# PLANT SPECIES DIVERSITY AND COMMUNITY CHARACTERISTICS OF FOREST ECOSYSTEMS OF NAGALAND, NORTHEAST INDIA

**A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY**

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# PLANT SPECIES DIVERSITY AND COMMUNITY CHARACTERISTICS OF FOREST ECOSYSTEMS OF NAGALAND, NORTHEAST INDIA

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**CERTIFICATE**

This is to certify that the thesis entitled **"*Plant species diversity and community characteristics of forest ecosystems of Nagaland, Northeast India*"** submitted to Mizoram University, Aizawl for the award of the degree of Doctor of Philosophy by **Mr. Aosanen Ao (Regd. No.: MZU/Ph. D/1142 of 27.04.2018)**, research scholar in the Department of Forestry, is the record of original research work carried out by him under my supervision. He has been duly registered and the thesis presented is worthy of being considered for the award of the Ph.D. degree. This work has not been submitted elsewhere for any degree in any other Universities.

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## DECLARATION

I, Aosanen Ao, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to 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.

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Date: (AOSANEN AO)

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## ABBREVIATIONS

| | |
|---|---|
| AGB | Aboveground Biomass |
| BGB | Belowground Biomass |
| C | Carbon |
| CBD | Convention on Biological diversity |
| CDM | Clean Development Mechanism |
| CF | Community Forest |
| $Co_2$ | Carbon dioxide |
| D-D curve | Dominance-Diversity Curve |
| DI | Disturbance Index |
| DP | Distribution Pattern |
| FAO | Food and Agriculture Organization |
| FRA | Forest Resources Assessment |
| FSI | Forest Survey of India |
| GHG | Greenhouse Gases |
| IVI | Important Value Index |
| PF | Plantation Forest |
| RAD | Rank Abundance Distribution |
| RET | Rare Endangered Threatened |
| UNEP | United Nations Environment Programme |

## CHAPTER 1

## General introduction

### 1.1 Forest ecosystem and human interaction

Forest ecosystems are three dimensional ecological system dominated by variety of trees, shrubs and herbs, and soil micro-flora and fauna that coexist in dynamic interaction with soil, water and air within earth matrix of the landscape (Chapin, *et al.,* 2000; Roy *et al.,* 2004; Brockerhoff *et al*., 2017a). Forest plays a crucial role in controlling earth's climate and biodiversity (Mishra *et al.,* 2004; Gairola *et al.,* 2008; Mandal *et al.,* 2013) and constitutes an important natural resource to mankind in many ways (Rahman *et al.,* 2019). Forest ecosystems are among the most important terrestrial ecosystems, which are referred as 'the lungs' of the earth as they absorb enormous amount of carbon dioxide from the atmosphere and release oxygen during the process of photosynthesis (Bartholomeus and Calders, 2014). Among the variety of the forests on the Earth, the tropical and sub-tropical forest harbour maximum plant diversity (Shaheen *et al.,* 2015) and are the richest biological community (Baraloto *et al*., 2013) holding maximum proportion of global biodiversity (Myers *et al.,* 2000). These forest are highly diverse (Anitha *et al.,* 2010) due to interaction of various species and niche variation (Peralta *et al.,,* 2020) which results into a favourable climatic condition such as temperature and humidity that support different species on the earth (Sharma and Kant, 2014). Forests, particularly moist tropical forests, are the richest habitat of biodiversity accounting for nearly about 90 percent to world's terrestrial biodiversity, that provide many goods and services to the society (Brockerhoff *et al*., 2017a; Gibson *et al.,* 2011). Tropical forest across the globe provides many ecological services that are essential for well-being of different communities (Brandon, 2014) such as species conservation, water regulation, preservation of soil erosion (Mwakalukwa *et al.,* 2014), nutrient cycling, preserving habitats for floral and faunal community (Naidu *et al.,* 2016), maintaining habitat for pollinator and pest control species, protection of water bodies from pollution and erosion (Proesmans *et al.,* 2019) and provisioning for the income for the people (Angelsen *et al.,* 2014). During the course of evolution, the biodiversity originated in the variety of forests depending on their climatic characteristics.

Biodiversity has close interactions with the forest environment in which they occur (Tripathi *et al.*, 2016). In early time, when the humans were the components of the forest ecosystems the forests of the world were rich in biodiversity with close interrelations to their components. After the humans isolated from the forests and developed their own settlements and increased their reliance on the forests resources for their comfortable living, the forests of the world have started degrading. Forest degradation has led to the loss of species, decrease in soil nutrients and overall changes in forest characteristics and their ability to provide goods and services to the human societies (Tilman *et al.,* 2001; Norberg *et al.,* 2001; Roy *et al.,* 2004; Brockerhoff *et al*., 2017a). This has pose a serious threat to the human civilization and therefore proper understanding of the forest characteristics in terms of species composition, diversity and biomass potential, and the factors responsible for changes in forest attributes in relation to abiotic and anthropogenic factors would be of immense importance.

Global forest area in the pre-industrial era was ~5.9 billion hectares which has declined to about 4 billion hectares. According to Food and Agricultural Report (FAO) 2020, the rate of deforestation declined globally from 2015 to 2020. As per the report, the forest area was declining at an alarming rate of ~12 million hectares in the period 2010 – 2015 which was further reduced to ~10 million hectares in the period 2015 – 2020. However, deforestation remains a global thread and also a matter of deep concern to the people over the world (United Nations, 2015). The total area of forest cover in the country is ~79.4 million hectares, which is ~24 per cent of the total geographical area of the country that is mainly confined to the biodiversity hotspots regions (e.g. Western Himalaya, Western Ghats, Indo-Burma and Andaman and Nicobar Islands) of India. According to India State of Forest Report (2015), there is an increased in India's forest and tree cover by 5081 $km^2$ with a major increase occurred in tree plantations.

## 1.2 Conservation of biodiversity

The word "Biodiversity" was coined from the two words "biological diversity" for the first time by Water G. Rosen in 1985 (Sarkar, 2002). Biodiversity refers to the variability of life within a species, an ecosystem, a region and whole across the planet (Heywood and Watson, 1995). Biodiversity has always been one of the most important components of forests that provide number of goods and services for the well-being of the human societies. Since time immemorial, life on earth has faced several period of massive extinction, which is considered as natural phenomenon. However, the crisis of current extinction of species in both floral and faunal community is the direct result of various human activities (Barbault, 2013). According to Millenum Ecosystem Assessment (2005), biodiversity is the heterogeneity of all habitats and ecological complexes among living organisms. Biodiversity is the variety of all life on earth including micro-organisms such as bacteria, fungi, algae etc. that make up our natural world (Torquebiau, 2016; Mekonen *et al.*, 2017). Each species and organism in the ecosystem works together to keep the ecosystem in balance and to sustain life on the Earth (Cresswell and Murphy, 2016). Terrestrial biodiversity is usually found higher in the region near equator (Gaston, 2000) which is responsible for warm climate and higher primary productivity (Field *et al.*, 2009). Marine biodiversity is found higher usually along Western pacific coast where sea surface temperature (SST) is highest and also in the mid-altitudinal band in all oceans (Titensor *et al.*, 2010). Biodiversity is found to be higher particularly in tropical forest ecosystem which covers only about 10% of earth's surface that contributes 90% of world's total species (Butler, 2019; Borah *et al.*, 2021). Tropical forest ecosystem is one of the major components of world's biodiversity as these forests are the most biodiverse than any other ecosystem in the world (FAO and UNEP, 2020).

After the evolution of industrial era and technological advancements, there is a major impact on the biosphere witnessing a sudden acceleration of extinction on various species without precedent (Planavsky *et al.*, 2021). Habitat destruction and fragmentation of habitat are the main source of species extinction (Karsail *et al.*, 2020; Negret *et al.*, 2020), and habitat loss is one of the biggest threat to biodiversity even today which require measures to reduce loss of habitat in most effective way to conserve the environment (Hoegh-Guldberg and Bruno. 2010). The study of ecological interaction also known as species interaction is significant in studying the biodiversity (Schoener, 1990). Ecological interaction is a complex process that includes various interactions among organism, nutrient cycling, food web etc.

However, these interaction varies depending on the evolutionary context and environmental factors in which they occur (Gujube and Deme, 2020). Therefore, it is often difficult to establish ecological relations between individual organisms and whole ecosystem (Agrawal *et al.*, 2007; Ricklef *et al.*, 2008; Brokker *et al.*, 2009). Nevertheless, there are various stages of interaction among species that are found throughout in different habitat and ecosystem (Harrison and Cornell, 2008). When studying an ecological community, based on various classes of ecological interaction, it allows scientist to explain the natural occurring processes and helps in predicting how human alteration to the nature can affect our biodiversity and ecosystem processes (Lang and Benbow, 2013).

Forests of the world are under extreme pressure for collecting fuel wood, timber and many other utility products and as a result losing their biodiversity wealth. Another key factor that gives immense pressure to forest and loss of biodiversity is the expansion of agriculture as human population increases (FAO, 2020a). Biodiversity has been found critical in regulating the functioning of forest ecosystem and certain threshold level of biodiversity has been found important for the proper functioning of the forest ecosystem below which it may collapse (Onaindia *et al.*, 2013).

### 1.3 United Nations on world forestry

A primary forest is a forest which is regenerated naturally dominated by native tree species which is undisturbed and no visible indication of any human activities and the ecological processes are not significantly changed (FAO, 2018). According to FAO and United Nations Environment Program (UNEP, 2020) report on the state of world's forest, it is a home to world's terrestrial biodiversity. Forest provides habitat to different species and maintains ecological balance. It is a home to 75% bird species, 68% mammal species and 80% amphibian species. Around 60% of plant species across the globe is found in tropics. According to the report, the total forest cover is ~31% against global land area and primary forest covers one-third of the total forest cover. The report also states that more than half of the world's total forest is found only in five countries namely United States of America, China, Canada, Brazil and Russia. According to the key findings of FAO report (2020), the major factors for declining in forest cover globally is deforestation, fragmentation and forest degradation, leading to loss of ongoing biodiversity at an alarming rate. These report states that nearly ~400 million hectares of forest land area since 1980's has been destroyed due to conversion of forest land to other land use system, though the deforestation rate has decreased in the past three decades. Over ~90 million hectares of forest cover has also adversely affected by natural calamities such as forest fire, droughts, frost and other weather events. Worldwide, there are five major climatic domain namely Tropical and subtropical, boreal, temperate and polar (FAO, 2012a) tropical forest constitutes the largest cover with 45% followed by 27% in boreal, 16% in temperate and nearly around 11% in the subtropical region (Buchhorn *et al.*, 2019).

According to data of Forest Resources Assessment (FRA 2020) report, the world has lost over 200 million hectares of forest land since 1990 which is almost equal to the size of Libya, North Africa. The report also states that the net forest loss from 1990-2000 is 7.8 million hectares per year which decline to 5 million hectares per year in 2000 – 2010 which further decline to 4.5 million hectares per year from 2010 – 2020. The report further states that the rate of decline in forest reduction since 1990 is due to decrease in deforestation in some countries and increase of forest areas in developing countries due to sustainable approach for forest conservation and more extension of forest area naturally due to less human activities. Due to uncontrolled deforestation, over 420 million hectares of forest cover has been destroyed prior to 1990. However, in the past five years (2015 – 2020), the annual rate of net forest loss due to deforestation has decreased from 12 million hectares (2010 – 2015) to 10 million hectares. The objectives of the Convention on Biological diversity (CBD) adopted in 1992 for conserving biodiversity was restructured and came up with a strategic plan for biodiversity conservation 2011 – 2020 (CBD, 2010) helped in reducing the rate of deforestation and rate of forest loss declined substantially (FRA, 2020).

### 1.4 Aboveground biomass and carbon stocks

Since the beginning of the industrial revolution, human activities became the primary source of increasing the emissions of greenhouse gases (GHG) at an alarming rate adding ~45% more carbon dioxide in the atmospheric which has increased the concentration from 280 ppm in pre-industrial age to over 420 ppm augmenting to 60% of total global warming (Shakun *et al.,* 2012). As per the United Nations Framework Conventions on Climate Change (1997), the carbon sequestration through biomass estimation on forest can be used as an appropriate approach for mitigating elevated concentrations of atmospheric $CO_2$. The quantity of biomass can determine the amount of carbon that is added to atmosphere or sequestered on the land when forests are managed for meeting emission targets (Gairola *et al.,* 2011). There is a constant exchange in carbon dioxide between the atmosphere, oceans bodies and other terrestrial ecosystems. Vegetation and soil has the potential to accumulate carbon, thereby reducing the rate of $CO_2$ formed in the atmosphere which is one of the main causes for climate change (Joshi *et al.*, 2013). Excessive deforestation and fragmentation of natural forest adversely affects the vegetation composition, stand structure and regeneration of species which ultimately affects the carbon sequestration process and depletion of forest carbon stock (Yousefpour *et al.,* 2015; Haddad *et al.,* 2015). Anthropogenic disturbances also causes alteration in forest structure resulting to ecological imbalance leading to reduction of potential carbon stocks in the forest (Swanson *et al.*, 2011). Studies have also shown that the rate of carbon sequestration process in the forest can be enhanced by adopting various sustainable forest management practices and plantation programs (Nelson *et al.,* 2016).

Studies suggest that natural forest ecosystem is very vital to forest health and management (Brockerhoff *et al.,* 2017b). The interaction of tree species to biotic and abiotic factors in a natural forest can be a primary resource use strategy (Joshi and Dhyani, 2018) and reduction of tree diversity may result in declining of biomass and carbon stock in a forest (Watanabe and Ortega, 2011). Good regeneration and diverse tree species composition in a primary forest contributes the highest amount of carbon sequestration and carbon stocks accumulated in tree biomass (Vallet and Perot, 2011; Nel and Hill, 2013). Tree species with higher girth class also helps in maintaining the forest structure and its ecological functions and act as major contributor in preserving the carbon stocks in the forest (Gandhi and Sundarapandian, 2017). According to FRA (2020), the total growing tock of trees decreased from over 560 billion $m^3$

(1990) to 550 billion $m^3$ (2020) due to various human activities that led to net decrease in primary forest. Deforestation and degradation are one of the major factors to forest loss, leading to accumulation of $CO_2$ in the atmosphere (Gogoi *et al.*, 2017). Recent studies on GHG emission shows that excessive deforestation and forest degradation accounts to 12% to over 17% for global green house gas emission (Pachauri and Reisinger, 2007; Van der *et al.*, 2010).

According to the key findings of global forest assessment report 2020 submitted to FAO, out of 4 billion hectares of world forest, ~60% of the forest are recovering from the past human disturbances that led to decline in forest area and over 3% of the world's natural forest are affected annually due to various anthropogenic factors, natural calamities and vice versa. Since early 1990's the world growing stock per unit area increased from 132 $m^3$/ha to 137 $m^3$/ha till 2020 (FAO, 2020). The total world forest living biomass (above- and below ground) contain about 606 gigatonnes and 59 gigatonnes in deadwood (Reichstein and Carvalhais, 2019). Nearly 44% of forest carbon is found in living biomass, 45% in soil organic matter and the rest carbon is stored in deadwood and forest litters (Justin *et al.*, 2015; Vavilala *et al.*, 2019).

High tree diversity and density in natural forest leads to increase in tree carbon stocks, enhancing carbon sequestration which helps in regulating forest ecosystem services (Yanusa *et al.*, 2015). Tropical forest in particular are the most diverse forest across the globe with high productive ecosystem covering over 6% of world's land surface area and are also considered as the largest repository for above ground biomass carbon (Pan *et. al,* 2013). Assessment of tree biomass, carbon stocks and sink potential in different forest types will play a crucial role in providing information for climate change mitigation and develop strategies for sustainable management of forest (Robiansyah, 2019).

### 1.5 Geography of Northeast India

India is recognized as one of the 17 mega diverse countries in the world, rich in biodiversity which accounts for four biodiversity hotspots in the world viz. the Western Himalayas, the Eastern Himalayas, the Indo-Burma region and the Western Ghats (Singha *et al.*, 2010). The total geographical area of India is ~329 million hectares and coastline of over 7500 km (Arisdason and Lakshminarasimhan, 2020). The country's ecological diversity is enormous ranging from hot climatic condition in the Northwest to cold in Trans-Himalayan region, tropical to subtropical forest in the Northeast region and Western Ghats and mangrove forest in Sunderbans (Sharma and Singh, 2000). There are 16 major forest types in India recognized by Champion and Seth (1968), constituting a forest cover of about 21.05% of total geographical area of the country (FSI, 2011). Due to unique ecosystem and rich biodiversity, about 28% of plants recorded in India are endemic, and also harbours over 47,000 plant species representing about 11.4% of world's total flora (Singh and Dash, 2014).

Northeast India consisting of seven states namely Assam, Manipur, Meghalaya, Nagaland, Sikkim, Mizoram, Tripura and Arunachal Pradesh is a land of undulating hills and plains with a variety of exotic rare flora and fauna. It is also popularly known as the Seven Sisters States or Land of the Seven Sisters. It is the eastern most region of the country connected to East India via a narrow squeezed between Nepal and Bangladesh, which shares one of the 36 biodiversity hotspots of the world. Physiographically, whole Northeast region can be categorized into the Eastern Himalayan region, Patkai mountain range, the Brahmaputra and the Barak valley (Singh *et al.,* 2013). Most part of Northeast India has a predominantly tropical type of climate with hot summers, heavy monsoons and mild winters (Dikshit and Dikshit, 2014a). Northeast India has some of the few remaining rainforest in the country that accounts to major part of the forest cover with diverse flora and fauna (Shankar and Tripathi, 2017). The third world's highest peak Kangchenjunga rising to an elevation of 8586 meter lies between Sikkim and Nepal. The whole of Northeast region receives the highest rainfall with an average annual precipitation of 2000 mm (Singh, 2020) and Cherrapunji (11,777 mm) and Mawsynram (11,871 mm) located in East Khasi hills, Meghalaya is the rainiest place in the world (Dikshit and Dikshit, 2014a; Murata *et al.,* 2020). The agriculture practice in the Northeast region can be broadly categorized into two types (i) settled cultivation practice in foothills, plains, valleys and terraces (ii) Shifting/Jhum cultivation in hills except in Sikkim state where settled cultivation is widely practiced on terraces (Das *et al.,* 2009).

Out of 68 million hectares of forest area in India, Northeast region accounts for over 16 million hectares which is roughly about one-fourth of the total forest area of the country (Dikshit and Dikshit, 2014b). The forest of Northeast region is known for its biodiversity richness accounts to two biodiversity hotspots namely the Himalayas and the Indo-Burma, out of four biodiversity hotspot in India (Tripathi *et al.*, 2016). According to the Indian Red Data Book published by the Botanical Survey of India (Chatterjee *et al.*, 2006), 10% of the flowering plants in the country are considered as endangered and out of 1500 endangered floral species, 800 were reported from Northeast India. Northeast region is known for its biodiversity richness which accounts to two biodiversity hotspots namely the Himalayas and the Indo-Burma region out of the four biodiversity hotspot in India (Tripathi *et al.*, 2016). The Northeast India is also popularly known for its profusion of orchids where 870 orchid species has been recorded from the region which constitutes 73% of total orchid found in India (De, 2020). About 34 orchid species recorded from the Northeast region are listed as threatened species in India (Ahmedullah and Nayar, 1990). Apart from its rich floristic diversity, Northeast India is also rich in ethnic diversity where the tribal population has enormous knowledge to use the natural resources from forest to sustain their livelihood (Deb *et al.*, 2008). Over 200 tribes from different ethnic groups with distinct cultures and traditions live in the region that depends on forest goods and services with agriculture as their main occupation (Singh, 2015). But due to population expansion and various human activities, the forest is facing an immense pressure leading to extinction of many species and degradation of natural forest (Giriraj *et al.*, 2008). Over exploitation of forest and uncontrolled deforestation has caused a severe damage to ecosystem leading to loss of habitats and changing pattern of vegetation (Samant *et al.*, 2000).

### 1.6 Forest of Nagaland

Nagaland is one of the frontier states of the Indian union and it is the eastern most among seven north eastern states commonly referred to as seven sisters. Nagaland became the $16^{th}$ state of Indian union on $1^{st}$ December 1963 with capital as Kohima. It is flanked by Assam state in the west, Myanmar in the east, Manipur in south and Arunachal Pradesh and Assam in the north. Nagaland like many other tribal regions in the north eastern India forms a region of high forest cover, high biodiversity and human ethnic diversity; it lies between $25^{\circ}10'$ N and $27^{\circ}4'$ N latitude and between $93^{\circ}15'$ E and $95^{\circ}20'$ E longitudes covering an area of 16,579 $km^2$ in northern extension of Arakan Yoma Ranges and it is the one of the smallest states of India. Almost the whole state is hilly except areas along the foothills flanking the Assam plains. The forest vegetation consists of mainly tropical forest, subtropical forest and temperate forest. The biodiversity of the state is essentially due to its unique geographic location where the altitude varies from 190 m in the plains to over 3000 m above sea level in the high hills. In Nagaland, more than 50% of land is under forest cover, however due to the community ownership only 11.7% of the forests are under control of Government and 5.5% under protection forest (FSI, 2011).

Nagaland enjoys a typical monsoon climate. The year can be divided into four seasons viz., winter (December – February), pre-monsoon (March – April), monsoon (May – September) and retreating monsoon (October – November). Nagaland experience heavy rainfall and the annual rainfall vary from 100 cm – 300 cm. In summer months, the weather is pleasant in the hills whereas in plains the temperature varies from 25°C – 34°C. In winters, the night temperature comes down to an average of 3°C. Nagaland is a young mountainous hilly state and the Naga Hills of Nagaland comprises of three range system (i) Patkai (the highest range) (ii) Barial (the mid-range) (iii) Disang (the lowest range). The two highest peaks of Nagaland are Mt. Saramati (3848 m) in the Patkai range and Japfu (3014 m) in the Barial range on the extreme east of the Indo-Burma boundary. Throughout winter Mt. Saramati peak remains snow capped and gradually melts down and flows into Likimro River. The five major river systems in the state are Dhansari, Barak, Dikhu, Doyang and Tizu. Tizu is the longest river in Nagaland that flows from Tuensang district to rest of the eastern part in the state.

In Nagaland, forest is the principle source of livelihood. Since time immemorial, tribals were mainly dependent on forest for food, shelter and medicine. The entire population of the state belongs to 16 major tribes, located in different segments and the land and the forest are traditionally owned by the village community, clans, phratry and individuals. The village community jhum/cultivable fallow forest covers the largest part of forest land in a village as well as in the state. Each year a part of this land is devoted for jhum cultivation. These areas mostly possess the secondary forest. There are also some community reserve forests which are maintained and preserved by the community. These forests are usually of climax type with rich biodiversity having no human interference.

During the past years, the pristine forest of Nagaland is facing an extreme anthropogenic pressures and human population expansion, the rich floral diversity of the state is being affected leading to destruction of habitat and fragmentation. In the recent years, forest fire has also taken its toll in destroying the natural forest which results to rapid depletion of rich flora in the state. The populations of several species are facing threat of survival in their natural habitats, while few are already on the verge of extinction (Mao *et al.,* 2009; Mao and Gogoi, 2010). The degradation of natural forest in the state has reached an alarming stage and it would be worst if conservation measures are not undertaken. Keeping in view of the state’s rich biodiversity, it is very important to conduct a detailed study on its floristic composition with complete inventory of all the plant wealth and document the entire species consisting of trees, herbs and shrubs covering the whole state before we loose many of these species during the course of development.

### 1.7 Scope of the study

Forest biodiversity is important for providing productive, protective and regulative functions and significantly affecting the human well-being on the planet. Tropical moist forests harbours rich biodiversity resource and play an important role in global carbon cycling. Biodiversity of these forests are facing tremendous pressure due to dense population, poverty, over exploitation due to reliance of many tribal communities on forest resources for their survival. Biodiversity study has been available for some small segments of the forest but complete biodiversity study of the Nagaland is lacking. Since the biodiversity loss is continuing so it is assumed that the many species may be getting lost before it is known for the region. Therefore, this study will be a complete of its kind taking into account the forest biodiversity of Nagaland.

## 1.8 Objectives

The present study proposes to achieve the following major objectives:

1. To determine plant species composition, diversity and community characteristics of forests of Nagaland.
2. To assess tree population structure, regeneration potential and deforestation status of different forest communities of Nagaland.
3. To calculate tree biomass and carbon stock of different forest communities of Nagaland.

**CHAPTER 2**

# Review of literature

## 2.1 Species composition, diversity and community characteristics

India is one of 17 mega biodiversity nations. The total geographical area of the country is about 2.4% of the world's total landmass, which harbours 47,513 plant species representing as much as 11.4% of world flora, 7.5% of world fauna and about which 28% of floral diversity that occur in the country are endemic (Singh and Dash, 2014; Venkataraman and Sivaperuman, 2018). The country consists of 4 biodiversity hotspots, namely Eastern Himalayas, Western Ghats, Northeast India (Indo-Burma) and Andaman and Nicobar Island (Sundaland) harboring rich vegetation, both in number as well as species density and diversity (Arisdason and Lakshminarasimhan, 2017; Cunningham and Beazley, 2018). Since the beginning of industrial revolution, human civilization has impacted biodiversity and environment in many crucial ways. Activities such as urbanization, fuel wood collection, meat production, oil industry, mining, transport, irrigation, fishing, logging and land clearing by humans to meet the demands of forest products and land for agriculture has ranked the major anthropogenic activities affecting sustainable forest management (Mittermeier *et al.*, 2011; Dagba *et al.*, 2017).

Sustainable management of natural forests is not possible without an understanding of how such forests actually work ecologically, economically, socio-culturally and interact with humans (Adekola *et al.*, 2015; Reddy *et al.*, 2020). Management of forest sustainably means optimizing their benefits such as fuelwood, timber extraction and food security to meet basic human needs in a way that it conserves the biodiversity and forest ecosystem for present and future generations (Kalkidan *et al.*, 2017). Biological resources serve about 40 per cent of the world's economy and nearly, 80 per cent of the needs of the people (Singh *et al.*, 2015). Several studies cites that the most severe threats to biodiversity and its ecosystem are forest degradation and fragmentation, dissemination of invasive species, excessive use of natural resources, climate change, pollution in aquatic and marine ecosystems due to various scientific test (Appannagari, 2017). The study of population ecology is fundamental for conservation management and one practical approach to assess the impact of exploitation is to predict future population size based on current population structure, growth and fecundity (Snider, and Brimlow, 2013; Courchamp *et al.,* 2015). Therefore, demographic studies are essential to simulate species dynamics over time (Wood and Gross, 2008; Barupal *et al.,* 2019).

In the recent years, quantitative floristic inventories and species diversity has been assessed to illustrate the forest vegetation, to understand the ecosystem dynamics and biodiversity conservation through sustainable ways (Pappoe *et al.,* 2010; Jayakumar *et al.,* 2011; Devi *et al.,* 2014). Forest inventory data is the primary source of information for forest management (Kohl and Marchetti, 2014). Forest inventories are estimated to provide information on species composition and distribution of plant community and forest resources, species diversity patterns and the relationship between the species, thus helps in enabling management decisions for biodiversity conservation at state level strategies (Krug and Santos, 2004; Gairola *et al.,* 2008; Ahmed *et al.,* 2010; Shaheen *et al.,* 2015; Alekseev *et al.,* 2019). Phytosociological attributes of plant communities in a forest reflects the species richness, diversity, dominance, spatial pattern and abundance of species (Ruschel *et al.,* 2007; Sahu *et al.,* 2008). Tree diversity is a basic aspect of forest ecosystem diversity (Tchouto *et al.* 2006) as it provides habitat and resources to all the other life forms in the forest (Rennolds and Laumonier, 2000; Addo-Fordjur *et al.,* 2009). Trees are fundamental to tropical forest biodiversity (Evariste *et al.,* 2010) and they inhabit the maximum tree diversity in the world (Naidu *et al.,* 2018). Tree diversity in a forest influences floristic diversity, climate, stand structure and geomorphology (Naidu and Kumar, 2016). Assessment of stand structure in any forest helps in understanding the forest ecosystem and also acts as a key element of stand biodiversity (Ozcelik, 2009). The rapid inventory of tree species which provide information of floristic diversity in a forest will serve as an important tool on conserving biodiversity resulted from deforestation and degradation (Mohandass and Davidar, 2009; Baraloto *et al.,* 2013).

Diversity of a plant community can be assessed by a variety of nonparametric measures such as Shannon diversity, Simpson dominance, Sorenson similarity, Menhinick and Margalef species richness, Pielou evenness indices, and these measures have gained approval among various researchers in studying the biodiversity richness in the recent past years (Tadesse *et al.,* 2017; Heip *et al.,* 1998). The most commonly and widely accepted tool for measuring diversity in a forest is Shannon and Weiner index (1963) which is also popularly known as Shannon diversity index. The key element of a diversity index is to estimate quantitative biological variability which can be later used to compare biological entities such as gene pools, species composition, habitats, landscapes etc. (Chiarucci and Bonini, 2005). The Simpson index (1949) also known as Simpson dominance index is widely used to determine the species dominance in a community as Shannon diversity index increases, the Simpson index decreases (Magurran, 1988). The Sorenson similarity index is used as an accepted tool to estimate the similarity between habitat or community based on species composition (Tripathi, 2013). The species richness was determined by following Menhinick index (1964). The assessment of species richness in a community provides an instantaneous expression of diversity (Magurran, 1988). Greater the number of species entered, higher the value of index (Ludwig and Reynolds, 1988; Moreno, 2001). Pielou index (1966) is the most commonly used for measurement of species evenness and it is significant to classify the pattern of species distribution in the given community. The value of this index ranges from 0 - 1 and obtain of value 1 shows complete evenness of species or the species are equally abundant (Moreno, 2001).

For several decades, a significant number of studies have been carried all over the world on various aspects of biodiversity. Tropical forest harbours the maximum biological communities on earth (Myers *et al.,* 2000; Silvertown, 2004) and these forest harbours more than half of the world’s species (Givnish, 1999; Singh and Kushwaha; 2005). Several researchers such as Swamy *et al.,* (2000); Eshaghi *et al.,* (2009); Ravenbakhsh *et al.,* (2015); Singh, (2015); Mehrvarz *et al.,*(2016); Borah *et al.,*(2021) investigated and studied the floristic composition and species diversity of different forest types revealing the existence of high species diversity in these forest and how anthropogenic activities are posing as a thread to biodiversity. Naidu and Kumar (2016) assessed the tree diversity and community composition of tropical forest in Eastern Ghats, Andhra Pradesh, India where it stated that floristic diversity of these forests is adversely affected by anthropogenic and mining activities. Sharma and Kant (2014) investigated the floristic composition and diversity of woody species in subtropical forest of Kandi Siwaliks, Jammu and Kashmir, India where the study revealed that forest degradation and fragmentation significantly leads to reduction of species richness in the forest, habitat loss, and isolation of smaller patches in the forested areas and affect ecosystem health and resilience. Various researchers such as Nath *et al.,* (2005); Thakur and Khare (2006); Kumar and Bhat (2006) and Tadesse *et al.,* (2017) conducted a detailed study on floristic composition and plant community analysis in different tropical forest over the world and exposed different intensities of disturbances to these forest.

