IMPACT OF ANTHRPOGENIC DISTURBANCE ON DIVERSITY AND DISTRIBUTION OF WOODY PLANTS IN REIEK FOREST, MIZORAM

By

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Submitted

In partial fulfillment of the requirement of the degree of Master of Philosophy in Environmental Science of Mizoram University, Aizawl.

CERTIFICATE

This is to certify that the thesis entitled "**Impact of anthropogenic disturbance on diversity and distribution of woody plants of Reiek forest, Mizoram**" submitted by **John Sangzuala** in partial fulfillment of the degree of Master of Philosophy under the Department of Environmental Science, Mizoram University, embodied the record of original investigation carried out by him under my supervision.

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June, 2019

DECLARATION

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

This is being submitted to the Mizoram University for the degree of Master of Philosophy in "**Impact of anthropogenic disturbance on diversity and distribution of woody plants of Reiek forest, Mizoram**".

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CHAPTER- 1

INTRODUCTION

Biodiversity is the measure of number, variety and variability of living organisms on earth, including all its elements, patterns and processes. The most cited definition of biodiversity is “the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems” (Convention on Biological Diversity- Article 2). The global biological diversity is depleting at an alarming rate, as there is tremendous increase in human population, imposing pressure on vegetation across the globe, and resulting into great loss of biodiversity rate (Meffe and Carroll, 1994; Dirzo and Raven, 2003; Sanderson et al., 2002). The vegetation depletion is linked with unsustainable harvesting, lack of awareness, and unrestricted grazing by domestic animals from nearby villages, people depend significantly on forests for firewood, timber, non-timber forest products, fodder for domestic animals, and manure for crop fields (Mahat et al., 1986; Maren et al., 2014).

1.1 Ecosystem and ecosystem services

An ecosystem comprises all of the living things (plants, animals and organisms) in a specified area, interacting with each other, and also with their non-living environments (weather, earth, sun, soil, climate, atmosphere). The system is dynamic in that it relates to the movement of energy inside it, and plants are the primary source of energy for animals. The system is complex because it involves multiple interconnected parts : the species, their habitats and niches, and other variables.

Ecosystem services are the benefits to the people from ecosystem. Biodiversity plays an important role in ecosystem functioning and in the many services it provides provisioning services such as food and water; regulating services such as the regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other non-material benefits.

Natural forests reflect a very unique terrestrial ecosystem of the world. Due to ever increasing population of mankind and its increase in demands, the dependence on forests has crossed the carrying capacity of the forests, and resultingintoa large-scale global deforestation and habitat degradation.

1.2 Human well-being and linkages with biodiversity and ecosystem services

The term "Human well-being" can be understood and considered as a unifying concept and a characteristic of both the objective and subjective factors which constitute health and quality of life. The components of human well-beinghave been defined by the Millennium Ecosystem Assessment (2005), as a security, basic material for a good life, health, good social relations, and freedom of choice and action.

Biodiversity represents the foundation of ecosystem that through the services it affects human well-being including provisioning services, supporting services and cultural services, all of which are the result of many factors, directly or indirectly linked with biodiversity and ecosystem services while others are independent.

1.3 Loss of biodiversity due to anthropogenic activities

Human activities are the main causes for changes in biological communities worldwide, and these changes can harm biodiversity and ecosystem functions. Ecosystem function is vital for supporting plant and animal communities and guaranteeing the long term survival of human population. The numerous causes of subsequent loss of biodiversity are known as drivers. Direct drivers explicitly influence ecosystem processes, while indirect drivers change the rate at which one or more of the direct drivers affect ecosystem processes. The Convention on Biological Diversity states that there are both indirect and direct human drivers. Some of the indirect human drivers are demographic, economic, sociopolitical, scientific and technological, and cultural and religious factors. On other hand, some of the direct human drivers are changes in local land use and land cover, species introductions or removals, external inputs, harvesting, air and water pollution, and climate change. The main factors impacting the loss of biodiversity as a whole can be population growth and over consumption. Increased human population leads to raised demands on nature to provide the needs of man, this results in clearing of more and more forest covers for agriculture, human settlements, and also for recreational purposes. Most of the forest resources are renewable but it takes years for regeneration processes, and because of lack of knowledge and also due to greed, man is exploiting forest resources beyond limit.

. Shifting cultivation and unregulated tree felling have led to massive destruction of virgin forests. The jhum cultivation, being the major agricultural system in Mizoram has contributed to the primary factor for loss of biodiversity at local level.

1.4 Scope of Study

In past few decades, there is enormous growth in human population, leading to struggle between natural resources and needs of people, and resulting into overexploitation of genetic resources, as greed is over the need. In fact, nature has great potential to fulfill theneeds of people but not greed. It has been observed that the forest resources of Mizoram have been depleted at an alarming stage due to various human activities like clear felling of trees, sand stone quarry, shifting cultivation, over cattle grazing. Moreover, researches on the subject are limited. In view of this, the present study aims to detail survey of Reiek forest in Mamit district of state, and to determine diversity-distribution of woody plants in the core zone and buffer zone. Undoubtedly, the outcome of present study may be a base-line for developing management strategies at a large. The objectives are laid down as follows.

Objectives

1. To study diversity and distribution of woody plant species in the core and buffer zones of Reiek forest.
2. To assess impact of disturbances on diversity-distribution of woody plants.
3. To formulate appropriate strategies for biodiversity conservation.

CHAPTER - 2

REVIEW OF LITERATURE

From available literature, it is revealed that the forest resources are depleting due course of time. Deforestation has caused shattering of large forest wedges and creating extensive forest boundaries (Broadbent et al., 2008). Such unsustainable exploitation is driving a sharp declinein biodiversity (Ehrlich and Holdren, 1971; Terborgh and van Schaik, 2002).

Deforestation rates contrast in different parts of the world, however, tropical forests show worst affected biomes, mainly exploited by human population on the peripheral lands contributing to excessive deforestation (Myers, 1988). The potential impact of logging in tropical rainforest ecosystem has direct environmental and biological consequences. Laurance, (2001) argued that logging opens mature forest area for establishment. The wellknown example of overexploitation of tropical forest species involves cutting of tropical hardwoods for timber (Asner et al., 2005).

The Montane Rain Forest (Breedlove, 1981), sometimes referred to as Tropical Montane Cloud Forest (Hamilton et al.,1995), is measured as one of the most diverse neotropical formations (Webster, 1995; Churchill et al., 1995; Rzedowski, 1996; Aldrich et al.,1997). Stands of MRF in the northern uplands of Chiapas (SE Mexico) have got concentrated human commotion for centuries, mostly in relative to slash-and-burn agriculture (Milpa system) practiced by Mayan and Mestizo people (Collier, 1975). Lately, large areas of MRF have been disjointed or permanently cleared for raising of sheep and cattle. Additional human events in the area include serious selective logging for fuel-wood and timber, and then establishment of coffee plantation (Lopez-Carmona, 1999).

In Ghana, cocoa farming is limited to the forest section where, as a natural under-storey crop, coffee cultivation in the past has been based on elimination of the forest under-storey and withdrawing the forest cover, to facilitate growth of cocoa saplings into trees by utilizing the forest rent of the recently empty area and the shade provided by the enduring forest trees. This practice of cocoa plantationwas the main reason for deforestation in the country. Regardless of the fact that some trees are left for shade, as the cocoa budding inflates into virgin forest ((Ruf and Zadi, 1998); Ministry of Environment and Science, 2002).

The use of remote sensing and GIS techniques for alteration revealing examination to detect the operational variations in-site resultant from natural forest progression by diverse natural disturbances like wind, fire, insects, hurricanes and more conspicuously by human land-use (Tucker et al., 1984; Gardner et al., 1991; Cablk et al., 1994; Johnson, 1994, Awaya et al., 1994; Jensen et al., 1995; Somporn, 1995; Kushwaha, 1997; Thanomsri et al., 1997; Singh et al., 2004).

The clearance of forest cover for construction of roads have numerous significant ecological effects, comprising changes in soil properties, drainage patterns, and forest accessibility (Wilkie et al., 1992). The gaps created in the forest, a key associate of many of the ecological alterations that occur after logging (Grieser Johns, 1997; Struhsaker, 1997).

Chittibabu and Parthasarathy (2000) have studied the changes in tree species diversity and stand attributes in relation to varying human disturbances in the evergreen forests of Eastern Ghats of India. In north east India, several site specific studies have been carried out to observe the impact of shifting cultivation and mining practices, both of which have been identified as major causes of disturbance to forest ecosystem in the state of Meghalaya. Shifting cultivation is practiced almost throughout the world (Hauck, 1974). In India, it is mainly practiced in the northeastern region and some parts of Orissa and the Western Ghats. Shifting cultivation or *jhum*, as it is locally called in northeast India, has been extensively studied by Toky and Ramakrishnan (1981,1982), Misra and Ramakrishnan (1981, 1983), Misra et al. (1992), covering the aspects like socio-economics, energetics, weed population dynamics and succession. All these studies have concluded that increasing population pressure against limited land resources has resulted into the shortened jhum cycle which in turn cause a negative impact on the soil quality, leading to reduced crop yield and vegetation cover in abandoned fallows as well. Tawnenga (1990) studied the shifting agriculture as practiced in Mizoram and suggested innovative approaches.

In the past, several in-depth studies have been carried out on the structure and functions of the broad-leaved forest ecosystems of Meghalaya by analyzing the effect of anthropogenic disturbance on plant diversity, community attributes and regeneration behavior of plantsin the sacred grove of Meghalaya (Mishra et al., 2003, 2004). Some significant contributions on the subject were, Community characteristics of a climax subtropical humid forest of Meghalaya and population structure of important tree species (Mishra et al., 2005); Vegetation characteristics of montane broad-leaved, mixed pine and pine forests of Meghalaya (Mishra and Laloo, 2006); Traditional knowledge and biodiversity conservationin the sacred groves of Meghalaya (Jeeva et al., 2006); Population structure, regeneration efficacy and status of medicinal plants in the disturbed and undisturbed sacred forests of Meghalaya (Laloo et al., 2006); Ecological perspectives of sacred grove in Meghalaya (Mishra, 2009); Plant diversity and community attributes of woody plants in subtropical humid forests of Meghalaya (Mishra and Jeeva, 2012); Biodiversity conservation measures for sacred groves of Meghalaya (Mishra, 2012);Sacred

Forest as a treasure house of plant diversity (Mishra,2013); Effect of anthropogenic disturbance on the tree diversity of Nokrek Biosphere Reserve in Meghalaya, India (Sangma and Mishra, 2017).

