence for their importance has recently been summarised by Stepien *et al.,* (1994) on woody plants and by Staswick (1994) on herbaceous species.

Phosphorus (P) is one of the key elements necessary for the growth of plants and animals. Phosphorus exists in soils and minerals, living organisms, and in the water column of lakes and wetlands. Although wetlands generally accumulate nutrients, they sometimes become net exporters of nutrients that had previously been taken up by plants (Mitsch and Gosselink, 1993). Phosphorus occurs in a sedimentary cycle with no significant gaseous loss mechanism, so it tends to accumulate in wetland systems. Retention of P is regulated by sedimentation and uptake and release by vegetation, periphyton, and microorganisms. P occurs as soluble and insoluble compounds in both organic and inorganic forms (Faulkner and Richardson, 1989). The vast majority of P is tied up in organic matter and inorganic sediments and is also rendered unavailable to plants and microorganisms through precipitation of insoluble phosphate and the adsorption of phosphate onto clay particles, peat, and Iron (Fe) and Aluminum (Al) hydroxides (Mitsch and Gosselink, 1993). Conversely, P can be released from sediments by diffusion, desorption, and re-suspension.

Potassium is found in soils in three different forms and a three ways dynamic equilibrium exists between them.

Non-exchangeable K ↔ Exchangeable K ↔ Soil solution K.

Potassium is taken up by plants from the soil solution, and the concentration in solution will be replenished by the exchangeable fraction. Some of non-exchangeable K can also be released into the soil solution and may thus be taken up by plants (McLean, 1961; Blanchet and

Bosh, 1967; Prasad and Power, 1997; Havlin *et al*., 1999; Brady and Weil, 1999). The capacity of soils to supply plants with K does not depend only on the amount of K reserve in soil, but also on the rate of availability of plants. The latter can be estimated only with suitable experiments in pots (Grimme and Nemeth, 1978). Some soils can provide enough for many years, but the release of K is slow to meet the need of crops (Arnold and Close, 1958; McLean and Watson, 1985; Johnston and Goulding, 1990).

CHAPTER III

STUDY AREA

STUDY AREA

3.1 Location

The permanent campus of the Mizoram University is selected as the study area. The Mizoram University was established on 2nd July 2001 under the Mizoram University Act, 2000. The Bill of Central University in Mizoram was passed by Rajya Sabha in 1999 and Lok Shaba in 2000 with an outlay of Rs. 25 crores for infrastructure development. The study area is situated in the western side at a distant of about 15 km away from the state capital Aizawl, just below Tanhril village **(Fig. 1a)**. The area of Mizoram University Campus is 978.1988 acres and lies between 23^{0}45’25" N and 23^{0}43’37" N latitudes and 92^{0}38’39’’ E and 92^{0}40’23" E longitudes. The elevation ranges from 300 m to 880 m above mean sea level (msl.) (**Fig.1b**).

3.2 Climate

The climate is humid and tropical, characterized by short winter, long summer with heavy rainfall. During the study period, temperature did not fluctuate much throughout the year which ranges from 13 ^{0}C to 36 ^{0}C. The highest temperature is observed during April and May, and the lowest is during December and January (**Fig. 2a**). The study area receives rains from the south-west monsoon. The precipitation was heavy in summer, generally from May to September, and lasts till late October. Normally July (376 mm) and August (453mm) were the rainiest months while December (10 mm) and January (8 mm) were the driest months (**Fig. 2b**). The average annual rain fall was about 182 mm.

Three seasons are generally observed in Mizoram (Pachuau, 1994).

(a) Cold or winter season

The winter season starts from November to February. Temperature ranges between 8^0C and 24^0C and a very less rainfall which is received from north-east, generally known as retreating monsoon. During this season morning mists are very common in most valleys.

(b) Warm or spring season

The spring season begins from March to the first part of May and is characterized by a bright sunshine and a clear blue sky. The temperature is fluctuated from 19^0C to 32^0C. Maximum isolation is received during this period due to the clear blue sky. This season is the hottest season in Mizoram.

(c) Rainy or summer season

Rainy season is the longest season, it lasts for nearly six months from second half of May to late October with varying rainfall from 100 mm (May) to 440 mm (August). This season receives south-west monsoon which blows Mizoram from south-west through Bay of Bengal, sometimes with violent storms in the beginning of the season. The temperature is high but declined to very low during raining.

3.3 Geology, rocks and soil

The soil of Mizoram is generally young, immature and sandy. In the study area, sedimentary rocks are seen at some places in the base lines and in watersheds. Rock plates and hard shales are present in the upper areas, where stone quarries are laying along the side of the PWD road. Soils of the study area are porous, sandy loam, humus and the top soil have been washed away by run off.

3.4 Vegetation

The vegetation of the campus falls under Tropical semi-evergreen forests. (Champion & Seth, 1968). Plant diversity in this area is quite rich particularly in the western sides representing the forests with less biotic disturbances. The most common tree species present in this area are :- *Aporusa octandra, Castanopsis tribuloides, Schima wallichii, Anogeissus acuminata, Bischofia javanica, Emblica officinalis, Glochidon sp.* etc. Some common species of shrubs are *Melastoma nepalensis, Clerodedrum infortunatum, Chromalaena odorata , Garcinia cowa,* etc. and some common herbaceous species are - *Imperata cylindrica, Mikania micrantha, Erianthus longisetosus, Thysanolaena maxima, Ageratum conyzoides, Bidens biternata , Knoxia corymbosa* etc. Bamboo species present in the study area are – *Melocanna baccifera, Dendrocalamus hamiltonii* and *Dendrocalamus longispathus.*

3.5 Drainage system

The area of the Mizoram University Campus is characterized by a series of undulating and slanting slopes of enchanting hill ridge with the western spur that falls under steep slope to the bank of Setlak stream. Setlak is the biggest stream in the study area and is joined by some other streams like Rultawi-lui, Hratdawng-lui, Lalmangkhawng-lui and Lungsumzau-lui. Other important streams are Chengkawl-lui and Kel-lui. Most of the streams run towards north-west direction till they meet the longest river in Mizoram, called 'Tlawng-lui' **(Fig. 1b.)**. ('Lui' means river or stream.)

3.6 Experimental sites

Three experimental sites were selected on the basis of disturbance gradient for the present study; they are - highly disturbed (HD), mildly disturbed (MD) and undisturbed (UD). The highly disturbed site is an open area where grasses and a few shrubs and trees are

present. The mildly disturbed site is a secondary forest where jhuming system of cultivation was practiced about 10 - 20 years ago, and the undisturbed site is a natural forest and rocky area, about 20 – 35 years old. There are a number of small steams or brooks traversing the study area; those streams remain dry in almost all seasons except in rainy season (**Photo plate 1**).

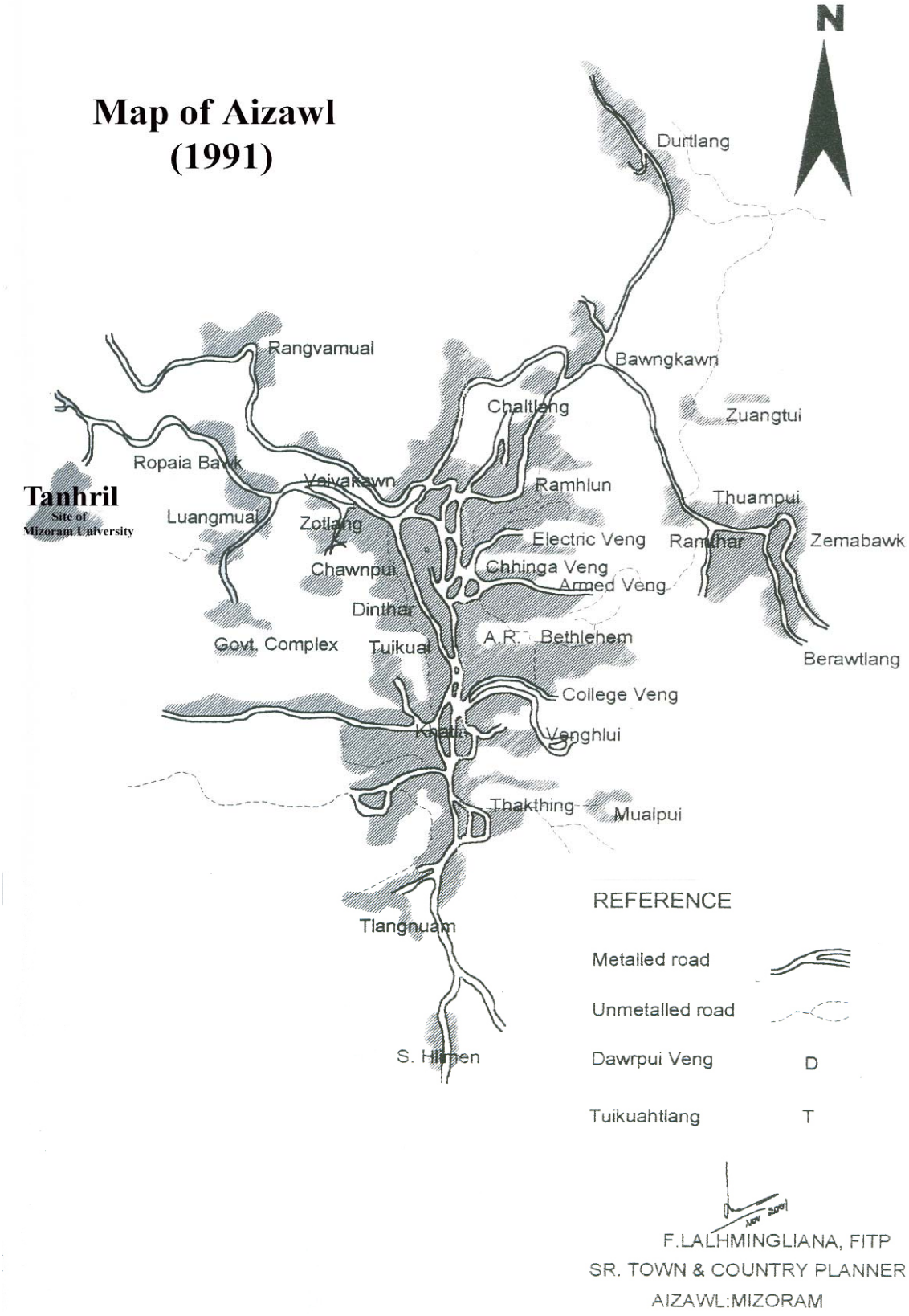

Fig. 1a. Map of Aizawl city under Town and Country Planner, Aizawl, Mizoram (1991).

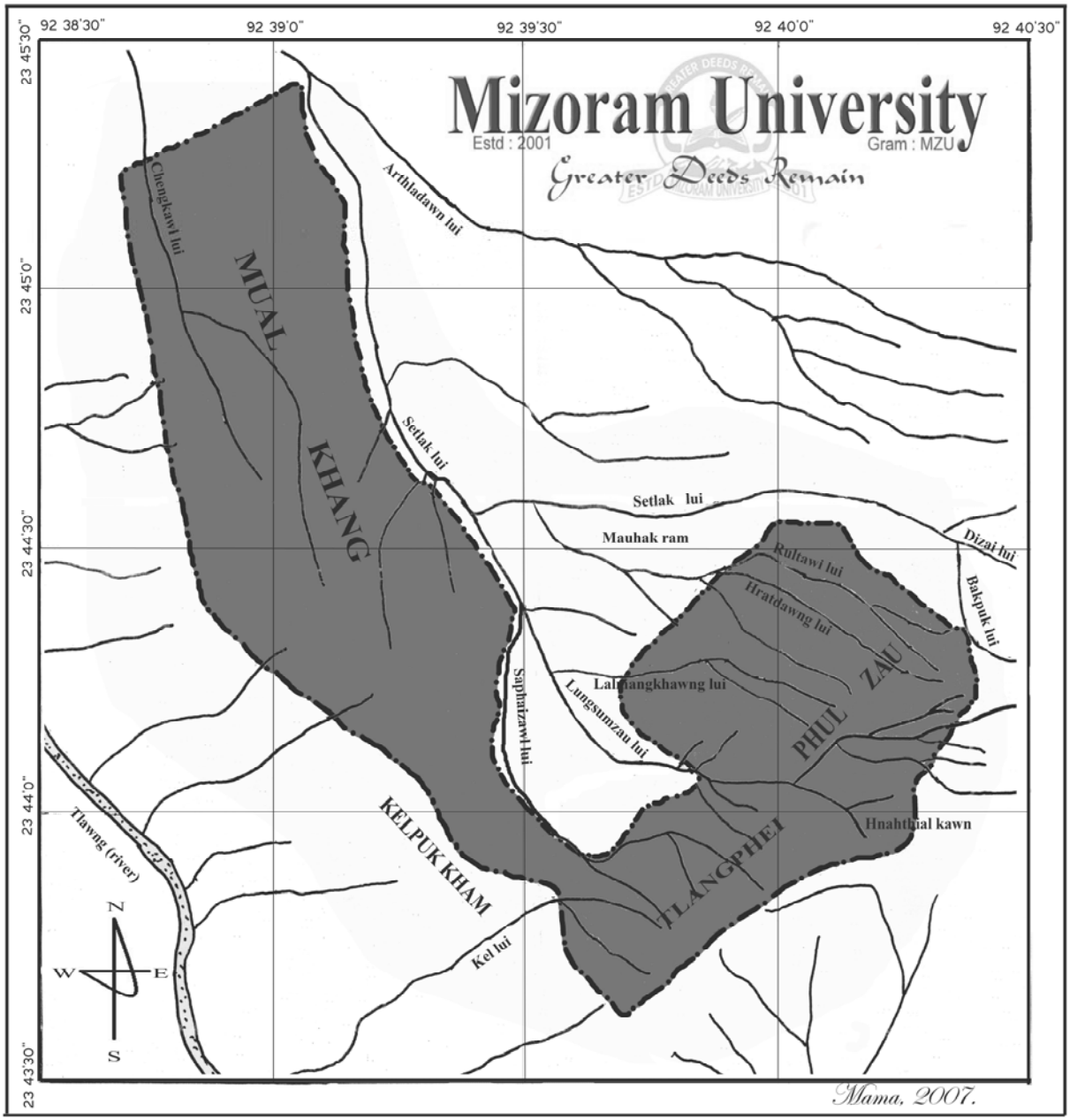

Fig. 1b. Map of Mizoram University Campus, Tanhril, Aizawl, showing boundaries and drainages.

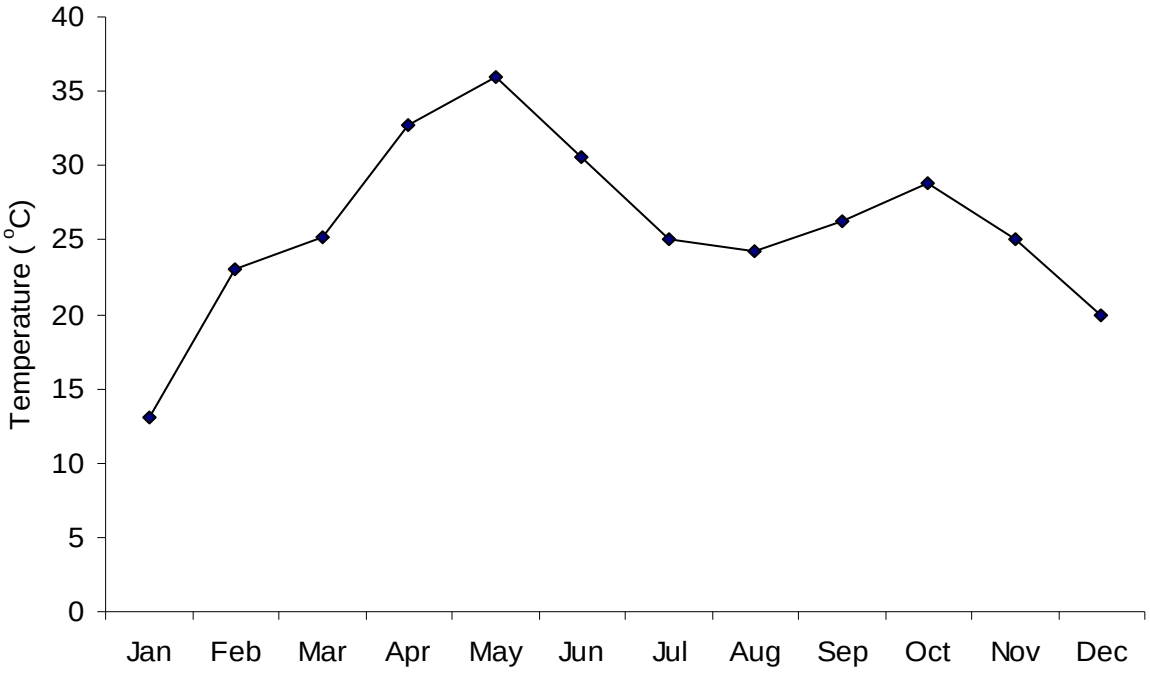

Fig. 2a. Average monthly temperature in the study area (2005).

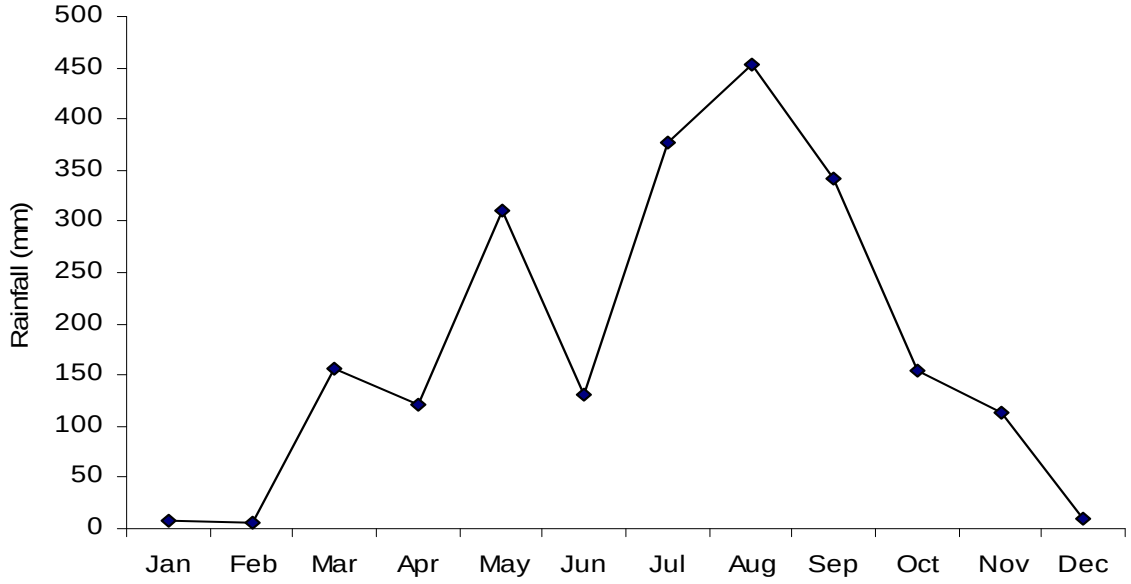

Fig. 2b. Average monthly rainfall in the study area (2005).

Photo plate 1.

Photo 1: Highly disturbed area.

Photo 2: Mildly disturbed area.

Photo 3: Undisturbed area.

CHAPTER IV

METHODOLOGY

METHODOLOGY

4.1 Field work

The study area was divided into three study sites on the basis of disturbance gradient *i.e*. highly disturbed (HD) area , mildly disturbed (MD) area, and undisturbed (UD) area for studying the status of plant diversity, community structures monthly soil condition and productivity of herbaceous species of the study area.

The field work was carried out within two years from January 2005 to December 2007. In the first year, *i.e*., January – December 2005, soil sample and biomass of herbaceous plants were collected from the three study sites and analyzed in the laboratory. Then in the next two years, *i.e*., January 2006 – December 2007, the study of plant diversity community structure and specimen collection were conducted from the three study sites.

4.2 Community analysis

Community analysis was carried out during rainy season when majority of the plants were at the peak of their growth. In every study sites, 30 quadrats of 10 m X 10 m (100 sq m) size were randomly laid to study tree species and shrub species. The tree species includes all the saplings, poles and trees present in the study area. The herbaceous species was studied by laying 50 quadrats of 1m X 1m (1sq m) size randomly in each study site.

4.2.1 Quantitative analysis

The important quantitative analysis such as density, frequency, and abundance of tree species, shrubs and herbs species were determined as per Curtis and McIntosh (1950).

(a) Density.

Density is an expression of the numerical strength of a species where the total number of individuals of each species in all the quadrats is divided by the total number of quadrats studied. Density is calculated by the equation:

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

(b) Frequency (%).

This term refers to the degree of dispersion of individual species in an area and usually expressed in terms of percentage occurrence. It was studied by sampling the study area at several places at random and recorded the name of the species that occurred in each sampling units. It is calculated by the equation:

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

(c) Abundance.

It is the study of the number of individuals of different species in the community per unit area. By quadrats method, samplings are made at random at several places and the number of individuals of each species was summed up for all the quadrats divided by the total number of quadrats in which the species occurred. It is represented by the equation:

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

4.2.2 Importance Value Index

This index is used to determine the overall importance of each species in the community structure. In calculating this index, the percentage values of the relative frequency, relative

density and relative dominance are summed up together and this value is designated as the Importance Value Index or IVI of the species (Curtis, 1959).

(a) Relative density.

Relative density is the study of numerical strength of a species in relation to the total number of individuals of all the species and can be calculated as:

$$\text{Relative density} = \frac{\text{Number of individual of the species}}{\text{Number of individual of all the species}} \times 100$$

(b) Relative frequency.

The degree of dispersion of individual species in an area in relation to the number of all the species occurred.

$$\text{Relative frequency} = \frac{\text{Number of occurrence of the species}}{\text{Number of occurrence of all the species}} \times 100$$

(c) Relative dominance.

Dominance of a species is determined by the value of the basal cover. Relative dominance is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area.

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

The total basal area was calculated from the sum of the total diameter of immerging stems. In trees, poles and saplings, the basal area was measured at breast height (1.5m) and by using the formula πr^2; but in case of herbaceous vegetation it was measured on the ground level by using calipers.

4.2.3 Similarity and dissimilarity indices

Indices of similarity and dissimilarity were calculated by using formulae as per Misra (1989) and Sorensen (1948) as follows:

Index of similarity (S) = 2C/A+B

Where, A = Number of species in the community A

B = Number of species in the community B

C = Number of common species in both the communities.

Index of dissimilarity = 1-S

4.2.4 Species richness, diversity and dominance indices

The species richness of the vascular plants was calculated by using the method 'Margalef's index of richness' (D_{mg}) (Magurran, 1988)

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

Where, S = Total number of species.

N = Total number of individuals.

Species diversity and dominance were evaluated by using the following methods. Shannon's diversity index and Simpson's index of dominance were calculated using important value index (IVI) of species.

(a) Shannon–Weaver (1963) index of diversity:

The formula for calculating the Shannon diversity index is

$$H' = - \sum p_i \text{ In } p_i$$

Where, H' = Shannon index of diversity

p_i = the proportion of important value of the i^{th} species ($p_i = n_i / N$, n_i is the important value index of i^{th} species and N is the important value index of all the species).

(b) Simpson (1949) index of Dominance:

The equation used to calculate Simpson's index was

$$D = \sum (p_i)^2$$

Where, D = Simpson index of dominance

p_i = the proportion of important value of the i^{th} species ($p_i = n_i / N$, n_i is the important value index of i^{th} species and N is the important value index of all the species).

As D increases, diversity decreases and Simpson's index was therefore usually expressed as 1 – D or 1/ D.

4.3 Life-form spectrum

The plant species found in the study area were grouped into different life form on the basis criteria outlined by Raunkiaer (1934), Misra (1968) and Ellenberg and Muller- Dombois (Domboise, 1974).

Life-form	Description (Position of perennating bud from the ground)
Megaphanerophyte	Above 30 m high
Mesophanerophyte	8 – 30 m high
Microphanerophyte	2 – 8 m high

Nanophanerophyte	Up to 2 m high
Chamaephyte	Up to 0.3 m high (low woody plants or herbs)
Geophyte	Underground
Theophyte	Survival in unfavorable condition through seeds (annual plants)
Epiphyte	Plants growing on other plants
Liana/ Scandent/ Climber	Mechanically dependent plant.

4.4 Herbaceous productivity

4.4.1 Biomass sampling.

Every month during the study period, 10 quadrats of 1 sq m were laid randomly in each of the three study sites- highly disturbed (HD), mildly disturbed (MD) and undisturbed (UD) areas. The above ground plant parts were taken from every quadrat and kept in polythene bags. Surface litters were hand-picked after the aboveground compartment of the vegetation had been clipped and kept in polythene bags. Below ground plant parts were taken by using soil monolith (15 cm x 15 cm x 30 cm) and kept in polythene bags.

The sampled materials of aboveground, litter and belowground compartments were transported to the laboratory. The aboveground compartment of each species was sorted out into living and standing dead. The aboveground compartment was separated into species-wise. Depending on necessity, the litter was cleaned with water to remove the adhering soil particles. Belowground biomass was extracted from the excavated soil monoliths by following floating method of McKell *et al*. (1961). The excavated soils were soaked in a bucket of water for about half an hour and then repeatedly washed in a large tray with fine jet of water using a 0.5 mm

mesh sieve. Large particles of stones, charcoals, debris, etc., retained by the sieve were hand picked. Then all the collected samples of aboveground compartments, litters and belowground compartments were dried in a hot-air oven at 80^0 C for 48 hours. Then the dry weights were taken with the help of balance (Misra, 1968).

4.4.2 Productivity measurement

The net primary productivity (NPP) of herbaceous species was calculated by using the methods such as

(1) peak live biomass,

(2) peak standing crop (live plus standing dead matter),

(3) maximum minus minimum live biomass,

(4) sum of positive increments in live biomass, and

(5) sum of positive increments in live and dead plus litter (Long *et al*., 1992; Scurlock *et al*., 2002; Singh and Yadava, 1974).

4.5. Plant collection, processing and identification

Extensive and intensive floristic survey was carried out in the study area at monthly intervals during the study period. Specimens of flowering and non-flowering vascular plants found in the study area were collected and processed in the laboratory.

The plant specimens collected from the study area were pressed between the absorbents under heavy pressure immediately after reaching the laboratory. Dried specimens were poisoned by dipping the whole plant in a solution of mercuric chloride in ethyl alcohol (115 g mercuric chloride dissolved in 4.5 liter ethyl alcohol, called *Kew Mixture*). After the specimens were

poisoned, they were dried and affixed (along with a label) on a mounting sheets [28 cm X 42 cm (±1 cm) dimension] by using Fevicol glue.

The Plant specimens were identified using various regional floras *viz*., Flora of Assam (Vol. 1 – 5) by Kanjilal *et al.* (1934-40); Flora of Mizoram (Vol. 1) by Singh *et al.* (2002); Flora of British India (Vol. 1 – 7) by Hooker, (1872-1879); Forests Flora of Meghalaya (Vol. 1 & 2) by Haridasan and Rao (1985-1987); The Flora of Tripura State (Vol. 1 & 2) by Deb (1981 &1983). Unidentified specimens were taken to the Assam Herbarium of the Botanical Survey of India, Shillong for proper identification and matching of the specimens. Identified specimens were deposited in the Herbarium of the Department of Forest Ecology, Biodiversity and Environmental Sciences, Mizoram University, Aizawl.

4.6 Physico-chemical properties of soil

4.6.1 Soil sampling

Soil samples were collected randomly from five permanent places in every three study sites at monthly intervals from January 2005 to December 2005. The soil samples were collected by using soil corer from 0 to 10 cm and 10 to 20 cm soil layers. The soil samples from the same study site and same layer were mixed thoroughly, air dried and passed through a 2mm mesh sieve to remove the stone pieces and large root particles. The composite soil sample was used for detail analysis.

4.6.2 Soil analysis

4.6.2.1 Physical properties of soil.

Soil moisture content

The moisture content of soil was determined by Gravimetric method/ Oven dry method (Allen *et al*., 1974) at monthly intervals. Ten gram of freshly collected soil sample was kept in a hot air oven at 105 ^{0}C for 24 hours. The air dried soil was then weighted again and recorded.

Soil texture

The soil texture was determined by Bouyoucos hydrometer method (Allen *et al*., 1974).

Water holding capacity

Water holding capacity of soil was determined by Keen's method by using copper cup of 5.6 cm internal diameter and 1.6cm height (Piper, 1942).

4.6.2.2. Chemical properties of soil.

Soil pH

Soil pH was measured by mixing 10 gram of freshly soil sample and 50ml of distilled water and stirred for 20 minutes in a 100 ml beaker using magnetic stirrer. The soil-water mixture was kept overnight and taken the reading with the help of Digital pH meter (Systronics 335).

Soil organic carbon

Soil organic carbon was determined by rapid dichromate oxidation technique (or Walkley and Black Method, 1934. *In* Maiti 2003). The organic matters in the soil were oxidized by

chromic acid (Potassium dichromate plus conc. $H_2 SO_4$) utilizing the heat of dilution of $H_2 SO_4$. The unreacted dichromate was determined by back titration with ferrous sulphate (Maiti 2003).

Total Nitrogen

The total nitrogen was determined by Kjeldahl method. The air-dried soil sample were digested in a block digestor in the presence of 10 – 15 ml of conc. $H_2 SO_4$ and 5 – 7 g of salt mixture *i.e.,* mixture of 250g K_2SO_4, 50g $CuSo_4.5H_2O$ and 5 g metallic Selenium as catalyst at the temperature between 360^o C and 410^o C. Distillation was done with the help of 'Kel Plus Nitrogen Estimation System' by adding 40 ml of 40% NaOH. The distillated sample was collected in a 250 ml conical flask containing 4% boric acid and three drops of bromocresol green and methyl orange, and then the colour appeared transparent. The sample was then titrated against 0.1N HCl.

Available phosphorus

Available phosphorus was determined after extracting soil phosphorus in 0.5 M sodium bicarbonate solution by Olsen's method. The extract was prepared by adding 2.5 g of soil sample in the 250 ml conical flask containing 50 ml of extracting solution ($NaHCO_3$), shaken for 30 minutes and the suspension was filtered through a Whatman No. 40 paper. Then 5 ml of the extract was taken into a 25 ml conical flask, to which 5 ml of Dickman and Bray's reagent was added drop by drop till the effervescence ceased. The content was diluted to 22 ml, adjusted the pH to 5.0 and added 1ml of diluted $SnCl_2$. Then the optical density was measured just after 10 minutes with the help of Systronics Spectrophotometer 119 at 660 nm (Maiti, 2003).

Exchangeable potassium

Exchangeable potassium of soil was determined by using flame photometer after extracting with 1N ammonium acetate solution. 5 g of soil sample was shaken with 25 ml of 1N ammonium acetate solution for 5 minutes and filtered through Whatman No. 1. Then the potassium concentration was determined by flame photometer by using K-filter (Ghosh 1983, Maiti 2003).

CHAPTER V

RESULTS

RESULTS

5.1 Plant diversity

In the present study, plant diversity in the Mizoram University Campus have been evaluated and documented for the first time both from taxonomical and phyto-sociological point of view. The name of the families are arranged according to the Bentham and Hooker's system of classification (1862-83) and a little with Hutchinson (1959) regarding splitting of the families. Metric units of centimeters and meters are used for measuring the height, length and width of the plant specimens. Angiosperms were the dominant component in the study area.

5.1.1 Families

In the present study, 107 families of vascular plants were recorded in the study area (**Table 1a & 1b**). Out of these, 53, 82 and 78 families were present in the highly disturbed area, mildly disturbed area and undisturbed area respectively (**Table 1c**).

Taxonomically, Asteraceae and Poaceae were the most dominant family (with 14 species) followed by Euphorbiaceae (9 species), Cyperaceae (8 species), Papilionaceae (8 species) and Rubiaceae (6 species) in highly disturbed area. Euphorbiaceae (16 species) was the most dominant family and followed by Rubiaceae (12 species), Lauraceae (11 species), Papilionaceae (9 species), Moraceae (8 species) and Asteraceae (6 species) in mildly disturbed area. Euphorbiaceae (14 species) was the most dominant family and followed by Papilionaceae (13 species), Rubiaceae (12 species), Lauraceae (10 species), Moraceae (9 species), Acanthaceae (6 species) and Mimosaceae (6 species) in the undisturbed area. The family-wise distribution of the species in the three study sites are shown in the **Table 1d.**

In the highly disturbed area, there were 48 families of angiosperms and 5 families of pteridophytes. Among the angiosperms, 45 families were dicotyledons and 3 families of monocotyledons. The mildly disturbed area contained 76 families of angiosperms and 6 families of pteridophytes. Among the angiosperms, 65 families were dicotyledons and 11 families were monocotyledons. In undisturbed area, there were 73 families of angiosperms, 1 family of gymnosperms and 4 families of pteridophytes. Among the angiosperms, there were 63 families of dicotyledons and 10 families of monocotyledons (**Table 1c**).

5.1.2 Genera

Altogether 290 genera of vascular plants were recorded in the three study sites (**Table 1b**). Out of which, 116, 164 and 172 genera were observed in highly disturbed, mildly disturbed and undisturbed areas respectively (**Table 1c**).

In the highly disturbed area, there were 111 genera of angiosperms and 5 genera of pteridophytes. Among the angiosperms, 91 genera were dicotyledons and 20 monocotyledons. The mildly disturbed area contained 155 genera of angiosperms and 9 genera of pteridophytes. Among the angiosperms, 134 genera were dicotyledons and 21 genera were monocotyledons. In undisturbed area, there were 167 genera of angiosperms, 1 genus of gymnosperms and 4 genera of pteridophytes. Among the angiosperms, there were 148 genera of dicotyledons and 19 genera of monocotyledons (**Table 1c**).

5.1.3 Species.

In the present study, 384 of vascular plants were recorded in the study area (**Table 1a & 1b**) of which, 136, 205 and 213 species were present in the highly disturbed area, mildly disturbed area and undisturbed area respectively (**Table 1c**).

In the highly disturbed area, there were 130 species of angiosperms and 6 species of pteridophytes. Among the angiosperms, 107 and 23 species represent dicotyledons and monocotyledons, respectively. The mildly disturbed site contains 196 species of angiosperms and 9 species of pteridophytes. Among the angiosperms, 173 species were dicotyledons and 23 species were monocotyledons. In undisturbed area, there were 208 species of angiosperms, 1 species of gymnosperms and 4 species of pteridophytes. Among the angiosperms, there were 187 species of dicotyledons and 21 species of monocotyledons (**Table 1c**).

The species recorded in the Mizoram University Campus, Tanhril were arranged in the natural order of Bentham and Hooker (1862-1883) as adopted by Kanjilal *et al.* (1922-1934) and Rao (1985) (**Table 1b & 1c**). Angiosperms were the dominant component in the study area followed by pteridophytes and gymnosperms. Similarly in "The Book of Mizoram Plants' by Sawmliana, (2003), 87% of the total species were angiosperms followed by gymnosperms (0.93%) and pteridophytes (0.93%). Among the angiosperms, dicotyledons were the dominant component (86.72%) and monocotyledons constitute 13.28% in the study area.

Plants found in the study area are briefly described and arranged in an alphabetical order. The abbreviations used for the local name are: (M) for Mizo and (LR) for Lalramnginglova, H. who has nomenclatured some local (Mizo) names for the first time. The vascular plant species present in the study area are briefly described as follows:

Abelmoschus moschatus Medicus. Family: Malvaceae. Local name: Uichhu-me/ Uichhu hlo/ Bawrsaiabe-suak (M).

An erect, hirsute herb to 1.5 m high. Leaves polymophous, lower ovate, acute, upper palmately 3-5 lobed; lobes spreading, lanceolate, coarsely toothed or serrate, acuminate; petiole long with deflexed hair. Flowers large, yellow with a purple center, solitary-axillary. Fruits fulvous-hairy, oblong-lanceolate, acute. Seeds reniform, black, striate.

Flr: September- October. Frt: October- December.

Acacia pennata (Linn.) Willd. Family: Mimosaceae. Local name: Khanghu (M).

Large scandent or lianas, with prickles. Leaf rachis 15-20 cm long; pinnae 8-16 pairs; leaflets 40-50 pairs, sessile, linear-oblong; base truncate, acute, glabrous. Flowers heads white or creamy white, terminal. Pods stalked, oblong or acute or acuminate at apex.

Flr. & Frt: July- February.

Acacia pruinescens Kurz. Family: Mimosaceae. Local name: Khang-pawl (M).

Large prickly scandent shrub. Leaf rachis 12-25 cm long; pinnae 6, 8-15 pairs; leaflets 5-8 x 1 mm, 40-60 pairs, sessile, linear-oblong, truncate at base, obtuse at apex. Flower heads yellow, in axillary panicles, acute. Pods strap-shaped, pale brown.

Flr. & Frt: April- January (Next year).

Acanthus leucastachyus Wall. Family- Acanthaceae. Local name: Unknown.

A shrub, decumbent stem, wooly. Leaves 7.6-7 x 2.5-6 cm, elliptic or oblong, obtuse or acute, spinous-serrate, sub-coriaceous, glabrous above, pubescent along the nerves beneath also whitened. Flowers usually in terminal hairy spikes. Seeds compressed, glabrous.

Flr: March. Frt: Rainy season

Acer laevigatum Wall**.** Family: Acanthaceae. Local name: Thing-khim (M).

A medium to large deciduous tree up to 15m tall with irregularly oval spreading crown; bark dark greyish-green. Leaves simple, oblong, ovate or elliptic lanceolate, 5-12 x 2.5-5 cm, base rounded or sub-acute, acuminate at apex, glabrous, entire to minutely serrulate along margins. Racemes sub-corymbose or panicled, glabrous, appearing with leaves terminals. Flowers white. Nuts elliptical, reddish when young.

Flr. & Frt: March- November.

Acer oblongum Wall. Family: Acanthaceae. Local name: Thing-phingphihlip (M).

Medium, deciduous tree, 8-15 m tall, often irregular, buttressed at base; bark brownish, laxly furrowed. Leaves 5-18 x 3-6 cm, opposite, often ternate in young shoots, oblong-elliptic or ovate-lanceolate; base rounded-obtuse, long acuminate at apex, entire along margins. Cymes panicled, corymbose, terminal or lateral. Flowers white. Nuts more or less angular.

Flr. & Frt: May- February (next year).

Achyranthes aspera Linn. Family: Amaranthaceae. Local name: Ui-hlo (M).

An erect or sub scandent herb; glabrous or pubescent. Leaves opposite, 3.5 -14.0 x 1.5 - 5.0 cm, ovate-elliptic, acute or sub-acute, rounded or narrowed down to the base, glabrous or pubescent. Flowers greenish-white, pink in elongated terminal spikes. Urticles oblong, enclosed in the perianth.

Flr. & Frt.: October- March.

Achyranthes bidentata Bl. Family: Amaranthaceae. Local name: Unknown.

A perennial herb; stem pubescent, more or less woody. Leaves 6-16 x 3-5 cm, elliptic-lanceolate, undulate margins, acuminate at the apex; lateral nerves 6-9 pairs. Flowers in terminal and axillary panicled spikes, whitish-red.

Flr: June- October. Frt: July- December.

Acrocarpus fraxinifolius Wight. ex Arn. Family**:** Caesalpiniaceae. Local name: Ngan-bawm (M).

A wide spreading, large deciduous tree; bark dark greyish brown, warty. Leaves bipinnate; leaflets 5-12 x 1.8-5.5 cm, oblong-ovate or oblong-lanceolate, acuminate at apex, glabrous. Flowers dull red-orange. Pods winged on the upper suture.

Flr. & Frt: February- June.

Actinadaphne obovata (Nees). Bl. Family: Lauraceae. Local name: Pa-khat (M).

An evergreen tree. Leaves 10-30 x 6-12 cm, broadly ovate-elliptic, shortly acuminate, narrowed down to the base. Flowers yellow, dioecious, in fascicles on extra axillary racemes; perianth silky outside, sub-equal; stamens 9 in 3 series; inner most glandular. Staminodes present in female flowers. Fruits ellipsoid.

Flr. & Frt: March- August.

Adenanthera pavonina Linn. Family**:** Mimosaceae. Local name: Senmaltet (M).

A medium sized deciduous tree. Pinnae 3-6 pairs; pinnules alternate, ovate-oblong, slightly unequal at base, puberulose beneath. Flowers yellow, in axillary or terminal panicles; sepals 5, connate, pubescent outside; petals 5, lanceolate, connate below; stamens 10, free; anther tip glanded; ovary sessile; style filiform. Pods *ca* 15.0 x 1.2 cm, flat, curved. Seeds bright red.

Flr. & Frt: April- September.

Aeginetia indica Roxb. Family**:** Orobachiaceae. Local name: Sanghar-vaibel (M).

A leafless parasite herb, purple colour; growing as root parasite on plants. Seeds yellow or white.

Flr. & Frt: July- November.

Aeschynanthus superba Clark. Family**:** Gesneriaceae. Local name: Bawltehlantai (M).

An epiphytic on tree or rock plant, often scandent; branches stout, wooly, thickened at the joints. Leaves 10-20 x 3-6 cm, elliptic-oblong, elliptic-lanceolate, acuminate; base cuneate or rounded. Flowers reddish, umbellate, terminal or no spurs of old wood. Capsule up to 45 x 30.4 cm.

Flr: August- October. Frt: November- January.

Ageratum conyzoides Linn. Family: Asteraceae. Local name: Vailen-hlo (M).

An erect aromatic herb; all parts hispidous. Leaves rhomboid-ovate triangular, 1.5-4 x 3-9 cm, crenate. Flower heads in dense terminal corymbs; florets numerous, white or blue-purple with companulate involucre. Pappus with 5-awned scales; Fruit black.

Flr. & Frt: Almost throughout the year.

Alangium chinense (Lour.) Harm. Family**:** Cornaceae / Alangiaceae. Local name: Arsa-nam (M).

A small tree. Leaves ovate, ovate-orbicular, acuminate, angled or shortly lobed, rounded or subcordate at base. Flowers creamy white, in axillary dichotomous cymes; calyx teeth acute. Drupes ovoid, slightly ribbed.

Flr. & Frt: May- October.

Albizia chinensis (Osb.) Merr. Family**:** Mimosaceae. Local name: Vang (M).

A medium-sized to large sized tree with flat top crown; bark dark-grey. Leaves bipinnate; rachis up to 45 cm long, pubescent, with a large gland above the base and smaller ones between the pinnae; pinnae 7-20 pairs; leaflets 20-40 pairs sessile, falcate-oblong, acute; midrib close to the upper, acute. Flowers dull-white, axillary and terminal panicled racemes. Fruits (pods) pale brown.

Flr: May- June Frt: October- April.

Albizzia procera (Roxb.) Benth. Family: Mimosaceae. Local name: Kang-tek (M).

A deciduous tall tree, up to 25 m tall. Leaf rachis 20-50 cm long; pinnae 3-5 pairs; leaflets 10-20 pairs, 2-5 x 1-2.3 cm, ovate-oblong, cuneate at base, mucronate at apex. Flowers sessile, white. Pods dark red.

Flr. & Frt: June-December.

Albizia thomsoni Brandis. Family**:** Mimosaceae. Local name: Thing-ri (M).

A tree; branches spreading. Leaves rachis with a basal gland, stipulate; pinnae 2-5 pairs; leaflets 6-24 pairs, 1-2 x 0.4-0.6 cm, elliptic or obliquely oblong. Flowers pale-yellow, sessile in solitary or panicled heads; calyx pubescent; corolla hairy outside. Pods thin, reddish brown, 8-12 seeded.

Flr. & Frt: April- August.

Alchornea tiliaefolia (Benth.) Muell. Family**:** Euphobiaceae. Local name: Zawngte-nawhlung (M).

A shrub or small tree; young parts minutely pubescent. Leaves 7.5-20 x 3.5-20 cm, alternate, orbicular or broad ovate, acuminate, dentate or serrate, dotted; lateral nerves 4-6 on

either half. Flowers small, cluster, monoecious or dioecious. Capsule pubescent, 3-laobed, purplish, tubercle.

Flr: May- June. Frt: August- September.

Allophylus cobbe Bl. Family: Sapindaceae. Local name: Unknown.

A large woody shrub. Leaves 7-16 x 2-7 cm, alternate, trifoliolate; leaflets variable, oblong-lanceolate or elliptic, oblique at base, acuminate at apex, crenulate, glabrous; lateral nerves 10-14 pairs. Flowers minute, greenish white.

Flr. &Frt: April- August.

Alocasia fornicata (Roxb.) Schott**.** Family: Araceae. Local name: Baibing (M).

A perennial herb; fibrous root. Leaves ovate-lanceolate, sagittate. Inflorescence spathulate, erect; spadix yellowish-white to clear white, constricted at the lower part, greenish white below the constriction.

Flr. & Frt: June- August.

Alpina bracteata Roxb. Family**:** Zingiberaceae. Local name: Aichal (M).

A tall herb upto 6.2 m high, in clumps with inclined stem. Leaves oblong-lanceolate, 5-10 x 30-45 cm wooly pubescent beneath. Flowers pure white with dark and yellow markings, on woody erect spike; rachis densely pubescent. Fruits large, globose. Seeds many.

Flr: April- May Frt: July- August.

Alseodaphne petiolaris Hook. Family**:** Lauraceae. Local name: Bul-pui (M).

A large tree; bark greyish-brown or dark grey with vertical fissures. Leaves 16-30 x 7-12 cm, elliptic or oblong or ovate-oblong, bluntly acuminate, rigidly coriaceous, glabrous. Panicles

terminal, 7-17 cm long, minutely rusty pubescent. Flowers about 0.25 cm across, minutely pubescent. Fruits oblong-ellipsoid, black when ripe.

Flr: October- January Frt: June- July.

Alstonia scholaris (Linn.) Br. Family: Apocynaceae. Local name: Thuamriat. (M).

A middle-sized to tall evergreen tree; branches whorled; bark ashy grey, lenticellate. Leaves 5-8, whorled, 3-5 x 8-20 cm, elliptic lanceolate or elliptic-oblong, bluntly acuminate, cunaete, narrowed in to a petiole. Flowers greenish white, in terminal umbellate cymes. Fruits (follicle) often pedulous and paired or forked, clustered, cylindric and linear up to 60 cm long. Seeds with hairs.

Flr: November- December. Frt: January- March.

Amaranthus viridis Linn. Family**:** Amaranthaceae. Local name: Unknown.

Erect or ascending herb. Leaves 2 -7 x 1.0 - 4.5 cm, ovate or deltoid-ovate to rhomboid-oblong, entire shortly mucronate, cuneate at base, petiolate. Flowers greenish-white, in small axillary clusters in axillary and terminal panicled spikes; bracts and bracteoles ovate-lanceolate; stamens 3. Urticles sub-globose.

Flr. & Frt: Almost throughout the year.

Ammania baccifera Linn. Family: Lythraceae. Local name: Unknown.

An erect herb, up to 60 cm tall, with quadrangular stem. Leaves opposite, decussate below, sometimes alternate above, narrowly elliptic lanceolate, tapering at both ends, gradually smaller upwards. Flowers minute, green, pedicelled, in few flowered or dense axillary umbellate cymes. Capsule globose.

Flr. & Frt: December- April.

Amomum dealbatum Roxb. Family**:** Zingiberaceae. Local name: Aidu (M).

A clumped herb to 2 m high with leafy stem. Leaves large, 10-15 x 60-180 cm, oblong-lanceolate, bright green above, pale and pubescent beneath. Flowers white; bracts reddish; lip white with yellow-red veins on very short peduncled spike. Fruits globose with 7-9 winged crenulate vertical ribs, arising from the bulb or rootstock.

Flr: April- May. Frt: April- August.

Amoora chittagonga (Miq.) Hiern. Family: Meliaceae. Local name: Thehlei-khak (M).

An evergreen tree. Leaves 15-30 cm long, rachis lepidote, 2-6 foliolate; leaflets 7-4 x 2.5-4.5 cm, alternate, elliptic, oblong-elliptic to lanceolate base oblique, narrowed, bluntly acuminate at apex; lateral nerves 12-16. Flowers whitish. Capsule obovoid-globose.

Flr. & Frt: August- March.

Andrachne cordifolia Muell. Arg. Family: Euphobiaceae. Local name: Unknown.

A small shrub with slender branches; young parts hairy. Leaves 2.5-7.5 x 1.7-3.0 cm., ovate-oblong or elliptic, obtuse, entire, thinly membranous, glabrous, pale and sparsely puberulous beneath; lateral nerves slender, almost obscure; base rounded or acute; petiole slender. Flowers monoecious on long, filiform pedicels.

Flr. & Frt: June- January (Next year).

Anisochilus pallidus Wall. Family: Labiatae / Lamiaceae. Local name: Lengser-suak (M).

A tall branched puberulose annual herb. Leaves 3.8 -17.7 cm long, long-petioled, ovate-lanceolate, acuminate, dentate, membranous. Spikes panicles. Fruiting calyx tomentose like a “Cat’s claw” recurved beak of upper lip closing the mouth.

Flr. & Frt: April- July.

Anogeissus acuminata (Roxb. ex D.C.) Guill. & Perr. Family: Combretaceae**.** Local name: Zairum (M).

A medium-sized to a large tree; branches pendulous; barks grey; branchlets and inflorescence tomentose. Leaves sub-opposite, bifarous, 1.5-3 x 4-4.5 cm, oblong to ovate-lanceolate, acute, punctuate; petiole short. Flowers minute, in globose peduncled heads, yellow in colour. Fruits samaroid, 2-winged, broader than long.

Flr: February- March. Frt: May- June.

Antidesma acidium Retz. Family**:** Euphobiaceae Local name: Thurte-an (M).

A deciduous shrub or small tree. Leaves 3.5-12 x 13-2.5 cm, obovate-elliptic to oblong-lanceolate, acute or acuminate, cuneate at base, pubescent along nerves beneath. Flowers greenish white, pedicellate in long racemes. Drupes globose or ovate, red when ripe.

Flr. & Frt: June- September.

Antidesma bunius Spreng. Family: Euphobiaceae. Local name: Tuai-tit (M).

A small evergreen tree. Leaves 5-17.5 x 2.5-11 cm, oblong-lanceolate, lanceolate, acuminate, mucronate, entire, coriaceous; lateral nerves 5-10 on either half. Flowers simple or racemes pubescent spikes, unisexual. Fruits ellipsoid, red when ripe.

Flr. & Frt: April-September.

Aporusa octandra (Buch-Ham. ex D.Don.) Vickery. Family: Euphorbiaceae. Local name: Chhawn-tual (M).

A small evergreen tree. Leaves 2-7 x 6.5-13 cm, oblong-lanceolate, acuminate, obscurely crenate; lateral nerves 5-7 pairs. Flowers clustered on the axils, yellow. Fruits ovoid-oblong, greenish-yellow.

Flr: February- April. Frt: June- August.

Arisaema tortuosum (Wall.) Schott. Family: Araceae. Local name: Telhawng (M).

A tuberous herb; tuber 5-7 cm across, depressed globose. Leaves compound; leaflets 7-9, central one 15-20 x 3.5-5 cm, lanceolate, acuminate, lateral ones gradually smaller, sessile. Spathe broadly cymbiform above the open tube, acuminate; spadix 1or 2 sexual, yellow, slender. Berries red.

Flr. & Frt: Not seen during study period.

Artemisia indica Willd. Family: Asteraceae. Local name: Sai (M).

A shrub. Leaves ovate in outline, irregular serrate, pubescent above, tomentose beneath. Flowers greenish white, in terminal or axillary. Fruits minutes, oblong-ellipsoid.

Flr. &Frt: December- February.

Artocarpus chama Buch.-Ham. Family: Moraceae. Local name: Tatkawng (M).

A large deciduous tree; young shoots clothed with dense stiff hair; bark grayish-brown with white patches. Leaves obovate or elliptic-oblong, rounded, dentate-serrate, 8-20 x 12-30 cm; lateral nerves 7-10 pairs; base rounded or sub-cordate; stipules large. Flower heads globose, long-peduncled. Fruits spherical, nodding, tubercled, yellow when ripe. Seeds ovoid, few.

Flr: February- March. Frt: April- August.

Artocarpus heterophyllus Lamk. Family**:** Moraceae. Local name: Lamkhuang. (M).

Evergreen tree, cultivated. Leaves 5-18 x 4-9 cm, elliptic or obovate, coriaceous, cuneate at base, darkgreen above, stipules large, caduceus. Flowers in cylindrical axillary and terminal

heads, embraced by leathery, caduceus sheath; parianth 2-lobed; stigma spathulate in female heads. Fruit oblong, tuberculed.

Flr. & Frt: March – August.

Artocarpus lakoocha Roxb. Family: Moraceae. Local name: Unknown.

A deciduous tree; bark dark-brown; young parts tomentose. Leaves 10-25 x 6-15 cm, elliptic ovate or oblong, entire or denticulate, acute or acuminate, pubescent beneath; stipules caduceus. Flowers orange-yellow; in axillary globose or ovoid, shortly stalked heads. Male heads ovoid; female heads sub-globose with exerted style. Fruits sub-globose.

Flr. & Frt: March- August.

Aspidopterys nutans (Roxb. ex. D.C.) Juss. Family: Malpighiaceae. Local name: Unknown.

A twining shrub. Leaves 6-18 x 3.5-12.0 cm, ovate-elliptic or orbicular, abruptly acuminate, silky pubescent beneath, entire. Flowers yellow, *ca* 0.7 cm long, in axillary or terminal panicles, bracteate. Fruits ovate-oblong, winged.

Flr. & Frt: August- January.

Bauhinia glauca (Wall. ex Benth.) Benth. Family: Caesalpiniaceae. Local name: Hrui-vaube (M).

A large scandent shrub. Leaves 4-8 x 3-7 cm, cordate or sub-orbicular at base, deeply cleft below the middle, glabrate above; basal nerves 7-9. Flowers in terminal or lateral, white. Pods oblong.

Flr. &Frt: August-January.

Beilschmiedia assamica Meissn. Family- Lauraceae. Local name: Bul-pui (M).

A large tree. Leaves opposite or sub-opposite, 7.5-20.3 x 3.3-9 cm, elliptic-oblong, lanceolate or elliptic, shortly blunt-acuminate; lateral nerves 8-12, prominent on both surface. Panicles usually shorter than the leaves, glabrous. Fruits elliptic or ovoid-oblong; base shortly contracted, black when mature.

Flr. & Frt: December-March.

Bidens biternata (Lour.) Merr. & Sheriff. Family: Asteraceae. Local name: Vawkpui-thal (M).

An annual herb; stem quadrangular, grooved, branches opposite. Leaves variable, opposite, biternate, scattered hairy; leaflets deeply 3-lobed, terminal one largest, serrate, acute; common petiole sheathing at the base. Flower heads white or yellow rays; ligules narrow; bracts biserrate; pappus 2-4 retrosely hispid bristles; achenes linear, quadrangular, covered with recurved hooks.

Flr: February- March Frt: April- August.

Bischofia javanica Bl. Family: Euphorbiaceae. Local name: Khuangthli (M).

A deciduous tree; branch spreading. Leaves alternate, 3 foliolate; leaflets 7-15 x 2.5-8 cm, elliptic-ovate, acuminate, serrate. Flowers greenish, dioecious in panicled racemes. Fruit globose.

Flr: March- April Frt: July- February (Next year).

Blechnum orientale Linn. Family- Blechnaceae. Local name: Unknown.

Caudex erect, forming massive trunk, covered with dense scales up to 50 cm tall. Stipe radially arranged on the top of the caudex, erect, scaly at base. Lamina up to 1.5 m long, deltoid-obovate, sterile; large pinnae linear; base decurrent on the axis, glabrous above, glaucous beneath. Stipes, rachis and costae raised.

Fertile: Not seen during study period.

Blumea laciniata (Roxb.) D.C. Family: Asteraceae. Local name: Khuanglawi (M).

An erected annual or perennial herb. Leaves lyrate or sharply lobed with margins sinuate. Flowers yellow. Achenes silky, pappus white.

Flr. & Frt: February- October.

Bochmeria rugulosa Wedd. Family: Urticaceae. Local name: Lenlang (M).

A small tree. Leaves 7.5-15 x 2.5-5 cm, alternate, elliptic-lanceolate, rounded at base, acute or bluntly acuminate at apex, crenate; lateral nerves 3. Dioecious spikes axillary, drooping.

Flr. & Frt: July- January.

Bombax insigne Wall. Family: Bombacaceae. Local name: Pangpui (M).

A large deciduous tree with clear bole; branches spreading; bark dark grey, with or without prickles. Leaves digitately 7-9 foliolate, 1-20 cm long, obovate-lanceolate, caupidate. Flowers showly, scarlet or white on short thick pedicles. Fruits oblong, woody, curved at apex.

Flr: December- February Frt: March- April.

Bridelia monoica (Lour.) Merr. Family: Euphobiaceae. Local name: Phaktel-thing (M).

A shrub. Leaves 4-7 x 1.5-3 cm, elliptic, oblong-lanceolate, acute, cuneate at base, entire. Flowers greenish yellow, axillary in clusters. Drupes globose.

Flr: August- October. Frt: October- January (Next year).

Bridelia stipularis (Linn.) Bl. Family: Euphorbiaceae. Local name: Phaktel-hrui (M).

A large more or less scrambling or drooping shrub; branchlets pubescent. Leaves 3-8 x 1-5 cm, elliptic-oblong or obovate, obtuse or rounded, membranous, glabrate above, tomentose beneath. Flowers monoecious, greenish, in numerous axillary clusters, spicate or panicled.

Flr. & Frt: December- March.

Buddleja asiatica Lour. Family- Buddlejaceae. Local name: Unknown.

A bushy shrub. Leaves opposite, oblong or ovate-lanceolate, glabrous to densely hairy above, wooly beneath; petiole tomentose. Inflorescence terminal and axillary, densely tomentose cymes. Flowers tetramerous white, sometimes light violet.

Flr. & Frt: January- December.

Butea parviflora Roxb. Family: Fabaceae/ Papilionaceae. Local name: Za-thoh (M).

Large woody climber; young parts and inflorescence silky tomentose. Leaves 3-foliolate; leaflets 7-18 x 4-11 cm, obovate-elliptic, lateral ones oblique, acute or acuminate, hairy beneath. Flowers creamy white, in large terminal pubescent panicles. Pod oblong.

Flr. & Frt: July- January (Next year).

Byttneria pilosa Roxb. Family: Sterculiaceae. Local name: Sazuk-nghawng-hlap (M).

A large woody climber. Leaves 5-15 x 5-14 cm, ovate, 3-4 sharp lobed, cordate at base, acuminate at apex, serrate-dentate at margins; lateral nerves 5-8. Flowers yellow, in axillary. Capsule sub-globose.

Flr. & Frt: September- May (next year).

Brusera serrata Wall. ex Colebr. Family: Burseraceae. Local name: Bil-thei (M).