Tripathi and Tripathi (2010) recorded a total of 157 species in a one hectare plot from subtropical forest of Meghalaya Northeast India. Similar study on species composition and diversity was conducted by Giliba *et al.,* (2011) in Miomba Woodland of Bereku Forest reserve, Tanzania where it recorded 110 species. Iqbal *et al.,* (2012) quantified the floristic diversity and species distribution of Montane forest of Western Ghats, India with special emphasis on RET (endangered and threatened) species. Out of 286 species recorded, 88 species were recorded as RET species in these forest. Tadesse *et al.,* (2017) estimated a detailed analysis of floristic composition and stand structure in West Shewa zone of Oromia region, Central Ethiopia where it recorded 214 species. Dutta and Devi (2013) compared the floristic richness and species distribution pattern of two reserve forest of Assam, India namely Hojai Reserve Forest and Kumorakata reserve forest where it concluded that tree diversity in these forest is adversely affected due to illegal felling for timbers and over exploitation of forest resources leading to species specific changes in the forest structure and can alter the species composition of the forest. Saurav and Das (2014) investigated plant species richness and phytosociological attributes in the temperate zone of Himalaya, India where the study revealed that the characteristics of the vegetation were heterogeneous in nature. The study concluded that the species with higher dominance determines and may alter the community structure in the forest. Similar study was also conducted in the tropical forest of El Ain Reserve forest, North Kordofon, Sudan by Bokhary and El Awad (2015) where the study recorded less tree diversity and higher herbs diversity due to less canopy cover giving an opportunity for undergrowth vegetation to access the direct sunlight leading to dominance of herb species.

Species richness is the total number of species present in the forest or community (Boulanger *et al.,* 2017). Recent past years, several researchers have determined species diversity and forest composition in different forest all over the world. Zhu *et al.,* (2015) recorded 1,657 species from the three altitudinal zones (<1,100 m; 1,100 – 1600 m; >1600 m) in a tropical mountain nature reserve, South west China. Dar and Sundarapandian (2016) studied the plant biodiversity pattern and species distribution in seven temperate forest types of Western Himalaya, India where it recorded a total of 177 plant species. The study revealed that trees and shrub communities were homogenously distributed whereas herbs showed heterogeneous distribution pattern. Wanjohi *et al.,* (2017) recorded 285 species in the tropical forest of Nakboi Reserve forest, Kenya exposing how human activities affect the species composition and diversity pattern in a forest. Similar floristic composition and species diversity of tropical forest has been studied by various researchers in India such as tropical wet evergreen forest of Western Ghats (Giriraj *et al.,* 2008), tropical forest in Eastern Ghats, Andhra Pradesh (Sahu *et al.,* 2012; Naidu and Kumar, 2016; Premavani *et al.,* 2017); tropical forest of Kedarnath Wildlife Sanctuary, Western Himalaya (Malik and Bhatt, 2015); subtropical forest of Kandi Siwaliks, Jammu and Kashmir (Sharma and Kant, 2014); subtropical wet evergreen forest of Meghalaya, Northeast India (Lynser and Tiwari, 2015); Hollongapar Gibbon Wildlife Sanctuary, Assam (Sarkar and Devi, 2014) respectively.

## 2.2 Population structure and regeneration status

The study of population structure in a forest and its natural regeneration pattern is inter-connected to each other (Devancy *et al.,* 2014). A forest population structure with high diversity of seedling, sapling and young trees indicates a good successful regeneration of species in the community (Sarkar and Devi, 2014; Saha *et al.,* 2016; Malik and Bhatt, 2016) while complete absence or low diversity of seedling or sapling of tree species in a forest ecosystem indicates a poor regeneration (Rahman *et al.,* 2011; Khalik *et al.,* 2013, Ao *et al.,* 2020). Hence the natural regeneration of a primary forest depends largely on the population structure of tree species characterized by production of seeds, establishment of seedling and sapling in the forest vicinity.

The study of population structure of tree species is an important tool to determine the mortality and natality rate of species in a natural forest (Jensen and Meilby, 2012; Neumann *et al.,* 2017). Population structure of trees in a forest are expressed interms of number of individuals present in a definite girth class distribution (10 – 30 cm, 30 – 60 cm, 60 – 90 cm, 90 – 120 cm, 120 – 150 cm) (Khumbongmayum *et al.,* 2006; Sarkar and Devi, 2014; Sen, 2018; Subba *et al.*, 2020). Assessment of population structure for woody species such as girth and density of individuals and stand distribution patterns are necessary for interpretation of forest structure in a community (Sahoo *et al.,* 2017). The population studies in forest ecosystems have been used to infer past changes (Agarwala *et al.,* 2016; Brockerhoff *et al.,* 2017b) and predict future changes in species composition and community structure by examining the size class distribution of woody species (Chaturvedi and Raghubanshi, 2014; Mehrvarz *et al.,* 2016). According to Saxena and Singh (1984) regeneration potential of tree species in a primary forest can be determined by the population structure patterns in the forest ecosystems. A satisfactory natural regeneration in a primary forest largely depends on the germination capacity of the seed and establishment of young trees in the forest (Griscom and Ashton, 2011; Sahu *et al.,* 2012). According to Odum (1971), the ratio of different age groups in a plant community determines the reproduction status and regeneration potential of the population and predicts the future course. Several studies reveal that, the past record of a particular species and its disturbances can be determined by the information on population structure of that species that can be further used to estimate the future trend of population of those species (Demel, 1997; Tella *et al.,* 2013). Generally, based on stand population structure, a natural forest can be broadly classified into frequently and infrequently reproducing forest (Knight, 1975a; Singh, 2017). Those forest with large number of individuals in lower girth class was expressed as frequently reproducing forest (Queenborough *et al.,* 2007; Vacchiano *et al.,* 2018) while those natural forest with minimum number of individuals in lower girth class and maximum in mid-girth class were termed as infrequently reproducing forest (Knight, 1975b; Dhar *et al.,* 1997; Pommerening, 2007). Hence, the existence of a species in a plant community largely depends on the regeneration of the young trees and establishment of seedlings and saplings.

Various workers have studied the population structure and regeneration status of woody species in different forest ecosystem all over the world. Yahya *et al.,* (2019) conducted a detailed survey on population structure and regeneration potential of tree species in one of the few remaining dry Afromontane forest located in central highlands of Ethiopia. Toyama *et al.,* (2015) studied the effect of illegal logging and clear felling for agriculture on primary evergreen lowland forest and deciduous forest of Kampong Thom, Cambodia and how it alters the community structure in a forest ecosystem. Similar study was also conducted by Nur *et al.,* (2016) where it highlights the threat of overexploitation and illegal cutting of trees and how it impacts the natural regeneration process of woody species of Shitalpur forest under Chittagong North Forest Division of Bangladesh. Nazib *et al.,* (2012) assessed the forest stand structure of Pahang National Park, Malaysia where the stem density was recorded highest in small diameter class indicating that stands are developing and natural regeneration of tree species is booming in the forest. Saha *et al.,* (2016) studied the community structure of temperate forest of Dhanaulti, Garhwal Himalaya with an aim to understand how an altitude influences the stand structure and regeneration pattern in a community. Maua *et al.,* (2020) conducted a study on tropical forest of South Nandi, Kenya to investigate the population structure and regeneration status of trees where the study showed a inverse-*J* shaped curve in DBH (diameter breast height) distribution pattern indicating that the woody species have good regeneration and that it's a healthy forest. Subashree *et al.,* (2020) also conduct a detailed survey on stand structure and regeneration potential in tropical forest around Kanyakumari Wildlife Sanctuary, Western Ghats India where the study showed a reverse-*J* shaped curve in the diameter class wise distribution and the dominant species from the study site showed fair to good regeneration potential.

In recent years, several authors have estimated the regeneration status of woody species based on various age, diameter and height classes (Cao *et al.,* 1996; Gunatilleke *et al.,* 2001; Shankar, 2001; Bhuyan *et al.,* 2003; Brearley *et al.,* 2004; Zaman *et al.,* 2011; Lynser and Tiwari, 2015; Kumar *et al.,* 2016; Endris et al., 2017; Maua *et al.,* 2020). Various studies on community structure of woody species and its association with regeneration potential in the forest ecosystem has been carried out in different forest types of India such as in Garhwal (Baduni and Sharma, 2001;

Bhandari, 2003; Pokhriyal *et al.,* 2010; Chauhan *et al.,* 2014; Singh *et al.,* 2015; Singh *et al.,* 2016; Sharma *et al.,* 2018), Central Himalaya (Rana *et al.,* 2015; Verma *et al.,* 2019), Eastern Himalaya (Bhuyan *et al.,* 2003; Rawat *et al.,* 2018), Western Himalayas (Pande *et al.,* 2002; Gairola *et al.,* 2014; Malik and Bhatt, 2016; Tiwari *et al.,* 2018), Northwestern Himalayas (Pant and Samant, 2012) Western Ghats (Swamy *et al.,* 2000; Parthasarathy, 2001; Subashree *et al.,* 2020), Eastern Ghats (Naidu and Kumar, 2016; Sundarapandian and Gandhi, 2020), Central India (Raj, 2018; Dash *et al.,* 2020); Northern part of India (Sood and Monik, 1991; Bargali *et al.,* 2013; Ganesan *et al.,* 2014; Pande *et al.,* 2014), Northwest (Kapoor *et al.,* 2020), Eastern region of India (Pradhan *et al.,* 2018; Sen, 2018; Kumar and Saikia, 2020), South India (George *et al.,* 2019) and Northeastern region of India (Bharali *et al.,* 2012; Dutta and Devi, 2013; Sarkar and Devi, 2014; Paul *et al.,* 2019; Iralu *et al.,* 2019; Ao *et al.,* 2020).

Detailed analysis of species composition, population structure and regeneration status of a primary forests are necessary as they form the basis for future plans to protect, manage and restore these vanishing natural resources. According to Brilliant *et al.,* 2012, in order to sustainably manage and conserve the native flora and fauna of the tropical forests in the region following objective should be carried out and studied such as assessment of forest inventory and description of the plant community and species richness of the tropical forest ecosystems; understanding the regeneration potential of the tree species; to study the patterns of secondary succession. Estimation of woody species in a natural forest is the major component for the formation of forest communities (Sundarapandian and Gandhi, 2020; Bhat *et al.,* 2020) as trees in a forest ecosystem influences floristic diversity, climate, stand structure and geomorphology (Naidu and Kumar, 2016; Dash *et al.,* 2020). The structure of forest in a community involves competition and interactions among the tree species as well as other environmental factors (Gadow *et al.,* 2012; Bano *et al.,* 2018). Micro-environmental factors which vary with seasonal changes also influences the species growth in various stages such as seedling, sapling and young trees of the plant communities that maintains the population structure of any given forest (Rahman, 2019; Quesada and Kuuluvainen, 2020). However due to increase in human population, many woody species in both natural and controlled forest are being destroyed at an alarming rate (Khumbongmayum *et al.,* 2006; Solefack *et al.,* 2018; Kaur *et al.,* 2020). Anthropogenic factors such as agricultural land expansion, overgrazing, illegal felling, extraction of wood for timber, fuelwood and other construction materials which lead to forest degradation and fragmentation in the country (Jhariya and Yadav, 2016; Borah *et al.,* 2016; Saikia and Khan, 2017). As a result, due to forest ecosystem loss, many biodiversity resources and their natural habitats are rapidly disappearing in the country (Napit, 2015; Bhat and Bankoti, 2015; Ao *et al.,* 2020). Therefore continuous assessment of plant diversity, stand structure and regeneration status in a forest ecosystem are very essential to provide a baseline information on forest ecology (Jayakumar and Nair, 2013; Amjad *et al.,* 2014; Gao *et al.,* 2017). Understanding the plant diversity pattern, distribution and structure of the forest also helps in identifying ecologically and economically important plant species (Naori *et al.,* 2015; Myo *et al.,* 2016; Mestre *et al.,* 2017). Thus the resent study was conducted with an aim to provide quantative information on plant species diversity, population structure and regeneration dynamics of woody species of different forest ecosystems of Nagaland, also to document the floral resources of the state so as to serve as a baseline information in carrying out further research programs on vegetation analysis of state forest and to implement sustainable management of the forest.

### 2.3 Tree biomass estimation and Carbon stock

As climate change is one of the most significant and insidious threats to biodiversity and ecosystem, where Green House Gases (GHG) have substantially increased, land conversions to agriculture and poor land management practices are the major contributors to the sharp increase in GHGs (IPCC, 2001). However the role of tree based system in the global carbon balance is widely recognized and determination of carbon sequestration through biomass estimation can be used for mitigating elevated concentrations of atmospheric $CO_2$ (Brown *et al.,* 1989). The aboveground biomass can be a major aspect for the study of carbon stocks, carbon storage potential and also carbon balance in the atmosphere (Ryan *et al.,* 2010).

One of the most significant ecological services provided by the forest is its dynamic role in carbon cycle (Saha and Bera, 2020) since the forest stores a large amount of carbon in the biomass, plant litters and soil (Slik *et al.,* 2013). According to Rodger (1993), it is estimated that around 86% of terrestrial biomass and over 70% of soil carbon is stored in a natural forest. In contrast, Vashum and Jayakumar (2012) also stated that natural forest can be a source as well as sink of carbon. Some studies suggest that plantation forest can also be an option for management of degraded ecosystem as it can help in increasing the biomass and carbon polls of the forest and restore biodiversity (Huston and Marland, 2003; Brockerhoff *et al.,* 2008). Many workers have demonstrated the scope of plantation forest and its ability to sequester a significant amount of atmospheric carbon (Ahirwal and Maiti, 2017; Singh *et al.,* 2018) and provide CDM (Clean Development Mechanism) on carbon market opportunities (Glamsrod *et al.,* 2011). N'Gbala *et al.,* (2017) estimated carbon stock on a 13 years old plantation forest of *Tectona grandis* in Western African region where it recorded 250 Mg C ha$^{-1}$ as compared to 200 Mg C ha$^{-1}$ in a secondary forest biomass. Guedes *et al.,* (2016) also reported 139 Mg C ha$^{-1}$ of soil organic carbon stocks in *Eucalyptus grandis* plantation and 135 Mg C ha$^{-1}$ in *Pinus taeda* plantation forest which were significantly higher than Miomba natural forest (87 Mg C ha$^{-1}$) of Mozambique.

The constant increase of of carbon-dioxide ($Co_2$) in the atmosphere currently at 416.09 ppm (as per earth's $Co_2$ data) remains as one of the major contributor to earth's global warming and the storage of carbon (C) in various forest ecosystem plays a vital role in combating the global warming, protecting us from the climate change adversity (Coelho *et al.,* 2020). According to Kothandaraman *et al.* (2020), the current carbon stocks in the world's forest is 861 ± 66 Pg C of which living biomass contributes 42%, deadwood 8%, litters 5%, and mineral soil 44% respectively. Soil is also very significant in terrestrial carbon sink which contributes around two-third of the total carbon pool (Scharlemann *et al.,* 2014). Over all, forest ecosystem is one of the largest terrestrial carbon pools playing a vital role in global carbon cycle of terrestrial ecosystem (Zhao *et al.,* 2019). According to Lal (2005), the amount of carbon stored in a forest is twice than $Co_2$ in the atmosphere.

Atmospheric $Co_2$ concentration has increased rapidly since the revolution of industrial era and most of this increase is possibly due to various anthropogenic activities such as burning of fossil fuel and clearing forest areas in large scale due to population expansion (Bargali *et al.,* 2018). Tree species richness are very significant in above and below ground biomass and carbon storages (Benito *et al.,* 2014) and reduction of tree diversity and stem density in a natural forest leads to depletion of carbon sink potential which is very much important in mitigating ecological services (Kittur *et al.,* 2014). Tree species with large girths are one of the major contributors in maintaining the carbon stocks in a primary forest (Clarke *et al.,* 1996). Covering only about 6% of total land area, tropical forest acts as the largest repository of above ground biomass (Pan *et al.,* 2013) and plays a vital role in regulating carbon cycles noth in global and regional level (Poorter *et al.,* 2015). Tropical forest which holds a maximum proportion of global biodiversity (Myers *et al.,* 2000) account to about 90% of world's terrestrial biodiversity (Brockerhoff *et al.,* 2017) fix over 3000 g C/$m^2$ per year and serve as one of the major potential sink for carbon storage (Malhi *et al.,* 1999). According to Pan *et al.* (2011), tropical forest stores carbon over 55% in tree biomass and about 32% in soil.

Based on all the above findings and literatures, a detailed study of floristic composition, tree population structure and regeneration status of the woody species is very much important in the forest of Nagaland and also to estimate the tree biomass stocked in different forest types of the study site.

**CHAPTER 3**

# Materials and method

## 3.1 Description of the study sites

### 3.1.1 Geography of Nagaland

The state of Nagaland lying in the hills and mountains of the northeastern part of the country became the 16th state of Indian union on 1st December 1963. Nagaland is bounded by Indian states of Arunachal Pradesh to the Northeast, Manipur to the south and Assam to the west and northwest and the country of Myanmar (Burma) to the east. With total geographical area of 16,579 $km^2$ and population of 1,978,502 as per 2011 census, it is the third smallest state of the Indian Union. Nagaland is geographically situated between 25°05' N and 27°10' N latitude and 93°28' E and 95°05' E longitude. Nagaland as per given unit area can be considered as one of the richest biodiversity centre due to its unique geographic location where the altitude varies from 190 m in the plains to 3048 m in the hills. According to State level Biodiversity Strategy and Action plan of Nagaland (2005), out of the total geographical area 85% (14,164 $km^2$) constitute the forest cover where 5,137 $km^2$ is dense forest and 9,027 $km^2$ is open forest. Nagaland has 12 administrative districts where Kohima district is the state's capital and Dimapur district is the only commercial centre and main gateway to Nagaland state. The state is consisting of 16 officially recognized tribal groups having diverse linguistic backgrounds. Owing to lack of linguistic homogeneity, English has been adopted as the official language of the state. Agriculture is the main occupation of the people of the state where shifting and terraced cultivations remains the dominant forms of land use practice in the state.

### 3.1.2 Climatic conditions

Nagaland's climate is primarily monsoon-influenced, with high humidity levels. Rainfall averages roughly 1,800–2,500 mm (70–100 in) each year, with the months of May to September receiving the most. The year can be divided into four seasons: winter (December to February), pre-monsoon (March to April), monsoon (May to September) and retreating monsoon (October to November). In winter season, the night temperature generally comes down to ~3° Celsius and in summer, the weather is quite pleasant in the hills with temperature ranges from 25° Celsius to ~38° Celsius in the plains. Frost is usually common at high elevations.

### 3.1.3 Topography

Nagaland is largely a young mountainous state and is surrounded by high hills, ridges, gorges, valleys and plains along the foot hills in the western part of the state. The hills of Nagaland are comprised of three ranges namely: Patkai (the highest range), Barial (the mid-range) and Disang (the lowest range). The hills of Patkai range stretches south from the Eastern Himalaya via the hills of Manipur and Mizoram to the Arakan Yoma range (Burma hills). In general, the hill range spans from northeast to southwest, with steep narrow valleys running alongside streams and river bottoms in between. The hills are lower on the west where they meet the plains of Assam and gradually rise to a height of about 1500 meters to above 3500 meters spreading towards eastern districts bordering with Myanmar.

### 3.1.4 Drainage system and river basins

The state is dissected by a number of perennial rivers and rivulets. The five major river systems in the state are Barak, Dhansiri, Dikhu, Doyang and Tizu. Of the rivers, Dhansiri, Doyang and Dikhu flow westward into the Brahmaputra. The Barak River flows from the Japfu range and continue flowing towards Southwest forming the boundary between Myanmar. The Tizu River on the other hand, flows towards east and joins the Chindwin River in Burma. All these rivers receive a number of tributaries which are short and run only for few kilometers. Tizu River is the longest river in Nagaland which flows from the Tuensang district to Kiphire and Phek districts from North to South in the Eastern part of the state.

### 3.1.5 Soil

The soils of Nagaland are derived from tertiary rocks belonging to Barail and Disang series. As per soil Resource Mapping of Nagaland State (Maji *et al.*, 2004), 72 soil families were identified and these were mapped into 36 soil units in the entire state. The soils of Nagaland belong to 4 orders, 7 suborders, 10 great groups and 14 subgroups. It is also observed that Inceptisols are the dominant soils followed by

Ultisols, Entisols and Alfisols. The Alfisols cover 3 %, Entisols 7%, Inceptisols 66% and Ultisols cover 27% of the total geographical area. The major soil problems of the area are strong soil acidity, high leaching of bases resulting to low base saturation status, low exchange capacity, limiting soil depth in steep hill slopes, erosion and landslides as a result of weak geological formations of Himalayan origin and humid climate with high rainfall.

### 3.1.6 Community based conservation on biodiversity

The forest is the principal source of livelihood. In Nagaland, about 92% of the land is unclassified and are under the community ownership, which may fall under any one of the recognized four categories: Private land, Clan land, Morung land, and Common land. The state government owns just about 7% of the total land area. Technically, the forests are also traditionally owned by the village community, clans and individuals who inherited them from their ancestors. It is a known fact that our ancestors were mainly dependent upon the plants for shelter, food and medicines. The Nagas follow the slash and burn method for agriculture but in the process, few branches are left uncut at the top of the trees and big old trees are merely lopped. This is apparently an idea of leaving a place of refuge for jungle spirits. Cutting of fuelwood is normally done during spring season along with slashing of jhum phase. Thus extraction of natural resources from the forest is strictly followed as a system of faith and believes of supernatural being for the betterment of an individual or society. For instance, it is forbidden to destroy the surrounding forests, which are in close proximity to the villages, as it is believed that this will result into loss of prosperity and investment with deceases. Behind traditional practices like conserving of certain trees while clearing jhum fields, prohibition on hunting during the mating seasons of the animal, underlies the beliefs that if such taboo are broken it will bring ill luck to the people and to the village. The practice of jhum cultivation in association with the Alder tree a nitrogen fixer plant is also an indigenous innovation towards sustenance and soil conservation.

### 3.2 Field work

The survey was carried out from March 2016 to August 2018 in the 11 districts (Mokokchung, Mon, Kiphire, Tuensang, Phek, Wokha, Zunhebhoto, Longleng, Kohima, Peren and Dimapur) of Nagaland, Northeast India. The study included forest inventory, species composition and diversity, population structure, regeneration status, deforestation and tree biomass and carbon stocks of the area.

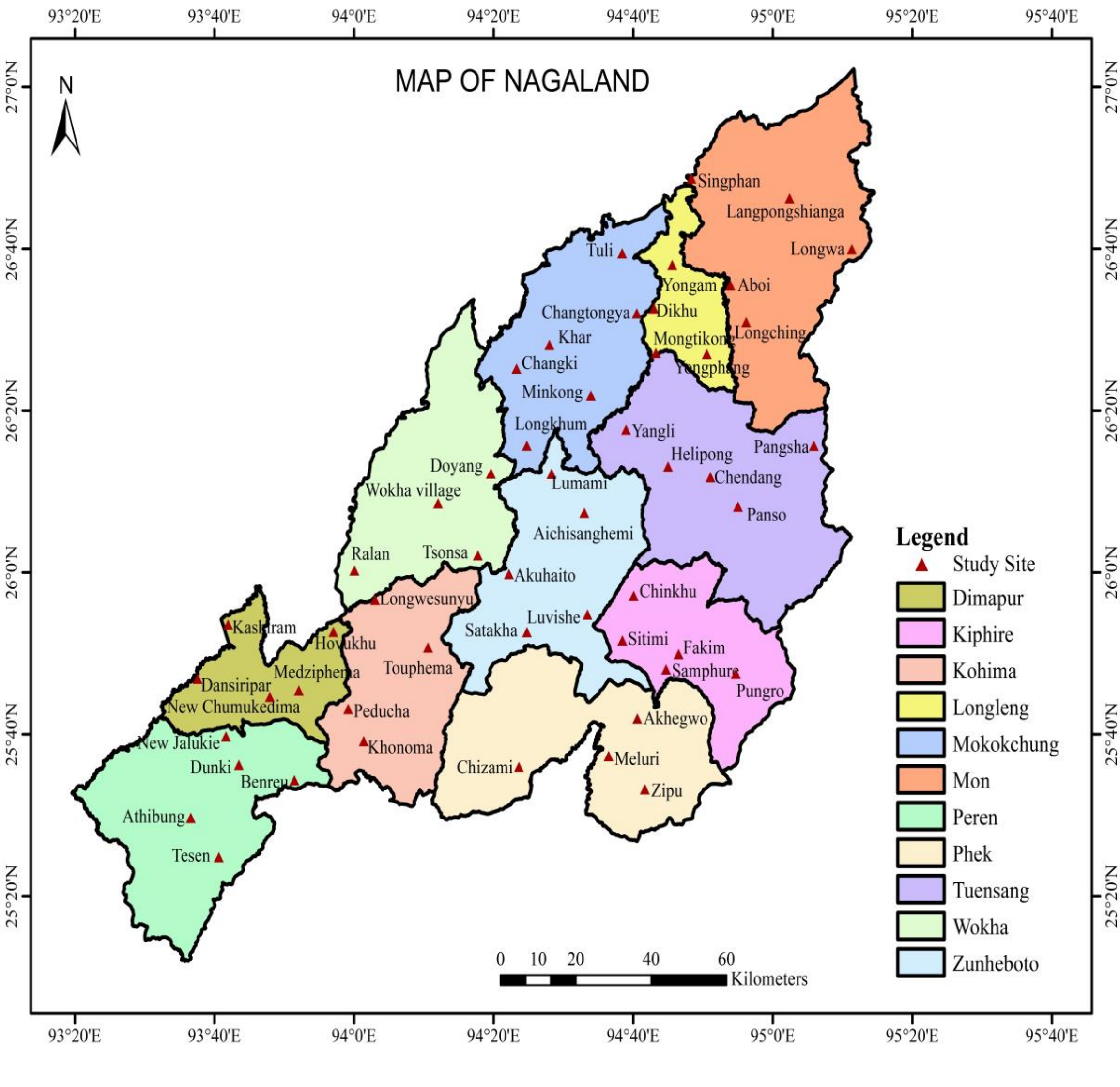


**Figure 3.1** Map showing fifty-two study sites under different districts of Nagaland, Northeast India

## 3.3 Sampling design

The sampling method was adopted according to the field manual manual for "vegetation carbon pool" assessment of India (Dadhwal *et al.,* 2009). In each forest site, a plot of 250 m × 250 m size was taken. At each corner of the plot, four 31.62 m × 31.62 m (0.1 ha) subplots were demarcated for tree vegetation and biomass inventory. Individuals with a girth ≥10 cm GBH were considered as woody species and were measured at 1.37 m above the ground. For understory vegetation, two 5 m × 5 m subplots were nested on the opposite corners for shrubs and four 1 m x 1 m for herbs (including epiphytes, lithophytes and climbers) in each corner were laid within each tree subplot. For sapling, plants with 3 to <10 cm girth with >10 cm height was considered whereas for seedling, plants with <3 cm girth, height upto 10 cm tall with 3 to 8 leaves were considered. The enumeration of sapling and seedling was done in same plot of 5 m x 5 m as laid for shrub. The tree species were collected and identified with the help of regional flora (Hooker 1872–1897; Kanjilal *et al.,* 1934–1940; Balakrishnan 1981–1983; Haridasan and Rao 1985–1987). The herbarium was prepared following Jain and Rao (1977) and deposited in the Nagaland University. Botanical Survey of India, Eastern Regional Circle, Shillong, Meghalaya was also consulted for correct identification of the plant species**.**

## 3.4 Quantative analysis:

Important community parameters such as frequency, density, abundance, basal area and important value index (IVI) of all the plant species were determined according to Misra (1968) and Mueller – Dombois and Ellenberg (1974). The IVI of trees, saplings and seedlings will be calculated by summing up the relative values of frequency, density and basal cover. Species abundance was determined by following Magurran model (1988).

**3.4.1 Frequency:** This term refers to the degree of dispersion of individual species in an area and usually expressed in terms of percentage occurrence.

$$\text{Frequency (\%)} = \frac{No.of\ quadrates of\ occurence of\ a\, species}{Total\, no.of\ quadrates studied} X\, 100$$

**3.4.2 Density:** Density is an expression of the numerical strength of a species where the total number of individuals of each species in all the quadrates is divided by the total number of quadrates studied.

$$\text{Density} = \frac{Total\ no.of\ individuals\ of\ a\ species}{Total\ no.of\ quadrates\ studied}$$

**3.4.3 Abundance:** It is the study of the number of individuals of different species in the community per unit area.

$$\text{Abundance} = \frac{No.of\ individuals\ of\ a\ species}{No.of\ quadrates\ of\ occurence\ of\ the\ species}$$

**3.4.4 Basal area:** The stem basal area is the cross-sectional area of the trunk ($m^2$) measured at the lowest point not influenced by basal swellings or buttresses. In trees, it is traditionally measured at 1.37 m above ground level.

Basal area = $\pi r^2$

**3.4.5 Important Value Index (IVI):** In order to interpret the dominance and ecological success of any species in a community with a single value, the concept of Important value index (IVI) has been developed. 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 (Misra 1968).

**3.4.6 Relative frequency:** The degree of dispersion of individual species in an area in relation to the number of all the species occurred.

$$\text{Relative Frequency} = \frac{Frequency\ of\ a\ species}{Total\ frequency\ of\ all\ the\ species} X\,100$$

**3.4.7 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:

Relative Density = $\frac{Density\ of\ a\ species}{Total\ density\ of\ all\ the\ species} X\, 100$

**3.4.8 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.

Relative dominance = $\frac{Basal\ area\ of\ individuals\ of\ a\ species}{Total\ basal\ area\ of\ all\ species} X\, 100$

**3.4.9 Distribution pattern:** The distribution pattern of species in the forest was determined by following Whitford's index (Whitford, 1948). If A/F ratio is <0.025, it indicates regular distribution, whereas from 0.025 to 0.05, it indicates random distribution and > 0.05, it indicate contagious or clumped distribution.

Distribution pattern = $\frac{Abundance(A)}{Frequency(F)}$

**3.4.10 Index of Richness:** Species richness index of the vascular plants was computed by following Margalef index (1958)

Dmg = (S-1)/ln (N)

Where, S denotes the total number of species and N denotes total number of individuals.

**3.4.11 Index of Diversity (H'):** Shannon-Weiner diversity Index was based on the information theory proposed by Shannon and Weaver (1963). It assumes that the individuals are randomly sampled from independently large population and all the species are represented in the sample.

H'= -∑ pi *ln* pi

Where, pi = the proportion of density of the *i-th* species (*pi* = *ni/N*), *ni* is the density of i-th species and *N* is the density of all the species.

**3.4.12 Index of Dominance (CD):** Simpson's index (1949) of dominance reflects the probability of any two individuals drawn at random from an infinitely large community belonging to the same species. The concentration of dominance was calculated using the following formula:

$$CD = \sum (pi)^2$$

Where, pi = the proportion of density of the *i-th* species (*pi* = *ni/N*), *ni* is the density of *i-th* species and *N* is the density of all the species.

**3.4.13 Evenness index (e):** Peilou's species evenness index (Pielou 1966) compares the actual diversity value to the maximum possible values which reflects the distributional pattern of the species in a community.

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

Where, H'= Shannon index of diversity, S= Number of species in the community.

**3.4.14 Index of Similarity**: Sorenson's index (1948) was computed to assess the similarity between the plant communities of the study area.

$$\text{Sorensen Similarity} = \frac{2C}{S1+S2}$$

Where, C is the numbers of species the two communities have in common, S1 is the total number of species found in community 1, and S2 is the total number of species found in community 2. Sorenson similarity gives a value between 0 and 1, the closer the value is to 1, the more the communities have in common i.e., complete community overlap is equal to 1 and complete community dissimilarity is equal to 0.