In Mizoram, ecologists have carried out research on various aspects of plant diversity and impact analysis of disturbance gradient. Some studies relating to the present investigation are- Change in phyto-sociological attributes and plant species diversity in secondary successional forests following stone mining in Aizawl district of Mizoram (Singh et al., 2011); Effect of anthropogenic activities on micro-environment and soil characteristics along disturbance gradient in the sub-tropical forest of Mizoram (Mishra, 2012); Recovery of plant diversity in sub-tropical forest of Mizoram (Singh et al., 2014a); Diversity of medicinally important plantsfrom Tanhril area of Mizoram (Singh et al., 2014b); Recovery of plant diversity and soil nutrients during stand development in subtropical forests of Mizoram (Singh et al., 2015a);Plant diversity changes along disturbance gradient in Mizoram (Singh et al., 2015b); Sandstone quarry in relation to change in diversity, distribution and community organization of trees in sub-tropical forest of Mizoram (Mishra,2016);Impact of disturbance on phyto-diversity in undisturbed and disturbed catchment areas of Serlui river in vicinity of Serlui-B hydel project (Sunar and Mishra, 2017).

CHAPTER - 3

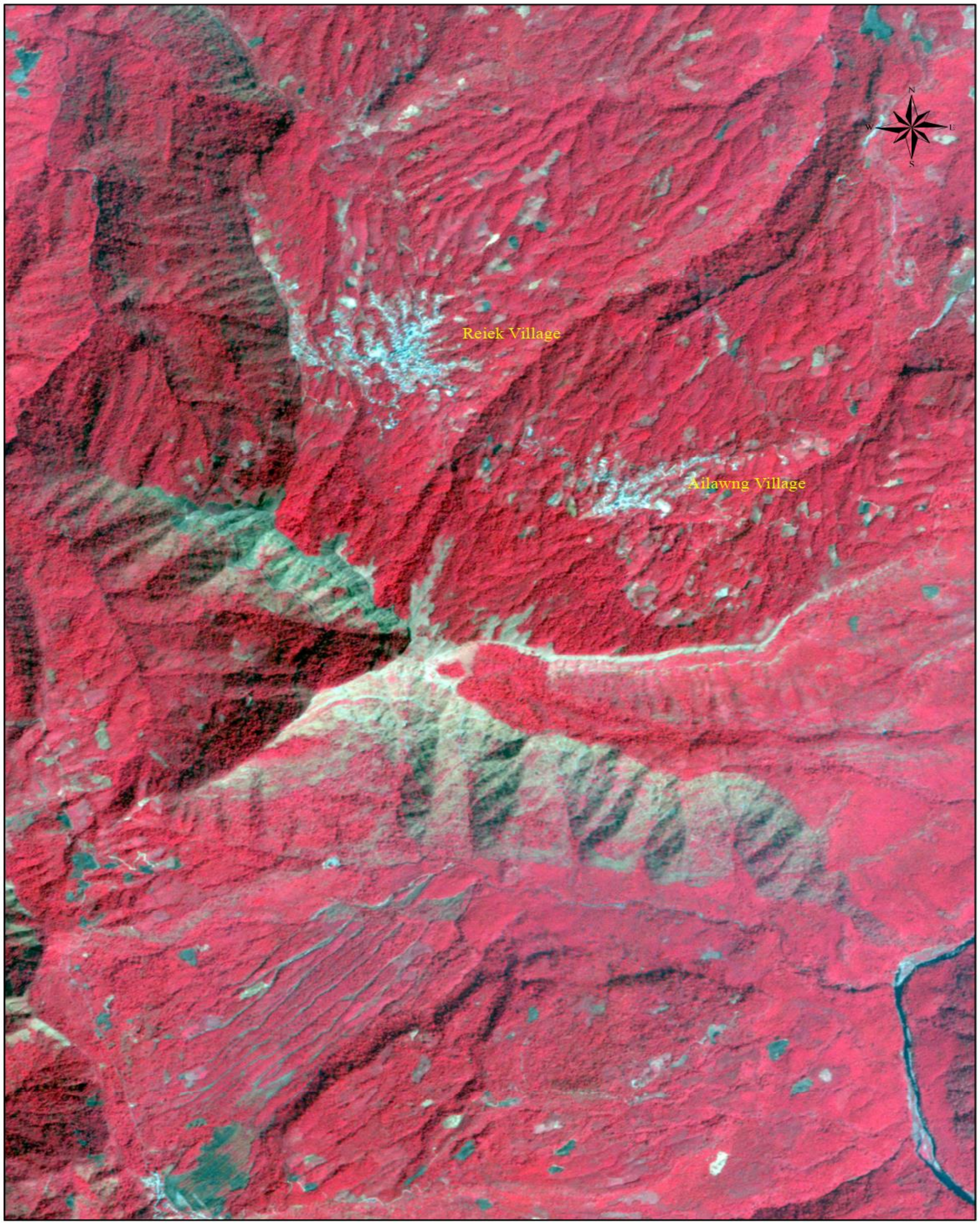
MATERIALS & METHODS

3.1 Description of Study area

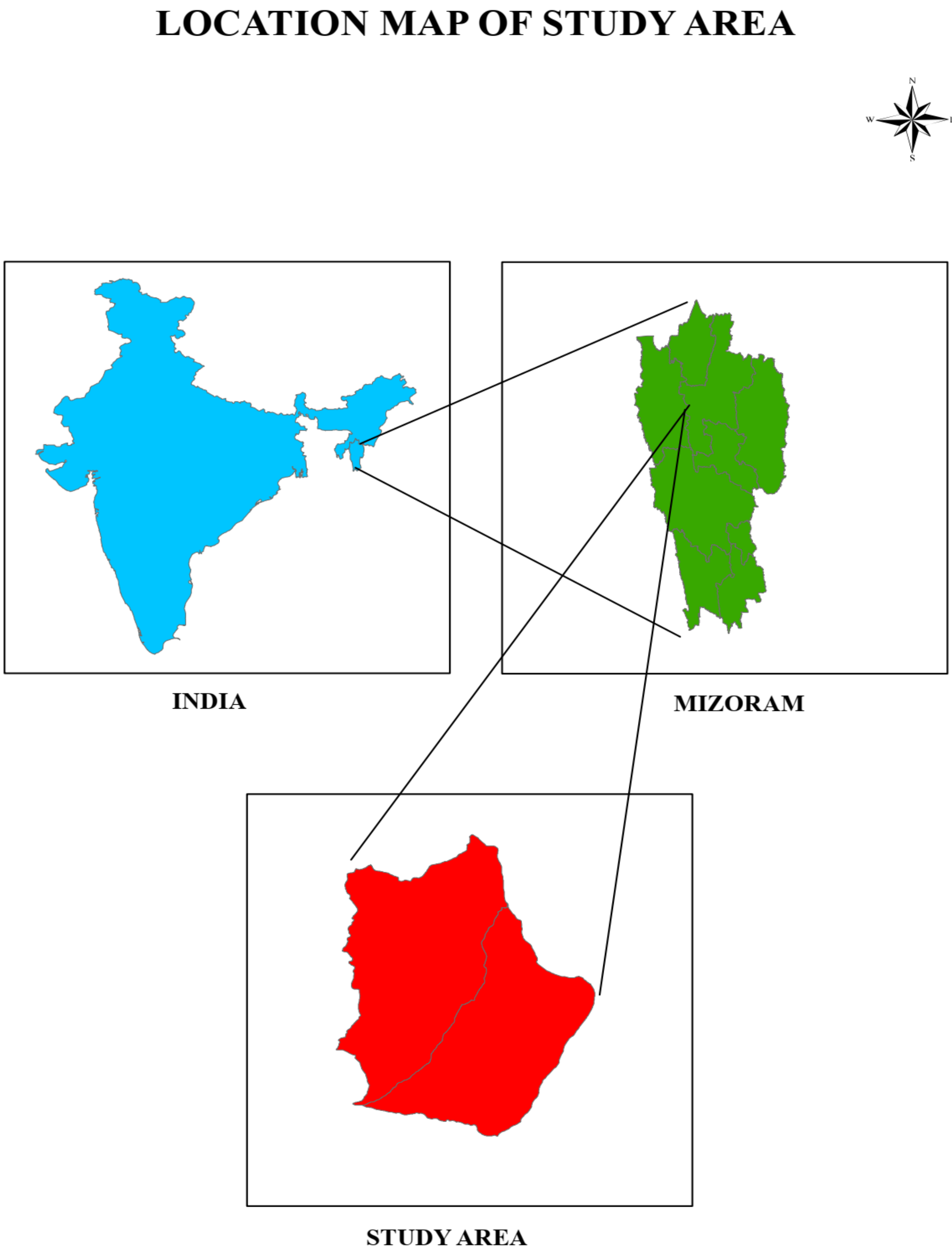
The Reiek forest lies between longitude $92^0$37' and $93^0$28'E and latitude $20^0$45' and $22^0$46'N. Reiek village is about 25 km away from the state capital Aizawl towards the west after crossing Tlawng river. Reiek forest covers an area about 1000 ha. and surrounded by cliffs on all sides except the northern aspect. The east and west precipices meet at Reiek peak which is 1485 m asl.

This forest had been protected and conserved by the descendants of Sailo Chiefs, particularly Mr. Lalluaia, since the 1890's. There are reserved and community forests in the village which are protected by different NGO's of the village such as the Young Mizo Association (YMA), the Mizo Upa Pawl (MUP), Mizo Hmeichhia Insuihkhawm Pawl (MHIP) and the Village Council. The periphery of the forest vegetation (buffer zone) is facing anthropogenic disturbances by the settlement surrounding the forest and vegetation is rather sparse. However, the core zone is still intact. To make the presentation more clearer, the map are given forSatellite imagery showing study area (Map 1), Location map of study area (Map 2), and Land-use/ Land-cover map of study area (Map 3).