A medium or large evergreen tree; young parts tomentose; bark grey. Leaves imparipinnate, *ca* 25 cm long; leaflets opposite, 4-13 x 2.0-3.5 cm, oblong-lanceolate, acuminate, rounded at base, distantly serrulate or entire. Flowers greenish, in axillary panicles. Drupe globose.

Flr. & Frt: April- July.

Caesalpinia cucullata Roxb. Family: Caesalpiniaceae. Local name: Hling-khang (M).

A straggling shrub; branches dark brown, prickly. Leaflets 3-6 pairs, 3.5-8.5 x 1.8-4.0 cm, ovate-elliptic, shortly acuminate, shinning above. Flowers yellow, in terminal or axillary racemes. Pods obliquely oblong, flat.

Flr. & Frt: April- February.

Cajanus cajan (Linn.) Millsp. Family: Fabaceae/ Papilionaceae. Local name: Behliang (M).

A bushy shrub. Leaves 3 foliolate, 1-4 cm long; leaflets 3-8.5 x 1-3 cm, narrowly elliptic or oblong-lanceolate; base cuneate; acute or acuminate at apex; lateral nerves 5-6 on lateral half. Flowers yellow, in corymbose cymes, red veins. Pods acuminate.

Flr. & Frt: April- February.

Cajanus goensis Dalz. Family: Fabaceae/ Papilionaceae. Local name: Zawng-bete (M).

A woody climber; pubescent terete branches. Leaves 3-foliolate; leaflets 2-10 x 2.5-7 cm, ovate-rhomboid, rounded or sub-cordate, acuminate-cuspidate at apex. Racemes terminal or axillary. Flowers yellow. Pods narrowly beaked, spreading, brown.

Flr. & Frt: August- February.

Calamus tenuis Roxb. Family: Arecaceae. Local name: Thil-te (M).

A slender cane. Leaves 35-60 cm long; leaflets numerous, equal length, linear-lanceolate, spinulose margins, acuminate at apex, lower leaflets larger than the upper ones; rachis armed with one row of short recurved spines. Flowers very small. Fruits globose, mucronate.

Flr. & Frt: Not seen during study period.

Callicarpa arborea Roxb. Family: Verbenaceae. Local name: Hnahkiah (M).

A small evergreen tree upto 15 m high; bark grey-brown, soft; branches angled. Leaves ovate-oblong or lanceolate, 5-15 x 15-30 cm, sub-acuminate, chartaceous, densely grey tomentose beneath; nerves 8-12 pairs; base acuminate. Flowers reddish-purple on 2-chotomous cymes on stelately tomentose peduncled. Fruits globose, smooth, purple when ripe.

Flr. & Frt: November- April.

Callicarpa longifolia Lamk. Family: Verbenaceae. Local name: Unknown.

A large shrub; stem whitish, young parts tomentose. Leaves 5-20 x 1.5-5 cm, lanceolate, elliptic or elliptic-lanceolate, cuneate at base, acuminate at apex, serrulate, glabrescent above, punctuate beneath; lateral nerves 10-30 pairs. Flowers purple, on lax cymes.

Flr. & Frt: Not seen during study period.

Camellia khasiana Wall. Family: Theaceae. Local name: Coffee-suak (M).

A shrub or small tree. Leaves 4-9 x 1.5-3.5 cm, elliptic-ovate, cuneate at base, acute at apex, entire or serrulate; lateral nerves 7-10 pairs. Flowers axillary or terminal, white. Capsules glabrous.

Flr. & Frt: January- October.

Camellia sinensis (Linn.) Kuntz. Family: Theaceae. Local name: Thingpui (M).

A large shrub or small tree, cultivated. Leaves 5-12 x 2.5-5 cm, obovate to oblong-elliptic, acute at base, acuminate at apex, serrate; lateral nerves 8-12 pairs. Flowers whitish. Capsules ovoid.

Flr. & Frt: January- September.

Canarium stritum Roxb. Family: Burseraceae. Local name: Beraw-thing (M).

A large straight tree; buttressed at the base; bark greenish-grey, young foliage crimson. Leaves up to 45 cm long; leaflets 3-8 pairs, ovate-lanceolate, acuminate, finely serrate, 4-8 x 10-20 cm, shinning above, ferruginous tomentose beneath; nerves 10-15 pairs. Flowers axillary fascicles, few flowered. Fruits ellipsoid or ovoid with a thick bony stone.

Flr: May- July Frt: November- January.

Canscora andrographiodes Griff. Family: Gentianaceae. Local name: Par-ngo (M).

An erect herb, 1.8 – 6 m. Leaves 1.2-2.5 x 0.5-1.2 cm, 3-nerved, sessile, lanceolate-ovate or oblong-lanceolate. Flowers irregular, sub-labiate, white in lax cymes; calyx 4-winged, corolla lobe-obovate; tube as long as calyx. Capsule oblong. Seeds brown.

Flr. & Frt: Winter season.

Capsicum annuum Linn. Family: Solanaceae. Local name: Hmarcha-te (M).

Under-shrub; branching profusely, cultivated. Flower white; pedicels solitary, rarely two at a node. Fruits variable in size, form and colour.

Flr: April- June Frt: June- September.

Carallia brachiata (Lour.) Merr. Family: Rhizophoraceae. Local name: Theiria (M).

A evergreen tree; bark vertical fissures, short branches. Leaves 5-12 x 2-7 cm, oblong-obovate, cuneate at base, acuminate at apex, entire, glabrous; lateral nerves 8-15 on either side. Flower sessile, greenish-yellow to white. Fruits depressed globose.

Flr. & Frt: February- May.

Carex spiculata Boott. Family: Cyperaceae. Local name: Unknown.

A tall herb, 60-90 cm high. Leaves narrow, longer than stem. Spikes oblong-lanceolate in slender naorrow panicles; spikelets 0.1-0.5 cm long. Glumes linear-oblong, mucronate. Nuts ellipsoid, brown.

Flr. & Frt: July- January.

Caryota urens Linn. Family: Arecaceae. Local name: Tum (M).

A tall stout palm, 10-15 m tall. Leaves large, 4-5 x 2-4 m, bipinnate, 16-20 cm long; petioles very stout; leaflets cuneiform, toothed. Flowers monoecious, a female between two males. Fruits globose, dark purple.

Flr. & Frt: March- August.

Cassia nodosa Buch.-Ham. ex Roxb. Family: Caesalpiniaceae. Local name: Makpa-zang-kang (M).

Small or medium tree. Leaf rachis 18-24 cm long, glabrescent or pubescent; leaflets 3.5-7 x 2-3 cm, 6-12 pairs, oblong or oblong-lanceolate, acute oblique at base, bluntly acuminate at apex, glabrous above. Racemes short corymbose. Flowers red or pinkish. Pods 25-50 cm long.

Flr: June- August. Frt: November- February.

Cassia occidentalis Linn. Family: Caesalpiniaceae. Local name: Se-behliang (M).

A erect under-shrub. Leaves glandular at base; stipules obliquely cordate; leaflets 3-5 pairs, 3-7 x 1.6-2.5 cm, ovate or elliptic, acuminate. Flowers orange-yellow, in short axillary corymbose racemes. Pods 8-12 x 0.5-0.6 cm, compressed, slightly recurved, septate, 20-30 seeded.

Flr. & Frt: June- August.

Cassia timoriensis D.C. Family: Caesalpiniaceae. Local name: Mithi-zawngtah (M).

A small tree. Leaf rachis 13-27 cm long; leaflets 1.5-4 x 0.4-1.2 cm, 10-18 pairs, oblong, obtuse, tomentose beneath. Racemes corymbose, axillary, panicled. Flowers yellow, pubescent. Pods flat, glossy.

Flr. & Frt: April- October.

Castanopsis indica D.C. Family: Fagaceae. Local name: Sehawr (M).

A medium to large sized tree. Leaves 7-19 x 2.5-8 cm, oblong-lanceolate, acuminate at apex, spinous-serrate, glabrous above, rusty tomentose beneath; lateral nerves 13-20 pairs. Male spikes in lax panicles; female spikes in axillary. Flowers solitary. Nuts ovoid, spiny.

Flr. & Frt: February- December.

Castanopsis tribuloides D.C. Family: Fagaceae. Local name: Thingsia (M).

A middle to large evergreen tree. Leaves 5-18 x 2.5-6 cm, oblanceolate, acuminate at apex, entire; lateral nerves 9-14 pairs. Flowers solitary, white, small, in terminal or axillary. Nuts spiny, globose or oval.

Flr. & Frt: September- December (next year).

Celastrus monosperma Lawson. Family: Celastraceae. Local name: Unknown.

A woody climber. Leaves 5-12 x 2-7 cm, elliptic or elliptic-oblong; base acute or rounded; bluntly or shortly acuminate at apex, serrate, coriaceous, glabrous, pinkish beneath. Flowers dioecious. Capsules obovoid.

Flr. & Frt: March- October.

Celtis australis Linn. Family: Ulmaceae. Local name: Anku (M).

A medium sized deciduous tree; branchlets drooping. Leaves 3.5-12.5 x 2-5 cm, alternate, ovate or ovate-lanceolate, acuminate at apex, serrate; basal nerves 3, pubescent, scabrid beneath. Drupes ovoid or elliptic.

Flr. & Frt: March- October.

Celtis tetrandra Roxb. Family: Ulmaceae. Local name: Thing-hmarcha (M).

A large tree; bark dark-grey. Leaves 3.5-11.5 x 2.0-6.5 cm, ovate, ovate-elliptic, acute, oblique at base, serrate, pubescent beneath; stipules linear. Flower greenish, in tomentose cymes. Drupes globose.

Flr. & Frt: February- November.

Centella asiatica (Linn.) Urban. Family: Apiaceae. Local name: Lambak (M).

A trailing or creeping herb; stem prostrate, sometimes reddish, rooting at the nodes. Leaves orbicular, crenate, 2-8 cm across, palmately nerved, deeply cordate, long petioled, up to 30 cm. Flowers pale pink, in clusters of umbels. Fruits ovoid, rugose, crowned by persistent petals. Seeds compressed.

Flr: March- June Frt: August- October.

Chromalaena odorata (Linn.) King & Robinson. Family: Asteraceae. Local name: Tlangsam/ Pholeng (M).

A staggling shrub, pungent smell when bruished; stem pubescent when young, soft. Leaves ovate lanceolate or triangular, acuminate, dentate-serrate, 3-nerved, base oblique, cuneate. Flowers terminal and supra-axillary corymbose heads, white in colour. Fruit minute, light and dispersed by wind.

Flr: November- December Frt: December- January.

Chukrasia tabularis Juss. Family: Meliaceae. Local name: Zawng-tei (M).

A large deciduous tree. Leaves pinnate; leaflets 10-15, alternate, 3-5 x 4-11 cm, elliptic-lanceolate or ovate, acuminate; lateral nerves 9-10 pairs. Flowers greenish white, terminal. Fruits ellipsoid.

Flr. & Frt: May- March.

Cinnamomum obtusifolium Roxb. ex Nees. Family: Lauraceae. Local name: Thakthing-suak (M).

A large tree; bark grey or brownish white. Leaves 15-30.5 x 3.8-8.8 cm, elliptic-oblong or elliptic, obtuse, acute or acuminate, glabrous; base 3 nerved. Panicles large, long peduncled, sub-terminal, usually exceeding the leaves, minutely pubescent or puberulose, glabrate with age. Flowers greenish white. Fruits ellipsoid or sub-globose, seated on the slightly enlarged perianth.

Flr: January- March Frt: Rainy season.

Cinnamomum tamala (Buch. – Ham.) Nees. Family: Lauraceae. Local name: Testpata (M).

A medium-sized tree, with spreading crown; bark dark brown with fine reticulating vertical fissures. Leaves 10-20 x 3-9 cm, oblong-lanceolate to elliptic or oblanceolate, shortly

acuminate, acute or obtuse, thinly coriaceous, shinning above, green on both surfaces; lateral nerves 6-7 on either half. Panicles terminal and from upper axils, pubescent, long peduncled. Flowers about 0.38 cm across, and as long, tomentose outside. Fruits strongly ribbed when very young, finally smooth, turgid aromatic.

Flr. & Frt: March- November.

Cinnamomum verum Presl. Family: Lauraceae. Local name: Thakthing (M).

A moderate sized tree, evergreen, all parts aromatic; bark dark brown. Leaves sub-opposite, ovate-lanceolate, acute or shortly acuminate, 2.5-4 x 6-12 cm, shinning above; base acute or rounded. Flowers greenish or pale yellow, in silky pubescent lax panicles usually longer than leaves. Fruits ellipsoid, dark purple when ripe, supported by enlarged perianth. Fruits globose with thick fleshy cup at the base.

Flr: March- April Frt: June- August.

Cissampelos pareira Linn. Family: Menispermaceae. Local name: Hnah-bial (M).

Climber; branchlets tomentose. Leaves ovate-orbicular, acuminate, mucronate, palmately nerved. Flowers greenish yellow, in pendulous cymes. Male flowers axillary, bracteate, bracteolate. Females flowers in the axils of bracts. Drupes obovoid, hirsute.

Flr. & Frt: December- July.

Cissus japonica **(**Wall.) Planchon. Family: Vitaceae. Local name: Sanghar-hmai (M).

A slender climber; branchlets pubescent. Leaves pedately 5 foliolate, terminal leaflets larger than the lateral ones; leaflets 3-10 x 2-5 cm, ovate to broadly lanceolate, acute at base, acute at apex, serrate; lateral nerves 4-7 pairs. Flowers bisexual, greenish. Berries globose.

Flr. & Frt: April-June.

Cissus repens Lam. Family: Vitaceae. Local name: Hruipawl (M).

A climbing shrub; young parts covered with white bloom. Leaves 5-11 x 3.5-9 cm, ovate, cordate at base, acute at apex, dentate, glabrous; lateral nerves 5-7 pairs. Flowers in axillary, greenish-red. Barries globose-ellipsoid, red.

Flr. & Frt: June- January (Next year).

Citrus medica Linn. Family: Rutaceae. Local name: Unknown.

A spiny shrub or small tree. Leaves 8-15 x 2-8 cm, elliptic-ovate or oblong-lanceolate, cuneate at base, obtuse at apex, crenate serrate. Flowers pink- purplish white. Fruit ovoid-oblong.

Flr. & Frt: January- December.

Clematis tortuosa (Wall. ex Hook. & Thomson.) Fischer. Family: Ranunculaceae. Local name: Hrui-pawnro (M).

A large woody climber; bark corky. Leaves 3-7 foliolate; leaflets 4-12 x 2.5-10 cm, ovate, rounded at base, acuminate at apex. Flowers greenish-yellow.

Flr: June- March (Next year). Frt: Not seen.

Clerodedrum infortunatum Linn. Family: Verbenaceae. Local name: Phuihnam-chhia (M).

Under-shrub, softly tomentose; branches 4- angled. Leaves opposite, 5-20 x 4-14 cm, ovate-cordate, acuminate, dentate, tomentose. Flowers white, tinged with pink in terminal sub-corymbose panicles, bracts folioceous, deciduous, pubescent. Drupes globose, within persistent calyx, black when mature.

Flr. & Frt.: March- July.

Clerodendrum colebrookianum Walp. Family: Verbenaceae. Local name: Phuihnam (M).

A shrub. Leaves opposite, 10-20 x 6-15 cm, ovate, acute, cordate at base. Flowers white, in terminal corymbose cymes; corolla tube slender. Drupes globose with acrescent copular calyx.

Flr. & Frt: August- December.

Coffea khasiana Hook. Family: Rubiaceae. Local name: Coffee-suak. (M).

A shrub. Leaves 7-10 x 0.5-3.5 cm, oblong or ovate-lanceolate, cuneate at base, caudate-acuminate at apex, entire, glabrous on both surface; lateral nerves 5-8 pairs. Flowers orange. Drupes ellipsoid.

Flr & Frt: August- December.

Coix lacryma-jobi Linn. Family: Poaceae. Local name: Ping-pih (M).

A perennial herb**;** culms 0.9-1.5 m tall, rooting at the lower nodes, glabrous. Leaves 20-50 x 2-5 cm, narrowly lanceolate, cordate, acuminate; sheath oblong, glabrous. Inflorescence in spiciform racemes of a female spikelet enclosed by a basal bract through which the rhachis grows out bearing the male spikelets above; peduncles stout. Male spikelets on a slender rhachis; glumes sub-equal, lower flat with 2 lateral winged keels; lemma oblong-lanceolate, membranous. Female spikelets ovoid, enclosed by a bony involucre, yellowish-white or bluish-grey; glumes lower ovate-lanceolate, upper ovate. Grains sub-globose.

Flr. & Frt: July- October.

Colona floribunda (Kurz.) Craib. Family: Tiliaceae. Local name: Hnahthap-te (M).

A small to medium-sized tree; young parts scabrid with short stellate hairs. Leaves 9-15 x 3-15 cm, rotudate-ovate, rounded at base, acute at apex, irregularly gland tooth; lateral nerves 4-6 nerves. Flowers small, clusters. Capsules ellipsoid.

Flr. & Frt: April- January.

Colquhounia coccinea Wall. Family: Labiatae / Lamiaceae. Local name: Kawih-thuang (M).

A rambling shrub 2.4 – 3 m high, tomentose or stellately hairy on stem and leaves. Leaves 3.8-12.7 x 1.2-6.3 cm, ovate or ovate-lanceolate, acuminate or acute, coarsely crenate, sub-coriaceous, stellately hairy above, stellately whitish tomentose beneath. Flowers orange or reddish, usually in axillary clustered or terminal racemes.

Flr. & Frt: August- February.

Combretum alatum Pers. Family: Combretaceae. Local name: Lenhruibuang (M).

A woody climber; bark reddish-brown. Leaves oblong-obovate or ovate-lanceolate, acuminate. Flowers greenish-white, ca 0.4 cm long in terminal dense panicled spikes. Petals inserted between the calyx lobe. Fruits winged, 1-seeded.

Flr. & Frt: December- April.

Combretum flagrocarpum Clark. Family: Combretaceae. Local name: Leihrui-sen (M).

A large scandent shrub. Leaves 0.5-18 x 3-10 cm, opposite, elliptic to elliptic-oblong or obovate, lanceolate, acuminate, pubescent along the nerves. Flowers yellow. Fruits orbicular, 4-winged.

Flr. & Frt: April- December.

Combretum roxburghii Spreng. Family: Combretaceae. Local name: Leihrui-sen (M).

An evergreen scandent shrub; young parts brown. Leaves 7-14 x 3-7 cm, opposite, elliptic, lanceolate or obovate-oblong, acuminate. Spikes dense, in terminal or axillary panicles. Flowers pentamerous, greenish white or brownish-red. Fruit oblong-ovate, 5-winged.

Flr. & Frt: November- April.

Conyza bonariensis (Linn.) Cronq. Family: Asteraceae. Local name: Buar (M).

An erect herb; stem appressed hairy, ripped. Leaves 2-6 cm long, linear-lanceolate, sub-acute, involucral bracts 3-serrate, linear, pilose. Ray florets *ca* 0.3 cm long, filiform. Achenes sparsely hairy. Pappus white.

Flr. & Frt: April- December.

Conyza lanceolaris (Roxb.) Druce. Family: Asteraceae. Local name: Buarze (M).

An erect annual herb. Leaves crowded at apex, 2.5-5.5 x 9-25 cm, elliptic-lanceolate or oblanceolate, acuminate, serrate; lateral nerves many. Flowers yellow to pale red. Achenes ribbed. Pappus red.

Flr. & Frt: April- May.

Cordia dichotoma Forst. Family: Boroginaceae. Local name: Muk-thing (M).

A moderate-sized deciduous tree with drooping branches; bark ashy-grey, wrinkled. Leaves broadly ovate or nearly orbicular, 8 x 12 cm, bluntish or acute, coarsely crenate, basal nerves-3, base cuneate; apex rounded or cornate. Flowers white, in lax terminal corymbose cymes, fragrant. Fruits ovoid, translucent and pale yellow when ripe, filled with visid pulp; 1-seeded.

Flr. & Frt: March- July.

Costus speciosus (Koenig) Sm. Family: Zingiberaceae. Local name: Sumbul (M).

A tall herb; stem somewhat spirally twisted, leafy, fleshy; rootstock creeping, tuberous. Leaves spirally arranged, 12-30 x 4-6 cm, elliptic or obovate or oblancealate, acuminate, sub-

sessile, silky pubescent beneath. Flower white, large, in terminal globose or ovoid spike; bracts *ca* 2 cm long, ovate, reddish. Capsule globose, trigonous with persistent calyx at apex.

Flr. & Frt: July- October.

Crassocephalum crepidioides (Benth.) Moore. Family: Asteraceae. Local name: Unknown.

Herb. Leaves alternate, pinnatifid. Heads discoid, outer florets ligulate, inner tubular; rays florets yellow. Involucre cylidric, numerous bracts in one series, with several narrow spreading accessory bracts at the base. Style arms slender.

Flr. & Frt: May- December.

Crotalaria mysorensis Roth. Family:- Fabaceae/ Papilionaceae. Local name: Unknown.

An erect shrub. Leaves 1.5-5 x 0.3-2 cm, simple, oblong-elliptic or elliptic-ovate; base obtuse; apex obtuse, membranous. Recemes terminal, laxly 3-12 flowers, yellow. Pods terete oblong, glabrous.

Flr. & Frt: July- December.

Croton caudatus Geisel. Family: Euphorbiaceae. Local name: Ranlung-damdawi (M).

A large scandent shrub; young parts stellately bristly, hairy; bark brownish-black, old bark exfoliating in pieces exposing a whitish surface; blaze greenish white; wood whitish. Leaves 1.5-6 x 0.8-3.5 in., ovate, sub-orbicular or ovate-acuminate, coarsely toothed or crenate-serrate, sub-coriaceous, scaberulous above, stellately pubiscent beneath, cordate or almost truncate. Racemes slender, 4.10 in. long, stellately pubescent. Flowers in fasciles; male flowers- tomentose; petals as long as sepals, wooly; stamens 18-30; female flowers- sepals ovate, oblong; petals very small.

Flr. & Frt: April- October.

Cryptolepis buchanani Roem. & Schult. Family: Asclepiadaceae. Local name: Theikelki-suak. (M).

Twining shrub; latex milky. Leaves 5-17 x 1.5-5.0 cm, oblong, ovate or oblong-acuminate or apiculate, cuneate at base. Flowers dull yellow, in axillary, short, pedunculate cymes. Follicles lanceolate, tapering, pointed. Seeds compressed black.

Flr. & Frt: May- December.

Curanga amara Juss. Family: Scrophulariaceae. Local name: Khatual (M).

A glabrous annul herb. Leaves 3.8-6 x 2-3 cm, opposite, ovate, rounded at base, acute at apex, crenate; lateral nerves 5-8 pairs. Flowers in terminal or pseudo-axillary racemes. Capsule orbicular.

Flr. & Frt: June- September.

Curculigo capitulata (Lour.) Kuntz. Family: Amaryllidaceae. Local name: Phaiphek (M).

A tufted herb. Leaves long, 5-13 x 20-85 cm, lanceolate, hairy beneath, acute at the base, cuspidate at apex; nerves parallel, many. Flowers in cluster, yellow, arising from the base. Fruits globose.

Flr. & Frt: May- October.

Cuscuta reflexa Roxb. Family: Cuscutaceae. Local name: Japan-hlo-ral (M).

A naked twiner; branches fleshy yellow. Flowers white, in clustered racemes; calyx copular; lobes ovate, obtuse; corolla lobes narrow ovate, reflexed; staminal filaments short. Capsule depressed, globose.

Flr. & Frt: October- March.

Cyathea spinulosa Wall. ex Hook. Family: Cyatheaceae. Local name: Kawk-pui (M).

Rhizomes arborescent, upto 3 m tall or even more. Stipe and rachis strongly aculeate, dark brown, base of the stipe covered with long hair-pointed black. Fronds bipinnate, upto 2 m long, elongate-lanceolate; pinnae deeply pinnatifid, sessile, serrulate, margin curved.

Fertile : Not seen during study period.

Cynodon dactylon (Linn.) Pers. Family: Poaceae. Local name: Phaitual hnim (M).

A perennial prostrate or creeping grass; rooting at nodes. Leaves linear-lanceolate; sheath compressed; ligule ciliate. Inflorescence slender 4-5 digitae spikes; spikelets *ca* 0.2 cm long, compressed, sessile, 1-flowered. Glumes lanceolate; lemma 3-nerved. Caryopsis oblong.

Flr. & Frt: Most part of the year.

Cyperus cyperoides (Linn.) Kuntz. Family: Cyperaceae. Local name: Unknown.

A perennial herb, slender with short creeping rhizome covered with the remains of old leaf sheaths. Leaves as long as the stem. Spikelets spirally arranged in cylindric pedunculate spikes in a simple terminal umbel, erect-patent in flower; glumes distichous lowest two empty. Nuts brown, oblong, curved, triquetrous.

Flr. & Frt: August- November.

Cyperus iria Linn. Family: Cyperaceae. Local name: unknown.

An annual erect herb, 20-60 cm long. Leaves linear, acuminate**;** sheath brown papery. Spikes cylindrical in compound umbels; spikelets linear-oblong, compressed, few-many flowered; glumes obovate, obtuse, keeled. Nuts obovate-elliptic, triquetrous.

Flr. & Frt: August- November.

Cyperus rotundus Linn. Family: Cyperaceae. Local name: Unknown.

A perennial erect herb**,** 15-65 cm high; rhizomes soloniferous. Leaves linear, acuminate, shorter than the stem; bracts 3, leafy. Spikes in simple or compound umbels; spikelets linear-lanceolate, reddish brown; glumes ovate, keeled. Nuts oblong, ovate, trigonous.

Flr. & Frt: July- December.

Cyrtococcum accrescens (Trin.) Stapf. Family: Poaceae. Local name: Unknown.

A perennial grass; branching from the base. Leaves linear-lanceolate or ovate-lanceolate, hairy; sheath ciliate on margins; ligule membranous. Inflorescence a panicle; spikelets pedicelled, 2 flowered. Lower floret sterile; upper bisexual. Glumes 3-5 nerved.

Flr. & Frt: July- November.

Cyrtococcum patens Camus. Family: Poaceae. Local name: Unknown.

A perennial herb. Culms 30-60cm long, rooting at the base, branchy, slender, nodes glabrous. Leaf-blades narrow, spreading flat, from broadly ovate to linear-lanceolate, finely acuminate; ligule membranous, short obtuse. Inflorescence a lax panicle, often nodding, spreading or contracted; branches spreading, long; spikelets almost round, green, reddish or brown; glumes herbaceous, membranous.

Flr. & Frt: June- October.

Dalbergia pinnata (Lour.) Prain. Family: Fabaceae/ Papilionaceae. Local name: Hrui-tengtere (M).

A scandent shrub, twinging left. Leaves imparipinnate; leaflets 8-15 pairs, 0.5 x 2-3.5 cm, oblong, mucronate, oblique at base. Flowers greenish white. Pods strap-shaped.

Flr. & Frt: March- October.

Dalbergia stipulacea Roxb. Family: Fabaceae/ Papilionaceae. Local name: Hrui-Zaizaw (M).

A small tree; branches spreading. Leaves imparipinnate; leaflets 17-23, 1.5-4 x 5-1.5 cm. elliptic-oblong, nearly oblique at base, glabrescent. Flowers purple, in axillary panicle; calyx teeth minute; stamens 10, diadelphous. Pods oblong, flat 1- seeded.

Flr. & Frt: April- December.

Davallia trichomanoides Bl. Family: Dennstaedtiaceae – Davallioideae. Local name: Unknown.

An epiphyte. Rhizome wide creeping, fleshy, densely covered with dark brown scales; scales lanceolate with hair-like apex, margins finely ciliate or puberulose. Pinnulus of the lower pinnae 3.-4.5 x 2 cm, deeply pinnatifid giving rise to oblong-rhomboid segments. Stipe erect, up to 10 cm long, fleshy glabrous. Sori elongated, marginal, terminal on the vein.

Sori: Not seen.

Debregeasia longifolia Wedd. Family: Urticaceae. Local name: Lehngo (M).

A large shrub or small tree; young parts silky pubescent. Leaves 5-17.5 x 0.7-4 cm, oblong-lanceolate or narrow elliptic, acute at base, acuminate at apex, serrulate, scabrid and dark green above, pale white or greyish tomentose beneath; lateral nerves 2-3 pairs. Flowers – male and female flowers whitish. Fruits in clusters, orange yellow.

Flr. & Frt: July- January.

Dendrocalamus hamitonii Nees. Family: Poaceae. Local name: Phul-rua (M).

A large bamboo with caespitose culm, tall, sending out branches from the nodes and bending downwards. Culm 12-25 m tall, much branch above; internodes 30-50 cm, wall *ca* 1.25

cm thick. Leaves *ca* 36 x 3 cm, variable in shape, lanceolate, acuminate at apex, smooth above, rough beneath, serrate-dentate margins.

Flr. & Frt : Not seen during study period.

Dendrocalamus longispathus Kurz. Family: Poaceae. Local name: Raw-nal (M).

An arborescent large, caespitose. Culms 15-20 m tall, leafy above. Culm sheaths chartaceous, covered on the back with dense, stiff adpressed brown or black hairs. Leaves oblong lanceolate or linear-lanceolate, acuminate, shortly petiolate, glabrous above, glabrescent beneath, scabrid on the margin; mid rib yellow, and sheath glabrous. Inflorescence a large panicle of interrupted spicate cluster of spikelets at the node of long sinuate branches; bracteolate at the base. Caryopsis ovoid, crowned by the persistent base of the style.

Flr. & Frt: Not seen.

Dendrocnide sinuata **(**Bl.) Chew. Family: Urticaceae. Loacal name: Thakpui (M).

A shrub, stinging hairy. Leaves alternate, 10-25 x 5.2-12.5 cm, broadly elliptic ovate, acuminate, rounded or cordate at base, crenate-serrate. Flowers white, dioecious in short dichotomous cymes; tepals 4, basally connate; staments 4. Achenes *ca* 0.5 cm in diameter, globose, tipped by style.

Flr. & Frt: August- January.

Derris robusta (Roxb.ex D.C.) Benth. Family: Fabaceae/ Papilionaceae. Local name: Thingkha (M).

A middle-sized tree. Leaflets7-23, 1.5-4.0 x 0.5-1.8 cm, elliptic, mucronate, subacute, oblique at base. Flowers white, *ca* 1 cm long, clustered in axillary long recemes. Pods 5-8 x 0.5-0.6 cm, narrow towards the both ends, winged along the upper suture; 1-5 seeded.

Flr. & Frt: April- October.

Derris thyrsflora (Benth.) Benth. Family: Fabaceae/ Papilionaceae. Local name: Hulhu (M).

A woody climber. Leaves 20-35 cm long; leaflets 5-9, 5-14 x 2-5 cm, elliptic to oblong lanceolate, base rounded or cuneate, abruptly acuminate at apex, entire, glabrous; lateral nerves 5-9 on either side. Flowers white. Pods flat with narrow wings on both sutures, glabrous.

Flr. & Frt: August- January.

Desmodium floribundum (D. Don.) Sweet ex G. Don. Family: Fabaceae/ Papilionaceae. Local name: Unknown.

An annual herb; branches angular, often switchy, densely pubescent along the ridges. Leaves trifoliate ; leaflets ovate or obovate-oblong, acute to sub acute, cuspidate, subcoriaceous. Racemes terminal and axillary, often panicled. Flowers in fascicles. Pods indented along both sutures.

Flr. & Frt: August- December.

Desmodium gyroides (Roxb.ex Link.) D.C. Family: Fabaceae/ Papilionaceae. Local name: Hmeithai-sarawh-tul (M).

An under-shrub. Leaves 1-3 foliolate; leaflets 1.2-5.5 x 0.8-2.8 cm oblong or obovate-oblong, obtuse, truncate at base; stipules linear, acuminate; stiple filiform. Flowers purplish pink, in axillary or terminal recemes. Pods 4-5 cm long, linear, hairy.

Flr. & Frt: September- January.

Desmodium pulchellum (Linn.) Benth. Family: Fabaceae/ Papilionaceae. Local name: Unknown.

A shrub; branches terete, pubescent. Leaves 3-foliolate, stipulate, petiole channeled; leaflets elliptic-oblong, sub-acute, rounded at base; terminal ones largest. Flowers creamy, shortly stalked, clustered in axillary and terminal recemes. Pods 0.3 x 0.8 cm, hidden by the bracts, 2 jointed.

Flr. & Frt: July- January.

Desmodium triangulare (Retz.) Merr. Family: Fabaceae/ Papilionaceae. Local name: Se-behliang (M).

An undershrub; branches triangular. Leaves 3 foliolate, leaflets 4-6 x 1.8-4.2 cm, elliptic lanceolate or oblong-elliptic, grey silky beneath, acute. Flowers reddish-yellow, in axillary umbels. Pods 2-4 jointed, grey silky hairy.

Flr. & Frt: June- November.

Desmodium triquetrum (Linn.) D.C. Family- Fabaceae/ Papilionaceae. Local name: Uifawma-ring (M).

An undershrub; branches angular. Leaves 1-foliolate, 3.0-10.5 x 0.6-0.3 cm, oblong-laceolate, acute, rounded at base; petiole winged; stipules acuminate, striate. Flowers purplish-pink, in axillary or terminal recemes. Pods 2.5-4.0 x 0.5 cm, flat hairy.

Flr. & Frts: October- January.

Dichrocephala integrifolia (Linn.) Kuntz. Family: Asteraceae. Local name: Unknown.

An erect pubescent herb. Leaves 3-11 cm long, obovate, alternate, pinnatisect or lyrate, serrate dentate. Heads *ca* 0.3 cm in diameter, globose in panicles; involucral bracts 2 seriate, linear; ray floret yellow, bilobed; disk florets 4 lobed. Achenes compressed. Pappus with 2 bristles.

Flr. & Frt: July- October.

Dicranopteris linearis (Burm.) Underwood. **var. *altissima*** Holtt. Family: Gleicheniaceae. Local name: Katchat-var (Ar-awpna) (M).

Tip of the rhizome densely covered with multicellular hairs, scales absent. Stipes 20-30 cm long, slender, straggling, rigid and polish; stipules small, 1 cm long. Fronds with a basal pair of stipule-like pinnae, 15-4 cm long; rachides repeatedly forked, covered with dark brown tomentum. Sori small, globose. Spores numerous, exine deeply grooved.

Sori: Almost throughout the year.

Dioscorea alata Linn. Family: Dioscoreaceae. Local name: Ram-bachim (M).

A twining herb; stem winged. Leaves alternate, 5.12 x 4.0-9.5 cm, broadly ovate; 5-nerved, acuminate, cordate at base; petioles 5-10 cm long. Flowers white, in axillary spikes. Capsules broadly obcordate.

Flr. & Frt: July- December.

Dioscorea bulbifer Linn. Family: Dioscoreaceae. Local name: Vawkpui-bahra (M).

A large twining herb; bulbils axillary tubercled. Leaves simple, alternate, 4-17 x 2.8-15.0cm, broadly ovate-cordate, acuminate; petioles 3-10 cm long. Male flowers in pendulous, axillary panicled spikes; female flowers 3-4 together in axillary spikes. Capsules quadrately oblong.

Flr. & Frt: July- December.

Dioscorea glabra Roxb. Family: Dioscoreaceae. Local name: Hra-kai (M).

A climber, glabrous, prickly at the base; tuber fleshy white. Leaves cordate, long. Flowers sub-globose, gibbous at the base. Seeds winged all around.

Flr. & Frt: Not seen during study period.

Diospyros glandulosa Lace. Family: Ebenaceae. Local name: Thei-vawkmit (M).

A tree; bark grayish-brown. Leaves alternate, *ca* 11 x 6 cm, ovate oblong, lanceolate or oblanceolate, obtuse or acute; lateral nerves 5-6 on either half; base shortly cuneate or narrowed into the petiole; petiole 1 cm long, densely brown pubescent. Flowers, male- in cymes of 3-6, pubescent; calyx 0.8 cm long; segment 4, oval or triangular; female- solitary; calyx 4-fid; tube short, segment orbicular, pubescent; corolla urceolate. Fruits globose with accrescent persistent calyx.

Flr. & Frt: Not seen during study period.

Diospyros lanceaefolia Roxb. Family: Ebenaceae. Local name: Zothing-hang (M).

A middle-sized evergreen tree; young shoot pubescent; bark blackish rough. Leaves 2-farios, 5-20 x 2.5-7.5 cm, narrow-elliptic or lanceolate to oblong-acuminate, shining above. Flowers 4-5 merous, sessile; male flowers sessile, clustered; female flowers solitary, sub-sessile in axils of fallen leaves. Calyx dissimilar in male and female flowers; corolla rusty and silky. Seeds up to 7, generally 3.

Flr : April- May Frt: December- February.

Diplazium maxima (D. Don.) Chatt. Family: Athyriaceae. Local name: Chakawk (M).

A terrestrial fern, erect; fronds erect. Leaves up to 2 m long, furrowed above, pubescent beneath; pinnae bipinnatifid, 8-10 pairs, lanceolate, serrate. Sori along acroscopic veinlets.

Sori: May- August.

Drimycarpus resemosus (Roxb.) Hook. Family: Anacardiaceae. Local name: Vawmbal (M).

A medium to large sized evergreen tree. Leaves 10-16 x 3-4.5 cm, lanceolate or oblong-lanceolate, base cuneate, acuminate at apex, coriaceous, wavy at margins, glabrous, shinning above; lateral nerves 16-24 pairs. Flowers unisexual, white; male flowers sessile; female flowers on slender puberulous pedicels. Drupes transversely ovoid-oblong, red when ripe.

Flr. & Frt: September- April.

Drymaria diandra Bl. Family: Caryophyllaceae Local name: Unknown.

A prostrate, spreading, branching herb. Leaves 8 -25 x 6- 118 mm, ovate or orbicular; base obtuse; apex acute; lateral nerves 2- 4. Flowers in axillary or terminal cymes, white. Capsule ovoid.

Flr. & Frt: Almost through out the year.

Dryptes lancifolia (Hook.) Pax. ex Hoffm. Family: Euphorbiaceae. Local name: Unknown.

A large or medium-sized tree. Leaves 9-18 x 2-5 cm, alternate, lanceolate, acuminate, entire, coriaceous, glabrous; lateral nerves 6-10 on either half. Flowers in axillary pubescent racemes.

Flr. & Frt: June- December.

Duabanga grandiflora (Roxb. ex D.C.) Walp. Family: Sonneratiaceae. Local name: Zuang (M).

A tall evergreen tree. Leaves 12-30 x 5-12 cm, opposite, oblong to ovate-lanceolate; base cordate; apex shortly acuminate, entire; lateral nerves 20-26 pairs. Flowers creamy-white, in compound terminal corymbose. Capsule ovoid-globose.

Flr. & Frt: March- October.

Dysoxylum binecteriferum (Roxb.) Hook.ex Bedd. Family: Meliaceae. Local name: Saha-tah (M).

A medium-sized tree. Leaves paripinnate, *ca* 35 cm long; leaflets 6-8, 6-22 x 3-9 cm, obliquely ovate-oblong, abruptly acuminate, cuneate at base. Flowers white, in large axillary panicles. Capsules obovoid, 4-celled.

Flr. & Frt: April- December.

Ebermaiera staurogyne Nees. Family: Acanthaceae. Local name: Unknown.

A sub-erect or decumbent herb. Leaves 5-21 x 2.5-4.5 cm, narrowly oblong, cuneate at base, obtuse at the apex, entire, glabrous; lateral nerves 8-12 pairs. Flowers blue, in terminal. Capsule oblong.

Flr. & Frt: August – February.

Ehretia acuminata Br. Family: Boroginaceae. Local name: Unknown.

A medium-sized deciduous tree. Leaves 5-14 x 2-5 cm, elliptic or ovate-oblong, acuminate, serrate. Flowers white, small. Drupes ovoid, small.

Flr. & Frt: May- November.

Elaeagnus pyriformis Hook. Family: Elaeagnaceae. Local name: Ram-sarzukte (M).

A scandent or staging shrub; branch spreading, brown. Leaves elliptic, acute, 2-3 x 3-7 cm, shinning above silvery beneath; base cuneate. Flowers pale or greenish-yellow in axillary clustered. Fruits pyriform, narrowed at both ends, yellowish when mature.

Flr: November- January. Frt: January- April.

Elaeocarpus aristatus Roxb. Family: Elaeocarpaceae. Local name: Theikel-ek (M).

A large tree. Leaves 12-25 x 3-8 cm, oblanceolate or obovate, base cuneate, acute or sub-acute at apex, minutely serrulate or sub entire, coriaceous, glabrous; lateral nerves 12-18 paired. Racemes axillary. Flowers white, drooping. Drupes ellipsoid.

Flr. & Frt: April- October.

Elaeocarpus floribundus Bl. Family: Elaeocarpaceae. Local name: Thinglung. (M).

A small or medium sized tree. Leaves alternate, 8-16.5 x 4.0-8.5 cm, ovate-elliptic, acute, cuneate or rounded at base, serrate. Flowers white, pedicellate, in axillary racemes. Drupe oblong, smooth, green.

Flr. & Frt: June- December.

Elaeocarpus lanceifolious Roxb. Family: Elaeocarpaceae. Local name: Kharuan (M).

A medium to large tree, young parts pubescent. Leaves 5-14 x 2.5-5.5 cm, lanceolate or elliptic-lanceolate; base cuneate; acuminate at apex, distantly crenate-serrate, glabrous or pubescent beneath; lateral nerves 6-8 pairs. Flowers white. Drupes ovoid-ellipsoid, rugose with 3-longitudinal grooves.

Flr. & Frt: March- December.

Embelia subcoriacea (Clark.) Mez. Local name: Tling (M). Family: Myrsinaceae.

An extensive woody climbing shrub; bark dark-grey. Leaves 5-15 x 2- 8 cm, acidic, elliptic or obovate-lanceolate, entire, acuminate, acute or obtuse; lateral nerves many, very slender. Flowers axillary, usually from old leafless branches. Fruits globose, red when ripe.

Flr. & Frt: May - December.

Embelia vestita Roxb. Family: Myrsinaceae. Local name: Unknown.

A scandent fairy woody shrub; bark whitish grey, warty, often with numerous lenticels. Leaves 3.5-7.5 x 1.2-3 cm, oblong-lanceolate or elliptic-lanceolate, closely serrulate, bluntly acuminate, gland-dotted, glossy, green above, glabrous; lateral nerve many, slender. Fruits globose.

Flr: December- January. Frt: March- May.

Emblica officinalis Goertn. Family: Euphorbiaceae. Local name: Sunhlu (M).

A small to medium-sized tree. Leaves 0.5-1.2 x 0.2-0.3 cm, sub-sessile, paler beneath, glabrous. Flowers yellowish, monoecious in axillary, clusters. Drupes globose, 6-lobed, yellowish when ripe.

Flr: February- April. Frt: August- February.

Engelhardtia spicata Lechen ex Blume. Family: Juglandaceae. Local name: Hnum (M).

A large deciduous tree. Leaflets 4-13, sub-opposite, 5-20.3 x 3.5-6.5 cm, narrow-oblong, oblong-lanceolate or elliptic-lanceolate, acute or obtuse, glabrescent above, pubescent beneath, clothed with orbicular gland. Male flowers in slender catkins, 6-20 cm long, often panicled; female flowers in pendulous spikes, 16-33 cm long. Nuts globose, villously hispid.

Flr. & Frt: December- May.

Entada pursaetha D.C. Family: Mimosaceae. Local name: Kawi-hrui. (M).

A large woody climber; branches terete; bark grayish-brown. Leaves bipinnate, main rachis grooved; leaflets 4-6 pairs, oblong-obtuse or acute, 2-3 x 4-6 cm, shinning above. Flowers creamy white to pale yellow, fragrant, in axillary or terminal panicled spikes. Pods woody, up to 130 cm long, falcate or curved, constricted between the seeds. Seeds compressed, discoidal, shinning on edge, brownish-orange powder on the center.

Flr: March- April Frt: March- May (Next year).

Eragrostis nutans Nees ex. Steud. Family: Poaceae. Local name: Zawnga-hrik (M).

A perennial grass; stem densely tufted, 30-45 cm tall, erect or geniculately ascending, simple or branched; upper inter-node long. Leaf-blades 7.5-12 cm long, very narrow strict, usually convolute, smooth, sometimes quite flat, glabrous; ligule a narrow membranous ring. Panicle ovate or oblong or sub-linear, sub-erect or nodding. Grains globose or globosely ellipsoid, reddish brown, smooth.

Flr. & Frt: May- September.

Eranthemum palatiferum Nees. Family: Acanthaceae. Local name: Vatezu-suak(M).

Under-shrub upto 1m tall. Leaves lanceolate, acuminate, tapering at the base, sparsely pubescent on the nerves beneath. Flowers in terminal racemose spikes, pink. Capsules *ca* 2.5 cm long, pubescent.

Flr: March Frt : April- June.

Erianthus longisetosus Anders. ex. Benth. Family: Poaceae. Local name: Luang (M).

Culms 2-2.5 m high, solid, terete, reed-like, simple or branched from a stout rhizome, almost woody below, smooth and glabrous, naked below the panicle. Leaf-blades 30-100 cm long, flat, lanceolate, tapering to a fine tip from a gradually narrowed base, smooth and glabrous on both surface or with short appressed hairs; ligule rounded and shortly ciliate. Panicle 15-45 cm long, made up of many, long, densely packed, solitary or binate, soft, drooping racemes clothed with pale, reddish or golden brown hairs, spreading at anthesis.

Flr & Frt: November- March (Next year).

Eriobotrya bengalensis Hook. Family: Rosaceae. Local name: Nghal-chhun (M).

A small tree. Leaves 8-13 x 4-8 cm, elliptic to lanceolate, cuneate at base, acuminate at apex, serrate; lateral nerves 8-15 on either side. Flowers white. Pome ovoid.

Flr. & Frt: September- April (Next year).

Eryngium foetidum Linn. Family: Apiaceae. Local name: Bahkhawr (M).

A diffused perennial foetid herb. Leaves simple, alternate, 4-10 x 0.5-3 cm, oblanceolate-spathulate, spinous-toothed at margins. Flowers white. Fruits ellipsoid.

Flr. & Frt: April- January (Next year).

Erythrina stricta Roxb. Family: Fabaceae/ Papilionaceae. Local name: Fartuah (M).

A medium-sized deciduous prickly tree. Leaflets broad ovoid to rhomboid-ovoid, 7-20 x 4.5-18.0 cm, acuminate, cuneate at base. Flowers deep-red, in terminal dense recemes; calyx spathacious. Pods 15-20 cm long, curved, torulose; 3-6 seeded.

Flr. & Frt: February- June.

Euonymus glaber Wall. Family: Celastraceae. Local name: Hawng-sen (M).

An evergreen tree. Leaves 7-10 x 3-4 cm, obovate-oblong to oblong, cuneate, acuminate, serrate upward, glabrous. Cymes axillary, dichotomously branched. Flowers white. Capsule obcordate.

Flr. & Frt: March- September.

Eurya acuminata D.C. Family: Theaceae. Local name: Sihneh ziksen (M).

A large shrub or tree. Leaves 2.5-9.5 x 1-2.5 cm, elliptic-oblong to elliptic-lanceolate; cuneate at base; acuminate at apex, crenate; lateral nerves 12-15 pairs. Flowers axillary, yellowish.

Flr. & Frt: July- December.

Eurya cerasifolia (D. Don.) Kobuski. Family: Theaceae. Local name: Sihneh zikvar (M).

An evergreen large shrub or small tree. Leaves 4-10 x 2-3.5 cm, elliptic-laceolate, acute at base, obliquely acuminate at apex, entire to serrulate; lateral nerves 15-20 pairs, orange. Flowers whitish, creamy white.

Flr. & Frt: November- June (Next year).

Fagerlindia faciculata (Roxb.) Tirvengadum. Family: Rubiaceae. Local name: Chhawntan (M).

A spiny shrub. Leaves 2.5-15 x 0.5-1.0 cm, fascicled, oblong-lanceolate, obtuse or rounded at base, acuminate at apex, entire; lateral nerves 9-11 on either half. Flowers white. Berry purplish black when ripe.

Flr. & Frt: March- May.

Ficus benjamina Linn. Family: Moraceae. Local name: Zamanhmawng (M).

A large tree with drooping branches. Leaves 3.5-14 x 1-5 cm, ovate elliptic or elliptic, entire, acuminate, glabrous; lateral nerves many. Receptacle axillary, in pairs, globose or ovoid. Achenes more or less reniform.

Flr. & Frt: October- April.

Ficus elastica Roxb. Family: Moraceae. Local name: Thelret (M).

A gigantic tree. Leaves 11.5-30 x 5-11 cm, elliptic to oblong, entire, bluntly and abruptly caudate, coriaceous; lateral nerves very fine, numerous, base rounded or narrowed. Receptacle enclosed in hooded involucres; male flowers pedicelled, scattered; female flowers mostly sessile.

Flr. & Frt: June- August.

Ficus geniculata Kurz. Family: Moraceae. Local name: Rihnim (M).

A large tree. Leaves ovate-oblong, acuminate, glabrous, coriaceous ; stipules ovate-lanceolate. Receptacles subglobose, shortly pedunculate, axillary, solitary or paired.

Flr. & Frt: October- March.

Ficus hirta Vahl. Family: Moraceae. Local name: Sazu-theipui (M).

A small tree or large shrub. Leaves 12.5-30.5 x 10-20 cm, variable, broad-ovate, sub-orbicular or ovate-lanceolate, acuminate, serrate, 3-5 lobbed or entire, densely hirsute; lateral nerves 4-7 pairs. Receptacle axillary, in pairs, globose or ovoid. Achenes minutely tuberculate, ellipsoid.

Flr. & Frt: November- July.

Ficus hispida Linn. Family: Moraceae. Local name: Paihte-maian (M).

A hispid shrub. Leaves opposite, 8-25 x 4-10 cm, broadly ovate-oblong or subovate, crenulate, acuminate, rounded or truncate at base, scrabous above, hipid beneath, minutely dentate, coriareous. Receptacles 1.0-2.5 cm in diameter, depressed globose, hispid, cluster on trunk and leafless hanging branches. Male perianth 3-lobed; stamen 1.

Flr. & Frt: Most part of the year.

Ficus prostrata Wall. Family: Moraceae. Local name: Unknown.

A small deciduous tree, glabrous. Leaves 7.5-20 x 3-6 cm, alternate, lanceolate or oblong-lanceolate, acuminate, entire; lateral nerves 12-14. Receptacle solitary or in pairs, sub-pyriform, dark brown.

Flr. & Frt: January- August.

Ficus religiosa Linn. Family: Moraceae. Local name: Hmawng hnah zum (LR).

A large deciduous tree. Leaves 11-18 x 7.5-12 cm, orbicular, ovate, entire, caudate-acuminate; lateral nerves 6-8 pairs. Flowers unisexual, minute. Receptacles in axillary, sessile, sub-globose, white when ripe.

Flr. & Frt: November- July.

Ficus semicordata Buch.-Ham. Family: Moraceae. Local name: Theipui (M).

A medium sized tree; bark yellowish-brown. Leaves alternate, 8-17 x 5-9 cm, oblong or elliptic-lanceolate, acute or acuminate at apex, unequal or cordate at base, entire or serrate, scabrous, petiolate. Receptacles *ca* 1.5 cm in diameter, globose or pyriform, paired clustered on leafless drooping branches from main trunk, hispid; basal bract 3. Male and gall flowers shortly pedicellate; stamen 1.

Flr. & Frt: August- November.

Ficus semicordata Buch.-Ham **var. *conglomerata*** (Roxb.) Kurz. Family: Moraceae. Local name: Theitit (M).

A small tree; twigs hirsute; bark reddish-brown. Leaves elliptic to oblong-lanceolate, 4-8 x 12-30 cm, acuminate, repand-serrate, scabrid above, less pubescent beneath base very unequal, semi-cordate or semi-sagittate; lateral nerves 8-15 pairs; male sepals 3; female sepals 4; receptacles globose or pyriform, hipid, in pair or clusters; fruiting branches running on the

ground or arising from the trunk and main branches, often ripen on the ground, dark-red when ripe.

Flr. & Frt: Most of the year, usually ripening in May- September.

Fimbristylis dichotoma (Linn.) Vahl. Family: Cyperaceae. Local name: Unknown.

Annual tufted herb, 15-50 cm high. Leaves linear, shorter than stem; sheath hairy. Spikelets *ca* 0.4 cm long, ovoid, globose, reddish brown; glumes *ca* 0.2 cm long, concave; 1-3 nerved; stigma 2 fid. Nuts obovate or elliptic.

Flr. & Frt: June- November.

Firmiana colorata (Roxb.) Br. Family: Sterculiaceae. Local name: Khaukhim (M).

A medium-sized tree. Leaves 10-18 x 10-20 cm, palmately 3-5 lobbed, lobes caudate-acuminate at apex, 5-7 nerved at base. Flowers yellow to red.

Flr. & Frt: April- October.

Flacourtia jangomas (Lour.) Raeusch. Family: Flacourtiaceae. Local name: Sakhi-thei (M).

A medium-sized tree, spiny; young parts pubescent. Leaves 3.5-10.0 x 2.0-4.5 cm, ovate or ovate-lanceolate, acuminate crenate-serrate. Flowers yellow, unisexual in axillary lax lacemes; sepals 5, small, hairy; petals absent. Fruits globose, dark-purple; 4-6 seeded.

Flr. & Frt: March- April.

Flemingia macrophylla (Willd.) Kuntze ex Merr. Family: Fabaceae/ Papilionaceae. Local name: Tuisithing (LR).

An erect shrub to 2 m high; stem rough, lenticelate, striate; branches angular, sulcate. Leaves 3-foliolate; petiole 3-quetrous, winged, 5 cm long; leaflets ovate-acuminate, 3 x 8 cm, 3-

nerved; stipule large, hipid above, pubescent along nerves beneath. Flowers white, streaked with pink, sessile, branched, terminal. Pods oblong, apiculate, 2 cm long, finely pubescent; seeds round, black, small.

Flr. & Frt: April- February.

Galinsoga parviflora Cav. Family: Asteraceae. Local name: Unknown.

A weak herb. Leaves opposite ovate or oblong-ovate acute or cuneate at base, obtuse or acute, shallowly serrate. Inflorescence teminal and axillary; ray florets white; disc florets pale yellow. Fruits achenses ovate angular.

Flr. & Frt: July- December.

Garcinia cowa Roxb ex D.C. Family: Guttiferae / Clusiaceae. Local name: Chengkek (M).

A shrub or small tree. Leaves lanceolate, acute narrowed down to the base. Flowers creamy pinkish red, dioecious, tetramerous, in few flowered cymes; perianth thick, fleshy. Barries obovoid, bright orange yellow.

Flr. & Frt: April- November.

Garcinia sopsopia (Buch-Ham.) Mabberley. Family: Guttiferae / Clusiaceae. Local name: Vawmva (M).

A medium to large tree. Leaves 6-20 x 4-9 cm, oblanceolate or broadly elliptic or obovate, base cuneate, shortly acuminate at apex, entire; lateral nerves 7-10 on either side. Male flowers in terminal, branchiate panicles, dull white; female flowers in terminal spikes. Berries globose to ellipsoid.

Flr. & Frt: November- July (Next year).

Garcinia xanthochymus Hook. ex Anderson. Family: Guttiferae / Clusiaceae. Local name: Tuaiha-beh (M).

A medium-sized tree. Leaves 10-35 x 5-12 cm, oblong-lanceolate, base cuneate, apex acute or acuminate; lateral nerves 20-25 pairs. Flowers 4-8 in axillary fascicle, pentamerous. Berries sub-globose.

Flr. & Frt: March- September.

Garuga floribunda var.gamblei Linn. (King ex Smith) Kalkman. Family: Burseraceae. Local name: Tuai-ram (M).

A tree; young parts pubescent. Leaves 30-45 cm long, alternate, imparipinnate; leaflets 7-13 x 2-3 cm , oblique-cuneate at base, acuminate at apex, serrate, young pubescent, Flowers whitish-yellow. Fruits not seen.

Flr. & Frt: February- October.

Globba mutiflora Wall. ex. Baker**.** Family: Zingiberaceae. Local name: Unknown.

An annual herb; rhizomes creeping. Leaves 15-25 cm long, oblong-lanceolate, acuminate, pubescent beneath. Flowers orange-yellow, in long narrow terminal panicles. Capsule sub-globose.

Flr. & Frt: June- September.

Glochidion khasicum Hook. Family: Euphorbiaceae. Local name: Thing-pawnchhia (M).

A medium sized tree. Leaves 5-15 x 2-6 cm, elliptic, ovate-elliptic, entire, acuminate, coriaceous, glabrous; lateral nerves 5-7 on either half. Male flowers shortly pedicelled; female flowers sub sessile. Capsule globose, 6-12 lobbed, reddish when ripe.

Flr: May- August. Frt: September- December.

Glochidion velutinum Wight. Family: Euphorbiaceae. Local name: Thing-pawnchhia (M).

A small tree. Leaves 3.5-12.5 x 3.5-0.6 cm, ovate, elliptic, oblong or lanceolate, acute, obtuse or abruptly and shortly acuminate, glabrous above, tomentose beneath; lateral nerves 5-10 on either half. Flowers in axillary clusters, male and female flowers usually together. Capsules depressed, 4-7 lobbed.

Flr. & Frt: September- January.

Gmelina arborea Roxb. Family: Verbenaceae. Local name: Thlanvawng (M).

A moderate-sized deciduous tree to 30 m tall. Leaves 8-15 x 5-20 cm, ovate, acute or acuminate, entire, cuneate at base, long petiolate with 2 basal glands. Flowers brownish-yellow, in axillary or terminal panicles. Drupes obovoid-pyriform, orange-yellow when mature.

Flr. & Frt: March- June.

Gnetum montanum M.G. Family: Gnetaceae. Local name: Thal-ping hrui / Thurpui (M).

A large evergreen climber; stem woody; bark dark-grey, corky; blaze brownish. Leaves opposite, 6-20 x 6.3-14 cm, elliptic, ovate-oblong, bluntly acuminate, entire, glabrous, glossy. Flowers dioecious, in rigid panicled spikes; bracts of males closely imbricate, those of females interrupted. Fruits drupaceous, stipitate, ellipsoid, reddish-orange when ripe.

Flr: Feb- April Frt: Winter season.

Goniothalamus sesquipedalis (Wall.) Hook. & Thomson**.** Family: Anonaceae. Local name: Kham (M).

A sparingly branch, erect under-shrub, up to 3 m tall. Leaves 20-30 x 5-10 cm, elliptic-oblong; base rounded or cuneate; acuminate at apex, entire and recurved at margins, glabrous,

coriaceous; lateral nerves 15-20 pairs. Flowers axillary, solitary, fascicled, greenish yellow, bracteate at base.

Flr. & Frt: May- December.

Grewia disperma Roth. ex Spreng. Family: Tiliaceae. Local name: Varitabelkang (M).