**3.4.15 Disturbance Index:** Disturbance index was calculated following Rao *et al.,* (1990).

$$DI = \frac{Total\ no. of\ cut\ stumps}{Total\ no. of\ individuals\ of\ all\ stands\ incluiding\ cut\ stumps} X\ 100$$

**3.4.16 Regeneration potential:** Regeneration potential of tree species was determined based on population size of seedlings and saplings (Bhuyan *et al.,* 2003; Khumbongmayum *et al.,* 2006). The regeneration is considered as good, if seedlings > or < saplings > adults; fair, if seedlings > or ≤ saplings ≤ adults; poor, if the species survives only in sapling stage, but no seedlings (saplings may be <, > or = adults); none if a species survives only in adult stage and new regeneration if a species is present only in seedling and sapling stage but no adults

**3.4.17 Estimation of plant biomass and carbon stock:** Total biomass (aboveground) of trees was estimated using the allometric equation developed for different forest types in Northeast India by Nath *et al.,* (2019):

$$AGB_{est} = 0.32\ (D^2H\delta)^{0.75} \times 1.34$$

Where, D is the DBH, H denotes the height of the tree and δ as specific wood gravity

Belowground biomass was estimated by using the equation developed by Cairns *et al.*, (1997):

$$BGB = \exp\,[-1.085 + 0.9256 \times \ln\,(AGB)]$$

The vegetation carbon stock was estimated assuming 45% carbon content of dry biomass (Vashum and Jayakumar 2012).

# CHAPTER 4

## Results

### 4.1 Overview of Nagaland biodiversity

Nagaland state with a total geographical area of 16,579 km$^2$ is in the extreme northeastern part of India and situated between 25°05' N and 27°10' N latitude and 93°28' E and 95°05' E longitude. Out of the total geographical area, 85.43% (14,164 km$^2$) is covered by the forest, out of which 5,137 km$^2$ dense forest and 9,027 km$^2$ open forest. Nagaland is particularly rich in biological and genetic diversity with high degree of endemism. It has about 73 % of the area covered with forests as against national average of 19.5 %. However, 80 % of the land and forests are owned and controlled by the village community, Khels/Clans, and by the individuals. Nagaland has the finest tropical and subtropical evergreen forests and it has also a unique broad leaved moist temperate forest with its rich flora and fauna elements of different bio-geographic zones. The vegetation of Nagaland represents the transition zone between the Indian, Indo-Malayan and Indo-Chinese bio-geographic region supporting a unique biodiversity as a meeting place of Himalayan Mountains with that of Peninsular India and South-East Asia, therefore; Patkai and Barial ranges of Nagaland is the bio-geographic gateway. Many ancient angiosperms and primitive flowering plants are found here as such, this area is considered as a cradle of flowering plants (Thakhtajan, 1969, Rao 1994). Several plants such as Orchids, Rhododendrons, Ferns, Bamboos, Zingibers and Lichens have expressed their maximum diversity in this state. The state is also known to have a great treasure of medicinal plants, and also faunal elements. Nagaland being as part of Eastern Himalayas is considered as one of the center of origin of rice and cucurbits, secondary origin of citrus, chilly and maize.

The biodiversity of the state is essentially due to its unique geographic location where the altitude varies gradient from flood plains of 190 meters and the high hills of Mt. Saramati, 3048 meters from the Mean Sea Level. A unique and rich terrestrial diversity of floral and fauna along the different gradient also support a diverse agriculture practices with their diverse ethnic groups. As this state is with a unique functions and roles in context of biodiversity, the wide variety of plants and animals in the mountain ecosystem has supported human existence and contributed to our well being. The interactions between the tribal people and the natural system have helped in maintaining the richness of species, communities and genetic materials in both production systems and wild lands of the mountain environment. The traditional utilization of biologically resources in the region not only reflects a diverse resource use pattern, but also the way of maintaining biodiversity in mountain ecosystems by the people. However, the rich biodiversity of this state is being impoverished disastrously along with the overall degradation of mountain environments due to human activities in last few decades.

In the traditional agro-ecosystems of Nagaland, the natural forest is an indispensable component. The peoples are engaged in agriculture, hunting and selected logging activities in the forests to supplement their needs and to earn cash income for their livelihood. On the other hand, foods and other human needs of plant origin collected in the forests include edible fruits, seeds, flowers, leaves, tubers, mushrooms, bamboo shoots, besides hundreds of medicinal plants, fibers and weaving materials and dying materials are gathered from the natural vegetations. There are diverse varieties of minor forest products which are valuable for home consumption as well as for sale in local markets. On the other hand, as local population pressure increases and market linkages with the outside are introduced, loss of indigenous control over collection of valuable forest products ensues. Combination of the rich indigenous knowledge system and scientific support should be utilized to boost the management of forest, agriculture, horticulture, soil, water etc. This will also ensure less pressure on forests for longer jhum cycles, conserve forest resources and sound income generation for the rural people.

**Table 4.1** Status of Nagaland Forest

| Legal Status | Forest Area (ha) | Total forest area (%) | Total Geographical area (%) |
|---|---|---|---|
| **Reserved Forests** | 8583 | 1 | 0.5177 |
| **Purchased Forest** | 19247 | 2.2 | 1.1558 |
| **Protected Forests** | 50756 | 5.9 | 3.0615 |
| **Wildlife Sanctuary** | 22237 | 2.6 | 1.3413 |
| **Village Forests** | | | |
| **i) Virgin Forests** | 477827 | 55.4 | 28.8212 |

| | | | |
|---|---|---|---|
| **ii) Degraded** | 284280 | 32.9 | 17.1467 |
| **Total** | 862930 | 100 | 52.0442 |

(As per Dept. of Environment, Forest & Climate Change, Govt. of Nagaland 31.01.2008)

## 4.2 District wise floristic composition, diversity and community characteristic of forest of Nagaland

### 4.2.1 Mokokchung District

#### 4.2.1.1 Floristic structure

*Tree species composition*

In the present study, a total of 777 individuals belonging to 118 species, 87 genera representing 49 families were recorded from the six community forest (Minkong, Khar, Tuli, Longkhum, Changki and Changtongya) of Mokokchung district, Nagaland, Northeast India. Out of these, 53 species belonging to 45 genera, 28 families and 139 individuals were recorded from Khar community forest (CF) followed by 52 species belonging to 44 genera, 29 families and 129 individuals from Minkong CF; 39 species belonging to 33 genera, 22 families and 140 individuals from Longkhum CF; 36 species belonging to 32 genera, 25 families and 117 individuals from Tuli CF; 29 species belonging to 28 genera, 19 families and 125 individuals from Changki CF and 26 species belonging to 25 genera, 19 families and 127 individuals from Changtongya CF of Nagaland respectively (Table 4.2.1). In Khar CF, based on Importnace Value Index (IVI), the dominant species were: *Morus laevigata* (21.54), *Vernonia arborea* (20.82) and *Hovenia dulcis* (17.93) and the co-dominant species were: *Rhus chinensis* (15.81), *Toona sureni* (14.30) and *Duabanga grandiflora* (12.92) (Table 4.2.2). The dominant families from this community were: Meliaceae, Fagaceae and Sapindaceae. In Minkong CF, the dominant tree species were: *Trema cannabina* (34.41), *Kydia calycina* (28.50) and *Callicarpa arborea* (24.44) and the co-dominant species were: *Juglans regia* (11.10), *Hovenia dulcis* (10.40) and *Actinodaphne obovata* (9.63) (Table 4.2.2). The most dominant families were: Malvaceae, Moraceae and Verbenaceae.

In Longkhum CF, the dominant species were: *Alnus nepalensis* (29.52), *Duabanga grandiflora* (23.85) and *Morus laevigata* (21.08) and the co-dominant species were: *Hovenia dulcis* (17.83), *Choerospondias axillaris* (13.75), *Juglans* *regia* (12.96), *Schima wallichii* (12.80) and *Gmelina arborea* (12.19) (Table 4.2.2). The dominant families were: Betulaceae, Moraceae, Anacardiacea and Verbenaceae. In Tuli CF, The dominant species were *Albizia procera* (25.93), *Sapium baccatum* (18.29) and *Gmelina arborea* (16.30) and the co-dominant species were *Macaranga indica* (15.37), *Livistona jenkinsiana* (14.69) and *Ficus semicordata* (13.21) (Table 4.2.2). The dominant families from this community were: Fabaceae, Moraceae and Euphorbiaceae. In Changki CF, The dominant species were *Dillenia indica* (28.04) followed by *Duabanga grandiflora* (27.22) and *Macaranga denticulata* (19.40) and the co-dominant species were *Croton roxburghii* (16.15), *Ailanthus integrifolia* (15.71) and *Bombax ceiba* (13.67), (Table 4.2.2). The most dominant families from this study site were: Euphorbiaceae, Dilleniaceae and Lythraceae. In Changtongya CF, the dominant species were: *Bombax ceiba* (23.55) followed by *Melia azedarach* (21.02) and *Gmelina arborea* (19.10) and the co-dominant species were *Canarium strictum* (17.76), *Elaeocarpus aristatus* (16.32) and *Eurya acuminata* (16.08) (Table 4.2.2). The dominant families from this community were: Euphorbiaceae, Theaceae and Phyllanthaceae. The maximum tree stand density (individuals $ha^{-1}$) was recorded from the Khar CF (330) followed by Minkong CF (327), Tuli CF (325), Longkhum CF (324), Changtongya CF (318) and Changki CF (313) respectively (Table 4.1.1). Whereas the highest basal area ($m^2 ha^{-1}$) was recorded from the Changtongya CF (38.03) followed by Longkhum CF (35.86), Changki CF (34.51), Tuli CF (26.65), Minkong CF (24.95) and Khar CF (22.95) (Table 4.2.1).

**Table 4.2.1** Phytosociological attributes of trees, shrubs and herbs in six study sites of Mokokchung District, Nagaland

| **Parameters** | **Longkhum** | **Minkong** | **Khar** | **Tuli** | **Changki** | **Changtongya** |
|---|---|---|---|---|---|---|
| **Trees** | | | | | | |
| No. of species | 39 | 52 | 53 | 36 | 29 | 26 |
| No. of genera | 33 | 44 | 45 | 32 | 28 | 25 |
| Families | 22 | 29 | 28 | 25 | 19 | 19 |
| Density (individuals $ha^{-1}$) | 324 | 327 | 330 | 325 | 313 | 318 |
| Basal area ($m^2ha^{-1}$) | 35.86 | 24.95 | 22.95 | 26.65 | 34.51 | 38.03 |
| Shannon diversity index (H') | 3.32 | 3.88 | 3.78 | 3.43 | 3.05 | 2.95 |
| Simpson dominance index (CD) | 0.06 | 0.03 | 0.04 | 0.05 | 0.08 | 0.09 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Margalef species richness index (Dmg) | 7.68 | 10.46 | 10.53 | 7.34 | 5.80 | 5.16 |
| Evenness (e) | 0.91 | 0.98 | 0.95 | 0.94 | 0.91 | 0.9 |
| Disturbance index (%) | 13 | 15 | 18 | 22 | 20 | 12 |
| **Shrubs** | | | | | | |
| No. of species | 21 | 33 | 19 | 20 | 25 | 30 |
| No. of genera | 18 | 30 | 17 | 19 | 23 | 24 |
| Families | 15 | 20 | 16 | 17 | 20 | 18 |
| Density (individuals $ha^{-1}$) | 5400 | 8800 | 4350 | 4050 | 6550 | 8850 |
| Shannon diversity index (H') | 2.76 | 3.12 | 2.53 | 2.46 | 2.97 | 3.10 |
| Simpson dominance index (CD) | 0.07 | 0.05 | 0.10 | 0.13 | 0.06 | 0.06 |
| Margalef species richness index (Dmg) | 4.27 | 6.19 | 4.03 | 4.32 | 4.92 | 5.60 |
| Evenness (e) | 0.91 | 0.89 | 0.85 | 0.82 | 0.92 | 0.91 |
| **Herbs** | | | | | | |
| No. of species | 25 | 28 | 21 | 23 | 20 | 22 |
| No. of genera | 22 | 26 | 20 | 23 | 18 | 19 |
| Families | 17 | 23 | 15 | 14 | 16 | 13 |
| Density (individuals $ha^{-1}$) | 51875 | 58750 | 81875 | 52500 | 47500 | 51250 |
| Shannon diversity index (H') | 2.98 | 3.18 | 2.61 | 2.83 | 2.64 | 2.81 |
| Simpson dominance index (CD) | 0.06 | 0.04 | 0.10 | 0.07 | 0.09 | 0.07 |
| Margalef species richness index (Dmg) | 5.43 | 5.94 | 4.10 | 4.97 | 4.39 | 4.79 |
| Evenness (e) | 0.92 | 0.95 | 0.86 | 0.90 | 0.88 | 0.91 |

**Table 4.2.2** Density (individuals ha$^{-1}$), Basal area (m$^2$ha$^{-1}$), Important value index (IVI) and Distribution pattern (DP) of tree species in six study sites of Mokokchung District, Nagaland

| Species | Family | Longkhum | | | | Minkong | | | | Khar | | | | Tuli | | | | Changki | | | | Changtongya | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP |
| *Acer thomsonii* Miq. | Aceraceae | | | | | 7.5 | 0.42 | 6.69 | R | | | | | | | | | | | | | | | | |
| *Acrocarpus fraxinifolius* Arn. | Leguminosae | | | | | | | | | | | | | 10 | 1.56 | 12.22 | R | 5 | 0.78 | 5.78 | C | | | | |
| *Actinodaphne obovata* (Nees) Bl. | Lauraceae | | | | | 7.5 | 1.11 | 8.09 | C | | | | | | | | | | | | | | | | |
| *Aglaia perviridis* Hiern | Meliaceae | 2.5 | 0.13 | 3.02 | RE | 7.5 | 0.64 | 7.56 | RE | 2.5 | 0.15 | 2.67 | R | | | | | | | | | | | | |
| *Aglaia spectabilis* (Miq.) S.S.Jain & S.Bennet | Meliaceae | 5 | 0.87 | 5.86 | C | | | | | 5 | 0.64 | 5.16 | C | | | | | | | | | | | | |
| *Ailanthus integrifolia* Lam. | Simaroubaceae | | | | | | | | | | | | | 7.5 | 1.33 | 8.95 | C | 12.5 | 2.71 | 15.71 | R | | | | |
| *Alangium chinense* (Lour.) Harms | Cornaceae | | | | | 5 | 0.18 | 4.96 | RE | 10 | 0.36 | 7.07 | R | | | | | | | | | | | | |
| *Albizia chinensis* (Osbeck) Merr. | Mimosaceae | | | | | 7.5 | 0.51 | 5.69 | C | 7.5 | 0.80 | 6.48 | C | | | | | | | | | 10 | 1.48 | 11.29 | R |
| *Albizia procera* (Roxb.)Benth. | Mimosaceae | 7.5 | 1.07 | 7.20 | C | | | | | | | | | 27.5 | 3.34 | 25.93 | R | 12.5 | 1.57 | 12.40 | R | | | | |
| *Alnus nepalensis* D.Don | Betulaceae | 27.5 | 5.50 | 29.52 | R | | | | | | | | | | | | | | | | | | | | |
| *Alstonia scholaris* (L.) R. | Apocynaceae | 7.5 | 1.16 | 7.44 | C | | | | | 5 | 0.93 | 6.18 | C | | | | | | | | | | | | |

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| Br. | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Altingia excelsa* Noronha | Altingiaceae | | | | | | | | | | | | | 5 | 0.38 | 4.64 | C | 10 | 1.07 | 10.14 | R | | | | |
| *Aquilaria agallocha* (Lour.) Roxb. | Thymelaeaceae | | | | | | | | | | | | | 5 | 0.76 | 6.05 | C | 7.5 | 1.44 | 8.48 | C | | | | |
| *Artocarpus chama* Buch.-Ham. | Moraceae | 7.5 | 0.62 | 5.95 | C | 5 | 0.77 | 5.98 | C | | | | | | | | | | | | | | | | |
| *Artocarpus lacucha* Buch.-Ham. | Moraceae | | | | | 5 | 0.47 | 4.74 | C | | | | | 7.5 | 0.32 | 5.15 | C | | | | | | | | |
| *Bauhinia purpurea* L. | Caesalpiniaceae | | | | | 5 | 0.39 | 4.45 | C | | | | | | | | | | | | | | | | |
| *Beilschmiedia roxburghiana* Nees | Lauraceae | | | | | 5 | 0.18 | 3.61 | C | | | | | | | | | | | | | | | | |
| *Betula alnoides* Buch.-Ham. ex. D. Don | Betulaceae | 5 | 0.72 | 5.44 | C | | | | | | | | | | | | | | | | | | | | |
| *Bischofia javanica* Blume | Euphorbiaceae | | | | | 2.5 | 0.34 | 3.48 | R | | | | | 7.5 | 0.97 | 7.60 | C | | | | | 7.5 | 1.21 | 7.66 | C |
| *Bombax ceiba* L. | Malvaceae | | | | | | | | | | | | | 5 | 0.68 | 5.76 | C | 12.5 | 2.01 | 13.67 | R | 22.5 | 3.83 | 23.55 | R |
| *Brassaiopsis hainla* (Buch.-Ham.) Seem. | Araliaceae | | | | | 10 | 0.46 | 7.61 | R | | | | | | | | | | | | | | | | |
| *Bridelia Retusa* (L.) A.Juss. | Euphorbiaceae | | | | | 7.5 | 1.07 | 7.92 | C | 2.5 | 0.37 | 3.46 | R | | | | | | | | | | | | |
| *Callicarpa arborea* Roxb. | Verbenaceae | 12.5 | 0.42 | 8.83 | R | 12.5 | 0.44 | 9.62 | RE | 5 | 0.13 | 3.36 | C | | | | | 10 | 0.40 | 12.05 | RE | 7.5 | 0.25 | 5.15 | C |
| *Canarium strictum* Roxb. | Burseraceae | | | | | | | | | 5 | 0.42 | 4.39 | C | 5 | 0.32 | 4.40 | C | 5 | 0.51 | 5.00 | C | 17.5 | 3.04 | 17.76 | C |
| *Castanopsis indica* (Roxb. ex Lindl.) A.DC. | Fagaceae | 7.5 | 0.61 | 5.91 | C | | | | | 7.5 | 0.25 | 4.54 | C | | | | | 12.5 | 1.40 | 13.84 | RE | | | | |
| *Choerospondias axillaris* | Anacardiaceae | 20 | 0.68 | 13.75 | R | 7.5 | 0.31 | 6.22 | R | 7.5 | 0.35 | 4.88 | C | | | | | | | | | 10 | 0.33 | 6.16 | C |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (Roxb.) B.L. Burtt & A.W. Hill | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Croton roxburghii* Balakr. | Euphorbiaceae | | | | | | | | | | | | | | | | | 22.5 | 1.10 | 16.15 | R | | | | |
| *Cyathea gigantea* (Wall. ex Hook.) Holttum | Cyatheaceae | | | | | | | | | | | | | 5 | 0.36 | 4.53 | C | | | | | | | | |
| *Cyathea henryi* (Baker) Copel. | Cyatheaceae | | | | | | | | | | | | | 5 | 0.26 | 4.19 | C | | | | | | | | |
| *Dillenia indica* L. | Dilleniaceae | | | | | | | | | | | | | 5 | 0.42 | 4.78 | C | 30 | 3.71 | 28.04 | R | | | | |
| *Diospyros stricta* Hort. ex Loudon | Ebenaceae | 7.5 | 0.74 | 6.28 | C | | | | | | | | | | | | | | | | | | | | |
| *Drimycarpus racemosus* (Roxb.) Hook. f. | Anacardiaceae | | | | | 5 | 0.48 | 4.81 | C | 5 | 0.59 | 4.99 | C | | | | | | | | | | | | |
| *Duabanga grandiflora* (DC.) Walp. | Lythraceae | 22.5 | 4.02 | 23.85 | R | | | | | 7.5 | 1.45 | 8.76 | C | | | | | 25 | 4.64 | 27.22 | R | 10 | 2.24 | 11.16 | C |
| *Echinocarpus dasycarpus* Benth. | Elaeocarpaceae | | | | | 2.5 | 0.43 | 3.84 | C | 5 | 1.28 | 7.40 | C | | | | | | | | | | | | |
| *Elaeocarpus aristatus* Roxb. | Elaeocarpaceae | | | | | | | | | | | | | 12.5 | 0.80 | 10.15 | C | | | | | 15 | 2.79 | 16.32 | C |
| *Elaeocarpus floribundus* Blume | Elaeocarpaceae | 5 | 0.81 | 5.69 | C | | | | | 7.5 | 0.82 | 6.54 | C | | | | | 7.5 | 0.82 | 6.71 | C | | | | |
| *Elaeocarpus tectorius* (Lour.) Poir. | Elaeocarpaceae | 2.5 | 0.13 | 3.03 | R | 5 | 0.32 | 5.52 | RE | 5 | 0.33 | 4.07 | C | 2.5 | 0.13 | 2.92 | R | 12.5 | 0.70 | 9.86 | R | | | | |
| *Engelhardia spicata* Lesch. ex Blume | Juglandaceae | 7.5 | 1.02 | 7.07 | C | | | | | 5 | 0.38 | 5.64 | RE | | | | | | | | | | | | |
| *Erythrina stricta* Roxb. | Leguminosae | | | | | | | | | 7.5 | 0.16 | 4.21 | C | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Eurya acuminata* DC. | Theaceae | | | | | 5 | 0.80 | 6.07 | C | 2.5 | 0.03 | 2.26 | R | 17.5 | 0.50 | 12.23 | R | 7.5 | 0.24 | 5.03 | C | 22.5 | 0.99 | 16.08 | R |
| *Eurya cerasifolia* (D.Don) Kobuski | Theaceae | | | | | 10 | 0.28 | 6.88 | R | | | | | | | | | | | | | | | | |
| *Ficus hispida* L.f. | Moraceae | | | | | 2.5 | 0.06 | 2.37 | R | | | | | | | | | | | | | | | | |
| *Ficus neriifolia* Sm. | Moraceae | | | | | | | | | 10 | 0.28 | 6.79 | R | | | | | | | | | | | | |
| *Ficus racemosa* L. | Moraceae | | | | | | | | | | | | | 7.5 | 1.00 | 7.69 | C | | | | | | | | |
| *Ficus semicordata* Buch.-Ham. ex Sm. | Moraceae | | | | | 2.5 | 0.13 | 2.63 | R | 2.5 | 0.08 | 2.44 | R | 17.5 | 0.76 | 13.21 | R | 10 | 0.34 | 8.04 | R | | | | |
| *Firmiana colorata* (Roxb.) R.Br. | Sterculiaceae | | | | | | | | | | | | | 5 | 0.31 | 4.35 | C | | | | | 12.5 | 1.29 | 11.58 | R |
| *Garcinia anomala* Planch. & Triana | Clusiaceae | 7.5 | 0.24 | 4.88 | C | | | | | | | | | | | | | | | | | | | | |
| *Garcinia cowa* Roxb. ex Choisy | Clusiaceae | | | | | | | | | 5 | 0.61 | 6.45 | RE | | | | | | | | | | | | |
| *Garcinia merguensis* Wight | Clusiaceae | 2.5 | 0.13 | 3.02 | R | 2.5 | 0.13 | 2.65 | R | 2.5 | 0.26 | 3.07 | R | 5 | 0.40 | 4.71 | C | 2.5 | 0.20 | 3.32 | R | | | | |
| *Garcinia pedunculata* Roxb. ex Buch.-Ham. | Clusiaceae | | | | | 5 | 0.25 | 3.88 | C | 7.5 | 0.44 | 5.19 | C | | | | | | | | | | | | |
| *Gmelina arborea* Roxb. | Verbenaceae | 10 | 2.58 | 12.19 | C | 7.5 | 0.72 | 6.54 | C | 7.5 | 1.23 | 7.98 | C | 15 | 2.24 | 16.31 | C | 7.5 | 1.28 | 8.04 | C | 17.5 | 2.74 | 19.10 | R |
| *Grewia serrulata* DC. | Malvaceae | | | | | 7.5 | 0.57 | 7.29 | R | | | | | 5 | 0.33 | 4.41 | C | | | | | | | | |
| *Hovenia dulcis* Thunb. | Rhamnaceae | 20 | 2.14 | 17.83 | RE | 10 | 0.81 | 8.99 | R | 10 | 1.42 | 10.79 | R | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ilex aquifolium* L. | Aquifoliaceae | 2.5 | 0.13 | 3.03 | R | 7.5 | 0.48 | 6.92 | R | 5 | 0.26 | 3.80 | C | | | | | | | | | | | | |
| *Ilex dipyrena* Wall. | Aquifoliaceae | 2.5 | 0.13 | 3.02 | R | 2.5 | 0.36 | 3.54 | R | 7.5 | 0.50 | 8.18 | RE | | | | | | | | | | | | |
| *Ilex embelioides* Hook.f. | Aquifoliaceae | 2.5 | 0.13 | 3.03 | R | 7.5 | 0.49 | 6.95 | R | | | | | | | | | | | | | | | | |
| *Iteadaphne caudata* (Nees) H.W. Li | Lauraceae | 5 | 0.14 | 3.83 | C | | | | | | | | | | | | | | | | | | | | |
| *Juglans regia* L. | Juglandaceae | 12.5 | 1.90 | 12.96 | R | 7.5 | 1.00 | 9.00 | R | 7.5 | 0.85 | 8.04 | R | | | | | | | | | | | | |
| *Kydia calycina* Roxb. | Malvaceae | | | | | 15 | 0.79 | 10.44 | C | | | | | | | | | | | | | | | | |
| *Lagerstroemia speciosa* (L.) Pers. | Lythraceae | | | | | | | | | | | | | 12.5 | 0.85 | 10.35 | R | 12.5 | 1.78 | 13.00 | R | | | | |
| *Lindera pulcherrima* (Nees) Benth. | Lauraceae | | | | | | | | | | | | | 15 | 0.47 | 9.69 | RE | | | | | | | | |
| *Lithocarpus elegans* (Blume) Hatus. ex Soepadmo | Fagaceae | 2.5 | 0.13 | 3.02 | R | 5 | 0.82 | 7.53 | RE | 7.5 | 1.01 | 7.20 | C | | | | | | | | | 2.5 | 0.07 | 3.11 | R |
| *Lithocarpus fenestratus* (Roxb.) REhder | Fagaceae | 7.5 | 0.17 | 4.67 | C | | | | | | | | | | | | | | | | | | | | |
| *Lithocarpus pachyphyllus* (Kurz) REhder | Fagaceae | | | | | | | | | 7.5 | 0.61 | 5.79 | C | | | | | | | | | | | | |
| *Litsea cubeba* (Lour.) Pers. | Lauraceae | | | | | | | | | 2.5 | 0.06 | 2.37 | R | | | | | | | | | | | | |
| *Litsea monopetala* (Roxb.) Pers. | Lauraceae | | | | | | | | | | | | | | | | | | | | | 7.5 | 0.69 | 8.43 | R |
| *Litsea salicifolia* (Roxb. ex Nees) Hook.f. | Lauraceae | | | | | | | | | | | | | | | | | | | | | 7.5 | 0.25 | 5.16 | C |
| *Livistona* | AREcaceae | | | | | | | | | | | | | 20 | 0.5 | 14.6 | R | | | | | | | | |

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| *jenkinsiana* Griff. | | | | | | | | | | | | | | | 1 | 9 | | | | | | | | | |
| *Macaranga denticulata* (Blume) Müll.Arg. | Euphorbiaceae | | | | | | | | | 2.5 | 0.11 | 2.54 | R | | | | | 27.5 | 1.00 | 19.40 | R | 15 | 0.64 | 12.79 | RE |
| *Macaranga indica* Wight | Euphorbiaceae | 10 | 0.41 | 6.12 | C | | | | | | | | | 20 | 0.69 | 15.37 | C | | | | | | | | |
| *Macaranga pustulata* King ex Hook.f. | Euphorbiaceae | | | | | 2.5 | 0.08 | 2.45 | R | | | | | | | | | | | | | | | | |
| *Macropanax dispermus* (Blume) Kuntze | Araliaceae | 5 | 0.61 | 5.14 | C | 7.5 | 0.77 | 8.07 | R | 2.5 | 0.20 | 2.87 | R | 2.5 | 0.29 | 3.52 | RE | | | | | | | | |
| *Magnolia hodgsonii* (Hook.f. & Thomson) H.Keng | Magnoliaceae | | | | | | | | | 5 | 0.16 | 4.84 | RE | | | | | | | | | | | | |
| *Mallotus roxburghianus* Müll.Arg. | Euphorbiaceae | | | | | | | | | | | | | | | | | 7.5 | 0.54 | 5.89 | C | | | | |
| *Mangifera andamanica* King | Anacardiaceae | | | | | 5 | 0.79 | 6.04 | C | | | | | | | | | | | | | | | | |
| *Mansonia dipikae* Purkayastha | Malvaceae | | | | | 7.5 | 0.61 | 6.07 | C | | | | | | | | | | | | | | | | |
| *Melia azedarach* L. | Meliaceae | | | | | | | | | | | | | | | | | | | | | 20 | 3.17 | 21.02 | R |
| *Micromelum integerrimum* (Buch.-Ham. ex Colebr.) M. Roem. | Rutaceae | | | | | | | | | | | | | | | | | | | | | 17.5 | 1.35 | 13.31 | R |
| *Morus laevigata* Wall. ex Brandis | Moraceae | 20 | 3.31 | 21.08 | RE | 7.5 | 1.24 | 8.63 | C | 15 | 2.85 | 17.35 | C | | | | | 7.5 | 1.36 | 8.27 | C | 10 | 1.55 | 11.49 | C |
| *Myrica* | Myricaceae | | | | | 10 | 0.4 | 7.51 | R | 5 | 0.1 | 3.44 | C | | | | | | | | | | | | |

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| *esculenta* Buch.-Ham. ex D. Don | | | | | | | 4 | | | | 5 | | | | | | | | | | | | | | |
| *Nephelium lappaceum* L. | Sapindaceae | 7.5 | 0.67 | 6.07 | C | | | | | 5 | 0.60 | 5.01 | C | | | | | | | | | | | | |
| *Oreocnide integrifolia* (Gaud.) Miq. | Urticaceae | | | | | 10 | 0.37 | 7.22 | R | | | | | | | | | | | | | | | | |
| *Oroxylum indicum* (L.) Kurz | Bignoniaceae | | | | | | | | | | | | | | | | | | | | | 17.5 | 0.71 | 11.63 | C |
| *Phoebe lanceolata* (Nees) Nees | Lauraceae | | | | | | | | | 7.5 | 0.40 | 5.08 | C | | | | | | | | | | | | |
| *Phyllanthus emblica* L. | Euphorbiaceae | | | | | | | | | 2.5 | 0.14 | 2.65 | R | | | | | | | | | | | | |
| *Prismatomeris tetrandra* (Roxb.) K.Schum. | Rubiaceae | | | | | | | | | | | | | | | | | 5 | 0.37 | 4.59 | C | | | | |
| *Prunus cerasoides* D. Don | Rosaceae | 7.5 | 0.87 | 6.65 | C | | | | | 2.5 | 0.32 | 3.26 | R | | | | | | | | | | | | |
| *Prunus nepaulensis* Hook.f. | Rosaceae | 5 | 0.21 | 4.01 | C | 5 | 0.36 | 4.30 | C | | | | | | | | | | | | | | | | |
| *Pterospermum lanceifolium* Roxb. | SterculiaceMyriae | | | | | | | | | | | | | 12.5 | 0.85 | 10.34 | RE | 7.5 | 0.50 | 5.77 | C | | | | |
| *Quercus griffithii* Hook.f. & Thomson ex Miq. | Fagaceae | | | | | | | | | 5 | 0.26 | 3.82 | C | | | | | | | | | | | | |
| *Quercus lamellosa* Sm. | Fagaceae | 2.5 | 0.15 | 3.08 | R | | 0.73 | 5.81 | C | 7.5 | 1.08 | 7.47 | C | | | | | | | | | | | | |
| *Quercus serrata* Thunb. | Fagaceae | | | | | 10 | 0.34 | 7.12 | R | | | | | | | | | | | | | | | | |
| *Rhus chinensis* | Anacardiaceae | 5 | 0.1 | 3.94 | C | | | | | 15 | 0.5 | 9.23 | C | | | | | | | | | | | | |