SATELLITE IMAGERY SHOWING STUDY AREA

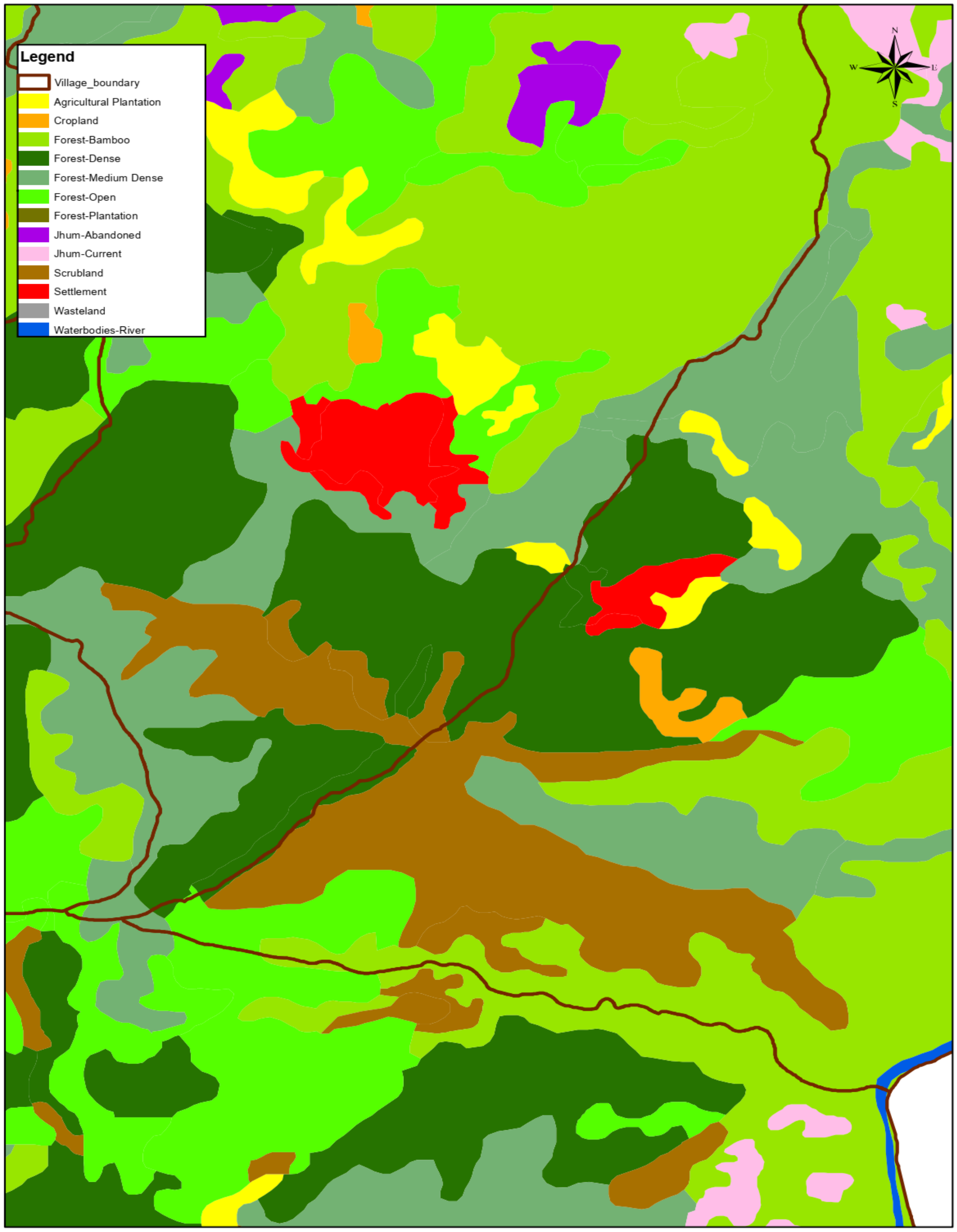


Map 1: Satellite imagery showing study area.



Map 2: Location map of study area.

LAND USE/LAND COVER MAP OF STUDY AREA



Map 3. Land-use/ Land-cover map of study area.

3.2 Selection of study sites and collection of field data

The field study was carried out following the methods as outlined in Misra (1968) and Meuller Dombois and Ellenberg (1974). For detailed ecological investigation, the minimal plot size was determined as 0.5 ha. and same area each of Core zone and Buffer zone were sampled following the quadrat method. All woody species were recorded in 10mx10m quadrat. The plant specimen were identified with the help of herbarium of the concerned Department and "Book of Mizoram Plants" by M.Sawmliana, and also counter-checked with flora available so far (Kanjilal and Kanjilal, 1934-40; Haridasan and Rao, 1985). The field data used for computation of phyto-socilological attributes namely- frequency, density, abundance, basal area, IVI, girth class distribution and various diversity-distribution indices**.**

3.3 Methods

3.3.1 Quantitative analysis

The quantitative characters viz frequency, density and abundance will be computed using the following formula

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

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

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

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

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

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

3.3.2 Importance Value Index (IVI)

In order to express the dominance and ecological success of any species, with a single value, the concept of IVI was used. The important value index was determined as sum of relative density, relative frequency, and relative abundance (Curtis, 1959).

The relative value will be measured using the following formulae.

a) $$\text{Relative frequency} = \frac{\text{Frequency of a species}}{\text{frequency of all species}} \times 100$$

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

c) $$\text{Relative abundance} = \frac{\text{Abundance of a species}}{\text{Abundance of all species}} \times 100$$

IVI = Relative Frequency + Relative Density + Relative Abundance

3.3.3 Girth class distribution: The girth or the diameter of the trunk is the most often measured parameter of trees. It is a measurement of the distance around the trunk of a tree measured perpendicular to the axis of the trunk. In is usually measured at breast height, or at 4.5 ft (1.4m) above ground level. The method is applied with a view to define the trees diameter into six girth classes, 30-60 m, 60-90 m, 90-120 m, 120-150 m, 150-180 m, >180 m.

4.3.4 Diversity and dominance indices

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

i) Species diversity index, Shannon-Wiener diversity index (Shannon, 1949) : is a commonly used index to characterize the diversity in a community. Shannon index combines species richness (the number of species in a given area) and their relative abundances. It is calculated using the formula,

$$H = \Sigma \text{ (ni/N) in (ni/N)}$$

Where, ni = Number of individuals of each species in the sample

N = Total number of individuals

ii) Species evenness index Pielou's evenness index (1975) : It is derived from Shannon index, the ratio of the observed value of Shannon index to the maximum value gives the Pielou's eveness index. The Values are between 0-1, which means the individuals are distributed equally/evenly. It is calculated using the formula,

$$H = H'/\text{InS}$$

Where, H' = Shannon's index value

S = Total number of species

iii) Species dominance index Simpson's index of dominance (1949): measures the probability that two individuals randomly selected from a sample will belong to the same species. Simpson gave the probability of any two individuals drawn from noticeably large community belonging to different species. It has been measured by the given formula,

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

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

N = Total no. of individuals

iv) Species richness index, Margalef's index of species richness (1972) : It is a measurement of the number of different species in a given area or a community. It is calculated using the formula,

$$Dmg = \frac{(S-1)}{\ln N}$$

Where, ln = natural log/logarithm

S = Species richness

N = Number of individuals

CHAPTER - 4

RESULTS AND DISCUSSION

4.1 Plant Community Characteristics

A total of 89 woody plant species (belonging to 53 genera and 42 families) and 86 woody plant species (belonging to 70 genera and 37 families) were recorded from core and buffer zones, respectively. Greater number of genera in buffer zone could be attributed due to elimination of the sensitive ones and more inclusion of disturbance tolerant ones on the buffer zone. The species richness was greater in the buffer zone (13.81) and less in the core zone (13.01). The number of families decreased from core (42) to buffer (37) zones respectively. The Shannon diversity index was more in the core zone (4.37) than in the buffer zone (4.32), Pielou's evenness index exhibited similar trend in the core (0.97) and buffer (0.97) zones respectively. Similarly, Simpson's dominance index did not show much differences in both the studied areas i.e, core (0.0128) and buffer (0.0126) zones, respectively (Table 1).

Table 1. Woody plant community attributes in core and buffer zones of Reiek forest.

Parameter	**Core zone**	**Buffer zone**
Number of families	42	37
Number of genera	53	70
Number of species	89	86
Number of individuals (0.5 ha)	865	471

Shannon Diversity index	4.37	4.32
Pielou's Evenness index	0.97	0.97
Simpson's Dominance index	0.0128	0.0126
Margalef's species richness index	13.01	13.81

The above findings reveal that there is no marked variation in the number of families and species in the two stands of the forest. But number of genera was significantly higher in buffer zone, indicating introduction of new genus supported by the small gaps created in the standwhich plays an important role in regeneration of tree species. The mild disturbances on the buffer zone create favourable habitat conditions and also the gaps created by disturbances allow migrants from the adjacent communities to get established. Probably due to this reason maximum species richness in adult tree, sapling and seedling layer were recorded in the buffer zone.The observations on diversity, dominance and evenness indices in two stands depict the stability of community as impact of disturbance in buffer zone is negligible.

4.2 Phyto-sociological attributes

In the core zone,the frequency (%) was found to be maximum for *Lithocarpus pachyphyllus* (Fagaceae) followed by *Castanopsis tribuloides* (Fagaceea), *Alphonsea ventricosa* (Annonaceae), *Rapanea capitellata* (Myrsinaceae), *Atalantia simplicifolia* (Rutaceae), *Croton hookeri* (Euphorbiaceae), *Helicia excels* (Protaceae), *Litsea lancifolia* (Lauraceae), *Rapanea capitellata* (Myrsinaceae), *Saprosma ternatum* (Rubiaceae) and the least frequency was recorded for *Schefflera vernulosa* (Araliaceae) and *Kydia calycina* (Malvaceae). The Density was highest for *Lithocarpus pachyphyllus* (Fagaceae) and *Alphonsea ventricosa* (Annonaceae) followed by

Helicia excels (Protaceae), *Castanopsis tribuloides* (Fagacaeae), *Aganope thyrsiflora* (Fabaceae), *Croton hookeri* (Euphorbiaceae), *Acer laevigatum* (Sapindaceae), *Heteropanax fragrans* (Araliaceae), *Mallotus philippensis* (Euphorbiaceae) and lowest for *Wendlandia grandis* (Rubiaceae) and *Kydia calycina* (Malvaceae) . The species *Pittosporum napaulense* (Pittosporaceae) was found to exhibit the highest abundance followed by *Choerospondias axillaris* (Annacardiaceae), *Schefflera vernulosa* (Araliaceae) and *Choerospondias axillaris* (Anacardiacea) and was lowest for *Wendlandia grandis* (Rubiaceae) and *Citrus macropetra* (Rutaceae) respectively (Table 2).

Table 2. Phyto-sociological attributes of woody plants in core zone of Reiek forest.

	Name of Species	Family	F (%)	D (0.5 ha)	Abundance	RF (%)	RD (%)	RA (%)	IVI
1	*Acer laevigatum* Wall Thing-khim	Sapindaceae	18	42	2.3	1.78	2.05	1.32	5.15
2	*Acronychia pedunculata* (L.) Mia (Par-arsi)	Rutaceae	14	22	1.5	1.39	1.08	0.86	3.33
3	*Aganope thyrsiflora* Polhill (Hul-hu)	Fabaceae	16	46	2.8	1.58	2.25	1.61	5.44
4	*Aglaia edulis* (Roxb.) Wall (Rai-thei)	Meliaceae	12	20	1.6	1.19	0.97	0.92	3.08
5	*Alphonsea ventricosa* Hook. f & Thomson (Zawng-balhla)	Annonaceae	24	54	2.2	2.38	2.64	1.26	6.28
6	*Alseodaphne petiolaris* Hook.f (Bul-pui)	Lamaceae	8	14	1.7	0.79	0.68	0.98	2.45
7	*Atalantia monophylla* DC Ram-ser	Rutaceae	6	10	1.2	0.59	0.49	0.69	1.77
8	*Atalantia simplicifolia* Roxb (Lallai-thing)	Rutaceae	22	40	1.8	2.18	1.96	1.03	5.17
9	*Balakata baccata* (Roxb) Esser (Thing-vawkpui)	Euphorbeaceae	14	24	1.7	1.39	1.17	0.98	3.54
10	*Betula cylindrostachys Wall* (Hring-zau)	Betulaceae	6	14	2.3	0.59	0.68	1.32	2.59
11	*Bruinsmia polysperma* (C.B.Clarke) Steenis (Thei-palingkawh)	Styraceae	6	10	1.6	0.59	0.49	0.92	2
12	*Callicarpa arborea* Roxb.	Verbeneaceae	8	18	2.2	0.79	0.88	1.26	2.93