A small tree; young parts pubescent. Leaves 6-12 x 2.2-5.0 cm, elliptic-lanceolate, acuminate, acute, serrate. Flowers yellowish-white. Drupe globose.

Flr. & Frt: June- November.

Gynura bicolor (Roxb. ex. Willd.) D.C. Family: Asteraceae. Local name: Buar (M).

A succulent, erect herbs; stems striate furrowed, corymbosely branch, glabrous. Leaves 8-30 x 2.5-7 cm, sessile, alternate spiral, oblong-obovate, oblanceolate, acute-acuminate, contracted or auricle at base, margins irregularly dentate, surface not smooth, florets orange red. Achenes narrow, many ribbed, glabrous; pappus hairs white, multi-seriate.

Flr. & Frt: June- September.

Haldina cordifolia (Roxb.) Ridsdale. Family: Rubiaceae. Local name: Lungkhup (M).

A small to large deciduous tree. Leaves 8-12 x 12-19 cm, broad, broadly ovate or orbicular-cordate; base cordate; acuminate at apex, coriaceous; lateral nerves 5-8 pairs. Flowers on sub-sessile, yellow in globose.Capsule small seeds winged.

Flr. & Frt: November- December.

Hedyotis scandens (Roxb.). Family: Rubiaceae. Local name: Kel-hnamtur (M).

A woody climbing shrub; branches glabrous; young parts minutely pubescent. Leaves 3-10 x 1-3 cm, opposite, oblong or elliptic-lanceolate, obtuse at base, acuminate at apex, undulate,

glabrous on both surfaces; lateral nerves 5-6 pairs. Flowers white, on axillary or terminal trichotomous sub-corymbs. Barries small, globose.

Flr. & Frt: November- March (Next year).

Hodgsonia macrocarpa (Bl.) Cogn. Family: Cucurbitaceae. Local name: Khaum (M).

A large climber; stem light grey, very warty. Leaves alternate, deeply 3-lobed; lobes acute or acuminate, *ca* 24 x 25 cm; nerves prominent beneath, anastomosing; tendril pinkish, coiled at apex; petiole 6 cm long, grooved, glandular. Flowers large, white tinged with yellow within. Fruits large, globose, depressed, 8-14 cm across, 12-grooved. Seeds ellipsoid.

Flr. & Frt: February- August.

Ichnanthus vicinus (Bail.) Merr. Family: Cyperaceae. Local name: Unknown.

A perennial herb. Culms 30-60 cm high, weak. Leaf-blades spreading, thin, flat, oblong-lanceolate, acuminate. Inflorescence a sub-pyramidal panicle; branches erect or drooping. Spikelets lanceolate, acuminate, green, often more or less hairy. Glumes spreading, herbaceous-membranous.

Flr. & Frt: June- December.

Ilex umbellulata (Wall.) Loes. Family: Aquifoliaceae. Local name: Thing-uihahni (M).

A tree, up to 18 m tall, young shoots glabrous. Leaves 10.5-14 x 5.-6 cm, ovate or elliptic-oblong, rounded or obtuse at base, acute-acuminate at apex, entire, undulate at margins, membranous; lateral nerves 9-12 pairs. Inflorescence sub-umblliform; flowers 4-5 merous. Male inflorescences 6-16 flowed. Drupes globose.

Flr. & Frt: April- September.

Imperata cylindrica (Linn.) Raeuschel. Family: Poaceae. Local name: Di (M).

A perennial grass, variable in size. Culms 0.3-2 m long; rootstocks hard, creeping, stoloniferous. Leaves 0.2-1.5 m long, linear-lanceolate, scabird on margins; ligule membranous, silky dorsally. Inflorescence a compact, cylindrical panicle. Spikelets *ca* 0.3 cm long, lanceolate, silky hairy; glumes subequal; lemma of bisexual floret ovate-lanceolate; stamens 2; stigmas 2. Caryopsis oblong.

Flr. & Frt: March- May.

Ipomoea hederifolia (Linn.). Family: Convolvulaceae.Local name: Nipui-par (M).

A twiner with dark red stems. Leaves 2-4 x 2.5-4.5 cm, cordate, acuminate, entire, basal nerves 2-4. Inflorescence in terminal or axillary. Flowers red. Capsule glabrous.

Flr. & Frt: June- Decermber.

Indigofera dosua Buch-Ham. ex. D. Don. Family: Fabaceae/ Papilionaceae. Local name: Unknown.

A shrub. Leaves 8-16 cm long; leaflets 37-53, 8-15 x 3-5 cm, narrowly oblong, base cuneate, obtuse-mucronate at apex, glabrous above, pubescent beneath. Racemes axillary, 10-20 flowers. Flowers reddish-orange. Pods linear oblong.

Flr. & Frt: April- September.

Inula cappa (Ham. ex. D. Don)**.** Family: Asteraceae. Local name: Buar-thau (M).

A stout aromatic shrub; young parts wooly. Leaves elliptic-lanceolate, brownish-silky or white on both surfaces, coarsely toothed, denticulate, 4 x 6 cm, wooly beneath; nerves 8-12 pairs. Flowers yellow, terminal heads, corymbose. Fruits pubescent; papus dirty white, feathery.

Flr. & Frt: September- February.

Itea macrophylla Wall. Family: Iteaceae. Local name: Thingpuithing (M).

A small tree or shrub. Leaves 10-20 x 6-13 cm, alternate, elliptic-oblong or broadly ovate, truncate at base, acuminate at apex, glandular-serrate; lateral nerves 7-10 pairs. Flowers white.

Flr. & Frt: April- January (Next year).

Jasminum glandulosum Wall. Family: Oleaceae. Local name: Hnahfim (M).

A scandent shrub; branches closely lenticellate; bark corky. Leaves simple, opposite, elliptic or ovate-lanceolate, acuminate, entire, membranous, glabrous. Flowers solitary and axillary or in few flowered trichotomous, corymbosely branched terminal cymes.

Flr. & Frt: August- March.

Jasminum undulatum Ker. Family: Oleaceae. Local name: Unknown.

A scandent shrub; branchlets pubescent; stem succulent. Leaves bifarious, ovate-lanceolate, acute or acuminate, entire, membranous, almost glabrous above with the exception of the midrib which is hairy; lateral nerves *ca* 3 on either half. Flowers white, slightly scented in capitate cymes, usually slender on pilose lateral branchlets.

Flr: September- October Frt: January- March.

Kadsura heteroclita (Roxb.) Craib. Family: Magnoliaceae. Local name: Thei-arbawm (M).

An evergreen climbing shrub, glabrous. Leaves 8-14 x 3-5.3 cm, elliptic to ovate-lanceolate; base rounded or cuneate; acute at apex, denticulate to entire; lateral nerves 10-15 pairs. Flowers axillary, solitary, in 3-4 whorls, whitish.

Flr. & Frt: August- December.

Knoxia corymbosa Willd. Family: Rubiaceae. Local name: Unknown.

An erect annual herb. Leaves 4-8.5 x 1-2.4 cm, lanceolate or linear-lanceolate; base cuneate; apex acuminate; lateral nerves 7-9 on either half. Flowers light purple, in corymbose cymes.

Flr. & Frt: August- January (Next year).

Kydia calycina Roxb. Family: Malvaceae. Local name: Thal-theh / Hnah-thap (M).

A medium sized deciduous tree. Leaves 4-10 x 6-14 cm, palmately 5-7 lobbed, ovate-orbicular, base subcordate, acute or obtuse at apex, entire or serrate, 5-9 nerved at base. Flowers axillary or terminal in close panicles, pink or white. Capsules subglobose.

Flr. & Frt: September- February (Next year).

Kyllingia brevifolia Rottb. Family: Cyperaceae. Local name: Pisaum-bur (M).

An herb, 15-30 cm high; rhizome slender, creeping, brown scaly. Leaves radical and sub-radical, linear, acuminate. Inflorescence a single globose terminal heads. Spikelets ovate-laceolate, 1 flowered; slumes sub-equal; stamens 2. Nuts ellipsoid, obtuse.

Flr. & Frt: June- November.

Lagerstroemia speciosa (Linn.). Family: Lythraceae. Local name: Thlado (M).

A medium to large deciduous tree. Leaves 3.5-8 x 9-15 cm, elliptic or elliptic-lanceolate, rounded at base, acuminate at apex, glabrous; lateral nerves 10-12. Flowers showy, mauve coloured, in large terminal peduncles. Capsule sub-globose.

Flr. & Frt: May- March (Next year).

Lantana camara Linn. **Var**. ***aculeata*** (Linn.). Family: Verbenaceae. Local name: Hlingpangpar/ Shillong-par (M).

An evergreen prickly shrub. Leaves 2-7.5 x 1.5-4.5 cm, ovate or triangular, crenate, acute; lateral nerves 5-7. Flowers complete, yellow to red, in sub-umbellate head. Drupes spherical.

Flr. & Frt: Throughout the year.

Lasianthus lucidus Bl. Family: Rubiaceae. Local name: Unknown.

An evergreen erect shrub. Leaves 5-12 x 2.5-4.3 cm, lanceolate or elliptic-ovate, caudate at base, acuminate at apex, entire; lateral nerves 5-7 pairs. Flowers white, sub-sessile or sessile in axillary cymes.

Flr. & Frt: April- December.

Leea asiatica Kurz. Family: Ampelidaceae. Local name: Kumtin-tuai (M).

A perennial shrub upto 2 m high, young parts pubescent; branches and leaf rachis subtended by crisped wings. Leaves 2-pinnate; leaflets 3-5 foliolate, 3-8 x 10-20 cm, ovate-lanceolate, coarsely serrate; base rounded or subcordate; petiole stout. Flower greenish-white to slightly pale-yellowish in terminal corymbose cymes. Fruits depressed-globose, shallowly lobed, puplish-black when ripe; 5-seeded.

Flr: May- July Frt: October- December.

Lepidagathis hyaline Nees. Family: Acanthaceae. Local name: Vangvat-tur (M).

A much branched herb; stems with 2-4 raised green lines, decurrent from the base of each leaf. Leaves variable in shape, ovate, oblong, entire, or undulate, acute or obtuse, glabrous above.

Spikes dense; bracts very densely 4-rowed, imbricate, ovate-oblong or lanceolate. Capsules small, oblong with a short beak.

Flr. & Frt: December – April.

Lepionurus sylvestris Bl. Family: Opiliaceae. Local name: Anpangthuam (M).

A large shrub, glabrous. Leaves 4-8 x 2-5 cm, alternate, oblong-lanceolate to elliptic or obovate, base acute, acuminate at apex, entire, glabrous; lateral nerves 6-9 pairs. Flowers greenish to pale yellow, bisexual. Drupe ellipsoid.

Flr. & Frt: March- August.

Licula peltata Roxb. Family: Arecaceae/ Palmae. Local name: Laisua (M).

An erect, slender shrub. Leaves palmately divided, orbicular, 90-140 cm diameter; segments narrowly abcuneate, *ca* 20, 3-5 lobed. Spikes projected outwards, drooping, flowers small, bisexual, sub-sessile. Drupes small, ellipsoid, orange colour.

Flr. & Frt: April- June.

Linostoma decandrum Wall. Family: Thymeleaceae. Local name: Ngaih-hih (M).

A climbing shrub. Leaves 5-9.3 x 2-3 cm, opposite or sub opposite, oblong-lanceolate or elliptic-oblong, acuminate, glabrous. Flowers 2-sexual, greenish white in umbellate. Perianth tube glabrous, oblong. Fruits ellipsoid, base acute, narrow above.

Flr. & Frt: November- February.

Litsea citrata Bl. Family: Lauraceae. Local name: Sernam (M).

A small evergreen tree, aromatic; bark grey, warty, thin. Leaves somewhat inequilateral, 7-15 x 2-4 cm, lanceolate or narrow ovate-lanceolate, caudate-acuminate, membranous, bright

green above, glaucous beneath. Flowers in capitate umbels solitary or in corymbs. Fruits 0.6-8 cm across.

Flr: November- February. Frt: June- July.

Litsea monopetala (Roxb) Pers. Family: Lauraceae. Local name: Nauthak (M).

A middle-sized evergreen tree. Leaves 9-20 x 5.0-10.5 cm, broadly elliptic, ovate or obovate, acute or rounded at apex, entire, tomentose beneath. Flowers greenish yellow, axillary in umbellate silky heads. Fruits ovoid.

Flr. & Frt: May- November.

Litsea salicifolia (Roxb. ex. Wall) Hook. Family: Lauraceae. Local name: Dawn-dung (M).

A shrub; branches silky pubescent. Leaves alternate 8-20 x 2.0-5.5 cm, elliptic or narrow lanceolate, acuminate, cuneate at base, entire, pubescent beneath. Flowers greenish yellow, in axillary clustered umbels. Fruits black, ellipsoid.

Flr. & Frt: February- June.

Lobelia angulata Forts. Family: Campanulaceae / Lobeliaceae. Local name: Choaka-thi (M).

A prostrate herb; rooting at nodes. Leaves 0.3-2.0 x 0.2-1.8 cm, ovate, acute, serrate. Flowers pinkish-white, solitary axillary. Berries sub-globose, crownded with calyx teeth.

Flr: April - May Frt: July – August.

Lycopodium cernuum Linn. Family: Lycopodiaceae. Local name: Unknown.

Terrestrial, branches prostrate, short creeping; roots in clumps at definite interval; fertile branches erect, divaricate. Leaves spirally arranged, decurrent on the stem, narrow linear, acute, finely ciliate. Strobili oblong, 0.5-1 cm long, sessile, borne terminally on the fertile branches.

Fertile: Not seen during the study period.

Lygodium flexosum (Linn.) Swartz. Family: Lygodiaceae/ Schizaeaceae. Local name: Dawnzem-pui (M).

Rhizomes short creeping, glabrous. Fronds glabrous; pinnae 3-5 lobes or clefted at the base, variable in sized, 1-5 x 2-3 cm, terminal lobe elongate, linear-oblong, serrulate margins, often clefted at apex. Sori protruding from the margins.

Fertile: January- September.

Lygodium scandens (Linn.) Swartz. Family: Lygodiaceae/ Schizaeaceae**.** Local name: Dawnzem (M).

Rhizomes short creeping, glabrous. Rachis 10-25 cm long, bears 7-8 fronds. Fronds glabrous, 2-3 lobes, terminal lobes elongate, caudate at base, obtuse at apex, entire, serrulate. Sori protruding out from the margins of the fertile pinnae.

Fertile: Not seen during the study period.

Macaranga indica Wight. Family: Euphorbiaceae. Local name: Khar-nu (M).

A middle-sized tree. Leaves 12.5-29 x 10-22 cm, peltate, triangular-ovate, orbicular-ovate, acuminate, denticulate or entire; lateral nerves 8-11 on either half. Male panicles branches zigzag; flowers pubescent, some what clusters; female panicles smaller, hairy. Flowers pedicelled. Capsules globose.

Flr: May- August. Frt: September- January.

Machilus kingii Hook. Family: Lauraceae. Local name: Bul chikhat (LR).

A small tree; bark grey warty and slightly reticulately fissured. Leaves 15-25 cm long, elliptic-lanceolate or oblanceolate, coriaceous, glaucous beneath; lateral nerves 8-10 on either side. Flowers 0.7 cm across; lobes adpressed-pubescent on both surfaces.

Flrs & Frts: Not seen during the study period.

Machilus odoratissima Nees. Family: Lauraceae. Local name: Bul chikhat (LR).

A middle-sized tree; bark dark-grey, somewhat rough outside up to 1.7 cm thick. Leaves crowded at the ends of branches, 6-19 x 2.5-6.3 cm, very variable in shape, oblanceolate, oblong-lanceolate, elliptic-oblong or obovate, shortly acuminate or acute; glabrous, dark green and shinning above, paler and slightly glaucous beneath. Flowers yellowish-green, scented; perianth tube obsolete. Fruits oblong or ellipsoid, purple and prim-rose when ripe.

Flr: March- April Frt: May- June.

Machilus parviflora Meissn. Family: Lauraceae. Local name: Nghaleng-lu-tar (M).

A small tree; bark grey or pale brown, rough outside. Leaves variable, 7.6-20.3 x 1.7-7 cm, narrowly oblong, oblong-lanceolate or oblanceolate, obtuse, sub-acute or obtusely acuminate, glaucous beneath. Flowers greenish yellow, *ca* 0.2 cm long, perianth sub-globose, glabrescent with age, obscurely puberulous within. Fruits ellipsoid.

Flr. & Frt: September- February.

Machilus villosa Hook. Family: Lauraceae. Local name: Bul-bawr (M).

A moderate-sized tree with spreading crown. Leaves 7.6-17.7 x 2.5-6.3 cm, elliptic to lanceolate or oblanceolate, usually acuminate, less often acute or obtuse, pale and shinning above, purplish brown or brown beneath. Flowers densely ferruginous, tomentose outside; lobes

broad, usually elliptic or elliptic lanceolate, obtuse or sub-acute, pubescent within *ca* 2.5 cm long.

Flr: December- March Frt: April- May.

Macropanax dispermum (Bl.) Kuntz. Family: Araliaceae. Local name: Phuanberh (M).

A large, evergreen, small tree, up to 9 m tall; bark grey, warty. Leaves digitate, 3-5 foliate, common petiole 12-35 cm long. Leaflets 7-15 x 2.5-5 cm, elliptic-lanceolate or oblong, base rounded or acute, acuminate at apex, denticulate or serrulate along margins, glabrous; lateral nerves 5-8 pairs. Flowers greenish-yellow. Fruits ovoid.

Flr. & Frt: July- February.

Maesa indica (Roxb.) D.C. Family: Myrsinaceae. Local name: Ar-ngeng (M).

An evergreen shrub. Leaves 5-17 x 2.0-5.5 cm, elliptic-oblong, ovate-lanceolate or elliptic-lanceolate, acute or acuminate, dentate with distinct teeth. Flowers white, *ca* 0.3 cm long, pedicelled,, simple or compound, nearly sessile axillary racemes. Barries globose, brownish.

Flr. & Frt: February- November.

Maesa ramentacea D.C. Family: Myrsinaceae. Local name: Ar-ngeng-pui (M).

A large shrub or small tree. Leaves 7-20 x 2.5-5.8 cm**,** ovate-lanceolate to elliptic-laceolate, entire, slightly recurved, acuminate; lateral nerves 6-9 pairs. Flowers white, small, in axillary, glabrous, compound racemes. Fruits succulent, whitish-brown.

Flr. & Frt: February- November.

Mallotus albus (Muell.- Arg). Family: Euphorbiaceae. Local name: Khar pawl (LR).

A middle sized tree; young parts stellate- tomentose. Leaves mostly alternate, 4-12 x 2-8 in., broadly ovate or sub-orbicular, acuminate, entire or sinuate-toothed, coriaceous, glabrous above, whitish or rusty-tomentose beneath; 3-5 nerved at base. Flowers dioecious, in axillary and terminal pyramidal panicles; male flowers- clustered; buds globose; anther- cells parallel; female flowers- solitary; calyx 4-5; cleft. Seeds blackish-brown, minutely tubercled.

Flr: March- April. Frt: October- February.

Mangifera indica Linn. Family: Anacardeaceae. Local name: Theihai (M).

An evergreen tree; branches spreading. Leaves 9-28 x 2.2-8.0 cm, oblong-lanceolate, acuminate or acute, coriaceous, margins undulate. Flowers creamy, in terminal panicles. Drupes ovoid.

Flr. & Frt: March- June.

Melastoma malabatricum Linn. Family: Melastomaceae. Local name: Builukham (M).

A bushy shrub. Leaves 5-12 x 3-5 cm, oblong-laceolate or elliptic-lanceolate, base rounded, acute or strongly acuminate at apex; basal nerves 3-5. Flowers in clusters, purple. Fruits subglobose-ovoid.

Flr. & Frt: Throughout the year.

Melastoma nepalensis Lodd. Family: Melastomaceae. Local name: Builukhampa (M).

A large shrub or small trees. Leaves 4-10 x 1.5-3.5 cm, oblong-lanceolate to ovate lanceolate, base rounded to acute, short acuminate at apex. Flowers in terminal clusters. Fruits ovoid.

Flr. & Frt: May- December.

Melia azedarach Linn. Family: Meliaceae. Local name: Nim-suak (M).

A medium-sized deciduous tree. Leaves 2-3 pinnate; leaflets 2.0-4.5 x 1.0-2.2 cm, ovate-lanceolate, acuminate, cuneate at base, oblique, serrate. Flowers light purple, in axillary paniculate cymes. Drupe fleshy, 1-seeded.

Flr. & Frt: March- December.

Meliosma pinnata (Roxb.) Maxim. Family: Sabiaceae. Loacl name: Bungbutuairam (M).

A small to medium-sized tree. Leaves pinnate; leaflets 3-7 pairs, 7-22 x 2-8 cm, opposite, ovate to ovate-oblong, elliptic to oblong or lanceolate, linear lanceolate, rounded at base, acuminate at apex; lateral nerves 7-10 pairs. Flowers minute, creamy white. Barries globose, red when ripe.

Flr. & Frt: May- September.

Melocanna baccifera (Roxb.) Kurz. Family: Poaceae. Local name: Mau-tak (M).

An arborescent grass, monopodial; stem greenish-yellow to dark green, up to 25 m long; nodes marked with brown scars; internodes 13 – 30 cm long; wall 0.2 -0.6 cm thick. Culm-sheath long, variable in size 5-10 x 12-27 cm. Leaves 3-7 x 15-32 cm, rounded at base, lanceolate, acuminate at apex, entire.

Flr. & Frt: After every 48 years (occurred in 2007).

Melochia corchorifolia Linn. Family: Sterculiaceae. Local name: Unknown.

An erect sparsely hairy herb; stem nearly hollow. Leaves 2.5-11 x 0.8-3.8 cm, oblong-ovate, rounded or truncate; 5-nerved at base; stipules linear, ciliate. Flowers pinkish white, nearly sessile. Capsule small, globose, hispid.

Flr. & Frt: July- September.

Melothria heterophylla (Lour.) Cogn. Family: Cucurbitaceae. Local name: Nauawimu (M).

An herbaceous climber. Leaves polymorphous, short petioled, hastate. Flowers dioecious, white; male flowers in axillary corymbs; female flowers solitary. Fruits red, oblong.

Flr. & Frt: April- October.

Merremia umbellata (Linn.) Hall. Family: Convolvulaceae. Local name: Thian-pa (M).

A climber. Leaves 2.5-8.5 x 0.5-2.2 cm, oblong lanceolate, mucronate to acuminate, entire, cordate at base. Flowers white, *ca* 3.5 cm long, in umbeliform cymes. Capsule ovoid. Seeds pubescent.

Flr. & Frt: February- September.

Merremia vitifolia (Burm.) Hall. Family: Convolvulaceae. Local name: Thian-nu (M).

A hairy herbaceous twiner. Leaves 2.5-10 cm long, broadly ovate, palmately 5-7 lobed, cordate at base; lobes acute or acuminate, hairy. Flowers yellow, *ca* 5 cm long in axillary 1-many flowered cymes. Capsules subglobose with enlarged calyx, 4-seeded. Seeds glabrous.

Flr. & Frt: September- March.

Mesua ferrea Linn. Family: Guttiferae / Clusiaceae. Local name: Herhse (M).

A medium to large evergreen tree. Leaves 7-12 x 1.7-3 cm, opposite, decussate, lanceolate or elliptic-lanceolate, base rounded, cuneate to acuminate at apex; lateral nerves many. Flowers solitary, terminal or in axils of upper leaves, white with brown or purple veins. Fruits ovoid.

Flr: April- May. Frt: October- January (Next year).

Michelia champaca Wall ex Hook. & Thomson. Family: Magnoliaceae. Local name: Ngiau (M).

A large evergreen tree. Leaves 10-18 x 5-6 cm, oblanceolate, ovate-elliptic or oblong, base acute or cuneate; abruptly acuminate at apex, entire, glabrous on either side; lateral nerves10-12 pairs. Flowers axillary, solitary, white. Fruits sessile, subglobose.

Flr. & Frt: March- November.

Microlepia strigosa (Thunb.) Presl. Family: Dennstaedtiaceae – Davallioideae**.** Local name: Katchat (M).

Rhizomes wide creeping. Stipe glabrous, dark grey. Fonds tripinnate, green, covered with white silky hairs. Primary pinnae lanceolate- acuminate; secondary pinnae attenuate, entire, pinnules. Sori sub-globose, sub-marginal.

Fertile: Not seen during study period.

Micromelum minutum (Forst.) Wight & Arn. Family: Rutaceae. Local name: Kahpuk chaw (M).

A small tree. Leaves imparipinnate; leaflets 9-15, alternate, 2.5-15.0 x 1.8-6.5 cm, oblique, ovate or lanceolate, acuminate. Flowers pale yellow, in terminal decompound cymes. Barries ovoid or oblong.

Flr. & Frt: November- June (Next year).

Microsarum superficiale (Bl.) Ching. Family: Polypodiaceae. Local name: Awmvel chikhat (M).

Rhizomes scandent, wide creeping; covered with lanceolate, spreading, brown scale. Fronds 15-42 x 2-4 cm, lanceolate, narrowed at base and apex, entire, dark green. Sori scattered on the whole surface of laminae, brown.

Fertile: Not seen during study period.

Mikania micrantha Kunth. Family: Asteraceae. Local name: Japan-hlo (M).

A dense climbing herb or twiner; branches slender, hairy**.** Leaves ovate-lanceolate or detoid-ovate, 1-5 x 3.5-10 cm, acuminate, crenate or undulate; base rounded cordate, sometimes villous beneath, 3-5 nerved at the base. Flower dirty white in compound carymbose heads. Fruits (achenes) linear-oblong with reddish pappus.

Flr. & Frt: October- Febuary.

Millettia pachycarpa Benth. Family: Fabaceae/ Papilionaceae. Loacal name: Rulei (M).

A large woody climbing shrub; young parts brownish velvety. Leaflets 5-11, 4.2-15.5 x 2.2-5.5 cm, ovate oblong or oblong-lanceolate acuminate, cuneate at base, brown tomentose beneath. Flowers mauve, in axillary recemes; calyx *ca* 0.3 cm long, brown tomentose; corolla *ca* 2 cm long; stamens monadephous. Pods 4-10 x 2.5-3.0 cm, glabrous; 1-3 seeded.

Flr. & Frt: March- November.

Mimosa pudica Linn. Family: Mimosaceae. Local name: Hlo-nuar (M).

A spreading, prickly under-shrub. Pinnae 4, digitately arranged, sensitive; pinnules 12-20 pairs, *ca* 0.5 x 0.1 cm, obliquely narrow oblong; stipule 0.5-0.7 cm long, linear-lanceolate, acuminate. Flower pinkish purple, in axillary peduncled globular heads. Pods 1.2-2.5 cm long, prickly, 3-4 jointed.

Flr. & Frt: July-December.

Mitragyna diversifolia Haviland. Family: Rubiaceae. Local name: Thinglung (M).

A medium-sized deciduous tree. Leaves 7.5-20 x 2.5-17.8 cm, orbicular, elliptic or ovate; base sub-cordate; apex acuminate; lateral nerves 6-8 pairs. Flower-heads greenish white. Capsules obovoid.

Flr. & Frt: Not seen during study period.

Mollugo pentaphylla Linn. Family: Molluginaceae. Local name: Unknown.

An erect or prostrate annual herb. Leaves whorl of 3-9, 1-5 x 0.2-1.5 cm, obovate or linear-lanceolate, cuneate at base, acute at apex, entire. Flowers white, in terminal or axillary. Capsule oblong.

Flr. & Frt: Throughout the year.

Morinda angustifolia Roxb. Family: Rubiaceae. Local name: Lum/ Par-arsi lian (M).

A large shrub. Leaves 9-30 x 3.5-9 cm, lanceolate or oblanceolate, entire; base cuneate; apex long acuminate; lateral nerves 8-12 pairs. Flowers in axillary, white. Fruits globose.

Flr. & Frt: April- August.

Morus macroura Miq. Family: Moraceae. Local name: Lungli (M).

A large tree. Leaves broadly ovate-orbicular, acuminate, subcordate at base, dentate, pubescent, sometimes 3-lobed. Flower monoecious, densed in axillary drooping catking. Male catkin villous; perianth 4 pertite; stamen 4; tepal pubescent. Fruit in spikes, yellow, cylindric. Fruits achene.

Flr. & Frt: February- July.

Mucuna pruriens (Linn.) DC. Family: Fabaceae/ Papilionaceae. Local name: Uite-me. (M).

An annual climber. Leaves 3- floliolate; leaflets 5-15 x 4-10 cm, elliptic or ovate, rounded at base, obtuse or acute at base. Flowers 10-20 on racemes. Pods S-shaped, turgid.

Flr. & Frt: January- December.

Murraya koenigii (Linn.) Spreng. Family: Rutaceae. Local name: Mungti (M).

A deciduous pubescent, strongly scented shrub. Leaves imparipinnate; leaflets 9-25, alternate, 0.5-4.3 x 0.2-1.8 cm, ovate lanceolate, oblique at base, pubescent beneath. Flowers white, *ca* 0.9 cm long, in terminal corymbose panicles. Barries ovoid.

Flr. & Frt: March- October.

Musa acuminata Colla. Family: Musaceae. Local name: Changel (M).

Pseudostems more slender than those of most cultivated bananas, usually 2 - 5 metres high, 10 - 30 cm. in diameter at base. Leaf blades oblong, 1 - 3 m. long, 15 - 75 cm. wide, truncate at apex, usually rounded at base, sometimes rounded on one side and acute on the other, midribs green. Inflorescence sub-horizontal or vertically deflexed; basal flowers female, the number of female "hands" varying up to about 10, upper hands male. Female flowers about 16 per bract in two rows; white, yellowish or slightly purple, with white or yellow tip and lobes; Male bud in advanced blooming ovoid to turbinate, usually acute, the bracts convolute, imbricate at the extreme tip only, or rather strongly imbricate. Bracts various shades of purple or red, from bright red to dark violet, ovate, usually acute at apex. Male flowers about 20 per bract, in two rows, white, cream, yellowish or pale orange, sometimes purplish. Fruit bunch asymmetrical if borne sub-horizontally, compact if vertically. Fruit 7 - 13 cm. long, 1.5 - 3 cm. in diameter, bright yellow at full ripeness. Seeds dull black, smooth or more commonly minutely tuberculate.

Flr & Frt: Through out the year.

Musa glauca Roxb. Family: Musaceae. Local name: Saisu (M).

A non-stoloniferous tree like herb to 3 m high; trunk below the leaves; pseudo-stem stout, cylindric, broadest at base and tapering towards the apex. Leaves oblong-lanceolate, up to 2.5 m long, acute; spike drooping from the base; bracts many, ovate green many flowered. Fruits pale greenish-yellow, obovoid-oblong.

Flr: March-July Frt: July-January.

Mussaenda frondosa Linn. Family: Rubiaceae. Local, name: Hrui-Vakep (M).

A scandent shrub with hirsute young stem. Leaves 4.5-13 x 2-8 cm, opposite, ovate, orbicular, elliptic-lanceolate or oblong, obtuse at base, cuneate at base; lateral nerves 6-10 pairs. Flowers orange-yellow.

Flr. & Frt: July- December.

Mussaenda glabra Vahl. Family: Rubiaceae. Local name: Vakep (M).

A climbing scandent shrub; bark brown, lenticellate. Leaves 5-15 x 1.5-4.5 cm, elliptic or oblong-lanceolate, acute at base, acuminate at apex, coriaceous; lateral nerves 5-6 pairs. Flowers in terminal cymes, white, greenish veins.

Flr. & Frt: April- December.

Mussaenda parryorum Fischer. Family: Rubiaceae. Local name: Vakep-Hrui (M).

A scandent shrub with smooth-cylindrical branches, pubescent at nodes, yellowish brown; young parts tomentose. Leaves *6-12 x 4-6* cm, elliptic, acuminate, attenuate at base, acuminate at apex; lateral nerves 7-9 pairs. Flowers in diffused sessile cymes, yellow.

Flr. & Frt: July- October.

Mussaenda roxburghii Hook. Family: Rubiaceae. Local name: Thing-Vakep (M).

A shrub large, erect; stem light brown. Leaves 6.5-19 x 3.5-7 cm, oblong-lanceolate or elliptic, acute at base, acuminate at apex, entire; lateral nerves 8-12 pairs. Flowers in terminal, yellowish orange.

Flr. & Frt: June-J anuary.

Neyraudia reynaudiana (Kunth.) King. ex Hitch. Family: Poaceae. Local name: Unknown.

A perennial tall grass. Culms 1-1.70 m high. Leaves long, flat; ligule villose ridge. Inflorescence a long panicle; glumes 3-nerved; palea keels ciliolate; stamens 3. Caryopsis linear.

Flr. & Frt: March- May.

Nyssa javanica (Bl.) Wanger. Family: Nyssaceae. Local name: Bul-thur (M).

A large tree. Leaves 9-14 x 2.5-8 cm, alternate, crowded apically, elliptic-ovate or oblong-laceolate, cuneat at base, apex acuminate, entire. Flowers unisexual, sessile, axillary, pedunculate heads. Drupes ellipsoid.

Flr. & Frt: April- December.

Olea dentata var. ***salicifolia*** Wall. Family: Oleaceae. Local name: Unknown.

A tree with spreading crown; branches lenticels, pubescent. Leaves 5-18 x 1-4.5 cm, lanceolate, serrate or distantly denticulate. Male flowers in axillary panicles exceeding the leaves; female flowers axillary or extra-axillary or terminal. Fruits ellipsoid, oblique.

Flr. & Frt: October- February.

Olea dioca Roxb. Family: Oleaceae. Local name: Unknown.

A small or middle-sized tree, or a shrub; bark greyish brown, warty. Leaves variable, 3.5-19 x 1-8 cm, elliptic-lanceolate, entire or serrate, acute or acuminate; lateral nerves 8-12 on either half. Flowers small, white, dioecious in axillary or extra-axillary lax panicle with very slender branching. Drupe blue when ripe, ovoid.

Flr. & Frt: March- November.

Oreocnide integrefolia Miq. Family: Urticaceae. Local name: Zuk-buh (M).

A small tree; young parts pubescent. Leaves alternate, 8-18 x 3.5-8.0 cm, oblong-lanceolate or elliptic-oblong, penninerved, acuminate, acute at base, pubescent beneath. Flower creamy, in globose cluster in cymes; male perianth 4 fid; stamens 4; female perianth tubular. Achenes clusters in head, white when ripe.

Flr. & Frt: December- August.

Oroxylum indicum (Linn.)Vent. Family: Bignoniaceae. Local name: Archang-kawm (M).

A small deciduous tree. Leaves opposite, large, long 2-3 pinnate; leaflets 1-12 x 4-9 cm, ovate-elliptic, acuminate, obliquely rounded or obtuse at base. Flowers puplish-green, in erect long racemes. Capsules flat, 30-85 x 4.5 cm, oblong, septicidally 2- valved, drooping.

Flr: January-August. Frt: November-March.

Oxalis corniculata Linn. Family- Oxalidaceae. Local name: Thurte-an (M).

A small herb; branches erect; roots at nodes, fibrous. Leaves stipulate, palmately 3-folioate; petioles slender, pubescent, ciliate at the margins. Flowers in axillary umbelliform inflorescence; peduncle slender, deflexed in fruits, more or less pubescent.

Flr. & Frt: June- December.

Oxyspora paniculata (D. Don) D.C. Family: Melastomaceae. Local name: Builukham-pa (M).

A **s**hrub, drooping down. Leaves 10-12 x 4-8 cm, opposite, elliptic, broadly lanceolate, base rounded to sub-cordate, acute to acuminate at apex; basal nerves 5-7. Flowers with purple pedicels, purplish-pink. Capsules ellipsoid.

Flr. & Frt: June- October.

Paederia foetida Linn. Family: Rubiaceae. Local name: Vawihuih-hrui (M).

A slender climbing shrub; foetid. Leaves 5-10 x 2-6 cm, opposite, lanceolate or elliptic-ovate, sub-cordate at base, acuminate at apex, entire; lateral nerves 5-7. Flowers in axillary or terminal cymose panicled, greyish purple.

Flr. & Frt: August- December.

Pandanus pseudofoetidus Roxb. Family: Pandanaceae. Local name: Zawng-lakhuih (M).

A shrub. Leaves acuminate, marginal spinules, incurved. Flowers dioecious, small, axillary spadices clothed with leafy spathes. Drupe crowded, angular.

Flr. & Frt: Not seen during study period.

Pandanus tectorius Soland ex Parkinson. Family: Pandanaceae. Local name: Ram-lakhuih (M).

A shrub or small tree. Leaves 80-180 cm long, drooping, glossy green, caudate-acuminate, marginal spines, ascending. Spadix with numerous sub-sessile cylindric spikes enclosed in long white fragrant caudate acuminate spathes. Flowers dioecious. Fruits oblong or globose syncarp of many drupes.

Flr. & Frt: August- September.

Panicum punctatum Burm. Family: Poaceae. Local name: Unknown.

A perennial grass. Culm rooting at nodes, spongy below. Leaves 10-18 cm long, linear, acute, scabrid on margins; sheath glabrous. Spikes longer than internodes; spikelets, ovate-oblong, imbricate sessile; glumes membranous. Caryopsis compressed.

Flr. & Frt: August- December.

Parkia roxburghii G.Don. Family: Mimosaceae. Local name: Zawngtah (M).

A medium-sized to large tree; bark light grey with white patches in old trunk, rough. Leaves 2-pinnae, leaf-rachis up to 45 cm long; leaflets 50-100 pairs, tiny, 0.1-0.3 x 0.4-0.6 cm, sessile, linear-lanceolate, pointed tip curved forward; base rounded; midrib nearer to upper side. Flowers in dense turbinate heads hanging on long peduncles, yellowish. Fruits oblique oblong. Pods flat, 3-4 x 20-45 cm, straight, curved or twisted, green when young, dark-brown when mature. Seeds 6-20, strongly foetid when crushed.

Flr: August-September. Frt: September-March.

Paspalum longifolium Roxb. Family: Poaceae. Local name: Unknown.

A perennial grass, glabrous. Leaves linear, acute, scaberulous at the margin; sheath very long, slightly hairy above. Rachis as broad as the rows of spikelets, flexuous at the margin; spikelets 4-seriate, imbricate, compressed, oblong, pubescent; glumes lower absent, upper ovate-oblong, membranous, 3-nerved, pubescent. Caryopsis rounded, blackish.

Flr. & Frt: July- January.

Passiflora edulis Sims. Family: Passifloraceae. Local name: Sap-thei (M).

A perennial woody climber, glabrous. Leaves 5-10 x 5-10 cm, alternate, 3-lobbed, base rounded; middle lobe protrude out than the other, obovate, elliptic, acute to acuminate, dentate,

glabrous. Flowers solitary, axillary or in terminal. Fruits ellipsoid-glandular, dark purple or brownish-purple.

Flr. & Frt: April- July.

Pennisetum polystachyon Schult. Family: Poaceae. Local name: Unknown.

A perennial or rarely an annual. Culms 2 m or more high, erect or geniculately ascending, sometime rooting at the lower nodes. Leaf-blades linear to lanceolate, rounded or narrowed at the base, acute, up to 45 cm. False spikes cylindric, very dense to somewhat lax, straight or flexuous, erect or nodding, purple, reddish-brown or orange-brown. Caryopsis oblong or elliptic-oblong.

Flr. & Frt: Not seen during study period.

Pentanura khasiana Kurz. Family: Asclepiadaceae. Local name: Theikelki (M).

A twining shrub, glabrous. Leaves 8-12 x 2-4 cm, lanceolate or elliptic-lanceolate, acuminate, coriaceous, glabrous, cuneate at the base; lateral nerves 7-9 pairs. Flowers small, in axillary fascicles. Follicles divaricate in curved.

Flr. & Frt: March- November.

Phlogacanthus wallichii Clark**.** Family: Acanthaceae. Local name: Vatezu (M).

A shrub or large herb. Leaves 23-30.5 x 7.5-11.5 cm, elliptic-acuminate, entire, undulate, thinly chartaceous, glabrous; lateral nerves 7-9 pairs. Flowers red, pubescent. Fruits not seen.

Flr: October – December. Frt: Not seen during study period.

Phoebe hainesiana Brandis. Family: Lauraceae. Local name: Bul-eng (M).

A medium to large tree. Leaves obovate or elliptic-ovate acuminate, narrowed down to the base. Inflorescence very much lax**.** Fruits ellipsoid.

Flr. & Frt: Not seen during study period.

Phoebe lanceolata Nees. Family: Lauraceae. Local name: Bul-fek (M).

A small tree; branches spreading. Leaves 4.0-17.5 x 0.5-2.8 cm, linear-lanceolate, acuminate, narrowed down to the base. Flowers creamy, in panicles, bracteate. Berries ellipsoid.

Flr. & Frt: April- November.

Phrynium capitatum Willd. Family: Marantaceae. Local name: Hnahthail (M).

An herb with creeping rootstocks and slender stem from tuberous rhizome. Leaves large, solitary, terminal, 30-50 x 15-20 cm, oblong or ovate-oblong, glossy, cuspidate. Flowers small, white. Fruits *ca* 1 cm long, oblong, 1-seeded.

Flr. & Frt: April- September.

Phyllanthus reticulatus (Poir) Baill. Family: Euphorbiaceae. Local name: Pi-bengbeh (M).

A large straggling or scrambling shrub; branch slender, pendent, lenticellate; stem often spinescent. Leaves distichous, 1.3-5 x 0.8-2.5 cm, ovate-oblong or elliptic, rounded, obtuse or acute, entire, glabrous, dark green above, pale and canescent beneath. Flower axillary, solitary or in few-flowered fascicles. Seeds triquetrous.

Flr: January- April. Frt: May- July.

Phyllanthus fraternus Webster. Family: Euphorbiaceae. Local name: Mithi-sunhlu (M).

An annual herb. Leaves 0.4-1.5 cm long, sessile, very variable, oblong or linear-oblong, apiculate or rounded. Flowers minute, axillary. Fruits echinate.

Flr. & Frt: June- November.

Physalis minima Linn. Family: Solanaceae. Local name: Kelasairawphit/ Tauhpuah (M).

An erect spreadingly branched herb. Leaves 1-12 x 0.5-6.0 cm, ovate, acute or obtuse, rounded at base, broadly toothed. Flowers pale yellow, solitary, axillary. Berries globose.

Flr. & Frt: October- April.

Piper diffusum Vahl. Family: Piperaceae. Local name: Pawh-rual (M).

A small diffused climbing shrub. Leaves 5-11 x 2-4 cm, alternate, peltate, elliptic-ovate, acute, acuminate, glabrous; 5-nerved. Fruits axillary, globose, black.

Flr. & Frt: October- January.

Piper peepuloides Roxb. Family: Piperaceae. Local name: Panhnah suak (M).

A perennial climber, glabrous. Leaves 5-10 x 1-4 cm, elliptic-oblong, ovate-laceolate, glabrous; 5-6 nerved. Flowers unisexual. Fruits minute.

Flr. & Frt: July- January.

Piper thomsonii Hook. Family: Piperaceae. Local name: Panhnah bawr (LR).

A scandent; stem rooting at the nodes, glabrous. Leaves 6-12 x 3.8-5 cm, ovate-oblong or elliptic-oblong, coriaceous, glabrous; 5-7 nerves from the above basal nerves; base cordate. Flowers dioecious; male spikes slender. Fruits spikes slender, loose, glabour. Fruits globose.

Flr. & Frt: June- December.

Piperomia pellucida (Linn.) H.B.K. Family: Piperaceae. Local name: Unknown.

An erect or diffuse succulent herb; stem pellucid. Leaves alternate, 1-3 x 0.5-2.5 cm, broadly ovate, acute, sub-turncate or cordate at base; 5-7 nerved. Flower minute, unisexual, in

axillary terminal or leaf-opposed short spikes; bracts pellate. Fruits globose, apically pointed, ribbed.

Flr. & Frt: Not seen during study period.

Pithecelobium bigeminum *auct. non* (Linn.) Mart. Family: Mimosaceae. Local name: Ardah (M).

A small to medium tree. Leaf rachis 2-10 cm long; pinnae 1-2 pairs; leaflets 1-3 pairs at the lower pinnae, 2-4 pairs on the terminal pinnae, 3-14 x 2-5 cm, oblong-lanceolate, acute at base, acuminate at apex. Heads 5-8 flowers, in axillary and terminal panicles; flowers white. Pods spirally twisted.

Flr. & Frt: February- December.

Plantago major Linn. Family: Plantaginaceae. Local name: Kelba-an (M).

A small herb. Leaves radical, 5-20 x 1.5-5.5 cm, ovate-oblong, obtuse, subentire, long petioled. Flowers greenish white, dense in long slender axillary spike. Fruits 2-seeded capsule.

Flr. & Frt: April- July.

Plectranthus hispidus Benth. Family: Labiatae / Lamiaceae. Local name: Unknown.

A stout erect perennial, shrubby, scaberulous, densely wooly. Calyx wooly. Nutlets very minute, ellipsoid.

Flr. & Frt: September- November.

Polygala arillata Buch.-Ham. ex. D. Don. Family: Polygalaceae. Local name: Unknown.

A shrub or small tree. Leaves 6-15 x 3-6 cm, elliptic, oblong-lanceolate, rounded at base, acuminate at apex, glabrous; lateral nerves 7-8 on either side. Flowers yellow.

Flr. & Frt: March- October.

Polygonum barbatum Linn. Family: Polygonaceae. Local name: Dawngria (M).

A stout herb. Leaves sessile, linear-lanceolate, tapering, strigose on the nerves beneath; ochrea tubular, strigose, with very long cilia at the mouth. Inflorescence terminal, short racemose spikes with closely imbricating bracts; bracts glabrous, short ciliate on the margins. Nutlets trigonomous.

Flr. & Frt: September- March.

Polygonum chinense Linn. Family: Polygonaceae. Local name: Taham (M).

A large climber. Leaves 2.5-7.5 cm long, lanceolate or deltoid-oblong, truncate or sub-cordate at the base. Flowers in terminal corymbose heads; peduncle hispidulous; bracts scarious. Nutlets trigonous.

Flr. & Frt: September- March.

Polygonum hydropiper Linn. Family: Polygonaceae. Local name: Unknown.

An erect or decumbent glabrous herb. Leaves 7-16.5 x 1.5-2 cm, linear-lanceolate or oblong-lanceolate, acute or acuminate, entire; stipules bristly, glandular. Flowers pinkish white, in lax slender filiform racemes; bracts truncate, ciliate on upper margins. Nutlets trigonous.

Flr. & Frt: September- March.

Pothos cathcartii Schott. Family: Araceae. Local name: Laiking-tairua (M).

A much branched climber. Leaves 7.5-15 cm long, oblong, ovate-oblong or lanceolate, acuminate. Spathe 1.2-2 cm broad, orbicular; spadix .6-.8 cm across sub-erect, oblong. Peduncle very stout. Barries scarlet.

Flr. &Frt: February- September.

Pothos scandens Linn. Family: Araceae. Local name: Unknown.

A climbing herb. Stem attach to a tree trunk, thick, succulent. Leaves alternate, *ca* 4 x 15 cm, lanceolate to elliptic-lanceolate, rounded at base. Spathe cymbiform; spadix yellow, globose. Barries oblong, scarlet.

Flr. & Frt: February- June.

Pronephrim nudatum Roxb. Family: Thelypteridaceae. Local name: Katchat (M).

Rhizome long creeping. Stipes scabrous, sparsely covered with dark brown membranous scales. Lamina unipinnate, rough; pinnae 10-15 pairs, lower pinnae the widest, tapering towards apex, 15-30 x 2-3 cm, acuminate, crenate at apex. Sori round, beneath pinnae.

Fertile: Not seen during study period.

Psychotria calocarpa Kurz. Family: Rubiaceae. Local name: Kawr-pelh (M).

An evergreen under-shrub; young parts puberulose. Leaves 12-23 x 3.5-10 cm, elliptic-lanceolate, ovate or oblong, narrow at base, acuminate at apex, entire; lateral nerves 11-13 pairs. Flowers in axillary or terminal peduncled umbellate cymes, whitish-yellow.

Flr. & Frt: March- February (Next year).

Psychotria denticulata Wall. Family: Rubiaceae. Local name: Unknown.

A large shrub. Leaves 10-20 x 6.5-12 cm, elliptic, obovate or oblanceolate, cuneate at base, acuminate at apex, entire; lateral nerves 14-16 pairs. Flowers in long peduncled terminal or axillary corymbose cymes, greenish.

Flr. & Frt: May- December.

Psychotria fulva Buch-Ham. Family: Rubiaceae. Local name: Unknown.

A shrub or under-shrub. Leaves 11-25 x 6-12 cm, decussate, elliptic, ovate-oblong, acute at base, acuminate at apex, entire; lateral nerves 14-18. Flowers in terminal or sub-terminal peduncled capitate cymes.

Flr. & Frt: January- December.

Pteridium aquilinum (Linn.) Kuhn. Family: Pteridaceae. Local name: Katchat (M).

Rhizome long-creeping, hairy, straight. Stipes hairy to almost glabrous higher up, hairs brown. Lamina 2-3 pinnate, subdeltate, hairy, hairs white; pinnae 10-15 pairs, alternate, lower pinnae the largest; pinnules lanceolate, obtuse at apex, entire. Sori marginal.

Fertile: Not seen during study period.

Pterospermum lanceaefolium Roxb. Family: Sterculiaceae. Local name: Siksil (M).

A tall evergreen tree. Leaves 10-38 x 8-25 cm, orbicular, ovate to elliptic-oblong, cordate at base, acute at apex, entire or denticulate; lateral nerves 3-6 pairs. Flowers solitary, white. Capsules oblong.

Flr. & Frt: March- October.

Pueraria lobata (Willd.) Ohwi. Family: Fabaceae / Papilionaceae. Local name: Kaikuang-ru/ Hrui-duk (M).

A large climber; branches with brownish hair. Leaves 3-foliolate; leaflets 10-16 x 7-16 cm, simple or 3 lobbed, ovate or ovate-rhomboid, base rounded, shortly acuminate at apex; lateral nerves 5-7 on either side. Racemes simple; flowers blue. Pods oblong.

Flr. & Frt: August- October.

Quercus listeria King. Family: Fabaceae/ Papilionaceae. Local name: Sehawr chi (LR).

A large tree. Leaves 10-32 x 7.5-12.5 cm, elliptic-oblong or oblong acuminate, entire, glabrous; lateral nerves 12-14 pairs. Male flowers in erect tomentose axillary and terminal panicles; female flowers spikes solitary, axillary. Friuts ellipsoid.

Flr. & Frt: October- November (Next year).

Randia wallichii Hook. Family: Rubiaceae. Local name: Unknown.

A medium-sized tree. Leaves 5-10 x 1.5-4 cm, elliptic, lanceolate, obtuse at base, acute at apex, entire, glabrous above, pubescent beneath; lateral nerves 6-10 pairs. Flowers in axillary or terminal cymes, whitish-yellow.

Flr. & Frt: June- December.

Ranunculus catoniensis D.C. Family: Ranunculaceae. Local name: Unknown.

An erect pubescent herb. Upper most leaves sessile with sheathing base; radical ones long petiolate, 3-partite; leaflets hairy, lobed and coarsely serrate. Flowers yellow, solitary. Achenes flattened in globose or oblong heads.

Flr. & Frt: April- June.

Rhamnus napalensis (Wall.) Lawson. Family: Rhamnaceae. Local name: Unknown.

A straggling shrub. Leaves 4-13 x 2.5-6.5 cm, long or elliptic-ovate, acuminate, rounded at base, serrate. Flowers greenish white, in axillary fascicled panicles. Druipes obovoid.

Flr. & Frt: September- December.

Rhaphidophora decursiva (Roxb.) Schott. Family: Araceae. Local name: Tu-bal (M).

A stout climber. Leaves 30-90 cm long, oblong pinnatifid with 6-12 segments; base cordate, segments falcately ensiform, acuminate; 3-4 nerves. Spathe 12.5-17.5 cm, cymbiform, yellow, beaked. Spadix shorter than the spathe, narrowly oblong.

Flr. & Frt: May- August

Rhus semialata Murr. Family: Anacardeaceae. Local name: Khawmhma (M).

A small tree, deciduous, young parts and inflorescence covered with brownish-grey pubescent; bark ashy-grey, warty. Leaves imparipinnate; leaflets 4-6 pairs, 2-7 x 5-15 cm, opposite, dentate, triangular or elliptic-ovate, acuminate, sharply serrate; base oblique or rounded. Flowers numerous, greenish-white, in large terminal pyramidal peduncles. Fruits subglobose or orbicular, compressed, reddish-brown when ripe.

Flrs: August- September Frts: November- March.

Rhus succedanea Linn. Family: Anacardeaceae. Local name: Chhimhruk (M).

A small tree. Leaves crowded at the end of the branchlets, 6-12 foliolate; leaflets 3.5-10.0 x 1.5-3.5 cm, ovate-lanceolate or oblong-elliptic, caudate-acuminate. Flowers pale yellow, in axillary drooping panicles. Drupes orbicular, compressed.

Flr. & Frt: March- December.

Rhynchoglossum obliquum Bl. Family: Gesneriaceae. Local name: Unknown.

A succulent tall herb. Leaves 5-12 x 2.5-5.3 cm, ovate, acuminate, membranous, almost glabrous; lateral nerves conspicuous, numerous, oblique. Flowers 5-merous in lax terminal racemes up to 25 cm long; bracteoles filiform; calyx campanulate, cleft, enlarge in fruit; corolla tube cylinder; stamens 2, perfect. Seeds smooth.

Flr. & Frt: September- October.

Rhynchotechum ellipticum D.C. Family: Gesneriaceae. Local name: Tiar-rep (M).

An erect under-shrub, 0.90 – 1.5 m tall with thickened stem; young parts tomentose. Leaves opposite, 12.7-33.0 x 3.8-12.7 cm, broad elliptic, abruptly acute, dentate, coriaceous, glabrate above, tomentose beneath. Flowers 0.3-0.4 cm across. Inflorescence usually from old wood. Berry 0.5-0.6 cm in diameter, whites, juicy. Seeds very minute.

Flr: October- January. Frt: February- March.

Ricinus communis Linn. Family: Euphorbiaceae. Local name: Mu-tih (M).

A large evergreen soft-wooded shrub or small tree. Leaves 5-23 cm across, alternate, palmately lobbed, peltate serrate. Flowers monoecious, yellowish white. Seeds with large caruncle.

Flr. & Frt: Throughout the year.

Rourea minor (Gaertn.) Leenh. Family: Connaraceae. Local name: Kehphek/ Pho-arh (M).

A large evergreen lianas. Leaves unifoliate to imparipinnate, common petiole terete; leaflets 5-9, alternate, oblong-lanceolate, or ovate-lanceolate, entire, glabrous on both sides. Flowers white. Follicles obliquely ellipsoid.

Flr. & Frt: January- June.

Roydsia suaveolens Roxb. Family: Capparaceae. Local name: Theiarbawm (M).

A woody climber with dotted white branchlets. Leaves 10-25 x 5-10 cm, simple, oblong or oblong-lanceolate, glabrous, shinning above. Inflorescence axillary or super-axillary, racemes or terminal panicles. Flowers white. Drupe ellipsoid or obovoid.

Flr. & Frt: May- December.

Rubus birmanicus Hook. Family: Rosaceae. Local name: Siali-nu-chhu (M).

A prickly shrub. Leaves 7-13.5 x 4-8 cm, palmately 5-lobbed, lobes acute or lanceolate at apex, serrate. Flowers white. Fruits red to yellow.

Flr. & Frt: July- October.

Rubus ellipticus Smith. Family: Rosaceae. Local name: Hmu-tau (M).

A prickly shrub. Leaves pinnately 3-foliote; leaflets 3-7 x 2-6 cm, orbicular or elliptic, caudate at base, obtuse at apex, serrate. Flowers white. Fruits red to yellow.

Flr. & Frt: March- July.

Rubus lasicarpus Smith. Family: Rosaceae. Local name: Unknown.

A prickly shrub. Leaves 5-7 foliolate, 3-5 x .5-3 cm, lanceolate or elliptic, rounded at base, acute at apex, serrate. Flowers pink. Fruits red.

Flr. & Frt: March- August.

Rubus niveus Thunb. Family: Rosaceae. Local name: Hmu-pa (M).

A prickly shrub; young shoots reddish and covered with a thin white powder. Leaves 7-foliolate; leaflets ovate, lanceolate, rounded at base, acute at apex, serrate; lateral nerves 8-13 on either side. Flowers pink. Fruits red to bluish-pink.

Flr. & Frt: March- August.

Rubus rosaefolius Smith. Family: Rosaceae. Local name: Hmubelbing (M).

A prickly shrub. Leaves pinnately 5 foliolate; leaflets 3-5 x 1-2 cm, ovate-lanceolate, rounded at base, acuminate at apex; laterals leaflets smaller than the terminal. Flowers white. Fruits orange-yellow.

Flr. & Frt: January- October.

Rungia parviflora (Retz.) Nees. Family: Acanthaceae. Local name: Unknown.

A diffuse or erect herb; stem terete below, faintly 4 angled above. Leaves 2.5-6 cm long, linear to narrowly lanceolate or elliptic, lineolate, narrowed at both ends, nearly glabrous except the nerves. Flowers very small, deep bright purple blue to a pale whitish lilac, in clustered short spikes. Capsules minute, compressed.

Flr. & Frt: November – April (Next year).

Saccolepis indica Chase. Family: Poaceae. Local name: Unknown.

A tufted annual grass. Culms 0.1-0.8 m, ascending or erect, branchy, striate, slender, compressed and with a leafy base, bare at the top. Inter-nodes long. Leaf-blades soft, spreading, linear-acuminate, base narrow or rounded, flat, glabrous or hairy below; ligule short, obtuse, shortly fimbriate at the summit. Inflorescence a narrow panicle, erect, spiciform, dense. Spikelets densely crowded, erect or spreading, longer than the pedicels, olive-green, sometimes purplish or bluish, ovoid-acute. Caryopsis oblong.

Flr. & Frt: July- October.

Sapium baccatum Roxb. Family: Euphorbiaceae. Local name: Thing-vawkpui (M).

A middle sized or large evergreen tree. Leaves 5-15 x 2.5-10 cm, young orange colour, old yellowish, ovate or ovate-lanceolate, acuminate, entire, glabrous above, glaucous beneath; lateral nerves 8-12 on either half. Flowers minute, yellowish white. Fruits reddish, berry-like.

Flr: April- July. Frt: August- December.

Sapium insigne Benth. Family: Euphorbiaceae. Local name: Sailu-tar (M).

A middle or large sized deciduous tree; bark thick, corky and deeply striate. Leaves 12.5-30 x 5-7.5 cm, elliptic or oblong-laceolate, acuminate, crenate-serrate, soft, glabrous; lateral nerves7-16 on either half. Spikes terminal, unisexual. Capsule ovoid.

Flr: October- February. Frt: May- July.

Sarcochlamys pulcherrima Gaud. Family: Urticaceae. Local name: Lehngo-hnahsin (M).