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| Mill. | | | 8 | | | | | | | | 4 | | | | | | | | | | | | | | |
| *Rhus griffithi* Hook.f. | Anacardiaceae | | | | | | | | | | | | | | | | | | | | | 7.5 | 0.29 | 5.26 | R |
| *Rhus javanica* L. | Anacardiaceae | | | | | | | | | 5 | 0.37 | 4.19 | C | | | | | | | | | | | | |
| *Sapindus mukorossi* Gaertn. | Sapindaceae | | | | | | | | | 5 | 0.48 | 4.58 | C | | | | | | | | | | | | |
| *Sapium baccatum* Roxb. | Euphorbiaceae | | | | | | | | | 2.5 | 0.33 | 3.31 | R | 12.5 | 2.08 | 18.29 | R | | | | | 10 | 2.51 | 14.01 | C |
| *Schima wallichii* Choisy | Theaceae | 15 | 1.57 | 12.80 | C | | | | | | | | | | | | | | | | | 15 | 1.78 | 13.66 | C |
| *Spondias pinnata* (L.f.) Kurz. | Anacardiaceae | | | | | | | | | | | | | 12.5 | 0.42 | 8.71 | R | 7.5 | 0.40 | 5.47 | C | | | | |
| *Sterculia guttata Roxb.* | Sterculiaceae | | | | | | | | | | | | | 7.5 | 0.48 | 7.42 | RE | | | | | | | | |
| *Sterculia hamiltonii* (Kuntze) Adelb. | Sterculiaceae | 5 | 0.24 | 4.11 | C | 5 | 0.20 | 3.68 | C | | | | | | | | | | | | | | | | |
| *Sterculia urens Roxb.* | Sterculiaceae | | | | | | | | | | | | | 5 | 0.42 | 6.42 | R | | | | | | | | |
| *Sterculia versicolor* Wall. | Sterculiaceae | | | | | 5 | 0.15 | 3.49 | C | | | | | | | | | | | | | | | | |
| *Sterculia villosa* Roxb. | Sterculiaceae | | | | | | | | | | | | | 7.5 | 0.58 | 6.12 | C | 7.5 | 0.55 | 5.93 | C | | | | |
| *Stereospermum chelonoides* (L.f.) DC. | Bignoniaceae | | | | | | | | | 5 | 0.35 | 4.15 | C | | | | | | | | | 7.5 | 0.95 | 7.00 | C |
| *Syzygium cumini* (L.) Skeels | Myrtaceae | | | | | | | | | 5 | 0.33 | 4.05 | C | | | | | | | | | | | | |
| *Terminalia myriocarpa* Van Heurck & Müll. Arg. | CombREtaceae | | | | | 2.5 | 0.37 | 3.61 | R | | | | | | | | | | | | | 12.5 | 2.10 | 13.70 | R |
| *Tetrameles nudiflora* R. Br. | Tetramelaceae | | | | | | | | | | | | | 7.5 | 0.98 | 7.64 | C | 5 | 0.82 | 5.91 | C | 5 | 1.07 | 6.52 | C |

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| *Toona ciliata* M.Roem. | Meliaceae | 5 | 0.55 | 4.96 | C | 5 | 0.31 | 5.47 | RE | 7.5 | 0.28 | 7.43 | RE | | | | | | | | | | | | |
| *Toona sureni* (Blume) Merr. | Meliaceae | 10 | 0.62 | 8.60 | R | 2.5 | 0.28 | 3.25 | R | 7.5 | 0.88 | 9.53 | RE | 2.5 | 0.29 | 3.52 | R | | | | | | | | |
| *Trema cannabina* Lour. | Ulmaceae | | | | | 17.5 | 0.76 | 11.09 | C | | | | | | | | | | | | | | | | |
| *Turpinia pomifera* (Roxb.) DC. | Staphyleaceae | | | | | 2.5 | 0.29 | 3.27 | R | | | | | | | | | | | | | | | | |
| *Vatica lanceifolia* (Roxb.) Blume Min. | Dipterocarpaceae | | | | | | | | | | | | | 2.5 | 0.13 | 2.91 | R | | | | | | | | |
| *Vernicia fordii* (Hemsl.) Airy Shaw | Euphorbiaceae | | | | | | | | | | | | | | | | | | | | | 10 | 0.70 | 7.12 | C |
| *Vernonia arborea* Buch.-Ham. | Asteraceae | | | | | 7.5 | 0.37 | 5.14 | C | 15 | 0.62 | 10.88 | RE | | | | | 10 | 2.04 | 12.96 | R | | | | |
| *Vitex canescens* Kurz | Lamiaceae | | | | | 2.5 | 0.13 | 2.63 | R | 10 | 0.40 | 7.22 | R | | | | | | | | | | | | |
| *Wendlandia wallichii* Wight & Arn. | Rubiaceae | | | | | | | | | | | | | 5 | 0.43 | 4.82 | C | | | | | | | | |
| *Xerospermum noronhianum* Blume | Sapindaceae | 2.5 | 0.17 | 3.12 | R | 2.5 | 0.13 | 2.64 | R | 7.5 | 0.52 | 6.88 | R | | | | | 2.5 | 0.20 | 3.31 | R | | | | |

**Key to abbreviation:** RE= Regular; R= Random; C= Clumped

*Shrub species composition*

In shrubs, a total of 81 species and 52 genera representing 34 families were recorded from the six community forest (Minkong, Khar, Tuli, Longkhum, Changki and Changtongya) of Mokokchung district, Nagaland, Northeast India. Out of these, 33 species belonging to 30 genera and 20 families were recorded from Minkong CF followed by 30 species belonging to 24 genera and 18 families from Changtongya CF; 25 species, 23 genera and 20 families from Changki CF; 21 species, 18 genera and 15 families from Longkhum CF; 20 species, 19 genera and 17 families from Tuli CF and 19 species belonging to 17 genera and 16 families were recorded from Khar CF of Nagaland respectively (Table 4.2.1). Based on IVI value, the most dominant shrub species in Minkong CF were *Daphne involucrata* (17.57), *Rubus lucens* (16.99), *Dendrocnide sinuata* (15.29), *Maesa indica* (11.88) and *Mussaenda roxburghii* (9.91) (Table 4.2.3) and the dominant families were Melastomataceae, Papilionaceae, Rosaceae and Urticaceae. In Changtongya CF, the most dominant species were: *Leea macrophylla* (19.92), *Maesa indica* (17.10), *Croton caudatus* (13.71), *Boehmeria japonica* (9.19) and *Clerodendrum japonicum* (8.87) (Table 4.2.3) *and* the dominant families were: Ericaceae, Euphorbiaceae, Papilionaceae and Zingiberaceae. In Changki CF, the most dominant species were: *Clerodendrum glandulosum* (20.76), *Boehmeria glomerulifera* (18.47), *Leea alata* (13.89), *Mussaenda frondosa* (12.13) and *Eupatorium adoratum* (11.37) (Table 4.2.3) and the dominant families were: Leeaceae, Melastomataceae, Verbenaceae and Zingiberaceae. In Longkhum CF, the dominant shrub species were: *Clerodendrum glandulosum* (21.03), *Eupatorium cannabinum* (19.18), *Sida cordifolia* (16.40), *Maesa indica* (15.48) and *Debregeasia saenab* (10.91) (Table 4.2.3) and the most dominant families were: Papilionaceae, Rosaceae, Rubiaceae and Verbenaceae. In Tuli CF, dominant species were: *Amomum pterocarpum* (34.95), *Dendrocnide sinuata* (27.54), *Urena labota* (25.07) and *Dracaena angustifolia* (12.63) (Table 4.2.3) and the dominant families were: Euphorbiaceae, Melastomataceae, Urticaceae and Zingiberaceae. In Khar CF, the most dominant shrub species were: *Phrynium capitatum* (30.45), *Eupatorium adoratum* (25.85), *Mussaenda roxburghii* (23.55) and *Boehmeria japonica* (15.36) (Table 4.2.3) and the dominant families were: Papilionaceae, Urticaceae and Zingiberaceae. The highest shrub density (individuals ha$^{-1}$) was recorded from Changtongya CF (8850) followed by Minkong CF (8800), Changki CF (6550), Longkhum CF (5400), Khar CF (4350) and Tuli CF (4050) respectively (Table 4.2.1).

*Herb species composition*

In herbs, a total of 109 species, 89 genera representing 41 families were recorded from the six community forest (Minkong, Khar, Tuli, Longkhum, Changki and Changtongya) of Mokokchung district, Nagaland, Northeast India. Of these, 28 species belonging to 26 genera and 23 families were recorded from Minkong CF followed by 25 species belonging to 22 genera and 12 families from Longkhum CF; 23 species, 23 genera and 14 families from Tuli CF; 22 species, 19 genera and 13 families from Changtongya CF; 21 species, 20 genera and 15 families from Khar CF and 20 species belonging to 18 genera and 16 families were recorded from Changki CF of Nagaland respectively (Table 4.2.1). Based on IVI value, the most dominant herb species in Minkong CF were: *Cheilocostus speciosus* (16.47), *Commelina benghalensis* (14.34), *Girardinia diversifolia* (13.28), *Gnetum latifolium* (10.49) and *Smilax aspera* (8.76) (Table 4.2.3) and the dominant families were Asteraceae, Leguminosae, Urticaceae and Zingiberaceae. In Longkhum CF, the most dominant species were *Elatostema hookerianum* (22.62), *Ophiorrhiza gracilis* (15.76), *Gonatanthus pumilus* (15.39), *Corydalis leptocarpa* (12.15) and *Calamagrostis emodensis* (10.10) (Table 4.2.3) and the dominant families were: Commelinaceae, Lamiaceae, Poaceae and Rubiaceae. In Tuli CF, the dominant species were: *Artemisia indica* (26.95), *Curculigo orchioides* (19.81), *Oxalis corniculata* (17.42), *Mikania micrantha* (13.96) and *Sarcopyramis napalensis* (13.90) (Table 4.2.3) and the dominant families were: Asteraceae, Gesneriaceae, Orchidaceae and Polygonaceae. In Changtongya CF, the dominant herb species were: *Aerides crassifolia* (26.11), *Desmodium microphyllum* (23.67), *Ageratina adenophora* (18.79), *Bidens pilosa* (13.790), *Digitaria ciliaris* (11.22) and *Debregeasia saenab* (10.91) (Table 4.2.3) the most dominant families were: Asteraceae, Orchidaceae, Papilionaceae and Urticaceae. In Khar CF, dominant species were: *Bidens pilosa* (26.32), *Curculigo orchioides* (24.79), *Mikania micrantha* (23.27) and *Gynura cusimbua* (11.34) (Table 4.2.3) and the dominant families were: Asteraceae, Hypoxidaceae, Urticaceae and Poaceae. In Changki CF, the most dominant shrub species were: *Bulbophyllum affine* (30.19), *Hypericum japonicum* (26.24), *Curculigo capitulata* (24.92) and *Drymaria cordata* (12.46) (Table 4.2.3) and the dominant families were: Asteraceae, Caryophyllaceae, Hypericaceae and Liliaceae. The highest herb density (individuals $ha^{-1}$) was recorded from Khar CF (81875) followed by Minkong CF (58750), Longkhum CF (51875), Tuli CF (52500), Changtongy CF (51250) and Changki CF (47500) respectively (Table 4.2.1).

**Table 4.2.3** Density (individuals ha$^{-1}$) and Important value index (IVI) of shrubs and herbs species in six study sites of Mokokchung District, Nagaland

| Species | Family | Longkhum | | Minkong | | Khar | | Tuli | | Changki | | Changtongya | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D | IVI | D | IVI | D | IVI | D | IVI | D | IVI | D | IVI |
| **Shrubs** | | | | | | | | | | | | | |
| *Abuliton indicum* (L.) Sweet | Malvaceae | | | 50 | 1.98 | | | | | | | | |
| *Acacia pennata* Dalzell & A.Gibson | Mimosaceae | | | 150 | 4.52 | | | | | | | 100 | 4.03 |
| *Acacia pruinescens* Kurz | Mimosaceae | 200 | 9.06 | | | | | | | | | | |
| *Agapetes macrantha* (Hook.) Benth. & Hook.f. | Ericaceae | | | 300 | 7.63 | | | | | | | | |
| *Amomum dealbatum* Roxb. | Zingiberaceae | | | 100 | 2.54 | | | | | | | | |
| *Amomum pterocarpum* Thwaites | Zingiberaceae | | | | | | | 1000 | 34.95 | 150 | 5.80 | 150 | 4.59 |
| *Amomum subulatum* Roxb. | Zingiberaceae | | | | | 50 | 3.59 | | | | | | |
| *Baliospermum solanifolium* (Burm.) Suresh | Euphorbiaceae | | | | | | | | | | | 200 | 6.61 |
| *Boehmeria glomerulifera* Miq. | Urticaceae | | | | | | | 50 | 3.80 | 750 | 18.47 | | |
| *Boehmeria japonica* (L.f.) Miq. | Urticaceae | | | 450 | 9.34 | 350 | 15.36 | | | | | 300 | 9.19 |
| *Breynia retusa* (Dennst.) Alston | Euphorbiaceae | | | 200 | 5.09 | | | 50 | 3.80 | 250 | 9.08 | | |
| *Calamus rotang* L. | Arecaceae | | | 50 | 1.98 | | | | | | | | |
| *Camellia oleifera* Abel | Theaceae | | | 350 | 6.79 | | | 100 | 7.60 | 200 | 6.56 | | |
| *Clerodendrum glandulosum* Lindl. | Verbenaceae | 750 | 21.03 | 150 | 4.52 | | | | | 900 | 20.76 | | |
| *Clerodendrum japonicum. Lindl.* | Verbenaceae | | | | | 100 | 7.18 | | | | | 400 | 8.87 |
| *Clerodendrum laevifolium* Blume | Verbenaceae | | | | | | | | | | | 350 | 6.85 |
| *Clerodendrum wallichii* Merr. | Verbenaceae | 250 | 9.99 | | | | | 150 | 8.83 | 300 | 9.84 | | |
| *Crotalaria juncea* L. | Papilionaceae | | | 100 | 2.54 | | | | | | | | |
| *Croton caudatus* Geiseler | Euphorbiaceae | | | 250 | 7.07 | | | 50 | 3.80 | | | 700 | 13.71 |
| *Daphne involucrata* Wall. | Thymelaeaceae | 100 | 3.64 | 1050 | 17.57 | | | | | | | 50 | 2.01 |
| *Debregeasia longifolia* (Burm.f.) Wedd. | Urticaceae | | | 200 | 5.09 | 150 | 8.33 | | | 50 | 2.52 | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Debregeasia saenab* (Forssk.) Hepper & J.R.I. Wood | Urticaceae | 300 | 10.91 | | | | | | | | | | |
| *Dendrocnide sinuata* (Blume) Chew. | Urticaceae | | | 850 | 15.29 | | | 700 | 27.54 | | | 150 | 4.59 |
| *Desmodium heterocarpon* (L.)DC. | Papilionaceae | 200 | 7.28 | 50 | 1.98 | | | | | 100 | 3.28 | | |
| *Desmodium laxiflorum* Sensu Miq., p.p. | Papilionaceae | | | | | 100 | 4.74 | | | | | 250 | 7.17 |
| *Desmodium oblongum* Benth. | Papilionaceae | | | 150 | 4.52 | 50 | 3.59 | | | | | | |
| *Desmodium triquetrum* (L.) DC. | Papilionaceae | | | | | | | 150 | 8.83 | | | | |
| *Desmodium velutinum* (Willd.)DC. | Papilionaceae | | | | | | | | | | | 200 | 5.16 |
| *Deutzia compacta* Craib | Hydrangeaceae | 50 | 2.71 | 100 | 3.95 | 100 | 7.18 | | | | | | |
| *Dracaena angustifolia* (Medik.) Roxb. | Dracaenaceae | 150 | 6.35 | | | | | 200 | 12.63 | 150 | 5.80 | | |
| *Elaeagnus conferta* Roxb. | Elaeagnaceae | 100 | 5.42 | | | | | | | | | | |
| *Eriobotrya bengalensis* (Roxb.) Hook.f. | Rosaceae | | | 150 | 4.52 | | | | | | | | |
| *Eupatorium adoratum* L. | Compositae | | | 400 | 7.36 | 700 | 25.85 | | | 400 | 11.37 | 450 | 7.98 |
| *Eupatorium cannabinum* L. | Compositae | 650 | 19.18 | | | | | | | | | | |
| *Ficus hirta* Vahl. | Moraceae | | | | | | | | | 250 | 7.33 | | |
| *Grewia abutilifolia* Vent. ex Juss. | Tiliaceae | | | | | | | 100 | 7.60 | | | | |
| *Hedychium marginatum* C.B.Clarke | Zingiberaceae | | | | | 100 | 7.18 | 150 | 8.83 | 150 | 4.04 | 100 | 2.58 |
| *Hibiscus sabdariffa* L. | Malvaceae | | | 50 | 1.98 | | | | | | | | |
| *Jasminum nervosum* Lour. | Oleaceae | | | | | | | | | 50 | 2.52 | | |
| *Leea alata* Edgew. | Leeaceae | | | | | | | | | 450 | 13.89 | | |
| *Leea compactiflora* Kurz | Leeaceae | 400 | 14.55 | | | 200 | 7.04 | 200 | 12.63 | 300 | 9.84 | 300 | 6.29 |
| *Leea macrophylla* Roxb. ex Hornem. | Leeaceae | | | | | | | | | | | 1250 | 19.92 |
| *Leucoceptrum canum* Sm. | Lamiaceae | | | 100 | 2.54 | | | | | | | | |
| *Lyonia macrocalyx* (J. Anthony) Airy Shaw | Ericaceae | | | | | | | | | | | 150 | 3.14 |
| *Maesa indica* (Roxb.) A. DC. | Myrsinaceae | 450 | 15.48 | 550 | 11.88 | | | | | 350 | 10.61 | 1000 | 17.10 |
| *Melastoma malabathricum* L. | Melastomataceae | | | 150 | 3.11 | | | 50 | 3.80 | 200 | 6.56 | 200 | 5.16 |
| *Millettia pachycarpa* Benth. | Papilionaceae | 150 | 8.13 | 200 | 5.09 | | | 100 | 5.03 | 100 | 5.04 | 150 | 3.14 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Mussaenda frondosa* L. | Rubiaceae | | | | | | | 150 | 8.83 | 450 | 12.13 | 100 | 4.03 |
| *Mussaenda glabra* Vahl | Rubiaceae | 200 | 9.06 | | | | | | | | | | |
| *Mussaenda macrophylla* wall. | Rubiaceae | | | | | | | | | | | 300 | 7.74 |
| *Mussaenda roxburghii* Hook.f. | Rubiaceae | 250 | 9.99 | 500 | 9.91 | 600 | 23.55 | | | | | | |
| *Neillia thyrsiflora* D. Don | Rosaceae | | | 100 | 3.95 | | | | | | | | |
| *Osbeckia nepalensis* Hook.f. | Melastomataceae | | | 150 | 4.52 | 150 | 8.33 | | | | | | |
| *Osbeckia stellata* Buch.-Ham. ex Ker Gawl. | Melastomataceae | | | | | | | 50 | 3.80 | 150 | 5.80 | | |
| *Oxalis acetosella* L. | Oxalidaceae | | | 200 | 6.50 | | | | | | | | |
| *Oxyspora paniculata* (D.Don) DC. | Melastomataceae | 150 | 6.35 | 50 | 1.98 | | | | | 200 | 6.56 | 150 | 4.59 |
| *Phlogacanthus tubiflorus* Ness | Acanthaceae | | | | | 100 | 7.18 | | | | | | |
| *Phrynium capitatum* Willd. | Marantaceae | | | | | 900 | 30.45 | | | | | | |
| *Rubus calophyllus* C. B. Clarke | Rosaceae | 50 | 2.71 | | | | | | | | | | |
| *Rubus ellipticus* Sm. | Rosaceae | | | 150 | 4.52 | | | | | | | | |
| *Rubus ferox* Vest | Rosaceae | | | 350 | 8.20 | | | | | | | | |
| *Rubus hexagynus* Roxb. | Rosaceae | | | | | | | 100 | 5.03 | | | | |
| *Rubus lucens* Focke | Rosaceae | | | 1000 | 17.00 | | | | | | | 250 | 5.72 |
| *Rubus moluccanus* L. | Rosaceae | 100 | 5.42 | | | | | | | | | 200 | 6.61 |
| *Rubus pedunculosus* D. Don | Rosaceae | | | | | 250 | 13.06 | | | | | | |
| *Sambucus adnata* DC. | Sambucaceae | 250 | 9.99 | | | 100 | 4.74 | | | | | | |
| *Sambucus javanica* Blume | Sambucaceae | | | | | | | | | 100 | 3.28 | | |
| *Securinega species* Comm. ex A.Juss. | Euphorbiaceae | | | 150 | 4.52 | | | | | | | | |
| *Senna hirsuta* (L.) H.S.Irwin & Barneby | Leguminosae | | | | | | | | | | | 150 | 4.59 |
| *Sida cordifolia* L. | Malvaceae | 500 | 16.40 | | | | | | | | | | |
| *Sterculia hamiltonii* (Kuntze) Adelb. | Sterculiaceae | | | | | 200 | 11.91 | 50 | 3.80 | 200 | 6.56 | 400 | 7.42 |
| *Strobilanthes denticulatus* (Wall. ex Nees) T.Anders. | Acanthaceae | | | | | | | | | 100 | 3.28 | | |
| *Symplocos paniculata* (Thunb.) Miq. | Symplocaceae | | | | | | | | | | | 150 | 4.59 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Urena labota* L. | Malvaceae | | | | | | | 600 | 25.07 | | | | |
| *Vaccinium sprengelii* (G.Don) Sleumer | Ericaceae | | | | | | | | | | | 50 | 2.01 |
| *Vaccinium vacciniaceum* (Roxb.) Sleumer | Ericaceae | | | | | | | | | | | 350 | 6.85 |
| *Vernonia saligna* DC. | Asteraceae | | | | | 50 | 3.59 | | | | | | |
| *Viburnum corylifolium* Hook.f. & Thomson | Caprifoliaceae | | | | | | | | | | | 300 | 7.74 |
| *Viburnum foetidum* Wall. | Caprifoliaceae | | | | | | | 50 | 3.80 | | | | |
| *Zanthoxylum acanthopodium* DC. | Rutaceae | | | | | 100 | 7.18 | | | 250 | 9.08 | | |
| *Zanthoxylum oxyphyllum* Edgew. | Rutaceae | 150 | 6.35 | | | | | | | | | | |
| **Herbs** | | | | | | | | | | | | | |
| *Acampe rigida* (Buch.-Ham. ex Sm.) P.F.Hunt | Orchidaceae | | | | | | | 625 | 3.46 | | | | |
| *Acanthephippium striatum* Lindl. | Orchidaceae | | | | | | | | | 1250 | 8.51 | | |
| *Achyranthes aspera* L. | Amaranthaceae | | | | | | | | | | | 1250 | 5.00 |
| *Achyranthes bidentata* Blume | Amaranthaceae | | | | | 3125 | 9.82 | | | | | | |
| *Aerides crassifolia* Parish & Rchb.f | Orchidaceae | | | | | | | | | | | 8125 | 26.11 |
| *Aerides rosea* Lodd. ex Lindl. & Paxton | Orchidaceae | | | | | | | 1250 | 6.93 | | | | |
| *Aeschynanthus acuminatus* Wall. Ex A. DC. | Gesneriaceae | | | | | | | | | 625 | 4.26 | | |
| *Ageratina adenophora (Spreng.) R.M.King & H.Rob.* | Asteraceae | | | | | | | | | | | 4375 | 18.79 |
| *Amorphophallus species* | Araceae | 1875 | 9.74 | | | | | | | | | | |
| *Andropogon munroi* C. B. Clarke | Poaceae | | | | | 1250 | 5.53 | | | | | | |
| *Anthogonium gracile* Wall. ex Lindl. | Orchidaceae | | | | | | | | | | | 625 | 3.78 |
| *Anthoxanthum horsfieldii* (Bennet) Reeder | Poaceae | | | | | 2500 | 9.05 | | | | | | |
| *Arisaema concinnum* Schott | Araceae | | | 2500 | 7.70 | | | | | | | | |
| *Artemisia indica* Willd. | Asteraceae | | | | | | | 9375 | 26.95 | | | | |
| *Artemisia vulgaris* L. | Asteraceae | | | | | | | | | | | 1250 | 5.00 |
| *Arthraxon echinatus* (Nees) Hochst. | Poaceae | 625 | 3.25 | | | | | | | | | | |
| *Arundinella purpurea* Hochst. ex Steud. | Poaceae | | | | | | | 1250 | 4.65 | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Bauhinia vahlii* Wight & Arn. | Caesalpiniaceae | | | 1250 | 5.58 | | | | | | | | |
| *Begonia palmata* D. Don | Begoniaceae | | | | | | | | | | | 1875 | 6.22 |
| *Begonia picta* Sm. Sm. | Begoniaceae | | | | | 625 | 2.76 | | | | | | |
| *Begonia roxburghii* A. DC. | Begoniaceae | | | | | | | | | 1875 | 6.89 | | |
| *Bidens pilosa* L. | Asteraceae | | | 1875 | 8.36 | 15000 | 26.3 | | | | | 3125 | 13.79 |
| *Bromus ramosus* Huds. | Poaceae | 1250 | 6.49 | | | | | | | | | | |
| *Bulbophyllum affine* Wall. ex Lindl. | Orchidaceae | | | | | | | | | 8750 | 30.2 | | |
| *Bulbophyllum candidum* Hook.f. | Orchidaceae | 1875 | 7.70 | | | | | | | | | | |
| *Bulbophyllum odoratissimum* (Sm.) Lindl. | Orchidaceae | | | | | 1250 | 5.53 | | | | | | |
| *Calamagrostis emodensis* Griseb. | Poaceae | 3125 | 10.11 | | | | | | | | | | |
| *Calanthe brevicornu* Lindl. | Orchidaceae | 625 | 3.25 | | | | | | | | | | |
| *Calanthe chloroleuca* Lindl. | Orchidaceae | | | | | 3125 | 7.82 | | | | | | |
| *Calanthe griffithii* Lindl. | Orchidaceae | 1875 | 7.70 | | | | | | | | | | |
| *Cardiocrinum giganteum* (Wall.) Makino | Liliaceae | | | | | | | | | 1250 | 5.57 | | |
| *Carex filicina* Nees | Cyperaceae | 625 | 3.25 | | | | | | | | | | |
| *Cheilocostus speciosus* (J.Koenig) C.D. Specht | Zingiberaceae | | | 5625 | 16.47 | | | | | 2500 | 8.2 | | |
| *Commelina benghalensis* L. | Commelinaceae | | | 4375 | 14.34 | | | | | | | | |
| *Commelina paludosa* Blume | Commelinaceae | | | | | | | 625 | 3.46 | | | 2500 | 7.44 |
| *Corydalis leptocarpa* Hook.f. & Thomson | Fumaraceae | 3125 | 12.15 | | | | | | | | | | |
| *Crotalaria humifusa* Graham ex Benth. | Papilionaceae | | | | | | | | | | | 625 | 3.78 |
| *Cryptochilus sanguineus* Wall. | Orchidaceae | 1250 | 4.45 | | | | | | | | | | |
| *Cuphea procumbens* Ortega | Lythraceae | 625 | 3.25 | | | | | | | | | | |
| *Curculigo orchioides* Gaertn. | Hypoxidaceae | | | 3125 | 8.77 | 13750 | 24.8 | 5625 | 19.81 | 6250 | 24.9 | | |
| *Cymbidium aloifolium* (L.) Sw. | Orchidaceae | | | 1875 | 6.64 | | | | | | | | |
| *Cyperus cyperinus* (Retz.) Suringar | Cyperaceae | | | | | | | | | | | 1250 | 5.00 |
| *Dendrobium chrysanthum Wall Ex.Lindl.* | Orchidaceae | | | | | | | 1875 | 8.12 | | | | |
| *Dendrobium fugax* Rch.f. | Orchidaceae | 2500 | 8.90 | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Dendrobium hookerianum* Lindl. | Orchidaceae | | | | | | | | | | | 1875 | 8.79 |
| *Dendrobium lituiflorum* Lindl. | Orchidaceae | | | 1250 | 5.58 | | | | | | | | |
| *Desmodium microphyllum* (Thunb.) DC. | Papilionaceae | | | | | | | | | 625 | 4.26 | 6875 | 23.67 |
| *Dichrocephala integrifolia* (L.f.) Kuntze | Asteraceae | | | | | | | | | 1250 | 8.51 | | |
| *Didymocarpus pedicellata* R.Br. | Gesneriaceae | 1875 | 7.70 | | | | | 625 | 3.46 | | | | |
| *Digitaria ciliaris* (Retz.) Koeler | Poaceae | | | | | | | | | | | 3125 | 11.23 |
| *Dioscorea glabra* Roxb. | Dioscoreaceae | | | 625 | 2.79 | | | | | | | | |
| *Dioscorea tomentosa* J. Koenig ex Spreng. | Dioscoreaceae | | | | | | | 1250 | 4.65 | | | 1875 | 8.79 |
| *Drymaria cordata* (L.) Willd. Ex Schult. | Caryophyllaceae | | | 1875 | 6.64 | | | 1875 | 8.12 | 3125 | 12.5 | 1250 | 5.00 |
| *Elatostema hookerianum* Wedd. | Urticaceae | 7500 | 22.62 | | | | | | | | | 625 | 3.78 |
| *Elatostema integrifolium* (D. Don) Wedd. | Urticaceae | | | | | 1875 | 6.29 | | | | | | |
| *Elatostema lineolatum* Wight | Urticaceae | | | | | | | 2500 | 7.03 | 625 | 4.26 | | |
| *Elatostema platyphyllum* Wedd. | Urticaceae | | | | | 2500 | 9.05 | | | | | | |
| *Elatostema sessile* J.R. Forster & G. Forster | Urticaceae | | | 625 | 2.79 | | | | | | | | |
| *Entada rheedei* Spreng. | Papilionaceae | | | 1250 | 5.58 | | | | | | | | |
| *Eria biflora* Griff. | Orchidaceae | | | | | | | | | | | 2500 | 10.01 |
| *Erythropalum scandens* Blume | Olacaceae | | | 625 | 2.79 | | | | | | | | |
| *Eupatorium ripens. L.* | Compositae | | | | | 1250 | 5.53 | | | | | | |
| *Fagopyrum acutatum* (Lehm.) Mansf. ex K. hammer | Polygonaceae | | | 1875 | 6.64 | | | | | | | | |
| *Fragaria nilgerrensis* Schltdl. ex J. Gay | Rosaceae | | | 1250 | 5.58 | | | | | | | | |
| *Galinsoga parviflora* Cav. | Asteraceae | | | | | | | | | 1250 | 5.57 | 625 | 3.78 |
| *Girardinia diversifolia* (Link) Friis | Urticaceae | | | 3750 | 13.28 | | | | | | | 1250 | 5.00 |
| *Gnetum latifolium* Blume | Gnetaceae | | | 3125 | 10.49 | | | | | | | | |
| *Gomphostemma strobilinum* Wall. ex Benth. | Lamiaceae | 1250 | 6.49 | 1875 | 6.64 | 1875 | 6.29 | | | 2500 | 11.1 | | |
| *Gonatanthus pumilus* (D.Don) Engl. & K.Krause | Araceae | 3750 | 15.39 | | | 3125 | 9.82 | | | | | | |
| *Gouania microcarpa* DC. | Rhamnaceae | | | | | | | | | | | 3125 | 11.23 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Gynura cusimbua* (D.Don) S. Moore | Asteraceae | | | | | 4375 | 11.3 | | | | | | |
| *Hedychium coronarium* J.Koenig | Zingiberaceae | | | 1250 | 5.58 | | | | | | | | |
| *Herpetospermum pedunculosum* (Ser.) C.B. Clarke (Climber) | Cucurbitaceae | | | | | 1250 | 5.53 | | | | | | |
| *Hypericum japonicum* Thunb. | Hypericaceae | | | | | | | | | 6875 | 26.2 | | |
| *Luzula effusa* Buchenau | Commelinaceae | 3125 | 10.11 | | | | | | | | | | |
| *Mikania micrantha* Kunth | Asteraceae | | | | | 12500 | 23.3 | 3750 | 13.96 | | | | |
| *Mimosa pudica L.* | Mimosaceae | | | | | 625 | 2.76 | | | | | | |
| *Mucuna macrocarpa* Wall. | Leguminosae | | | 625 | 2.79 | | | | | | | | |
| *Ophiopogon intermedius* D.Don | Liliaceae | 1875 | 7.70 | | | 3750 | 8.58 | | | | | | |
| *Ophiorrhiza gracilis* Kurz | Rubiaceae | 5000 | 15.76 | | | | | | | | | | |
| *Ophiorrhiza rugosa* (D.Don) Deb & Mondal | Rubiaceae | 1250 | 6.49 | | | | | | | | | | |
| *Oxalis corniculata* L. | Oxalidaceae | | | 2500 | 7.70 | | | 4375 | 17.42 | 3125 | 9.52 | | |
| *Oxalis debilis* Kunth | Oxalidaceae | 625 | 3.25 | | | | | | | | | | |
| *Papilionanthe teres* (Roxb.) Schltr. | Orchidaceae | 2500 | 8.90 | 3125 | 8.77 | | | 1875 | 8.12 | | | 625 | 3.78 |
| *Peperomia pellucida* (L.) Kunth | Piperaceae | 1875 | 7.70 | | | | | | | | | | |
| *Pericampylus glaucus* (Lam.) Merr. | Orchidaceae | | | | | | | 1250 | 4.65 | | | | |
| *Persicaria chinensis* (L.) H. Gross | Polygonaceae | | | | | | | 2500 | 9.31 | | | | |
| *Phaius tankervilleae* (Banks) Blume | Orchidaceae | | | | | | | 625 | 3.46 | | | | |
| *Pholidota convallariae* (E.C.Parish & Rchb.f.) Hook.f. | Orchidaceae | | | | | | | | | | | 2500 | 10.01 |
| *Pilea symmeria* Wedd. | Urticaceae | | | | | 4375 | 9.34 | | | | | | |
| *Pimpinella sikkimensis* C. B. Cl. | Apiaceae | | | | | 1250 | 3.53 | | | | | | |
| *Polygonatum cirrhifolium* (Wall.) Royle | Convallariaceae | | | | | 2500 | 7.05 | | | 625 | 4.26 | | |
| *Polygonum emodi* Meisn. | Polygonaceae | | | | | | | 1875 | 8.12 | | | | |
| *Porana paniculata* Roxb. | Convolvulaceae | | | 2500 | 7.70 | | | | | | | | |
| *Pycreus sulcinux* (C.B.Clarke) C.B.Clarke | Cyperaceae | | | | | | | | | 1250 | 5.57 | | |
| *Rhaphidophora decursiva* (Roxb.) Schott | Araceae | | | | | | | 2500 | 9.31 | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Rhynchoglossum notonianum* (Wall.) B.L. Burtt | Gesneriaceae | | | | | | | 625 | 3.46 | | |
| *Rhynchostylis retusa Bl.* | Orchidaceae | | | | | | | 1875 | 8.12 | | |
| *Saccharum longisetosum* Nayaran. ex Bor | Poaceae | | | 1875 | 6.64 | | | | | | |
| *Sarcopyramis napalensis* Wall. | Melastomataceae | | | | | | | 3750 | 13.96 | | |
| *Smilax aspera* L. | Smilacaceae | | | 3125 | 8.77 | | | | | | |
| *Spatholobus roxburghii* Benth. | Leguminosae | | | 1250 | 3.85 | | | | | | |
| *Spermacoce hispida* L. | Rubiaceae | | | | | | | 625 | 3.46 | | |
| *Spilanthes acmella* (L.) L. | Asteraceae | | | | | | | | | 1875 | 9.83 |
| *Stephania glandulifera* Miers | Menispermaceae | | | | | | | | | 625 | 4.26 |
| *Tetrastigma lanceolarium* (Roxb.) Planch. | Vitaceae | 1250 | 4.45 | 1875 | 6.64 | | | | | | |
| *Tinospora sinensis* (Lour.) Merr. | Menispermaceae | | | 1875 | 4.92 | | | | | | |
| *Vanda tessellata* (Roxb.) Hook. ex G.Don | Orchidaceae | | | | | | | | | 1250 | 5.57 |
| *Viola serpens* Wall. | Violaceae | 625 | 3.25 | | | | | | | | |