	(Hnah-kiah)								
13	*Calophyllum polyanthum* Wall. ex Planch & Triana (Sente-zel)	Clusiaceae	16	40	2.5	1.58	1.96	1.43	4.97
14	*Caphalotaxus griffithii* Hook. F. (Tu-far)	Cephalotaxaceae	6	8	1.3	0.59	0.39	0.75	1.73
15	*Carallia brachiata* (Lour) Merr. (Thei-ria)	Rhizophoraceae	8	12	1.5	0.79	0.59	0.86	2.24
16	*Castanopsis echinocarpa* Mia (Then-ngo)	Fagaceae	14	34	2.4	1.39	1.66	1.38	4.43
17	*Castanopsis indica* (Roxb. ex Lindl) A.DC (Se-hawr)	Fagaceae	10	20	2	0.99	0.98	1.15	3.12
18	*Castanopsis tribuloides* (Sm)*A. DC.* (Thing-sia)	Fagaceae	24	48	2	2.38	2.35	1.15	5.88
19	*Celtis timorensis* Span (Zo-thing-chang)	Cannabaceae	14	28	2	1.39	1.37	1.15	3.91
20	*Choerospondias axillaris* Thei-khuang-chawm	Anacardiaceae	6	18	3	0.59	0.88	1.72	3.19
21	*Cinnamomum verum* J. Presel (Thakthing)	Lauraceae	20	32	1.8	1.98	1.56	1.03	4.57
22	*Citrus macropetra* Mont. var. annamensis Tanaka (Ram-ser-tawk)	Rutaceae	6	6	1	0.59	0.29	0.57	1.45
23	*Croton hookeri* Veitch (Bakenfung)	Euphorbiaceae	22	48	2.1	2.18	2.35	1.21	5.74
24	*Dimycarpus racemosus* (Roxb) Hook.f. (Vawmbal)	Anacardiaceae	12	24	2	1.18	1.17	1.15	3.5
25	*Diospyrus lancifolia* Wallich ex Hireu (Zo-thing-hang)	Ebanaceae	12	22	1.8	1.19	1.08	1.03	3.3
26	*Elaeocarpus aristatus* Roxb. (Thei-kel-ek)	Elaeocarpaceae	10	22	2.2	0.99	1.08	1.26	3.33
27	*Elaeocarpus floribundulus* Blume (Um-khal)	Elaeocarpaceae	10	18	1.8	0.99	0.88	1.03	2.9
28	*Embelia tsjeriam* Cottam (Roem & Schult) A.DC (Rah-sen)	Myrsinaceae	12	34	2.8	1.19	1.66	1.61	4.46
29	*Engelhardtia spicata* Laschen, ex Blume (Hnum)	Juglandaceae	10	18	0.6	0.99	0.88	0.34	2.21
30	*Eriobotrya bengalensis (Roxb.)* Hook.f.	Rosaceae	16	32	2	1.58	1.56	1.15	4.29

	(Nghal-chhun)								
31	*Eurya cerasifolia* (D.Don) Kobuski (Si-hneh)	Theaceae	14	26	1.8	1.39	1.27	1.03	3.69
32	*Eurya loquaiana* Dun Zo-sihneh	Pentaphylaceae	12	26	2.6	1.19	1.27	1.49	3.95
33	*Ficus maclellandii* King (Hmawng)	Moraceae	12	18	1.5	1.19	0.88	0.86	2.93
34	*Firmiana colorata* (Roxb.) R.Br. (Khau-khim)	Sterculiaceae	12	26	2.1	1.18	1.27	1.21	3.66
35	*Garcinia cowa* Roxb. (Zo-chengkek)	Clusiaceae	4	6	1.5	0.39	0.29	0.86	1.54
36	*Garcinia sopsopia* (Buch-Ham) Mabb. (Vawmva)	Clusiaceae	4	6	1.5	0.39	0.29	0.86	1.54
37	*Garcinia xanthocymus* Hook. f. ex T. Anderson (Tuai-habeh)	Clusiaceae	8	10	1.2	0.79	0.49	0.69	1.97
38	*Glochidion khasicum* (Mull. Arg.) Hook. f. (Thing-pawn-chhia)	Euphorbiaceae	4	10	2.5	0.39	0.48	1.43	2.3
39	*Helicia excels* (Roxb) Blume (Sial-hma)	Protaceae	22	52	2.3	2.17	2.54	1.32	6.03
40	*Heteropanax fragrans* (Roxb.) Seem (Chang-khen)	Araliaceae	16	42	2.6	1.58	2.05	1.49	5.12
41	*Kydia calycina* Roxb. (Thal-teh)	Malvaceae	2	4	2	0.19	0.19	1.15	1.53
42	*Lithocarpus elegans* (Blume) Hatus. ex Soepadmo (Thingpui-thing-hnah-hlai)	Fagaceae	16	36	2.2	1.58	1.76	1.26	4.6
43	*Lithocarpus pachyphyllus* (Kurz) Rehder (Then-sen)	Fagaceae	28	54	1.9	2.77	2.64	1.09	6.5
44	*Litsea cubeba* (Lour) Pers (Ser-nam)	Lauraceae	6	12	2	0.59 9	0.59	1.15	2.33 9
45	*Litsea lancifolia* Roxb.ex Nees (Hnah-pawte)	Lauraceae	22	36	1.6	2.18	1.76	0.91	4.85
46	*Macaranga peltata* (Roxb) Mull. Arg. (Khar-duap)	Euphorbiaceae	10	22	2.2	0.99	1.08	1.26	3.33
47	*Macropanax undulates* (Wall. Ex. G.Don) Seem (Phuan-berh)	Araliaceae	10	24	2.2	0.99	1.17	1.26	3.42
48	*Mallotus philippensis* (Lam) Mull.Arg	Euphorbiaceae	16	42	2.6	1.58	2.05	1.49	5.12

	(Bawng-khei)								
49	*Mangifera sylvatica* Roxb. (Haifavang)	Anacardiaceae	14	22	1.5	1.39	1.08	0.86	3.33
50	*Mesua ferrea* Linn. (Herhse)	Clusiaceae	20	40	2	1.98	1.96	1.15	5.09
51	*Michelia champaca* Linn (Ngiau)	Magnoliaceae	4	10	2.5	0.39	0.49	1.43	2.31
52	*Mitragyna diversifolia* (Wall. ex G.Don) Havil (Pual-eng)	Rubiaceae	8	14	1.7	0.79	0.68	0.98	2.45
53	*Olea dioica* Roxb. (Se-vuak)	Oleaceae	8	20	2.5	0.79	0.98	1.43	3.2
54	*Olea salicifolia* Wall. ex G. Don (Thing-thiang)	Oleaceae	10	12	1.2	0.99	0.59	0.69	2.27
55	*Ostodes paniculata* Blume (Bel-tur)	Euphorbiaceae	6	12	2	0.59	0.59	1.15	2.33
56	*Persea glaucescens* (Nees) Hand-Mazz (Sa-per-bul)	Lauraceae	8	18	2.2	0.79	0.88	1.26	2.93
57	*Phoebe attenuate* (Nees) Nees (Bul-bawr)	Lauraceae	4	6	1.5	0.39	0.29	0.86	1.54
58	*Pithecolobium bigeminum* (L.) Mart (Ar-dah-te)	Mimosaceae	16	32	2	1.58	1.56	1.14	4.28
59	*Pittosporum napaulense* (DC) Rehder & Wilson (Thing-pho-arh)	Pittosporaceae	4	14	3.5	0.39	0.68	2.01	3.08
60	*Premna coriacea* C.B. Clarke (Kuam)	Verbanaceae	6	16	2.3	0.59	0.78	1.32	2.69
61	*Premna racemosa* Wall. ex Schaver (Thing-sa-um)	Verbanaceae	8	14	1.7	0.79	0.68	0.98	2.45
62	*Pterospernum semisagittatum* Buch-Ham ex Roxb. (Mu-khau)	Sterculiaceae	14	26	1.8	1.39	1.27	1.03	3.69
63	*Pyrularia edulis* (Wall)A.DC (Thlum-zu)	Santalaceae	12	24	2	1.18	1.17	1.14	3.49
64	*Quercus glauca* Thunb (Hrum-hriau)	Fagaceae	14	22	1.5	1.39	1.08	0.86	3.33
65	*Raevesia wallichii* R. Br. (Tu-khau)	Sterculiaceae	4	10	2.5	0.39	0.49	1.43	2.31
66	*Randia wallichii* Hook. f. (Sa-phut)	Rubiaceae	10	22	2.2	0.99	1.08	1.26	3.33
67	*Rapanea capitellata* (Wall) Mez.	Myrsinaceae	22	44	2	2.18	2.15	1.15	5.48

	(Pial-thleng)								
68	*Rhus chinensis* Mill (Khawm-hma)	Anacardiaceae	6	10	1.6	0.59	0.49	0.91	1.99
69	*Rhus succedanae* L. (Chhim-hruk)	Anacardiaceae	10	18	1.8	0.99	0.88	1.03	2.9
70	*Saprosma ternatum* (Wall) Hook. f (Pelh-vawm)	Rubiaceae	22	42	1.9	2.18	2.05	1.09	5.32
71	*Schefflera vernulosa* (Wight & Arn) Harms (Kel-buh-te)	Araliaceae	2	6	3	0.19	0.29	1.72	2.2
72	*Schima walichii* Choisy (Khiang)	Theaceae	16	36	2.2	1.58	1.76	1.26	4.6
73	*Smilax perfoliata* Lour (Kai-ha)	Smilacaceae	12	20	1.6	1.19	0.98	0.91	3.08
74	*Sterculia hamiltonii (Kuntez)* Adelb. (Tligi leh Ngama-in chhawlthuaina)	Sterculiaceae	6	12	2	0.59	0.58	1.15	2.32
75	*Styrax serrulatus* Roxb. (Hmar-hleng)	Styraceae	16	34	2.1	1.58	1.66	1.21	4.45
76	*Sycopsis griffithiana* Oliv. (Pi-chili-meem)	Hamamelidaceae	6	12	2	0.59	0.59	1.15	2.33
77	*Symplocos cochinchinensis* (Lour.) S.Moore ssp. lauriana (Retz.) Noot. (Thing-phut)	Symplocaceae	18	38	2.1	1.78	1.85	1.21	4.84
78	*Syzygium claviflorum* (Roxb) Wall ex A.M. Cowan & Cowan (Hmui-fa-rial)	Myrtaceae	12	30	2.5	1.18	1.48	1.43	4.09
79	*Syzygium cumini* (L) Skeels (Lenhmui)	Myrtaceae	10	26	2.6	0.99	1.27	1.49	3.75
80	*Syzygium claviflorum* (Roxb) Wall ex A.M. *Cowan & Cowan* (Hmui-fa-rial)	Myrtaceae	10	18	2.2	0.99	0.88	1.26	3.13
81	*Syzygium fruticosum DC* (Hmuifang-rawngbel)	Myrtacaeae	10	32	2	0.99	1.56	1.15	3.7
82	*Syzygium praecox* (Roxb) Rathakar. & N.C.Nair (Hmuifang)	Myrtaceae	12	18	1.5	1.19	0.89	0.86	2.94
83	*Tabernaemontana divaricate* (L) R.Br. ex Roem & Schlut (Kelte-beng beh)	Apocynaceae	14	14	1.8	1.39	0.69	1.03	3.11
84	*Toona ciliata* M.Roem (Tei-pui)	Meliacaee	6	10	1.6	0.59	0.49	0.91	1.99
85	*Trema orientalis* (L) Blume (Bel-phuar)	Ulmaceae	8	16	1.2	0.79	0.78	0.69	2.26
86	*Viburnum foetidum* Wall.	Adoxaceae	4	6	1.5	0.39	0.29	0.86	1.54