A shrub or small tree; bark dark-brown. Leaves 7.5-18.5 x 1.0-2.8 cm, lanceolate, acuminate, narrowed down to the base, white beneath. Flower creamy, cluster in spikes; perianth 5 partite; sepaloid in male and 4 lobed; campanulate in female; stigma sessile. Achenes oblique within perianth.

Flr. & Frt: June- December.

Saurauia napaulensis D.C. Family: Saurauiaceae. Local name: Tiarpui (M).

A small tree. Leaves 15-25 x 5-10 cm, elliptic-oblanceolate, rounded at base, acute at apex, crenate, glabrous above, tomentose beneath; lateral nerves 30-35 pairs. Flowers pink, in axillary panicles. Fruits fleshy, green.

Flr. & Frt: April- August.

Saurauia panduana Wall. Family: Saurauiaceae. Local name: Tiar (M).

A small evergreen tree. Leaves 10-25 x 7-10 cm, elliptic-ovate to lanceolate, rounded at abase, acute at apex, serrate; lateral nerves 20-30 pairs. Flowers many flowered, whitish pink. Berries globose, white.

Flr. & Frt: April- December.

Schefflera venulosa (Wight & Arn.) Harm. Family: Araliaceae. Local name: Kel-buh (M).

A scandent, epiphytic or terrestrial shrub. Leaves digitately 3-7 foliolate; leaflets elliptic-oblong, obtuse or acuminate. Flowers pale yellow, polygamous in terminal panicles umbels or racemes; calyx truncate, lobed; petals nearly connate. Fruits subglobose, angled, fleshy.

Flr. & Frt: March- October.

Schima wallichii (D.C.) Korthals. Family: Theaceae. Local name: Khiang (M).

A medium to large sized tree; young parts yellowish-red. Leaves 6-15 x 4-6 cm, elliptic-lanceolate, cuneate at base, acute at apex, entire, glabrous above, pubescent beneath; lateral nerves 8-20 pairs. Flowers axillary, white. Capsules globose.

Flr: April- May Frt: November- March.

Scleria terrestris Linn. Family: Cyperaceae. Local name: Thip (M).

A tall herb, 80-150 cm high; rhizome woody. Leaves 30-60 x .03-.05 cm, lanceolate, acuminate, scabrid on veins and margins; sheath winged. Panicles long, stiffy pyramidal. Spikelets unisexual, purplish; bracts linear; glumes ovate. Nuts ovoid.

Flr. & Frt: August- December.

Scoparia dulcis Linn. Family: Scrophulariaceae. Local name: Perhpawng-chaw (M).

A small erect glabrous herb, stiff. Leaves opposite, elliptic or rhomboid, entire or sub-entire or serrate on the upper half. Flowers in terminal or pseudo-axillary, white. Fruit globose.

Flr. & Frt: March- December.

Securinega virosa (Roxb. ex. Willd) Baill. Family: Euphorbiaceae. Local name: Saisiak (M).

A shrub. Leaves 2-6 x 1.2-3 cm, ovate, rounded at apex, mucronate, acute at base, entire. Flowers greenish yellow, in axillary clusters. Male flowers pedicellate; female flowers shortly pedicellate. Capsules white, fleshy, globose.

Flr: May- August. Flr: August- September.

Setaria palmifolia (Koenig) Stapf. Family: Poaceae. Local name: Unknown.

A perennial herb with woody base. Culms branching, decumbent. Leaves lanceolate, acuminate, plicate, fanlike, glabrous or sparsely hairy; ligules of long hairs. Panicle nodding; rachis stout, scabrid, branches alternate, distant, filiform. Spikelets sessile or shortly pedicelled, ovoid, glabrous; glumes lower ovate, 5 nerved; upper glumes larger, 7-nerved.

Flr. & Frt: August- January.

Sida acuta Burm. Family: Malvaceae. Local name: Khing-khih (M).

A sparsely hairy under-shrub. Leaves 2-7 x 0.5-1.5 cm, linear-lanceolate, acute, serrate; stipules paired, unequal. Flowers yellow, *ca* 1 cm long, axillary, solitary or in 2-3 flowered clusters; calyx lobes acute; petals obovate. Mericarps 6-10, rugose, 2 awned at apex.

Flr. & Frt: August- May.

Smilax perfoliata Lour. Family: Liliaceae. Local name: Kaiha (M).

A prickly climbing shrub. Leaves 6-21 x 3-12 cm, elliptic-lanceolate or oblong-lanceolate, retuse or shortly acuminate, cuneate or cordate at base; petiole stout, short, auricled at base; tendril from the tips of auricles. Flowers *ca* 1.2 cm long, in axillary racemosely developing many umbels. Berries globose or sub-globose, red when ripe.

Flr. & Frt: June- January.

Solanum anguivi Lamk. Family: Solanaceae. Local name: Tawk-te (M).

A much branched stellately tomentose, prickly undershrub. Leaves 4-18 x 2-9 cm, ovate-oblong, sinuate or lobed, acute, prickly along nerves. Flowers violate, ovate, acute. Barries globose.

Flr. & Frt: June- December.

Solanum khasinum Clark. Family: Solanaceae. Local name: At-hlo (M).

A prickly herb. Leaves 4-11 x 4-17 cm long, ovate, base sub-cordate, lobed or angled, hirsute and prickly on both surfaces and petioles. Flowers white, in axillary racemes. Fruit globose.

Flr. & Frt: July- February.

Solanum nigrum Linn. Family: Solanaceae. Local name: An-hling (M).

An erect, glabrous, much branched herb. Leaves 2-12 x 0.5-4.5 cm, ovate-oblong-lanceolate, toothed or lobed, acute or acuminate. Flowers white, in extra axillary drooping umbellate cymes. Barries, black when ripe, globose.

Flr & Frt: February- October.

Solanum torvum Sw. Family: Solanaceae. Local name: Tawk-pui (M).

A stellate tomentose shrub, branches; prickles scattered. Leaves 6-20 x 3-10 cm, ovate-elliptic to oblong, acute or acuminate, broadly sinuate lobed, tomentose, midrib sparsely prickle. Flowers white, in many flowered corymbose cymes. Barries globose.

Flr. & Frt: June- October.

Sonerila maculata Roxb. Family: Melastomaceae. Local name: Thaksen-hlo (M).

A small herb; stems with spreading hairs. Leaves 3-10 x 2-5 cm, opposite, ovate to lanceolate; base unequal to rounded; acute to attenuate at apex, serrulate and ciliate; lateral nerves 4-6 pairs. Flowers 3-merous, purple, axillary. Capsule glabrous, oblong, funnel shaped.

Flr. & Frt: August- February (Next year).

Spermacoca hispida Linn. Family: Rubiaceae. Local name: Unknown.

A procumbent herb with perennating rootstocks, scabrid, hispid. Leaves 1.2-3.8 x 0.8-1.5 cm, sessile or sub-sessile, obovate, oblong or elliptic, acute or obtuse at apex, scabrid. Flowers whorled, blue or white.

Flr. & Frt: August- December.

Sphenomeris chinensis (Linn.) Maxon. Family: Dennstaedtiaceae – Lindsayaoideae. Local name: Unknown.

Rhizome short creeping to semierect, densely covered with paleae. Paleae hair-like, 1-celled broad, ferruginous. Fronds bi-or tripinnate, lanceolate, upto 7-50 x 3-15 cm, glabrous. Sori marginal, rather submarginal inside the marginal flap, terminal on free veinlets.

Fertile: Not seen during study area.

Spilanthes oleracea Clark. Family: Asteraceae. Local name: Ankasa-te (M).

A small annual herb. Leaves opposite, 2-5 x 0.5-2.5 cm, ovate-lanceolate, acute at base, cuneate at base, serrate or dentate, glabrous. Flowers heads solitary, in axillary or terminal; Florets yellow.

Flr. & Frt: February- October.

Spondias pinnata (Linn.) Kurz. Family: Anacardeaceae. Local name: Tawitaw (M).

A small to medium sized deciduous tree; barks white or brownish-grey, furrowed and horizontally wrinkled. Leaves imparipinnate; leaflets 3-6 pairs, sub-opposite, 7-16 x 4-6 cm, elliptic-oblong, shortly acuminate, entire. Flowers greenish-white, in terminal panicles. Drupes ovoid, fleshy.

Flr: March- April. Frts: January- March (Next year).

Sporobolus diander (Retz) Beauv. Family: Poaceae. Local name: Unknown**.**

A perennial grass. Culms 20-45 cm long, tufted. Leaves linear, filiform; sheath glabrous; ligule hairy. Inflorescence a panicle. Spikelets *ca* 0.2 cm long, acute; lower glumes nerveless; upper 1-nerved; lemma lanceolate, 1-nerved; palea nerveless. Caryopsis oblong-ovoid.

Flr. & Frt: August- December.

Stellaria media (Linn.) Villars. Family: Caryophyllaceae. Local name: Changkalrit/ Chabet ban (M).

A spreading annual herb. Leaves 0.5-4 x 0.4-1.5 cm, ovate, acuminate, cordate at base. Flowers in axillary, terminal. Capsule ovoid.

Flr. & Frt: April- October.

Sterculia coccinea Roxb. Family: Sterculiaceae. Local name: Thlingi-leh-Ngama-inchawlthuai-na (M).

A shrub or small tree. Leaves 12-26 x 5-10 cm, oblanceolate or oblong-elliptic, acuminate at base, acuminate at apex, coriaceous; lateral nerves 10-12 pairs. Flowers in axillary, pinkish red.

Flr. & Frt: April- October.

Sterculia urens Roxb. Family: Sterculiaceae. Local name: Pangkhau (M).

A medium to large sized soft woody tree. Leaves simple, digitately 3-5 lobbed, rounded at base, caudate-acuminate at each apex, entire. Flowers yellow, in terminal panicles; panicles tomentose.

Flr. & Frt: October- April.

Sterculia villosa Roxb. ex Smith. Family: Sterculiaceae. Local name: Khau-pui (M).

A medium-sized tree; young parts tomentose. Leaves 14-40 cm long, crowded at the ends of branches, deeply palmately 5-7, cordate, tomentose beneath; lobes ovate-oblong, acuminate. Flowers yellow, polygamous. Follicle sessile, brownish stellate tomentose outside.

Flr. & Frt: March- July.

Stereospermum colais (Buch.-Ham. ex. Dillw.) Mabber. Family: Bignoniaceae. Local name: Zih-nghal (M).

A large deciduous tree. Leaves imparipinnate; leaflets 7-9, 6-12 x 3.5-6.8 cm, ovate-lanceolate, acuminate, serrate and entire. Flowers yellowish, in lax terminal panicles. Capsules 30-50 cm long, spirally twisted.

Flr. & Frt: April- August.

Strobilanthes maculatus Nees. Family: Acanthaceae. Local name: Ramting (M).

A shrub. Leaves 10-15 x 2.5-11 cm, ovate, ovate-lanceolate, acuminate, serrate, rather membranous, lanceolate on the upper surface; lateral nerves 9-11 on either half, slender. Flowers in terminal panicled hairy spikes, somewhat interrupted at the base, pale-blue. Seeds orbicular, shaggy with long hairs.

Flr. & Frt: October- November

Strobilanthes petiolaris Nees. Family: Acanthaceae. Local name: Unknown.

A shrub. Leaves ovate-acuminate, almost glabrous; base narrowed into the petiole; lateral nerves 7 on either half. Flowers in linear panicled hairy spike; corolla purplish or rose.

Flr. & Frt: Not seen during study period.

Strobilanthes simonsii Anders. Family: Acanthaceae. Local name: Ramting (M).

An under-shrub; branches pubescent. Leaves 5-15 x 2.5-5 cm, broadly lanceolate or elliptic-lanceolate, acuminate, arcuate-serrate, sub-coriaceous, minutely lanceolate; lateral nerves 7-9 on either half, slender. Flowers in ellipsoid, puberulous heads, white.

Flr. & Frt: September- December.

Styrax polyspermum Clark. Family: Styraceae. Local name: Theipalingkawh (M).

A small to medium tree. Leaves 7.5-15 x 2.5-6 cm, elliptic or oblong and lanceolate, crenate, acute, glabrous: lateral nerves 10 pairs. Flowers in terminal or axillary dichotomously branched compound cymes. Fruits ellipsoid.

Flr. & Frt: March- June.

Styrax serrulatum Roxb. Family: Styraceae. Local name: Hmar-hleng (M).

A small evergreen tree. Leaves 3.8-6.3 x 2-3.8 cm, lanceolate, elliptic, ovate-elliptic or oblong, acuminate, serrulate, glabrous above. Flowers in axillary pedunculate fascicles or small racemes or sub-paniculately racemed at the ends of branchlets. Fruits ellipsoid, rusty-tomentose.

Flr. & Frt: March- December.

Syzygium claviflorum (Roxb.) Wall ex Cowan. Family: Myrtaceae. Local name: Hmuifarial (M).

A small to medium sized, evergreen tree. Leaves 5-16 x 1.5-5 cm, oblong-lanceolate, base acute or cuneate, acuminate at apex, glabrous, lateral nerves many. Flowers sessile. Berries ovoid-oblong, blue when ripe.

Flr. & Frt: March- June.

Syzygium cumini (Linn.) Skeels. Family: Myrtaceae. Local name: Hmui-pui/ Lenhmui (M).

Middle to large evergreen tree; bark grey. Leaves 5-15 x 2.5-7.5 cm, oblong-elliptic to ovate, acuminate or acute, narrowed at base, glabrous. Flowers greenish white, in lateral or terminal trichotomous panicled. Barries 1-2 cm in diameter, oblong, purple black.

Flr. & Frt: March- July.

Syzygium operculatum (Roxb.) Niedenzuvar. **var. *obovatum*** (Wall. ex Duthie) Gamble. Family: Myrtaceae. Local name: Hmui-zubel (M).

An evergreen, glabrous tree. Leaves 7-13 x 3-8 cm, obovate or oblanceolate; base acute; apiculate at apex, glabrous; lateral nerves 8-12 pairs. Flowers white, sessile. Berries globose.

Flr. & Frt: April- August.

Tabernaemontana divaricata (Linn.) Br. ex Roem. & Schultes. Family: Apocynaceae. Local name: Par-arsi (M).

An evergreen bushy shrub; stem greenish white, exuding milky juice; branches lenticelate, warty. Leaves opposite, 2.5-6 x 5-20 cm, elliptic-oblong or oblanceolate, acute, undulate, glossy green above, pale beneath; base narrow, oblique. Flowers pure white fragrant, in

axillary or terminal dischotomous cymes; follicle 2, divericate, red inside. Seeds enclosed in a red aril, striate.

Flr: May- November. Frt: December- February.

Terminalia arjuna (Roxb.) Wight & Arn. Family: Combretaceae. Local name: Arjun (M).

A deciduous tree. Leaves sub-opposite, 7.5-14.5 x 3-9 cm, oblong, coriaceous with 2 glands at base, obtuse or rounded at apex. Flowers yellowish-white, in pedulous, axillary and terminal spikes; bracteolates linear. Fruits ovoid or oblong, fibrous, woody 5-winged.

Flr: March- May Frt: August- February.

Tetrastigma bracteolatum (Wall.) Planchon. Family: Vitaceae. Local name: Hrui-rithet (M).

A climber; stems woody, red, glabrous; tendrils simple. Leaves 3-foliolate; leaflets ovate or ovate-lanceolate 4-10.5 x 3.5-6 cm, base rounded or cuneate in terminal leaflets, oblique in laterals, acuminate at apex, cuspidate-serrate along margins, membranous, glabrous above, puberulous on nerves beneath. Cymes axillary, pubescent, corymbose with divaricate ramifications. Flowers *ca* 1cm across, tetramerous, dioecious, whitish pubescent outside. Berries globose, black when ripe.

Flr. & Frt: August- March (Next year).

Tetrastigma leucostaphylum (Dennst.) Alston ex Mabb. Family- Vitaceae. Local name: Thurpui (M).

A large soft climber. Leaves pedately 5 foliolate; leaflets *ca* 6-15 x 3-7 cm, lanceolate or ovate, terminal; leaflets larger than the lateral ones, acute at base, acuminate at apex, serrate; lateral nerves 8-10 pairs. Flowers unisexual, green. Berries globose, red when ripe.

Flrs & Frts: February-September.

Thladiantha calcarata Clark. Family: Cucurbitaceae. Local name: Kangmang (M).

A large climber. Leaves 6-11 x 5-7 cm, cordate-ovate, sub-acute to acuminate apex, denticulate, rough above. Flowers yellow, dioecious. Fruits oblong, longitudinally 12-15 nerved.

Flr. & Frt: May- November.

Thunbergia grandiflora (Roxb. ex Rottl) Roxb. Family: Acanthaceae. Local name: Vako-hrui (M).

A woody climbing shrub. Leaves opposite, 10-20 x 5-11 cm, ovate or detoid-ovate, deep cordate. Flowers light blue, in terminal racemes; bracts large, foliaceous brownish silky outside. Capsules with 4 quetrous beak.

Flr. & Frt: September- January.

Thysanolaena maxima (Roxb.) Kuntz. Family: Poaceae. Local name: Hmunphiah (M).

A perennial tufted grass. Culms 1-2.5 m long, erect. Leaves 30-50 cm long, acuminate; sheath loose; ligule membranous. Inflorescence a large panicle. Spikelets 1-2-nate, minute, 2-flowered; lower glume ovate-acute. Caryopsis ovoid.

Flr. & Frt: November- May.

Tinospora cordifolia (Willd.) Hook. & Thomson. Family: Menispermaceae. Local name: Hrui-vankai (M).

A deciduous succulent climber; stem with scattered lenticels. Leaves 3.5-12.5 x 3-11 cm, ovate or orbicular, acute or acuminate, cordate at the base. Flowers greenish yellow, in axillary or terminal racemes. Male flowers fascicled; female flowers solitary. Drupes globose.

Flr. & Frt: January- May.

Tithonia diversifolia (Miller) Blake. Family: Asteraceae. Local name: Bawngpu-par (M).

A large herb or under-shrub. Leaves 6-25 x 3-21 cm, ovate-rotundate, narrowed-cuneate at base, acuminate at apex, crenate or lobed at margins. Flowers heads solitary, in terminal; florets yellow.

Flr. & Frt: Novemberr- January (Next year).

Toona ciliata Roemer. Family: Meliaceae. Local name: Tei-pui (M).

A large deciduous tree. Leaves long, paripinnate; leaflets 5-25, 4-14 x 1.8-4.2 cm, obliquely ovate or lanceolate, acuminate, entire or undulate, glabrous and shinning. Flowers white, 0.8-1.0 cm long, in drooping terminal panicles. Capsules oblong. Seeds membranous, winged at ends.

Flr. & Frt: January- June.

Tragia involucrata Linn. Family: Euphorbiaceae. Local name: Zawng-kangthai (M).

A perennial twiner with hispid stinging hairs. Leaves 2.5-10 x 1-5 cm, alternate, variable, ovate or oblong, acuminate, serrate, hispid; lateral nerves 4-5 on either side. Flowers monoecious, in terminal. Capsule hispid.

Flr: July- September. Flr: September- October.

Trema orientalis (Linn.) Bl. Family: Ulmaceae. Local name: Belphuar (M).

A moderate-sized fast growing and short-lived tree; branches and branchlets somewhat ascending; twigs adpressed pubescent; bark thin, greenish-grey or bluish-green, smooth. Leaves drooping, 5-15 x 2.5-7.5 cm, ovate, ovate-lanceolate or ovate-oblong; more or less grey or white

pubescent or tomentose beneath; basal nerve 3-7 (generally 3). Male cymes dense, sometimes lax; female cymes lax; sepals flat. Fruit drupe.

Flr. & Frt: March- August.

Trevesia palmata (Roxb.) Vis. Family: Araliaceae. Local name: Kawhte-bel (M).

An unbranched prickly shrub. Leaves orbicular, palmatified or palmatisect; lobes oblong-elliptic, acuminate, serrate. Flowers pale yellow, polygamous in terminal panicled umbels. Fruits fleshy, crowded by persistent calyx.

Flr. & Frt: March- June.

Trichosanthes tricuspidata Lour. Family: Cucurbitaceae. Local name: Choak-khaum (M).

A large climber; tendril 3-fid. Leaves palmately 3-5 lobed, ovate, cordate, denticulate, scabous; petioles 3-10 cm long; bracts conspicuous. Male raceme few flowered with large bract; calyx tube *ca* 4 cm long, striate, villose; staminal filaments villose. Fruit globose, bright red with longitudinal orange streaks.

Flr. & Frt: July- November.

Triumfetta pilosa Roth. Family: Tiliaceae. Local name: Semeibawm (M).

A woody based herb; branchlets hispid. Leaves 5-10 x 2-5 cm, elliptic lanceolate, cordate or rounded at base, acuminated at apex, serrate, pubescent above, tomentose beneath. Flowers in axillary or leaf-opposed lateral cymes, yellow. Capsules globose.

Flr. & Frt: Almost throughout the year.

Ulmus lancifolia Roxb. Family: Ulmaceae. Local name: Phan (M).

A corky large deciduous tree . Leaves 2.5-11 x 1.3-4 cm, lanceolate, elliptic-lanceolate , bluntly acuminate at apex, serrate or crenate, glabrous; nerves reticulate.

Flr. & Frt: November- June.

Uncaria laevigata Wall. Family: Rubiaceae. Local name: Ralsamkuai zikvar (LR).

A large climbing scandent shrub; stem woody with recurved axillary hook. Leaves 7-15 x 5-10 cm, elliptic or ovate-lanceolate, rounded at base, bluntly acuminate at apex, glabrous on both surfaces. Flowers in axillary or terminal peduncled panicles, small, *ca* 1.5 cm long.

Flr. & Frt: October- February (Next year).

Uncaria sessilifructus Roxb. Family: Rubiaceae. Local name: Ralsamkuai ziksen (M).

An extensive climber; stem woody; young parts red with pubescent curved axillary hooks. Leaves 5-7 x 3-4.5 cm, elliptic, rounded at base, acuminate at apex, entire; lateral nerves 4-5 pairs. Flowers in axillary and terminal panicled heads, yellow, 2.5-3.5 cm long.

Flr. & Frt: October- April.

Urena lobata Linn. Family: Malvaceae. Local name: Se-hnap (LR).

A stellate hairy, under-shrub. Leaves variable; upper ones small, elliptic, oblong-ovate, acute, serrate; lower ones large, orbicular, 3-5 lobed; stipules linear. Flowers bright pink, axillary, solitary; apicalyx adnate to the base of calyx; calyx *ca* 0.5 cm long; lobes lanceolate, hairy; corolla 1.2-1.8 cm long; pinkish with a purple center. Fruits globular, glochidiate, indehiscent.

Flr. & Frt: July- February.

Viburnum mullaha Buch.-Ham.ex D. Don. Family: Caprifoliaceae. Local name: Vawng-ser (M).

A large aromatic shrub. Leaves 5-12 x 1.5-5.5 cm, opposite, elliptic or oblong, lanceolate, cuneate, acuminate, dentate. Flowers in terminal, sub-globose corymbs. Drupes red when ripe, rounded oblong.

Flr. & Frt: May- July.

Vitex heterophylla Roxb. Family: Verbenaceae. Local name: Thlengreng (M).

A large tree. Leaves usually 5 foliolate, elliptic-oblong or elliptic, entire, acuminate; lateral nerves 6-10. Flowers yellowish-white, in terminal. Drupes globose.

Flr. & Frt: May- July.

Vitex peduncularis Wall. ex Schauer. Family: Verbenaceae. Local name: Thing-khawilu (M).

A medium-sized to large semi-decideous tree; stem fluted at the base; bark dark-grey; young parts pubescent; rachis winged. Leaves 3-folialate; leaflets lanceolate, 2-5 x 6-16 cm; base acute. Flowers yellowish-white or greenish-white, in axillary lax peduncled. Fruits obovoid.

Flr: April- May. Frt: July- September.

Wendlandia grandis Hook. Family: Rubiaceae. Local name: Batling (M).

A small evergreen tree. Leaves 7-10 x 4-6 cm, opposite, ovate-elliptic, cuneate at base, acuminate at apex, glabrous above, pubescent beneath; lateral nerves 8-10 pairs. Flowers sessile, white. Fruits globose.

Flr. & Frt: January- June.

Willughbeia edulis Roxb. Family: Apocynaceae. Local name: Vuakdup (M).

A woody climber. Leaves 10-15 x 3-5 cm, ovate-oblong, acuminate, undulate at the margins, cuneate at base; lateral nerves 10-16 pairs. Flowers in axillary, yellowish. Fruits pyriform, bright red when ripe.

Flr. & Frt: Not seen during study period..

Zanthoxylum armatum D.C. Family: Rutaceae. Local name: Arhrik-reh (M).

A prickly shrub or small tree. Leaves 3 foliolate; leaflets 5-11, 3-8 x 1-3 cm, opposite, elliptic, oblong-lanceolate. acute at base, acuminate at apex, serrulate. Flowers unisexual, yellowish, in terminal.

Flr: April- June. Frt: October- December.

Photo plate 2

Flowers

6 nos.

Photo plate 3

Flowers

6 nos.

Table 1a. Status of plant diversity in the study area.

Variable	**Richness in quadrats studied**
Total species	384
Genera	290
Families	107
No. of individuals in all the quadrat studies	12,512
Angiosperms (species)	369
Gymnosperms (species)	1
Pteridophytes (species)	14

Table 1b. Taxonomic diversity in the study area.

Natural Order	**Family**	**Genera**	**Species**
Pteridophytes	10	13	14
Gymnosperms	1	1	1
Angiosperms 1. Dicotyledons (a) Polypetalae (1) Thalamiflorae	15	31	38
(2) Disciflorae	16	29	34
(3) Calyciflorae	18	54	74
(b) Gamopetalae (1) Bicarpellatae	16	43	52
(2) Heteromerae	3	4	8
(3) Inferae	4	31	38
(c) Monochlamydeae (1) Curvembryeae	2	3	7
(2) Daphnales	3	9	17
(3) Micrembryeae	1	2	4
(4) Unisexuals	6	30	48
2. Monocotyledons	12	40	49
Total	**107**	**290**	**384**

Table 1c. Taxonomic diversity in the three different study sites.

Natural order	Families			Genera			Species		
	HD	MD	UD	HD	MD	UD	HD	MD	UD
Pteridophytes	5	6	4	5	9	4	6	9	4
Gymnosperms	-	-	1	-	-	1	-	-	1
Angiosperms									
2. Dicotyledons									
(a) Polypetalae									
(1) Thalamiflorae	6	9	14	7	13	22	7	17	24
(2) Disciflorae	5	12	7	6	18	15	7	21	16
(3) Calyciflorae	10	17	16	21	32	39	27	42	47
(b) Gamopetalae									
(1) Bicarpellatae	10	10	12	18	17	24	21	19	30
(2) Heteromerae	2	3	2	2	4	3	2	7	5
(3) Inferae	3	3	3	20	17	14	21	19	17
(c) Monochlamydeae									
(1)Curvembryeae	2	3	1	3	3	1	5	5	1
(2) Daphnales	2	2	3	3	7	7	4	12	12
(3) Micrembryeae	-	-	1	-	-	1	-	-	4
(4) Unisexuals	5	6	4	11	23	22	13	31	31
2. Monocotyledons	3	11	10	20	21	19	23	23	21
Total	**53**	**82**	**78**	**116**	**164**	**172**	**136**	**205**	**213**

Table 1d. Family-wise distribution of species in the three study sites.

Family	HD		MD		UD	
	Genera	Species	Genera	Species	Genera	Species
Acanthaceae	3	3	3	4	6	6
Aceraceae			1	1		
Amaranthaceae	2	2	1	1	1	1
Amaryllidaceae			1	1		
Ampelidaceae			1	1	1	1
Anacardiaceae	1	1	2	3	4	4
Annonaceae					1	1
Apiaceae	2	2	1	1	1	1
Apocynaceae			2	2	2	2
Aquifoliaceae	1	1	1	1		
Araceae			3	3	3	3
Araliaceae			2	2	3	3
Asclepiadaceae	1	1	1	1		
Asteraceae	13	14	6	6	3	3
Athyriaceae			1	1	1	1
Bignoniaceae			2	2	2	2
Blechnaceae	1	1			1	1
Bombacaceae					1	1
Boroginaceae	1	1			1	1
Buddlejaceae/ Logoniaceae			1	1		
Burseraceae					3	3

Caesalpiniaceae	1	1	3	4	3	4
Campanulaceae /Lobeliaceae	1	1				
Capparidaceae					1	1
Caprifoliaceae			1	1		
Caryophylaceae	1	1			1	1
Celastraceae					1	1
Combretaceae	1	1	3	4	2	3
Comellinaceae			1	1	1	1
Connaraceae			1	1	1	1
Convolvulaceae	3	3	1	1	1	2
Cornaceae/ Alangiaceae	1	1	1	1	1	1
Cucabitaceae	1	1	2	2	3	3
Cyatheaceae					1	1
Cyperaceae	6	8	3	3	1	1
Dennstaedtiaceae/Davallioideae			2	2		
Dicksoniaceae			1	1		
Dioscoreacea			1	3		
Ebenaceae			1	2	1	1
Elaeagnaceae					1	1
Elaeocarpaceae	1	1	1	2	1	1
Euphobiaceae	7	9	14	16	12	14
Fagaceae	1	1	1	2		
Flacourtiaceae					1	1
Gentianaceae	1	1	1	1	1	1
Gesneraceae			1	1	2	2
Gleicheniaceae	1	1	1	1		
Gnetaceae					1	1
Guttiferae / Clusiaceae			1	2	2	3
Jaglandaceae	1	1	1	1		
Labiatae / Lamiaceae	2	2	1	1		
Lauraceae	2	3	6	11	5	10
Liliaceae	1	1	1	1	1	1
Lycopodiaceae	1	1				
Lygodiacea/Schizaeaceae	1	2	1	1		
Lythraceae	2	2	1	1	2	2
Magnoliaceae			1	1	1	1
Malpighiaceae	1	1				
Malvaceae	2	3	2	2	2	2
Marcantaceae			1	1	1	1
Melastomaceae	1	2	2	3	2	2
Meliaceae			4	4	3	3
Menispermaceae	1	1	1	1	2	2
Mimosaceae	4	6	5	6	5	6
Molluginaceae					1	1
Moraceae	1	1	3	8	3	9
Musaceae			1	1	1	1
Myrsinaceae	1	1	2	3	2	4
Myrtaceae			1	3	1	2

Nyssaceae			1	1		
Oleaceae					2	4
Opiliaceae			1	1	1	1
Orobunchiaceae					1	1
Oxalidaceae	1	1				
Palmae					3	3
Pandanaceae			1	1	1	1
Papilionaceae/ Fabaceae	7	8	6	9	10	13
Passifloraceae					1	1
Piperaceae					2	4
Plantaginaceae	1	1				
Poaceae	13	14	5	5	3	5
Polygalaceae			1	1		
Polygonaceae	1	3	1	3		
Polypodiaceae			3	3		
Pteridaceae	1	1				
Ranunculaceae					2	2
Rhamnaceae			1	1		
Rhizophoraceae			1	1		
Rosaceae	1	3	1	2	2	3
Rubiaceae	6	6	10	12	8	12
Rutaceae			2	2	2	2
Sabiaceae			1	1		
Sapindaceae			1	1		
Saurauiaceae			1	1	1	1
Saxifragaceae			1	1	1	1
Scrophulariaceae	1	1			1	1
Solanaceae	2	4			1	1
Sterculiaceae	1	1	2	3	3	4
Styraceae			1	2		
Theaceae	1	1	3	5	1	1
Thelypteridaceae			1	1	1	1
Thymeleaceae	1	1	1	1		
Tiliaceae	1	1	1	1	3	3
Ulmaceae	1	1	2	2	3	4
Urticaceae			2	2	4	4
Verbenaceae	3	3	4	5	4	7
Vitaceae	2	3	2	3	2	3
Zingiberaceae			3	3	4	4
Total	**116**	**136**	**164**	**205**	**172**	**213**

5.2 Phyto-sociological analysis

5.2.1 Community analysis

The community structure recorded and analyzed for different levels of disturbances are as follows:

5.2.1.1 Highly disturbed area

A total of 136 species were recorded under this area, out of which 26 species were represented by trees, 40 species by shrubs and the remaining 70 species were represented by hebaceous species.

Tree species

In the highly disturbed area, *Aporusa octandra* (126.67 individuals/ ha) has the highest density. The other tree species having high density were *Schima wallichii* (73.33 individuals/ ha), *Rhus semialata* (63.33 individuals/ ha), *Wendlandia grandis* (60.00 individuals/ ha) and *Albizia chinensis* (53.33 individuals/ ha). Frequency of the tree species like *Aporusa octandra* (33.33), *Wendlandia grandis* (33.33), *Albizia chinensis* (30.00), *Callicarpa arborea* (30.33) and *Rhus semialata* (30.00) were found to be more pronounced in the highly disturbed area. However, the most abundant tree species was *Aporusa octandra* (3.80) followed by *Litsea monopetala* (3.20), *Schima wallichii* (2.44), *Albizia thomsoni* Brandis (2.33) and *Rhus semialata* (2.11). **(Table 2a).**

Among tree species, *Aporusa octandra* was the dominant species with highest IVI (32.05) followed by *Schima wallichii* (IVI = 24.09). The other co-dominant species were *Wendlandia*

grandis (IVI = 21.23), *Rhus semialata* (IVI = 19.46), *Albizia chinensis* (IVI = 19.00) and *Castanopsis tribuloides* (IVI = 17.87) **(Table 5a).**

Shrub species

In the highly disturbed area, *Chromolaena odorata* (710.00 individuals/ ha) has the highest density. The other shrub species having high density were *Rubus birmanicus* (396.67 individuals/ ha), *Cassia occidentalis* (170.00 individuals/ ha), *Melastoma nepalensis* (110.00 individuals/ ha) and *Tithonia diversifolia* (110.00 individuals/ ha).The shrubby species like *Chromolaena odorata* (76.67), *Cassia occidentalis* (56.67), *Dalbergia stipulacea* (40.00), *Melastoma nepalensis* (33.33) and *Rubus birmanicus* (33.33) were found to be more frequent in the highly disturbed area. However, the most abundant species was *Rubus birmanicus* (11.90) followed by *Chromolaena odorata* (9.26), *Tithonia diversifolia* (8.25), *Tragia involucrata* (7.00) and *Paederia foetida* (3.67). **(Table 2b).**

Among the shrub species, *Chromolaena odorata* was the dominant species with highest IVI (57.24) followed by *Rubus birmanicus* (IVI = 38.83). The other co-dominant species were *Cassia occidentalis* (IVI = 17.39), *Bridelia stipularis* (IVI = 14.84), *Dalbergia stipulacea* (IVI = 13.70) and *Melastoma nepalensis* (IVI = 11.82) **(Table 5b).**

Herbaceous species

In the highly disturbed area, *Imperata cylindrica* (35120 individuals/ ha) has the highest density. The other herbaceous species having high density were *Knoxia corymbosa* (20400 individuals/ ha), *Ichnanthus vicinus* (8400 individuals/ ha), *Polygonum hydropiper* (7400 individuals/ ha) and *Eragrostis nutans* (6600 individuals/ ha). The herbaceous species like *Imperata cylindrica* (60.00), *Knoxia corymbosa* (30.00), *Ichnanthus vicinus* (14.00) and *Inula*

cappa (14.00) were found to be more frequent in the highly disturbed area. The most abundant species was *Imperata cylindrica* (58.53) followed by *Lycopodium cernuum* (12.00), *Sphenomeris chinensis* (10.50), *Stellaria media* (7.67) and *Polygonum hydropiper* (7.40) **(Table 2c).**

Among the herbaceous species, *Imperata cylindrica* was the dominant species with highest IVI (83.26) followed by *Erianthus longisetosus* (IVI = 24.16). The other co-dominant species were *Knoxia corymbosa* (IVI = 10.03), *Scleria terrestris* (IVI = 7.12), *Inula cappa* (IVI = 6.89) and *Stellaria media* (IVI = 6.71) **(Table 5c).**

5.2.1.2 Mildly disturbed area

A total of 205 species were recorded in the mildly disturbed area, out of which 82, 77 and 46 belong to tree species, shrub species and herbaceous species respectively.

Tree species

Tree species were mixed with bamboo species in the mildly disturbed area and they are treated as tree component in the present study.

In the mildly disturbed area, *Castanopsis tribuloides* (400.00 individuals/ ha) had the highest density. The other tree species having high density were *Wendlandia grandis* (306.67 individuals/ ha), *Aporusa octandra* (250.00 individuals/ ha), *Phoebe lanceolata* (226.67 individuals/ ha) and *Schima wallichii* (216.67 individuals/ ha). The tree species like *Aporusa octandra* (70.00), *Castanopsis tribuloides* (70.00), *Schima wallichii* (53.33), *Phoebe lanceolata* (46.67) and *Wedlandia grandis* (43.33) and *Machilus villosa* (43.33) were found to be more frequent in the mildly disturbed area. However, the most abundant tree species was

Wendlandia grandis (7.08) followed by *Bischofia javanica* (6.00), *Haldina cordifolia* (6.00), *Melocanna baccifera* (6.00) and *Castanopsis tribuloides* (5.71) **(Table 3a).**

Among the tree species, *Castanopsis tribuloides* was the dominant species with highest IVI (20.81) followed by *Aporusa octandra* (IVI = 15.91). The other co-dominant species were *Wendlandia grandis* (IVI = 15.48), *Schima wallichii* (IVI = 14.40), *Styrax serrulatum* (IVI = 13.94) and *Phoebe lanceolata* (IVI = 12.63) **(Table 6a).**

Shrub species

In the mildly disturbed area, *Garcinia cowa* (403.33 individuals/ ha) has the highest density. The other shrub species having high density were *Chromolaena odorata* (310 individuals/ ha), *Rourea minor* (290.00 individuals/ ha), *Lepionurus sylvestris* (253.33 individuals/ ha) and *Cissampelos pareira* (220.00 individuals/ ha). The shrub species like *Cissus repens* (60.00), *Cissampelos pareira* (56.67), *Clerodendrum infortunatum* (50.00), *Coffea khasiana* (50.00) and *Rourea minor* (50.00) were found to be more frequent in the mildly disturbed area. However, the most abundant species was *Garcinia cowa* (10.08) followed by *Chromolaena odorata* (9.30), *Thunbergia grandiflora* (8.00), *Lepionurus sylvestris* (6.91) and *Dendrocnide sinuata* (6.60) (**Table 3b).**

Among the shrub species, *Bridelia stipularis* was the dominant species with highest IVI (15.98) followed by *Camellia sinensis* (IVI = 11.12). The other co-dominant species were *Leea asiatica* (IVI = 10.95), *Garcinia cowa* (IVI = 10.20), *Clerodendrum infortunatum* (IVI = 9.40) and *Zanthoxylum armatum* (IVI = 9.20) **(Table 6b).**

Herbaceous species

In the mildly disturbed area, *Thysanolaena maxima* (14800 individuals/ ha) has the highest density. The other herbaceous species having high density were *Imperata cylindrica* (6600 individuals/ ha), *Ichanthus vicinus* (5800 individuals/ ha), *Panicum punctatum* (5400 individuals/ ha) and *Pteridium aquilinum* (4600 individuals/ ha). The herbaceous species like *Costus speciosus* (20.00), *Ichnanthus vicinus* (20.00), *Panicum punctatum* (18.00), *Pteridium aquilinum* (18.00) and *Commelina sikkimensis* (16.00) were found to be more frequent in the mildly disturbed area. However, the most abundant species was *Thysanolaena maxima* (10.54) followed by *Sphenomeris chinensis* (6.00), *Imperata cylindrica* (5.50), *Ageratum conyzoides* (3.60) and *Diplazium maxima* (3.50) **(Table 3c).**

Among herbaceous species, *Alpina bracteata* was the dominant species with highest IVI (37.35) followed by *Thysanolaena maxima* (IVI = 17.44). The other co-dominant species were *Amomum dealbatum* (IVI = 16.60), *Inula cappa* (IVI = 12.31), *Microsarum superficiale* (IVI = 10.43) and *Ichnanthus vicinus* (IVI = 9.63) **(Table 6c).**

5.2.1.3 Undisturbed area

A total of 214 species were recorded in the undisturbed area, out of which 101, 78 and 35 respectively belonged the number of tree species, shrub species and herbaceous species.

Tree species

Tree species were mixed with bamboo species in the undisturbed area and they are treated as tree component in the present study.

In the undisturbed area, *Alangium chinense* (186.67 individuals/ ha) has the highest density. The other tree species having high density were *Eriobotrya bengalensis* (183.33 individuals/ ha), *Bischofia javanica* (180.00 individuals/ ha), *Macropanax dispermus* (173.33 individuals/ ha) and *Celtis australis* (150.00 individuals/ ha). The tree species like *Bischofia javanica* (66.67), *Alangium chinense* (56.67), *Eriobotrya bengalensis* (53.33), *Vitex heterophylla* (50.00) and *Machilus villosa* (46.67) were found to be more frequent in the undisturbed area. However, the most abundant tree species was *Dendrocalamus longispathus* (15.00) followed by *Dendrocalamus hamitonii* (12.00), *Melocanna baccifer* (12.00), *Brusera serrata (*5.00) and *Grewia desperma* (5.00) **(Table 4a)**.

Among the tree species, *Alangium chinense* and *Bischofia javanica* were the dominant species with highest IVI (11.55) and (11.25) respectively, and followed by *Eriobotrya bengalensis* (IVI = 10.71), *Macropanax dispermus* (IVI = 9.91), *Celtis australis* (IVI = 8.27) and *Vitex heterophylla* (IVI = 7.84) **(Table 7a)**.

Shrub species

In the undisturbed area, *Dendrocnide sinuata* (180.00 individuals/ ha) has the highest density. The other shrub species having high density were *Chromolaena odorata* (173.33 individuals/ ha), *Coffea khasiana* (150.00 individuals/ ha), *Phyllanthus reticulatus* (150.00 individuals/ ha) and *Rubus birmanicus* (136.67 individuals/ ha). The shrub species like *Coffea khasiana* (46.67), *Maesa indica* (46.67), *Thunbergia grandiflora* (36.67) and *Millettia pachycarpa* (33.33) were found to be more frequent in the undisturbed area. However, the most abundant species was *Chromolaena odorata* (17.33) followed by *Desmodium pulchellum* (10.00), *Rhynchotechum ellipticum* (10.00), *Dendrocnide sinuata* (7.71) and *Rubus birmanicus* (6.83) **(Table 4b).**

Among the shrub species, *Bridelia stipularis* was the dominant species with highest IVI (38.19) followed by *Debregeasia longifolia* (IVI = 15.61). The other co-dominant species were *Leea asiatica* (IVI = 14.71), *Coffea khasiana* (IVI = 10.65), *Acacia pennata* (IVI = 9.18) and *Maesa indica* (IVI = 8.52) **(Table 7b).**

Herbaceous species

In the undisturbed area, *Eranthemum palatiferum* (20600.00 individuals/ ha) has the highest density. The other herbaceous species having high density were *Achyranthes aspera* (10400.00 individuals/ ha), *Ichanthus vicinus* (6600.00 individuals/ ha), *Lepidagathis hyaline* (6000.00 individuals/ ha) and *Phrynium capitatum* (4600.00 individuals/ ha). The herbaceous species like *Eranthemum palatiferum* (34.00), *Lepidagathis hyaline* (22.00), *Ichnanthus vicinus* (20.00), *Achyranthes aspera* (16.00) and *Commelina sikkimensis* (14.00) were found to be more frequent in the undisturbed area. However, the most abundant species was *Phrynium capitatum* (7.67) followed by *Achyranthes aspera* (6.50), *Desmodium triquetrum* (6.50), *Eranthemum palatiferum* (6.06) and *Centilla asiatica* (6.00) **(Table 4c).**

Among the herbaceous species, *Eranthemum palatiferum* was the dominant species with highest IVI (43.64) followed by *Alpina bracteata* (IVI = 42.39). The other co-dominant species were *Amomum dealbatum* (IVI = 38.46), *Achyranthes aspera* (IVI = 18.35), *Lepidagathis hyaline* (IVI = 15.93) and *Ichnanthus vicinus* (IVI = 15.18) **(Table 7c).**

5.2.2 Sorensen's index of similarity (S)

In the present study, Sorensen's index of similarity (S) among the three study sites was not too high. The value of similarity (S) of the vascular plant species between mildly disturbed

(MD) site and undisturbed (UD) was found to be highest (0.44) followed by the value (0.34) between highly disturbed (HD) site and mildly disturbed (MD) site, and lowest between highly disturbed (HD) site and undisturbed (UD) site (0.28) **(Table 8a).**

In tree species, the highest value of similarity (S) was also found between MD site and UD site (0.48) and lowest between HD site and UD site (0.28) **(Table 8b)**. In shrub species, the highest value of similarity (S) was observed between MD site and UD site (0.40) while the lowest value was found between HD site and UD site (0.34) **(Table 8c)**. In herbaceous species, the value of similarity (S) between MD site and UD site was highest (0.35) while lowest between HD site and UD site (0.26) **(Table 8d)**.

5.2.3 Species richness, diversity and dominance indices

5.2.3.1 Margalef's index of species richness (D_{mg})

In tree species, the value of species richness (D_{mg}) was highest in UD area (14.28) followed by MD area (11.50) and lowest in HD area (4.58) **(Table 9a)**. In shrub species, the highest value of species richness (D_{mg}) was found to be highest in UD area (10.99) followed by MD area (10.31) and lowest in HD area (5.85) **(Table 9b)**. In herbaceous species, the value of species richness (D_{mg}) was found to be highest in HD area (8.71) followed by MD area (7.18) and lowest in UD area (5.53) **(Table 9c)**.

5.2.3.2 Shannon's index of diversity (H')

Shannon's diversity index was calculated on the basis of important values. The value of species diversity (H') in tree species was highest in UD area (4.32) and lowest in HD area (3.07) **(Table 9a)**. The shrub species diversity (H') in the study area was highest in MD area

(4.03) and lowest in HD area (3.12) **(Table 9b)**. The diversity (H') of herbaceous species was maximum in MD area (3.55) and minimum in UD area (2.99) **(Table 9c)**.

5.2.3.3 Simpson's index of dominance (D)

Simpson index of dominance was calculated by using the important value of the plant species. The value of dominance (D) in tree species was found to be highest in UD area (62.5) and lowest in HD area (18.86) **(Table 9a)**. In shrub species, the value of dominance (D) was highest in MD area (45.45) and lowest in HD area (13.69) **(Table 9b)**. In herbaceous species, the value of dominance (D) was highest in MD area (25.64) and lowest in HD area (10.86) **(Table 9c)**.

5.2.4 Life-form spectrum

In the present study, the vascular plant species were divided into nine different classes of life-forms as outlined by Raunkiaer's life-form spectrum (Misra, 1968) and Ellenberg and Muller-Domboise (Domboise, 1974). Raunkiaer's life-forms in the study area are shown in **Table 10a & 10b.**

In the highly disturbed site, the highest percentage of life-form classes was found in therophytes (43.38 %) followed by lianas, scandents, and climbers (L.S.C) (16.18 %) and lowest in chamaephytes (3.68); megaphanerophytes were absent in this area **(Fig. 3b & Table 10b)**. In the mildly disturbed site, the highest percentage was found in mesophanerophytes (28.43 %) followed by lianas, scandents, and climbers species (19.12 %) and lowest in epiphytes (0.49); megaphanerophytes were absent in this area **(Fig. 3c & Table 10b)**. In the undisturbed site, the highest percentage was also found in mesophanerophytes (34.27 %)

followed by lianas, scandents, and climbers species (17.84 %) and lowest in epiphytes and megaphanerophytes (0.47 %) **(Fig. 3d & Table 10b)**.

The highest percentage of life-form classes was observed in mesophanerophytes and lowest in megaphanerophytes in the whole study area. The percentages of megaphanerophytes, mesophanerophytes, microphanerophytes, nanophanerophytes, chamaephytes, geophytes, therophytes, epiphytes and lianas, scandents, and climbers species in the present study were 0.26 %, 25.78 %, 15.10 %, 12.24 %, 4.69 %, 5.47 %, 19.01 %, 0.52 % and 16.93 % respectively **(Table 10a & Fig. 3a)**.

Table 2a. Density, frequency % and abundance of tree species in the highly disturbed (HD) area.

Name of the species	Density (Indv. ha^{-1})	Frequency (%)	Abundance
Alangium chinense (Lour.) Harms.	13.33	10.00	1.33
Albizia chinensis (Osb.) Merr.	53.33	30.00	1.78
Albizia thomsoni Brandis	23.33	10.00	2.33
Albizzia procera (Roxb.) Benth.	13.33	10.00	1.33
Aporusa octandra (Buch.-Ham. ex D. Don) Vickery.	**126.67**	**33.33**	**3.80**
Artocarpus heterophyllus Lam.	3.33	3.33	1.00
Callicarpa arborea Roxb.	43.33	30.00	1.44
Castanopsis tribuloides DC.	33.33	20.00	1.67
Derris robusta (Roxb.ex DC) Benth.	23.33	13.33	1.75
Ehretia acuminata Br.	3.33	3.33	1.00
Elaeocarpus floribundas Bl.	10.00	6.67	1.50
Emblica officinalis Goertn.	40.00	20.00	2.00
Engelhardtia spicata Lechen ex Bl.	10.00	10.00	1.00
Glochidion khasicum Hook.	23.33	20.00	1.17
Glochidion velutinum Wight.	10.00	10.00	1.00
Haldina cordufolia (Roxb.) Ridsdale.	20.00	13.33	1.50
Ilex umbellulata (Wall.) Loes.	20.00	16.67	1.20
Lagerstroemia speciosa Linn.	6.67	6.67	1.00
Litsea monopetala (Roxb.) Pers.	53.33	16.67	3.20
Phoebe lanceolata Nees.	13.33	10.00	1.33
Rhus semialata Murr.	63.33	30.00	2.11
Sapium baccatum Roxb.	13.33	13.33	1.00
Sapium insigne Benth.	13.33	13.33	1.00
Schima wallichii (DC.) Korthals.	73.33	30.00	2.44
Trema orientalis (Linn.) Bl.	13.33	13.33	1.00
Wendlandia grandis Hook.	60.00	33.33	1.80

Table 2b. Density, frequency % and abundance of shrub species in the highly disturbed (HD) area.

Name of the species	Density (Indv. ha^{-1})	Frequency (%)	Abundance
Acacia pennata (Linn.) Willd.	6.67	6.67	1.00
Aspidopterys nutans (Roxb. ex. DC.) Juss.	13.33	10.00	1.33
Bridelia stipularis (Linn.) Bl.	50.00	26.67	1.88
Butea parviflora Roxb.	60.00	30.00	2.00
Cajanus cajan (Linn.) Millsp.	20.00	13.33	1.50
Cassia occidentalis Linn.	170.00	56.67	3.00
Chromolaena odorata (Linn.) King & Robinson	**710.00**	**76.67**	9.26
Cissampelos pareira Linn.	30.00	20.00	1.50
Cissus japonica **(**Wall.) Planchon.	30.00	13.33	2.25
Cissus repens Lam.	80.00	23.33	3.43
Clerodendrum infortunatum Linn.	83.33	30.00	2.78
Coffea khasiana Hook.	26.67	10.00	2.67
Combretum flagrocarpum Clarke.	66.67	30.00	2.22
Cryptolepis buchanani Roem. & Schult.	3.33	3.33	1.00
Dalbergia stipulacea Roxb.	80.00	40.00	2.00

Derris thyrsflora Benth.	36.67	13.33	2.75
Entada pursaetha DC.	6.67	6.67	1.00
Lantana camara Linn. **var** *aculeata* Linn..	16.67	6.67	2.50
Linostoma decandrum Wall.	26.67	13.33	2.00
Litsea salicifolia (Roxb. ex. Wall) Hook.	30.00	13.33	2.25
Maesa indica (Roxb.) Wall.	66.67	26.67	2.50
Melastoma malabatricum Linn.	30.00	13.33	2.25
Melastoma nepalensis Lodd.	110.00	33.33	3.30
Merreremia vitifolia (Burm.f.) Hall.	13.33	10.00	1.33
Millettia pachycarpa Benth.	13.33	10.00	1.33
Mussaenda frondosa Linn.	13.33	13.33	1.00
Paederia foetida Linn.	36.67	10.00	3.67
Plectranthus hispidus Benth.	16.67	10.00	1.67
Rubus birmanicus Hook.	396.67	33.33	**11.90**
Rubus niveus Thunb.	6.67	6.67	1.00
Rubus rosifolius Smith.	6.67	6.67	1.00
Securingea virosa (Roxb. ex wild) Baill.	13.33	10.00	1.33
Smilax perfoliata Lour.	16.67	10.00	1.67
Solanum anguivi Lam.	3.33	3.33	1.00
Solanum torvum Sw.	13.33	6.67	2.00
Tetrastigma bracteolatum (Wall.) Planchon.	50.00	23.33	2.14
Thunbergia grandiflora (Roxb. ex Rottl.) Roxb.	13.33	10.00	1.33
Tithonia diversifolia (Miller.) Blake.	110.00	13.33	8.25
Tragia involucrata Linn.	70.00	10.00	7.00
Urena lobata Linn.	46.67	23.33	2.00

Table 2c. Density, frequency % and abundance of herbaceous species in the highly disturbed (HD) area.

Name of the species	**Density (Indv. ha^{-1})**	**Frequency (%)**	**Abundance**
Achyranthes aspera Linn.	1800	8.00	2.25
Ageratum conyzoides Linn.	3200	10.00	3.20
Amaranthus viridis Linn.	800	2.00	4.00
Ammania baccifera Linn.	5200	8.00	6.50
Anisochilus pallidus Wall.	600	4.00	1.50
Bidens biternata (Lour.) Merr. & Sheriff.	3600	12.00	3.00
Blechnum orientale Linn.	400	4.00	1.00
Blumea laceniata (Roxb.) DC.	2200	10.00	2.20
Canscora andrographiodes Griff.	600	4.00	1.50
Carex spiculata Boott.	1600	8.00	2.00
Centilla asiatica (Linn.) Urban.	3200	8.00	4.00
Coix lacryma-jobi Linn.	800	4.00	2.00
Conyza bonariensis (Linn.) Cronq. in Bull.	3600	12.00	3.00
Conyza lanceolaris (Roxb.) Druce.	800	4.00	2.00
Crassocephalum crepidioides (Benth.) Moore.	1800	10.00	1.80
Cuscuta reflexa Roxb.	4200	8.00	5.25
Cynodon dactylon (Linn.) Pers.	5200	10.00	5.20
Cyperus cyperoides (Linn.) Kuntz.	5000	10.00	5.00
Cyperus iria Linn.	3000	8.00	3.75
Cyperus rotrundus Linn.	5200	8.00	6.50
Cyrtococcum accrescens (Trin) Stapf.	1200	6.00	2.00

Cystococcum patens (Linn.) Cowan	5200	8.00	6.50
Desmodium triquetrum (Linn.) DC.	800	4.00	2.00
Dichrocephala integrifolia (Linn.) Kuntz.	2000	6.00	3.33
Dicranopteris linearis (Burm.) Underwood. **var.** *altissima* Holtt.	1800	8.00	2.25
Eragrostis nutans Nees ex. Steud.	6600	12.00	5.50
Erianthus longisetosus Anderss. ex. Benth.	3600	6.00	6.00
Eryngium foetidium Linn.	1000	4.00	2.50
Fimbristylis dichotoma (Linn.) Vahl.	3000	6.00	5.00
Galinsoga parviflora Cav.	3800	12.00	3.17
Gynura bicolor Roxb. ex Willd.	2800	12.00	2.33
Ichnanthus vicinus (Bail.) Merr.	8400	14.00	6.00
Imperata cylindrica (Linn.) Raeuschel.	**35120**	**60.00**	**58.53**
Impomoea hederifolia Linn.	800	6.00	1.33
Inula cappa Ham. ex. D. Don**.**	3400	14.00	2.43
Knoxia corymbosa Willd.	20400	30.00	6.80
Kyllingia brevifolia Rottb.	2800	6.00	4.67
Lepidagathis hyaline Nees in. Wall.	1800	8.00	2.25
Lobelia angulata Forts.	1000	6.00	1.67
Lycopodium cernuum Linn.	2400	2.00	12.00
Lygodium flexosum (Linn.) Swartz.	1800	12.00	1.50
Lygodium scandens (Linn.) Swartz.	1400	10.00	1.40
Melochia corchorifolia Linn	600	6.00	1.00
Melothria heterophylla (Lour.) Cogn.	400	4.00	1.00
Mikania micrantha Kunth.	2000	10.00	2.00
Mimosa pudica Linn.	2600	8.00	3.25
Mucuna pruriens (Linn.) DC.	1000	8.00	1.25
Neyraudia reynaudiana (Kunth.) King. ex. Hitch.	2200	6.00	3.67
Oxalis corniculata Linn.	2200	6.00	3.67
Paspalum longifolium Roxb.	5600	12.00	4.67
Pennisetum polystachyon Schult.	1400	6.00	2.33
Physalis minima Linn.	400	4.00	1.00
Plantago major Linn.	2800	10.00	2.80
Polygonum alatum Buch-Ham.	2000	6.00	3.33
Polygonum chinense Linn.	3800	12.00	3.17
Polygonum hydropiper Linn.	7400	10.00	7.40
Rungia parviflora Clark.	5200	12.00	4.33
Saccolepis indica Chase.	1600	8.00	2.00
Scleria terrestris Linn.	1200	2.00	6.00
Scoparia dulcis Linn.	1600	4.00	4.00
Setaria palmifolia (Koenig) Stapf.	3000	8.00	3.75
Sida acuta Burm.	1800	6.00	3.00
Solanum khasinum Clark.	2000	8.00	2.50
Solanum nigrum Linn.	400	2.00	2.00
Sphenomeris chinensis (Linn.) Maxon.	4200	4.00	10.50
Spilanthes oleracea Clark.	4400	12.00	3.67
Sporobolus diander (Retz) Beauv.	1800	6.00	3.00
Stellaria media (Linn.) Villars.	4600	6.00	7.67
Thysanolaena maxima (Roxb.) Kuntz.	3800	8.00	4.75
Triumfetta pilosa Roth.	1000	8.00	1.25

Table 3a. Density, frequency % and abundance of tree species in the mildly disturbed (MD) area.