### 4.2.1.2 Species diversity indices

Various diversity indices (e.g Shannon diversity index, Simpson dominance index, Menhinick species richness index and Pielou’s Evenness Index) was calculated to use as a mathematical measure of species diversity for different plant communities (trees, shrubs and herbs) recorded from six community forest of Mokokchung district, Nagaland.

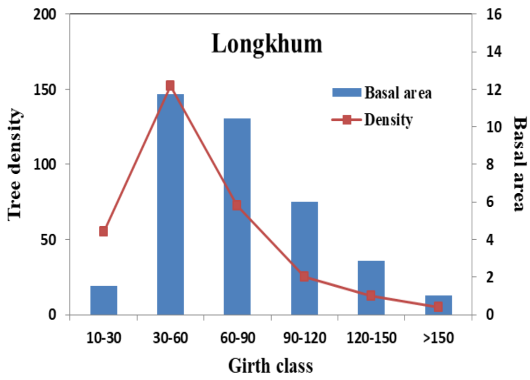
In trees, Shannon diversity index (H') value recorded highest in Minkong CF (3.88) followed by Khar CF (3.78), Tuli CF (3.43), Longkhum CF (3.32), Changki CF (3.05) and the lowest in Changtongya CF (2.95). The Simpson dominance index (CD) in the present study ranged from 0.03 – 0.09 where the CD was recorded highest in Changtongya CF (0.09) followed by Changki CF (0.08), Longkhum CF (0.06), Tuli CF (0.05), Khar CF (0.04) and lowest in Minkong CF (0.03). Whereas the Margalef species richness index (Dmg) was recorded highest in Khar CF (10.53) followed by Minkong CF (10.46), Longkhum CF (7.68) and Tuli CF (7.34). The lowest Dmg was recorded in Changtongya CF (5.16) and Changki CF (5.80). The Pielou’s evenness index (e) of tree species ranged from 0.90 – 0.98 indicating that the community is quite even in the six community forest (Table 4.2.1).

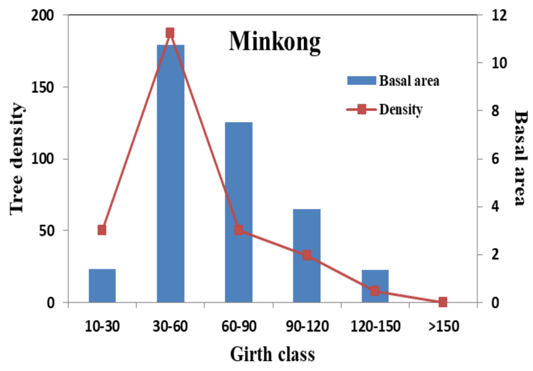
In shrubs, the Shannon diversity index (H') in the present study ranged from 2.46 – 3.12 where the highest H' was recorded in Minkong CF (3.12) followed by Changtongya CF (3.10), Changki CF (2.97), Longkhum CF (2.76), Khar CF (2.53) and Tuli CF (2.46). The Simpson dominance index (CD) was recorded highest in Tuli CF (0.13) and lowest in Minkong CF (0.05) following the rule as Shannon diversity increases Simpson dominance index decreases. The Margalef species richness index (Dmg) in the present study ranged from 4.03 – 6.19 and the Pielou’s evenness index (e) of the six community forest ranged from 0.82 – 0.91. The community forest (Changki, Changtongya and Longkhum) showed more species evenness as compared to other community forest (Table 4.2.1).

In herbs, the highest Shannon diversity index (H') was recorded in Minkong CF (3.18) followed by Longkhum CF (2.98), Tuli CF (2.83), Changtongya CF (2.81), Changki CF (2.64) and lowest was recorded in Khar CF (2.61) respectively. The community forest such as Khar and Changki recorded higher dominance value (0.10 and 0.09) than other community forest. The Margalef species richness index (Dmg) ranged from 4.10 – 5.94 and the Pielou's evenness index (e) ranged from 0.86 – 0.95 where Minkong, Longkhum, Changtongya and Tuli CF showed more species evenness than other community forest (Table 4.2.1).

### 4.2.1.3 Population structure of tree species in various girth-classes

The tree density and basal area varied with girth classes in different community forest. The density of young trees (10 – 60 cm girth class) contributed 54% (Changtongya CF) to 73% (Khar CF) of the total tree density in all the community. Similarly, the contribution of basal area varied from 33 – 52% in these communities (Figure 5.2.1). The contribution of older tree density was highest (8% of the total) in Changki CF, whereas no older individuals were recorded in Tuli CF. The contribution of basal cover by older tree followed the pattern similar to that of tree density. Overall population structure of all communities showed a reverse *J*-shaped population curve indicating a good forest health and high species richness (Figure 4.2.1). Higher density in lower girth classes indicates a good regeneration potential of the forest showing that the future plant communities can be sustained unless there is any major biotic or abiotic changes in the forest ecosystem.



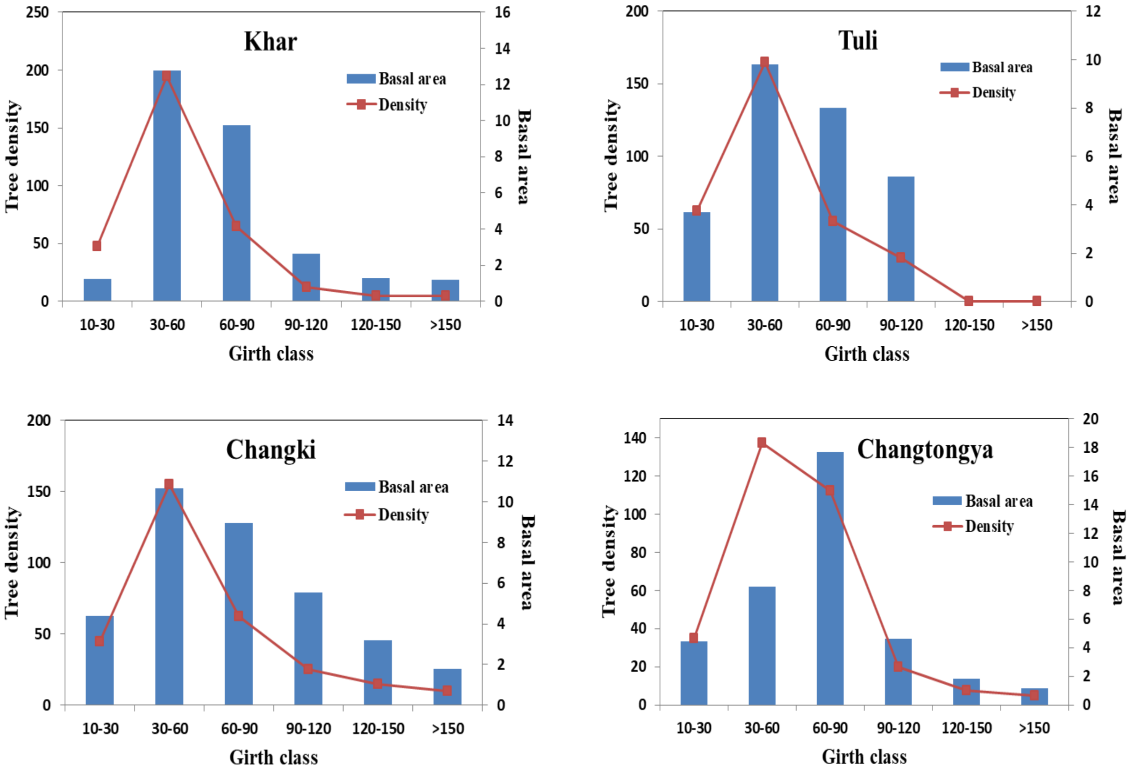
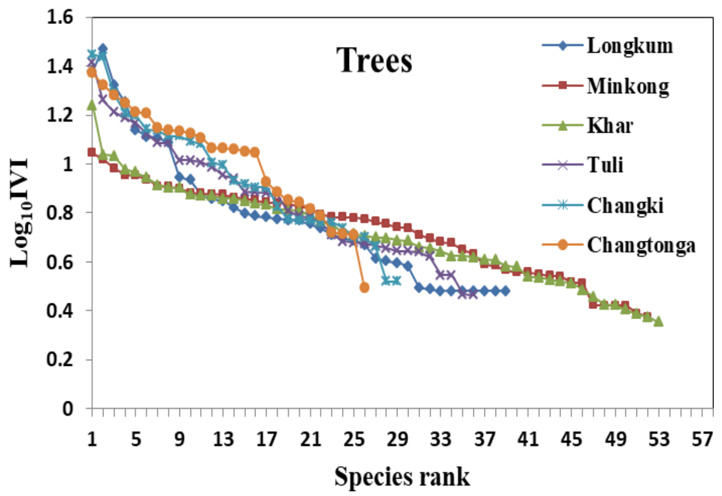
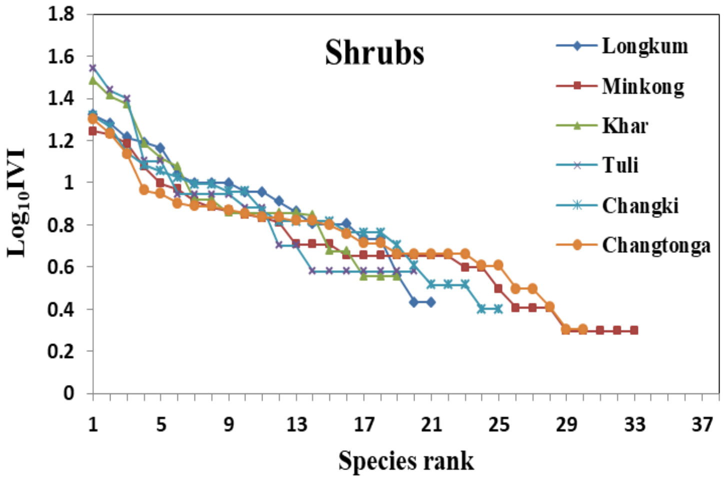



**Figure 4.2.1** Contributions of tree stand density and basal area based on girth class contribution in six study sites of Mokokchung District, Nagaland

### 4.2.1.4 Dominance-diversity curve

Dominance-diversity curve (% IVI on log scale plotted against species rank) showed mixed nature of vegetation with site wise variations in different communities. On the basis of dominance-diversity curve on tree species Minkong, Khar and Longkhum CF showed high equitability and low dominance and the dominance-diversity curve in these communities followed a log-normal distribution pattern indicating high species diversity in the forest (Figure 4.2.2). Whereas the community forest such as Changki, Changtongya and Tuli showed high dominance and low equitability indicating low species richness due to various anthropogenic pressure such as timber extraction on species like *Alnus nepaulensis, Duabanga grandiflora, Gmelina arborea, Sapium baccatum, Terminalia species* etc. The dominance-diversity curve in these communities followed a broken stick distribution pattern. In shrubs and herbs community, the dominance-diversity curve of Changki, Changtongya and Tuli CF showed high equitablity and low dominance of species and followed a log-normal distribution pattern indicating high species richness of undergrowth vegetation in the community (Figure 5.2.2). Whereas community forest such as Minkong, Khar and Longkhum showed low equitablity and high dominance of species and the dominance-diversity curve followed short hooked curve pattern indicating low species diversity which may result due to grazing, dense canopy cover of trees and various anthropogenic activities.



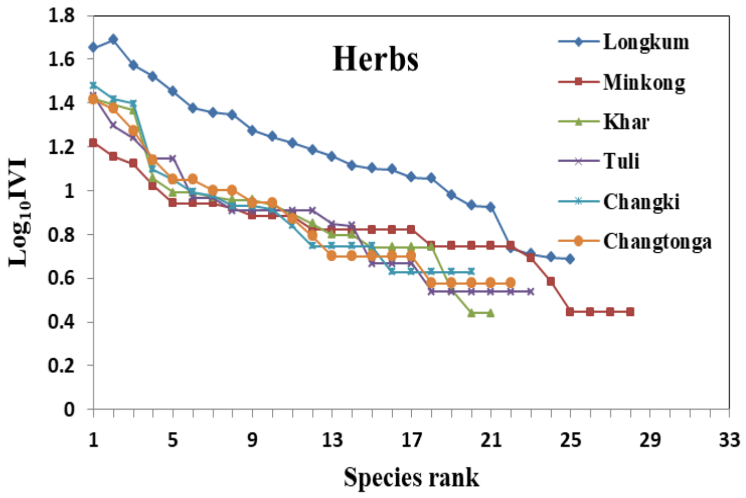



**Figure 4.2.2** Dominance-Diversity curve for trees, shrubs and herbs in six study sites of Mokokchung District, Nagaland

### 4.2.1.5 Distribution pattern of tree species

The distribution patterns of tree species in different community forest were determined by following Whitford index. A/F ratios of each individual species provide the idea of distribution of species in a given community. The distribution pattern of species in the study site was classified into regular, random and clumped/contagious distribution. The Whitford index revealed that most of the plant species in all the six community forest showed clumped distribution pattern. In Longkhum CF, it was observed that 56% of the species showed clumped type of distribution, 63% as random distribution and only 8% as regular distribution pattern. In Minkong CF, the random distribution pattern showed maximum with 46% followed by clumped distribution (42%) and regular distribution (12%) pattern. In Khar CF, 55 % showed clumped distribution, 32% as random distribution and 13% as regular distribution pattern. In Tuli CF, 56% of the total plant species showed clumped distribution pattern, 33% as random distribution and only 11% as regular distribution pattern. In Changki CF, 45% showed clumped distribution, 48% as random distribution and only 7% showed regular distribution pattern. In Changtongya CF, 54% of the total plant species showed clumped distribution pattern, 42% as random distribution and only 4% showed regular distribution pattern (Table 4.2.2).

#### 4.2.1.6 Sorenson's similarity indices for tree species

In the present study, the highest similarity of 57% was recorded between Longkhum and Khar CF followed by Tuli and Changki CF with 55% similarity in tree species composition. Whereas 46% each similarity index was observed between Longkhum and Minkong CF and Minkong and Khar CF. The lowest value of similarity index was observed between Minkong and Changki CF and Longkhum and Changtongya CF with only 22% each respectively (Table 4.2.4).

**Table 4.2.4** Sorenson Similarity indices for tree species between six study sites of Mokokchung District, Nagaland

| Study area | Longkhum | Minkong | Khar | Tuli | Changki | Changtongya |
|---|---|---|---|---|---|---|
| **Longkhum** | x | | | | | |
| **Minkong** | 0.46 | x | | | | |
| **Khar** | 0.57 | 0.46 | x | | | |
| **Tuli** | 0.24 | 0.27 | 0.25 | x | | |
| **Changki** | 0.29 | 0.22 | 0.34 | 0.55 | x | |
| **Changtongya** | 0.22 | 0.23 | 0.3 | 0.29 | 0.33 | x |

#### 4.2.1.6 Disturbance pattern

The intensity of disturbance in various community forests is shown in table 4.2.1. The disturbance index based on cut stump was highest at Tuli (22%) followed by Changki (20%) and Khar (18%) since the region is dominant with species such as *Dillenia indica*, *Duabanga grandiflora*, *Gmelina arborea* and *Sapium baccatum* which is considered as an important timber species for the local people and also due to various anthropogenic pressure on account of fuelwood requirements and agriculture tools.

### 4.2.2 Mon district

#### 4.2.2.1 Floristic structure

*Tree species composition*

In the present study, a total of 716 individuals belonging to 104 species and 79 genera representing 46 families were recorded from the four community forest (Langpongshianga, Aboi, Longchung and Longwa) and Singphan WLS of Mon district, Nagaland, Northeast India. Out of these, 47 species belonging to 41 genera, 31 families and 161 individuals were recorded from Longching CF followed by 35 species belonging to 30 genera, 22 families and 158 individuals from Aboi CF; 39 species belonging to 29 genera, 22 families and 138 individuals from Langpongshianga CF; 30 species belonging to 26 genera, 22 families and 126 individuals from Singphan CF and 26 species belonging to 23 genera, 17 families and 133 individuals from Longwa CF of Nagaland respectively (Table 4.2.5). Based on IVI value, the dominant tree species in Longching CF were: *Alstonia scholaris* (18.80), *Bischofia javanica* (15.14) and *Terminalia myriocarpa* (15.76) and the co-dominant species were: *Lithocarpus elegans* (13.89), *Magnolia rabaniana* (12.17), and *Schima wallichii* (11.66) (Table 4.2.6). The most dominant families were: Anacardiaceae, Euphorbiaceae, Fagaceae and Magnoliaceae. In Aboi CF, the dominant tree species were: *Gmelina arborea* (18.45), *Schima wallichi* (17.51) and *Duabanga grandiflora* (24.4) and the co-dominant species were: *Stereospermum chelonoides* (14.93), *Sterculia versicolor* (14.54) and *Garcinia pedunculata* (14.22) (Table 4.2.6). The most dominant families were: Anacardiaceae, Betulaceae and Moraceae. In Langpongshianga CF, the dominant species were *Schima wallichii* (28.29) and *Duabanga grandiflora* (25.75) and the co-dominant species were *Alstonia scholaris* (14.42), *Callicarpa arborea* (13.66) and *Gmelina arborea* (12.32) (Table 4.2.6). The dominant families were: Fagaceae, Magnoliaceae and Verbenaceae. In Singphan, the dominant species were: *Dipterocarpus retusus* (24.96) and *Phoebe goalparensis* (18.93) and the co-dominant species were: *Ficus lamponga* (14.23), *Shorea assamica* (14.22) and *Gmelina arborea* (14.13) (Table 4.2.6). The dominant families were: Dipterocapceae, Lauraceae and Moraceae. In Longwa CF, the dominant species were: *Acer thomsonii* (24.11), *Rhododendron* *arboreum* (22.27) and *Quercus lamellosa* (22.14) and the co-dominant species were: *Lithocarpus pachyphyllus* (21.76) and *Cephalotaxus grifithii* (21.33) (Table 4.2.6). The most dominant families were: Elaeocarpaceae, Ericaceae, Fagaceae and Taxaceae. The tree stand density (individuals $ha^{-1}$) ranged from 333 – 403 where the highest density was recorded from Singphan (423) and Longching CF (403) and the lowest density was recorded from Longwa CF (333). The basal area ($m^2ha^{-1}$) ranged from 24.88 – 39.61 where the highest basal area was recorded from Singphan (39.61) and the lowest basal area from Aboi (24.88) and Langpongshianga CF (28.70) (Table 4.2.5).

*Shrub species composition*

In shrubs, a total of 100 species and 56 genera representing 37 families were recorded from four community forest (Langpongshianga, Aboi, Longchung and Longwa) and Singphan WLS of Mon district, Nagaland, Northeast India. Out of these, 37 species belonging to 32 genera and 23 families were recorded from Langpongshianga CF followed by 34 species, 30 genera and 24 families from Longwa CF; 32 species, 30 genera and 21 families from Singphan; 29 species, 27 genera and 23 families from Aboi CF and 24 species, 21 genera and 20 families from Longching of Nagaland respectively (Table 4.2.5). Based on IVI value, the most dominant shrub species in Langpongshianga CF were: *Sambucus javanica* (11.10), *Mussaenda macrophylla* (10.98) and *Rubus calycinus* (10.57) (Table 4.2.7) and the dominant families were: Melastomataceae, Rosaceae and Urticaceae. In Longwa CF, the most dominant species were: *Clerodendrum bracteatum* (17.65), *Musseanda glabra* (14.78) and *Osbeckia crinita* (13.82) (Table 4.2.7) and the dominant families were: Berberidaceae, Rosaceae and Lamiaceae. In Singphan, the most dominant species were: *Leea macrophylla* (17.09), *Clerodendrum chinensis* (14.34) and *Phlogacanthus curviflorus* (12.69) (Table 4.2.7) and the dominant families were: Leeaceae, Rubiaceae and Theaceae. In Aboi CF, the dominant shrub species were *Clerodendrum japonicum* (15.32), *Musseanda glabra* (14.55) and *Boehmeria hamiltonia* (13.96) (Table 4.2.7) and the most dominant families were Ericaceae, Melastomataceae and Urticaceae. In Longching CF, dominant species were: *Ardisia grifithii* (19.02), *Leea alata* (17.70) and *Clerodendrum glandulosum* (15.32) (Table 4.2.7) and the dominant families were: Leguminosae and Rosaceae. The highest shrub density (individuals $ha^{-1}$) was recorded from Longwa CF (10450) followed by Langpongshianga CF (9300), Singphan (9100), Longching CF (8100) and Aboi CF (7350) respectively (Table 4.2.5).

**Table 4.2.5** Phytosociological attributes of trees, shrubs and herbs in five study sites of Mon District, Nagaland

| Parameters | Longching | Aboi | Langpongshianga | Singphan | Longwa |
|---|---|---|---|---|---|
| **Trees** | | | | | |
| No. of species | 47 | 35 | 32 | 30 | 26 |
| No. of genera | 41 | 30 | 29 | 26 | 23 |
| Families | 31 | 22 | 22 | 22 | 17 |
| Density (individuals $ha^{-1}$) | 403 | 395 | 345 | 423 | 333 |
| Basal area ($m^2ha^{-1}$) | 36.59 | 24.88 | 28.70 | 39.61 | 30.29 |
| Shannon diversity index (H') | 3.63 | 3.30 | 3.11 | 3.27 | 2.90 |
| Simpson dominance index (CD) | 0.03 | 0.03 | 0.04 | 0.04 | 0.06 |
| Margalef species richness index (Dmg) | 9.05 | 6.71 | 6.29 | 5.65 | 5.11 |
| Evenness (e) | 0.94 | 0.92 | 0.89 | 0.96 | 0.89 |
| Disturbance index (%) | 25 | 15 | 19 | 12 | 22 |
| **Shrubs** | | | | | |
| No. of species | 24 | 29 | 37 | 32 | 34 |
| No. of genera | 21 | 27 | 32 | 30 | 30 |
| Families | 20 | 23 | 23 | 21 | 24 |
| Density (individuals $ha^{-1}$) | 8100 | 7350 | 9300 | 9100 | 10450 |
| Shannon diversity index (H') | 2.89 | 2.98 | 3.29 | 3.14 | 3.17 |
| Simpson dominance index (CD) | 0.07 | 0.06 | 0.04 | 0.05 | 0.05 |
| Margalef species richness index (Dmg) | 4.52 | 5.61 | 6.89 | 5.96 | 6.18 |
| Evenness (e) | 0.90 | 0.88 | 0.91 | 0.90 | 0.88 |
| **Herbs** | | | | | |
| No. of species | 33 | 31 | 38 | 36 | 41 |
| No. of genera | 33 | 28 | 38 | 35 | 38 |
| Families | 22 | 21 | 23 | 30 | 22 |
| Density (individuals $ha^{-1}$) | 84375 | 86250 | 89000 | 125625 | 151250 |
| Shannon diversity index (H') | 3.13 | 3.15 | 3.50 | 3.08 | 3.53 |
| Simpson dominance index (CD) | 0.06 | 0.05 | 0.03 | 0.06 | 0.05 |
| Margalef species richness index (Dmg) | 6.52 | 6.09 | 7.14 | 6.60 | 7.29 |
| Evenness (e) | 0.89 | 0.92 | 0.96 | 0.86 | 0.95 |