	(Zo-thei)								
87	*Walsura robusta* Roxb. (Perh-te)	Meliaceae	6	18	1.3	0.59	0.88	0.75	2.22
88	*Wendlandia grandis* (Hook. f.) Cowan (Ba-tling)	Rubiaceae	4	4	1	0.39	0.19	0.57	1.15
89	*Ziziphus incurva* Roxb. (Hel)	Rhamnaceae	8	16	2	0.79	0.78	1.15	2.72

In the buffer zone, the frequency (%) was recorded to be the highest for the species *Michelia champaca* (Magnoliaceae) which was followed by *Eurya cerasifolia* (Theaceae), *Helicia excels* (Protaceae), *Balakata baccata* (Euphorbiaceae), *Cinnamomum glandululiferum* (Lauraceae) and was lowest for *Rhus chinensis* (Anacardiaceae), *Alphonsea ventricosa* (Annonaceae), *Atalantia monophylla* (Rutaceae), *Bruinsmia polysperma* (Styraceae), *Citrus macropetra* (Rutaceae), *Pithecolobium bigeminum* (Mimosaceae) accordingly. The density of the wodden plants was highest for *Schima walichii* (Theaceae), *Michelia champaca* (Magnoliaceae) which were followed by *Ziziphus incurve* (Rhamnaceae), *Eriobotrya bengalensis* (Rosaceae) and was lowest for *Viburnum foetidum* (Adoxaceae), *Atalantia monophylla* (Rutaceae) and *Bruinsmia polysperma* (Styraceae) respectively. The abundance in the plant community was found to be highest for *Pithecolobium bigeminum* (Mimosaceae), and *Alphonsea ventricosa* (Annonacaeae) and followed by *Aganope thyrsiflora* (Fabaceae), *Kydia calycina* (Malvaceae), *Engelhardtia spicata* (Juglandaceae) and lowest for *Trema orientalis* (Ulmacaeae), *Atalantia monophylla* (Rutaceae), *Bruinsmia polysperma* (Styaraceae), *Citrus macropetra* (Rutaceae), *Mangifera sylvatica* (Anacardiaceae), *Raevesia wallichii* (Sterculiaceae) respectively (Table 3).

Table 3. Phyto-sociological attributes of woody plants in buffer zone of Reiek forest.

	Name of Species (Local Name)	Family	F (%)	D (0.5 ha)	Abundance	RF (%)	RD (%)	RA (%)	IVI
1	*Acer laevigatum* Wall (Thing-khim)	Sapindaceae	4	6	1.5	0.62	0.56	1.06	2.24
2	*Acronychia pedunculata* (L.) Mia (Par-arsi)	Rutaceae	6	12	2	0.94	1.13	1.42	3.49
3	*Aganope thyrsiflora* Polhill (Hul-hu)	Fabaceae	6	16	2.6	0.94	1.50	1.85	4.29
4	*Alphonsea ventricosa* Hook. f & Thomson (Zawng-balhla)	Annonaceae	2	6	3	0.31	0.56	2.13	3
5	*Alseodaphne petiolaris* Hook.f (Bul-pui)	Lamaceae	4	8	2	0.62	0.75	1.42	2.79
6	*Anogeissus acuminate* Roxb. ex DC Guillium *et al* (Zai-rum)	Combretaceae	8	10	1.2	1.25	0.94	0.85	3.04
7	*Atalantia monophylla* DC (Ram-ser)	Rutaceae	2	2	1	0.31	0.19	0.71	1.21
8	*Atalantia simplicifolia* Roxb (Lallai-thing)	Rutaceae	10	22	2.2	1.56	2.07	1.56	5.19
9	*Balakata baccata* (Roxb) Esser (Thing-vawkpui)	Euphorbeaceae	12	20	1.6	1.87	1.88	1.14	4.89
10	*Betula cylindrostachys Wall* (Hring-zau)	Betulaceae	6	12	2	0.94	1.13	1.42	3.49
11	*Bruinsmia polysperma* (C.B.Clarke) Steenis (Thei-palingkawh)	Styraceae	2	2	1	0.31	0.19	0.71	1.21
12	*Callicarpa arborea* Roxb. (Hnah-kiah)	Verbeneaceae	8	14	1.7	1.25	1.32	1.21	3.78
13	*Calophyllum polyanthum* Wall. ex Planch & Triana (Sente-zel)	Clusiaceae	6	14	2.3	0.94	1.32	1.63	3.89
14	*Carallia brachiata* (Lour) Merr. (Thei-ria)	Rhizophoraceae	6	8	1.3	0.94	0.75	0.92	2.61
15	*Castanopsis echinocarpa* Mia (Then-ngo)	Fagaceae	8	12	1.5	1.25	1.13	1.06	3.44
16	*Castanopsis indica* (Roxb. ex Lindl) A.DC (Se-hawr)	Fagaceae	8	14	1.7	1.25	1.32	1.21	3.78
17	*Castanopsis tribuloides* (Sm)*A. DC.* (Thing-sia)	Fagaceae	10	14	1.4	1.56	1.32	0.94	3.82

18	*Celtis timorensis Span* (Zo-thing-chang)	Cannabaceae	4	6	1.5	0.62	0.56	1.06	2.24
19	*Choerospondias axillaris* (Thei-khuang-chawm)	Anacardiaceae	6	8	1.3	0.94	0.75	0.92	2.61
20	*Cinnamomum glandululiferum (*Wall) Meisner	Lauraceae	12	22	1.8	1.87	2.07	1.29	5.23
21	*Cinnamomum verum* J. Presel (Thakthing)	Lauraceae	12	22	1.8	1.87	2.07	1.28	5.22
22	*Citrus macropetra* Mont. var. annamensis Tanaka (Ram-ser-tawk)	Rutaceae	2	2	1	0.31	0.19	0.71	1.21
23	*Coffea khasiana (Korth) Deb & Lahiri* (Ngul-ri-thet)	Rubiaceae	10	14	1.4	1.56	1.32	0.99	3.87
24	*Croton hookeri* Veitch (Bakenfung)	Euphorbiaceae	4	6	1.5	0.62	0.56	1.06	2.24
25	*Dimycarpus racemosus* (Roxb) Hook.f. (Vawmbal)	Anacardiaceae	12	14	1.6	1.87	1.32	1.14	4.33
26	*Elaeocarpus floribundulus* Blume (Um-khal)	Elaeocarpaceae	10	16	1.6	1.56	1.50	1.14	4.2
27	*Embelia tsjeriam* Cottam (Roem & Schult) A.DC (Rah-sen)	Myrsinaceae	6	12	2	0.94	1.13	1.42	3.49
28	*Engelhardtia spicata* Laschen, ex Blume (Hnum)	Juglandaceae	8	20	2.5	1.25	1.88	1.77	4.9
29	*Eriobotrya bengalensis (Roxb.)* Hook.f. (Nghal-chhun)	Rosaceae	6	24	4	0.94	2.26	2.84	6.04
30	*Erythrina stricta Roxb* (Far-tuah)	Fabaceae	10	14	1.4	1.56	1.32	0.99	3.87
31	*Eurya cerasifolia (D.Don) Kobuski* (Si-hneh)	Theaceae	14	26	1.8	2.19	2.44	1.29	5.92
32	*Eurya loquaiana Dun* (Zo-sihneh)	Pentaphylaceae	10	18	1.8	1.56	1.69	1.29	4.54
33	*Ficus maclellandii* King (Hmawng)	Moraceae	4	6	1.5	0.62	0.56	1.06	2.24
34	*Ficus retusa L.* (Rihnim)	Moraceae	8	10	1.2	1.25	0.94	0.85	3.04
35	*Firmiana colorata* (Roxb.) R.Br. (Khau-khim)	Sterculiaceae	10	12	1.2	1.56	1.13	0.85	3.54
36	*Garcinia xanthocymus* Hook. f. ex T. Anderson (Tuai-habeh)	Clusiaceae	4	6	1.5	0.62	0.56	1.06	2.24

37	*Glochidion khasicum* (Mull. Arg.) Hook. f. (Thing-pawn-chhia)	Euphorbiaceae	16	24	1.5	2.5	2.26	1.06	5.82
38	*Helicia excels* (Roxb) Blume *Sial-hma*	Protaceae	14	22	1.5	2.19	2.07	1.06	5.32
39	*Heteropanax fragrans* (Roxb.) Seem (Chang-khen)	Araliaceae	12	18	1.5	1.87	1.69	1.06	4.62
40	*Kydia calycina Roxb.* (Thal-teh)	Malvaceae	6	16	2 .6	0.94	1.50	1.84	4.28
41	*Ligustrum robustrum* (Roxb.) Blume (Chawmzil)	Oleaceae	6	10	1.6	0.94	0.94	1.14	3.02
42	*Lithocarpus elegans* (Blume) Hatus. ex Soepadmo (Thingpui-thing-hnah-hlai)	Fagaceae	12	24	2	1.87	2.26	1.45	5.58
43	*Lithocarpus pachyphyllus* (Kurz) Rehder (Then-sen)	Fagaceae	10	20	2	1.56	1.88	1.42	4.86
44	*Litsea cubeba* (Lour) Pers (Ser-nam)	Lauraceae	8	14	1.7	1.25	1.32	1.21	3.78
45	*Litsea lancifolia* Roxb.ex Nees (Hnah-pawte)	Lauraceae	4	6	1.5	0.62	0.56	1.06	2.24
46	*Macaranga indica* Wight (Hnah-khar)	Euphorbiaceae	6	8	1.3	0.94	0.75	0.92	2.62
47	*Macaranga peltata* (Roxb) Mull. Arg. (Khar-duap)	Euphorbiaceae	10	14	1.4	1.56	1.32	0.99	3.87
48	*Macropanax undulates* (Wall. ex. G.Don) Seem (Phuan-berh)	Araliaceae	4	6	1.5	0.62	0.56	1.06	2.24
49	*Mangifera sylvatica* Roxb. (Haifavang)	Anacardiaceae	8	8	1	1.25	0.75	0.71	2.71
50	*Mesua ferrea* Linn. (Herhse)	Clusiaceae	6	10	1.6	0.94	0.94	1.14	3.02
51	*Michelia champaca* Linn (Ngiau)	Magnoliaceae	16	26	1.6	2.5	2.44	1.14	6.08
52	*Mitragyna diversifolia* (Wall. ex G.Don) Havil (Pual-eng)	Rubiaceae	4	8	2	0.62	0.75	1.42	2.79
53	*Olea dioica* Roxb. (Se-vuak)	Oleaceae	4	6	1.5	0.62	0.56	1.06	2.24
54	*Olea salicifolia* Wall. ex G. Don (Thing-thiang)	Oleaceae	6	8	1.3	0.94	0.75	0.92	2.61
55	*Ostodes paniculata* Blume (Bel-tur)	Euphorbiaceae	10	14	1.4	1.56	1.32	0.99	3.87