Name of the species	Density (Indv. ha^{-1})	Frequency (%)	Abundance
Acer laevigatum Wall.	50.00	16.67	3.00
Alangium chinense (Lour.) Harms.	3.33	3.33	1.00
Albizia chinensis (Osb.) Merr.	50.00	23.33	2.14
Albizia thomsoni Brandis	33.33	16.67	2.00
Alseodaphne petiolaris Hook.	33.33	10.00	3.33
Amoora chittagonga (Miq.) Hiern	10.00	6.67	1.50
Anogeissus acuminata (Roxb. ex DC.) Guill. & Perr.	53.33	33.33	1.60
Antidesma bunius Spreng.	3.33	3.33	1.00
Aporusa octandra (Buch.-Ham. ex D. Don) Vickery.	250.00	**70.00**	3.57
Artocarpus lakoocha Roxb.	13.33	10.00	1.33
Beilschmiedia assamica Meissn.	30.00	10.00	3.00
Bischofia javanica Bl.	20.00	3.33	6.00
Bochmeria rugulosa Wedd.	13.33	10.00	1.33
Callicarpa arboria Roxb.	60.00	26.67	2.25
Carallia brachiata (Lour.) Merr.	3.33	3.33	1.00
Cassia nodosa Buch.-Ham. ex Roxb.	13.33	6.67	2.00
Cassia timoriensis DC.	6.67	6.67	1.00
Castanopsis indica DC.	43.33	16.67	2.60
Castanopsis tribuloides DC.	**400.00**	**70.00**	5.71
Celtis tetrandra Roxb.	63.33	26.67	2.38
Cinnamomum obtusifolium Roxb. ex Nees.	10.00	6.67	1.50
Cinnamomum tamala (Buch. – Ham.) Nees.	3.33	3.33	1.00
Cinnamomum verum Presl.	23.33	16.67	1.40
Colona floribunda (Kurz.) Craib.	16.67	6.67	2.50
Derris robusta (Roxb. ex DC.) Benth.	26.67	13.33	2.00
Diospyros glandulosa Lace.	3.33	3.33	1.00
Diospyros lanceaefolia Roxb.	6.67	3.33	2.00
Duabanga grandiflora (Roxb. ex DC) Walp.	3.33	3.33	1.00
Dysoxylum binecteriferum (Roxb.) Hook.ex Beddome.	10.00	6.67	1.50
Elaeocarpus aristatus Roxb.	3.33	3.33	1.00
Elaeocarpus lanceifolious Roxb.	43.33	16.67	2.60
Emblica officinalis Goertn.	116.67	36.67	3.18
Engelhardtia spicata Lechen ex Bl.	36.67	13.33	2.75
Ficus hirta Vahl.	46.67	16.67	2.80
Ficus prostrata Wall.	20.00	10.00	2.00
Ficus semicordata Buch.-Ham **var**. *conglomerata* Roxb.	13.33	6.67	2.00
Ficus semicordata Buch.-Ham.	26.67	10.00	2.67
Garcinia sopsopia (Buch-Ham.) Mabberley.	3.33	3.33	1.00
Glochidion khasicum Hook.	136.67	40.00	3.42
Gmelina arborea Roxb.	6.67	6.67	1.00
Haldina cordufolia (Roxb.) Ridsdale.	60.00	10.00	6.00
Ilex umbellulata (Wall.) Loes.	30.00	13.33	2.25
Itea macrophylla Wall.	43.33	16.67	2.60
Litsea monopetala (Roxb.) Pers.	66.67	23.33	2.86
Macaranga indica Wight.	40.00	20.00	2.00
Machilus kingii Hook.	23.33	13.33	1.75

Machilus odoratissima Nees	20.00	10.00	2.00
Machilus villosa Hook.	106.67	43.33	2.46
Macropanax dispermus (Bl.) Kuntze.	40.00	16.67	2.40
Maesa ramentacea DC.	13.33	10.00	1.33
Mallotus albus (Muell.- Arg).	13.33	3.33	4.00
Mangifera indica Linn.	13.33	3.33	4.00
Melia azedarach Linn.	3.33	3.33	1.00
Meliosma pinnata (Roxb.) Maxim.	3.33	3.33	1.00
Melocanna baccifer (Roxb.) Kurz.	40.00	6.67	6.00
Micromelum minutum (Forst.) Wight & Arn.	10.00	6.67	1.50
Morus macroura Miq.	20.00	10.00	2.00
Musa glauca Roxb.	3.33	3.33	1.00
Nyssa javanica (Bl.) Wanger.	6.67	6.67	1.00
Oroxylum indicum (Linn.)Vent.	13.33	10.00	1.33
Parkia roxburghii (DC.) Merr.	3.33	3.33	1.00
Phoebe lanceolata Nees.	226.67	46.67	4.86
Phoebe hainesiana Brandis.	36.67	13.33	2.75
Pithecelobium bigeminum auct. non (Linn.) Mart.	90.00	30.00	3.00
Polygala arillata Buch.-Ham. ex. D. Don.	6.67	6.67	1.00
Rhus semialata Murr.	83.33	23.33	3.57
Rhus succedanea Linn.	20.00	10.00	2.00
Sapium baccatum Roxb.	30.00	13.33	2.25
Saurauia panduana Wall.	143.33	30.00	4.78
Schima wallichii (DC.) Korthals.	216.67	53.33	4.06
Sterculia villosa Roxb. ex Sm.	26.67	16.67	1.60
Stereospermum colais (Buch. -Ham. ex. Dillw.) Mabber.	40.00	16.67	2.40
Styrax polyspermum Clark.	13.33	3.33	4.00
Styrax serrulatum Roxb.	186.67	40.00	4.67
Syzygium claviflorum (Roxb.) Wall. ex. Cowan.	16.67	6.67	2.50
Syzygium cumini (Linn.) Skeels.	23.33	10.00	2.33
Syzygium operculatum (Roxb.) Niedenzuvar.var.*obovatum* (Wall. ex Duthie.)	10.00	3.33	3.00
Terminalia arjuna (Roxb.)Wight & Arn	10.00	6.67	1.50
Toona ciliata Roemer.	13.33	6.67	2.00
Ulmus lancifolia Roxb.	3.33	3.33	1.00
Vitex peduncularis Wall ex Schauer.	10.00	6.67	1.50
Wendlandia grandis Hook.	306.67	43.33	**7.08**

Table 3b. Density, frequency % and abundance of shrub species in the mildly disturbed (MD) area.

Name of the species	**Density (Indv. ha^{-1})**	**Frequency (%)**	**Abundance**
Acacia pruinescens Kurz.	23.33	13.33	1.75
Acanthus leucastachyus Wall.	46.67	23.33	2.00
*Alchornea tiliaefolia (*Benth.) Muell. Arg.	30.00	13.33	2.25
Allophylus cobbe Bl.	16.67	10.00	1.67
Antidesma acidium Retz.	53.33	20.00	2.67
Bauhinia glauca (Wall. ex Benth.) Benth.	10.00	10.00	1.00
Bridelia stipularis (Linn.) Bl.	53.33	33.33	1.60
Buddleja asiatica Lour.	10.00	10.00	1.00

Byttneria pilosa Roxb.	46.67	30.00	1.56
Caesalpinia cucullata Roxb.	73.33	26.67	2.75
Camellia kissi Wall.	10.00	10.00	1.00
Camellia sinensis (Linn.) Kuntz.	13.33	10.00	1.33
Chromolaena odorata (Linn.) King & Robinson	310.00	33.33	9.30
Cissampelos pareira Linn.	220.00	56.67	3.88
Cissus repens Lam.	210.00	**60.00**	3.50
Clerodendrum colebrookianum Walp.	13.33	6.67	2.00
Clerodendrum infortunatum Linn.	200.00	50.00	4.00
Coffea khasiana Hook.	186.67	50.00	3.73
Colquhounia coccinea Wall.	10.00	6.67	1.50
Combretum alatum Pers.	6.67	6.67	1.00
Combretum roxburghii Spreng.	136.67	43.33	3.15
Dalbergia pinnata (Lour.) Prain.	6.67	6.67	1.00
Dalbergia stipulacea Roxb.	130.00	40.00	3.25
Dendrocnide sinuata **(**Bl.) Chew.	110.00	16.67	6.60
Derris thyrsflora (Benth.)	123.33	40.00	3.08
Desmodium gyroides (Roxb.ex Link) DC.	13.33	10.00	1.33
Desmodium triangulare (Retz.) Merr.	86.67	30.00	2.89
Embelia subcoriacea (Clark.) Mez.	66.67	30.00	2.22
Entada pursaetha DC.	33.33	16.67	2.00
Eurya acuminata DC.	36.67	10.00	3.67
Eurya cerasifolia (D. Don.) Kobuski.	46.67	26.67	1.75
Ficus hispida Linn.	23.33	16.67	1.40
Flemingia macrophylla (Willd.) Kuntz ex Merr.	23.33	10.00	2.33
Garcinia cowa Roxb. ex DC.	**403.33**	40.00	**10.08**
Hedyotis scandens Roxb.	26.67	20.00	1.33
Hodgsonia macrocarpa (Bl.) Cogn.	23.33	13.33	1.75
Kadsura heteroclita (Roxb.) Craib.	33.33	23.33	1.43
Lasianthus lucidus Bl.	16.67	10.00	1.67
Leea asiatica Kurz.	90.00	20.00	4.50
Lepionurus sylvestris Bl.	253.33	36.67	6.91
Linostoma decandrum Wall.	40.00	20.00	2.00
Maesa indica (Roxb.) Wall.	93.33	43.33	2.15
Malvastrum tricuspidatum Gray.	33.33	16.67	2.00
Melastoma malabatricum Linn.	16.67	13.33	1.25
Melastoma nepalensis Lodd.	146.67	33.33	4.40
Merreremia umbellata (Linn.) Hall.	33.33	26.67	1.25
Millettia pachycarpa Benth.	63.33	23.33	2.71
Morinda angustifolia Roxb.	66.67	30.00	2.22
Mussaenda glabra Vahl.	90.00	40.00	2.25
Mussaenda parryorum Fischer.	136.67	36.67	3.73
Mussaenda roxburghii Hook.	6.67	6.67	1.00
Oxyspora paniculata (D. Don) DC.	3.33	3.33	1.00
Paederia foetida Linn.	80.00	20.00	4.00
Pandanus pseudofoetidus Roxb.	33.33	16.67	2.00
Pentanura khasiana Kurz.	26.67	16.67	1.60
Phyllanthus reticulatus (Poir). Baill.	143.33	40.00	3.58
Pueraria lobata (Willd.) Ohwi.	53.33	26.67	2.00
Rhamnus napalensis Wall.	20.00	10.00	2.00
Rhynchoglossum obliquum Bl.	6.67	6.67	1.00
Ricinus communis Linn.	73.33	30.00	2.44

Rourea minor (Gaertner) Leenh.	290.00	50.00	5.80
Rubus birmanicus Hook.	16.67	6.67	2.50
Rubus ellipticus Smith.	36.67	20.00	1.83
Securingea virosa (Roxb. ex wiild) Baill.	46.67	30.00	1.56
Smilax perfoliata Lour.	13.33	10.00	1.33
Sterculia coccinea Roxb.	26.67	10.00	2.67
Strobilanthes maculatus Nees.	156.67	50.00	3.13
Tabernaemontana divaricata (Linn.) Br. ex. Roem. & Schultes.	60.00	26.67	2.25
Tetrastigma bracteolatum (Wall.) Planchon.	26.67	10.00	2.67
Tetrastigma leucostaphylum (Dennst.) Alston ex Mabb.	33.33	10.00	3.33
Thunbergia grandiflora (Roxb. ex Rottl.) Roxb.	26.67	3.33	8.00
Tragia involucrata Linn.	23.33	13.33	1.75
Trevesia palmata (Roxb.) Vis.	33.33	13.33	2.50
Uncaria laevigata Wall.	50.00	23.33	2.14
Viburnum mullaha Buch.-Ham.ex D. Don	13.33	10.00	1.33
Willughbeia edulis Roxb.	3.33	3.33	1.00
Zanthoxylum armatum DC.	30.00	6.67	4.50

Table 3c. Density, frequency % and abundance of herbaceous species in the mildly disturbed (MD) area.

Name of the species	**Density (Indv. ha^{-1})**	**Frequency (%)**	**Abundance**
Abelmoschus moschatus Medicus.	600	4.00	1.50
Achyranthes bidentata Bl.	2000	8.00	2.50
Ageratum conyzoides Linn.	3600	10.00	3.60
Alocasia fornicate (Roxb.) Schott**.**	400	4.00	1.00
Alpina bracteata Roxb. Rose.	2800	12.00	2.33
Amomum dealbatum Roxb.	1600	8.00	2.00
Arisaema tortuosum (Wall.) Schott.	800	6.00	1.33
Canscora andrographiodes Griff.	1200	6.00	2.00
Centilla asiatica (Linn.) Urban.	2400	12.00	2.00
Cibotium baromtez (Linn.) Sm.	1400	8.00	1.75
Commelina sikkimensis Clark	3400	16.00	2.13
Conyza bonariensis (Linn.) Cronq.	1200	6.00	2.00
Costus speciosus (Koenig.) Sm.	3000	**20.00**	1.50
Curculigo capitulata (Lour.) Kuntz.	1400	8.00	1.75
Cyperus cyperoides (Linn.) Kuntz.	2400	10.00	2.40
Davallia trichomanoides Bl.	2000	8.00	2.50
Desmodium triquetrum (Linn.) DC.	1400	8.00	1.75
Dicranopteris linearis (Burm.) Underwood. **var.** *altissima* Holtt.	1600	6.00	2.67
Dioscorea alata Linn.	600	6.00	1.00
Dioscorea bulbifera Linn.	1200	10.00	1.20
Dioscorea glabra Roxb.	1000	6.00	1.67
Diplazium maxima (D. Don.) Chatt.	2800	8.00	3.50
Gynura bicolor (Roxb.ex Willd.)	2800	8.00	3.50
Ichnanthus vicinus (Bail.) Merr.	5800	**20.00**	2.90
Imperata cylindrica (Linn.) Raeuschel.	6600	12.00	5.50
Inula cappa (Ham. ex. D. Don)**.**	4200	12.00	3.50

Lygodium flexosum (Linn.) Swartz.	600	6.00	1.00
Melothria heterophylla (Lour.) DC.	1200	6.00	2.00
Microlepia strigosa (Thunb.) Presl.	1000	6.00	1.67
Microsarum superficiale (Bl.) Ching.	800	8.00	1.00
Mikania micrantha Kunth.	3000	10.00	3.00
Panicum punctatum Burm.	5400	18.00	3.00
Phrynium capitatum Willd.	3200	10.00	3.20
Phylanthus urinaria Linn.	3400	10.00	3.40
Polygonum alatum Buch-Ham.	3400	16.00	2.13
Polygonum barbatam Linn.	1800	10.00	1.80
Polygonum chinense Linn.	2000	10.00	2.00
Pothos scandens Linn.	600	4.00	1.50
Pronephrium nudatum Roxb.	2000	8.00	2.50
Pteridium aquilinum (Linn.) Kuhn.	4600	18.00	2.56
Saccolepis indica Chase.	4000	14.00	2.86
Scleria terrestris (Linn.)	3000	10.00	3.00
Spermacoca hipida Linn.	2200	10.00	2.20
Sphenomeris chinensis (Linn.) Maon.	2400	4.00	6.00
Strobilanthes simonsii Anders.	1600	6.00	2.67
Thysanolaena maxima (Roxb.) Kuntz.	**14800**	14.00	**10.57**

Table 4a. Density, frequency % and abundance of tree species in the undisturbed (UD) area.

Name of the species	Density (Indv. ha^{-1})	Frequency (%)	Abundance
Acrocarpus fraxinifolius Wight.ex Arn.	10.00	10.00	1.00
Actinadaphne obovata (Nees) Bl.	93.33	36.67	2.55
Adenanthera pavonina Linn.	3.33	3.33	1.00
Alangium chinense (Lour.) Harms.	**186.67**	56.67	3.29
Albizia chinensis (Osb.) Merr.	20.00	16.67	1.20
Albizia thomsoni Brandis	23.33	10.00	2.33
Alstonia scholaris (Linn.) Br.	6.67	3.33	2.00
Anogeissus acuminata (Roxb. ex DC.) Guill. & Perr.	13.33	10.00	1.33
Aporusa octandra (Buch.-Ham. ex D.Don) Vickery.	36.67	20.00	1.83
Artocarpus chama Buch.-Ham.	6.67	6.67	1.00
Artocarpus heterophyllus Lam.	20.00	6.67	3.00
Artocarpus lakoocha Roxb.	86.67	36.67	2.36
Bischofia javanica Bl.	180.00	**66.67**	2.70
Bombax insigne Wall.	10.00	6.67	1.50
Bridelia monoica (Lour.) Merr.	36.67	20.00	1.83
Brusera serrata Wall. ex. Colebr.	16.67	3.33	5.00
Callicarpa arboria Roxb.	43.33	20.00	2.17
Canarium stritum Roxb.	3.33	3.33	1.00
Caryota urens Linn.	3.33	3.33	1.00
Cassia nodosa Buch.-Ham. ex Roxb.	10.00	10.00	1.00
Castanopsis tribuloides DC.	36.67	10.00	3.67
Celtis australis Linn.	150.00	43.33	3.46
Celtis tetrandra Roxb.	3.33	3.33	1.00
Chukrasia tabularis Juss.	6.67	6.67	1.00
Cinnamomum obtusifolium Roxb. ex Nees.	13.33	10.00	1.33
Cinnamomum verum Presl.	10.00	3.33	3.00
Colona floribunda (Kurz.) Craib.	103.33	33.33	3.10

Cordia dichotoma Forst.	40.00	20.00	2.00
Cyathea gigantea Wall ex Hook.	26.67	10.00	2.67
Dendrocalamus hamitonii Nees.	40.00	3.33	12.00
Dendrocalamus longispathus Kurz.	50.00	3.33	**15.00**
Derris robusta (Roxb.ex DC) Benth.	96.67	36.67	2.64
Diospyros lanceaefolia Roxb.	10.00	6.67	1.50
Drimycarpus resemosus (Roxb.) Hook.	23.33	16.67	1.40
Dryptes lancifolia (Hook.) Pax. ex Hoffm.	16.67	13.33	1.25
Duabanga grandiflora (Roxb. ex DC) Walp.	10.00	6.67	1.50
Dysoxylum binecteriferum (Roxb.) Hook. ex Beddome.	40.00	23.33	1.71
Ehretia acuminata Br.	23.33	10.00	2.33
Elaeocarpus floribundas Bl.	53.33	26.67	2.00
Emblica officinalis Goertn.	23.33	13.33	1.75
Eriobotrya bengalensis Hook.	183.33	53.33	3.44
Erythrina stricta Roxb.	3.33	3.33	1.00
Euonymus glaber Wall. in Roxb.	20.00	10.00	2.00
Ficus benjamina Linn.	53.33	20.00	2.67
Ficus elatica Roxb.	3.33	3.33	1.00
Ficus geniculata Kurz.	10.00	10.00	1.00
Ficus prostrata Wall.	33.33	20.00	1.67
Ficus religiosa Linn.	36.67	13.33	2.75
Firmiana colorata (Roxb.) Br.	10.00	10.00	1.00
Flacourtia jangomas (Lour.) Raeusch.	13.33	13.33	1.00
Garcinia xanthochymus Hook.ex Anderson.	3.33	3.33	1.00
Garuga floribunda var.*gamblei* Linn.(King ex W. Smith) Kalkman	6.67	6.67	1.00
Glochidion velutinum Wight.	10.00	6.67	1.50
Gmelina arborea Roxb.	6.67	6.67	1.00
Grewia desperma Rottl. ex Spreng.	33.33	6.67	5.00
Haldina cordufolia (Roxb.) Ridsdale.	16.67	13.33	1.25
Itea macrophylla Wall.	13.33	3.33	4.00
Kydia calycina Roxb.	40.00	16.67	2.40
Lagerstroemia speciosa Linn.	13.33	10.00	1.33
Litsea citrata Bl.	13.33	10.00	1.33
Litsea monopetala (Roxb.) Pers.	50.00	26.67	1.88
Macaranga indica Wight.	90.00	26.67	3.38
Machilus parviflora Meissn.	6.67	6.67	1.00
Machilus villosa Hook.	86.67	46.67	1.86
Macropanax dispermus (Bl.) Kuntz.	173.33	43.33	4.00
Maesa ramentacea DC.	20.00	16.67	1.20
Mangifera indica Linn.	73.33	20.00	3.67
Melocanna baccifer (Roxb.) Kurz.	40.00	3.33	12.00
Mesua ferrea Linn.	16.67	10.00	1.67
Michelia champaca Wall. ex Hook. & Thomson.	3.33	3.33	1.00
Mitragyna diversifolia Haviland.	63.33	36.67	1.73
Morus macroura Miq.	50.00	33.33	1.50
Murraya koenigii (Linn.) Spreng.	16.67	6.67	2.50
Musa acuminata Colla.	56.67	13.33	4.25
Olea dentate var. *salicifolia* Wall.	16.67	10.00	1.67
Olea dioca Roxb.	10.00	10.00	1.00
Oreocnide integrefolia Miq.	33.33	16.67	2.00

Oroxylum indicum (Linn.)Vent.	50.00	40.00	1.25
Pandanus tectorius Soland ex Parkinson	10.00	3.33	3.00
Parkia roxburghii (DC.) Merr.	6.67	6.67	1.00
Phoebe lanceolata Nees.	66.67	30.00	2.22
Phoebe hainesiana Brandis.	13.33	6.67	2.00
Pithecelobium bigeminum auct. non (Linn.) Mart.	6.67	3.33	2.00
Pterospermum lancifolium Roxb.	10.00	10.00	1.00
Quercus listeria King.	3.33	3.33	1.00
Randia wallichii Hook	83.33	33.33	2.50
Rhus succedanea Linn.	6.67	6.67	1.00
Saurauia napaulensis DC.	86.67	30.00	2.89
Schima wallichii (DC.) Korthals.	16.67	16.67	1.00
Spondias pinnata (Linn.) Kurz.	43.33	20.00	2.17
Sterculia urens Roxb.	16.67	13.33	1.25
Sterculia villosa Roxb. ex Sm.	26.67	16.67	1.60
Stereospermum colais (Buch. -Ham. ex Dillw.) Mabber.	50.00	33.33	1.50
Syzygium cumini (Linn.) Skeels.	20.00	13.33	1.50
Syzygium operculatum (Roxb.) Niedenzuvar.**var**.*obovatum* (Wall. ex Duthie.)	13.33	10.00	1.33
Toona ciliata M.Roemer.	33.33	20.00	1.67
Trema orientalis (Linn.) Bl.	26.67	13.33	2.00
Ulmus lancifolia Roxb.	6.67	3.33	2.00
Vitex heterophylla Roxb.	120.00	50.00	2.40
Vitex peduncularis Wall. ex Schauer.	20.00	10.00	2.00
Wendlandia grandis Hook.	3.33	3.33	1.00

Table 4b. Density, frequency % and abundance of shrub species in the undisturbed (UD) area.

Name of the species	**Density (Indv. ha^{-1})**	**Frequency (%)**	**Abundance**
Acacia pennata (Linn.) Willd.	30.00	13.33	2.25
Andrachne cordifolia Muell.	20.00	16.67	1.20
Artemisia indica Willd.	16.67	13.33	1.25
Bridelia stipularis (Linn.) Bl.	66.67	30.00	2.22
Caesalpinia cucullata Roxb.	30.00	13.33	2.25
Cajanus goensis Dalz.	13.33	3.33	4.00
Calamus tenuis Roxb.	3.33	3.33	1.00
Callicarpa longifolia Lam.	36.67	20.00	1.83
Cassia occidentalis Linn.	33.33	13.33	2.50
Chromolaena odorata (Linn.) King & Robinson	173.33	10.00	**17.33**
Cissampelos pareira Linn.	73.33	20.00	3.67
Cissus repens Lam.	66.67	10.00	6.67
Citrus medica Linn.	3.33	3.33	1.00
Clematis tortuosa (Wall ex Hook. & Thomson.) Fischer.	46.67	20.00	2.33
Clerodendrum colebrookianum Walp.	23.33	6.67	3.50
Clerodendrum infortunatum Linn.	83.33	16.67	5.00
Coffea khasiana Hook.	150.00	**46.67**	3.21
Combretum flagrocarpum Clark.	100.00	23.33	4.29
Combretum roxburghii Spreng.	83.33	26.67	3.13
Crotalaria mysorensis Roth.	10.00	6.67	1.50

Croton caudatus Geisel.	46.67	16.67	2.80
Debregeasia longifolia Wedd.	60.00	23.33	2.57
Dendrocnide sinuata **(**Bl.) Chew.	**180.00**	23.33	7.71
Derris thyrsflora Benth.	26.67	10.00	2.67
Desmodium pulchellum (Linn.) Benth.	33.33	3.33	10.00
Elaeagnus pyriformis Hook.	13.33	6.67	2.00
Embelia subcoriacea (Clark.) Mez.	13.33	6.67	2.00
Embelia vestita Roxb.	16.67	10.00	1.67
Fagerlindia faciculata (Roxb.) Tirvengadum.	33.33	16.67	2.00
Garcinia cowa Roxb. ex DC.	66.67	13.33	5.00
Gnetum montanum MG.	6.67	3.33	2.00
Goniothalamus sesquipedalis (Wall.) Hook. & Thomson**.**	20.00	10.00	2.00
Hodgsonia macrocarpa (Bl.) Cogn.	16.67	10.00	1.67
Indigofera dosua Buch-Ham. ex. D. Don.	43.33	13.33	3.25
Jasminum glandulosum Wall.	13.33	10.00	1.33
Jasminum undulatum Ker.	46.67	16.67	2.80
Leea asiatica Kurz.	76.67	20.00	3.83
Lepionurus sylvestris Bl.	56.67	13.33	4.25
Licuala peltata Roxb.	16.67	10.00	1.67
Litsea salicifolia (Roxb. ex. Wall) Hook.	36.67	13.33	2.75
Maesa indica (Roxb.) Wall.	133.33	**46.67**	2.86
Malvastrum tricuspidatum Gray.	10.00	6.67	1.50
Melastoma nepalensis Lodd.	40.00	10.00	4.00
Merreremia umbellata (Linn.) Hall.	26.67	13.33	2.00
Merreremia vitifolia (Burm.) Hall.	46.67	23.33	2.00
Millettia pachycarpa Benth.	93.33	33.33	2.80
Mussaenda frondosa Linn.	33.33	20.00	1.67
Mussaenda glabra Vahl.	60.00	10.00	6.00
Passiflora edulis Sims.	3.33	3.33	1.00
Phlogacanthus wallichii Clark**.**	66.67	23.33	2.86
Phyllanthus reticulatus (Poir). Bail.	150.00	30.00	5.00
Piper diffusum Vahl.	13.33	10.00	1.33
Piper peepuloides Roxb.	16.67	10.00	1.67
Piper thomsonii Hook.	13.33	10.00	1.33
Psychotria calocarpa Kurz.	36.67	13.33	2.75
Psychotria denticulata Wall.	16.67	13.33	1.25
Psychotria fulva Buch-Ham.	40.00	10.00	4.00
Pueraria lobata (Willd.) Ohwi.	23.33	10.00	2.33
Rhaphidophora decursiva (Roxb.) Schott.	33.33	13.33	2.50
Rhynchotechum elliptium DC.	33.33	3.33	10.00
Rourea minor (Gaertner) Leenh.	33.33	16.67	2.00
Roydsia suaveolens Roxb.	26.67	6.67	4.00
Rubus birmanicus Hook.	136.67	20.00	6.83
Rubus lasicarpus Sm.	6.67	3.33	2.00
Sarcochlamys pulcherrima Gaud.	6.67	3.33	2.00
Schefflera venulosa (Wight & Arn.) Harm.	36.67	16.67	2.20
Securingea virosa (Roxb. ex willd) Bail.	46.67	26.67	1.75
Smilax perfoliata Lour.	36.67	16.67	2.20
Strobilanthes petiolaris Nees.	40.00	13.33	3.00
Tabernaemontana divaricata (Linn.) Br. ex. Roem. & Schultes.	90.00	16.67	5.40
Tetrastigma bracteolatum (Wall.) Planchon.	120.00	33.33	3.60

Tetrastigma leucostaphylum (Dennst.) Alston ex Mabb.	36.67	13.33	2.75
Thladiantha calcerata Clark.	33.33	10.00	3.33
Thunbergia grandiflora (Roxb. ex Rottl.) Roxb.	133.33	36.67	3.64
Tinospora cordifolia (Willd.) Hook. & Th.	50.00	16.67	3.00
Trevesia palmata (Roxb.) Vis.	26.67	16.67	1.60
Trichosanthes tricuspidata Lour.	20.00	10.00	2.00
Uncaria sessilifructus Roxb.	16.67	6.67	2.50

Table 4c. Density, frequency % and abundance of herbaceous species in the undisturbed (UD) area.

Name of the species	**Density (Indv. ha^{-1})**	**Frequency (%)**	**Abundance**
Achyranthes aspera Linn.	10400	16.00	6.50
Aeginetia indica Roxb.	600	2.00	3.00
Aeschynanthus superba Clak.	400	2.00	2.00
Alpina bracteata Roxb.	2600	6.00	4.33
Amomum dealbatum Roxb.	2800	10.00	2.80
Arisaema tortuosum (Wall.) Schott.	800	6.00	1.33
Blechnum orientale Linn.	1200	4.00	3.00
Canscora andrographiodes Griff.	1400	8.00	1.75
Capsicum annuum Linn.	200	2.00	1.00
Centilla asiatica (Linn.) Urban.	2400	4.00	6.00
Commelina sikkimensis Clark.	4200	14.00	3.00
Costus speciosus (Koenig) Sm.	600	4.00	1.50
Curanga amara Juss.	1200	4.00	3.00
Cyrtococcum accrescens (Trin) Stapf.	1000	4.00	2.50
Cystococcum patens (Linn) Cowan.	3400	10.00	3.40
Desmodium floribundum (D. Don.) Sweet ex G. Don.	4000	10.00	4.00
Desmodium triquetrum (Linn.) DC.	2600	4.00	6.50
Diplazium maxima (D. Don.) Chatt.	3000	6.00	5.00
Drymaria diandra Bl.	600	4.00	1.50
Ebermaiera staurogyne Nees.	600	4.00	1.50
Eranthemum palatiferum. Nees	**20600**	**34.00**	6.06
Globba multiflora Wall.	400	2.00	2.00
Ichnanthus vicinus (Bail) Merr.	6600	20.00	3.30
Lepidagathis hyaline Nees.	6000	22.00	2.73
Mikania micrantha Kunth.	600	6.00	1.00
Mollugo pentaphylla Linn.	400	2.00	2.00
Phrynium capitatum Willd.	4600	6.00	**7.67**
Phyllanthus fraternus Webster.	1200	2.00	6.00
Piperomia pellucida (Linn.) H.B.K.	800	6.00	1.33
Pothos cathcartii Schott.	1200	8.00	1.50
Pronephrium nudatum Roxb.	1400	6.00	2.33
Ranunculus catoniensis D.C.	200	2.00	1.00
Sonerila maculata Roxb.	2000	4.00	5.00
Thysanolaena maxima (Roxb.) Kuntz.	1200	6.00	2.00
Triumfetta pilosa Roth.	2000	6.00	3.33

Table 5a. Relative density, relative frequency, relative dominance and important value index (IVI) of tree species in the highly disturbed (HD) area.

Name of the species	Relative density (%)	Relative frequency (%)	Relative dominance (%)	IVI
Alangium chinense (Lour.) Harms.	1.71	2.34	1.96	6.01
Albizia chinensis (Osb.) Merr.	6.84	7.03	5.13	19.00
Albizia thomsoni Brandis	2.99	2.34	1.48	6.82
Albizzia procera (Roxb.) Benth.	1.71	2.34	1.40	5.46
Aporusa octandra (Buch.-Ham. ex D.Don) Vickery.	16.24	7.81	8.00	**32.05**
Artocarpus heterophyllus Lam.	0.43	0.78	2.16	3.36
Callicarpa arborea Roxb.	5.56	7.03	4.52	17.11
Castanopsis tribuloides DC.	4.27	4.69	8.91	17.87
Derris robusta (Roxb.ex DC) Benth.	2.99	3.13	4.81	10.92
Ehretia acuminata Br.	0.43	0.78	0.73	1.93
Elaeocarpus floribundas Bl.	1.28	1.56	0.87	3.71
Emblica officinalis Goertn.	5.13	4.69	2.53	12.34
Engelhardtia spicata Lechen ex Bl.	1.28	2.34	6.01	9.64
Glochidion khasicum Hook.	2.99	4.69	4.62	12.30
Glochidion velutinum Wight.	1.28	2.34	2.07	5.69
Haldina cordufolia (Roxb.) Ridsdale.	2.56	3.13	2.79	8.48
Ilex umbellulata (Wall.) Loes.	2.56	3.91	2.09	8.56
Lagerstroemia speciosa Linn.	0.85	1.56	4.16	6.58
Litsea monopetala (Roxb.) Pers.	6.84	3.91	4.85	15.59
Phoebe lanceolata Nees.	1.71	2.34	0.70	4.76
Rhus semialata Murr.	8.12	7.03	4.31	19.46
Sapium baccatum Roxb.	1.71	3.13	3.97	8.81
Sapium insigne Benth.	1.71	3.13	2.73	7.56
Schima wallichii (DC.) Korthals.	9.40	7.03	7.66	24.09
Trema orientalis (Linn.) Bl.	1.71	3.13	5.82	10.65
Wendlandia grandis Hook.	7.69	7.81	5.72	21.23

Table 5b. Relative density, relative frequency, relative dominance and important value index (IVI) of shrub species in the highly disturbed (HD) area.

Name of the species	Relative density (%)	Relative frequency (%)	Relative dominance (%)	IVI
Acacia pennata (Linn.) Willd.	0.26	0.92	0.18	1.36
Aspidopterys nutans (Roxb. ex. DC.) Juss.	0.51	1.38	0.10	1.99
Bridelia stipularis (Linn.) Bl.	1.93	3.67	9.24	14.84
Butea parviflora Roxb.	2.31	4.13	1.90	8.34
Cajanus cajan (Linn.) Millsp.	0.77	1.83	0.36	2.97
Cassia occidentalis Linn.	6.56	7.80	3.04	17.39
Chromolaena odorata (Linn.) King & Robinson	27.38	10.55	19.32	**57.24**
Cissampelos pareira Linn.	1.16	2.75	0.03	3.94
Cissus japonica **(**Wall.) Planchon.	1.16	1.83	0.10	3.09
Cissus repens Lam.	3.08	3.21	0.47	6.76
Clerodendrum infortunatum Linn.	3.21	4.13	4.21	11.55
Coffea khasiana Hook.	1.03	1.38	1.79	4.20
Combretum flagrocarpum Clark in Hook.	2.57	4.13	3.70	10.40
Cryptolepis buchanani Roem. & Schult.	0.13	0.46	0.10	0.68

Dalbergia stipulacea Roxb.	3.08	5.50	5.11	13.70
Derris thyrsflora Benth.	1.41	1.83	5.34	8.59
Entada pursaetha DC.	0.26	0.92	5.88	7.05
Lantana camara Linn. **Var**. *aculeata* Linn.	0.64	0.92	0.11	1.67
Linostoma decandrum Wall.	1.03	1.83	0.81	3.67
Litsea salicifolia (Roxb. ex. Wall) Hook.	1.16	1.83	0.80	3.79
Maesa indica (Roxb.) Wall.	2.57	3.67	2.17	8.41
Melastoma malabatricum Linn.	1.16	1.83	0.96	3.95
Melastoma nepalensis Lodd.	4.24	4.59	2.99	11.82
Merreremia vitifolia (Burm.) Hall.	0.51	1.38	0.08	1.97
Millettia pachycarpa Benth.	0.51	1.38	1.32	3.21
Mussaenda frondosa Linn.	0.51	1.83	0.18	2.53
Paederia foetida Linn.	1.41	1.38	0.19	2.98
Plectranthus hispidus Benth.	0.64	1.38	0.22	2.23
Rubus birmanicus Hook.	15.30	4.59	18.94	38.83
Rubus niveus Thunb.	0.26	0.92	0.11	1.29
Rubus rosifolius Sm.	0.26	0.92	0.08	1.26
Securingea virosa (Roxb. ex wild) Bail.	0.51	1.38	3.68	5.57
Smilax perfoliata Lour.	0.64	1.38	0.16	2.17
Solanum anguivi Lam.	0.13	0.46	0.05	0.64
Solanum torvum Sw.	0.51	0.92	0.40	1.84
Tetrastigma bracteolatum (Wall.) Planchon.	1.93	3.21	0.43	5.57
Thunbergia grandiflora (Roxb. ex Rottl.) Roxb.	0.51	1.38	0.07	1.96
Tithonia diversifolia (Miller.) Blake.	4.24	1.83	3.40	9.48
Tragia involucrata Linn.	2.70	1.38	0.26	4.34
Urena lobata Linn.	1.80	3.21	1.72	6.73

Table 5c. Relative density, relative frequency, relative dominance and important value index (IVI) of herbaceous species in the highly disturbed (HD) area.

Name of the species	**Relative density (%)**	**Relative frequency (%)**	**Relative dominance (%)**	**IVI**
Achyranthes aspera Linn.	0.33	1.32	0.29	1.94
Ageratum conyzoides Linn.	0.58	1.65	0.60	2.84
Amaranthus viridis Linn.	0.15	0.33	0.51	0.99
Ammania baccifera Linn.	0.94	1.32	0.25	2.52
Anisochilus pallidus Wall. Vern.	0.11	0.66	0.40	1.17
Bidens biternata (Lour.) Merr. & Sheriff.	0.65	1.98	1.71	4.34
Blechnum orientale Linn.	0.07	0.66	0.17	0.91
Blumea laceniata (Roxb.) DC.	0.40	1.65	0.95	2.99
Canscora andrographiodes Griff.	0.11	0.66	0.25	1.02
Carex spiculata Boott.	0.29	1.32	0.13	1.74
Centilla asiatica (Linn.) Urban.	0.58	1.32	0.18	2.08
Coix lacryma-jobi Linn.	0.15	0.66	2.22	3.03
Conyza bonariensis (Linn.) Cronq.	0.65	1.98	2.56	5.19
Conyza lanceolaris (Roxb.) Druce.	0.15	0.66	1.09	1.89
Crassocephalum crepidioides (Benth) Moore.	0.33	1.65	0.76	2.73
Cuscuta reflexa Roxb.	0.76	1.32	0.68	2.77
Cynodon dactylon (Linn.) Pers.	0.94	1.65	0.60	3.19
Cyperus cyperoides (Linn.) Kuntz.	0.91	1.65	0.71	3.27
Cyperus iria Linn.	0.54	1.32	0.26	2.12

Cyperus rotrundus Linn.	0.94	1.32	0.56	2.82
Cyrtococcum accrescens (Trin) Stapf.	0.22	0.99	0.06	1.27
Cystococcum patens (Linn.) Cowan	0.94	1.32	0.17	2.43
Desmodium triquetrum (Linn.) DC.	0.15	0.66	0.41	1.22
Dichrocephala integrifolia (Linn.) Kuntz.	0.36	0.99	0.52	1.87
Dicranopteris linearis (Burm.) Underwood. **var.** *altissima* Holtt.	0.33	1.32	0.09	1.74
Eragrostis nutans Nees ex. Steud.	1.20	1.98	0.22	3.40
Erianthus longisetosus Anderson. ex. Benth.	0.65	0.99	22.52	24.16
Eryngium foetidium Linn.	0.18	0.66	2.77	3.61
Fimbristylis dichotoma (Linn.) Vahl.	0.54	0.99	0.24	1.77
Galinsoga parviflora Cav.	0.69	1.98	0.21	2.88
Gynura bicolor (Roxb. ex Willd.)	0.51	1.98	3.46	5.95
Ichnanthus vicinus (Bail) Merr.	1.52	2.31	0.22	4.06
Imperata cylindrica (Linn.) Raeuschel.	63.74	9.90	9.62	**83.26**
Impomoea hederifolia Linn.	0.15	0.99	0.05	1.18
Inula cappa (Ham. ex. D.Don)**.**	0.62	2.31	3.96	6.89
Knoxia corymbosa Willd.	3.70	4.95	1.38	10.03
Kyllingia brevifolia Rottb.	0.51	0.99	0.17	1.67
Lepidagathis hyaline Nees in Wall.	0.33	1.32	0.27	1.92
Lobelia angulata Forts.	0.18	0.99	0.07	1.24
Lycopodium cernuum Linn.	0.44	0.33	0.36	1.12
Lygodium flexosum (Linn.) Swartz.	0.33	1.98	0.05	2.35
Lygodium scandens (Linn.) Swartz.	0.25	1.65	0.05	1.95
Melochia corchorifolia Linn	0.11	0.99	0.84	1.94
Melothria heterophylla (Lour.) Cogn.	0.07	0.66	0.42	1.16
Mikania micrantha Kunth.	0.36	1.65	0.53	2.54
Mimosa pudica Linn.	0.47	1.32	0.59	2.38
Mucuna pruriens (Linn.) DC.	0.18	1.32	0.18	1.68
Neyraudia reynaudiana (Kunth.) King. ex. Hitch.	0.40	0.99	4.45	5.84
Oxalis corniculata Linn.	0.40	0.99	0.19	1.58
Paspalum longifolium Roxb.	1.02	1.98	1.18	4.18
Pennisetum polystachyon Schult.	0.25	0.99	0.71	1.96
Physalis minima Linn.	0.07	0.66	0.60	1.33
Plantago major Linn.	0.51	1.65	1.14	3.30
Polygonum alatum Buch-Ham.	0.36	0.99	0.76	2.12
Polygonum chinense Linn.	0.69	1.98	1.04	3.71
Polygonum hydropiper Linn.	1.34	1.65	2.77	5.76
Rungia parviflora Clark.	0.94	1.98	0.47	3.40
Saccolepis indica Chase.	0.29	1.32	0.72	2.33
Scleria terrestris Linn.	0.22	0.33	6.57	7.12
Scoparia dulcis Linn.	0.29	0.66	0.51	1.47
Setaria palmifolia (Koenig) Stapf.	0.54	1.32	0.33	2.20
Sida acuta Burm.	0.33	0.99	2.79	4.11
Solanum khasinum Clark. in Hook.	0.36	1.32	0.20	1.88
Solanum nigrum Linn.	0.07	0.33	0.62	1.03
Sphenomeris chinensis (Linn.) Maxon.	0.76	0.66	0.32	1.74
Spilanthes oleracea Clark.	0.80	1.98	0.42	3.20
Sporobolus diander (Retz) Beauv.	0.33	0.99	1.67	2.99
Stellaria media (Linn.) Villars.	0.83	0.99	4.89	6.71
Thysanolaena maxima (Roxb.) Kuntz.	0.69	1.32	1.87	3.88
Triumfetta pilosa Roth.	0.18	1.32	1.47	2.97

Table 6a. Relative density, relative frequency, relative dominance and important value index (IVI) of tree species in the mildly disturbed (MD) area.

Name of the species	Relative density (%)	Relative frequency (%)	Relative dominance (%)	IVI
Acer laevigatum Wall.	1.32	1.36	1.95	4.62
Alangium chinense (Lour.) Harms.	0.09	0.27	0.54	0.90
Albizia chinensis (Osb.) Merr.	1.32	1.90	1.29	4.51
Albizia thomsoni Brandis	0.88	1.36	1.64	3.88
Alseodaphne petiolaris Hook.	0.88	0.82	2.33	4.03
Amoora chittagonga (Miq.) Hiern	0.26	0.54	1.03	1.84
Anogeissus acuminata (Roxb. ex DC.) Guill. & Perr.	1.40	2.72	2.14	6.27
Antidesma bunius Spreng.	0.09	0.27	0.15	0.51
Aporusa octandra (Buch.-Ham. ex D.Don) Vickery.	6.58	5.71	3.62	15.91
Artocarpus lakoocha Roxb.	0.35	0.82	1.08	2.25
Beilschmiedia assamica Meissn.	0.79	0.82	1.45	3.05
Bischofia javanica Bl.	0.53	0.27	0.10	0.90
Bochmeria rugulosa Wedd.	0.35	0.82	0.61	1.78
Callicarpa arboria Roxb.	1.58	2.17	2.17	5.92
Carallia brachiata (Lour.) Merr.	0.09	0.27	0.29	0.65
Cassia nodosa Buch.-Ham. ex Roxb.	0.35	0.54	0.86	1.75
Cassia timoriensis DC.	0.18	0.54	0.10	0.82
Castanopsis indica DC.	1.14	1.36	1.72	4.22
Castanopsis tribuloides DC.	10.54	5.71	4.57	**20.81**
Celtis tetrandra Roxb.	1.67	2.17	2.09	5.93
Cinnamomum obtusifolium Roxb. ex Nees.	0.26	0.54	0.08	0.89
Cinnamomum tamala (Buch. – Ham.) Nees.	0.09	0.27	0.40	0.76
Cinnamomum verum Presl.	0.61	1.36	0.39	2.37
Colona floribunda (Kurz.) Craib.	0.44	0.54	0.62	1.60
Derris robusta (Roxb. ex DC) Benth.	0.70	1.09	0.85	2.64
Diospyros glandulosa Lace.	0.09	0.27	0.24	0.60
Diospyros lanceaefolia Roxb.	0.18	0.27	0.23	0.68
Duabanga grandiflora (Roxb. ex DC.) Walp.	0.09	0.27	0.95	1.31
Dysoxylum binecteriferum (Roxb.) Hook. ex Beddome.	0.26	0.54	0.50	1.30
Elaeocarpus aristatus Roxb.	0.09	0.27	0.04	0.40
Elaeocarpus lanceifolious Roxb.	1.14	1.36	1.03	3.53
Emblica officinalis Goertn.	3.07	2.99	2.08	8.15
Engelhardtia spicata Lechen ex Bl.	0.97	1.09	2.48	4.53
Ficus hirta Vahl.	1.23	1.36	2.29	4.88
Ficus prostrata Wall.	0.53	0.82	0.31	1.65
Ficus semicordata Buch.-Ham.	0.70	0.82	1.86	3.38
Ficus semicordata Buha.-Ham **var**. *conglomerata* Roxb.	0.35	0.54	0.21	1.11
Garcinia sopsopia (Buch-Ham.) Mabberley.	0.09	0.27	0.24	0.60
Glochidion khasicum Hook.	3.60	3.26	1.56	8.42
Gmelina arborea Roxb.	0.18	0.54	0.27	0.99
Haldina cordufolia (Roxb.)Ridsdale.	1.58	0.82	2.07	4.47
Ilex umbellulata (Wall.) Loes.	0.79	1.09	1.02	2.89
Itea macrophylla Wall.	1.14	1.36	1.58	4.08
Litsea monopetala (Roxb.) Pers.	1.76	1.90	2.64	6.30
Macaranga indica Wight.	1.05	1.63	2.11	4.79

Machilus kingii Hook.	0.61	1.09	0.44	2.14
Machilus odoratissima Nees.	0.53	0.82	0.49	1.83
Machilus villosa Hook.	2.81	3.53	3.12	9.46
Macropanax dispermus (Bl.) Kuntz.	1.05	1.36	1.24	3.65
Maesa ramentacea DC.	0.35	0.82	0.29	1.45
Mallotus albus (Muell.- Arg).	0.35	0.27	0.12	0.74
Mangifera indica Linn.	0.35	0.27	0.19	0.82
Melia azedarach Linn.	0.09	0.27	0.54	0.90
Meliosma pinnata (Roxb.) Maxim.	0.09	0.27	0.19	0.55
Melocanna baccifer (Roxb.) Kurz.	1.05	0.54	0.28	1.87
Micromelum minutum (Forst.) Wight & Arn.	0.26	0.54	0.13	0.94
Morus macroura Miq.	0.53	0.82	1.20	2.54
Musa glauca Roxb.	0.09	0.27	0.77	1.13
Nyssa javanica (Bl.) Wanger.	0.18	0.54	0.08	0.80
Oroxylum indicum (Linn.)Vent.	0.35	0.82	0.47	1.63
Parkia roxburghii (DC.) Merr.	0.09	0.27	0.47	0.83
Phoebe lanceolata (Nees.) Nees.	5.97	3.80	2.86	12.63
Phoebe hainesiana Brandis.	0.97	1.09	0.91	2.97
Pithecelobium bigeminum auct. non (Linn.) Mart.	2.37	2.45	2.95	7.77
Polygala arillata Buch.-Ham. ex. D. Don.	0.18	0.54	0.27	0.99
Rhus semialata Murr.	2.19	1.90	1.44	5.54
Rhus succedanea Linn.	0.53	0.82	0.67	2.01
Sapium baccatum Roxb.	0.79	1.09	1.33	3.21
Saurauia panduana Wall.	3.78	2.45	2.36	8.58
Schima wallichii (DC.) Korthals.	5.71	4.35	4.35	14.40
Sterculia villosa Roxb. ex Sm.	0.70	1.36	1.22	3.28
Stereospermum colais (Buch. -Ham. ex. Dillw.) Mabber.	1.05	1.36	2.11	4.52
Styrax polyspermum Clark.	0.35	0.27	0.21	0.84
Styrax serrulatum Roxb.	4.92	3.26	5.76	13.94
Syzygium claviflorum (Roxb.) Wall. ex. Cowan	0.44	0.54	0.46	1.44
Syzygium cumini (Linn.) Skeels.	0.61	0.82	0.88	2.31
Syzygium operculatum (Roxb.) Niedenzuvar. **var**.*obovatum* (Wall. ex Duthie.)	0.26	0.27	0.67	1.20
Terminalia arjuna (Roxb.)Wight & Arn	0.26	0.54	0.35	1.16
Toona ciliata Roemer.	0.35	0.54	0.50	1.40
Ulmus lancifolia Roxb.	0.09	0.27	0.54	0.90
Vitex peduncularis Wall. ex Schauer.	0.26	0.54	0.50	1.30
Wendlandia grandis Hook.	8.08	3.53	3.87	15.48

Table 6b. Relative density, relative frequency, relative dominance and important value index (IVI) of shrub species in the mildly disturbed (MD) area.

Name of the species	**Relative density (%)**	**Relative frequency (%)**	**Relative dominance (%)**	**IVI**
Acacia pruinescens Kurz.	0.44	0.79	4.94	6.17
Acanthus leucastachyus Wall.	0.88	1.38	1.03	3.29
Alchornea tiliaefolia (Benth.) Muell. Arg.	0.57	0.79	1.83	3.18
Allophylus cobbe Bl.	0.32	0.59	0.48	1.39
Antidesma acidium Retz.	1.01	1.18	1.34	3.53
Bauhinia glauca (Wall. ex Benth.) Benth.	0.19	0.59	2.30	3.08

Bridelia stipularis (Linn.) Bl.	1.01	1.96	13.00	**15.98**
Buddleja asiatica Lour.	0.19	0.59	0.18	0.96
Byttneria pilosa Roxb.	0.88	1.77	1.09	3.74
Caesalpinia cucullata Roxb.	1.39	1.57	1.01	3.97
Camellia kissi Wall.	0.19	0.59	0.53	1.31
Camellia sinensis (Linn.) Kuntz.	0.25	0.59	10.28	11.12
Chromolaena odorata (Linn.) King & Robinson	5.87	1.96	1.35	9.19
Cissampelos pareira Linn.	4.17	3.34	0.07	7.58
Cissus repens Lam.	3.98	3.54	0.40	7.92
Clerodendrum colebrookianum Walp.	0.25	0.39	0.23	0.87
Clerodendrum infortunatum **(**Linn.)	3.79	2.95	2.66	9.40
Coffea khasiana Hook.*f*	3.54	2.95	2.63	9.12
Colquhounia coccinea Wall.	0.19	0.39	0.15	0.73
Combretum alatum Pers.	0.13	0.39	0.04	0.56
Combretum roxburghii Spreng.	2.59	2.55	1.95	7.10
Dalbergia pinnata (Lour.) Prain.	0.13	0.39	0.01	0.52
Dalbergia stipulacea Roxb.	2.46	2.36	1.78	6.59
Dendrocnide sinuata **(**Bl.) Chew.	2.08	0.98	0.57	3.64
Derris thyrsflora (Benth.)	2.34	2.36	3.94	8.63
Desmodium gyroides (Roxb.ex Link) DC.	0.25	0.59	0.15	1.00
Desmodium triangulare (Retz.) Merr.	1.64	1.77	0.67	4.08
Embelia subcoriacea (Clark.) Mez.	1.26	1.77	0.50	3.53
Entada pursaetha DC.	0.63	0.98	4.51	6.12
Eurya acuminata DC.	0.69	0.59	1.31	2.59
Eurya cerasifolia (D.Don) Kobuski.	0.88	1.57	3.55	6.01
Ficus hispida Linn.	0.44	0.98	0.92	2.34
Flemingia macrophylla (Willd.) Kuntze ex Merr.	0.44	0.59	0.22	1.25
Garcinia cowa Roxb. ex DC.	7.64	2.36	0.20	10.20
Hedyotis scandens Roxb.	0.51	1.18	0.06	1.74
Hodgsonia macrocarpa (Bl.) Cogn.	0.44	0.79	0.03	1.26
Kadsura heteroclita (Roxb.) Craib.	0.63	1.38	0.04	2.05
Lasianthus lucidus Bl.	0.32	0.59	0.09	0.99
Leea asiatica Kurz.	1.70	1.18	8.07	10.95
Lepionurus sylvestris Bl.	4.80	2.16	0.24	7.20
Linostoma decandrum Wall.	0.76	1.18	0.28	2.22
Maesa indica (Roxb.) Wall.	1.77	2.55	0.58	4.90
Malvastrum tricuspidatum Gray.	0.63	0.98	0.80	2.42
Melastoma malabatricum Linn.	0.32	0.79	0.12	1.22
Melastoma nepalensis Lodd.	2.78	1.96	0.34	5.08
Merreremia umbellata (Linn.) Hall.	0.63	1.57	0.05	2.25
Millettia pachycarpa Benth.	1.20	1.38	1.20	3.77
Morinda angustifolia Roxb.	1.26	1.77	1.20	4.23
Mussaenda glabra Vahl.	1.70	2.36	0.25	4.31
Mussaenda parryorum Fischer.	2.59	2.16	0.10	4.85
Mussaenda roxburghii Hook.	0.13	0.39	0.10	0.62
Oxyspora paniculata (D.Don) DC.	0.06	0.20	0.03	0.29
Paederia foetida Linn.	1.52	1.18	0.04	2.73
Pandanus pseudofoetidus Roxb.	0.63	0.98	1.33	2.95
Pentanura khasiana Kurz.	0.51	0.98	0.15	1.64
Phyllanthus reticulatus (Poir). Baill.	2.71	2.36	0.28	5.35
Pueraria lobata (Willd.) Ohwi.	1.01	1.57	0.10	2.69
Rhamnus napalensis Wall.	0.38	0.59	0.11	1.08

Rhynchoglossum obliquum Bl.	0.13	0.39	0.57	1.09
Ricinus communis Linn.	1.39	1.77	4.23	7.39
Rourea minor (Gaertner) Leenh.	5.49	2.95	0.23	8.67
Rubus birmanicus Hook.	0.32	0.39	0.05	0.76
Rubus ellipticus Sm.	0.69	1.18	0.55	2.42
Securingea virosa (Roxb. ex Willd) Bail.	0.88	1.77	0.06	2.71
Smilax perfoliata Lour.	0.25	0.59	0.22	1.06
Sterculia coccinea Roxb.	0.51	0.59	0.01	1.10
Strobilanthes maculatus Nees.	2.97	2.95	0.55	6.47
Tabernaemontana divaricata (Linn.) Br. ex. Roem. & Schultes.	1.14	1.57	0.05	2.76
Tetrastigma bracteolatum (Wall.) Planchon.	0.51	0.59	0.05	1.14
Tetrastigma leucostaphylum (Dennst.) Alston ex Mabb.	0.63	0.59	0.01	1.23
Thunbergia grandiflora (Roxb. ex Rottl.) Roxb.	0.51	0.20	0.00	0.70
Tragia involucrata Linn.	0.44	0.79	2.47	3.70
Trevesia palmata (Roxb.) Vis.	0.63	0.79	1.12	2.54
Uncaria laevigata Wall.	0.95	1.38	0.10	2.42
Viburnum mullaha Buch.-Ham.ex D.Don	0.25	0.59	0.05	0.89
Willughbeia edulis Roxb.	0.06	0.20	0.03	0.29
Zanthoxylum armatum DC.	0.57	0.39	8.24	9.20

Table 6c. Relative density, relative frequency, relative dominance and important value index (IVI) of herbaceous species in the mildly disturbed (MD) area.

Name of the species	**Relative density (%)**	**Relative frequency (%)**	**Relative Dominance (%)**	**IVI**
Abelmoschus moschatus Medicus.	0.50	0.91	0.21	1.62
Achyranthes bidentata Bl	1.68	1.82	0.35	3.84
Ageratum conyzoides Linn.	3.02	2.27	0.95	6.24
Alocasia fornicata (Roxb.) Schott**.**	0.34	0.91	0.95	2.20
Alpina bracteata Roxb. Rose.	2.35	2.73	32.27	**37.35**
Amomum dealbatum Roxb.	1.34	1.82	13.44	16.60
Arisaema tortuosum (Wall.) Schott.	0.67	1.36	5.16	7.19
Canscora andrographiodes Griff.	1.01	1.36	0.16	2.53
Centilla asiatica (Linn.) Urban.	2.01	2.73	0.12	4.86
Cibotium baromtez (Linn.) Sm.	1.17	1.82	0.21	3.20
Commelina sikkimensis Clark.	2.85	3.64	0.08	6.57
Conyza bonariensis (Linn.) Cronq.	1.01	1.36	1.14	3.51
Costus speciosus (Koenig) Sm.	2.52	4.55	1.26	8.32
Curculigo capitulata (Lour.) Kuntz.	1.17	1.82	2.60	5.59
Cyperus cyperoides (Linn.) Kuntz.	2.01	2.27	0.73	5.02
Davallia trichomanoides Bl.	1.68	1.82	1.43	4.93
Desmodium triquetrum (Linn.) DC.	1.17	1.82	0.43	3.43
Dicranopteris linearis (Burm.) Underwood. **var.** *altissima* Holtt.	1.34	1.36	0.12	2.82
Dioscorea alata Linn.	0.50	1.36	0.16	2.03
Dioscorea bulbifera Linn.	1.01	2.27	0.46	3.74
Dioscorea glabra Roxb.	0.84	1.36	0.18	2.38
Diplazium maxima (D.Don.) Chatt.	2.35	1.82	1.38	5.54
Gynura bicolor (Roxb.ex Willd.)	2.35	1.82	4.55	8.72

Ichnanthus vicinus (Bail) Merr.	4.87	4.55	0.22	9.63
Imperata cylindrica (Linn.) Raeuschel.	5.54	2.73	1.20	9.47
Inula cappa (Ham. ex. D.Don)**.**	3.52	2.73	6.06	12.31
Lygodium flexosum (Linn.) Swartz.	0.50	1.36	0.02	1.89
Melothria heterophylla (Lour.) DC.	1.01	1.36	0.19	2.56
Microlepia strigosa (Thunb.) Presl.	0.84	1.36	0.10	2.30
Microsarum superficiale (Bl.) Ching.	0.67	1.82	7.94	10.43
Mikania micrantha Kunth.	2.52	2.27	0.88	5.67
Panicum punctatum Burm.	4.53	4.09	0.73	9.35
Phrynium capitatum Willd.	2.68	2.27	2.92	7.87
Phylanthus urinaria Linn.	2.85	2.27	0.18	5.30
Polygonum alatum Buch-Ham.	2.85	3.64	0.44	6.93
Polygonum barbatam Linn.	1.51	2.27	0.35	4.13
Polygonum chinense Linn.	1.68	2.27	1.00	4.95
Pothos scandens Linn.	0.50	0.91	0.31	1.72
Pronephrium nudatum Roxb.	1.68	1.82	0.13	3.63
Pteridium aquilinum (Linn.) Kuhn.	3.86	4.09	0.30	8.25
Saccolepis indica Chase.	3.36	3.18	1.65	8.18
Scleria terrestris Linn.	2.52	2.27	4.11	8.90
Spermacoce hipida Linn.	1.85	2.27	0.48	4.60
Sphenomeris chinensis (Linn.) Maon.	2.01	0.91	0.16	3.08
Strobilanthes simonsii Anderson.	1.34	1.36	0.48	3.19
Thysanolaena maxima (Roxb.) Kuntz.	12.42	3.18	1.84	17.44

Table 7a. Relative density, relative frequency, relative dominance and important value index (IVI) of tree species in the undisturbed (UD) area.