**Table 4.2.6** Density (individuals ha$^{-1}$), Basal area (m$^2$ha$^{-1}$), Important value index (IVI) and Distribution pattern (DP) of tree species in five study sites of Mon District, Nagaland

| Species | Family | Longching | | | | Aboi | | | | Langpongshianga | | | | Singphan | | | | Longwa | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** |
| *Abies densa* Griff. | Pinaceae | | | | | | | | | | | | | | | | | 7.5 | 2.24 | 13.82 | RE |
| *Acer sikkimense* Miq. | Aceraceae | 5 | 0.16 | 3.61 | RE | 5 | 0.18 | 4.82 | RE | 5 | 0.46 | 5.09 | C | 7.5 | 0.13 | 3.38 | C | | | | |
| *Acer thomsonii* Miq. | Aceraceae | | | | | | | | | | | | | | | | | 32.5 | 2.66 | 24.11 | R |
| *Actinodaphne obovata* (Nees) Blume | Lauraceae | | | | | | | | | | | | | | | | | 10 | 1.00 | 11.87 | RE |
| *Adina polycephala* Benth. | Rubiaceae | | | | | | | | | | | | | 20 | 0.90 | 10.86 | R | | | | |
| *Ailanthus integrifolia* Lam. | Simaroubaceae | | | | | | | | | | | | | 10 | 1.77 | 9.39 | R | | | | |
| *Albizia chinensis* (Osbeck) Merr. | Mimosaceae | | | | | | | | | 10 | 1.33 | 9.58 | C | | | | | | | | |
| *Albizia procera* (Roxb.) Benth. | Mimosaceae | | | | | 7.5 | 0.61 | 8.56 | RE | 7.5 | 0.69 | 6.61 | C | | | | | | | | |
| *Alnus nepalensis* D.Don | Betulaceae | 7.5 | 0.91 | 6.29 | R | 15 | 1.47 | 13.92 | RE | 7.5 | 1.16 | 8.27 | C | | | | | | | | |
| *Alstonia scholaris* (L.) R. Br. | Apocynaceae | 32.5 | 2.50 | 18.80 | R | | | | | 15 | 1.72 | 14.42 | C | | | | | | | | |
| *Altingia excelsa* Noronha | Altingiaceae | 15 | 1.38 | 10.41 | RE | | | | | | | | | | | | | | | | |
| *Amoora wallichii* King | Meliaceae | | | | | 12.5 | 0.91 | 12.47 | RE | 12.5 | 1.19 | 11.86 | R | | | | | | | | |
| *Aquilaria agallocha* Roxb. | Thymelaeaceae | | | | | | | | | | | | | 20 | 0.98 | 12.35 | RE | | | | |
| *Artocarpus chama* Buch.-Ham. | Moraceae | 7.5 | 1.05 | 7.64 | RE | 7.5 | 0.67 | 6.00 | C | 7.5 | 1.43 | 9.21 | C | 10 | 1.40 | 8.45 | R | | | | |
| *Bauhinia divergens* Baker | Caesalpiniaceae | | | | | 5 | 0.18 | 4.79 | RE | 7.5 | 0.26 | 5.13 | C | 15 | 0.18 | 5.29 | C | 5 | 0.23 | 3.65 | C |
| *Bauhinia purpurea* L. | Caesalpiniaceae | | | | | 12.5 | 0.41 | 7.63 | R | | | | | | | | | | | | |
| *Beilschmiedia roxburghiana* Nees | Lauraceae | | | | | 7.5 | 0.43 | 5.03 | C | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Betula alnoides* Buch.-Ham. ex D.Don | Betulaceae | 10 | 1.39 | 10.17 | RE | 7.5 | 1.75 | 10.34 | C | | | | | | | | | | | | |
| *Bischofia javanica* Blume | Euphorbiaceae | 27.5 | 1.62 | 15.14 | RE | | | | | | | | | 15 | 0.67 | 9.09 | R | | | | |
| *Callicarpa arborea* Roxb. | Verbenaceae | 5 | 0.13 | 2.56 | R | | | | | 20 | 0.50 | 13.66 | R | | | | | | | | |
| *Castanopsis indica* (Roxb. ex Lindl.) A.DC. | Fagaceae | | | | | | | | | | | | | 17.5 | 1.33 | 12.63 | RE | 20 | 1.26 | 15.73 | RE |
| *Castanopsis lanceifolia* (Oerst.) Hickel & A.Camus | Fagaceae | | | | | | | | | 5 | 0.15 | 4.02 | C | | | | | | | | |
| *Cephalotaxus griffithii* Hook.f. | Taxaceae | | | | | | | | | | | | | | | | | 30 | 2.04 | 21.33 | R |
| *Choerospondias axillaris* (Roxb.) B.L. Burtt & A.W. Hill | Anacardiaceae | 15 | 0.46 | 8.86 | RE | 15 | 0.42 | 8.29 | C | 10 | 0.24 | 7.83 | R | | | | | | | | |
| *Cupressus torulosa* D.Don ex Lamb. | Cupressaceae | | | | | | | | | | | | | | | | | 7.5 | 1.12 | 10.13 | RE |
| *Dipterocarpus retusus* Blume | Dipterocarpaceae | | | | | | | | | | | | | 27.5 | 5.28 | 24.96 | R | | | | |
| *Drimycarpus racemosus* (Roxb.) Hook.f. ex Marchand. | Anacardiaceae | | | | | | | | | 7.5 | 0.36 | 5.46 | C | | | | | | | | |
| *Duabanga grandiflora* DC. Walp. | Lythraceae | 7.5 | 1.30 | 7.35 | R | 20 | 1.57 | 15.61 | R | 30 | 3.14 | 25.75 | R | 25 | 1.96 | 14.72 | R | | | | |
| *Echinocarpus dasycarpus* Benth. | Elaeocarpaceae | | | | | | | | | | | | | | | | | 5 | 0.15 | 4.77 | RE |
| *Elaeocarpus floribundus* Blume | Elaeocarpaceae | | | | | | | | | | | | | | | | | 2.5 | 0.75 | 4.63 | R |
| *Elaeocarpus lanceifolius* Roxb. | Elaeocarpaceae | | | | | | | | | | | | | 22.5 | 0.38 | 8.86 | C | | | | |
| *Elaeocarpus tectorius* (Lour.) Poir. | Elaeocarpaceae | 7.5 | 0.34 | 5.71 | RE | 5 | 0.12 | 3.18 | C | 7.5 | 0.19 | 4.87 | C | | | | | 5 | 0.48 | 4.48 | C |
| *Engelhardtia spicata* Lesch. Ex Blume | Juglandaceae | 7.5 | 0.85 | 5.15 | C | | | | | 7.5 | 0.99 | 7.67 | C | | | | | | | | |
| *Erythrina arborescens* Roxb. | Leguminosae | 5 | 0.14 | 3.57 | RE | | | | | | | | | | | | | | | | |
| *Erythrina variegata* L. | Leguminosae | 5 | 0.14 | 2.61 | C | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (Minimum) | | | | | | | | | | | | | | | | | | | | | |
| *Eurya acuminata* DC. | Theaceae | 2.5 | 0.12 | 1.93 | R | 2.5 | 0.11 | 2.48 | R | | | | | | | | | | | | |
| *Exbucklandia populnea* (R. Br. ex Griff.) R. W. Br. | Hamamelidaceae | | | | | | | | | | | | | | | | | 10 | 0.93 | 10.23 | RE |
| *Ficus auriculata* Lour. | Moraceae | | | | | 5 | 0.22 | 3.54 | C | | | | | 5 | 0.17 | 4.18 | RE | | | | |
| *Ficus lamponga* Miq. | Moraceae | | | | | | | | | | | | | 7.5 | 3.42 | 14.26 | RE | | | | |
| *Ficus neriifolia* Sm. | Moraceae | 5 | 0.14 | 2.60 | C | | | | | | | | | | | | | | | | |
| *Ficus semicordata* Buch.-Ham. Ex Sm. | Moraceae | 10 | 0.43 | 7.54 | RE | | | | | | | | | 5 | 0.14 | 4.10 | RE | | | | |
| *Firmiana colorata* (Roxb.) R.Br. (Deciduous) | Sterculiaceae | | | | | 7.5 | 0.46 | 5.17 | C | | | | | | | | | | | | |
| *Garcinia anomala* Planch. & Triana | Clusiaceae | 10 | 0.24 | 6.06 | RE | | | | | | | | | | | | | | | | |
| *Garcinia lanceifolia* Roxb. | Clusiaceae | 5 | 0.11 | 2.52 | C | | | | | | | | | | | | | | | | |
| *Garcinia pedunculata* Buch.-Ham. Ex Sm. | Clusiaceae | 5 | 0.18 | 3.68 | RE | 22.5 | 0.72 | 14.22 | RE | | | | | | | | | | | | |
| *Garcinia sopsopia* (Buch.-Ham.) Mabb. | Clusiaceae | 5 | 0.23 | 2.84 | C | 7.5 | 0.32 | 6.00 | R | 5 | 0.10 | 3.85 | C | | | | | | | | |
| *Gmelina arborea* Roxb. | Verbenaceae | 15 | 1.57 | 10.93 | R | 27.5 | 1.81 | 18.45 | R | 12.5 | 1.32 | 12.32 | R | 15 | 1.77 | 13.14 | RE | | | | |
| *Gnetum gnemon* (parl.) Markgr. | Gnetaceae | | | | | | | | | | | | | 10 | 0.10 | 3.91 | C | | | | |
| *Gynocardia odorata* R. Br. | Achariaceae | 2.5 | 0.09 | 1.85 | R | | | | | | | | | | | | | | | | |
| *Hovenia dulcis* Thunb. | Rhamnaceae | 10 | 0.98 | 9.05 | RE | | | | | | | | | | | | | | | | |
| *Ilex excelsa* (Wall.) Hook. fil. | Aquifoliaceae | | | | | | | | | | | | | | | | | 5 | 0.14 | 4.74 | RE |
| *Iteadaphne caudata* (Nees) H.W. Li | Lauraceae | 2.5 | 0.09 | 1.83 | R | | | | | | | | | | | | | | | | |
| *Juglans regia* L. | Juglandaceae | 15 | 1.51 | 10.76 | R | | | | | | | | | | | | | | | | |
| *Kydia calycina* Roxb. | Malvaceae | 5 | 0.13 | 2.58 | C | 7.5 | 0.22 | 4.18 | C | | | | | | | | | | | | |
| *Lithocarpus elegans* (Blume) Hatus. ex | Fagaceae | 22.5 | 1.62 | 13.89 | RE | | | | | | | | | | | | | 7.5 | 1.41 | 11.08 | RE |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soepadmo | | | | | | | | | | | | | | | | | | | | | |
| *Lithocarpus fenestratus* (Roxb.) Rehder | Fagaceae | | | | | | | | | 7.5 | 2.16 | 11.72 | C | | | | | | | | |
| *Lithocarpus pachyphyllus* (Kurz) Rehder | Fagaceae | | | | | | | | | | | | | | | | | 27.5 | 2.40 | 21.76 | R |
| *Litsea cubeba* (Lour.) Pers. | Lauraceae | | | | | | | | | | | | | | | | | 12.5 | 0.25 | 7.36 | R |
| *Livistonia jenkinsiana* Griff. | Arecaceae | 5 | 0.17 | 2.67 | C | | | | | | | | | | | | | | | | |
| *Macaranga denticulata* (Blume) Müll.Arg. | Euphorbiaceae | | | | | 20 | 0.43 | 11.00 | R | 12.5 | 0.34 | 8.90 | R | | | | | | | | |
| *Macaranga indica* Wight | Euphorbiaceae | | | | | 12.5 | 0.30 | 7.17 | R | 7.5 | 0.21 | 7.00 | R | | | | | | | | |
| *Macaranga pustulata* King ex. Hook.f. | Euphorbiaceae | 10 | 0.29 | 6.18 | RE | | | | | | | | | | | | | | | | |
| *Macropanax dispermus* (Blume) Kuntze | Araliaceae | 12.5 | 0.61 | 8.65 | RE | 2.5 | 0.16 | 2.69 | R | 10 | 0.79 | 7.67 | C | 5 | 0.12 | 2.76 | C | 5 | 0.22 | 5.02 | RE |
| *Magnolia cathcartii* (Hook.f. & Thomson) Noot. | Magnoliaceae | 2.5 | 0.08 | 1.80 | R | 10 | 0.36 | 8.19 | RE | 12.5 | 0.28 | 8.69 | R | | | | | 2.5 | 0.09 | 2.45 | R |
| *Magnolia rabaniana* (Hook.f. & Thomson) D.C.S.Raju & M.P.Nayar | Magnoliaceae | 7.5 | 2.71 | 12.17 | RE | 5 | 0.26 | 3.73 | C | 7.5 | 1.09 | 8.03 | C | | | | | | | | |
| *Mallotus phillipianum* (Lam.) Müll.Arg. | Euphorbiaceae | 5 | 0.44 | 3.41 | C | | | | | | | | | | | | | | | | |
| *Mangiferae sylvatica* Roxb. | Anacardiaceae | 7.5 | 0.44 | 4.05 | C | | | | | | | | | | | | | | | | |
| *Melia azedarach* L. | Meliaceae | 7.5 | 0.96 | 6.43 | R | 7.5 | 0.99 | 7.31 | C | | | | | | | | | | | | |
| *Mesua ferrea* L. | Clusiaceae | | | | | | | | | | | | | 17.5 | 0.84 | 10.10 | R | | | | |
| *Morus laevigata* Wall. ex Brandis | Moraceae | | | | | 15 | 1.19 | 11.39 | C | 20 | 2.11 | 19.27 | R | | | | | | | | |
| *Myrica esculanda* Buch.-Ham. ex D.Don | Myricaceae | 7.5 | 0.37 | 5.80 | RE | 20 | 0.88 | 12.82 | R | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Nephelium lappaceum* L. | Sapindaceae | | | | | 7.5 | 0.45 | 5.11 | C | 7.5 | 0.43 | 5.70 | C | | | | | | | | |
| *Phoebe goalparensis* Hutch. | Lauraceae | | | | | | | | | | | | | 20 | 3.59 | 18.93 | RE | | | | |
| *Phoebe lanceolata* (Nees) Nees | Lauraceae | 2.5 | 0.69 | 3.48 | R | | | | | | | | | 5 | 0.30 | 4.50 | RE | | | | |
| *Pongamia pinnata* (L.) Pierre | Leguminosae | | | | | | | | | | | | | 12.5 | 1.02 | 10.65 | RE | | | | |
| *Prunus napaulensis* (Ser.) Steud. | Rosaceae | | | | | | | | | | | | | | | | | 10 | 1.43 | 11.91 | RE |
| *Pterospermum acerifolium* (L.) Willd. | Sterculiaceae | | | | | | | | | | | | | 7.5 | 0.83 | 6.43 | R | | | | |
| *Quercus lamellosa* Sm. | Fagaceae | | | | | | | | | | | | | | | | | 12.5 | 3.89 | 22.14 | RE |
| *Rhododendron arboreum* Sm. | Ericaceae | | | | | | | | | | | | | | | | | 40 | 1.42 | 22.27 | R |
| *Rhododendron fulgens* hook.f. | Ericaceae | | | | | | | | | | | | | | | | | 10 | 0.51 | 7.46 | R |
| *Rhus chinensis* Mill. | Anacardiaceae | 7.5 | 0.22 | 4.40 | R | 12.5 | 0.27 | 7.07 | R | 10 | 0.31 | 8.05 | R | | | | | | | | |
| *Rhus griffithi* Hook. f. | Anacardiaceae | | | | | 10 | 0.29 | 6.53 | R | | | | | | | | | | | | |
| *Sapindus mukorossi* Gaertn. | Sapindaceae | | | | | | | | | | | | | 10 | 0.97 | 8.67 | RE | | | | |
| *Sapium baccatum* Roxb. | Euphorbiaceae | | | | | | | | | | | | | 22.5 | 1.76 | 14.90 | RE | | | | |
| *Sauraruia roxburghii* wall. | Actinidiaceae | 2.5 | 0.08 | 1.82 | R | | | | | | | | | | | | | | | | |
| *Saurauia nepaulensis* DC. | Actinidaceae | | | | | | | | | 10 | 0.35 | 6.15 | C | | | | | | | | |
| *Schefflera venulosa* (Wight & Arn.) Harms | Araliaceae | 5 | 0.17 | 3.65 | RE | | | | | | | | | | | | | | | | |
| *Schima khasiana* Dyer | Theaceae | | | | | | | | | | | | | | | | | 22.5 | 2.34 | 20.06 | RE |
| *Schima wallichii* Choisy | Theaceae | 15 | 1.48 | 11.66 | RE | 22.5 | 1.89 | 17.51 | R | 32.5 | 3.07 | 28.29 | R | 30 | 1.42 | 14.53 | C | | | | |
| *Shorea assamica* Dyer | Dipterocarpaceae | | | | | | | | | | | | | 7.5 | 3.91 | 14.22 | R | | | | |
| *Shorea robusta* Gaertn. | Dipterocarpaceae | | | | | | | | | | | | | 5 | 3.19 | 11.79 | RE | | | | |
| *Sterculia roxburghii* | Malvaceae | | | | | | | | | | | | | | | | | 12.5 | 0.36 | 9.12 | RE |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| wall. | | | | | | | | | | | | | | | | | | | | | |
| *Sterculia versicolor* Wall. | Sterculiaceae | | | | | 25 | 0.99 | 14.54 | R | | | | | | | | | | | | |
| *Stereospermum chelonoides* (L.f.) DC. | Bignoniaceae | 5 | 3.02 | 10.46 | C | 5 | 3.05 | 14.93 | C | 7.5 | 1.45 | 9.28 | C | | | | | | | | |
| *Styrax serrulatus*Roxb. | Styracaceae | | | | | | | | | 7.5 | 0.14 | 4.71 | C | | | | | | | | |
| *Syzygium cumini* (L.) Skeels | Myrtaceae | 5 | 0.39 | 3.27 | C | | | | | | | | | 20 | 0.14 | 7.66 | C | | | | |
| *Talauma hodgsonii* J. D. Hooker & Thomson | Magnoliaceae | | | | | | | | | | | | | 15 | 0.32 | 8.20 | R | | | | |
| *Taxus baccata* L. | Taxaceae | | | | | | | | | | | | | | | | | 17.5 | 1.57 | 15.99 | RE |
| *Terminalia bellerica* (Gaertn.) Roxb. | Combretaceae | | | | | | | | | | | | | 12.5 | 0.62 | 7.09 | C | | | | |
| *Terminalia myriocarpa* Van Heurck & Müll. Arg. | Combretaceae | 15 | 3.34 | 15.76 | R | 17.5 | 0.68 | 12.81 | RE | 7.5 | 0.39 | 5.56 | C | | | | | | | | |
| *Toona ciliata* M. Roem | Meliaceae | | | | | | | | | | | | | | | | | 5 | 0.28 | 3.81 | C |
| *Trema cannabina* Lour. | Cannabaceae | 5 | 0.17 | 3.64 | RE | | | | | | | | | | | | | | | | |
| *Tsuga dumosa* (D.Don) Eichler | Pinaceae | | | | | | | | | | | | | | | | | 7.5 | 1.11 | 10.07 | RE |
| *Xerospermum noronhianum* Blume | Sapindaceae | 2.5 | 1.17 | 4.79 | R | 2.5 | 0.13 | 2.55 | R | 7.5 | 0.34 | 5.39 | C | | | | | | | | |

**Key to abbreviation:** RE= Regular; R= Random; C= Clumped

*Herb species composition*

In herbs, a total of 152 species, 110 genera representing 54 families were recorded from the four community forest (Langpongshianga, Aboi, Longchung and Longwa) and Singphan WLS of Mon district, Nagaland, Northeast India. Of these, 41 species belonging to 38 genera and 22 families were recorded from Longwa CF followed by 38 species belonging to 38 genera and 23 families from Langpongshianga CF; 36 species, 35 genera and 30 families from Singphan; 33 species, 33 genera and 22 families from Longching CF and 31 species, 28 genera and 21 families from Aboi CF of Nagaland respectively (Table 4.2.5). Based on IVI value, the most dominant herb species in Longwa CF were: *Astilbe rivularis* (4.91), *Anemone vitifolia* (14.08) and *Geranium tuberaria* (2.84) (Table 4.2.7) and the dominant families were: Asteraceae, Rosaceae and Zingiberaceae. In Langpongshianga CF, the most dominant species were: *Leucus ciliata* (8.95), *Artemesia indica* (8.40), *Lasia spinosa* (8.38) and *Ipomoea pilata* (8.37) (Table 5.3.3) and the dominant families were: Asteraceae, Rubiaceae and Urticaceae. In Singphan, the dominant species were *Cayratia japonica* (20.02), *Curculigo capitulata* (17.03) and *Sida acuta* (15.54) (Table 4.2.7) and the dominant families were Araceae, Asteraceae and Gesneriaceae. In Longching CF, the dominant herb species were: *Boehmeria macrophylla* (19.75), *Girardinia diversifolia* (16.05) and *Spermacoce hispida* (13.83) (Table 4.2.7) and the most dominant families were: Asteraceae, Cyperaceae and Urticaceae. In Aboi CF, dominant species were: *Laportea bulbifera* (17.15), *Dioscorea glabra* (15.70) and *Cheilocostus speciosus* (14.25) (Table 4.2.7) and the dominant families were: Asteraceae, Rubiaceae and Zingiberaceae. The highest herb density (individuals ha$^{-1}$) was recorded from Longwa CF (151250) followed by Singphan (125625), Langpongshianga CF (89000), Aboi CF (86250) and Longching CF (84375) respectively (Table 4.2.5).

**4.2.2.2 Species diversity indices**

High diversity and low dominance is considered as the major characteristic feature of a natural forest which is also shown in the present study. In trees, Shannon diversity index (H') was recorded highest in Longching CF (3.63) followed by Aboi CF (3.30), Singphan WLS (3.27), Langpongshianga CF (3.11) and lowest H' was recorded in Longwa CF (2.90). The Simpson dominance index (CD) in the present study ranged from 0.03 – 0.06 where the CD was recorded highest in Longwa CF (0.06) and lowest in Longching CF (0.03) whereas the Margalef species richness index (Dmg) was recorded highest in Longching CF (9.05) and lowest in Longwa CF (5.11). The Pielou's evenness index (e) of tree species ranged from 0.89 – 0.96 indicating high evenness of species within the community forest (Table 4.2.5).

In shrubs, the Shannon diversity index (H') in the present study ranged from 2.89 – 3.29 where the highest H' was recorded in Langpongshianga CF (3.29) followed by Longwa CF (3.17), Singphan WLS (3.14), Aboi CF (2.98) and Longching CF (2.89). Whereas the Simpson dominance index (CD) was recorded highest in Longching CF (0.07) and lowest in Langpongshianga CF (0.04). The Margalef species richness index (Dmg) ranged from 4.52 – 6.89 corresponding with the H' value and the Pielou's evenness index (e) in the present study (0.88 – 0.91) revealed that there is even distribution of species within the community forest (Table 4.2.5).

In herbs, the highest Shannon diversity index (H') was recorded in Longwa CF (3.53) followed by Langpongshianga CF (3.50), Aboi CF (3.15), Longching CF (3.13) and lowest was recorded in Singphan WLS (3.08) respectively. The Simpson dominance index (CD) value (0.03 – 0.06) of the present study decreased as H' value increased. The Margalef species richness index (Dmg) value (4.10 – 5.94) corresponds well with the H' value and the Pielou's evenness index (e) ranged from 0.86 – 0.95 indicating even distribution of species within the community (Table 4.2.5).

**Table 4.2.7** Density (individuals ha$^{-1}$) and Important value index (IVI) of shrubs and herbs species in five study sites of Mon District, Nagaland