56	*Persea glaucescens* (Nees) Hand-Mazz (Sa-per-bul)	Lauraceae	10	16	1.6	1.56	1.50	1.14	4.2
57	*Phoebe attenuate* (Nees) Nees (Bul-bawr)	Lauraceae	8	10	1.2	1.25	0.94	0.85	3.04
58	Pithecolobium bigeminum (L.) Mart (Ar-dah-te)	Mimosaceae	2	6	3	0.31	0.56	2.13	3
59	*Pittosporum napaulense* (DC) Rehder & Wilson (Thing-pho-arh)	Pittosporaceae	6	10	1.6	0.93	0.94	1.14	3.01
60	*Premna coriacea* C.B. Clarke (Kuam)	Verbanaceae	6	8	1.3	0.94	0.75	0.92	2.61
61	*Premna racemosa* Wall. ex Schaver (Thing-sa-um)	Verbanaceae	14	22	1.5	2.19	2.07	1.06	5.32
62	*Pterospernum semisagittatum* Buch-Ham ex Roxb. (Mu-khau)	Sterculiaceae	4	10	2.5	0.62	0.94	1.77	3.33
63	*Pyrularia edulis* (Wall)A.DC (Thlum-zu)	Santalaceae	6	10	1.6	0.94	0.94	1.14	3.02
64	*Quercus glauca* Thunb (Hrum-hriau)	Fagaceae	6	12	2	0.94	1.13	1.42	3.49
65	*Raevesia wallichii R. Br.* (Tu-khau)	Sterculiaceae	6	6	1	0.94	0.56	0.71	2.21
66	*Randia wallichii* Hook. f. (Sa-phut)	Rubiaceae	4	6	1.5	0.62	0.56	1.06	2.24
67	*Rapanea capitellata* (Wall) Mez. (Pial-thleng)	Myrsinaceae	8	10	1.2	1.25	0.94	0.85	3.04
68	*Rhus chinensis* Mill (Khawm-hma)	Anacardiaceae	2	4	2	0.31	0.38	1.42	2.11
69	*Rhus succedanae L.* (Chhim-hruk)	Anacardiaceae	8	10	1.2	1.25	0.94	0.85	3.04
70	*Saprosma ternatum* (Wall) Hook. f (Pelh-vawm)	Rubiaceae	4	10	2.5	0.62	0.94	1.77	3.33
71	*Schefflera vernulosa* (Wight & Arn) Harms (Kel-buh-te)	Araliaceae	8	10	1.2	1.25	0.94	0.85	3.04
72	*Schima walichii* Choisy (Khiang)	Theaceae	10	26	2.6	1.56	2.44	1.84	5.84
73	*Sterculia hamiltonii* (Kuntez) Adelb. (Tligi leh Ngama-in	Sterculiaceae	4	6	1.5	0.62	0.56	1.06	2.24

	chhawlthuaina)								
74	*Styrax serrulatus* Roxb. (Hmar-hleng)	Styraceae	4	8	2	0.62	0.75	1.42	2.79
75	*Syzygium claviflorum (*Roxb) Wall ex A.M. Cowan & Cowan (Hmui-fa-rial)	Myrtaceae	8	14	1.7	1.25	1.32	1.20	3.77
76	*Syzygium cumini* (L) Skeels (Lenhmui)	Myrtaceae	6	8	1.3	0.94	0.75	0.92	2.61
77	*Syzygium diospyrifolium* Wall. ex Duthie S.N. Mitra (Hnun-thlum)	Myrtaceae	4	4	1	0.62	0.38	0.71	1.71
78	*Syzygium fruticosum* DC (Hmuifang-rawngbel)	Myrtacaeae	10	18	1.8	1.56	1.69	1.29	4.54
79	*Syzygium praecox* (Roxb) Rathakar. & N.C.Nair (Hmuifang)	Myrtaceae	8	12	1.5	1.25	1.13	1.06	3.44
80	*Toona ciliate* M.Roem (Tei-pui)	Meliacaee	8	14	1.7	1.25	1.32	1.20	3.77
81	*Trema orientalis* (L) Blume (Bel-phuar)	Ulmaceae	10	10	1	1.56	0.94	0.71	3.21
82	*Viburnum foetidum* Wall. (Zo-thei)	Adoxaceae	2	2	1	0.31	0.19	0.71	1.21
83	*Walsura robusta* Roxb. (Perh-te)	Meliaceae	8	14	1.7	1.25	1.32	1.21	3.78
84	*Wendlandia grandis* (Hook. f.) Cowan (Ba-tling)	Rubiaceae	12	18	1.5	1.87	1.69	1.06	4.62
85	*Zanthoxylum armatum* DC. Ar-hrik-reh	Rutaceae	10	12	1.2	1.56	1.13	0.85	3.54
86	*Ziziphus incurva* Roxb. (Hel)	Rhamnaceae	12	25	2.1	1.87	2.35	1.49	5.71

4.3 Species Dominance

The IVI of the dominant species varied markedly from the core zone to the buffer zone of the forest. The importance values of *Michelia champaca*, *Eriobotrya bengalensis*, *Eurya cerasifolia, Schima wallichii*, *Glochidion khasicum, Ziziphus incurva*, *Lithocarpus elegans, Premna racemosa, Cinnamomum glandululiferum, Cinnamomum verum, Atalantia simplicifolia, Engelhardtia spicata, Balakata baccata, Wendlandia grandis, Eurya loquaiana, Syzygium fruticosum*, etc. increased from the core zone of the forest to the buffer zone, where as, those of *Lithocarpus pachyphyllus, Alphonsea ventricosa, Helicia excels, Castanopsis tribuloides, Croton* *hookeri, Rapanea capitellata, Aganope thyrsiflora, Saprosma ternatum, Atalantia simplicifolia, Acer laevigatum, Heteropanax fragrans, Mallotus philippensis, Mesua ferrea, Calophyllum polyanthum,etc.* showed a decrease trend from core to buffer zones, respectively (Table 4).

Table 4.Dominance (based on IVI) of woody plant species in core and buffer zones of Reiek forest.

Core zone			**Buffer zone**		
Rank	Species	IVI	Rank	Species	IVI
1	*Lithocarpus pachyphyllus*	6.5	1	*Michelia champaca*	6.08
2	*Alphonsea ventricosa*	6.28	2	*Eriobotrya bengalensis*	6.04
3	*Helicia excelsa*	6.03	3	*Eurya cerasifolia*	5.92
4	*Castanopsis tribuloides*	5.88	4	*Schima wallichii*	5.84
5	*Croton hookeri*	5.74	5	*Glochidion khasicum*	5.82
6	*Rapanea capitellata*	5.48	6	*Ziziphus incurva*	5.71
7	*Aganope thyrsiflora*	5.44	7	*Lithocarpus elegans*	5.58
8	*Saprosma ternatum*	5.32	8	*Helicia excelsa*	5.32
9	*Atalantia simplicifolia*	5.17	9	*Premna racemosa*	5.32
10	*Acer laevigatum*	5.15	10	*Cinnamomum glandululiferum*	5.23
11	*Heteropanax fragrans*	5.12	11	*Cinnamomum verum*	5.22
12	*Mallotus philippensis*	5.12	12	*Atalantia simplicifolia*	5.19
13	*Mesua ferrea*	5.09	13	*Engelhardtia spicata*	4.9
14	*Calophyllum polyanthum*	4.97	14	*Balakata baccata*	4.89
15	*Litsea lancifolia*	4.85	15	*Lithocarpus pachyphyllus*	4.86
16	*Symplocos cochinchineusis*	4.84	16	*Heteropanax fragrans*	4.62
17	*Lithocarpus elegans*	4.6	17	*Wendlandia grandis*	4.62

18	*Schima walichii*	4.6	18	*Eurya loquaiana*	4.54
19	*Cinnamomum verum*	4.57	19	*Syzygium fruticosum*	4.54
20	*Embelia tsjeriam*	4.46	20	*Dimycarpus racemosus*	4.33
21	*Styrax serrulatus*	4.45	21	*Aganope thyrsiflora*	4.29
22	*Castanopsis echinocarpa*	4.43	22	*Kydia calycina*	4.28
23	*Eriobotrya bengalensis*	4.29	23	*Elaeocarpus floribundulus*	4.2
24	*Pithecolobium bigeminum*	4.28	24	*Persea glaucescens*	4.2
25	*Syzygium claviflorum*	4.09	25	*Calophyllum polyanthum*	3.89
26	*Eurya loquaiana*	3.95	26	*Coffea khasiana*	3.87
27	*Celtis timorensis*	3.91	27	*Erythrina stricta*	3.87
28	*Syzygium cumini*	3.75	28	*Macaranga peltata*	3.87
29	*Syzygium fruticosum*	3.7	29	*Ostodes paniculata*	3.87
30	*Eurya cerasifolia*	3.69	30	*Castanopsis tribuloides*	3.82
31	*Pterospernum semisagittatum*	3.69	31	*Callicarpa arborea*	3.78
32	*Firmiana colorata*	3.66	32	*Castanopsis indica*	3.78
33	*Balakata baccata*	3.54	33	*Litsea cubeba*	3.78
34	*Dimycarpus racemosus*	3.5	34	*Walsura robusta*	3.78
35	*Pyrularia edulis*	3.49	35	*Syzygium claviflorum*	3.77
36	*Macropanax undulatus*	3.42	36	*Toona ciliate*	3.77
37	*Acronychia pedunculata*	3.33	37	*Firmiana colorata*	3.54
38	*Elaeocarpus aristatus*	3.33	38	*Zanthoxylum armatum*	3.54
39	*Macaranga peltata*	3.33	39	*Acronychia pedunculata*	3.49
40	*Mangifera sylvatica*	3.33	40	*Betula cylindrostachys*	3.49
41	*Quercus glarica*	3.33	41	*Embelia tsjeriam*	3.49
42	*Randia wallichii*	3.33	42	*Quercus glarica*	3.49
43	*Diospyrus lancifolia*	3.3	43	*Castanopsis echinocarpa*	3.44