Name of the species	**Relative density (%)**	**Relative frequency (%)**	**Relative dominance (%)**	**IVI**
Acrocarpus fraxinifolius Wight.ex Arn.	0.27	0.62	0.05	0.95
Actinadaphne obovata (Nees.) Blume.	2.55	2.27	0.79	5.61
Adenanthera pavonina Linn.	0.09	0.21	0.01	0.31
Alangium chinense (Lour.) Harms.	5.10	3.51	2.94	**11.55**
Albizia chinensis (Osb.) Merr.	0.55	1.03	0.27	1.85
Albizia thomsoni Brandis	0.64	0.62	0.29	1.54
Alstonia scholaris (Linn.) Br.	0.18	0.21	0.09	0.48
Anogeissus acuminata (Roxb. ex DC.) Guill. & Perr.	0.36	0.62	0.29	1.27
Aporusa octandra (Buch.-Ham. ex D.Don) Vickery.	1.00	1.24	0.20	2.44
Artocarpus chama Buch.-Ham.	0.18	0.41	0.23	0.82
Artocarpus heterophyllus Lam.	0.55	0.41	0.68	1.64
Artocarpus lakoocha Roxb.	2.37	2.27	0.74	5.38
Bischofia javanica Bl.	4.92	4.12	2.20	11.25
Bombax insigne Wall.	0.27	0.41	3.48	4.17
Bridelia monoica (Lour.) Merr.	1.00	1.24	0.31	2.55
Brusera serrata Wall. ex. Colebr.	0.46	0.21	0.29	0.96
Callicarpa arboria Roxb.	1.19	1.24	0.94	3.37
Canarium stritum Roxb.	0.09	0.21	0.02	0.32
Caryota urens Linn.	0.09	0.21	0.26	0.55
Cassia nodosa Buch.-Ham. ex Roxb.	0.27	0.62	0.46	1.36
Castanopsis tribuloides DC.	1.00	0.62	0.80	2.42
Celtis australis Linn.	4.10	2.68	1.49	8.27

Celtis tetrandra Roxb.	0.09	0.21	0.41	0.71
Chukrasia tabularis Juss.	0.18	0.41	0.69	1.29
Cinnamomum obtusifolium Roxb. ex Nees.	0.36	0.62	0.43	1.41
Cinnamomum verum Presl.	0.27	0.21	0.01	0.49
Colona floribunda (Kurz.) Craib.	2.83	2.06	1.27	6.15
Cordia dichotoma Forst.	1.09	1.24	1.23	3.56
Cyathea gigantean Wall. ex Hook.	0.73	0.62	1.00	2.35
Dendrocalamus hamitonii Nees.	1.09	0.21	1.04	2.34
Dendrocalamus longispathus Kurz.	1.37	0.21	1.05	2.62
Derris robusta (Roxb.ex DC) Benth.	2.64	2.27	1.57	6.48
Diospyros lanceaefolia Roxb.	0.27	0.41	0.94	1.63
Drimycarpus resemosus (Roxb.) Hook.	0.64	1.03	1.79	3.46
Dryptes lancifolia (Hook.) Pax. ex Hoffm.	0.46	0.82	0.71	1.99
Duabanga grandiflora (Roxb. ex DC.) Walp.	0.27	0.41	2.73	3.42
Dysoxylum binecteriferum (Roxb.) Hook. ex Beddome.	1.09	1.44	1.32	3.85
Ehretia acuminata Br.	0.64	0.62	2.14	3.40
Elaeocarpus floribundas Bl.	1.46	1.65	1.39	4.50
Emblica officinalis Goertn.	0.64	0.82	1.49	2.96
Eriobotrya bengalensis Hook.	5.01	3.30	2.40	10.71
Erythrina stricta Roxb.	0.09	0.21	0.71	1.01
Euonymus glaber Wallich in Roxb.	0.55	0.62	1.06	2.23
Ficus benjamina Linn.	1.46	1.24	1.47	4.17
Ficus elatica Roxb.	0.09	0.21	0.11	0.41
Ficus geniculata Kurz.	0.27	0.62	0.77	1.66
Ficus prostrata Wall.	0.91	1.24	0.71	2.86
Ficus religiosa Linn.	1.00	0.82	2.29	4.12
Firmiana colorata (Roxb.) Br.	0.27	0.62	2.13	3.02
Flacourtia jangomas (Lour.) Raeusch.	0.36	0.82	0.39	1.58
Garcinia xanthochymus Hook.ex Anderson.	0.09	0.21	0.45	0.75
Garuga floribunda var.*gamblei* Linn.(King ex W. Sm.) Kalkman	0.18	0.41	0.78	1.37
Glochidion velutinum Wight.	0.27	0.41	0.46	1.15
Gmelina arborea Roxb.	0.18	0.41	0.35	0.95
Grewia desperma Rottl. ex Spreng.	0.91	0.41	1.32	2.65
Haldina cordufolia (Roxb.) Ridsdale.	0.46	0.82	1.14	2.42
Itea macrophylla Wall.	0.36	0.21	0.63	1.20
Kydia calycina Roxb.	1.09	1.03	1.04	3.17
Lagerstroemia speciosa (Linn.)	0.36	0.62	0.77	1.75
Litsea citrata Bl.	0.36	0.62	0.60	1.58
Litsea monopetala (Roxb.) Pers.	1.37	1.65	1.70	4.72
Macaranga indica Wight.	2.46	1.65	1.96	6.07
Machilus parviflora Meissn.	0.18	0.41	0.35	0.95
Machilus villosa Hook.	2.37	2.89	1.89	7.14
Macropanax dispermus (Bl.) Kuntz.	4.74	2.68	2.49	9.91
Maesa ramentacea DC.	0.55	1.03	0.45	2.03
Mangifera indica Linn.	2.01	1.24	0.90	4.14
Melocanna baccifer (Roxb.) Kurz.	1.09	0.21	0.22	1.52
Mesua ferrea Linn.	0.46	0.62	0.28	1.35
Michelia champaca Wall. ex Hook. & Thomson.	0.09	0.21	0.26	0.55
Mitragyna diversifolia Haviland.	1.73	2.27	1.68	5.68
Morus macroura Miq.	1.37	2.06	1.81	5.24

Murraya koenigii (Linn.)Spreng.	0.46	0.41	0.33	1.20
Musa acuminata. Colla.	1.55	0.82	1.56	3.94
Olea dentata **var**. *salicifolia* Wall.	0.46	0.62	1.02	2.09
Olea dioca Roxb.	0.27	0.62	0.34	1.23
Oreocnide integrefolia Miq.	0.91	1.03	1.05	2.99
Oroxylum indicum (Linn.)Vent.	1.37	2.47	0.43	4.27
Pandanus tectorius Soland ex Parkinson	0.27	0.21	0.55	1.03
Parkia roxburghii (DC.) Merr.	0.18	0.41	0.91	1.50
Phoebe lanceolata Nees.	1.82	1.86	0.82	4.50
Phoebe hainesiana Brandis.	0.36	0.41	0.65	1.43
Pithecelobium bigeminum auct. non (Linn.) Mart.	0.18	0.21	0.33	0.72
Pterospermum lancifolium Roxb.	0.27	0.62	0.60	1.50
Quercus listeria King.	0.09	0.21	0.26	0.55
Randia wallichii Hook.	2.28	2.06	1.02	5.36
Rhus succedanea Linn.	0.18	0.41	0.18	0.78
Saurauia napaulensis DC.	2.37	1.86	2.39	6.61
Schima wallichii (DC.) Korthals.	0.46	1.03	2.27	3.75
Spondias pinnata (Linn.) Kurz.	1.19	1.24	1.47	3.90
Sterculia urens Roxb.	0.46	0.82	1.64	2.92
Sterculia villosa Roxb. ex Sm.	0.73	1.03	1.78	3.54
Stereospermum colais (Buch. -Ham. ex. Dillw.) Mabber.	1.37	2.06	1.79	5.22
Syzygium cumini (Linn.) Skeels.	0.55	0.82	0.73	2.10
Syzygium operculatum (Roxb.) Niedenzuvar.var.*obovatum* (Wall. ex Duthie.)	0.36	0.62	0.50	1.48
Toona ciliata Roemer.	0.91	1.24	1.71	3.86
Trema orientalis (Linn.) Bl.	0.73	0.82	1.25	2.81
Ulmus lancifolia Roxb.	0.18	0.21	0.51	0.90
Vitex heterophylla Roxb.	3.28	3.09	1.47	7.84
Vitex peduncularis Wall. ex Schauer.	0.55	0.62	0.75	1.92
Wendlandia grandis Hook.	0.09	0.21	0.11	0.41

Table 7b. Relative density, relative frequency, relative dominance and important value index (IVI) of shrub species in the undisturbed (UD) area.

Name of the species	**Relative density (%)**	**Relative frequency (%)**	**Relative dominance (%)**	**IVI**
Acacia pennata (Linn.) Willd.	0.82	1.15	7.22	9.18
Andrachne cordifolia Muell.	0.54	1.43	2.46	4.44
Artemisia indica Willd.	0.45	1.15	0.63	2.23
Bridelia stipularis (Linn.) Bl.	1.81	2.58	33.79	**38.19**
Caesalpinia cucullata Roxb.	0.82	1.15	1.50	3.46
Cajanus goensis Dalz.	0.36	0.29	0.07	0.72
Calamus tenuis Roxb.	0.09	0.29	0.52	0.89
Callicarpa longifolia Lam.	1.00	1.72	0.62	3.34
Cassia occidentalis Linn.	0.91	1.15	0.69	2.75
Chromolaena odorata (Linn.) King & Robinson	4.72	0.86	0.66	6.24
Cissampelos pareira Linn.	2.00	1.72	0.04	3.76
Cissus repens Lam.	1.81	0.86	0.11	2.79
Citrus medica Linn.	0.09	0.29	0.52	0.90

Clematis tortuosa (Wall. ex Hook. & Thomson.) Fischer.	1.27	1.72	1.51	4.50
Clerodendrum colebrookianum Walp.	0.64	0.57	0.32	1.53
Clerodendrum infortunatum Linn.	2.27	1.43	1.32	5.02
Coffea khasiana Hook.	4.08	4.01	2.55	10.65
Combretum flagrocarpum Clark.	2.72	2.01	1.68	6.41
Combretum roxburghii Spreng.	2.27	2.29	1.80	6.36
Crotalaria mysorensis Roth.	0.27	0.57	0.09	0.93
Croton caudatus Geisel.	1.27	1.43	0.07	2.78
Debregeasia longifolia Wedd.	1.63	2.01	11.97	15.61
Dendrocnide sinuata **(**Bl.) Chew.	4.90	2.01	0.86	7.77
Derris thyrsflora Benth.	0.73	0.86	1.36	2.95
Desmodium pulchellum (Linn.) Benth.	0.91	0.29	0.03	1.22
Elaeagnus pyriformis Hook.	0.36	0.57	0.06	0.99
Embelia subcoriacea (Clark.) Mez.	0.36	0.57	0.15	1.09
Embelia vestita Roxb.	0.45	0.86	0.15	1.46
Fagerlindia faciculata (Roxb.) Tirvengadum.	0.91	1.43	0.20	2.54
Garcinia cowa Roxb. ex DC.	1.81	1.15	0.11	3.07
Gnetum montanum MG.	0.18	0.29	0.02	0.49
Goniothalamus sesquipedalis (Wall.) Hook. & Thomson**.**	0.54	0.86	0.14	1.54
Hodgsonia macrocarpa (Bl.) Cogn.	0.45	0.86	0.04	1.35
Indigofera dosua Buch-Ham. ex. D.Don.	1.18	1.15	0.18	2.51
Jasminum glandulosum Wall.	0.36	0.86	0.06	1.29
Jasminum undulatum Ker.	1.27	1.43	0.13	2.83
Leea asiatica Kurz.	2.09	1.72	10.90	14.71
Lepionurus sylvestris Bl.	1.54	1.15	0.12	2.81
Liculala peltata Roxb.	0.45	0.86	0.27	1.58
Litsea salicifolia (Roxb. ex. Wall) Hook.	1.00	1.15	0.10	2.24
Maesa indica (Roxb.) Wall	3.63	4.01	0.88	8.52
Malvastrum tricuspidatum Gray.	0.27	0.57	0.56	1.40
Melastoma nepalensis Lodd.	1.09	0.86	0.15	2.10
Merreremia umbellata (Linn.) Hall.	0.73	1.15	0.03	1.90
Merreremia vitifolia (Burm.) Hall.	1.27	2.01	0.06	3.34
Millettia pachycarpa Benth.	2.54	2.87	2.28	7.68
Mussaenda frondosa Linn.	0.91	1.72	0.13	2.75
Mussaenda glabra Vahl.	1.63	0.86	0.09	2.58
Passiflora edulis Sims.	0.09	0.29	0.05	0.42
Phlogacanthus wallichii Clark**.**	1.81	2.01	0.18	4.00
Phyllanthus reticulatus (Poir). Bail.	4.08	2.58	0.31	6.97
Piper diffusum Vahl.	0.36	0.86	0.02	1.24
Piper peepuloides Roxb.	0.45	0.86	0.01	1.33
Piper thomsonii Hook.	0.36	0.86	0.02	1.24
Psychotria calocarpa Kurz.	1.00	1.15	0.01	2.15
Psychotria denticulata Wall.	0.45	1.15	0.29	1.89
Psychotria fulva Buch-Ham.	1.09	0.86	0.00	1.95
Pueraria lobata (Willd.) Ohwi.	0.64	0.86	0.06	1.55
Rhaphidophora decursiva (Roxb.) Schott.	0.91	1.15	1.04	3.09
Rhynchotechum elliptium DC.	0.91	0.29	0.07	1.26
Rourea minor (Gaertner) Leenh.	0.91	1.43	3.54	5.88
Roydsia suaveolens Roxb.	0.73	0.57	0.01	1.31
Rubus birmanicus Hook.	3.72	1.72	0.12	5.56

Rubus lasicarpus Sm.	0.18	0.29	0.01	0.48
Sarcochlamys pulcherrima Gaud.	0.18	0.29	0.04	0.51
Schefflera venulosa (Wight & Arn.) Harm.	1.00	1.43	0.25	2.69
Securingea virosa (Roxb. ex willd) Bail.	1.27	2.29	0.90	4.46
Smilax perfoliata Lour.	1.00	1.43	0.04	2.47
Strobilanthes petiolaris Nees.	1.09	1.15	0.02	2.26
Tabernaemontana divaricata (Linn.) Br. ex. Roem. & Schultes.	2.45	1.43	0.24	4.13
Tetrastigma bracteolatum (Wall.) Planchon.	3.27	2.87	0.09	6.22
Tetrastigma leucostaphylum (Dennst.) Alston ex Mabb.	1.00	1.15	0.09	2.24
Thladiantha calcerata Clark.	0.91	0.86	0.01	1.78
Thunbergia grandiflora (Roxb. ex Rottl.) Roxb.	3.63	3.15	0.04	6.82
Tinospora cordifolia (Willd.) Hook. & Th.	1.36	1.43	0.18	2.98
Trevesia palmata (Roxb.) Vis.	0.73	1.43	2.29	4.45
Trichosanthes tricuspidata Lour.	0.54	0.86	0.11	1.51
Uncaria sessilifructus Roxb.	0.45	0.57	0.74	1.77

Table 7c. Relative density, relative frequency, relative dominance and important value index (IVI) of herbaceous species in the undisturbed (UD) area.

Name of the species	**Relative density (%)**	**Relative frequency (%)**	**Relative dominance (%)**	**IVI**
Achyranthes aspera Linn.	11.16	6.25	0.94	18.35
Aeginetia indica Roxb.	0.64	0.78	0.09	1.51
Aeschynanthus superba Clark.	0.43	0.78	0.13	1.34
Alpina bracteata Roxb.	2.79	2.34	37.26	42.39
Amomum dealbatum Roxb.	3.00	3.91	31.55	38.46
Arisaema tortuosum (Wall.) Schott.	0.86	2.34	5.81	9.02
Drymaria diandra Bl.	0.64	1.56	0.21	2.41
Blechnum orientale Linn.	1.29	1.56	0.24	3.09
Canscora andrographiodes Griff.	1.50	3.13	0.29	4.91
Capsicum annuum Linn.	0.21	0.78	0.11	1.10
Centilla asiatica (Linn.) Urban.	2.58	1.56	0.17	4.31
Commelina sikkimensis Clark.	4.51	5.47	0.11	10.08
Costus speciosus (Koenig) Sm.	0.64	1.56	0.85	3.05
Curanga amara Juss.	1.29	1.56	0.11	2.96
Cyrtococcum accrescens (Trin) Stapf.	1.07	1.56	0.03	2.67
Cystococcum patens (Linn.) Cowan.	3.65	3.91	0.10	7.66
Desmodium floribundum (D. Don.) Sweet ex G. Don.	4.29	3.91	0.83	9.03
Desmodium triquetrum (Linn.) DC.	2.79	1.56	0.76	5.11
Diplazium maxima (D.Don.) Chatt.	3.22	2.34	1.30	6.86
Ebermaiera staurogyne Nees.	0.64	1.56	0.10	2.30
Eranthemum palatiferum Nees.	22.10	13.28	8.25	**43.64**
Globba multiflora Wall.	0.43	0.78	0.10	1.31
Ichnanthus vicinus (Bail) Merr.	7.08	7.81	0.28	15.18
Lepidagathis hyaline Nees.	6.44	8.59	0.90	15.93
Mikania micrantha Kunth.	0.64	2.34	0.28	3.27
Mollugo pentaphylla Linn.	0.43	0.78	0.17	1.38
Phrynium capitatum Willd.	4.94	2.34	4.67	11.95
Phyllanthus fraternus Webster.	1.29	0.78	0.07	2.14

Piperomia pellucida (Linn.) H.B.K.	0.86	2.34	0.23	3.44
Pothos cathcartii Schott.	1.29	3.13	0.45	4.86
Pronephrium nudatum Roxb.	1.50	2.34	0.37	4.22
Ranunculus catoniensis DC.	0.21	0.78	0.08	1.07
Sonerila maculata Roxb.	2.15	1.56	0.06	3.76
Thysanolaena maxima (Roxb.) Kuntz.	1.29	2.34	0.18	3.81
Triumfetta pilosa Roth.	2.15	2.34	2.90	7.39

Table 8a. Sorensen's index of similarity and dissimilarity of vascular plant species among the three study sites. HD: Highly disturbed area. MD: Mildly disturbed area. UD: Undisturbed area.

Similarity index (S)		
	MD	UD
HD	0.34	0.28
MD		0.44
Dissimilarity index (1-S)		
	MD	UD
HD	0.66	0.72
MD		0.56

Table 8b. Sorensen's index of similarity and dissimilarity of tree species in the three study sites. HD: Highly disturbed area. MD: Mildly disturbed area. UD: Undisturbed area.

Similarity index (S)		
	MD	UD
HD	0.33	0.28
MD		0.48
Dissimilarity index (1-S)		
	MD	UD
HD	0.67	0.72
MD		0.52

Table 8c. Sorensen's index of similarity and dissimilarity of shrub species among the three study sites. HD: Highly disturbed area. MD: Mildly disturbed area. UD: Undisturbed area.

Similarity index (S)		
	MD	UD
HD	0.36	0.34
MD		0.40
Dissimilarity index (1-S)		
	MD	UD
HD	0.64	0.66
MD		0.60

Table 8d. Sorensen's index of similarity and dissimilarity of herbaceous species among the three study sites. HD: Highly disturbed area. MD: Mildly disturbed area. UD: Undisturbed area.

Similarity index (S)		
	MD	UD
HD	0.27	0.26
MD		0.35
Dissimilarity index (1-S)		
	MD	UD
HD	0.73	0.74
MD		0.65

Table 9a. Diversity indices of tree species in the three study sites. HD: Highly disturbed area. MD: Mildly disturbed area. UD: Undisturbed area.

Trees			
Parameters	**HD**	**MD**	**UD**
Total no of species (S)	26	82	101
Total no of individuals (N)	234	1139	1097
Margalef's richness (Dmg)	4.58	11.50	14.28
Shannon index of diversity (H')	3.07	3.95	4.32
Simpson index of dominance (D); (1/D or 1-D)	18.86 or (0.95)	37.03 or (0.97)	62.5 or (0.98)

Table 9b. Diversity indices of shrub species in the three study sites.

Shrubs			
Parameters	**HD**	**MD**	**UD**
Total no of species (S)	40	77	78
Total no of individuals (N)	778	1584	1102
Margalef's richness (Dmg)	5.85	10.31	10.99
Shannon index of diversity (H')	3.12	4.03	3.91
Simpson index of dominance (D); (1/D or 1-D)	13.69 or (0.93)	45.45 or (0.98)	30.30 or (0.97)

Table 9c. Diversity indices of herbaceous species in the three study sites.

Herbs			
Parameters	**HD**	**MD**	**UD**
Total no of species (S)	70	46	35
Total no of individuals (N)	2755	524	466
Margalef's richness (Dmg)	8.71	7.18	5.53
Shannon index of diversity (H')	3.45	3.55	2.99
Simpson index of dominance (D); (1/D or 1-D)	10.86 or (0.91)	25.64 or (0.96)	13.33 or (0.92)

Table 10a. Raunkiaer's life-forms in the whole study area.

Raunkiar's life-forms	**Pecentage (%)**
Megaphanerophyte	0.26
Mesophanerophyte	25.78
Microphanerophyte	15.10
Nanophanerophyte	12.24
Chamaephyanerophyte	4.69
Geophyte	5.47
Therophyte	19.01
Epiphyte	0.52
Lianas, Scandents or/ and Climbers (LSC).	16.93

Table 10b. Raunkiaer's life-forms in the three study sites. HD: Highly disturbed area. MD: Mildly disturbed area. UD: Undisturbed area.

Raunkiaer's life-forms (%)	**HD**	**MD**	**UD**
Megaphanerophyte	0.00	0.00	0.47
Mesophanerophyte	13.24	28.43	34.27
Microphanerophyte	7.35	18.14	16.43
Nanophanerophyte	11.03	12.75	12.68
Chamaephyte	3.68	2.45	4.69
Geophyte	5.15	8.33	4.23
Therophyte	43.38	10.29	8.92
Epiphyte	0.00	0.49	0.47
Lianas, Scandents or/ and Climbers (LSC)	16.18	19.12	17.84

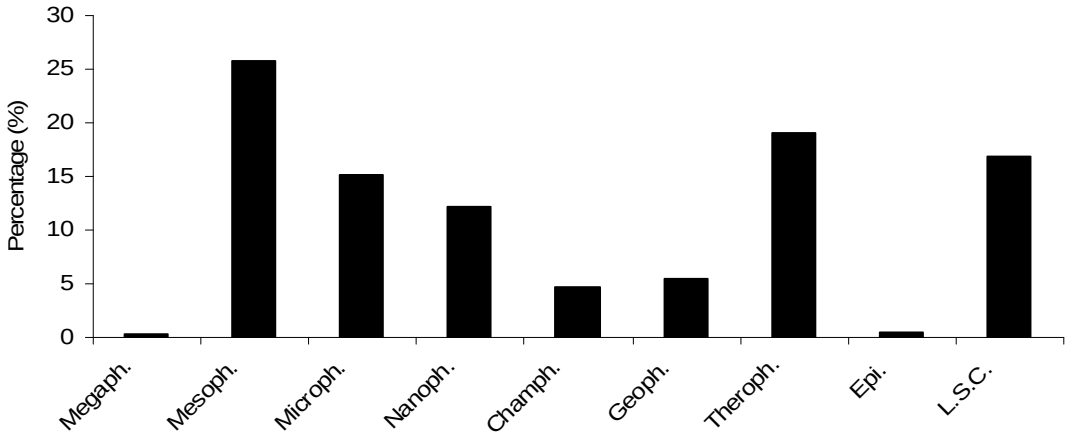

Fig. 3a. Raunkiaer's life-forms in the whole study area. Megaph.= Megaphanerophyte; Mesoph.= Mesophanerophyte; Microph.= Microphanerophyte; Nanoph.= Nanophanerophyte; Champh.= Chamaephyte; Geoph.= Geophyte; Theroph.= Therophyte; Epi.= Epiphyte; L.S.C.= Lianas, Scandents and Climbers.

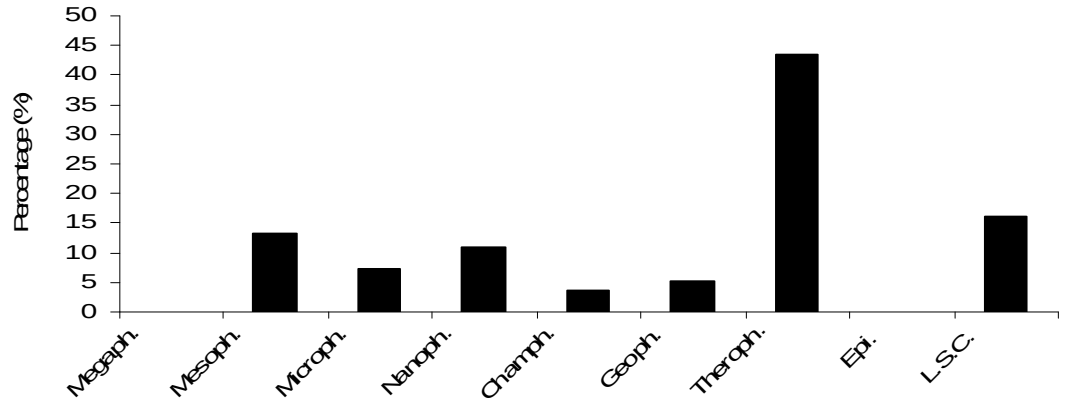

Fig. 3b. Raunkiaer's life-forms in the highly disturbed area.

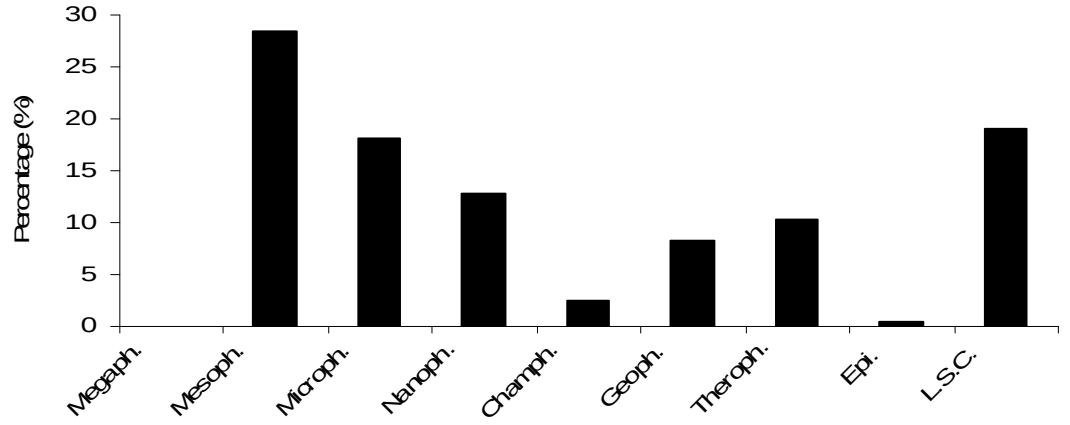

Fig. 3c. Raunkiaer's life-forms in the mildly disturbed area.

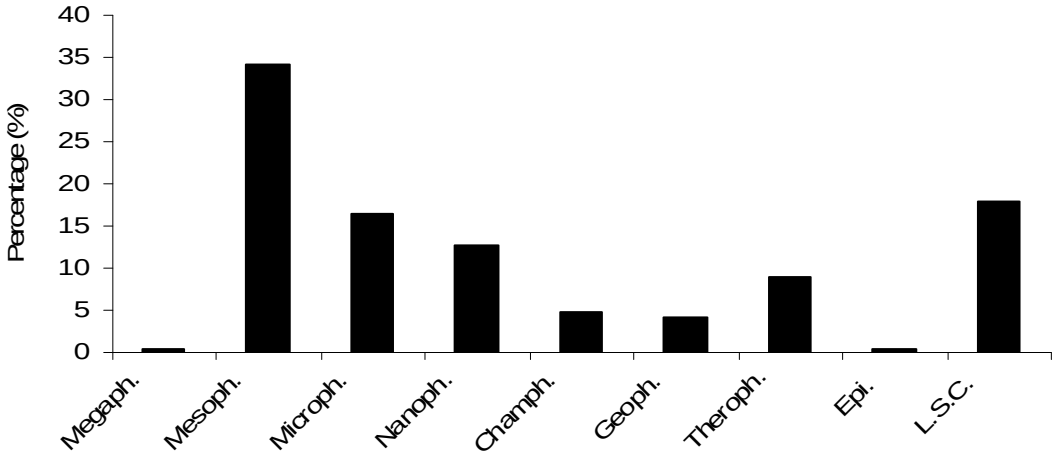

Fig. 3d. Raunkiaer's life-forms in the undisturbed area.

5.3 Productivity of herbaceous species

5.3.1 Biomass of herbaceous species

In the highly disturbed area, the above ground biomass (AGB) ranged from 149 g/m^2 (May) to 514 g/m^2 (August), below ground biomass (BGB) varied from 62 g/m^2 (March) to 470 g/m^2 (October) and dead matters (sum of standing dead and litter) fluctuated from 124 g/m^2 (October) to 414 g/m^2 (March). In the mildly disturbed area, the above ground biomass (AGB) ranged from 85.4 g/m^2 (March) to 164.9 g/m^2 (August), below ground biomass (BGB) varied from 83.4 g/m^2 (February) to 134 g/m^2 (September) and dead matters (sum of standing dead and litter) fluctuated from 60.9 g/m^2 (January) to 125.6 g/m^2 (May). In the undisturbed area, the above ground biomass (AGB) ranged from 13.6 g/m^2 (March) to 23.5 g/m^2 (September), below ground biomass (BGB) varied from 4.3 g/m^2 (March) to 19.7 g/m^2 (September) and dead matters (sum of standing dead and litter) fluctuated from 3.7 g/m^2 (October to) 6.9 g/m^2 (April) **(Table 11a and Fig. 4a, 4b & 4c)**.

The total biomass (sum of AGB, BGB and dead matters) of herbaceous species was highest in the month of August (1146 g/m^2) and lowest in March (625 g/m^2) in the highly disturbed area. In the mildly disturbed area, the highest value occurred in August (379.5 g/m^2) and lowest in February (261.9 g/m^2) and in the undisturbed area, highest in September (47.2 g/m^2) and lowest in March (24.4 g/m^2**) (Table 11a)**.

5.3.2 Productivity of herbaceous species

In the highly disturbed area, the peak live biomass (PLB) per year was 1398.00 g/m^2/yr; peak standing crop (PSC) per year was 1104.00 g/m^2/yr; maximum minus minimum live

biomass (MMLB) per year was 773.00 g/m^2/yr; sum of positive increment in live biomass (SPILB) per year was 898.00 g/m^2/yr; and sum of positive increment in live & dead biomass (SPILDB) was 1021.00 g/m^2/yr (**Table 11b**).

In the mildly disturbed area, the peak live biomass product (PLB) per year was 424.50 g/m^2/yr; Peak standing crop (PSC) per year was 333.90 g/m^2/yr; maximum minus minimum live biomass (MMLB) per year was 130.10 g/m^2/yr; sum of positive increment in live biomass (SPILB) per year was 142.20 g/m^2/yr; and sum of positive increment in live & dead biomass (SPILDB) was 213.70 g/m^2/yr (**Table 11b**).

In the undisturbed area, the peak live biomass product (PLB) per year was 52.80 g/m^2/yr; Peak standing crop (PSC) per year was 45.70 g/m^2/yr; maximum minus minimum live biomass (MMLB) per year was 25.30 g/m^2/yr; sum of positive increment in live biomass (SPILB) per year was 27.70 g/m^2/yr; and sum of positive increment in live & dead biomass (SPILDB) was 32.70 g/m^2/yr (**Table 11b**).

The net primary production of herbaceous species was found to be highest in the highly disturbed area and followed by mildly disturbed area and lowest in the undisturbed area.

Table 11a. Monthly variation in biomass of herbaceous species (g/m^2) in three study (2005). AGB: Above ground biomass (g/m^2). BGB: Below ground biomass (g/m^2). Dead matters: Sum of standing dead and litter.

Site	Plant parts	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
HD	AGB	327.0	227.0	149.0	240.0	149.0	248.0	380.0	514.0	465.0	446.0	380.0	354.0	323.3
	BGB	360.0	178.0	62.0	73.0	122.0	135.0	414.0	454.0	420.0	470.0	405.0	380.0	289.4
	Dead matter	389.0	400.0	414.0	397.0	360.0	308.3	196.7	178.0	135.0	124.0	146.0	222.0	272.5
	Total	1076.0	805.0	625.0	710.0	631.0	691.3	990.7	1146.0	1020.0	1040.0	931.0	956.0	885.2
MD	AGB	127.0	97.0	85.4	94.2	99.1	116.0	129.6	164.9	162.0	155.0	149.0	135.0	126.2
	BGB	109.0	83.4	98.0	86.0	88.0	100.0	100.0	130.6	134.0	130.0	126.0	119.0	108.7
	Dead matter	60.9	81.5	109.0	107.0	125.6	124.0	117.8	84.0	68.7	61.8	62.8	66.7	89.2
	Total	296.9	261.9	292.4	287.2	312.7	340.0	347.4	379.5	364.7	346.8	337.8	320.7	324.0
UD	AGB	18.0	14.4	13.6	17.1	14.7	17.1	21.7	23.4	23.5	23.0	20.0	19.2	18.8
	BGB	11.5	5.2	4.3	7.5	9.5	11.0	14.5	16.7	19.7	17.3	16.0	13.5	12.2
	Dead matter	6.1	6.8	6.5	9.6	7.2	6.3	5.2	4.3	4.0	3.7	4.3	4.9	5.7
	Total	35.6	26.4	24.4	34.2	31.4	34.4	41.4	44.4	47.2	44.0	40.3	37.6	36.8

Table 11b. Net primary production (NPP) of herbaceous species in the three study sites (2005). PLB: Peak live biomass Method. PSC: Peak standing crop Method. MMLB: Maximum minus Minimum live biomass method. SPILB: Sum of positive increment in live biomass. SPILDB: Sum of positive increment in live and dead biomass.

Sl no.	Methods	Study sites		
		HD	MD	UD
1	PLB ($g/m^2/yr$)	1398.00	424.50	52.80
2	PSC ($g/m^2/yr$)	1104.00	333.90	45.70
3	MMLB ($g/m^2/yr$)	773.00	130.10	25.30
4	SPILB ($g/m^2/yr$)	898.00	142.20	27.70
5	SPILDB ($g/m^2/yr$)	1021.00	213.70	32.70

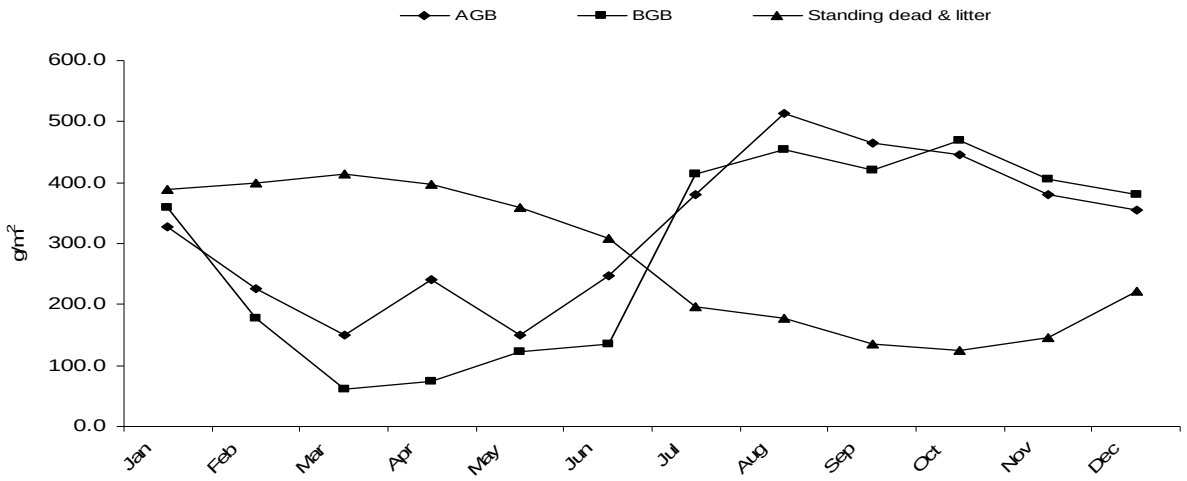

Fig. 4a. Monthly variation of biomass of herbaceous species (g/m^2) in highly disturbed area (2005). AGB: Above ground biomass (g/m^2). BGB: Below ground biomass (g/m^2).

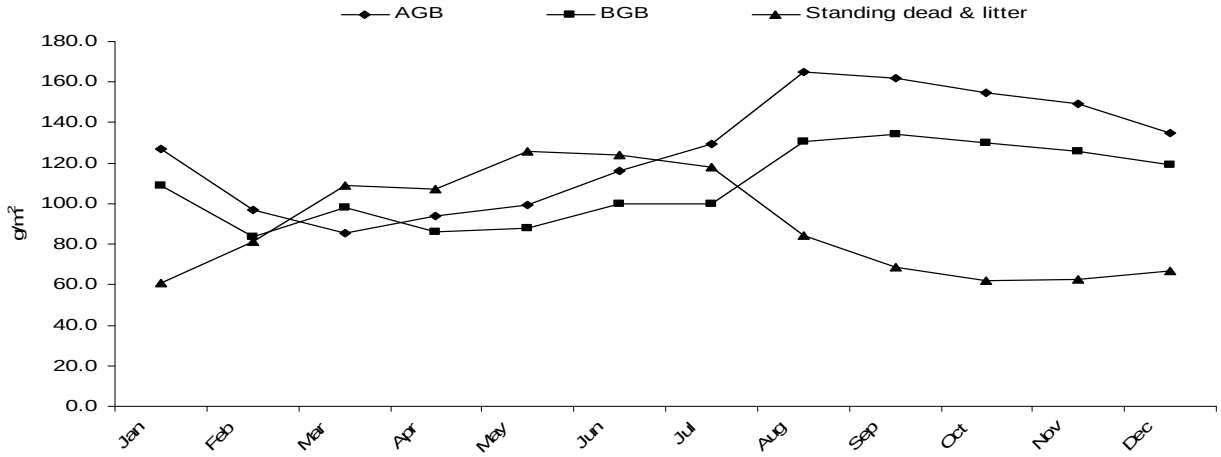

Fig. 4b. Monthly variation of biomass of herbaceous species (g/m^2) in mildly disturbed area (2005). AGB: Above ground biomass (g/m^2). BGB: Below ground biomass (g/m^2).

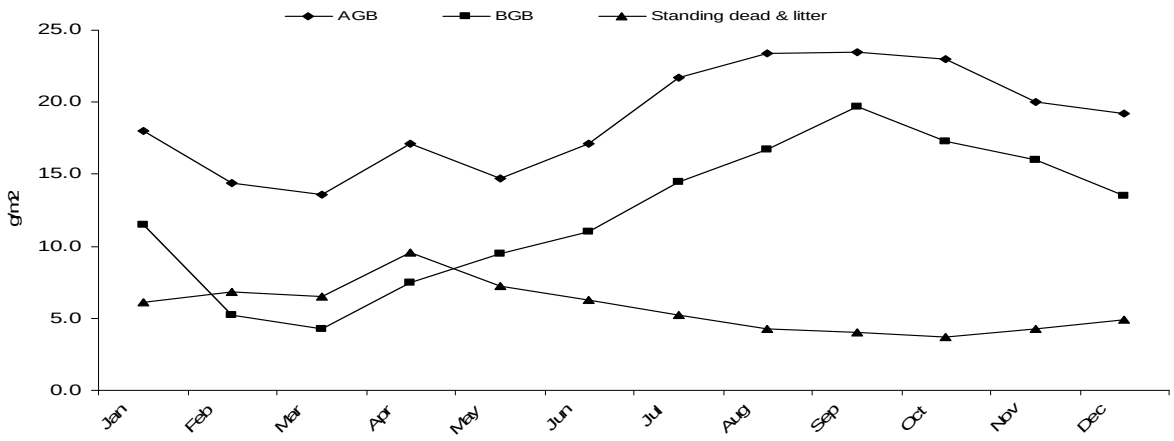

Fig. 4c. Monthly variation of biomass of herbaceous species (g/m^2) in undisturbed area (2005). AGB: Above ground biomass (g/m^2). BGB: Below ground biomass (g/m^2).

5.4 Physico-chemical properties of soil

5.4.1 Physical properties of soil

5.4.1.1 Soil moisture content (SMC)

In the highly disturbed area, the percentage of soil moisture content ranged from 6.7 % to 21.8 % at 0-10 cm and 7.5 % to 20.9 % at 10-20 cm soil depth. In the mildly disturbed area, the percentage of soil moisture content varied from 5.5 % to 31.3 % at 0-10 cm and 8.7 % to 29.6 % at 10-20 cm soil layer. In the Undisturbed area, the percentage of soil moisture content varied from 10.2 % to 28.6 % at 0-10cm and 14.1 % to 25.9 % at 10-20 cm soil depth **(Table. 12)**.

The moisture content of soil was highest in June and July (21.8 %) in 0-10 cm and lowest in March (7 %) at 10-20 cm depth of soil in the highly disturbed area **(Fig. 5a)**. In the mildly disturbed area, the amount of soil moisture was found to be highest in August (31.3 %) at 0-10 cm and lowest in February (5.5 %) at 0-10 cm soil depth **(Fig. 5b)**. In undisturbed area, soil moisture content was maximum in July (28.6 %) at 0- 10 cm and minimum (10.2 %) in February at 0-10 cm soil depth **(Fig. 5c)**.

The highest soil moisture content was found in August (31.3 %) at 0-10 cm soil depth in the mildly disturbed area and lowest in February (5.5 %) at 0-10 cm soil depth in the mildly disturbed area **(Table 12)**.

In the highly disturbed area, the soil moisture content of the study area was highest in rainy/ summer season (20.14 %) at 10-20 cm soil depth and lowest in winter (9.55 %) at 0-10 cm soil depth. The average annual soil moisture content was 14.31 % at 0-10 cm and 15.73 % at 10-20 cm soil depth. In the mildly disturbed area, the soil moisture content was highest in rainy/

summer season (27.12 %) at 0-10 cm soil depth and lowest in winter (11.63 %) at 0-10 cm soil depth. The average annual soil moisture content was 19.72 % at 0-10 cm and 19.07 % at 10-20 cm soil depth. In the undisturbed area, the soil moisture content was highest in rainy/summer season (25.54 %) at 0-10 cm soil depth and lowest in spring (15.10 %) at 10-20 cm soil depth. The annual soil moisture content was 21.23 % at 0-10 cm and 19.73 % at 10-20 cm soil depth **(Table 24)**.

5.4.1.2 Soil Texture

The texture of the soil was sandy loam at the two vertical layers of soil (*i.e.*, 0-10 cm and 10-20 cm) in the highly disturbed area; sandy-clay-loam at the two vertical layers of soil in the mildly disturbed area; in the undisturbed area, the sandy-clay-loam was found only at 10-20 cm and sandy loam at 0- 10 cm soil depth. The percentage of clay content was found to be highest at 10-20 cm in mildly disturbed area and lowest at 0-10 cm soil depth in highly disturbed area **(Table 13)**.

In the highly disturbed area, the upper most layer (0-10 cm) of the soil contained 12.63 % of clay, 6.87 % of silt and 80.5 % of sand while the lower layer (10-20 cm) comprised 12.88 % of clay, 4.37 % of silt and 82.75 % of sand. In the mildly disturbed area, the upper most layer (0-10 cm) of the soil contained 21.38% of clay, 7.5% of silt and 71.12% of sand while the lower layer (10-20 cm) comprised 23.25 % of clay, 6.25 % of silt and 70.5 % of sand. In the undisturbed area, the upper most layer (0-10 cm) of the soil contained 13.25 % of clay, 6.25 % of silt and 80.5 % of sand while the lower layer (10-20 cm) comprised 15.38 % of clay, 10 % of silt and 74.62 % of sand **(Table 13)**.

5.4.1.3 Water holding capacity (WHC)

In the highly disturbed area the percentage of WHC was found to be 60.90 % at 0-10 cm and 58.00 % at 10-20 cm soil depth. In the mildly disturbed area the value of WHC ranged from 73.10 % at 10-20 cm to 74.90 % at 0-10 cm soil depth. In the undisturbed area the percentage of WHC was found to be 84.00 % at 0-10 cm and 72.00 % at 10-20 cm soil depth **(Table 14)**.

The highest water holding capacity (WHC) was found at 0-10 cm soil depth in undisturbed area and lowest at 10-20 cm soil depth in highly disturbed area **(Fig. 6)**.

Table 12. Monthly variation of soil moisture content (%) at three sites of the study area (2005).

Sites	Soil depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Highly disturbed area	**0 - 10 cm**	6.7	7.3	7	9.7	17.4	21.8	21.8	20	19.6	16.2	16	8.2	14.31
	10 - 20 cm	7.5	9.4	9	15.4	19.2	20.6	20.9	19.4	20.8	19	18	9.6	15.73
Mildly Disturbed area	**0 - 10 cm**	11.2	5.5	12.8	18.0	23.7	25.8	27.5	31.3	28.1	22.9	20	9.8	19.72
	10 - 20 cm	13.3	8.7	10.3	13.5	21.6	24.3	22.9	29.6	24.8	26	20.8	13	19.07
Undisturbed area	**0 - 10 cm**	15.2	10.2	18.2	17.2	24.8	19.0	28.6	27.4	26.4	26.3	25.1	16.3	21.23
	10 - 20 cm	16.9	14.1	14.8	14.2	16.3	21.2	24.8	25.9	22.7	22.9	22.8	20.1	19.73

Table 13. Soil texture at three sites of the study area (2005).

Sites	Soil Depth	Clay (%)	Silt (%)	Sand (%)	Textural class
Highly disturbed area	**0 – 10 cm**	12.63	6.87	80.5	Sandy loam
	10 - 20 cm	12.88	4.37	82.75	Sandy loam
Mildly disturbed area	**0 – 10 cm**	21.38	7.5	71.12	Sandy-Clay-loam
	10 - 20 cm	23.25	6.25	70.5	Sandy-Clay-loam
Undisturbed area	**0 – 10 cm**	13.25	6.25	80.5	Sandy loam
	10 – 20 cm	15.38	10	74.62	Sandy-clay -loam

Table 14. Water holding capacity at the three sites of the study area (2005).

Site	Soil Depth	WHC (%)
Highly disturbed area	0 - 10cm	60.90
	10 - 20cm	58.00
Mildly disturbed area	0 - 10cm	74.90
	10 - 20cm	73.10
Undisturbed area	0 - 10cm	84.00
	10 - 20cm	72.00

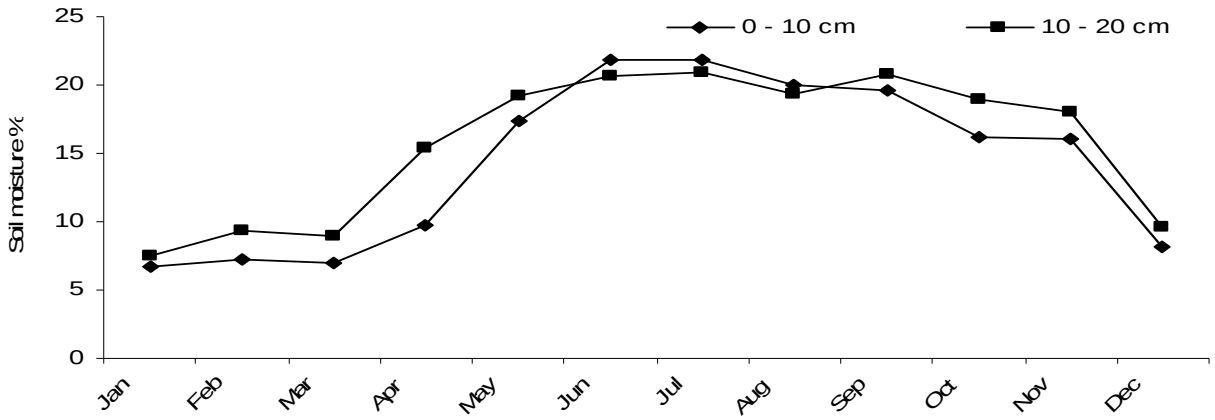

Fig. 5a. Monthly variation of soil moisture content (%) in highly disturbed area (2005).

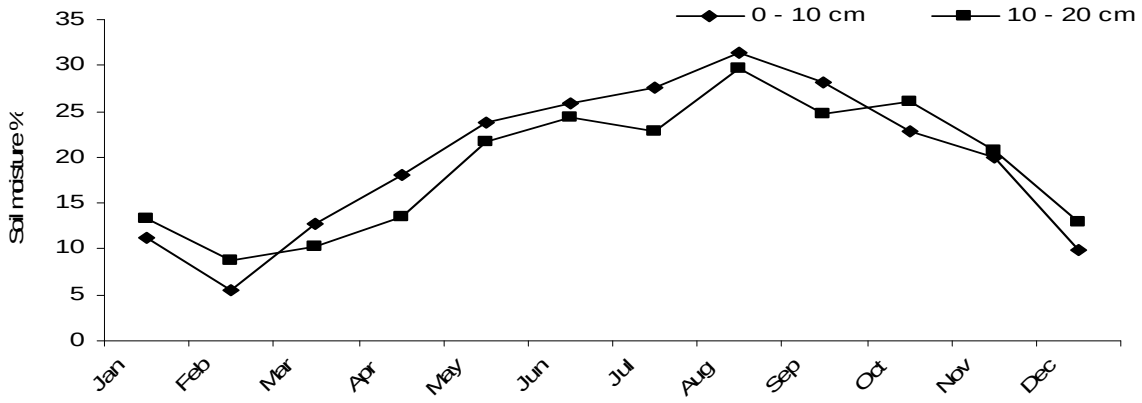

Fig. 5b. Monthly variation of soil moisture content (%) in mildly disturbed area (2005).

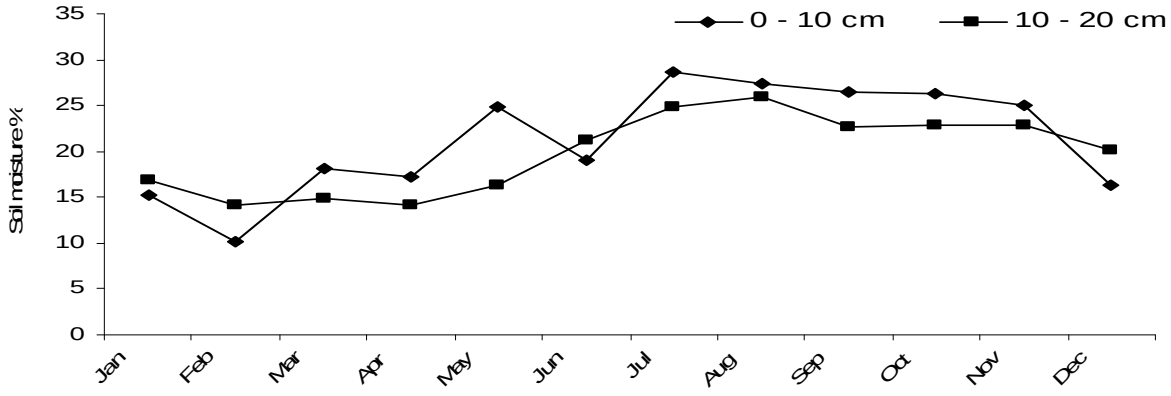

Fig. 5c. Monthly variation of soil moisture content (%) in undisturbed area (2005).

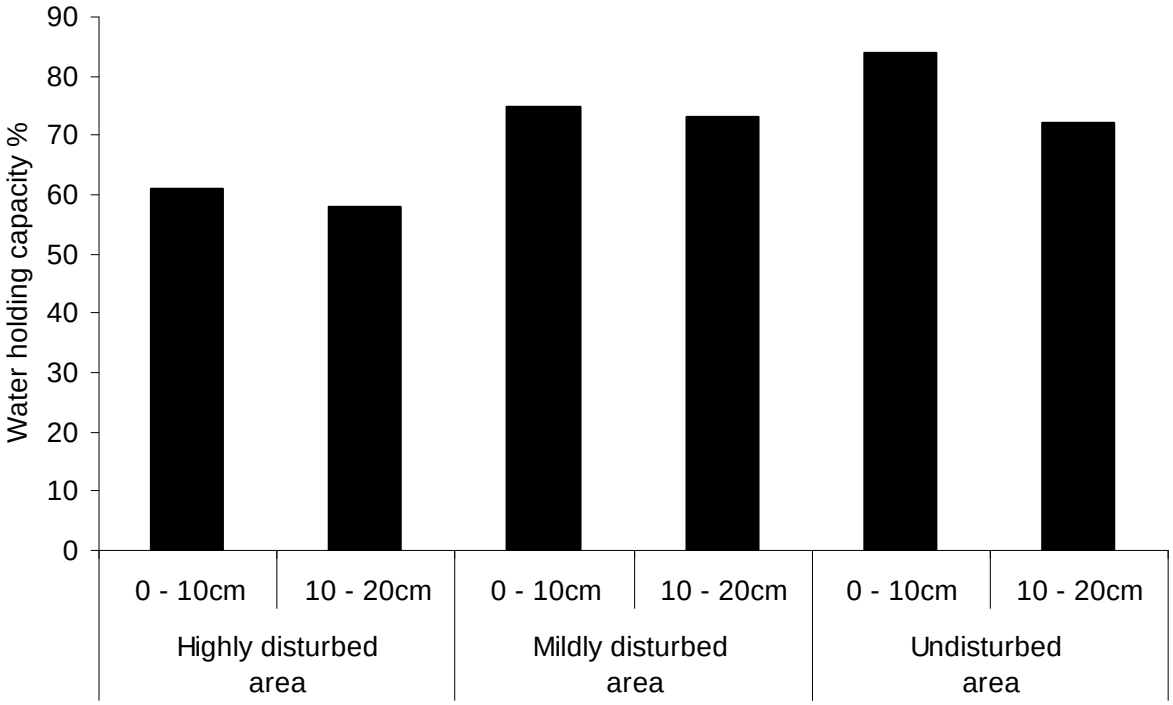

Fig. 6. Water holding capacity at the three sites in the study area.

5.4.2 Chemical properties of soil

5.4.2.1 Soil pH

The soil of the study area was generally acidic (pH = 4.75 to 6.82) at 0-20 cm soil depth. The pH was fluctuated across the month and soil depth in both the layers of soil in all the study sites. In the highly disturbed area the soil pH was fluctuated from 4.85 to 6.49 at 0-10 cm soil depth and from 4.75 to 6.24 at 10-20 cm soil depth. In mildly disturbed area it ranged from 4.89 to 6.32 at 0-10 cm soil layer and from 4.91 to 6.14 at 10-20 cm soil layer. In the undisturbed area the pH varied from 5.67 to 6.82 at 0-10 cm soil layer and from 5.79 to 6.62 at 10 -20 cm soil layer **(Table 15)**.

In the highly disturbed area, pH of soil was peak in July (6.49) at 0-10 cm soil depth and lowest in May (4.85) at 10-20 cm soil depth **(Fig. 7a)**. In the mildly disturbed area, the maximum pH was found in November (6.32) at 0-10 cm and minimum in April (4.89) at 0-10 cm soil depth **(Fig. 7b)**. In the undisturbed area, the maximum pH was observed in November (6.82) at 0-10 cm and minimum in December (5.67) at 0-10 cm soil depth **(Fig. 7c)**.

The highest pH of soil was found at 0-10 cm soil depth in the month of November (6.82) in the undisturbed area and lowest at 10-20 cm soil depth in the month of May (4.85) in the highly disturbed area **(Table 15)**.

Monthly variation of pH of soil in the highly disturbed area was found to be highest in rainy/ summer season (6.05) at 0-10 cm and lowest in spring (5.41) at 0-10 cm soil depth and the average annual pH was 5.77 at 0-10 cm and 5.73 at 10-20 cm soil depth. In the mildly disturbed area, the pH of soil was highest in winter (5.73) at 0-10 cm and lowest in spring (5.25) at 10-20 cm soil depth. The average annual pH 5.46 at 0-10 cm and 5.41 at 10-20 cm soil depth. In the

undisturbed area, the pH of soil was found to be highest in spring (6.39) at 10-20 cm and lowest in winter (6.21) at 0-10 cm. The average annual pH was 6.34 at 0-10 cm and 6.32 at 10-20 cm soil depth **(Table 24)**.

5.4.2.2 Soil organic carbon (SOC)

The soil organic carbon content was fluctuated at different soil depths and in different months throughout the year. In the highly disturbed area, the percentages of organic carbon of soil ranged from 1.67% to 3.41% at 0-10 cm and 1.38% to 2.50% at 10-20 cm soil depth. In mildly disturbed area it ranged from 2.37% to 4.09% at 0-10 cm and 2.15% to 3.29% at 10-20 cm soil depth. In undisturbed area the soil organic carbon also fluctuated from 2.16% to 4.63% at 0-10 cm and 1.62% to 3.60% at 10-20 cm soil layer **(Table 16)**.

The percentage of soil organic carbon was highest in the month of July (3.41 %) at 0-10 cm soil depth and lowest in April (1.38 %) at 10-20 cm soil depth in the highly disturbed area **(Fig. 8a)**. In the mildly disturbed area, soil organic content was highest in July (4.09 %) at 0-10 cm soil depth and lowest in December (2.15 %) at 10-20 cm depth of soil **(Fig. 8b)**. In the undisturbed area, it was highest in August (4.63 %) at 0-10 cm soil depth and lowest in March (1.62 %) at 10-20 cm soil depth **(Fig. 8c)**.