| Species | Family | Longching | | Aboi | | Langpongshianga | | Singphan | | Longwa | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D | IVI | D | IVI | D | IVI | D | IVI | D | IVI |
| **Shrubs** | | | | | | | | | | | |
| *Abelmoschus manihot* (Roxb.) Hochr. | Malvaceae | | | 150 | 6.39 | | | | | | |
| *Acacia pennata* (L.)Willd. | Mimosaceae | 300 | 8.25 | | | 300 | 4.52 | | | | |
| *Acacia pruinescens* Kurz | Mimosaceae | | | | | 100 | 2.37 | | | 250 | 6.65 |
| *Acalypha hispida* Burm.f. | Euphorbiaceae | | | | | | | 100 | 2.35 | | |
| *Agapetes angulata* (Griff.) Hook.f. | Ericaceae | | | | | | | 150 | 4.15 | | |
| *Agapetes discolor* C. B. Clarke | Ericaceae | | | 350 | 9.11 | | | | | 500 | 9.04 |
| *Agapetes flava* (Hook.f.) Sleumer | Ericaceae | | | | | 400 | 9.50 | | | | |
| *Agapetes salicifolia* C.B. Clarke | Ericaceae | | | 300 | 9.88 | | | 350 | 7.60 | | |
| *Aralia armata* (Wall. Ex G. Don) Seem | Araliaceae | 500 | 9.20 | | | 100 | 3.67 | | | | |
| *Aralia thomsonii* Seem. ex C.B. Clarke | Araliaceae | | | | | | | | | 200 | 5.11 |
| *Ardisia crispa* (Thunb.) A.DC. | Primulaceae | | | | | | | 200 | 5.95 | | |
| *Ardisia griffithii* C.B. Clarke | Myrsinaceae | 1050 | 19.02 | 100 | 4.26 | | | | | | |
| *Artemesia nilagirica* (C.B. Clarke) Pamp. | Asteraceae | | | | | | | 100 | 2.35 | | |
| *Berberis aristata* DC. | Berberidaceae | | | 450 | 11.92 | 200 | 4.75 | | | 150 | 4.63 |
| *Berberis wallichiana* DC. | Berberidaceae | | | | | | | | | 400 | 7.02 |
| *Boehmeria hamiltoniana* Wedd. | Urticaceae | | | 600 | 13.96 | | | | | | |
| *Boehmeria japonica* (L.f.) Miq. | Urticaceae | | | | | 150 | 4.21 | | | | |
| *Buddleja macrostachya* Benth. | Buddlejaceae | | | | | 100 | 2.37 | | | | |
| *Buddleja asiatica* Lour. | Buddlejaceae | | | | | | | | | 100 | 3.08 |
| *Calamus leptospadix* Griff. | Arecaceae | | | | | | | 150 | 5.40 | | |
| *Calotropis gigantea* (L.) Dryand. | Apocynaceae | | | | | | | 100 | 2.35 | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Camellia kissi* Wall. | Theaceae | 550 | 12.85 | | | | | | | 200 | 4.04 |
| *Camellia oleifera* Abel | Theaceae | | | | | 500 | 7.97 | 150 | 4.15 | | |
| *Clerodendrum bracteatum* Wall. ex Walp. | Lamiaceae | | | | | | | | | 1400 | 17.65 |
| *Clerodendrum chinense* (Osbeck) Mabb. | Verbenaceae | | | | | | | 850 | 14.34 | | |
| *Clerodendrum glandulosum* Lindl. | Verbenaceae | 750 | 15.32 | | | 150 | 2.91 | | | | |
| *Clerodendrum japonicum* (Thunb.) Sweet | Verbenaceae | | | 700 | 15.32 | | | | | | |
| *Corylopsis himalayana* Griff. | Hamamelidaceae | 200 | 7.01 | | | | | 200 | 5.95 | 150 | 3.56 |
| *Crotalaria assamica* Benth. | Papilionaceae | 250 | 9.15 | | | 50 | 1.84 | | | | |
| *Crotalaria cytisoides* DC. | Papilionaceae | | | 150 | 4.94 | | | | | 300 | 7.13 |
| *Daphne bholua* (W.W. Sm. & Cave) B.L. Brutt | Thymelaeaceae | | | | | | | 400 | 8.15 | 100 | 3.08 |
| *Daphne papyraceae* Wall. Ex G. Don | Thymelaeaceae | | | 200 | 7.07 | | | | | | |
| *Debregeasia longifolia* (Burm.f.) Wedd. | Urticaceae | 50 | 2.13 | 100 | 4.26 | 250 | 5.29 | 50 | 1.80 | | |
| *Debregiasia saenab* (Forssk.) Hepper & J.R.I. Wood | Urticaceae | | | | | 100 | 3.67 | | | 350 | 6.54 |
| *Dichroa febrifuga* Lour. | Hydrangeaceae | | | | | | | | | 100 | 2.02 |
| *Dracaena angustifolia* (Medik.) Roxb. | Dracaenaceae | 100 | 4.26 | 550 | 13.28 | 50 | 1.84 | 300 | 7.05 | | |
| *Eriobotrya bengalensis* (Roxb.) Hook.f. | Rosaceae | | | | | | | 250 | 6.50 | 100 | 2.02 |
| *Eupatorium odoratum* L. | Asteraceae | | | 50 | 2.13 | 150 | 4.21 | | | | |
| *Eurya japonica* Thunb. | Theaceae | | | | | 350 | 8.96 | 350 | 7.60 | | |
| *Flemingia semialata* Roxb. | Papilionaceae | | | | | 600 | 7.75 | | | | |
| *Flueggea virosa* (Roxb. ex Willd.) Royle | Euphorbiaceae | 100 | 4.26 | 250 | 6.30 | | | 50 | 1.80 | 200 | 4.04 |
| *Garcinia merguensis* Wight | Clusiaceae | | | | | 250 | 7.88 | | | | |
| *Gaultheria Hookeri* C.B. Clarke | Ericaceae | | | | | 150 | 5.51 | | | 150 | 4.63 |
| *Gaultheria trichophylla* Royle | Ericaceae | 300 | 8.25 | | | | | | | | |
| *Hypericum uralum Buch.-Ham. ex D.Don* | Hypericaceae | | | | | | | | | 400 | 8.08 |
| *Ixora nigricans* R. Br. Ex Wight & Arn. | Rubiaceae | | | | | | | 100 | 3.60 | | |
| *Justicia adhatoda* L. | Acanthaceae | | | | | | | 150 | 5.40 | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Justicia vasculosa* Wall. | Acanthaceae | | | | | 400 | 9.50 | | | | |
| *Leea alata* Edgew. | Leaceae | 950 | 17.79 | | | 300 | 7.12 | | | | |
| *Leea asiatica* (L.) Ridsdale | Leeaceae | | | | | | | 550 | 9.79 | | |
| *Leea guineensis* G. Don | Leeaceae | | | 100 | 4.26 | | | | | | |
| *Leea macrophylla* Roxb. ex Hornem. | Leeaceae | | | | | | | 1100 | 17.09 | | |
| *Leucoceptrum canum* Sm. | Lamiaceae | | | 400 | 9.79 | 50 | 1.84 | | | 250 | 4.52 |
| *Maesa chisia* Buch.-Ham. ex D. Don | Myrsinaceae | | | | | | | 600 | 11.59 | 650 | 10.48 |
| *Maesa ramentacea* (Roxb.) A. DC. | Primulaceae | | | 500 | 9.70 | 750 | 9.36 | | | | |
| *Mahonia napalensis* DC. Ex Dippel | Berberidaceae | | | | | 50 | 1.84 | 100 | 3.60 | 350 | 6.54 |
| *Mahonia pycnophylla* (Fedde) Takeda | Berberidaceae | 600 | 13.47 | 100 | 4.26 | | | | | | |
| *Melastoma malabathricum L.* | Melastomataceae | | | 100 | 4.26 | | | 350 | 7.60 | | |
| *Melastoma nepalense* Lodd. | Melastomataceae | 450 | 11.62 | | | | | | | | |
| *Milletia extensa* (Benth.) Baker | Papilionaceae | | | | | | | 300 | 5.80 | | |
| *Morinda angustifolia* Roxb. | Rubiaceae | | | | | 150 | 4.21 | 100 | 2.35 | | |
| *Mussaenda glabra* Vahl | Rubiaceae | | | 750 | 14.55 | | | | | | |
| *Mussaenda macrophylla* wall. | Rubiaceae | | | | | 900 | 10.98 | | | | |
| *Mussaenda roxburghii* Hook.f. | Rubiaceae | | | | | | | 450 | 9.95 | | |
| *Musseanda glabra* Vahl | Rubiaceae | | | | | | | | | 1100 | 14.78 |
| *Nerium oleander* L | Oleaceae | | | | | | | 50 | 1.80 | | |
| *Osbeckia crinita* Benth. ex C.B. Clarke | Melastomataceae | | | | | | | | | 1000 | 13.82 |
| *Osbeckia nepalensis* Hook.f. | Melastomataceae | | | | | 50 | 1.84 | | | | |
| *Oxyspora cernua* (Roxb.) Hook. f. & Thomson ex Triana | Melastomataceae | | | 100 | 4.26 | | | 500 | 10.49 | | |
| *Oxyspora vagans* (Roxb.) Wall. | Melastomataceae | | | | | 400 | 9.50 | | | 150 | 4.63 |
| *Phlogacanthus curviflorus* Ness | Acanthaceae | | | 50 | 2.13 | 50 | 1.84 | 700 | 12.69 | | |
| *Phlogacanthus tubiflorus* Ness | Acanthaceae | 100 | 2.75 | 200 | 5.62 | | | | | 200 | 6.17 |
| *Plectranthus ternifolius* D. Don | Lamiaceae | 200 | 5.50 | 50 | 2.13 | 100 | 2.37 | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Pogostemon elsholtzioides* Benth. | Lamiaceae | | | | | | | 150 | 5.40 | | |
| *Ricinus communis* L. | Euphorbiaceae | | | | | | | 100 | 3.60 | | |
| *Rubus accuminatus* Sm. | Rosaceae | | | 150 | 4.94 | 450 | 8.73 | | | | |
| *Rubus calycinus* Wall. Ex D. Don | Rosaceae | | | | | 500 | 10.57 | | | | |
| *Rubus ellipticus* Sm. | Rosaceae | | | | | | | | | 100 | 3.08 |
| *Rubus hexagynus* Roxb. | Rosaceae | 300 | 9.76 | | | | | | | | |
| *Rubus hirtus* Hegetschw. | Rosaceae | 100 | 2.75 | | | | | | | | |
| *Rubus niveus* Thunb. | Rosaceae | | | | | 100 | 3.67 | | | 350 | 6.54 |
| *Rubus rosifolius* Sm. | Rosaceae | 250 | 6.12 | | | | | | | 200 | 5.11 |
| *Rubus sumatranus* Miq. | Rosaceae | 150 | 6.40 | | | | | | | | |
| *Rubus wardii* Merr. | Rosaceae | | | | | 50 | 1.84 | | | | |
| *Sambucus javanica* Blume. | Sambucaceae | | | 250 | 7.75 | 550 | 11.11 | | | | |
| *Securinega virosa* (Roxb. Ex Willd.) Baill. | Euphorbiaceae | | | | | 150 | 5.51 | | | | |
| *Senna alata* (L.) Roxb. | Leguminosae | 150 | 4.88 | | | | | | | | |
| *Solanum aculeatissimum* Jacq. | Solanaceae | | | | | | | | | 150 | 3.56 |
| *Solanum torvum* Sw. | Solanaceae | 100 | 4.26 | 100 | 2.81 | 50 | 1.84 | | | | |
| *Sorbus microphylla* (Wall. ex Hook.f.) Wenz. | Rosaceae | | | | | | | | | 250 | 6.65 |
| *Sterculia hamiltonii* (Kuntze) Adelb. | Sterculiaceae | 400 | 9.48 | | | | | | | | |
| *Symplocos glomerata* King ex C.B. Clarke | Symplocaceae | | | | | 300 | 7.12 | | | | |
| *Symplocos lucida* (Thunb.) Siebold & Zucc. | Symplocaceae | | | 200 | 5.62 | | | | | | |
| *Symplocos paniculata* (Thunb.) Miq. | Symplocaceae | 200 | 5.50 | | | | | | | 100 | 2.02 |
| *Vernonia species* | Asteraceae | | | | | | | | | 50 | 1.54 |
| *Viburum corylifolium* Hook.f & Thomson | Caprifoliaceae | | | 50 | 2.13 | | | | | 300 | 6.06 |
| *Zanthoxylum acanthopodium* DC. | Rutaceae | | | | | | | | | 150 | 4.63 |
| *Zanthoxylum khasianum* Hook.f. | Rutaceae | | | | | | | 50 | 1.80 | | |
| *Zanthoxylum nitidum*(Roxb.) DC. | Rutaceae | | | 300 | 6.98 | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Zanthoxylum oxyphyllum* Edgew. | Rutaceae | | | | | | | | | 50 | 1.54 |
| **Herbs** | | | | | | | | | | | |
| *Acmella oleracea* (L.) R.K.Jansen | Asteraceae | 1875 | 4.69 | | | | | | | | |
| *Acorus calamus* L. | Acoraceae | 1250 | 3.95 | | | | | 1250 | 3.29 | | |
| *Aeschynanthus acuminatus* Wall. Ex A. DC. | Gesneriaceae | 2500 | 6.67 | | | | | 2500 | 4.29 | | |
| *Aeschynanthus micranthus* C.B. Clarke | Gesneriaceae | | | | | | | 1875 | 4.94 | | |
| *Ageratina adenophora* (Spreng.) R.M.King & H.Rob. | Asteraceae | | | | | | | 7500 | 10.57 | | |
| *Ageratum conyzoides* (L.) L. | Asteraceae | | | | | | | 5000 | 8.58 | | |
| *Allamanda cathartica* L. | Apocynaceae | | | | | | | 1250 | 3.29 | | |
| *Alpinia malaccensis* (Burm.)f. Roscoe | Zingiberaceae | 625 | 1.98 | 625 | 2.11 | | | | | | |
| *Amaranthus spinosus* L. | Amaranthaceae | | | | | | | 3125 | 7.09 | | |
| *Amomum dealbatum* Roxb. | Zingiberaceae | | | | | | | 625 | 1.65 | | |
| *Ampelocissus latifolia* (Roxb.) Planch. | Vitaceae | | | | | | | 2500 | 4.29 | | |
| *Anaphalis adnata* Wall. Ex DC. | Asteraceae | | | | | 2500 | 5.03 | | | | |
| *Anaphalis contorta* (D. Don) Hook.f. | Asteraceae | | | | | | | | | 3750 | 5.60 |
| *Anaphalis grifithii* Hook.f. | Asteraceae | | | 3750 | 8.51 | | | | | | |
| *Anemone vitifolia* Buch.-Ham. ex DC. | Ranunculaceae | | | | | | | | | 15000 | 14.08 |
| *Arisaema concinnum* Schott | Araceae | | | | | 2000 | 4.47 | | | | |
| *Arisaema griffithii* Schott | Araceae | | | | | | | | | 1250 | 1.87 |
| *Artemesia indica* Willd. | Asteraceae | | | | | 5500 | 8.40 | | | | |
| *Artemisia parviflora* Roxb. Ex D. Don | Asteraceae | 2500 | 7.90 | | | | | | | | |
| *Artemisia vulgaris* L. | Asteraceae | | | | | | | | | 5000 | 6.43 |
| *Asparagus officinalis* L. | Liliaceae | | | | | 1500 | 2.80 | | | | |
| *Asparagus racemosus* Willd. | Liliaceae | 1875 | 4.69 | 1875 | 4.95 | | | 3750 | 7.58 | | |
| *Aspidopterys indica* (Willd.) W. Theob. | Malpighiaceae | | | | | | | 1875 | 4.94 | | |
| *Astilbe rivularis* Buch.-Ham. ex D. Don | Saxifragaceae | | | | | | | | | 16250 | 14.91 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Begonia palmata* D. Don | Begoniaceae | 4375 | 10.12 | | | | | 3125 | 5.94 | | |
| *Begonia roxburghii* A. DC. | Begoniaceae | | | 4375 | 9.24 | | | | | | |
| *Bidens bipinnata* L. | Asteraceae | | | 2500 | 7.07 | | | | | | |
| *Bidens tripartita* L. | Asteraceae | 1875 | 4.69 | | | 3500 | 6.15 | | | | |
| *Blumea laciniata* (Wall. ex Roxb.) Don. | Asteraceae | 5000 | 10.86 | | | | | | | | |
| *Blumea repanda* (Roxb.) Hand. Mazz. | Asteraceae | | | | | | | | | 1250 | 1.87 |
| *Boehmeria clidemioides* Miq. | Urticaceae | | | | | | | | | 1875 | 3.32 |
| *Boehmeria macrophylla* Hornem. | Urticaceae | 12500 | 19.75 | | | | | | | | |
| *Bulbophyllum affine* Wall. Ex Lindl. | Orchidaceae | | | | | 2000 | 4.47 | | | | |
| *Bulbophyllum roxburghii* (Lindl.) Rchb.f. | Orchidaceae | 1250 | 3.95 | | | | | | | | |
| *Calamus floribundus* Griff. | Arecaceae | | | 625 | 2.11 | | | | | | |
| *Canabis sativa* L. | Ulmaceae | | | | | | | 1875 | 3.79 | | |
| *Carex baccans* Nees | Cyperaceae | | | 3125 | 7.79 | | | | | | |
| *Carex composita* Boott | Cyperaceae | 1250 | 2.72 | | | | | | | | |
| *Catharanthus roseus* (L.) G.Don | Apocynaceae | | | | | | | 625 | 1.65 | | |
| *Cayratia japonica* (Thunb.) Gagnep. | Vitaceae | | | | | | | 19375 | 20.02 | | |
| *Cheilocostus speciosus* (J.Koenig) C.D. Specht | Costaceae | 2500 | 6.67 | 7500 | 14.25 | | | | | | |
| *Cissus repens* Lam. | Vitaceae | | | 1250 | 2.84 | | | | | | |
| *Clematis acuminata* DC. | Ranunculaceae | | | | | | | 1250 | 3.29 | | |
| *Clematis acutangula* Hook.f. & Thomson | Ranunculaceae | 625 | 1.98 | | | | | | | | |
| *Clitoria mariana* L. | Papilionaceae | 1250 | 2.72 | | | 3000 | 6.70 | | | | |
| *Codonopsis javanica* (Blume) Hook.f. & Thomson | Campanulaceae | 2500 | 6.67 | 3750 | 9.90 | 1000 | 2.23 | 5000 | 8.58 | | |
| *Codonopsis tubulosa* Komarov | Campanulaceae | | | | | | | | | 5625 | 7.89 |
| *Coelogyne barbata* Lindl. ex Griff. | Orchidaceae | 3750 | 9.38 | | | | | | | | |
| *Coelogyne rigida* E.C. Parish & Rchb.f | Orchidaceae | | | | | | | | | 3125 | 5.19 |
| *Colocasia species* Schott | Araceae | | | | | | | 625 | 1.65 | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Commelina diffusa* Burm.f. | Commelinaceae | 625 | 1.98 | | | | | | | | |
| *Commelina paludosa*Blume | Commelinaceae | | | | | 1500 | 2.80 | | | | |
| *Conocephalus suaveolens* Blume | Moraceae | | | 4375 | 10.63 | | | | | | |
| Costus speciosus (J.Koenig) Sm. | Costaceae | | | | | | | 1250 | 3.29 | | |
| *Crassocephalum crepaliodes* (Benth.) S.Moore | Asteraceae | 3125 | 8.64 | | | | | 4375 | 6.93 | | |
| *Crawfurdia angustata* C.B. Clarke | Gentianaceae | | | | | | | | | 1250 | 1.87 |
| *Curculigo capitulata* (Lour.) Kuntze | Hypoxidaceae | | | | | 2500 | 3.92 | 15625 | 17.04 | | |
| *Cyclosorus parasiticus* (L.) Farw. | Thelypteridaceae | | | | | | | 625 | 1.65 | | |
| *Cymbidium elegans* Lindl. | Orchidaceae | | | | | | | 1875 | 3.79 | | |
| *Cymbidium lancifolium* Hook. | Orchidaceae | 1875 | 5.93 | | | 2000 | 5.58 | | | | |
| *Cymbopogon citratus* (DC. Ex Nees) Stapf | Poaceae | | | | | | | 625 | 1.65 | | |
| *Cyperus cyperinus* (Retz.) Suringar | Cyperaceae | | | 1875 | 6.34 | | | | | | |
| *Cyperus cyperoides* (L.) Kuntze. | Cyperaceae | 625 | 1.98 | | | | | | | | |
| *Cyperus rotundus* L. | Cyperaceae | | | | | | | 5625 | 9.08 | | |
| *Dendrobium acinaciforme* Roxb. | Orchidaceae | | | | | | | | | 4375 | 7.06 |
| *Dendrobium bicameratum* Lindl. | Orchidaceae | 1250 | 3.95 | | | | | | | | |
| *Dendrobium chrysanthum* Wall. Ex Lindl. | Orchidaceae | | | 3750 | 9.90 | 3000 | 6.70 | | | | |
| *Dendrobium jenkinsii* Wall. ex Lindl. | Orchidaceae | | | | | | | | | 1875 | 4.36 |
| *Dioscorea bulbifera* L. | Dioscoreaceae | | | | | | | | | 6875 | 7.67 |
| *Dioscorea glabra* Roxb. | Dioscoreaceae | | | 8750 | 15.70 | | | | | | |
| *Dioscorea pentaphylla* L. | Dioscoreaceae | 1875 | 5.93 | | | | | | | | |
| *Diplazium esculentum* (Retz.) Sw. | Woodsiaceae | | | | | | | 1250 | 2.14 | | |
| *Drymaria cordata* (L.) Willd. Ex Schult. | Caryophyllaceae | | | | | | | | | 6250 | 7.26 |
| *Dysphania ambrosioides* (L.) Mosyakin & Clemants | Chenopodiaceae | | | 1250 | 4.23 | 1000 | 3.35 | | | | |
| *Elatostema lineolatum* Wight | Urticaceae | | | 1875 | 3.56 | | | | | | |
| *Elatostema monandrum* (Buch.-Ham. ex D. Don) H. Hara | Urticaceae | 1250 | 3.95 | | | 2500 | 3.92 | | | | |

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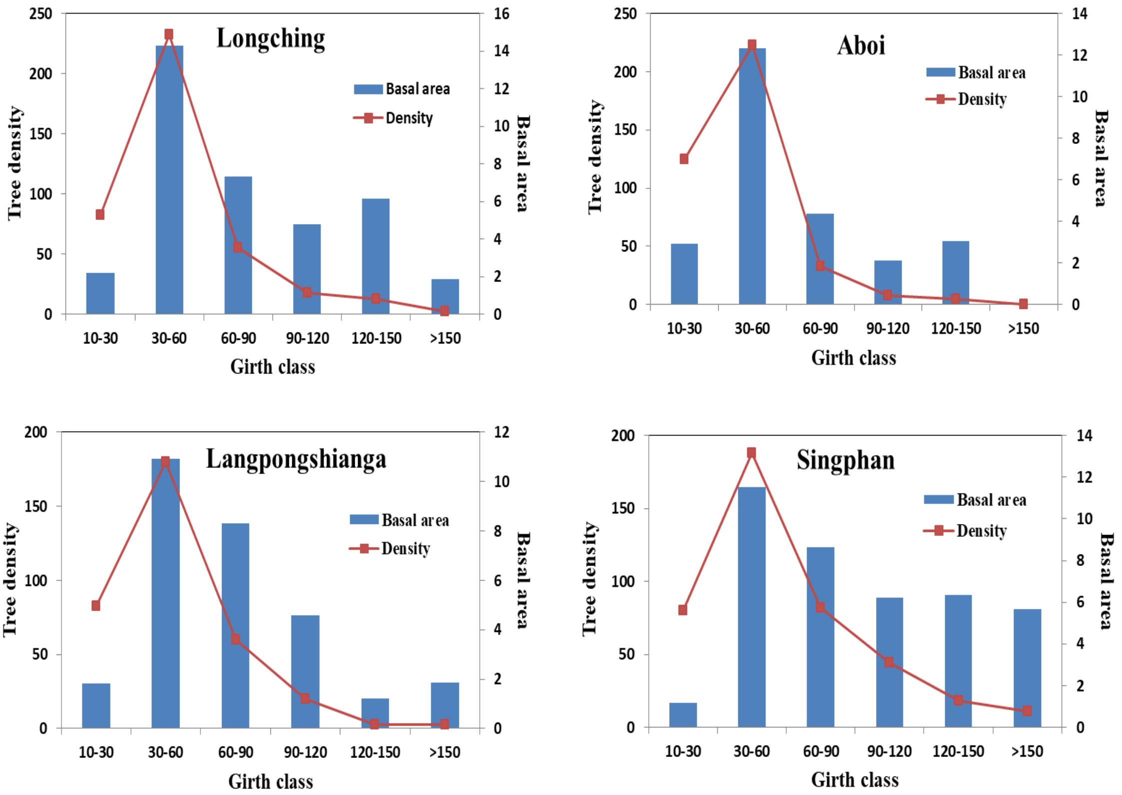
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Entada rheedi* Spreng. | Papilionaceae | | | | | | | 2500 | 4.29 | | |
| *Eria biflora* Griff. | Orchidaceae | | | 1250 | 2.84 | | | | | 2500 | 3.74 |
| *Eria vittata* Lindl. | Orchidaceae | | | | | 4000 | 7.83 | | | | |
| *Fagopyrum esculentum* Moench | Polygonaceae | | | | | | | 1875 | 3.79 | | |
| *Fragaria nilgerrensis* Schltdl. ex J. Gay | Rosaceae | | | | | | | | | 1250 | 1.87 |
| *Fragaria nubicola* (Lindl. ex Hook.f.) Lacaita | Rosaceae | | | | | | | | | 3750 | 5.60 |
| *Geranium nepalense* Sweet | Geraniaceae | | | | | 1500 | 5.02 | | | | |
| *Geranium tuberaria* Cambess | Geraniaceae | | | | | | | | | 13125 | 12.84 |
| *Girardinia diversifolia* (Link) Friis | Urticaceae | 9375 | 16.05 | | | | | | | | |
| *Globba multiflora* Wall. Ex Baker | Zingiberaceae | | | 2500 | 7.07 | | | | | 7500 | 9.13 |
| *Hedychium coronarium* J.Koenig | Zingiberaceae | | | | | | | | | 1250 | 1.87 |
| *Hedyotis scandens* Roxb. | Rubiaceae | | | | | 4500 | 8.39 | | | | |
| *Hedyotis vestita* R. Br. Ex G. Don | Rubiaceae | | | 1250 | 2.84 | | | | | | |
| *Hodgsonia macrocarpa* (Blume) Cogn. | Cucurbitaceae | | | | | | | 5000 | 7.43 | | |
| *Holboellia latifolia* Wall. | Lardizabalaceae | 1250 | 3.95 | 1875 | 6.34 | | | | | 11875 | 12.02 |
| *Hypericum japonicum*Thunb. | Hypericaceae | | | | | 1000 | 3.35 | | | | |
| *Impatiens parkinsonii* C.E.C. Fisch. | Balsaminaceae | | | 1250 | 4.23 | | | | | | |
| *Impatiens porrecta* Wall. | Balsaminaceae | 625 | 3.21 | | | | | | | | |
| *Inula nervosa* Wall. Ex DC. | Asteraceae | | | | | | | | | 2500 | 3.74 |
| *Ipomoea nil* (L.) Roth | Convolvulaceae | | | | | | | | | 1875 | 3.32 |
| *Ipomoea pileata* Roxb. | Convolvulaceae | | | | | 3500 | 8.38 | | | | |
| *Ipomoea poranoides* C.B. Clarke | Convolvulaceae | 2500 | 7.90 | | | | | | | | |
| *Jasminum attenuatum* Roxb. Ex DC. | Oleaceae | | | | | 2000 | 5.58 | | | | |
| *Laportea bulbifera* (Siebold & Zucc.) Wedd. | Urticaceae | | | 10000 | 17.15 | | | | | | |
| *Lasia spinosa* (L.) Thwaites | Araceae | | | | | 3500 | 8.38 | 1875 | 4.94 | | |
| *Leucas ciliata* Benth. | Lamiaceae | | | | | 5000 | 8.95 | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Leucas pilosa* Benth. | Lamiaceae | | | | | | | | | 2500 | 4.78 |
| *Lygodium flexuosum* (L.) Sw. | Lygodiaceae | | | 1250 | 2.84 | | | | | | |
| *Lygodium japonicum* Thunb. | Lycopodiaceae | | | | | 2500 | 7.25 | | | | |
| *Mikania cordata* (Burm.f.) B.L. Rob | Asteraceae | | | | | | | | | 625 | 1.45 |
| *Mirabillis jalapa* L. | Nyctaginaceae | 1250 | 2.72 | | | | | | | | |
| *Molineria capitulata* (Lour.) Herb. | Hypoxidaceae | 1875 | 4.69 | | | | | | | | |
| *Mucuna macrocarpa* Wall. | Leguminosae | | | | | | | 625 | 1.65 | | |
| *Nephrolepis cordifolia* (L.) C. Presl | Nephrolepidiaceae | | | 625 | 2.11 | 1000 | 3.35 | | | | |
| *Ophiorrhiza fasciculata* D. Don | Rubiaceae | | | | | | | | | 1250 | 1.87 |
| *Ophiorrhiza gracilis* Kurz | Rubiaceae | | | 625 | 2.11 | | | | | | |
| *Ophiorrhiza oppositiflora* Hook.f. | Rubiaceae | | | | | 4000 | 6.72 | | | | |
| *Otochilus porrecrus* Lindl. | Orchidaceae | | | | | 1000 | 2.23 | | | | |
| *Paederia foetida* L. (Vines) | Rubiaceae | | | | | 3500 | 7.27 | 1250 | 2.14 | | |
| *Pholidota imbricata* Lindl. | Orchidaceae | | | | | 1500 | 5.02 | | | | |
| *Pilea anisophylla* (Hook.f.) Wedd. | Urticaceae | 1250 | 3.95 | | | | | | | | |
| *Pilea bracteosa* Wedd. | Urticaceae | | | | | 1000 | 3.35 | | | | |
| *Plantago asiatica* (Wall.) Z. Yu Li. | Plantaginaceae | | | 2500 | 7.07 | | | 1250 | 3.29 | | |
| *Pleione maculuta* (Lindl.) Lindl. & Paxton | Orchidaceae | | | | | 2000 | 4.47 | | | | |
| *Pogostemon auricularius* (L.) Hassk. | Lamiaceae | | | | | | | | | 3125 | 5.19 |
| *Polygonum paniculatum* L. | Polygonaceae | | | | | | | | | 1875 | 4.36 |
| *Polygonum pubescens* Blume | Polygonaceae | | | 4375 | 7.85 | | | | | | |
| *Porana paniculata* Roxb. | Convolvulaceae | | | | | | | 2500 | 4.29 | 1250 | 1.87 |
| *Potentilla fulgens* Wall. ex Sims | Rosaceae | | | | | | | | | 1250 | 1.87 |
| *Rhynchoglossum obliquum* Blume | Gesneriaceae | | | | | 1000 | 3.35 | | | | |
| *Rubia cordifolia* L. | Rubiaceae | | | | | 1500 | 5.02 | | | | |
| *Rubia manjith* Roxb. ex Fleming | Rubiaceae | | | | | | | | | 3750 | 5.60 |
| *Selaginella chrysorrhizos* Spring | Selaginellaceae | | | | | | | | | 625 | 1.45 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Selaginella ciliaris* (Retz.) Spring | Selaginellaceae | | | | | 2500 | 7.25 | | | | |
| *Senecio densiflorus*Wall. Ex DC. | Asteraceae | | | | | 2000 | 6.69 | | | | |
| *Senecio scandens* Buch.-Ham. ex D. Don | Asteraceae | | | | | | | | | 2500 | 3.74 |
| *Sida acuta* Burm f. | Malvaceae | | | | | | | 13750 | 15.54 | | |
| *Smilax aspera* L. | Smilacaceae | | | | | | | | | 1250 | 2.91 |
| *Smilax ovalifolia*Roxb. ex D. Don | Smilacaceae | | | | | 500 | 1.67 | | | | |
| *Smithia ciliata* Royle | Papilionaceae | | | | | | | | | 1875 | 3.32 |
| *Spatholobus roxburghii* Benth. | Leguminosae | | | | | | | | | 625 | 1.45 |
| *Spermacoce hispida* L. | Rubiaceae | 7500 | 13.83 | | | | | | | | |
| *Strobilanthes adnatus* C.B. Clarke | Acanthaceae | | | 3750 | 8.51 | | | | | | |
| *Strobilanthus affinis* (Griff.) Terao ex J.R.I. Wood & J.R. Benn. | Acanthaceae | | | | | 2500 | 6.14 | | | | |
| *Thunbergia grandiflora* (Roxb. ex Rottl.) Roxb. | Acanthaceae | | | | | | | 625 | 1.65 | | |
| *Thysanolaena latifolia* (Roxb. ex Hornem.) Honda | Poaceae | | | | | 3500 | 6.15 | | | | |
| *Urtica dioica* L. | Urticaceae | | | | | | | | | 625 | 1.45 |
| *Vaccinium lamellatum* P.F. Stevens | Ericaceae | | | | | | | | | 2500 | 5.82 |
| *Vanda bicolor* Griff. | Orchidaceae | | | | | | | | | 1250 | 2.91 |
| *Vanda tessellata* (Roxb.) Hook. ex G.Don | Orchidaceae | 625 | 1.98 | | | | | | | | |

### 4.2.2.3 Population structure of tree species in various girth-classes

The present study showed that the tree density and basal area varied in different communities (Table 4.2.5). In all the study sites, the highest tree density was recorded in the girth class 30 – 60 cm. The density of young trees (10 – 30 cm girth class) contributed 18% (Longwa CF) to 23% (Langpongshianga CF) of the total tree density in all the community forest. In the girth class 60 – 90 cm, Singphan WLS recorded the highest tree density (82 individuals ha$^{-1}$) and lowest in Aboi CF (38 individuals ha$^{-1}$) (Figure 5.2.3). The contribution of older tree density was highest in Singphan WLS (73 individuals ha$^{-1}$) which contributed 17% of the total tree density whereas no individuals was recorded in Aboi CF. The maximum basal area in the younger trees (10-60 cm girth class) was recorded in Longching CF (16 m$^2$ha$^{-1}$) and lowest in Longwas CF (13 m$^2$ha$^{-1}$) (Figure 4.2.3). The overall population structure of all the communities showed a reverse *J*-shaped population curve indicating a high species diversity and good regeneration of species.



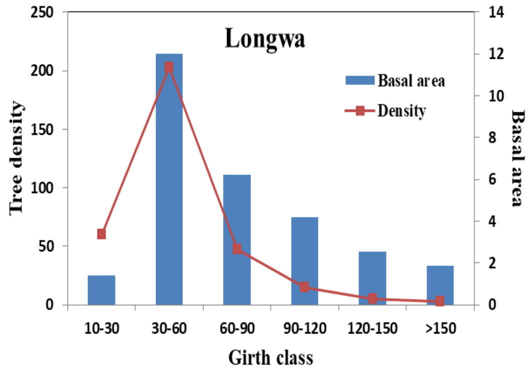



**Figure 4.2.3** Contributions of tree stand density and basal area based on girth class contribution in five study sites of Mon District, Nagaland

### 4.2.2.3 Dominance-diversity curve

The dominance-diversity curve of tree species showed high equitability and low dominance in all the community forest and followed log normal distribution pattern except on Longwa CF which showed low equitability and high dominance and followed a broken stick distribution pattern indicating low species richness in the forest due to anthropogenic pressure for timber extraction and shifting cultivation (Figure 5.2.4). Among the community forest, *Duabanga grandiflora* was the most dominant tree species in Langpongshianga CF followed by *Acer thomsonii* (Longwa CF), *Alstonia scholaris* (Longching CF), *Gmelina arborea* (Aboi CF) and *Dipterocarpus retusus* (Singphan WLS). The other co-dominant species were *Callicarpa arborea, Lithocarpus elegans, Phoebe goalparensis, Quercus lamellosa* and *Stereospermum chelonoides* (Table 4.2.6). In shrubs and herbs, the dominance-diversity curve in all the community showed high equitability and low dominance in all the community forest and followed a log normal distribution pattern except on Longching CF, where the dominance-diversity curve of herb species showed low equitability and high dominance and followed a short hooked curve pattern (Figure 4.2.4) indicating low species diversity which may be attributed to dense canopy cover of trees and grazing of undergrowth vegetation by domesticated and wild animals.

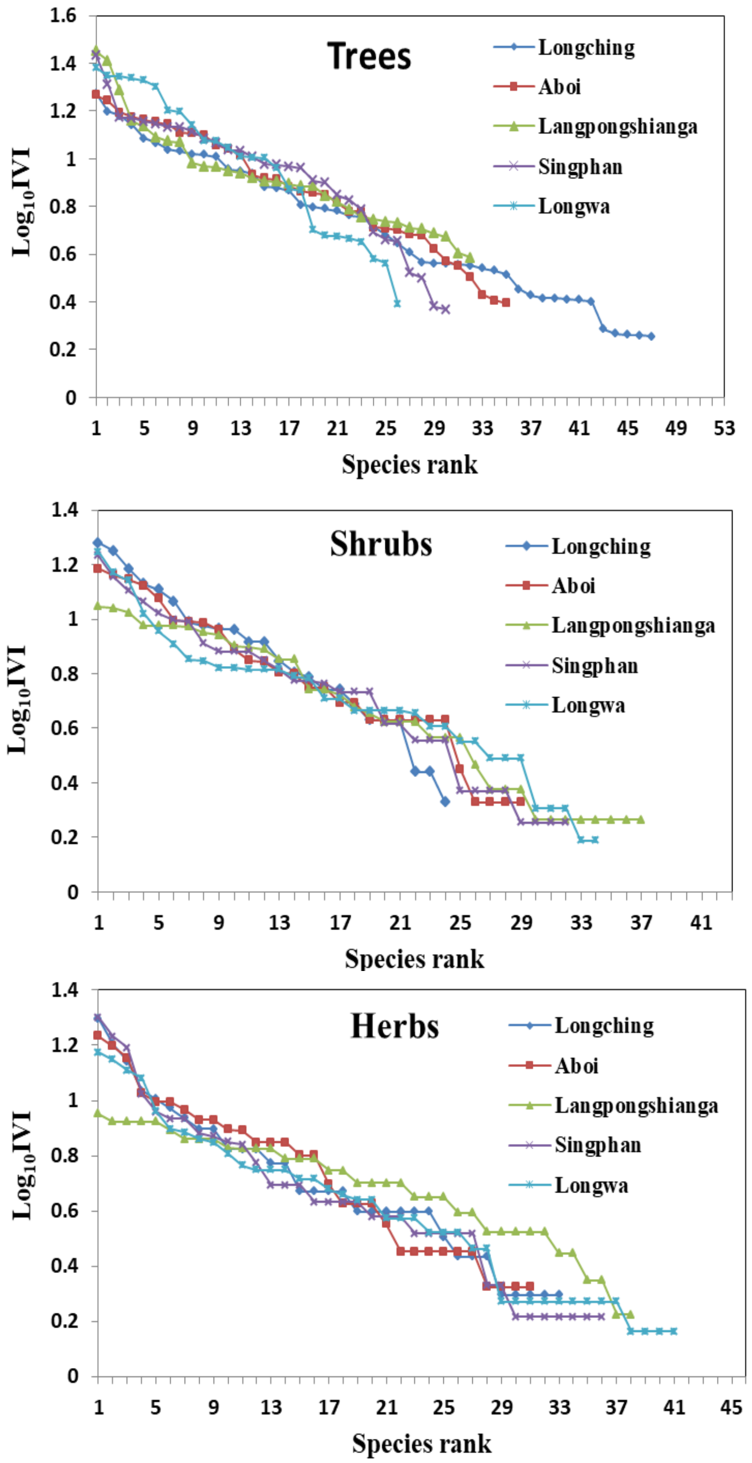



**Figure 4.2.4** Dominance-Diversity curve for trees, shrubs and herbs in five study sites of Mon District, Nagaland

#### 4.2.2.5 Distribution pattern of tree species

In any natural forest, Contagious or clumped distribution is considered as the most common distribution pattern whereas random distribution occurs in an even forest and regular distribution pattern of species occurs on those forests where there is a high competition between the individuals. The Whitford index (A/F ratio) of trees in the present study showed that community forests (Longwa and Longching) and Singphan WLS exhibited maximum regular distribution pattern contributing 58%, 43%, and 40% respectively indicating high species competition between individuals whereas Langpongshianga CF recorded the highest clumped/contagious distribution pattern (66%) indicating clusteredness of individuals. Aboi CF shared the maximum random distribution (40%) indicating uneven distribution of individuals at unpredictable distances in the community (Table 4.2.6).

#### 4.2.2.6 Sorenson's similarity indices for tree species

In the present study, the highest similarity (66%) of species was recorded between Aboi and Langpongshianga followed by Longching and Aboi (54%) and Langpongshianga and Longching (48%). The lowest value of species similarity was observed between Longching and Longwa CF; Singphan and Longwa CF with only 11% each respectively which is resulted due to variations in altitudes, soil types, habitat and various ecological conditions of the forest (Table 4.2.8).

**Table 4.2.8** Sorenson Similarity indices for tree species between five study sites of Mon District, Nagaland

| Study area | Longching | Aboi | Langpongshianga | Singphan | Longwa |
|---|---|---|---|---|---|
| **Longching** | x | | | | |
| **Aboi** | 0.54 | x | | | |
| **Langpongshianga** | 0.48 | 0.66 | x | | |
| **Singphan** | 0.26 | 0.25 | 0.23 | x | |
| **Longwa** | 0.11 | 0.13 | 0.14 | 0.11 | x |

#### 4.2.2.7 Disturbance pattern

The disturbance index was highest at Longching (25%) followed by Longwa (22%) and Lanpongshianga CF (19%). The high disturbance maybe attributed to extraction of timber species such as *Alstonia scholaris*, *Duabanga grandiflora*, *Gmelina arborea, Schima wallichii, Terminalia myriocarpa, Quercus lamellosa* etc., which is dominant in these regions. Maximum lopping was observed at Longching and Aboi CF by the local people on account of fuelwood requirements. The disturbance index on different study sites is shown in table 4.2.5.