44	*Olea dioica*	3.2	44	*Syzygium praecoxum*	3.44
45	*Choerospondias axillaris*	3.19	45	*Pterospernum semisagittatum*	3.33
46	*Syzygium diospyrifolium*	3.13	46	*Saprosma ternatum*	3.33
47	*Castanopsis indica*	3.12	47	*Trema orientalis*	3.21
48	*Tabernae Montana divaricata*	3.11	48	*Anogeissus acuminata*	3.04
49	*Aglaia edulis*	3.08	49	*Ficus retusa*	3.04
50	*Pittosporum napaulense*	3.08	50	*Phoebe attenuata*	3.04
51	*Smilax perfoliata*	3.08	51	*Rapanea capitellata*	3.04
52	*Syzygium praecoxum*	2.94	52	*Rhus succerdanae*	3.04
53	*Callicarpa arborea*	2.93	53	*Schefflera vernulosa*	3.04
54	*Ficus maclellandii*	2.93	54	*Ligustrum robustrum*	3.02
55	*Persea glaucescens*	2.93	55	*Mesua ferrea*	3.02
56	*Elaeocarpus floribundulus*	2.9	56	*Pyrularia edulis*	3.02
57	*Rhus succerdanae*	2.9	57	*Pittosporum napaulense*	3.01
58	*Ziziphus incurva*	2.72	58	*Alphonsea ventricosa*	3
59	*Premna coriacea*	2.69	59	*Pithecolobium bigeminum*	3
60	*Betula cylindrostachys*	2.59	60	*Alseodaphne petiolaris*	2.79
61	*Alseodaphne petiolaris*	2.45	61	*Mitragyna diversifolia*	2.79
62	*Mitragyna diversifolia*	2.45	62	*Styrax serrulatus*	2.79
63	*Premna racemosa*	2.45	63	*Mangifera sylvatica*	2.71
64	*Litsea cubeba*	2.33	64	*Macaranga indica*	2.62
65	*Ostodes paniculata*	2.33	65	*Carallia brachiata*	2.61
66	*Sycopsis griffithiana*	2.33	66	*Choerospondias axillaris*	2.61
67	*Sterculia hamiltonii*	2.32	67	*Olea salicifolia*	2.61
68	*Michelia champaca*	2.31	68	*Premna coriacea*	2.61
69	*Raevesia wallichii*	2.31	69	*Syzygium cumini*	2.61

70	*Glochidion khasicum*	2.3	70	*Acer laevigatum*	2.24
71	*Olea salicifolia*	2.27	71	*Celtis timorensis*	2.24
72	*Trema orientalis*	2.26	72	*Croton hookeri*	2.24
73	*Carallia brachiata*	2.24	73	*Ficus maclellandii*	2.24
74	*Walsura robusta*	2.22	74	*Garcinia xanthocymus*	2.24
75	*Engelhardtia spicata*	2.21	75	*Litsea lancifolia*	2.24
76	*Schefflera vernulosa*	2.2	76	*Macropanax undulates*	2.24
77	*Bruinsmia polysperma*	2	77	*Olea dioica*	2.24
78	*Rhus chinensis*	1.99	78	*Randia wallichii*	2.24
79	*Toona ciliata*	1.99	79	*Sterculia hamiltonii*	2.24
80	*Garcinia xanthocymus*	1.97	80	*Raevesia wallichii*	2.21
81	*Atalantia monophylla*	1.77	81	*Rhus chinensis*	2.11
82	*Caphalotaxus griffithii*	1.73	82	*Syzygium diospyrifolium*	1.71
83	*Garcinia cowa*	1.54	83	*Atalantia monophylla*	1.21
84	*Garcinia sopsopia*	1.54	84	*Bruinsmia polysperma*	1.21
85	*Phoebe attenuata*	1.54	85	*Citrus macropetra*	1.21
86	*Viburnum foetidum*	1.54	86	*Viburnum foetidum*	1.21
87	*Kydia calycina*	1.53			
88	*Citrus macropetra*	1.45			
89	*Wendlandia grandis*	1.15			

4.4 Family Dominance

The most dominant families (based on number of species) in the core zone were Euphorbiaceae, Fagaceae, and Lauraceae with 6 species each, while in biffer zone Lauraceae maintained position with 7 species and Euphorbiaceae and Fagaceae along with Rubiaceaebe came co-dominant families with 6 species each. The mono-specific families amounted to 25 and 19 in core and buffer zones, respectively (Table 5).

Table 5.Family dominance (based on number of species in respective family) of woody plant species in core and buffer zones of Reiek forest.

Sl	Core zone	No. of species	Buffer zone	No. of species
1	Euphorbiaceae	6	Lauraceae	7
2	Fagaceae	6	Euphorbiaceae	6
3	Lauraceae	6	Fagaceae	6
4	Anacardiaceae	5	Rubiaceae	6
5	Myrtaceae	5	Anacardiaceae	5
6	Clusiaceae	5	Myrtaceae	5
7	Rubiaceae	4	Rutaceae	4
8	Rutaceae	4	Sterculiaceae	4
9	Sterculiaceae	4	Araliaceae	3
10	Araliaceae	3	Clusiaceae	3
11	Meliaceae	3	Malvaceae	3
12	Verbenaceae	3	Oleaceae	3
13	Elaeocarpaceae	2	Verbenaceae	3
14	Myrsinaceae	2	Fabaceae	2
15	Oleaceae	2	Moraceae	2
16	Styraceae	2	Myrsinaceae	2
17	Theaceae	2	Styraceae	2
18	Adoxaceae	1	Theaceae	2
19	Annonaceae	1	Adoxaceae	1
20	Apocynaceae	1	Annonaceae	1

21	Betulaceae	1	Betulaceae	1
22	Cannabaceae	1	Cannabaceae	1
23	Cephalotaxaceae	1	Combretaceae	1
24	Ebanaceae	1	Elaeocarpaceae	1
25	Fabaceae	1	Juglandaceae	1
26	Hamamelidaceae	1	Magnoliaceae	1
27	Juglandaceae	1	Malvaceae	1
28	Magnoliaceae	1	Mimosaceae	1
29	Malvaceae	1	Pentaphylacaceae	1
30	Mimosaceae	1	Pittosporaceae	1
31	Moraceae	1	Proteaceae	1
32	Pentaphylacaceae	1	Rhamnaceae	1
33	Pittosporaceae	1	Rhizophoraceae	1
34	Proteaceae	1	Rosaceae	1
35	Rhamnaceae	1	Santalaceae	1
36	Rhizophoraceae	1	Sapindaceae	1
37	Rosaceae	1	Ulmaceae	1
38	Santalaceae	1		
39	Sapindaceae	1		
40	Smilacaceae	1		
41	Symplocaceae	1		
42	Ulmaceae	1		

4.5 Girth-class distribution

The girth class distribution was extended up to >180 cm in the core zone, however, it was restricted to the girth class 120-150 cm in the buffer zone. Lower girth classes harvest markedly high density and in the buffer zone the girth class 30-60 cm accounted for highest population while in the core zone the girth class 60-90 accounted highest population. The higher density in the lower girth classes indicates that anthropogenic disturbances adversely affects vegetation of buffer zone, and at the same time the gap is filled up with growth of shrubs. The girth class indicates that trees of intermediate girth classes covered a larger area than the young and mature trees in the core zone. However, in the buffer zone, the young trees accounted higher area than the intermediate trees, the buffer zone had a low density of mature trees and there was no tree of >150 cm girth (Table 6, Fig. 1).

Table 6.Girth class distribution of woody plants in core and buffer zones of Reiek forest.

Girth Class	Number of individuals	
	Core zone	Buffer zone
30-60	145	235
60-90	320	120
90-120	162	67
120-150	135	49
150-180	43	0
>180	60	0

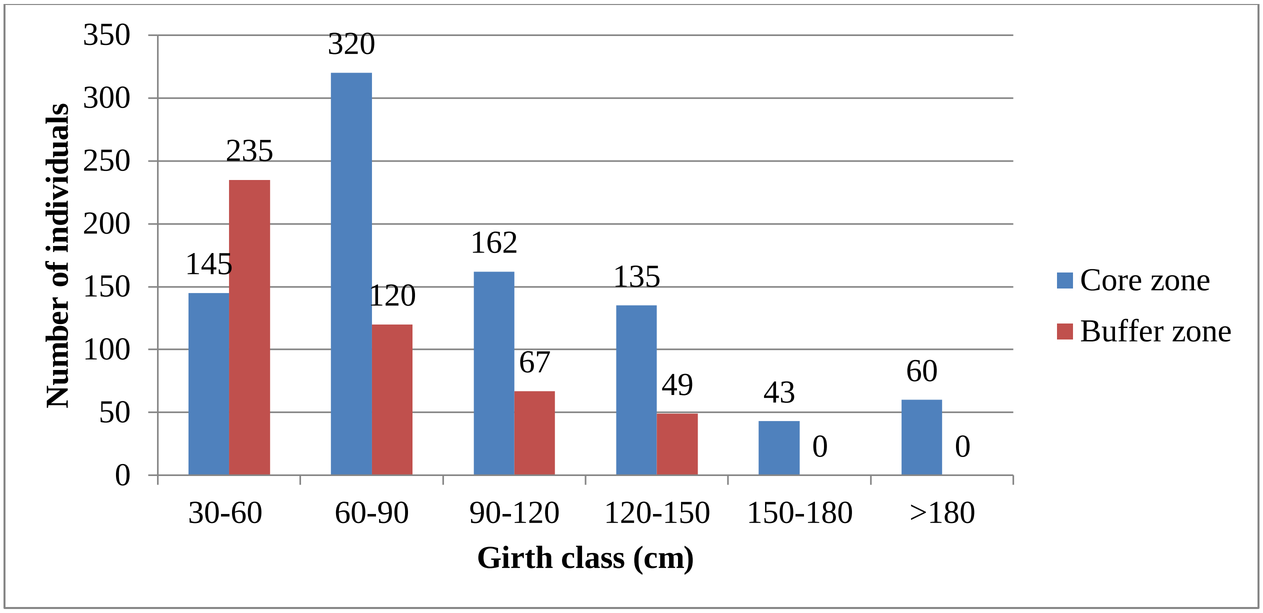


Fig 1.Girth class distribution of plants in core and buffer zones of Reiek forest.

The findings reveals that human activities namely, extraction of timber, collection of fuel-wood and cattle grazing in the buffer zone have led to change in botanical composition, species richness and colonization. The tree density, frequency and abundance decreased significantly from core zone to buffer zone (Table 2 & 3), a progressive reduction of tree density from the core zone to buffer zone in the present study comply with the findings of Bhuyan et al. (2001) in the tropical wet evergreen forest of Arunachal Pradesh, north east India which can be attributed to minor anthropogenic activities occurring in the buffer zone of the forest. The loss of woody species richness is highly linked with anthropogenic disturbance (Mishra et al., 2004; Terborg, 1992). *Lithocarpus pachyphyllus*, the dominant species in the core zone was replaced by *Michelia champaca* in the buffer zone(Table 4). Human disturbances such as felling of trees in the buffer zone of the forest favour the germination of other opportunists species (pioneers) improving their regeneration(Ohsawa et al, 1986). The regeneration composition of tree species in the gaps created due to human activities depends on the history of the forest community, seed availability and the biology of the species (Hubbell and Foster, 1992).The alteration in plant community organization and colonization in forest patches resulting from anthropogenic activities and internal biological processes (Whittaker, (1975; Connell, 1978). The resultant higher species richness in the buffer zone of the forest is in conformity with the results of these workers. A similar trend in results has also been reported by Thorington et al.(1982), Parthasarathy and Karthikeyan (1997) and Parthasarathy and Sethi (1997). Euphorbiaceae (6 species), the dominant family in the core zone was replaced by Lauraceae (7 species) in the buffer zone(Table 5).The shift in position of species and families in terms of dominance may be due to change in micro-climate led by disturbance in the buffer zone.