The amount of soil organic carbon in the soil of the study area was found to be highest in August (4.63 %) at 0-10 cm in the undisturbed area and lowest in April (1.38 %) at 10-20 cm in the highly disturbed area **(Table 16)**.

In the highly disturbed area, the highest amount of soil organic carbon was found in rainy/ summer season (2.81%) at 0-10 cm and lowest in winter (1.67%) at 10-20 cm soil depth,

and the average annual amount of soil organic carbon was 2.43% at 0-10 cm and 1.83% at 10-20 cm soil depth. In the mildly disturbed area, the organic carbon in a soil was found to be highest in rainy/ summer season (3.62%) at 0-10 cm and lowest in winter (2.21%) at 10-20 cm soil depth, and the average annual amount of soil organic carbon was 3.21% at 0-10 cm and 2.49% at 10-20 cm soil depth. In the undisturbed area, the maximum soil organic carbon was observed in rainy/ summer (3.88%) at 0-10 cm and lowest in winter (2.11%) at 10-20 cm soil depth. The average annual amount of soil organic carbon was 3.27% at 0-10 cm and 2.58% at 10-20 cm soil depth **(Table 14)**.

5.4.2.3 Total soil nitrogen

The total soil nitrogen was fluctuated in different soil depths and months throughout the year. In the highly disturbed area, it fluctuated from 0.09% to 0.37% at 0-10 cm and 0.02% to 0.25% at 10-20 cm soil depth. In the mildly disturbed area, the percentage of total soil nitrogen varied from 0.13% to 0.38% at 0-10 cm and 0.06% to 0.18% at 10-20 cm soil depth. In the undisturbed area, the fluctuation of total soil nitrogen varied from 0.15% to 0.45% at 0-10 cm and 0.03% to 0.28% at 10-20 cm soil depth **(Table 17)**.

The total soil nitrogen was maximum during August (0.37 %) at 0-10 cm and minimum in January – March (0.02 %) at 10-20 cm soil depth in the highly disturbed area **(Fig. 9a)**. In the mildly disturbed area, the maximum total soil nitrogen was found in August (0.38 %) at 0-10 cm and minimum in May (0.06 %) at 10-20 cm soil depth **(Fig. 9b)**. In the undisturbed area, total soil nitrogen reached the peak in July (0.45%) at 0-10 cm and the lowest in November (0.03 %) at 10-20 cm soil depth **(Fig. 9c)**.

The amount of total nitrogen in the soil was found to be highest in July (0.45 %) at 0-10 cm in the undisturbed area and lowest in the months of January, February and March (0.02 %) at each 10-20 cm soil depth in the highly disturbed area **(Table 17)**.

In the highly disturbed area, the maximum amount of total soil nitrogen was observed in rainy/ summer season (0.28%) at 0-10 cm and minimum in spring (0.04%) at 10-20 cm soil depth. In the mildly disturbed area, the percentage of total soil nitrogen was highest in rainy/ summer (0.34%) at 0-10 cm and lowest in spring (0.09%) at 10-20 cm soil depth. In the undisturbed area, the highest amount of total soil nitrogen was found in rainy/ summer (0.34%) at 0-10 cm and lowest in winter (0.07%) at 10-20 cm soil depth **(Table 24)**.

The average annual total soil organic carbon were 0.20% at 0-10 cm and 0.12% at 10-20 cm soil depth in the highly disturbed area; 0.26% at 0-10 cm and 0.12% at 10-20 cm soil depth in the mildly disturbed area; 0.26% at 0-10 cm and 0.14% at 10-20 cm soil depth in the undisturbed area **(Table 24)**.

The C:N ratio in diferrent months at the three sites of the study area were shown in **Table 18.**

5.4.2.4 Available phosphorus

The concentration of available phosphorus in soil was also fluctuated in different soil depths and months in a year. In the highly disturbed area, it ranged from 1.00 µg/g to 4.00 µg/g at 0-10 cm and 1.00 µg/g to 3.26 µg/g at 10-20 cm soil depth. In the mildly disturbed area, it varied from 0.89 µg/g to 6.00 µg/g at 0-10 cm and 0.44 µg/g to 5.09 µg/g at 0-10 cm soil depth.

In the undisturbed area, the variation of the available phosphorus ranged from 3.68 µg/g to 7.20 µg/g at 0-10 cm and 3.30 µg/g to 6.16 µg/g at 10-20 cm soil depth **(Table 19)**.

The available phosphorus was maximum in the month of August (4.00 µg/g) at 0-10 cm soil depth and minimum in December (1.00 µg/g) in the soil depth of 10-20cm in the highly disturbed area **(Fig. 10a)**. In the mildly disturbed area, available phosphorus was highest in August (6.00 µg/g) at 0-10 cm and lowest in the month of January (0.44 µg/g) at 10-20 cm soil depth **(Fig. 10b)**. In the undisturbed area, it is also found to be highest in September (7.20 µg/g) at 0-10 cm soil depth and lowest in December (3.30 µg/g) at 10-20 cm soil layer **(Fig. 10c)**.

The maximum amount of available phosphorus was found in September (7.20 µg/g) at 0-10 cm soil depth in the undisturbed area and minimum in January (0.44 µg/g) at 10-20 cm soil depth in the mildly disturbed area **(Table 19)**.

In the highly disturbed area, the amount of available phosphorus was highest in rainy/ summer season (3.18 µg/g) at 0-10 cm and lowest in winter (1.07 µg/g) at 10-20 cm soil depth. In the mildly disturbed area, the highest amount of available phosphorus was observed in rainy/ summer (4.90 µg/g) at 0-10 cm and lowest in winter (1.13 µg/g) at 10-20 cm soil depth. In the undisturbed area, the highest available phosphorus was found in rainy/ summer (6.14 µg/g) at 0-10 cm and lowest in winter (3.44 µg/g) at 10-20 cm soil depth **(Table 24)**.

The average (annual) amount of available phosphorus were 2.33 µg/g at 0-10 cm and 2.01 µg/g at 10-20 cm soil depth in the highly disturbed area, 3.15 µg/g at 0-10 cm and 2.55 µg/g at 10-20 cm soil depth in the mildly disturbed area and 4.92 µg/g at 0-10 cm and 4.37 µg/g at 10-20 cm soil depth in the undisturbed area **(Table 24)**.

5.4.2.4 Exchangeable potassium

The amount of exchangeable potassium in a soil at the study area was greatly fluctuating throughout the year and had different ranges in different vertical soil layers. In the highly disturbed area, the amount of exchangeable potassium ranged from 657 µg/g to 866 µg/g at 0-10 cm and 595 µg/g to 720 µg/g at 10-20 cm soil depth. In the mildly disturbed area, its concentration varied from 593 µg/g to 760 µg/g at 0-10 cm and 511 µg/g to 626 µg/g at 10-20 cm soil depth. In the undisturbed area, the amount of exchangeable potassium also fluctuated from 426 µg/g to 544 µg/g at 0-10 cm and 334 µg/g to 437 µg/g at 10-20 cm soil depth **(Table 20)**.

The concentration of exchangeable potassium was maximum in June (866 µg/g) at 0-10 cm and minimum in April (959 µg/g) at 10-20 cm soil depth in the highly disturbed area **(Fig. 11a)**. In mildly disturbed area, the concentration of exchangeable was highest in the month of July (760 µg/g) at 0-10 cm and lowest in June (511 µg/g) at 10-20 cm soil depth **(Fig. 11b)**. In undisturbed area, it was highest in July (544 µg/g) at 0-10 cm and lowest in June (384 µg/g) at 10-20 cm soil depth **(Fig. 11c)**.

The amount of exchangeable potassium was highest in June (866 µg/g) at 0-10 cm soil depth in the highly disturbed area and lowest in June (334 µg/g) at 10-20 cm soil depth in the undisturbed area **(Table 20)**.

In the highly disturbed area, the maximum amount of exchangeable potassium was observed in rainy/ summer season (745 µg/g) at 0-10 cm and minimum in spring (652 µg/g) at 10-20 cm soil depth. In the mildly disturbed area, the concentration of exchangeable potassium was highest in spring (687 µg/g) at 0-10 cm and lowest in winter (575 µg/g) at 10-20 cm soil

depth. In the undisturbed area, the highest amount of exchangeable potassium was found in rainy/ summer (488 µg/g) at 0-10 cm and lowest in spring (342 µg/g) at 10-20 cm soil depth **(Table 24)**.

The everage (annual) amount of exchangeable potassium were 738 µg/g at 0-10 cm and 662 µg/g at 10-20 cm soil depth in the highly disturbed area, 672 µg/g at 0-10 cm and 576 µg/g at 10-20 cm soil depth in the mildly disturbed area and 475 µg/g at 0-10 cm and 373 µg/g at 10-20 cm soil depth in the undisturbed area **(Table 24)**.

The seasonal variation of the annual amount of soil moisture content, pH, organic carbon, total nitrogen, C:N ratio, available phosphorus and exchangeable potassium is being presented in **Table 24.**

Table 15. Monthly variation of soil pH at three sites in the study area (2005).

Sites	Soil depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Highly disturbed area	0 - 10 cm	5.56	5.67	5.51	5.86	4.85	6.05	6.49	6.18	5.41	6.13	5.71	5.87	5.77
	10 - 20 cm	5.39	5.62	5.37	5.96	4.75	5.87	6.24	6.18	5.39	6.21	5.84	5.98	5.73
Mildly disturbed area	0 - 10 cm	5.46	5.76	5.88	4.89	5.02	5.02	5.06	5.11	5.39	6.26	6.32	5.38	5.46
	10 - 20 cm	5.39	5.52	5.67	5	5.09	4.91	5.09	5.16	5.37	6.14	5.96	5.59	5.41
Undisturbed area	0 - 10 cm	6.47	6.28	6.26	6.61	6.35	6.12	6.05	6.48	6.52	6.41	6.82	5.67	6.34
	10 - 20 cm	6.51	6.21	6.28	6.41	6.49	6.11	6.52	6.23	6.37	6.62	6.31	5.79	6.32

Table 16. Monthly variation of soil organic carbon (%) at three sites in the study area (2005).

Sites	Soil depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Highly Disturbed area	0 - 10 cm	1.89	1.73	1.67	2.43	2.56	3.04	3.41	3.32	2.18	2.09	2.81	2.08	2.43
	10 - 20 cm	1.71	1.68	1.59	1.38	2.30	2.45	2.50	2.11	1.47	1.49	1.54	1.75	1.83
Mildly Disturbed area	0 - 10 cm	2.48	2.26	2.37	3.56	3.64	3.03	4.09	3.84	3.67	3.48	3.70	2.39	3.21
	10 - 20 cm	2.21	2.21	2.30	2.38	3.29	2.90	2.83	2.73	2.31	2.28	2.28	2.15	2.49
Undisturbed area	0 - 10 cm	2.38	2.16	2.34	3.63	3.25	3.61	3.72	4.63	3.84	3.60	3.54	2.57	3.27
	10 - 20 cm	2.06	1.86	1.62	2.68	2.99	3.01	3.41	3.60	2.93	2.28	2.46	2.08	2.58

Table 17. Monthly variation of total soil nitrogen (%) in soil at three sites in the study area (2005).

Sites	Soil depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Highly disturbed area	0 - 10 cm	0.12	0.09	0.11	0.14	0.11	0.16	0.26	0.37	0.29	0.32	0.25	0.21	0.20
	10 - 20 cm	0.02	0.02	0.02	0.06	0.04	0.09	0.16	0.20	0.24	0.25	0.18	0.10	0.12
Mildly Disturbed area	0 - 10 cm	0.14	0.13	0.25	0.27	0.21	0.27	0.37	0.38	0.34	0.36	0.26	0.16	0.26
	10 - 20 cm	0.10	0.09	0.08	0.13	0.06	0.12	0.17	0.17	0.11	0.18	0.13	0.10	0.12
Undisturbed area	0 - 10 cm	0.15	0.15	0.31	0.22	0.24	0.33	0.45	0.33	0.35	0.23	0.17	0.17	0.26
	10 - 20 cm	0.05	0.08	0.15	0.18	0.15	0.18	0.28	0.20	0.15	0.11	0.03	0.12	0.14

Table 18. C:N ratio in different months at three sites in the study area (2005).

Sites	Soil depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Highly Disturbed area	0 - 10 cm	16	18	15	17	24	19	13	9	8	7	11	10	12
	10 - 20 cm	86	70	84	22	55	27	16	11	6	6	9	18	16
Mildly Disturbed area	0 - 10 cm	17	18	10	13	18	11	11	10	11	10	14	15	12
	10 - 20 cm	21	24	29	18	55	24	17	16	20	13	18	22	21
Undisturbed area	0 - 10 cm	16	14	8	17	14	11	8	14	11	15	20	15	13
	10 - 20 cm	38	23	11	15	20	17	12	18	19	20	91	17	18

Table 19. Monthly variation of available phosphorus (µg/g) in soil at three sites in the study area (2005).

Sites	Soil depth (cm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Highly disturbed area	0 - 10 cm	1.43	1.53	1.80	2.12	2.88	2.70	3.63	4.00	3.26	2.30	1.27	1.00	2.33
	10 - 20 cm	1.26	1.31	1.53	1.68	2.37	2.92	3.26	3.18	2.88	1.95	1.00	0.72	2.02
Mildly disturbed area	0 - 10 cm	0.89	1.15	1.33	2.80	3.40	4.67	4.93	6.00	5.20	3.70	2.70	1.00	3.15
	10 - 20 cm	0.44	0.88	1.00	2.33	3.00	3.76	4.05	5.09	3.80	3.08	2.20	1.00	2.55
Undisturbed area	0 - 10 cm	3.68	3.87	3.80	4.38	4.48	5.05	5.46	7.00	7.20	6.00	4.20	3.90	4.92
	10 - 20 cm	3.33	3.43	4.32	3.97	3.97	4.48	4.64	6.00	6.16	5.14	3.71	3.30	1.37

Table 20. Monthly variation of exchangeable potassium (µg/g) in soil at three sites in the study area (2005).

Sites	Soil depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Highly disturbed area	**0-10cm**	731	718	748	709	731	866	754	760	686	657	754	744	738
	10-20cm	660	647	691	595	671	720	710	660	620	623	671	676	662
Mildly disturbed area	**0-10cm**	653	620	729	640	693	593	760	680	683	636	725	653	672
	10-20cm	562	535	540	570	620	511	626	580	582	582	618	586	576
Undisturbed area	**0-10cm**	460	463	433	520	472	446	544	460	531	460	480	426	475
	10-20cm	400	413	338	344	344	334	377	360	437	376	411	345	373

Table 21. Monthly variation of soil moisture content (%), soil pH, soil organic carbon (%), total soil nitrogen (%), C: N ratio, available phosphorus (µg/g) and exchangeable potassium (µg/g) in highly disturbed area.

Parameters	Soil depth (cm)	Highly disturbed area												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Soil moisture content (%)	00-10 cm	6.70	7.30	7.00	9.70	17.40	21.80	21.80	20.00	19.60	16.20	16.00	8.20	14.31
	10-20 cm	7.50	9.40	9.00	15.40	19.20	20.60	20.90	19.40	20.80	19.00	18.00	9.60	15.73
Soil pH	00-10 cm	5.56	5.67	5.51	5.86	4.85	6.05	6.49	6.18	5.41	6.13	5.71	5.87	5.77
	10-20 cm	5.39	5.62	5.37	5.96	4.75	5.87	6.24	6.18	5.39	6.21	5.84	5.98	5.73
Soil organic carbon (%)	00-10 cm	1.89	1.73	1.67	2.43	2.56	3.04	3.41	3.32	2.18	2.09	2.81	2.08	2.43
	10-20 cm	1.71	1.68	1.59	1.38	2.30	2.45	2.50	2.11	1.47	1.49	1.54	1.75	1.83
Total soil nitrogen (%)	00-10 cm	0.12	0.09	0.11	0.14	0.11	0.16	0.26	0.37	0.29	0.32	0.25	0.21	0.20
	10-20 cm	0.02	0.02	0.02	0.06	0.04	0.09	0.16	0.20	0.24	0.25	0.18	0.10	0.12
C:N ratio	00-10 cm	16	18	15	17	24	19	13	9	8	7	11	10	14
	10-20 cm	86	70	84	22	55	27	16	11	6	6	9	18	34
Available phosphorus (µg/g)	00-10 cm	1.43	1.53	1.80	2.12	2.88	2.70	3.63	4.00	3.26	2.30	1.27	1.00	2.33
	10-20 cm	1.26	1.31	1.53	1.68	2.37	2.92	3.26	3.18	2.88	1.95	1.00	0.72	2.01
Exchangeable potassium (µg/g)	00-10 cm	731	718	748	709	731	866	754	760	686	657	754	744	738
	10-20 cm	660	647	691	595	671	720	710	660	620	623	671	676	662

Table 22. Monthly variation of soil moisture content (%), soil pH, soil organic carbon (%), total soil nitrogen (%), C: N ratio, available phosphorus (µg/g) and exchangeable potassium (µg/g) in mildly disturbed area.

Parameters	Soil depth (cm)	Mildly disturbed area												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Soil moisture content (%)	00-10 cm	11.20	5.50	12.80	18.00	23.70	25.80	27.50	31.30	28.10	22.90	20.00	9.80	19.72
	10-20 cm	13.30	8.70	10.30	13.50	21.60	24.30	22.90	29.60	24.80	26.00	20.80	13.00	19.07
Soil pH	00-10 cm	5.46	5.76	5.88	4.89	5.02	5.02	5.06	5.11	5.39	6.26	6.32	5.38	5.46
	10-20 cm	5.39	5.52	5.67	5	5.09	4.91	5.09	5.16	5.37	6.14	5.96	5.59	5.41
Soil organic carbon (%)	00-10 cm	2.48	2.26	2.37	3.56	3.64	3.03	4.09	3.84	3.67	3.48	3.70	2.39	3.21
	10-20 cm	2.21	2.21	2.30	2.38	3.29	2.90	2.83	2.73	2.31	2.28	2.28	2.15	2.49
Total soil nitrogen (%)	00-10 cm	0.14	0.13	0.25	0.27	0.21	0.27	0.37	0.38	0.34	0.36	0.26	0.16	0.26
	10-20 cm	0.10	0.09	0.08	0.13	0.06	0.12	0.17	0.17	0.11	0.18	0.13	0.10	0.12
C:N ratio	00-10 cm	17	18	10	13	18	11	11	10	11	10	14	15	13
	10-20 cm	21	24	29	18	55	24	17	16	20	13	18	22	23
Available phosphorus (µg/g)	00-10 cm	0.89	1.15	1.33	2.80	3.40	4.67	4.93	6.00	5.20	3.70	2.70	1.00	3.15
	10-20 cm	0.44	0.88	1.00	2.33	3.00	3.76	4.05	5.09	3.80	3.08	2.20	1.00	2.55
Exchangeable potassium (µg/g)	00-10 cm	653	620	729	640	693	593	760	680	683	636	725	653	672
	10-20 cm	562	535	540	570	620	511	626	580	582	582	618	586	576

Table 23. Monthly variation of soil moisture content (%), soil pH, soil organic carbon (%), total soil nitrogen (%), C: N ratio, available phosphorus (µg/g) and exchangeable potassium (µg/g) in undisturbed area.

Parameters	Soil depth (cm)	Undisturbed area												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Soil moisture content (%)	00-10 cm	15.20	10.20	18.20	17.20	24.80	19.00	28.60	27.40	26.40	26.30	25.10	16.30	21.23
	10-20 cm	16.90	14.10	14.80	14.20	16.30	21.20	24.80	25.90	22.70	22.90	22.80	20.10	19.73
Soil pH	00-10 cm	6.47	6.28	6.26	6.61	6.35	6.12	6.05	6.48	6.52	6.41	6.82	5.67	6.34
	10-20 cm	6.51	6.21	6.28	6.41	6.49	6.11	6.52	6.23	6.37	6.62	6.31	5.79	6.32
Soil organic carbon (%)	00-10 cm	2.38	2.16	2.34	3.63	3.25	3.61	3.72	4.63	3.84	3.60	3.54	2.57	3.27
	10-20 cm	2.06	1.86	1.62	2.68	2.99	3.01	3.41	3.60	2.93	2.28	2.46	2.08	2.58
Total soil nitrogen (%)	00-10 cm	0.15	0.15	0.31	0.22	0.24	0.33	0.45	0.33	0.35	0.23	0.17	0.17	0.26
	10-20 cm	0.05	0.08	0.15	0.18	0.15	0.18	0.28	0.20	0.15	0.11	0.03	0.12	0.14
C:N ratio	00-10 cm	16	14	8	17	14	11	8	14	11	15	20	15	14
	10-20 cm	38	23	11	15	20	17	12	18	19	20	91	17	25
Available phosphorus (µg/g)	00-10 cm	3.68	3.87	3.80	4.38	4.48	5.05	5.46	7.00	7.20	6.00	4.20	3.90	4.92
	10-20 cm	3.33	3.43	4.32	3.97	3.97	4.48	4.64	6.00	6.16	5.14	3.71	3.30	4.37
Exchangeable potassium (µg/g)	00-10 cm	460	463	433	520	472	446	544	460	531	460	480	426	475
	10-20 cm	400	413	338	344	344	334	377	360	437	376	411	345	373

Table 24. Seasonal variation of soil moisture content (%), soil pH, soil organic carbon (%), total soil nitrogen (%), C: N ratio, available phosphorus (µg/g) and exchangeable potassium (µg/g) in Mizoram University campus, Tanhril (2005).

Parameters	Soil depth (cm)	Study site											
		Highly disturbed area				Mildly disturbed area				Undisturbed area			
		Spring	Rainy/ Summer	Winter	Annual	Spring	Rainy/ Summer	Winter	Annual	Spring	Rainy/ Summer	Winter	Annual
Soil moisture content (%)	00-10 cm	11.37	19.88	**9.55**	14.31	18.17	**27.12**	**11.63**	19.72	20.07	**25.54**	16.70	21.23
	10-20 cm	14.53	**20.14**	11.13	15.73	15.13	25.52	13.95	19.07	**15.10**	23.50	18.48	19.73
Soil pH	00-10 cm	**5.41**	**6.05**	5.70	5.77	5.26	5.37	**5.73**	5.46	6.41	6.32	6.31	6.34
	10-20 cm	5.36	5.98	5.71	5.73	**5.25**	5.33	5.62	5.41	**6.39**	6.37	**6.21**	6.32
Soil organic carbon (%)	00-10 cm	2.22	**2.81**	2.13	2.43	3.19	**3.62**	2.71	3.21	3.07	**3.88**	2.66	3.27
	10-20 cm	1.75	2.00	**1.67**	1.83	2.66	2.61	**2.21**	2.49	2.43	3.05	**2.11**	2.58
Total soil nitrogen (%)	00-10 cm	0.12	**0.28**	0.17	0.20	0.24	**0.34**	0.17	0.26	0.25	**0.34**	0.16	0.26
	10-20 cm	**0.04**	0.19	0.08	0.12	**0.09**	0.15	0.11	0.12	0.16	0.19	**0.07**	0.14
C:N ratio	00-10 cm	19	11	14	14	13	11	16	13	13	12	16	14
	10-20 cm	53	13	45	34	34	18	21	23	15	17	42	25
Available phosphorus (µg/g)	00-10 cm	2.27	**3.18**	1.31	2.33	2.51	**4.90**	1.44	3.15	4.22	**6.14**	3.91	4.92
	10-20 cm	1.86	2.84	**1.07**	2.01	2.11	3.96	1.13	2.55	4.09	5.28	**3.44**	4.37
Exchangeable potassium (µg/g)	00-10 cm	729	**745**	737	738	**687**	670	663	672	475	**488**	457	475
	10-20 cm	**652**	667	664	662	577	576	**575**	576	**342**	377	392	373

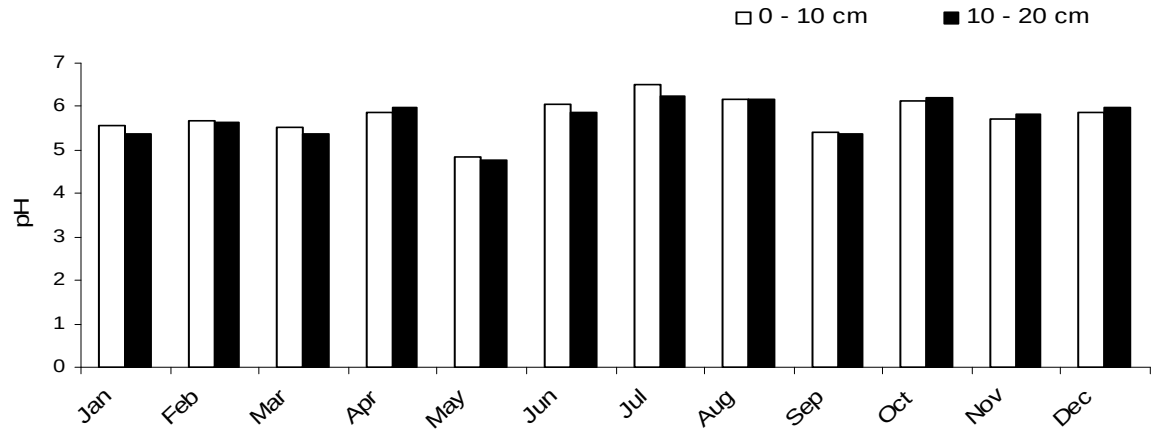

Fig. 7a. Monthly variation of soil pH in the highly disturbed area (2005).

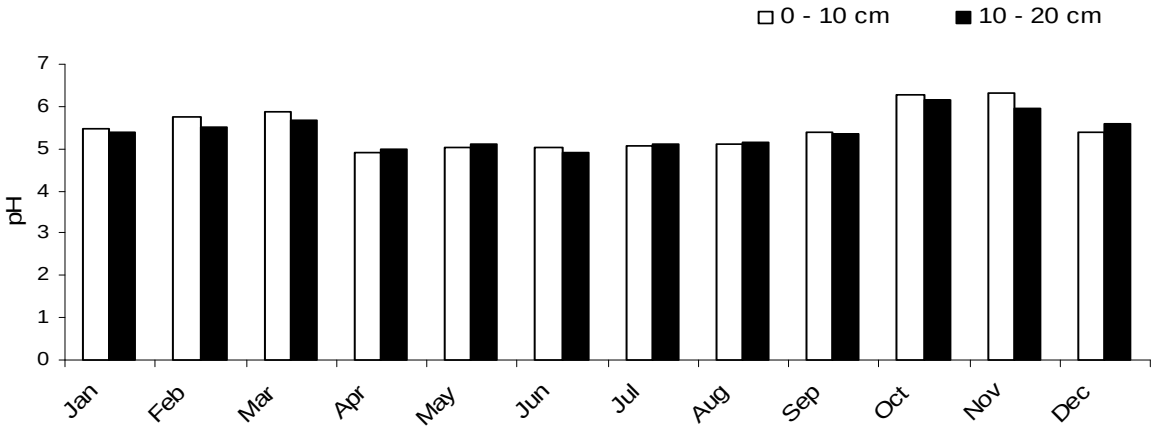

Fig. 7b. Monthly variation of soil pH in the mildly disturbed area (2005).

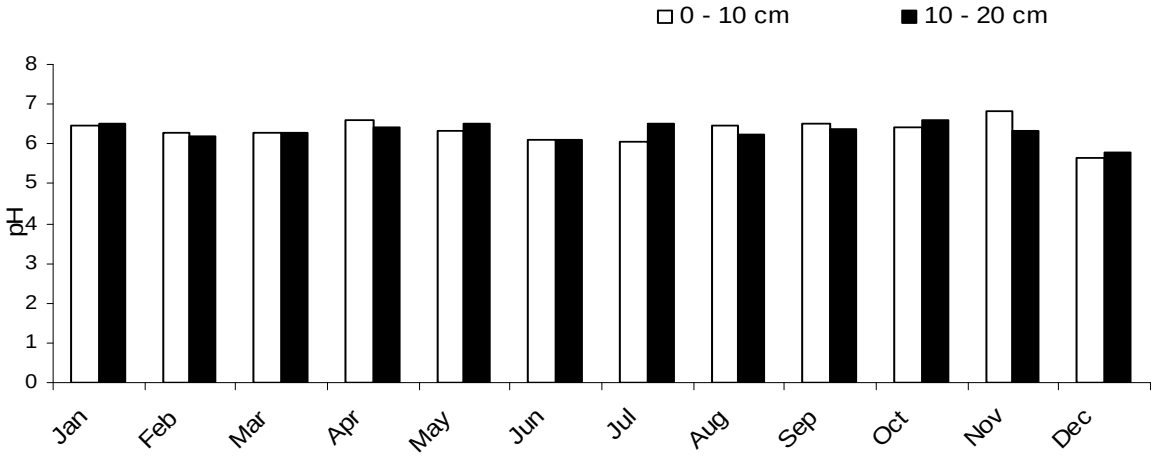

Fig. 7c. Monthly variation of soil pH in the undisturbed area (2005).

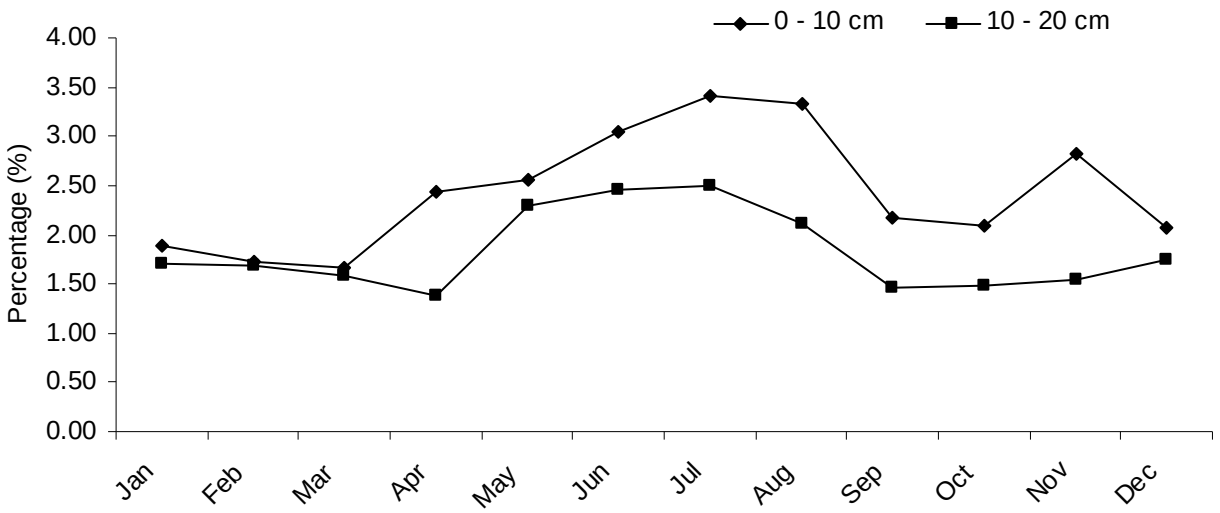

Fig. 8a. Monthly variation of soil organic carbon in highly disturbed area (2005).

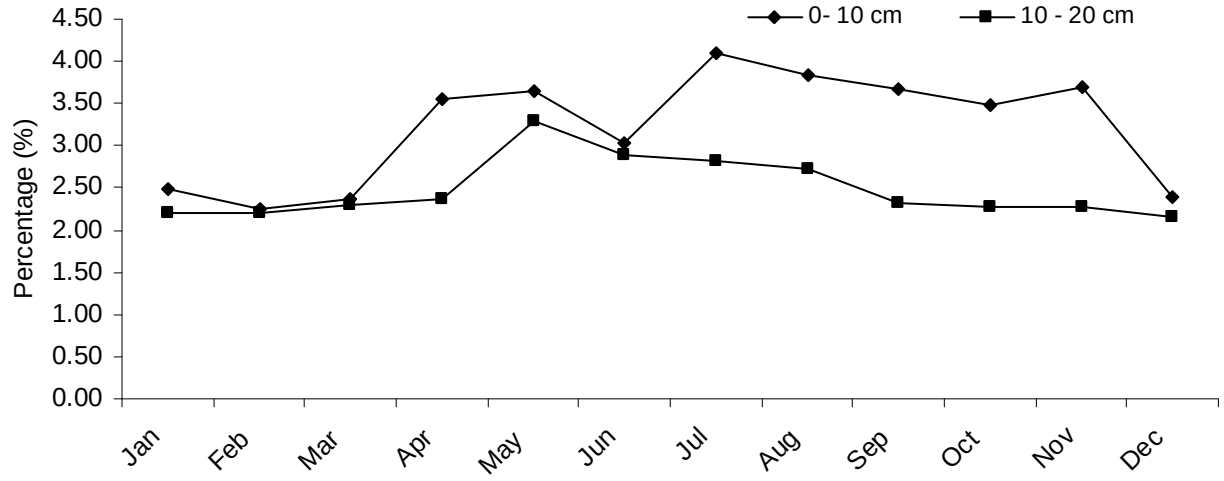

Fig. 8b. Monthly variation of soil organic carbon in mildly disturbed area (2005).

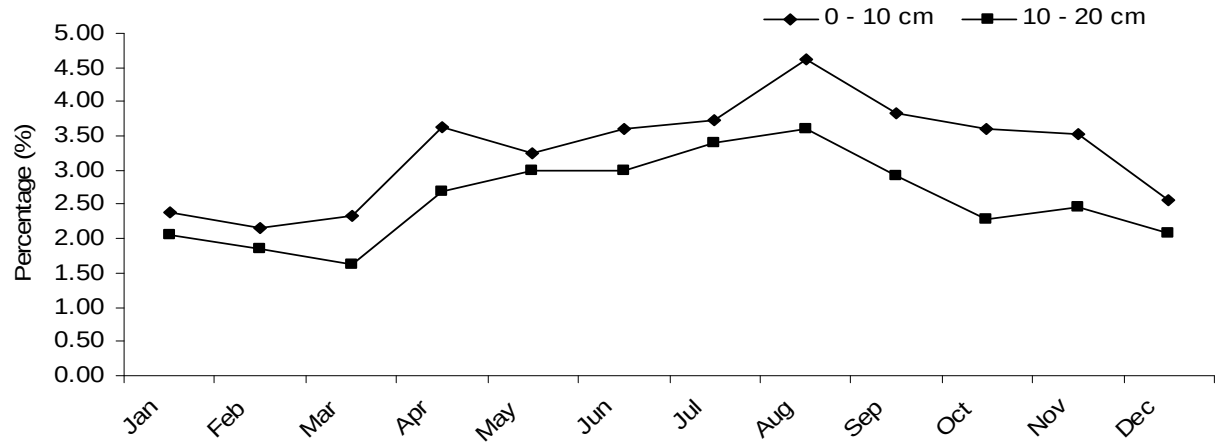

Fig. 8c. Monthly variation of soil organic carbon in undisturbed area (2005).

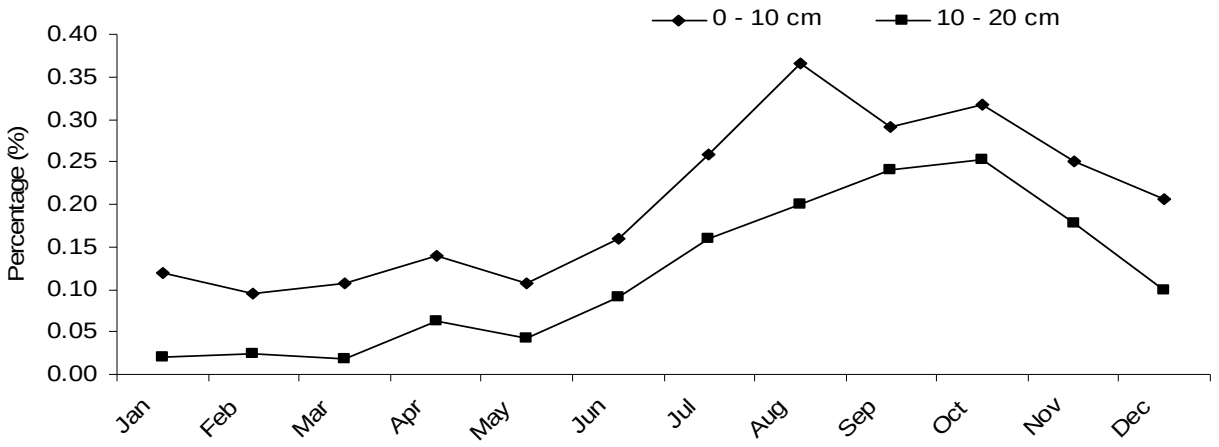

Fig. 9a. Monthly variation of total soil nitrogen in highly disturbed area (2005).

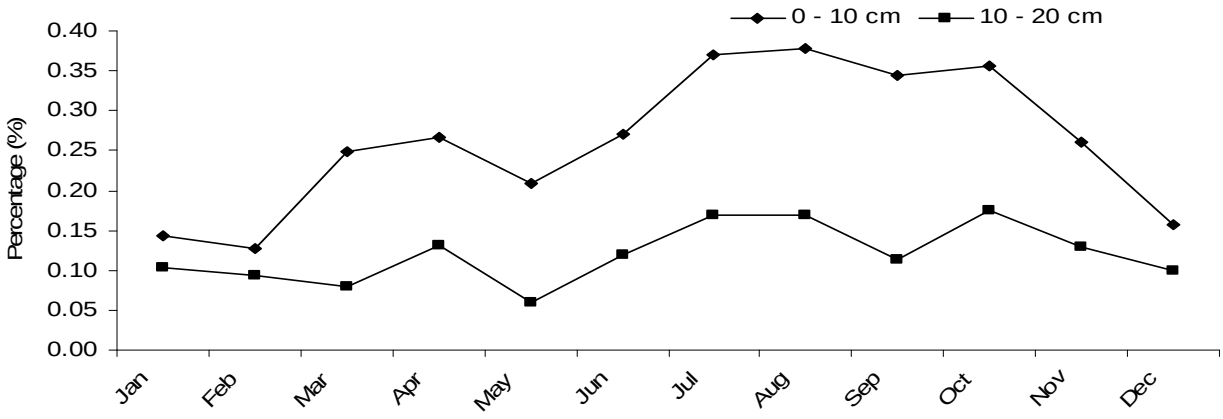

Fig. 9b. Monthly variation of total soil nitrogen in mildly disturbed area (2005).

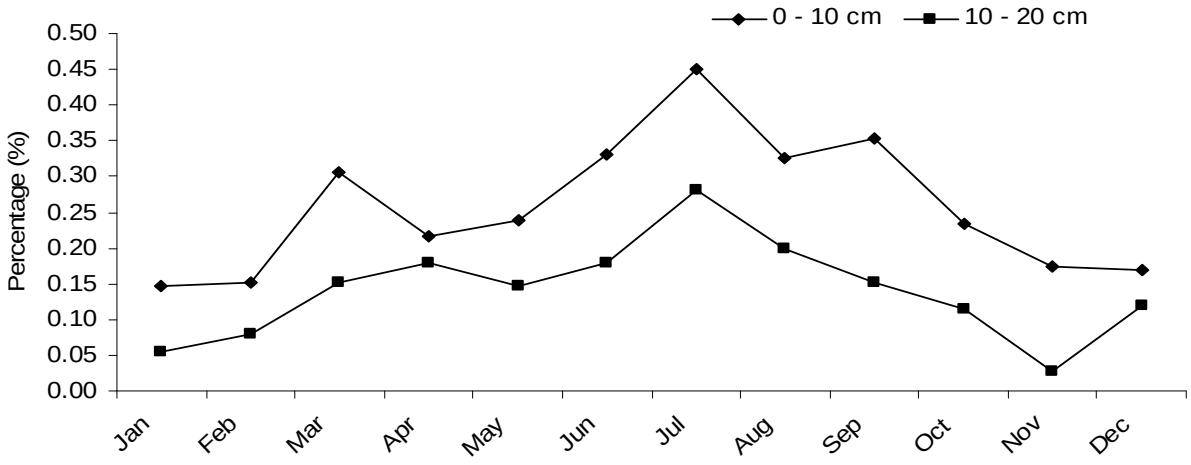

Fig. 9c. Monthly variation of total soil nitrogen in undisturbed area (2005).

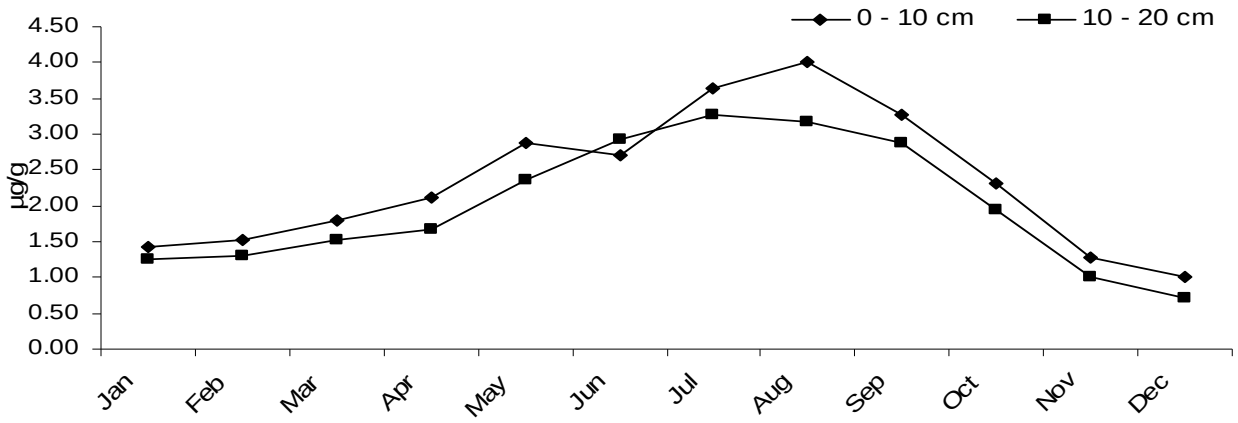

Fig. 10a. Monthly variation of available phosphorus (µg/g) in highly disturbed area (2005).

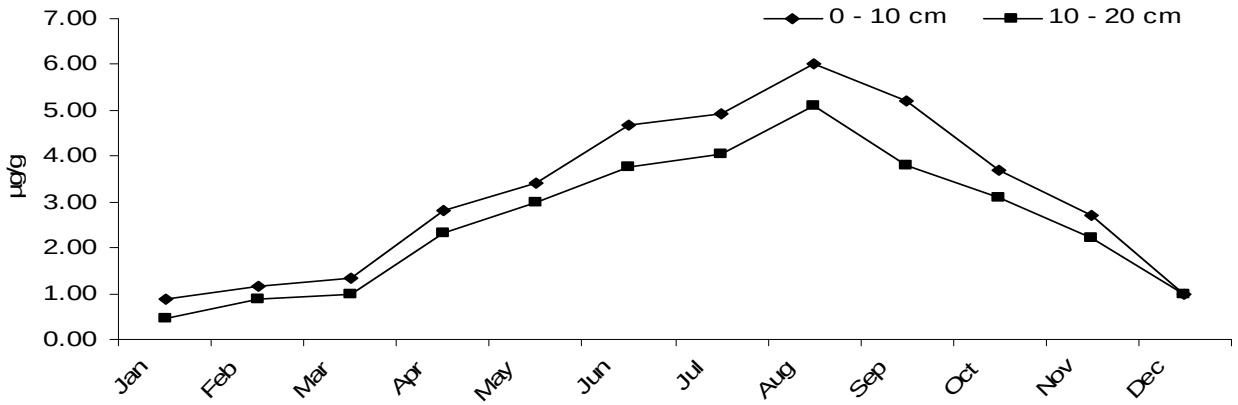

Fig. 10b. Monthly variation of available phosphorus (µg/g) in mildly disturbed area (2005).

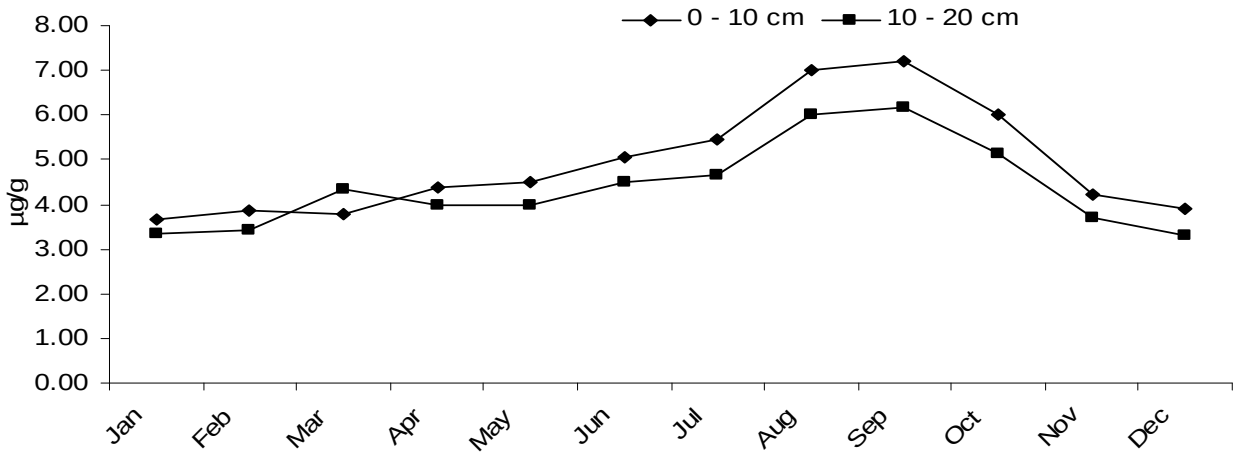

Fig. 10c. Monthly variation of available phosphorus (µg/g) in undisturbed area (2005).

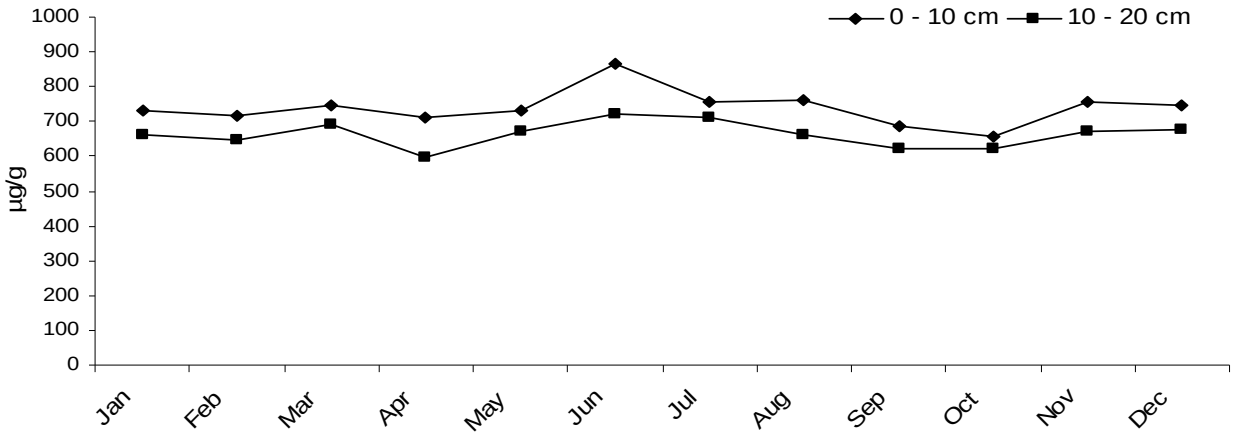

Fig. 11a. Monthly variation of exchangeable potassium (µg/g) in highly disturbed area (2005).

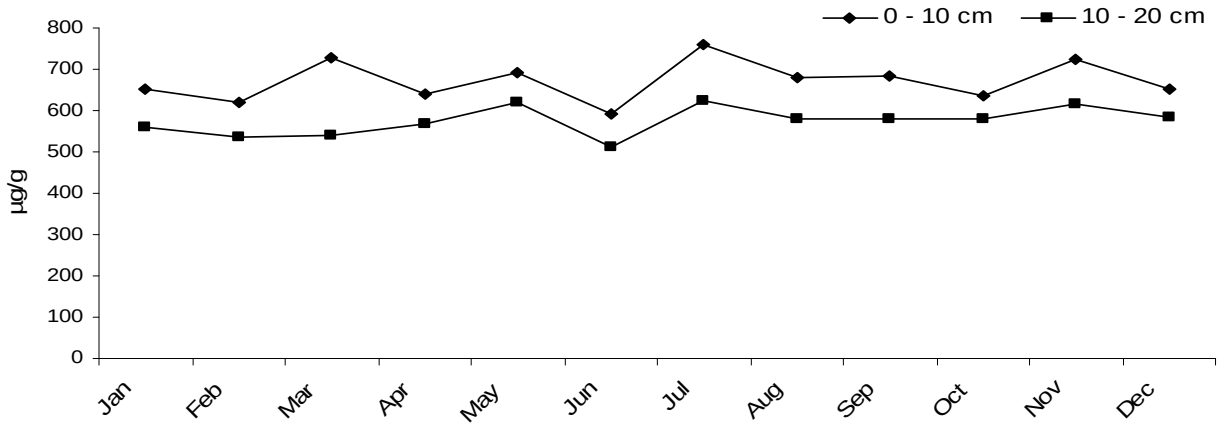

Fig. 11b. Monthly variation of exchangeable potassium (µg/g) in mildly disturbed area (2005).

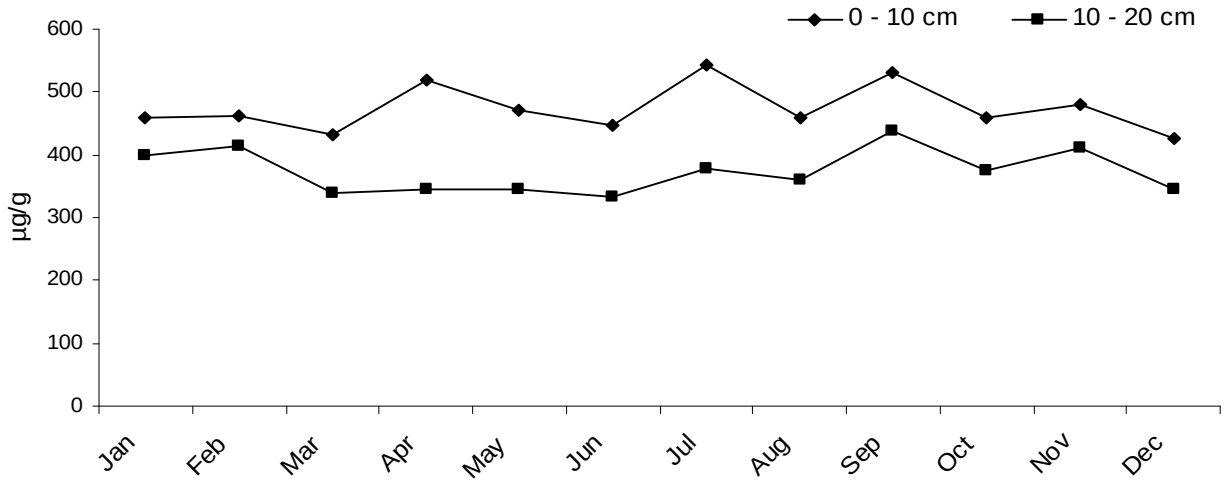

Fig. 11c. Monthly variation of exchangeable potassium (µg/g) in undisturbed area (2005).

CHAPTER VI

DISCUSSION

DISCUSSION

6.1 Plant diversity

The study area harbored 384 species of vascular plants from a total of 12512 individuals enumerated within the quadrats laid in the study area, including 369 (96.09%) species of angiosperms, 14 (3.65%) species of pteridophytes and 1 (0.12%) species of gymnosperms. This is about 28.24% of the total species recorded in 'The Flora of Lushai Hills' (Fischer, 1938) and 39.75% of 'The Book of Mizoram Plants' (Sawmliana, 2003). Most of the plants are evergreen species, and the deciduous species occupy a lesser extent areas. Singh (1997) recorded 2358 species of plant from Mizoram out of which 2141 species in 905 genera and 176 families belonged to angiosperms, 6 (in six genera and four families) to gymnosperms and 211 (in sixty six genera and thirty five families) to pteridophytes. Of the 2141 species of angiosperms, 1641 species were dicotyledons, while the rest belonged to the monocotyledons. Modern workers have also contributed towards enumeration of plant specimens such as 'Flora of Mizoram, Vol - I' by Singh *et al*. (2002) and he recorded 884 species under 403 genera belonging to 90 families of angiosperms from Mizoram.

6.2 Community structure

In highly disturbed area, the IVI values of different species ranges from 0.91 to 83.26, 0.64 to 57.24 and 1.93 to 32.05 in herbaceous species, shrubby species and tree species, respectively. In the mildly disturbed area, the IVI values also ranges from 0.21 to 32.27, 0.29 to 15.98 and 0.40 to 20.81 in herbaceous species, shrubby species and tree species, respectively. In undisturbed area, the IVI values of different species ranges from 1.07 to 43.64, 0.42 to 38.19 and 0.31 to 11.55 in herbaceous species, shrubby species and tree species, respectively. Vidyasagaran *et al.* (2000) reported that the important value index of riparian wet evergreen forest and moist

deciduous forest of Wynaad ranged from 0.89 to 66.68 and 1.51 to 66.84 respectively. Relatively higher IVI values in the study sites due to the fact that the areas constituted higher relative density and relative frequency.

The three study sites were different in the presence and absence of plant species; this could be the result of anthropogenic activities around and inside the study area. Kumar (2004) has also evaluated the similarity and dissimilarity of tree and shrubby species between MD area and HD area in the sub-tropical forest of Garhwal Himalayas.

The H' value in tropical rain forests of Barro Colorado Island generally varies between 5.06 in young stand to 5.4 in an old stand (Knight, 1975). But, Pascal (1988) has shown that the value of H' in the climax evergreen forests of Western Ghats form a cloud of points between 3.6 and 4.3. The Shannon-Wiener's index (H') values showed that the diversity of the study sites were lower than the record for tropical forests but almost similar to that of the Western Ghats.

The data analyzed from the present study revealed that the species diversity was very high. For the tropical forests the average value reported was 0.06 cd (concentration of dominance) (Knight, 1975), which is equivalent to 0.94 D (Simpson's index of dominance). The values of Simpson's index of dominance in the study sites were almost similar to that of the tropical forests. Basha (1987) has reported that the value of Simpson's index of dominance in evergreen forest of Silent Valley was 0.94. Jose *et al*. (1994) has also reported that the value of Simpson's index of dominance in the Shola forest of Eravikulam was 0.95.

Dominance of Mesophanerophytes (25.78 %) in the study area indicates its closeness with the vegetation of the tropical life zone of Raunkiaer (1934). Similar life-form composition has been observed in the tropical forest of Costa Rica (Lieberman *et al*., 1996).

The process of degradation at the study area can be understood from the result of this vegetation analysis which indicates that more and more diverse species existed in tree stratum on the undisturbed area compared to lesser number of tree species in mildly disturbed area and their nearly absence on highly disturbed area. The herbaceous and shrubby communities were dominant in mildly disturbed area followed by highly disturbed area and undisturbed area which indicates that more and more space vacated by the tree stratum is taken over by herbs and shrub communities. The process of forest degradation ultimately results into increase in area under highly disturbed site which is characterized by a few tree species and small number of shrubs. The same results were worked out by Sanjeev *et al*. (2006) in Mussoorie Hills of Garhwal Himalayas, India.

6.3 Productivity of herbaceous species

Generally, the minimum AGB occurred in February and the maximum AGB was measured in July to October. This could be the result of heavy monsoon rain and high temperature during rainy season. Topp (1993) reported that the amount of water in the soil affects directly the growth of plants. The peak values in BGB and AGB at the same time, but the BGB often fluctuated due to decomposition of dead roots. Singh and Yadava (1974) estimated that about 84 % of the standing dead material is transferred to the litter compartment each year, approximately 73 % of annual above ground primary productivity in monsoon grassland.

Based on the current study, mean biomass and NPP varied in the three different study sites. Highly disturbed area had the highest biomass and NPP. The reason is easy to understand because of high density of herbaceous plant community in this area. Mildly disturbed area had median biomass and NPP values. In this area, the values of biomass and NPP are medium due to the existence of trees and shrubby. The lowest biomass and NPP occurred in the undisturbed area because this area had high density of shrubby and trees.

In the present study, the values of peak standing crops (PSC) were 1104 gm^{-2} to 45.70 gm^{-2} in the whole study area. Other studies done by Singh (1972), Singh and Yadava (1974), Shankar *et al.* (1973), San Jose and Medina (1976) and Gupta and Singh (1982) in monsoonic grassland found average value of about 3000 gm^{-2} of primary productivity. However, Shankar *et al*. (1973) in Jhansi, India and San Jose and Medina (1976) in Calboza, Venezuela noted that the values ranged from (1019 gm^{-2} and 492 gm^{-2} respectively) for above ground primary productivity.

6.4 Physico-chemical properties of soil

The results of soil physico-chemical analysis clearly revealed that the anthropological disturbance changes the physical and chemical properties of soil in the three study sites. The over exploitation of the vegetal cover consequences the soil erosion with decline in soil fertility. It has been reported that canopy harvesting in the forest results in soil erosion of the topsoil due to extreme rain fall events (Scholes *et at*., 1994) and increases in bulk density (Hajabbasi *et al*., 1997). The total porosity of soil in the study area was 73.03% in HD area, 77.7% in MD area and 77.7% in UD area, and the bulk density was 0.70 g/cm^3 in HD area, 0.60 g/cm^3 in MD area and 0.58 g/cm^3 in UD area (Lalramenga, 2006 a; 2006 b).

The examination shows that the water content of the soil was lowest in the highly disturbed area, followed by the soil of mildly disturbed area and highest in the undisturbed area. The mean moisture content of the soil was found to be highest in rainy/ summer followed by spring and lowest in winter season at 0-20 cm soil depth. It is clear that the soil moisture content was fully controlled by the seasonal rainfall in the study area. Lower in the surface soil layer during winter season could be the result of higher evaporation from the soil and plant surfaces and percolation and infiltration of water to the lower depths (Tiwari *et al*., 1992). The amount of water in the soil directly affected the growth of plants (Topp, 1993). Lowest soil moisture content in HD area could be the result of high amount of water loss by runoff from the hill slopes and high evaporation from the exposed soil due to the lesser vegetal cover than the two other study sites.

Water holding capacity of the soil was highest in undisturbed area and declined towards the highly disturbed area relating to decrease in silt particles in the soil. The clay content was more in the lower layer of soil (10-20 cm) whereas WHC of soil was higher in upper layer of soil (0-10 cm), and soil organic carbon was higher in the upper layer of soil, which indicated that a stronger influence of soil organic carbon on WHC than the clay particles. It has been reported that there was a positive correlation between clay content and WHC of soil (Congdon and Herbohn, 1993; Schloes *et al*., 1994). Yadav and Bodolka (1973) have been reported that higher WHC at deodar forest soil in Uttar Pradesh, and Arunachalam *et al*. (1996) and Maithani (1996) also reported higher WHC in older forest regrowth in north-east India where soil organic matter was as high as 11%.

The soils of HD area (5.70) and MD area (5.43) were more acidic in nature than the soil of UD area (6.33); this could be the result of the ground fire in past few years before the study

was conducted. Juo *et al.* (1995) reported that the clearing and burning of forest raised the acidity of soil. The acidic soil due to burning of vegetation was also recorded by Nayak and Srivastava (1995). In some cases, higher pH was also recorded in burn forest than undisturbed forest. Singh *et al*. (1995) recorded higher soil pH in young jhum fallows than bamboo forest and natural forests of north-eastern India. Fritze *et al*. (1998) have also reported that the application of wood ash raised the soil pH and the degree of base saturation to the same extent as burning from a Myrtillus type of forest and clear-cut and burn forest of Finland.

In the study area, the values of soil organic carbon were higher in upper layer (0-10 cm) and declined towards the lower layer (10-20 cm). The same results were also worked out by Ramakrishnan and Toky (1981) and Singh *et al*. (1991b). Greater accumulation of organic carbon in the surface layer is ascribed to slow microbial decomposition of litter in acidic soils as reported by Nayak and Srivastava (1995) from humid sub-tropical soil in north east India.

In the present study, the amount of soil organic carbon was highest in the months of rainy/ summer season due to the high rate of decomposition in the presence of available moisture and warm temperature. In strongly seasonal climate where the decomposition rate is fast, highly varied composition of litter protects the soil surface throughout the year and promotes organic matter accumulation (Brown *et al*., 1994). In winter and spring seasons, the amount of soil organic carbon was lower, this could be the result of slower rate of litter decomposition due to the unavailability of moisture and required temperature in the soil.

In the three study sites, the concentration of total nitrogen at the surface layer of the soil was higher and declined with increase in soil depth; this could be due to the higher organic matter concentration in the upper layer. Misra (1968) reported that with decline in soil organic

matter there would be decline in total soil nitrogen The decrease in the amount of total soil nitrogen with increase in soil depth was also reported by some workers- Singh *et al*. (1991a); Regina *et al.* (1992); Sirajul *et al.* (1995); Pinjari *et al*. (1999). Lower concentration of total nitrogen in winter and spring season could be the result of low decomposition rate due to the lesser amount of soil moisture and deceased in temperature. Deka (1981) reported lower values of total nitrogen during dry winter period. Haron *et al*. (1997) also reported the significant relations between the percentages decomposed organic matter and total nitrogen from a commercial plantation of Malaysia.

In the present study, the available phosphorus was found to be higher in the upper layer of soil and also higher in the months of rainy/ summer season, these could be due to the faster decomposition rate of litter and animal debris in the presence of adequate high temperature and soil moisture in the upper layer of soil and in this season. Lower amount of phosphorus in converted system of land use from forest were reported by some workers- Srivastava and Singh (1991); Regina *et al*. (1992); Henrot and Robertson (1994).

Highest potassium concentration was found in highly disturbed area could be the result of ash content left in the soil after burning of litter and small herbaceous plants during dry winter period. A great fluctuation in the concentration of potassium was observed during study, this could be the result of potassium cycles through vegetation and soil solely as an unbound ion, and is easily leached from living and decomposing tissues compared to other nutrient.

The seasonal rainfall and destruction of vegetation by any means has a drastic effect on most of the physical and chemical properties of soil and also on the productivity of herbaceous plants.

CHAPTER VII

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

Summary

The Mizoram University was established on 2nd July 2001 under the Mizoram University Act, 2000. The Bill of Central University in Mizoram was passed by Rajya Sabha in 1999 and Lok Shaba in 2000. The area of Mizoram University Campus is 978.1988 acres and lies between $23^0$45’25" N and $23^0$43’37" N latitudes and $92^0$38’39’’ E and $92^0$40’23" E longitudes. The elevation is ranging from 720 m to 880 m above mean sea level (msl.) The climate is humid and tropical, characterized by short winter, long summer with heavy rainfall. The highest temperature is observed during April and May, and the lowest is during December and January. The study area receives rains from the south-west monsoon. The precipitation was heavy in summer, generally from May to September, and lasts till late October. Normally July (376 mm) and August (453mm) were the rainiest months while December (10 mm) and January (8 mm) were the driest months.

Three experimental sites were selected on the basis of disturbance gradients for the present study: they are - highly disturbed (HD), mildly disturbed (MD) and undisturbed (UD). The highly disturbed site is an open area where grasses and a few shrubs and trees are present. The mildly disturbed site is a secondary forest where jhuming system of cultivation was practiced about 10 - 20 years ago, and the undisturbed site is a natural forest and rocky area, about 20 – 35 years old. There are a number of small steams or brooks traversing the study area; those streams remain dry in almost all seasons except in rainy season.

The field work was carried out within two years from January 2005 to December 2007. In the first year, *i.e.*, January – December 2005, soil and biomass of herbaceous plants were analyzed

from the three study sites in the laboratory. Then in the next two years, *i.e.*, January 2006 – December 2007, plant diversity and community structure and specimen collection were conducted from the three study sites.

The important research findings of the present study are summarized as under:

1. The study area harbored 384 species of vascular plants from a total of 12512 individuals enumerated within the quadrats laid in the study area, including 369 (96.09%) species of angiosperms, 14 (3.65%) species of pteridophytes and 1 (0.12%) species of gymnosperms.

2. There are 384 species in 290 genera and 107 families of vascular plants in the study area. Out of which, 136 species in 116 genera and 53 families are observed in the highly disturbed area; 205 species in 164 genera and 82 families are present in the mildly disturbed area; 213 species in 172 genera and 78 families are present in the undisturbed area.

3. Taxonomically, Asteraceae (14 species) and Poaceae (14 species) are the most dominant families in HD area, while Euphorbiaceae (16 species in MD area and 14 species in UD area) are the most dominant families in MD and UD area, respectively.

4. In HD area, tree species like *Aporusa octandra* has the highest density (126.67 individuals/ ha), frequency (33.33), abundance (3.80) and IVI (32.05). The shrub species like *Chromolaena odorata* has the highest density (710.00 individuals/ ha), frequency (76.67) and IVI (57.24) while *Rubus birmanicus* has the highest abundance

(11.90). In herbaceous species, *Imperata cylindrica* has the highest density (35120 individuals/ ha), frequency (60.00 %), abundance (58.53) and important value index or IVI (83.26).

5. In MD area, tree species like *Castanopsis tribuloides* has the highest density (400.00 individuals/ ha) and IVI (20.81) while *Aporusa octandra* (70.00) and *Wendlandia grandis* (7.08) frequency and abundance respectively. In shrub species, *Garcinia cowa* has the highest density (403.33 individuals/ ha) and abundance (10.08) while *Cissus repens* (60.00) and *Bridelia stipularis* (15.98) has the highest frequency and IVI, respectively. The herbaceous species like *Thysanolaena maxima* has the highest density (14800 individuals/ ha) and abundance (10.54) while *Costus speciosus* (20.00), *Alpina bracteata* (37.35) has the highest frequency and IVI, respectively.

6. In UD area, tree species like *Alangium chinense* (186.67 individuals/ ha), *Bischofia javanica* (66.66), and *Dendrocalamus longispathus* (15.00) have the highest density, frequency and abundance, respectively, while *Alangium chinense* has the highest IVI (11.55). In shrub species, *Dendrocnide sinuata* (180.00 individuals/ ha), *Coffea khasiana* (46.67), *Chromolaena odorata* (17.33), *Debregeasia longifolia* (15.61) were found to be the highest density, frequency, abundance and IVI , respectively. The herbaceous species like *Eranthemum palatiferum* has the highest density (20600.00 individuals/ ha), frequency (34.00) and IVI (43.64) while *Phrynium capitatum* (7.67) has the highest abundance.

7. The value of similarity (S) of the vascular plant species between MD and UD sites was highest (0.44) followed by the value (0.34) between HD and MD sites, and lowest between HD and UD sites (0.28).

8. In tree species the value of species richness (D_{mg}) was highest in UD area (14.28) followed by MD area (11.50) and lowest in HD area (4.58). In shrub species, the highest value of species richness (D_{mg}) was found to be highest in UD area (10.99) followed by MD area (10.31) and lowest in HD area (5.85).In herbaceous species, the value of species richness (D_{mg}) was found to be highest in HD area (8.71) followed by MD area (7.18) and lowest in UD area (5.53).

9. The value of species diversity (H') of tree species was highest in UD area (4.32) and lowest in HD area (3.07). The shrub species diversity (H') in the study area was highest in MD area (4.03) and lowest in HD area (3.12). The diversity (H') of herbaceous species was maximum in MD area (3.55) and minimum in UD area (2.99).

10. In tree species, the highest value of dominance was observed in UD area (62.5) and lowest in HD area (18.86). In shrub species, the value of dominance (D) was highest in MD area (45.45) and lowest in HD area (13.69). The value of dominance (D) in herbaceous species was found to be highest in MD area (25.64) and lowest in HD area (10.86).

11. The highest percentage of life-form classes was observed in mesophanerophytes and lowest in megaphanerophytes in the whole study area. Therophytes has the highest percentage in HD area while mesophanerophytes in MD and UD areas.

12. The total biomass (sum of AGB, BGB and dead matters) of herbaceous species was highest in the month of August (1146.00 g/m^2) and lowest in March (625.00 g/m^2) in HD area. In MD area, the highest value observed in August (379.00 g/m^2) and lowest in February (261.00 g/m^2). In UD area, highest in September (47.20 g/m^2) and lowest in March (24.40 g/m^2**).**

13. The net primary production of herbaceous species was found to be highest in HD area and followed by MD area and lowest in UD area in every method products.

14. The highest soil moisture content was found in August (31.3%) at 0-10 cm soil depth in MD area and lowest in February (5.5%) at 0-10 cm soil depth in MD area.

15. The texture of the soil was sandy loam at the two vertical layers of soil (*i.e.*, 0-10 cm and 10-20 cm) in HD area, sandy-clay-loam at the two vertical layers of soil in MD area, but in UD area, the sandy-clay-loam was found only at 10-20 cm and sandy loam at 10-20 cm soil depth. The percentage of clay content was found to be highest at 10-20 cm in MD area and lowest at 0-10 cm soil depth in HD area.

16. The percentage of water holding capacity was found to be highest (84.00%) at 0-10 cm soil depth in UD area and lowest (58.00%) at 10-20 cm soil depth in HD area.

17. The highest pH of soil was found in November (6.82) at 0-10 cm soil depth in UD area and lowest in May (4.75) at 10-20 cm soil depth in HD area.

18. The soil organic carbon content was fluctuated at different soil depths and in different months throughout the year. The amount of soil organic carbon in the soil of the study area was found to be highest in August (4.63 %) at 0-10 cm in UD area and lowest in April (1.38 %) at 10-20 cm in HD area.

19. The amount of total nitrogen in the soil was found to be highest in July (0.45 %) at 0-10 cm in UD area and lowest in the months of January (0.02 %), February (0.02 %), and March (0.02 %) at 10-20 cm soil depth each in HD area.

20. The maximum amount of available phosphorus was found in September (7.20 µg/g) at 0-10 cm soil depth in UD area and minimum in January (0.44 µg/g) at 10-20 cm soil depth in MD area.

21. The amount of exchangeable potassium was highest in June (866 µg/g) at 0-10 cm soil depth in HD area and lowest in June (334 µg/g) at 10-20 cm soil depth in UD area.

Conclusion

Ever since the inception of the Mizoram University (MZU) Aizawl on 2nd July 2001 under the Mizoram University Act 2000, substantial developments have started progressively, particularly, during the first ten years of development (2001 – 2011). The infrastructural developments such as roads, buildings, etc. greatly effects and altered the

landscape ecology and natural resources which resulted into deforestation, habitat fragmentation, and destruction of plant communities from their natural habitats. The primary aim of the present research is descriptive documentation of the first-hand information on the community structure of plant diversity and soil characteristics of the landmass of the campus. It is hoped that this piece of research work naturally forms the basis of the pillars of milestone on biodiversity of MZU Campus and act as a referential material assistance for the future research inputs as well as the general information about the wealth of the Campus.

REFERENCES

REFERENCES

Adhikari, R.S., Ricari, H.C., Rawatt, Y.S. and Singh, S.P. (1991). High altitude forest: Composition diversity and profile structure in a part of Kumaun Himalaya. *Tropical Ecology,* **32**: 86 - 97.

Agarwal, S.K. (2002). International Cooperation on Biodiversity. *In*: *Biodiversity Conservation.* Rohini Books, Jaipur, India, pp. 79-111.

Alexander, M. (1977). *Introduction to soil microbiology* (2nd Edition). John Wiley and sons. New York.

Allens, S.C., Grimshaw, H.M., Parkinson, J.A. and Quarmby C. (1974). *Chemical Analysis of Ecological materials. Blackwell Scientific Publication,Oxford.*

Anderson, J.M. (1971). Methods and preliminary result of estimation of biomass and primary production in south Swedish mixed deciduous woodland. *In:* Duvigneaud, P. (ed.). *Productivity of forest ecosystem*. UNESCO, Paris, pp. 281-288.

Anderson, J.M. and Flanagan, P.W. (1990). Biological process regulating organic matter decomposition in tropical soils. In: Coleman, D.C., Oades, J.M. and Uehera, G (eds.) . *Dynamic of soil organic matter in tropical ecosystem*. NifTAL project. University of Hawaii Press, Honolulu, pp .97-123.

Andresse, J. P. and Koopmans, T.T. (1984). A monitoring study on nutrient cycles in soils used for shifting cultivation under various climatic conditions in tropical Asia. I. the influence of simulated burning on form and availability of plant nutrients; *Agric. Ecosys. Environ,* **12:** 1-16.

Anon (1979). Satellite Remote Sensing Survey of Mizoram, Sunderbad.

Anon (2003). *State of Forest Report, 2003*. Forest Survey of India, Dehra Dun.

Arnold, P.W. and Close, B.M. (1958). Potassium uptake by cation-exchange resins and minerals. *Nature,* **182**: 1504-1505.

Arunachalam, A., Pandey, H.N., Tripathi, R.S. and Maithani, K. (1996). Biomass and production of fine and course roots during a regrowth of a disturbed subtropical humid forest in north-east India. *Vegetatio*, 123: 73-80.

Arunachalam, K., Arunachalam, A., Tripathi, R.S. and Pandey, H.N. (1997). Dynamics of microbial population during the aggradations phase of selectively logged sub-tropical humid forest in north-eastern India. *Tropical Ecology*, **38**: 333-341.

Aweto, A.O. (1981). Secondary succession and soil fertility restoration in South-western Nigeria. II. Soil fertility restoration. *Journal of Ecology*, **69**: 609-614.

Balabane, N. (1996). Turnover of clay associated organic nitrogen in different aggregated size classes of a cultivated silty loam. *European Journal of soil science*, **47**: 285-291.

Barber S.A. (1984). *Soil nutrient bioavailability. A mechanistic approach*. Willey & Sons, Inc. New York, pp.188–238.

Barik, S.K., Pandey, H.N., Tripathi, R.S. and Rao, P. (1992). Micro-environmental variability and species diversity in tree fall gaps in a subtropical broad-leaved forest. *Vegetatio*, **103**: 31–40.

Basha, S.C. (1987). *Studies on the ecology of evergreen forests of Kerela with specisl reference to Silent Valley and Attapady*. PhD Thesis, Universoty of Kerela, Trivandrum. pp. 232.

Benbi, D.K. and Richter, J. (2004). Nitrogen dynamic: *In*: *Handbook of Processes and Modelling in the Soil-Plant System*, D.K.Benbi and R.Neider, (eds). Viva Books Private Limited, New Delhi, India, pp. 409 - 481.

Binkley, D. and Giardina, C. (1998). Who do tree species affect soils? The warp and woof of tree–soil interactions. *Biogeochemistry.* **1–2**: 89–106.

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

Blanchet, R. and Bosh, M. (1967). Potassium balances of soils and the potassium nutrition of plants as influenced by fixation and liberation of non-exchangeable K ions. *Ann. Agr*. **18**: 601-621.

Bongers, F., Popman, J., del Castillo, M. and Carbias, J. (1988). Structure and floristic composition of the lowland rainforest of Los Tuxtlas. Mexico, *Vegetatio*, **74**: 55 – 80.

Bora, P.J. and Kumar, Y. (2003). *Floristic diversity of Assam; Study of Pabitora wildlife sanctuary*. Daya Publishing House, Delhi, India. 845p.

Borah, D.K., Rattan, R.K. and Banrejee, N.K. (1992). Effect of soil organic matter on absorption of Zn, Mn and Cu in soils. *J. Ind.Soc. Soil Sci*., **40**: 277 - 282.

Bourlier, F. and Headley, M. (1970).The ecolgy of tropical savanna. *Ann. Rev. Ecol*., **1**: 125–152.

Brady, N.C. and Weil, R.R. (1999). *The Nature and Properties of soil* (12th ed). Prentice Hall, New Jersey.

Brown, S., Anderson, J.M., Woomer, P.L. and Barrois, E.C. (1994). Soil biological processes in tropical ecosystem. In: *Biological management of tropical soil fertility (P.L. Woomer and J.M. Swift eds.)*, John Wiley and Sons, Chichester, U.K., pp. 15-46.

Brungi, E. F. (1974). *Okosysteme in den tropen umschau*, **74**: 405-410.

Burel, F., Baudry, J., Butet, E., Clergeau, P., Delettre, Y., Le Coeur, D., Dubs, F., Morvan, N., Paillat ,G., Petit, S., Tenail, C., Brunel, E. and Lefeuvre, J.C. (1998). Comparative biodiversity along a gradient of Agricultural landscapes. *Acta. Oecologica,* **19(1)**: 47-60.

Burke, I. C., Lauenroth, W. K., Vinton, M. A., Hook , P. B., Kelly, R.H., Epstein, H. E., Aguiar, M. R., Robles, M. D., Aguilera, M. O., Murphy, K. L., and Gill, R. A. (1998). Plant–soil interactions in temperate grasslands. *Biogeochemistry,* **42**: 121–143.

Burke, I. C., Reiners, W. A., and Schimel, D. S. (1989). Organic matter turnover in a sagebrush steppe landscape. *Biogeochemistry*, **7**: 11–31.

Cao, M. and Zhang, J. (1997). Tree species diversity of tropical forest vegetation in Xishuangbanna, S W China*. Biodiversity and Conservation*, **6**: 995-1006.

Champion, H.G. and Seth, S.K. (1968a). *A Revised Survey of forest Types of India*. FRI, Dehradun, 404 p.

Champion, H.G. and Seth, S.K. (1968b). *A Revised Survey of forest Types of India*. FRI, Dehra Dun, pp 1-388.

Chapin III, F.S., Schulze, E.D. and Mooney, H.A. (1990): The ecology and economics of storage in plants. - *Annu. Rev. Ecol. Syst.,* **21**: 423-447.

Chapin, F. S., III. (1993). Functional role of growth forms in ecosystem and global processes. *In*: Ehleringer, J. R. and Field, C. B. (eds.). *Scaling physiological processes: leaf to globe*. Academic Press, San Diego, California, USA, pp 287–311

Chauvet, M. and Oliver, L. (1993). La Biodiversite. Enjeu planetaire. Preserver notre patrimoine genetique. Editions Sang de la Terra, Paris.

Chiou, C.T. (1990). Roles of organic matter, minerals and moisture in sorption of non-ionic compounds and pesticides by soil. *In*: MacCarthy, P., Clapp, C.E., Malcolm, R.L. and Bloom, P.R. (eds.). *Humic substances in soil and crop sciences.* Selected readings. SSSA/ASA, Madison, pp. 111-161.

Clement, C.R., Hopper, M.J., Jones, L.H.P. and Leafe, E.L. (1978). The uptake of nitrate by *Lolium perenne* from flowing nutrient solution. II. Effect of light, defoliation, and relationship to CO2 flux. *J. exp. Bot*., **29**: 1173-1183,

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

Connell, J.H. (1978). Diversity in tropical rainforests and coral reefs. *Science*, **199**: 1302-1309.

Cote, L., Brown, S., Pare, D., Fyler, J. and Bauhus, J. (2000). 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.

Curtis, J.T. (1959). *The vegetation of Wisconsin*: An ordination of plant comunioties. University Wisconsin press. Madison, Wis., USA.

Curtis, J.T. and McIntosh,R.P. (1950). *The interrelation of certain analytic synthetic phytosociological characters. Ecology*. **31**: 43-445.

De Vos, J.A., Raats, P.A.C. and Vos, E.C. (1994). Microscopic soil physical processes considered within an agronomical and a soil biological context. *Agriculture, Ecosystems and Environment*. **51**: 43-73.

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

Deb, D.B. (1981 & 1983). *The Flora of Tripura State*, *Vols 1 & 2*. Today and Tomorrow's Prin. And Publ., New Delhi.

Deka, H.K. (1981). *Studies on soil microbial population of jhum fallow of different ages*. Ph.D. Thesis, NEHU, Shillong, India.

Devi, A.S. (2002). *Litter decomposition and nutrient mineralization in dry tropical decidous forest ecosystem of Manipur*. Ph.D. Thesis (Not published). Department of Life Science, Manipur University, Imphal.

Dixon, R. K., Brown, S., Houghton, R.A., Soloman, A.M., Trexler, M.C. and Wisniewski, J. (1994). Carbon pools and fluxes of global forest ecosystem. *Science*, **263**: 185-190.

Domboise, D.M. and Ellenberg, H. (1974). Aims and methods of vegetation ecology. John Wiley & Sons Inc, Canada. Pp. 449-465.

Dregne, H.., Kassas, E., M. and Rozanov, B. (1991). A new assessment of the World status of desertification. *Desertification Control Bulletin*, **20**: 6-29.

Eijsackers, M. and Zehnder, A.J.B. (1990). Litter decomposition: A Russian Matrichoka doll. *Biogeochemistry*, **11**: 153-174.

Falloon, P.D. and Smith, P. (2000). Modeling refractory soil organic matter. *Biology and Fertility of Soils,* **30**: 388–398.

Fan, S.M., Wofsy, S. C., Bakwin, P. S. and Jacob, D. J. (1990). Atmosphere biosphere exchange of CO2 and O3 in the Central Amazon forest. *Journal of Geophysical Research*, **95**:16851–16864.

Faulkner, S.P. and Richardson, C.J. (1989). Physical and chemical characteristics of freshwater wetland soils. In: D.A. Hammer (ed.), *Constructed Wetlands for Wastewater Treatment*. Lewis Publishers, Chelsea, MI, pp 41-72.

Field, C. B., Behrenfeld, M. J., Randerson, J. T. and Falkowski, P. (1998). Primary production of the biosphere: integrating terrestrial and oceanic components. *Science,* **281**: 237–240.

Fischer C.E.C. (1938). *The Flora of the Lushai Hills.* Firma KLM, Pvt. Ltd. Calcutta.

Fischer, C.E.C. (1938). The flora of Lushai hills. *Rec. Bot. Surv. India,* 12(2): 75-161.

Fischer, R.A., Corbet, A.S. and Williams, C.B. (1943). The relationship between the number of species and the number of individuals in a random sample of an animal population, *J. Ecol*., **12**: 42-58.

Flint, M. (1991). *Biological Diversity and Developing countries*: Issues and Options, ODA.

Fritze, H., Pennanen, T. and Kitunen, V. (1998). Characterization of dissolved carbon from burned humus and its effects on microbial activity and community structure. *Soil Biol. Biochem,* 30: 687-693.

Gage, A.T. (1899a). A Botanical tour in the south Lushai Hills. Periodic expert Book Agency, Delhi- 32.

Gage, A.T. (1899b). A botanical tour in the South Lushai Hills. *Rec. Bot. Suv. India,* **1**: 361-369.

Gallego, H. A., Santa, R.I. and Roco, M. (1993). Biomass equations and nutrient distribution for Quercus pyrinaica Willd. *Forest Mesogee,* **53**: 75 – 82.

Ganesh, T., Ganesan, R., Devy, M.S., Davidar, P. and Bawa, K.S. (1996). Assessment of plant diversity at a mid-elevation evergreen forest of Kalakad – Mudanthurai Tiger Reserve, India, *Curr. Science,* **71**: 379-392

Gaston, K.J. (1996). *Biodiversity. A Biology of Numbers and Difference.* Blackwell. Oxford. UK.

Gentry, A.H. (1988). Tree species richness upper Amazonian forests. *Proc.Natl. Acad.,* **85**: 156-159.

Gerbilskii, N.L. and Petrunkevitch, A. (1955). Inter-specific biological groups of acipenserines and their reproduction in the low regions of rivers with biological flow. *Systematic Zoo.,* **4**: 81-99.

Ghate, C., Bhagwat, S., Gokhale, Y., Gour-Broome, V. and Barve, V. (1997). Assessing the tropical forest plant diversity: A case study from the western Ghats, India. *International journal of ecology and environmental science*, **23**: 419-444.

Ghosh, A.B., Bajaj, J.C., Hasan, R. and Singh, D. (1983). *Soil and water Testing Merthods.* IARI, New Delhi. Pp. 66.

Grace, J., Lloyd, J., McIntyre, J., Miranda, A., Meir, P., Miranda, H., Moncrieff, J., Massheder, J., Wright, I. and Gash J. (1995a). Fluxes of carbon dioxide and water vapour over an undisturbed tropical forest in south-west Amazonia. *Global Change Biology,* **1**: 1–12.

Grace, J., Lloyd, J., McIntyre, J., Miranda, A. C., Meir, P., Miranda, H. S., Nobre, C., Moncrieff, J., Massheder, J. and Malhi, Y. (1995b). Carbon dioxide uptake by an undisturbed tropical rain forest in southwest Amazonia, 1992 to 1993. *Science,* **270**: 778–780.

Grimme, H. and Nemeth, K. (1978). The evaluation of soil K status by means of soil testing. *In*: *Proc. 11th Congress Inter*. Potash Inst., Bern. pp. 99-108.

Gupta, S.R. and Singh, J.S. (1982). Influence of floristic composition on the net primary production and dry matter turnover in a tropical grassland. *Aust. J. Ecol.,* **7**: 363 – 374.

Hajabbasi, M.A., Jalalian, A. and Karimzadeh, H.R. (1997). Deforestation effect on soil physical and chemical properties, Lordegan, Iran. *Plant and Soil*, 190: 301-308.

Hare, M.A., Lantagne, D.O., Murphy, P.G. and Checo, H. (1997). Structure and tree species composition in a sub-tropical dry forest in the Dominican Republic; comparison with a dry forest Puerto Rico. *Tropical Ecology*, **38(1)**: 1-17.

Haridasan, K. and Rao, R.R. (1985 & 1987). *Forest Flora of Meghalaya.Vols 1 & 2*. BSMPS, Dehradun, India.

Haron, K., Brookes, P.C., Anderson, J.M. and Zakaria, Z.Z. (1997). Microbial biomass and soil organic matter dynamics in oil palm (*Elaeis guinensis* Jacq.) plantation, West Malaya. *Soil Biol. Biochem.,* **30**: 547-552.

Harte, J., Kinzig, A. and Murphy, P.G. (1999). Self similarity in the distribution and abundance of species. *Science,* **284**: 334 – 336.

Hassink, J. (1997). The capacity of soil to preserve organic C and N by their association with clay and silt particles. *Plant and Soil*. **191**: 77-87.

Havlin, J.L., Beaton, J.D., Tisdale, S.L. and Nelson, W.L. (1999). Soil fertility and fertilizers. *In*: *An Introduction to Nutrient Management*, (6th ed). Prentice Hall, New Jersey.

Henrot Jacqueline and Robertson, G.P. (1994). Vegetation removal in two soils of the humid tropics. Effect on microbial biomass. *Soil Biol. Biochem*., **15**: 111-114.

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 atterns.http://creativecommon.org/licenses/by nc-sa/2.5

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

Hooker, J.D. (1872-1897). *The Flora of the British India.* Vol. 1-7. London.

Hooper, D. U., and P. M. Vitousek. (1997). The effects of plant composition and diversity on ecosystem processes. *Science*, **277**: 1302–1305.

Howard, P.J.A., Howard, D.M. and Lowe, L.E. (1997). Effect of tree species and soil physio-chemical conditions on the nature of soil organic matter. *Soil Biol. Biochem.,* **30**: 285-297.

Hubbell, S.P and Foster, R.B. (1983). Diversity of canopy trees in a neotropical forest and implications for conservation. *In*: Sutton, S.L., Whitmore, T.C. and Chadwick , A.C. (eds.). *Tropical rain forest: Ecology and Management*. Blackwell Scientific Publishers, Oxford, pp. 25-41.

Hubbell, S.P. and Foster, R.B. (1992). Short term dynamics of a neo-tropical forest: change within limits. *Bioscience,* **42**: 822-828.

Indian Institute of Remote Sensing (2003). Department of Space. Government of India, Dehra Dun, pp 104-115.

Johnston, A.E. and Goulding, K.W.T. (1990). The use of plant and soil analysis to predict potassium supplying capacity of soil. In development of Potassium Fertilizer Recommendation. *Proc of the 22nd colloquium of the international Potash institute held at Soligorski*, USSR, IPI, Worblaufen, Bern, Switzerland, pp 177-204.

Johnston, M. and Gillman, M. (1995). Tree population studies in low-diversity for Guyana. Floristic composition and stand structure. *Biodiv. Conserv.,* 4: 339-362.

Jose, S., Sreepathy, A., Kumar, B. and Venugopal, V.K. (1994). Structural, floristic and edaphic attributes of grassland- Shola forests of Eravikulam in Peninsular India. *For. Eco. Management*, **65** (2-3): 279 – 291.

Joshi, N.V. and Suresh, H.S. (1997). Hierarchical partitioning of tree diversity across spatial scale: A case study from the Nilgiri Biosphere Reserve, South India. *International Journal of Ecology and Environmental Sciences,* **23**: 185-196.

Juo, A.S.R., Franzluebbers, K., Dabiri, A. and Ikhile, B. (1995). Changes in soil properties during long-term fallow and continuous cultivation after forest clearing in Nigeria. *Agriculture, Ecosystem and Environment*, **56**: 9-18.

Kadomura, H. (1996). Desertification-expectations on new confrontation, *Environmental Information Science*, **25(1)**: 49-51.

Kanjilal, U.N., Kanjilal, P.C., Das, A., De, R.N. and Bor, N.L. (1934-1940). *Flora of Assam.* Vols. 1-5. Govt. Press, Shillong.

Keller, M., Clark, D. A., Clark, D. B., Weitz, A. M. and Veldkamp, E. (1996). If a tree falls in the forest. . . *Science,* **273**: 201.

Keren, R. (2004). Soil alkalinization: *In:* Benbi, D. K. and Nieder, R. (eds.) *Handbook of Processes and Modeling in the Soil-Plant System*. Viva Book Pvt. Ltd., New Delhi.

Khan, M.L., Rai, J.P.N. and Tripathi, R.S. (1986). Regeneration and survival of tree seedlings and sprout in the tropical deciduous and sub tropical forest in Meghalaya. India: *Forest Ecologyg and Management,* **14**: 293-304.

Khan, M.L., Rai, J.P.N. and Tripathi, R.S. (1987). Population structure of some tree species in disturbed and protected subtropical forest of north east India. *Acta Oecologica,* **8**: 247 – 255.

Kieft, T. L., Carleton, S. W., Loftin, R. Aguilar, S. R., Craig, J. A. and Skaar, D. A.. (1998). Temporal dynamics in soil carbon and nitrogen resources at a grassland–shrubland ecotone. *Ecology,* **2**: 671–683.

Kindermann, J., Wurth, G., and Kohlmaier, G. H. (1996). Interannual variation of carbon exchange fluxes in terrestrial ecosystems. *Global Biogeochemical Cycles,* **10**: 737–755.

Knight, D.H. (1975). A phyto-sociologocal analysis of species rich tropical forests on Barro Colorado Island, Panama. *Ecol. Monogr*. **45**: 259-289.

Koidzumi, H., Ohkuro, T. and Mariko, S. (2000) New invitation to biology; Biology of grassland and desert. Kyoritsu-Shuppansya, Tokyo, Japan, 249 p.

Krebs, J.C. (1989). *Ecological methodology*. Harper and Row, New York.

Kumada, K., Ohta, S., Arai, S., Kitamura, M. and Imai, K. (1985). Changes in soil organic matter and nitrogen fertility during the slash and burn and cropping phases in experimental shifting cultivation; *Soil Sci. Plant Nutr.,* **31:** 611-623.

Kumar, M., Sharma, C.M. and Rajwar, G.S. (2004). A study on community structure and diversity of a sub-tropical forest of Garhwal Himalayas. *The Indian Forester*, **130** (2): 207-214.

Kunnin, W.E., Hartly, S. and Lennon, J.J. (2000). Scaling down on the challenge of estimating abundance from occurrence patterns. *Am. Nat*., **156**: 560 – 566.

Kuylenstierna, J.C.I., Cambridge, H., Cinderby, S. and Chadwick, M. J. (1995). Terrestrial ecosystem sensitivity to acid deposition in developing countries. *Water, Air and Soil pollution*, **85**: 2319-2324.

Lalnunmawia, F. (2003). Ph.D. Thesis. Comparative study on growth and productivity 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.

Lalramenga, P.C. (2006,a). *Studies on plant diversity of undisturbed forest in Mizoram University campus, Tanhril*. M.Sc. Project report, Mizoram university, Aizawl, India.

Lalramenga, P.C. (2006,b). *Ecological analysis of herbaceous plant in open grassland and secondary forest of Mizoram University campus*, Tanhril. M.Sc. Project report, Mizoram university, Aizawl, India.

Lalramnghinglova, H. (1997). *Bamboo. In*: Jha, L.K. (ed.). *Natweal Resources management Vol.1*. A.P.H. Publishing Corporation, New Delhi, pp. 257-267.

Lalramnghinglova, H. (1997). *Handbook of common trees of Mizoram,* 110 p.

Lalramnghinglova, H. (2003). *Ethno-medicinal plants of Mizoram.* Bishen Singh Mahendra Pal Singh, Dehra Dun, 333 p.

Landon, J.R., (1984). Booker Tropical Soil Manual. A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics. Booker Agriculture International Ltd., Essex, 191 p.

Lawesson, J.E., de Blust, G., Grashof, G., Fir bank, L, Honnay, O., Hermy, M., Habitz,P., and Jensen, L.M. (1998). Species diversity and area relationships in Danish birch forest. *Forest Ecology and Management,* **106**: 235-245.

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. *J. Ecol*., **84**: 137-152.

Long S.P., Jones M.B. and Roberts M.J. (1992). *Primary productivity of grass ecosystems of the tropics and sub-tropics.* Chapman and Hall, London, UK. 267 pp.

Lorain, J.H. (1940*). Dictionary of The Lushai Language.* The Asiatic Society (Rep.1975) Calcutta, pp.1-447.

Lovejoy, T.E. (1980a). Foreword. *In*: Soule, M.E. and Wilcox, B.A (eds.).*Conservation Biology: An evolutionary-ecological perspective*, Sinauer Associates, Sunderban, Mass.

Lovejoy, T.E. (1980b). Changes in biological diversity. In: Barney, G.O. (ed.), *The Global 2000 Report to the President*, Vol.2. *The technical report,* pp.327-332. Penguin Books, Harmondsworth, U.K.

Lowton, K. (1955). Chemical composition of soil. *In*: *Chemistry of the Soil*. F.E.Bear (eds). New York, Reinhold Publishing, pp. 53 - 84.

Luo, T.X., Li, W.H. and Zhu, H.Z. (2002). Estimated biomass and productivity of natural vegetation on the Tibetan Plateau. *Ecol. Appl.,* **12**: 980–997.

Magurran, A.E. (1988a). *Ecological diversity and its measurement*. Princeton University Press, New Jersey.

Magurran, A.E. (1988b). *Ecological diversity and its measures*. Croom Helm Ltd., London.

Magurran, A.E. (2004). *Measuring biological diversity.* Blackwell Publishing Company, USA/UK.

Maithani, K. (1996). *Microbial nutrient dynamics and mineralization in degraded subtropical forest ecosystem undergoing recovery*, Ph.D. Thesis, NEHU, Shillong, India.

Maiti, A .K. and Chakrabarti, S. (2002). Depletion of forest – A threat to environment and livelihood: A case study of North East India. *In: Forest resources in North East India.* Datta Ray, B. and Alam, K. (eds). Omsons Publication, New Delhi.

Maiti, S.K. (2003). *Hand Book of Methods in Environmental studies*. ABD Publishers, Jaipur (India).

Manokaran, N. and Kochummen, K.M. (1990). A re-examination of data on structure and floristic composition of hill and lowland dipterocarp forest in Peninsular Malaysia. *Malayan Nat. J.,* **44**: 61-75.

May, R.M. (1975). Patterns of species abundance and diversity. *In*: Cody, M.L. and Dimond, J.M. (eds.). *Ecology and evolution of communities*. Belknap Press, Harvard University, Cambridge. pp 340-379.

Mayer, M.P. (1996) Executive Summary. *Hot spots of endemic plants of India, Nepal and Bhutan*. TBG RI, Palode, Thiruvananthapuram, Kerala, India. pp. 9-19.

McKell, C.M., Wilson, A.M. and Jones, M.B. (1961). A floating method for easy separation of roots from soil sample. *Arono. J.,* **58**: 465-472.

McLean, A.J. (1961). Potassium supply power of some Canadian soils. *Can.J.Soil Sci.,* **41**: 196-206.

McLean, E.O. and Watson, M.E. (1985). Soil measurement of plant-available potassium. *In: Munson ed. Potassium in Agriculture*. ASA-CSSA-SSSA Madison. pp 277-308

McNaughton, S. J., Oesterheld, M., Frank, D. A., and Williams, K. J. (1989). Ecosystem level patterns of primary productivity and herbivory in terrestrial habitats. *Nature.,* **341**: 142–144.

McNaughton, S.J. and Wolf, L.L. (1970). Dominance and the niche in ecological system. *Science*, **167**: 131 – 138.

McNeely, J. A. (1988). *Economics and Biological Diversity: Developing and Using Economic Incentive to Conserved Biological Resources*, IUCN.

McNeely, J.A., Miller,K.R., Mittermeier,R. and Werner,T. (1990). *Conserving the World's Biological Diversity.* IUCN, WRI, World Bank,WWF US, C.I., Washington D.C.

McPherson, G. (1997). *Ecology and management of North American savannas*. University of Arizona Press, Tucson, Arizona, USA.

Melillo, J. M., McGuire, A. D., Kicklighter, D. W., Moore, B. III, Vorosmarty, C. J., and Schloss, A. L. (1993). Global climate change and terrestrial net primary production. *Nature*., **363**: 234–240.

Mengel K. and Kirkby E.A. (1987). *Principles of plant nutrition*. International potash institute. Bern, Switzerland, pp. 427– 452.

Middleton, N. J., and Thomas, D. S. G. (1992). *World Atlas of Desertification*. Hodder Arnold, London, U.K, pp 77-92.

Millard, P. (1988): The accumulation and storage of nitrogen by herbaceous plants. *Plant, Cell and Environment*, **11**: 1-8.

Mishra, B.K. and Ramakrishnan, P.S. (1983). Slash and burn agriculture at higher elevations in north-eastern India. II. Soil fertility changes. *Agriculture, Ecosystems and Environment,* **9**: 83-96.

Misra, R. (1968).*Ecology Work Book*. Oxford and IBH Publishing Company. New Delhi.

Misra, R. (1989). *Manual of plant ecology*, 3rd edition. Oxford & IBH Publishing Co., New Delhi.

Mitsch, W.J. and Gosselink, J.G. (1993). *Wetlands* (2nd edition). Van Nostrand Reinhold Company, NY.

Mooney, H.A. (2002).The debate on the role of biodiversity in ecosystem in functioning. *In*: Loreau, M., Naeem, S., and Inchausti, P. (eds.). *Biodiversity Ecosystem functioning*. Oxford University Press, Oxford, UK, pp. 12 – 17.

Myers, N. (1984). *The primary source: Tropical forests and our future*. W. W. Norton, New York.

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

Myers, N. (2001). Hotspots. *Encyclopedia of Biodiversity*, **1**: 371-381.

Myers, N., Russell, A., Mittermeir, C.G., Mittermeir, G., Gustavo, A.B. da Fonseca and Jennifer Kent (2000). Biodiversity hotspots for conservation priorities. *Nature*, **403**: 853-858.

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

Nilsson, S. I., (2004). Soil Acidification: *In*: *Handbook of Processes and Modeling in the Soil-Plant System*. Benbi, D. K. and Nieder, R. (eds.). Viva Book Pvt. Ltd., New Delhi.

Nordin, A., Näsholm, T. (1997). Nitrogen storage forms in nine boreal understorey plant species. *Oecologia*. **110**: 487-492.

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.

Odum, E. P. (1971). *Fundamentals of ecology*. Saunders, Philadelphia, Pennsylvania, USA.

Okigbo, B. N. (1984) Problems and prospects of shifting cultivation; *In*: Bunting, A. H. and Bunting, E. (eds.). *The future of shifting cultivation in Africa and task of Universities.* Rome, FAO.

Ourry, A., Boucaud, J. And Duyme, M.(1990): Sink control of nitrogen uptake and assimilation during regrowth after-cutting of ryegrass (*Lolium perenne* L.). *Plant Cell Environ.*, **13**: 185-190.

Ovington, J. D. (1962). Quantitative ecology and the woodland ecosystem concept. *Advan. Ecol. Res*., **1**: 103-193.

Ovington, J.D., Heitkamp, D. and Lawrence, D.B. (1963). Plant biomass and productivity of prairie, savanna, oakwood and maize field in central Minnesota. *Ecology*, **44**: 52-63.

Pachuau, R. (1994). Physical Geography of Mizoram: Climate. In *Geography of Mizoram.* R.T. Enterprise, Aizawl, Mizoram. India, pp 41-54.

Padien, D. J. and Lajtha, K. (1992). Plant spatial pattern and nutrient distribution in pinyon–juniper woodlands along an elevational gradient in northern New Mexico. *International Journal of Plant Science*, **153**: 425–433.

Palmer, M.W. (1995). How should one count species. *Nat. Areas J.*, **15**: 124 – 135.

Pandey, A.N. and Singh, J.S. (1984/ 1985). Mechanism of ecosystem recovery: A case study from Kumaun Himalaya. *Reclamation and Revegetation Research*, **3**: 271-292.

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

Pascal, J.P. (1988). *Wet evergreen forest of Western Ghats of India*. French Institute, Podicherry, pp 343.

Pauker, S. J., and Seastedt, T. R. (1996). Effects of mobile tree islands on soil carbon storage in tundra ecosystems. *Ecology*, **77**: 2563–2567.

Paul, E.A., Follett, R.F., Leavitt, S.W., Halvorson, A., Peterson, G.A. and Lyon, D.J. (1997). Radiocarbon dating for determination of soil organic matter pool sizes and dynamics. *Soil Science Society of America Journal,* **61 (4)**: 1058–1067.

Phetchawee, S., Kanareugsa, C., Sittibusaya, C. and Khunathai, H. (1985). Potassium availablity in the soil of Thailand. *In*: *Proceeding of the 19th Colloquium of the international Potash Institute*. Worblaufen-Bern: International Potash Institute, pp. 73- 92.

Phillips, O. L., Malhi, Y., Higuchi, N., Laurance, W. F., Nu´n˜ ez, P. V., Va´squez, R. M., Laurance, S. G., Ferreira, L. V., Stern, M., Brown, S. and Grace, J. (1998). Changes in the carbon balance of tropical forests: evidence from long-term plots. *Science*, **282**: 439–442.

Pinjari, F., Allesandra, T., Anna, B. and Paolo, S. (1999). Use of biochemical indices in the Mediterranean environment: Comparison among soils under different forest vegetation. *Journal of Microbiological Methods*, 36: 21-28.

Piper, C.S. (1942). *Soil and Plant Analysis*. Han Publication, Bombay.

Prasad, R. and Power, J.F. (1997). *Soil fertility Management for Sustainable Agriculture.* CRC Press, LLC.

Prasad, R. N., Pati Ram and Munna Ram (1980). Soils of north eastern hill region and their properties; *J. Meghalaya Sci. Soc.,* **4**: 35-46.

Preston, F.W. (1948). The commonness and rarity of species. *Ecology*, **29**: 254-283.

Preston, F.W. (1962). The canonical distribution of commonness and rarity. Part II. *Ecology*, **43**: 410-432.

Proctor, J., Anderson., J.M., Chai, P. and Vallack, H.W. (1983). Ecological studies in four contrasting rain forests in Gunung Mulu National Park, Sarawak. I. Forest Environment: Structure and Floristic. *J. Ecol*., **71**: 237-260.

Proctor, J., Lee, Y.F., Langley, A.M., Munro, W.R.C. and Nelson, T. (1988). Ecological studies on Gunung Salima, a small ultra basic mountain in Sabah, Malaysia. I Environment, forest structure and floristic. *J. Ecol*., **76**: 320-340.

Purvis, A. and Hector, A. (2000). Getting the measure of biodiversity. *Nature*, **405**: 212 – 219.

Raich, J.W., and Nadelhoffer, K.J. (1989). Belowground carbon allocation in forest ecosystems: global trends. *Ecology,* **70 (5)**: 1346–1354.

Ramakrishnan, P.S. and Toky, O.P. (1981). Soil nutrient status of hill agro-ecosystem and recovery pattern after slash and burn agriculture (jhum) in north-east India. *Plant and Soil*, **60**: 41-64.

Rao, A.S and Verma, D.M. (1982).*Cyperaceae of North-East India*. B.S.I., Howrah.

Rao, P. (1992). *Ecology of gap phase regeneration in a subtropical broad-leaved climax forest of Meghalaya*. Ph.D Thesis (unpublished), NEHU, Shillong.

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

Rao, R.R. and Hajra, P.K. (1986). Floristic diversity of the eastern Himalaya in a conservation perspective. *Proc. Ind. Acad. Sci. Suppl.* Nov, pp 103 – 125.

Raunkier, C. (1934). *The life form of plants and statistical geography*. Claredon press, Oxford.

Rawat, R.S. (2005). Studies on interrelationship of woody vegetation density and soil characteristics along an altitudinal gradient in a montane forest of Garhwal Himalayas. *Indian Forester*, pp 990-994.

Reddy, K.R., Feijtel, T.C. and Patrick, W.H. (1986). Effect of soil redox condition on microbial oxidation of organic matter. *In*: *The Role of Organic Matter in Modern Agriculture.* Chen, Y. and Avnimelech, Y. Netherland (eds.). Martinus Nijhoff Publishers, pp. 117 - 155.

Regina, C., Luizao, O., Bade, A.T. and Thomas, R. (1992). Seasonal variation of soil microbial biomass- the effect of clearfelling a tropical rainforest and establishment of pasture in the Central Amazon. *Soil Biol. Biochem.,* **24**: 805-813.

Reid, W.V. and Miller, K.R. (1989). *Keeping Options Alive*, World Resources Institute, Washington D.C.

Richards, P. W. (1996). *The tropical rainforest*. (2nd Edition). Cambridge University Press.

Richards, P.W. (1977). Tropical forests and woodland: An overview. *Agro-ecosystem*, **3**: 225-238.

Richardson, J.A. (1958). The effect of temperature on the growth of plants on pit heaps. *J. of Ecol.*, **46**: 537-546.

Rosnitschek-Schimmel, I. (1985a). Seasonal dynamic of nitrogenous compounds in a nitrophylic weed. I. Changes in inorganic and organic nitrogen fractions of the different plant parts of *Urtica dioica*. *Plant Cell Physiol*., **26**: 169-176.

Rosnitschek-Schimmel, I.(1985b). Seasonal dynamic of nitrogenous compounds in a nitrophylic weed II. The role of free amino acids and proteins as nitrogen store in *Urtica dioica*. – *Plant Cell Physiol*., **26**: 177-183.

Russell, E.W. (1980). *Soil condition and plant growth* (10th Edition). Longman, Landon.

Sagisaka, S.(1987): Amino acid pools in herbaceous plants at the wintering stage and at the beginning of growth. - *Plant Cell Physiol*., **28**: 171-178.

Sala, O.E., Chapin III, F.S., Armesto, J.J., Berlow, E., Bloomfield, J. and Dirzo, R. (2000). Global biodiversity scenario for the year 2100. Review: Biodiversity. *Science,* **287**: 1770-1774.

San Jose, J.J. and Medina, Y.E. (1976). Organic matter production in the *Trachypogon* Savanna at Calobozo, Venezuela. *Tropical Ecol*., **17**: 113-124.

Sanjeev, Gera, M. and Sankhayan, P.L. (2006). Phytosociological analysis of Arnigad micro-watershed in Mussorie Hills of Garhwal Himalayas. *Indian Forester, (Jan. 2006, Issue)*: pp 19- 30.

Santantanio, D., Hermann, R.K. and Overton, W.S. (1979). Root biomass studies in forest ecosystem. *Pedobiol*., **17**: 1-31.

Sawmliana, M. (1998). *Some Mizo Botanical Names and Zoological Names.* FERI, Bethlehem, Aizawl.

Sawmliana, M. (2003). *The Book of Mizoram Plants*, Lois Bet, Chanmari, Aizawl.

Saxena, A.K. and Singh, J.S. (1982). A phytosociological analysis of woody species in forest communities of a part of Kumayun, Himalaya. *Vegetation,* **50**: 3-22.

Schimel, D.S. (1995). Terrestrial ecosystems and the carbon cycle. *Global Change Biology*, **1**: 77–91.

Schlesinger, W. H. and Pilmanis, A. M. (1998). Plant–soil interactions in deserts. *Biogeochemistry,* **1–2**: 169–187.

Schlesinger, W. H., Reynolds, J. F., Cunningham, G. L., Huenneke, L. F., Jarrell, W. M., Virginia, R.A. and Whitford, W. G.(1990). Biological feedbacks in global desertification. *Science,* **24**: 1043–1048.

Schlesinger, W.H. (1977). Carbon balance in terrestrial detritus. *Annual Review of Ecology and Systematics,* **8**: 51–81.

Schnitzer, M. (1991). Soil organic matter – the next 75 years. *Soil Science*, **151**: 41-58.

Scholes, R. and Archer, S. (1994). Tree–grass interactions in savannas. *Annual Review of Ecology and Systematics*, **28**: 517–544.

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

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

Scholes, R.J. (1990). The influence of soil fertility on the ecology of Southern Africa dry Savannas. *Journal of Biogeography*, **17**: 415-419.

Scurlock J.M.O., Johnson K. and Olson R.J. (2002). Estimating net primary productivity from grassland biomass dynamics measurements. *Global Change Biology,* **8**: 736–753.

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

Shankar, U. (2000). Namdapha proposed Biosphere Reserve: Biodiversity characterization, propagation packages and conservation issues. *Proc. Biosphere Reserve in India and Management*, KFRI, Kerela, pp. 228-239.

Shankar, V., Shankarnarayanan, K.A and Rai, P. (1973). Primary productivity energetic and nutrient cycling in *Schenia heteropogon* grassland. I. Seasonal variation in composition, standing crop and net production. *Tropical Ecol*., **14**: 238-251.

Shannon, C.E. and Weaver, W. (1963). *The mathematics theory of communication*. University of Illinois press, Urbana, 117pp.

Sharma, P. D. (1997).*Ecology and Environment*. Rastogi Publications. Meerut, India, pp.49-78.

Shukla, U. (1995). *Grasses of North East India*. Scientific Publishers, Jhodpur.

Simpson, E.H.(1949). Measurements of Diversity. *Nature*, **163**: 188.

Singh, A.K. (1972). *Structure and primary net production and mineral content of two grassland communities of Chakai hills, Varnasi*, Ph.D. thesis, Banaras Hindu University, Varanasi, India.

Singh, B., Singh, L. and Dhillon, N.S. (1995). A mathematical model for predicting urease activity in soil of Punjab. *Journal of the Indian society of soil science*, **43**: 686-688.

Singh, D.K., Wadhwa, B.M. and Singh, K.P. (1990). A conspectus of orchids of Mizoram.: Their status and conservation. *J. Orchids. Soc. India,* **4(1-2)**: 51-64.

Singh, J,N. and Mudgal, V. (1998) Studies on forest regeneration pattern and natural soil conservation of Nokrek Biosphere, Meghalaya. *Indian journal of Forestry*, **21(4)**: 373-376.

Singh, J. (1980). *Studies on structural and functional aspect of two subtropical humid forest types of Meghalaya*. Ph.D Thesis (unpublished), NEHU, Shillong.

Singh, J., Borah, I.P. and Boruah, A. (1995). Soil characteristics under three diffrent plant communities of North-East India. *Indian Forester*, pp. 1130 - 1133.

Singh, J.S. and Joshi, M.C., (1979). Tropical grasslands primary production. *In*: Coupland, R.T. (ed.). *Grassland ecosystem of the world*. Cambridge university press, Cambridge, pp. 197-218.

Singh, J.S. and Yadava, P.S. (1974). Seasonal variation in composition, plant biomass and net primary productivity of tropical grassland at Kurukshetra, India. Ecol. Monogr., **44**: 351-376.

Singh, J.S., Raghubanshi, A.S. and Varshney, C.K. (1994). Integrated biodiversity research for India. *Current Science*, **66**: 109-112.

Singh, K.P. (1997). Mizoram. In: V. Mudgal and P.K. Hajra (eds.), Floristic diversity and conservation strategies in India. III. pp 1217 – 1256, BSI, Dehra Dun.

Singh, M.P., Singh, B.S. and Dey, S. (2002). Plant Biodiversity: *Plant Biodiversity and Taxonomy.* Daya Publishing House, Delhi.

Singh, N.P., Singh, K.P. and Singh, D.K. (2002). *Flora of Mizoram, Vol-I*. Shiva Offset press, Dehra Dun, India.

Singh, R.S., Raghubanshi, A.S. and Singh, J.S. (1991a). Nitrogen mineralization in dry tropical savanna: Effect of burning and grazing. *Soil Biol. Biochem*., **23**: 269-273.

Singh, R.S., Srivastavas, S.C., Raghubanshi, A.S., Singh, J.S. and Singh, S.P. (1991b). Microbial C, N and P in dry tropical savanna: Effect of burning and grazing. *Journal of Applied Ecology.*, **28**: 869-878.

Singh, O. P and Datta, B.(1987). Cation exchange capacity of Mizoram soils on varying physiography and climate in relation to some soil characteristics; *Indian J. Hill Farmg.*, pp 19-17.

Sirajul Karim, A.J.M., Egashira, R., Yamada, Y., Haider, J. and Nahar, K. (1995). Long-term application of organic residues to improve soil properties and to increase crop yield in terrace soil of Bangladesh. *J. Fac. Agr. Kyushu University*, **39**: 149-165.

Sorensen, T.(1948). A method of establishing groups of equal amplitude in plant society based on the similarity of species content. *K.Danske, Vedenk. Selsk,* **5** : 1-34.

Srivastava, S.C. and Singh, J.S (1991). Microbial biomass C, N and P in dry tropical forest soils-effect of alternate land-uses and nutrient flux. *Soil Biol. Biochem*., **23**: 117-124.

Stapanian, M.C.,Casell, D.L. and Cline, S.P. (1997). Regional pattern of local diversity of trees; association with anthropozenies disturbance. *Forest Ecology and Management*, **93**: 33-44.

Staswick, P.E.(1994): Storage proteins of vegetative plant tissues. - Annu. Rev. Plant Physiol. *Plant mol. Biol*., **45**: 303-322.

State of Forest Report 2003, Ministry of Environment, Forests & Wildlife, New Delhi, pp.1-84.

Stepien, V., Sauter, J.J. and Martin, F.(1994): Vegetative storage proteins in woody plants. *Plant Physiol. Biochem*., **32**: 185-192.

Tackaberry, M.C. and Kellman, D.L. (1996). Pattern of tree species richness along peninsular extensions of tropical forest; The missing species extrapolation techniques. *Journal of Tropical Ecology*, **13**: 449-458.

Takhtajan, A.L. (1969). *Flowering Plants: Origin and Dispersal.* Oliver and Boyd, Edinburgh. (English translated by C. Jeffrey).

Tanner, E.V.J. (1977). Four Montane rain forest of Jamaica; A quantitative characterisation of floristic, the soil and foliar mineral levels, and a discussion of interrelations. *Journal of Ecology*, **65**: 883-918.

Thornton, B. and Millard, P. (1993). The effects of nitrogen supply and defoliation on the seasonal internal cycling of nitrogen in *Molina caerulea*. *J. exp. Bot*., **44**: 531-536.

Tian, H., Melillo, J. M., Kicklighter, D. W., McGuire, A. D., Helfrich, J. V. K. I., Moore III, B. and Vo¨ro¨smarty, C. J. (1998). Effect of inter-annual climate variability on carbon storage in Amazonian ecosystems. *Nature*, **396**: 664–667.

Tilman, D., Knops, J., Wedin, D., Reich, P., Ritchie, M. and Siemann, E. (1997). The influence of functional diversity and composition on ecosystem processes. *Science,* **277**: 1300–1302.

Tiwari, S.C., Tiwari, B.K. and Mishra, R.R. (1992). Variation in some physico-chemical properties of pineapple orchard soils of north-east India. *Journal of Indian Soil Science Society*, **40**: 204-208.

Toky, O. P. and Ramakrishnan, P. S. (1981). Cropping and yields in agricultural systems of the north-eastern hill region of India; *Agro-Ecosystems,* **7**: 11-25

Topp, G.C. (1993). Soil water content. In: *Soil sampling and methods of analysis* (M.R. Carter ed.), Lewis Publishers, USA, pp. 541-557.

Trivedi, P.R. (2000).*Global Diversity*. Author press, Laxmi Nagar, Delhi (India), pp: 1-2.

Trochain, J. L. (1980). Ecologie vegetale de la zone intertropicale non desertique universite paulsabatier, *Toulouse,* **7**: 336–339.

Valencia, R., Balslev, H. and Paz, Y. and Mino, G.C. (1994). High tree alpha-diversity in Amazon Equador. *Biodiv. Conserv.*, **3**: 653-694.

Vidyasagaran K, Pramod, G.K. and Gopikumar, K. (2000). Ecological studies in a high land riverine island forest ecosystem, Kuruva, Wyaad. *Proc. Intl. Symp. on Tropical Forest Research*, Kerela Forest Research Institute, Peechi, Kerela, 2 – 4 August 2000.

Volenec, J. J., Ourry, A. and Joern, B. C. (1996): A role of nitrogen reserves in forage re-growth and stress tolerance. *Physiologia Plantarum*, **97**: 185-193.

Wilson, E.O. and Peter, F.M. (1988). *Biodiversity*. National Academy Press, Washington D.C.

Wilson, E.O. and Willes, E.O. (1992). *The Diversity of Life*. Norton, New York, U.S.A.

Yadav, J.S.P. and Bodolka, K.C. (1973). Soil characteristics of deodar forest in Western Himalayas of Uttar Pradesh. *Proceeding of Indian National Academy of Science*, **43(A)**: 239-245.