The results on plant community attributes are in conformity with the work of some ecologists who carried out researches on similar line in the sacred groves and sub-tropical forests of Meghalaya (Mishra et al., 2003, 2004; 2005; Mishra, and Laloo, 2006; Jeeva et al., 2006; Laloo et al., 2006; Mishra, 2009; Mishra and Jeeva, 2012; Mishra, 2012,2013; Sangma and Mishra, 2017).

The past works carried out by scientists on diversity-distribution of plants along disturbance gradient inMizoram also reported a similar trends in results (Mishra, 2012, 2016; Singh et al., 2011, 2014a and b, 2015a and b; Sunar and Mishra, 2017).

__CHAPTER-5__

CONSERVATION STRATEGIES

During the investigation it was felt that the people settled in surrounding of forest are not well aware about significance of trees, and human activities like fuel-wood collection, grazing, extraction of timber are extended in the buffer zone, however core zone is intact. Because of anthropogenic disturbance, small gaps are created in buffer zone of forest, leading to scope for plantation with suitable species and also to facilitate natural regeneration process. The local indigenous people should be taken in to confidence for protection to determine proper management of forest, using ethno-medicinal wisdom recognition.

On account of above facts, the following conservation strategies may be formulated for proper management of forest on sustained basis.

1. Launching of public awareness program to ensure proper management of forest at local level.
2. Implementation of proper protection measures to facilitate natural regeneration in the buffer zone.
3. Implementation of *In-situ* conservation technique especially plantation in gaps. Nursery technology be standardized for important species selected for plantation. The selection of species for re-vegetating degraded sites should be as follows-
    - Native species- To enhance biodiversity
    - Species attractive to frugivore- To encourage seed dispersal
    - Species forming mutualistic relationship with animals- To faster wildlife population.
    - Poorly dispersed species (heavy seeds)- To facilitate colonization
    - Fast growing species- To occupy site and to exclude weeds
    - Threatened species- To conserve such species

- Species tolerant of poor soil- To facilitate rehabilitation
- Nitrogen fixing species- To improve soil fertility
- Economically important species- To provide economic goods
- Fire tolerant species- To use in fire prone landscape.

4. Integration of traditional and formal science, and launch of integrated management approaches involving Government institutions, NGOs and rural indigenous community. This may lead to sustainable development.
5. The indigenous people be rewarded and credited by the Government for their unique knowledge on ethno-medicinal plants, for more effective 'Traditional Knowledge System'. This may encourage young generation to continue this tradition, which may lead to biodiversity conservation on sustained basis.

CHAPTER–6

CONCLUSIONS

On the basis of findings of present investigation it has been concluded that-

1. Anthropogenic activities altered botanical composition with respect to woody species, to a great extent. The overall dominance increased for certain species with increase in disturbance stress in buffer zone of the forest. Moreover, small gaps lead to greater opportunity for growth and survival of such species.
2. The dominant species and families in core zone no longer maintained their position in buffer zone (disturbed). The shift in position seems to be linked with the disturbance.
3. The tree species absent in buffer zone appear to be more vulnerable to disturbance.
4. A wide range of girth class (>180 cm) in core zone supported very high tree basal area. On contrary, girth-class restricted 120-150cm. This indicates felling of marure trees from buffer zone.
5. Log-normal dominance-distribution curve indicating the complex and stable community. Core zone showed more stability, andeven sharing of IVI among species.
6. For effective management, the local indigenous people be taken into confidence with regards to protection measures to be implemented and plantation work to be carried out.

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DEGREE	:	M.Phil.
DEPARTMENT	:	Environmental Science
TITLE OF DISSERTATION	:	Impact of anthropogenic disturbance on diversity and distribution of woody plants in Reiek forest, Mizoram.
DATE OF PAYMENT OF ADMISSION (Commencement of First Sem)	:	24/8/2017
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APPROVAL OF RESESARCH PROPOSAL

1. BOS	:	19/4/2018
2. SCHOOL BOARD	:	27/04/2018
REGISTRATION NO.& DATE	:	MZU/M.Phil./463 of 02.05.2018
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EXTENSION (IF ANY)	:	Yes, one semester (Till 31.07.2019)

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M.Sc	MZU	2017	I	76.1

ABSTRACT

Biodiversity refers to the variety of life on the earth, it is the measure of the number, variety and variability of living organisms, including all its elements, patterns and processes. Anthropogenic activities are the main reason for changes in biological communities worldwide, and these changes can harm biodiversity and ecosystem functions. Ecosystem function is vital for supporting plant and animal communities and guaranteeing the long term survival of human populations. The numerous causes of subsequent loss of biodiversity are known as drivers. Direct drivers explicitly influence ecosystem processes, while indirect drivers change the rate at which one or more of the direct drivers affects ecosystem processes. Some of the indirect human drivers are demographic, economic, sociopolitical, scientific and technological, and cultural and religious factors. Some of the direct human drivers are changes in local land use and land cover, species introductions or removals, external inputs, harvesting, air and water pollution, and climate change. The main factor impacting the loss of biodiversity as a whole can be population growth and over consumption. The major reason can be due to increasing human pressure which results the alteration of most natural habitats across the globe. In general, the vegetation is depleting rapidly because of unsustainable harvesting, lack of awareness, and unrestricted grazing by domestic animals from nearby villages, people depend significantly on forests for firewood, timber, non-timber forest products, fodder for domestic animals, and manure for crop fields leading to deforestation. Deforestation has caused shattering of large forest wedges and created extensive forest boundaries.

For detailed investigation, Reiek forest had been selected for plant community inventory and status of biodiversity (woody plants), and also to assess the impact of anthropogenic disturbances on diversity and distribution of such plants.

The Reiek forest is situated in Mamit district of the state of Mizoram, and is a remnant of climax vegetation lying in between longitude 92^037’ and 93^028’E and latitude 20^045’ and 22^046’N. Reiek village is about 25 km away from the state capital Aizawl towards the west after crossing Tlawng river. The area of Reiek forest is about 1000 ha. and surrounded by cliffs on all sides except the northern aspect. The east and west precipices meet at Reiek peak which is 1485 m asl (above sea level).

The forest had been protected and conserved by the descendants of Sailo Chiefs, particularly Mr. Lalluaia, since the 1890’s. There are reserved and community forests in the village which are protected by different NGO’s of the village such as the Young Mizo Association (YMA), the Mizo Upa Pawl (MUP), Mizo Hmeichhia Insuihkhawm Pawl (MHIP) and the Village Council. The periphery of the forest vegetation (buffer zone) is facing anthropogenic disturbances by the settlement surrounding the forest and vegetation is rather sparse. However, the core zone is still intact.

For vegetation analysis one ha area each of the core and buffer zones of Reiek forest were sampled. The standard methods were followed for field inventory and ecological analyses for various community characteristics.

The findings depict that a total of 89 woody plant species (belonging to 53 genera and 42 families) and 86 woody plant species (belonging to 70 genera and 37 families) were recorded from core and buffer zones, respectively. Greater number of genera in buffer zone could be attributed due to elimination of the sensitive ones and more inclusion of disturbance tolerant ones on the buffer zone. The species richness was greater in the buffer zone (13.81) and less in the core zone (13.01). The number of families decreased from core (42) to buffer (37) zones respectively. The Shannon diversity index was more in the core zone (4.37) than in the buffer zone (4.32), Pielou’s evenness index exhibited similar trend in the core (0.97) and buffer (0.97) zones respectively. Similarly, Simpson's dominance index did not show much differences in both the studied areas i.e., core (0.0128) and buffer (0.0126) zones, respectively.

The activities of humans accelerates the loss of species *Lithocarpus pachyphyllus*, the dominant species in the core zone was replaced by *Michelia champaca* in the buffer zone. Similarly, Euphorbiaceae (6 species), the dominant family in the core zone was replaced by Lauraceae (7 species) in the buffer zone. The shift in position of species and family may be due to change in micro-climate led by disturbance in buffer zone. The mono-specific families amounting to 25 and 19 in core and buffer zones, respectively. The various diversity indices did not show marked variation. The girth class distribution was extended >180 cm in core zone, however, it was restricted to girth class 120-150 cm in buffer zone. Moreover, lower girth classes harvest markedly high density. It indicates that anthropogenic disturbances adversely affecting vegetation of buffer zone, and same time gap is filled up with growth of shrubs.

The tree density, frequency and abundance decreased significantly from core to buffer zones a progressive reduction of tree density from the core zone to buffer zone in the present study comply with past studies in the tropical wet evergreen forest of Arunachal Pradesh, North East India which can be attributed to minor anthropogenic activities occurring in the buffer zone of the forest, these activities include cutting of trees for timber, collection of fuel wood and cattle grazing and also the extraction of trees of higher girth classes in the buffer zone .

On account of findings, it may be concluded that:

1. Anthropogenic activities altered botanical composition with respect to woody species, to a great extent. The overall dominance increased for certain species with increase in

disturbance stress in buffer zone of the forest. Moreover, small gaps lead to greater opportunity for growth and survival of such species.

2. The dominant species and families in core zone no longer maintained their position in buffer zone (disturbed). The shift in position seems to be linked with the disturbance.
3. The tree species absent in buffer zone appear to be more vulnerable to disturbance.
4. A wide range of girth class (>180 cm) in core zone supported very high tree basal area. On contrary, girth-class restricted 120-150cm. This indicates felling of mature trees from buffer zone.
5. Log-normal dominance-distribution curve indicating the complex and stable community. Core zone showed more stability, and even sharing of IVI among species.

The study recommends following strategies for conservation of biodiversity on sustained basis:

1. Launching of public awareness programme to ensure proper management of forest at local level.
2. Implementation of proper protection measures to facilitate natural regeneration in the buffer zone.
3. Implementation of *In-situ* conservation technique especially plantation in gaps. Nursery technology be standardized for important species selected for plantation. The selection of species for re-vegetating degraded sites should be as follows-
    - Native species- To enhance biodiversity
    - Species attractive to frugivore- To encourage seed dispersal
    - Species forming mutualistic relationship with animals- To faster wildlife population.
    - Poorly dispersed species (heavy seeds)- To facilitate colonization
    - Fast growing species- To occupy site and to exclude weeds

- Threatened species- To conserve such species
- Species tolerant of poor soil- To facilitate rehabilitation
- Nitrogen fixing species- To improve soil fertility
- Economically important species- To provide economic goods
- Fire tolerant species- To use in fire prone landscape.

4. Integration of traditional and formal science, and launch of integrated management approaches involving Government institutions, NGOs and rural indigenous community. This may lead to sustainable development.
5. The indigenous people be rewarded and credited by the Government for their unique knowledge on ethno-medicinal plants, for more effective 'Traditional Knowledge System'. This may encourage young generation to continue this tradition, which may lead to biodiversity conservation on sustained basis.

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