### 4.2.3 Kiphire district

#### 4.2.3.1 Floristic structure

*Tree species composition*

In the present study, a total of 721 individuals belonging to 112 species and 65 genera belonging to 41 families were recorded from the four community forest (Sitimi, Chinkhu, Pungro and Samphure) and Fakim WLS of Kiphire district, Nagaland, Northeast India. Out of these, 60 species, 40 genera, 27 families and 173 individuals were recorded from Fakim; 50 species, 38genera, 25 families and 161 individuals from Sitimi; 40 species, 32 genera, 24 families and 150 individuals from Chinkhu; 35 species, 29 genera, 22 families and 121 individuals from Pungro and 30 species, 25 genera, 20 families and 116 individuals from Samphure community forest of Nagaland respectively (Table 4.2.9). Based on IVI value, the dominant tree species in Fakim WLS were: *Betula alnoides* (17.12), *Lithocarpus pachyphyllus* (12.50) and *Michelia oblong* (11.37) and the co-dominant species were: *Quercus lamellosa* (10.58), *Cinnamomum zeylanicum* (9.53) and *Magnolia insignis* (9.51) (Table 4.2.10). The most dominant families were: Fagaceae, Lauraceae and Rosaceae. In Sitimi, the dominant tree species were: *Cinnamomum* glaucescens (15.52), *Prunus cerasoides* (13.64), *Acer oblongum* (13.3) and the co-dominant species were: *Hovenia dulcis* (12.62) and *Taxus baccata* (12.00) (Table 4.2.10). The most dominant families were: Euphorbiaceae, Fagaceae, Magnoliaceae and Rosaceae. In Chinkhu, the dominant species were *Litsea monopetala* (22.68), *Lithocarpus xylocarpus* (22.32) and *Magnolia campbelli* (20.74) and the co-dominant species were: *Castanopsis indica* (13.15) and *Michelia oblonga* (11.54) (Table 4.2.10). The dominant families were: Elaeocarpaceae, Lauraceae and Magnoliaceae. *Pinus kesiya* recorded the highest IVI in Pungro and Samphure CF with corresponding values 125.97 and 121.22 respectively (Table 4.2.10) and the co-dominant species of Pungro were: *Schima wallichi* (12.51) and *Taxus baccata* (9.17) with dominant families: Fagaceae and Theaceae. Whereas the co-dominant species of Samphure were: *Lithocarpus elegans* (13.74) and *Taxus wallichiana* (13.50) (Table 4.2.10) and dominant families were: Clusiaceae and Fagaceae. The tree stand density (individuals $ha^{-1}$) in the community forest ranged from 290 – 433 where the highest density was recorded from Fakim WLS (433) and lowest density was recorded from Samphure (290). The basal area ($m^2ha^{-1}$) ranged from 28.92 – 42.80 where the highest basal area was recorded from Fakim WLS (42.80) and the lowest basal area from Pungro community forest (28.92) respectively (Table 4.2.9).

*Shrub species composition*

In shrubs, a total of 79 species and 48 genera representing 29 families were recorded from the four community forest (Sitimi, Chinkhu, Pungro and Samphure) and Fakim WLS of Kiphire district, Nagaland. Out of these, 28 species, 23 genera and 20 families were recorded from Fakim followed 26 species, 22 genera and 19 families from Chinkhu; 25 species, 23 genera and 18 families from Pungro; 23 species, 21 genera and 16 families from Samphure and 21 species belonging to 20 genera and 15 families were recorded from Sitimi respectively (Table 4.2.9). Based on IVI value, the most dominant shrub species in Fakim WLS were: *Buddleja asiatica* (22.06), *Gaultheria griffithiana* (20.63) and *Polygonum molle* (19.92) (Table 4.2.11) and the dominant families were: Ericaceae and Rosaceae. In Chinkhu, the most dominant species were: *Mahonia nepalensis* (15.50), *Rubus moluccanus* (13.57) and *Viburnum corylifolium* (11.65) (Table 4.2.11) and the dominant families were: Ericaceae, Rosaceae and Symplocaceae. In Pungro, the dominant shrub species were: *Callicarpa rubella* (19.43), *Coriaria nepalensis* (17.89) and *Corylopsis himalyana* (16.35) (Table 4.2.11) and the most dominant families were: Asteraceae, Leguminosae and Rosaceae. In Samphure, dominant species were: *Oxyspora cernua* (23.49), *Rubus rosifolius* (22.76) and *Desmodium heterocarpon* (21.30) (Table 4.2.11) and the dominant families were: Ericaceae, Melastomataceae and Rosaceae. In Sitimi, the most dominant species were: *Ardisia neriifolia* (24.86), *Oxyspora paniculata* (22.84) and *Sida rhombifolia* (20.82) (Table 4.2.11) and the dominant families were: Berberidaceae, Ericaceae and Hydrangeaceae. From the present study, the highest shrub density (individuals $ha^{-1}$) was recorded from Fakim WLS (7000) followed by Samphure (6850), Pungro (6500), Chinkhu (5200) and Sitimi (4950) respectively (Table 4.2.9).

**Table 4.2.9** Phytosociological attributes of trees, shrubs and herbs in five study sites of Kiphire District, Nagaland

| Parameters | Fakim | Sitimi | Chinkhu | Pungro | Samphure |
|---|---|---|---|---|---|
| **Trees** | | | | | |
| No. of species | 60 | 50 | 40 | 35 | 30 |
| No. of genera | 40 | 38 | 32 | 29 | 25 |
| Families | 27 | 25 | 24 | 22 | 20 |
| Density (individuals $ha^{-1}$) | 433 | 403 | 375 | 303 | 290 |
| Basal area ($m^2ha^{-1}$) | 42.8 | 39.71 | 37.71 | 28.92 | 33.65 |
| Shannon diversity index (H') | 3.90 | 3.69 | 3.43 | 2.36 | 2.29 |
| Simpson dominance index (CD) | 0.02 | 0.03 | 0.04 | 0.30 | 0.20 |
| Margalef species richness index (Dmg) | 11.45 | 9.64 | 7.78 | 7.09 | 6.10 |
| Evenness (e) | 0.92 | 0.94 | 0.93 | 0.66 | 0.67 |
| Disturbance index (%) | 8 | 14 | 13 | 21 | 24 |
| **Shrubs** | | | | | |
| No. of species | 28 | 21 | 26 | 25 | 23 |
| No. of genera | 23 | 20 | 22 | 23 | 21 |
| Families | 20 | 15 | 19 | 18 | 16 |
| Density (individuals $ha^{-1}$) | 7000 | 4950 | 5200 | 6500 | 6850 |
| Shannon diversity index (H') | 2.84 | 2.73 | 2.96 | 2.90 | 2.70 |
| Simpson dominance index (CD) | 0.08 | 0.08 | 0.04 | 0.06 | 0.08 |
| Margalef species richness index (Dmg) | 5.46 | 4.35 | 5.38 | 4.93 | 4.47 |
| Evenness (e) | 0.85 | 0.89 | 0.91 | 0.90 | 0.86 |
| **Herbs** | | | | | |
| No. of species | 37 | 19 | 24 | 31 | 17 |
| No. of genera | 35 | 18 | 22 | 26 | 16 |
| Families | 23 | 10 | 14 | 18 | 11 |
| Density (individuals $ha^{-1}$) | 103750 | 33125 | 75625 | 61875 | 46250 |
| Shannon diversity index (H') | 3.27 | 2.63 | 2.79 | 3.21 | 2.62 |
| Simpson dominance index (CD) | 0.04 | 0.08 | 0.06 | 0.05 | 0.08 |
| Margalef species richness index (Dmg) | 7.04 | 4.53 | 4.80 | 6.53 | 3.71 |
| Evenness (e) | 0.91 | 0.89 | 0.87 | 0.93 | 0.92 |

**Table 4.2.10** Density (individuals ha$^{-1}$), Basal area (m$^{2}$ha$^{-1}$), Important value index (IVI) and Distribution pattern (DP) of tree species in five study sites of Kiphire District, Nagaland

| Species | Family | Fakim | | | | Sitimi | | | | Chinkhu | | | | Pungro | | | | Samphure | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP |
| *Acer laevigatum* Wall. | Sapindaceae | 7.5 | 0.60 | 3.90 | C | | | | | | | | | | | | | | | | |
| *Acer oblongum* Wall. ex DC. | Acearceae | 16 | 0.88 | 7.08 | C | 20 | 1.78 | 13.13 | RE | 10 | 0.74 | 6.99 | R | | | | | | | | |
| *Acer pectinatum* Wall. ex G. Nicholson | Acearceae | 7.5 | 0.53 | 3.75 | C | 7.5 | 0.80 | 4.79 | C | | | | | | | | | | | | |
| *Acer thomsonii* Miq. | Sapindaceae | 7.5 | 0.98 | 6.44 | RE | | | | | | | | | | | | | | | | |
| *Aglaia perviridis* Hiern. | Meliaceae | 10 | 1.19 | 6.65 | R | 2.5 | 0.20 | 2.05 | R | | | | | 2.5 | 0.17 | 3.03 | R | | | | |
| *Alangium chinense* (Lour.) Harms | Cornaceae | | | | | | | | | | | | | | | | | 2.5 | 0.06 | 2.91 | R |
| *Albizia julibrissin* Durazz. | Mimosaceae | | | | | 5 | 0.29 | 2.90 | C | 5 | 0.35 | 3.45 | C | 7.5 | 0.59 | 9.37 | RE | | | | |
| *Albizia odoratissima* (L.f.) Benth. | Mimosaceae | 10 | 1.25 | 6.79 | R | 7.5 | 0.56 | 6.02 | RE | | | | | 5 | 0.32 | 6.00 | RE | 2.5 | 0.16 | 3.23 | R |
| *Alnus nepalensis* D.Don | Betulaceae | | | | | 10 | 1.04 | 8.78 | RE | | | | | 2.5 | 0.16 | 3.00 | R | | | | |
| *Bauhinia divergens* Baker | Caesalpiniaceae | 2.5 | 0.20 | 1.87 | R | | | | | 2.5 | 0.06 | 2.01 | R | 5 | 0.16 | 5.44 | RE | | | | |
| *Bauhinia purpurea* L. | Caesalpiniaceae | | | | | | | | | 7.5 | 0.17 | 5.99 | RE | 5 | 0.27 | 5.81 | RE | | | | |
| *Bauhinia vahlii* Wight & Arn. | Caesalpiniaceae | | | | | | | | | | | | | 2.5 | 0.07 | 2.68 | R | | | | |
| *Bauhinia variegata* L. | Caesalpiniaceae | | | | | 2.5 | 0.26 | 2.20 | R | | | | | | | | | | | | |
| *Beilschmiedia roxburghiana* Nees | Lauraceae | 5 | 1.02 | 4.30 | C | | | | | | | | | | | | | | | | |
| *Berberis aristata* DC. | Berberidaceae | 5 | 0.33 | 2.72 | C | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Betula alnoides* Buch.-Ham. ex. D. Don | Betulaceae | 15 | 1.27 | 17.13 | R | | | | | 12.5 | 0.87 | 10.35 | RE | 2.5 | 0.32 | 3.54 | R | | | | |
| *Brassaiopsis hainla* (Buch.-Ham.) Seem. | Araliaceae | 10 | 0.83 | 5.83 | R | | | | | 12.5 | 0.56 | 8.34 | R | | | | | | | | |
| *Camellia oleifera* Abel. | Theaceae | 10 | 1.50 | 8.19 | RE | | | | | | | | | | | | | | | | |
| *Caryota urens* L. | Arecaceae | 7.5 | 0.65 | 4.85 | R | | | | | | | | | 5 | 0.44 | 6.38 | RE | 2.5 | 0.11 | 3.08 | R |
| *Castanopsis argentea* (Blume) A.DC. | Fagaceae | | | | | | | | | | | | | | | | | 12.5 | 0.76 | 14.11 | RE |
| *Castanopsis indica* (Roxb. ex Lindl.) A.DC. | Fagaceae | | | | | 12.5 | 0.86 | 8.03 | RE | 15 | 2.12 | 13.15 | R | | | | | 7.5 | 0.31 | 7.27 | R |
| *Castanopsis tribuloides* (Sm.) A.DC. | Fagaceae | | | | | 15 | 1.44 | 11.03 | RE | | | | | | | | | | | | |
| *Cephalotaxus griffithii* Hook.f. | Cephalotaxaceae | 5 | 0.24 | 2.50 | C | 5 | 0.46 | 3.32 | C | 5 | 0.31 | 3.33 | C | 5 | 0.41 | 6.30 | RE | 2.5 | 0.22 | 3.41 | R |
| *Cinnamomum glaucescens* (Nees) Hand.-Mazz. | Lauraceae | | | | | 27.5 | 1.99 | 15.52 | R | | | | | | | | | | | | |
| *Cinnamomum species* | Lauraceae | 12.5 | 1.53 | 8.83 | RE | | | | | | | | | | | | | | | | |
| *Cinnamomum zeylanicum* Blume | Lauraceae | 17.5 | 1.35 | 9.53 | R | 10 | 0.46 | 4.56 | C | 15 | 0.74 | 9.48 | R | | | | | | | | |
| *Cycas species* L. | Cycadaceae | | | | | | | | | | | | | 2.5 | 0.06 | 2.65 | R | | | | |
| *Dipterocarpus retusus* Blume | Dipterocarpaceae | | | | | 2.5 | 1.25 | 4.69 | C | 7.5 | 1.06 | 7.17 | R | | | | | | | | |
| *Docynia indica* (Wallich.) Decne. | Rosaceae | 12.5 | 1.61 | 8.18 | C | | | | | | | | | | | | | | | | |
| *Elaeocarpus braceanus* Watt ex C.B.Clarke | Elaeocarpaceae | 5 | 0.32 | 2.70 | C | 12.5 | 1.14 | 9.66 | RE | 10 | 0.83 | 7.22 | R | | | | | | | | |
| *Elaeocarpus floribundus* Blume | Elaeocarpaceae | | | | | 2.5 | 0.22 | 2.09 | R | 5 | 0.18 | 4.16 | R | | | | | | | | |
| *Elaeocarpus* | Elaeocarpaceae | 12.5 | 0.77 | 7.10 | RE | | | | | 2.5 | 0.25 | 2.51 | R | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *lanceifolius* Roxb. | | | | | | | | | | | | | | | | | | | | | |
| *Elaeocarpus tectorius* (Lour.) Poir. | Elaeocarpaceae | 10 | 1.26 | 7.65 | RE | | | | | | | | | 7.5 | 0.25 | 8.19 | RE | 5 | 0.26 | 6.28 | RE |
| *Engelhardtia spicata* Lesch. ex Blume | Juglandaceae | | | | | 7.5 | 0.61 | 5.23 | R | | | | | 2.5 | 0.14 | 2.93 | R | 2.5 | 0.36 | 3.83 | R |
| *Erythrina arborescens* Roxb. | Leguminosae | | | | | | | | | | | | | 5 | 0.21 | 5.61 | RE | | | | |
| *Eurya acuminata* DC. | Theaceae | 2.5 | 0.13 | 1.70 | R | 10 | 0.33 | 6.06 | RE | | | | | | | | | 2.5 | 0.17 | 3.26 | R |
| *Eurya cerasifolia (D. Don) Kobuski* | Theaceae | | | | | | | | | | | | | 2.5 | 0.15 | 2.96 | R | | | | |
| *Exbucklandia populnea* (R.Br. ex Griff.) R.W.Br. | Hamamelidaceae | 12.5 | 1.80 | 8.60 | C | 7.5 | 0.72 | 4.58 | C | 10 | 0.68 | 8.00 | RE | | | | | 5 | 0.35 | 4.65 | C |
| *Ficus hirta* Vahl. | Moraceae | 2.5 | 0.14 | 1.72 | R | | | | | | | | | | | | | | | | |
| *Ficus lamponga* Miq. | Moraceae | 2.5 | 0.14 | 1.73 | R | | | | | | | | | | | | | 5 | 0.42 | 6.75 | RE |
| *Ficus neriifolia* Sm. | Moraceae | | | | | 12.5 | 0.41 | 6.88 | RE | | | | | | | | | | | | |
| *Ficus semicordata* Buch.-Ham. ex. Sm. | Moraceae | | | | | | | | | 12.5 | 1.09 | 9.76 | R | | | | | | | | |
| *Ficus species* | Moraceae | 5 | 0.28 | 3.44 | RE | | | | | | | | | | | | | | | | |
| *Garcinia anomala* Planch. & Triana | Clusiaceae | 5 | 0.27 | 2.59 | C | | | | | 5 | 0.36 | 3.45 | C | 5 | 0.11 | 5.25 | RE | 2.5 | 0.19 | 3.31 | R |
| *Garcinia cowa* Roxb. ex Choisy | Clusiaceae | 2.5 | 0.13 | 1.69 | R | | | | | | | | | 5 | 0.28 | 4.24 | C | | | | |
| *Garcinia merguensis* Wight | Clusiaceae | | | | | | | | | | | | | | | | | 7.5 | 0.40 | 9.43 | RE |
| *Garcinia sopsopia* (Buch. -Ham.) Mabb. | Clusiaceae | | | | | | | | | 7.5 | 0.67 | 6.13 | R | | | | | 5 | 0.16 | 5.99 | RE |
| *Glochidion sphaerogynum* (Müll.Arg.) Kurz | Euphorbiaceae | | | | | 15 | 1.14 | 10.26 | RE | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Hovenia dulcis* Thunb. | Rhamnaceae | | | | | 15 | 2.07 | 12.62 | RE | | | | | | | | | | | | |
| *Hydnocarpus kurzii* (King) Warb. | Flacourtiaceae | 2.5 | 0.19 | 1.84 | R | | | | | 5 | 0.59 | 4.07 | C | 2.5 | 0.11 | 2.83 | R | 5 | 0.74 | 7.69 | RE |
| *Ilex excelsa* (Wall.) Hook. fil. | Aquifoliaceae | 2.5 | 0.09 | 1.61 | R | 5 | 0.24 | 2.77 | C | 10 | 0.40 | 6.08 | R | | | | | | | | |
| *Illicium griffithii* Hook.f. & Thomson | Schisandraceae | 5 | 0.25 | 2.55 | C | 5 | 0.73 | 4.01 | C | 5 | 0.90 | 4.90 | C | | | | | | | | |
| *Lindera latifolia* Hook. fil. | Lauraceae | | | | | | | | | | | | | | | | | 5 | 0.17 | 4.13 | C |
| *Lithocarpus dealbatus* (Hook.f. & Thomson ex Miq.) Rehder | Fagaceae | | | | | 7.5 | 1.12 | 6.51 | R | | | | | | | | | | | | |
| *Lithocarpus elegans* (Blume) Hatus. ex Soepadmo | Fagaceae | | | | | | | | | | | | | | | | | 10 | 0.92 | 13.74 | RE |
| *Lithocarpus fenestratus* (Roxb.) Rehder | Fagaceae | | | | | | | | | | | | | 2.5 | 0.22 | 3.19 | R | | | | |
| *Lithocarpus pachyphyllus* (Kurz) Rehder | Fagaceae | 17.5 | 2.64 | 12.50 | R | | | | | | | | | | | | | | | | |
| *Lithocarpus spp.* | Fagaceae | 10 | 1.11 | 8.14 | RE | | | | | | | | | | | | | | | | |
| *Lithocarpus xylocarpus* (Kurz) Markgr. | Fagaceae | 10 | 1.31 | 8.59 | RE | 10 | 0.81 | 8.19 | RE | 37.5 | 2.87 | 22.32 | R | | | | | | | | |
| *Litsea cubeba* (Lour.) Pers. | Lauraceae | | | | | 5 | 0.33 | 3.90 | RE | | | | | | | | | | | | |
| *Litsea monopetala* (Roxb.) Pers. | Lauraceae | 5 | 0.51 | 3.13 | C | 2.5 | 0.24 | 2.15 | R | 30 | 3.76 | 22.68 | R | | | | | | | | |
| *Litsea species* | Lauraceae | 2.5 | 0.11 | 1.65 | R | | | | | | | | | | | | | | | | |
| *Lyonia ovalifolia* (Wall.) Drude | Ericaceae | | | | | 5 | 0.37 | 3.09 | C | | | | | | | | | | | | |
| *Macaranga* | Euphorbiaceae | | | | | | | | | 5 | 0.56 | 4.00 | C | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *denticulata* (Blume) Müll.Arg. | | | | | | | | | | | | | | | | | | | | | |
| *Macaranga indica* Wight | Euphorbiaceae | | | | | 15 | 1.11 | 10.20 | RE | | | | | | | | | 5 | 0.26 | 6.28 | RE |
| *Macaranga pustulata* King ex J. D. Hook. | Euphorbiaceae | | | | | 7.5 | 0.33 | 4.54 | R | | | | | | | | | | | | |
| *Macropanax dispermus* (Blume) Kuntze | Araliaceae | 5 | 0.61 | 3.35 | C | | | | | | | | | | | | | 2.5 | 0.24 | 3.46 | R |
| *Magnolia campbellii* Hook.f.&Thomson. | Magnoliaceae | 5 | 0.40 | 2.88 | C | 5 | 1.41 | 6.64 | RE | 27.5 | 3.28 | 20.74 | R | | | | | 5 | 0.59 | 5.35 | C |
| *Magnolia champaca* (L.) Baill. ex Pierre | Magnoliaceae | 2.5 | 0.19 | 1.83 | R | | | | | | | | | | | | | | | | |
| *Magnolia insignis* Wall. | Magnoliaceae | 16 | 1.22 | 9.51 | RE | 2.5 | 0.19 | 2.01 | R | 2.5 | 1.10 | 4.75 | R | 5 | 0.38 | 6.18 | RE | | | | |
| *Magnolia oblonga* (Wall. ex Hook.f. & Thomson) Figlar | Magnoliaceae | 15 | 2.03 | 11.37 | RE | 2.5 | 0.29 | 2.27 | R | 15 | 1.07 | 11.54 | RE | | | | | | | | |
| *Magnolia rabaniana* (Hook.f. & Thomson) D.C.S.Raju & M.P.Nayar | Magnoliaceae | | | | | 5 | 0.36 | 3.06 | C | 2.5 | 0.79 | 3.93 | R | 2.5 | 0.16 | 3.00 | R | | | | |
| *Mahonia nepalensis* DC. ex Dippel | Berberidaceae | | | | | | | | | | | | | 7.5 | 0.41 | 8.72 | RE | | | | |
| *Mallotus tetracoccus* (Roxb.) Kurz | Euphorbiaceae | 2.5 | 0.20 | 1.86 | R | 20 | 1.68 | 11.94 | R | | | | | | | | | | | | |
| *Morus alba* L.(Min.) | Moraceae | | | | | 2.5 | 0.22 | 2.09 | R | | | | | | | | | | | | |
| *Myrica esculenta* Buch.-Ham. ex D. Don | Myricaceae | | | | | | | | | | | | | 5 | 0.44 | 6.40 | RE | | | | |
| *Phoebe lanceolata* (Nees) Nees | Lauraceae | 7.5 | 0.80 | 6.02 | RE | | | | | 10 | 0.86 | 9.65 | RE | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Phoenix species* L. | Arecaceae | | | | | | | | | | | | | 2.5 | 0.09 | 2.76 | R | | | | |
| *Photinia integrifolia* Lindl. | Rosaceae | | | | | | | | | | | | | 2.5 | 0.11 | 2.83 | R | | | | |
| *Pinus Kesiya* Royle ex Gordon | Pinaceae | | | | | | | | | | | | | 155 | 19.75 | 125.97 | C | 147.5 | 21.14 | 121.22 | C |
| *Prunus arborea* (Hook.f.) Kalkman | Rosaceae | 5 | 0.47 | 3.05 | C | 7.5 | 1.20 | 7.64 | R | 7.5 | 0.92 | 7.97 | RE | 2.5 | 0.23 | 3.22 | R | 2.5 | 0.21 | 3.36 | R |
| *Prunus cerasoides* Buch.-Ham. ex. D. Don | Rosaceae | 7.5 | 0.90 | 6.25 | RE | 12.5 | 2.72 | 13.64 | R | | | | | | | | | | | | |
| *Prunus nepalensis* Hook.f. | Rosaceae | 2.5 | 0.22 | 1.91 | R | 5 | 0.42 | 4.13 | RE | | | | | | | | | | | | |
| *Pyrus pashia* Buch.-Ham. ex. D. Don | Rosaceae | 10 | 0.49 | 5.06 | R | 2.5 | 0.28 | 2.25 | R | | | | | | | | | 5 | 0.27 | 4.42 | C |
| *Pyrus spp.* | Rosaceae | 5 | 0.26 | 2.55 | C | | | | | | | | | | | | | | | | |
| *Quercus griffithii* Hook.f. & Thomson ex Miq. | Fagaceae | | | | | | | | | | | | | 5 | 0.29 | 5.90 | RE | 5 | 0.16 | 5.97 | RE |
| *Quercus lamellosa* Sm. | Fagaceae | 12.5 | 1.93 | 10.58 | RE | 10 | 1.63 | 8.43 | R | 10 | 1.53 | 9.07 | R | | | | | | | | |
| *Quercus serrata* Murray | Fagaceae | | | | | | | | | | | | | | | | | 7.5 | 0.52 | 9.79 | RE |
| *Rhamnus napalensis* (Wall.) M.A. Lawson | Rhamnaceae | 5 | 0.35 | 2.76 | C | | | | | | | | | | | | | | | | |
| *Rhododendron arboreum* Sm. | Ericaceae | 12.5 | 1.24 | 8.16 | RE | 7.5 | 0.58 | 6.08 | RE | | | | | 5 | 0.20 | 5.57 | RE | 5 | 0.18 | 6.04 | RE |
| *Rhododendron fulgens* hook.f. | Ericaceae | | | | | | | | | 12.5 | 0.58 | 7.23 | C | | | | | | | | |
| *Rhododendron macabeanum* Watt ex Balf.f. | Ericaceae | | | | | 2.5 | 0.07 | 1.70 | R | 5 | 0.17 | 2.95 | C | | | | | 7.5 | 0.32 | 7.31 | R |
| *Rhododendron species* | Ericaceae | 2.5 | 0.23 | 1.92 | R | | | | | | | | | | | | | | | | |
| *Rhus chinensis* Mill. | Anacardiaceae | | | | | | | | | 2.5 | 0.84 | 4.07 | R | | | | | | | | |
| *Rhus javanica* L. | Anacardiaceae | | | | | | | | | 5 | 1.58 | 6.70 | C | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Saurauia napaulensis* DC. | Actinidaceae | | | | | 2.5 | 0.20 | 2.04 | R | | | | | | | | | | | | |
| *Schima khasiana* Dyer | Theaceae | 2.5 | 0.16 | 1.78 | R | 5 | 0.25 | 3.70 | RE | 5 | 1.11 | 6.62 | RE | 2.5 | 0.16 | 3.00 | R | 5 | 0.40 | 6.69 | RE |
| *Schima wallichii* (DC.) Korth. | Theaceae | 7.5 | 0.74 | 4.23 | C | | | | | | | | | 10 | 0.80 | 12.51 | RE | | | | |
| *Shorea assamica* Dyer | Dipterocarpaceae | 2.5 | 0.20 | 1.86 | R | | | | | | | | | 2.5 | 0.23 | 3.25 | R | | | | |
| *Sorbus microphylla* (Wall. ex Hook.f.) Wenz. | Rosaceae | | | | | 2.5 | 0.31 | 2.32 | R | 2.5 | 0.10 | 2.11 | R | | | | | | | | |
| *Sterculia coccinea* Roxb. | Malvaceae | 2.5 | 0.20 | 1.85 | R | | | | | 5 | 0.89 | 6.05 | RE | 5 | 0.30 | 5.91 | RE | 2.5 | 0.27 | 3.56 | R |
| *Syzygium cumini (L.) Skeels* | Myrtaceae | | | | | 2.5 | 0.23 | 2.11 | R | | | | | | | | | | | | |
| *Taxus baccata* L. | Taxaceae | 12.5 | 1.10 | 7.00 | C | 17.5 | 1.58 | 12.01 | RE | 5 | 0.26 | 3.20 | C | 7.5 | 0.53 | 9.17 | RE | | | | |
| *Taxus wallichiana* Zucc. | Taxaceae | | | | | | | | | | | | | | | | | 5 | 3.33 | 13.50 | C |
| *Terminalia chebula* Retz. (Min.) | Clusiaceae | | | | | 5 | 1.70 | 7.37 | RE | | | | | | | | | | | | |
| *Toona ciliata* M.Roem. | Meliaceae | 5 | 0.72 | 4.44 | RE | 10 | 1.06 | 8.83 | RE | 15 | 1.45 | 11.37 | R | | | | | | | | |
| *Toona sureni* (Blume) Merr. | Meliaceae | 2.5 | 0.20 | 1.86 | R | | | | | | | | | 5 | 0.38 | 6.21 | RE | | | | |
| *Trevesia palmata* (Roxb. ex Lindl.) Vis. | Araliaceae | | | | | | | | | 5 | 1.07 | 6.51 | RE | | | | | | | | |
| *Turpinia species* | Staphyleaceae | 5 | 0.39 | 2.85 | C | | | | | | | | | | | | | | | | |
| *Ziziphus incurva* Roxb. | Rhamnaceae | 2.5 | 0.15 | 1.75 | RE | | | | | | | | | | | | | | | | |

**Key to abbreviation:** RE= Regular; R= Random; C= Clumped

*Herb species composition*

In herbs, a total of 112 species, 86 genera representing 40 families were recorded from the four community forest (Sitimi, Chinkhu, Pungro and Samphure) and Fakim WLS of Kiphire district, Nagaland. Of these, 37 species, 35 genera and 23 families were recorded from Fakim WLS followed by 31 species, 26 genera and 18 families from Pungro; 24 species, 22 genera and 14 families from Chinkhu; 19 species, 18 genera and 10 families from Sitimi and 17 species, 16 genera and 11 families from Samphure community forest of Nagaland respectively (Table 4.2.9). Among the community forest, the most dominant herb species in Fakim were: *Cyclea peltata* (17.31), *Fagopyrum acutatum* (16.11) and *Chaerophyllum villosum* (14.30) (Table 4.2.11) and the dominant families were: Araliaceae, Polygonaceae and Ranunculaceae. In Pungro, the most dominant species were: *Geranium nepalense* (17.56), *Artemesia indica* (15.54) and *Ajuga integrifolia* (13.52) (Table 4.2.11) and the dominant families were: Caryophyllaceae and Orchidaceae. In Chinkhu, the dominant species were: *Bidens pilosa* (23.55), *Dysphania ambrosioides* (23.89) and *Fragaria nubicola* (21.05) (Table 4.2.11) and the dominant families were: Asteraceae and Lamiaceae. In Sitimi, the dominant species were: *Artemisia indica* (21.32), *Jasmimum dispermum* (19.43) and *Codonopsis javanica* (17.55) (Table 4.2.11) and the most dominant families were: Asteraceae, Orchidaceae and Ranunculaceae. In Samphure, dominant species were: *Geranium nepalense* (18.68), *Impatiemts latiflora* (25.98) and *Polygonum pubescens* (24.62) (Table 4.2.11) and the dominant families were: Asteraceae and Caryophyllaceae. The highest herb density (individuals $ha^{-1}$) was recorded from Fakim WLS (103750) followed by Chinkhu (75625), Pungro (61875), Samphure (46250) and Sitimi (33125) respectively (Table 4.2.9).

**Table 4.2.11** Density (individuals ha$^{-1}$) and Important value index (IVI) of shrubs and herbs species in five study sites of Kiphire District, Nagaland

| Species | Family | Fakim | | Sitimi | | Chinkhu | | Pungro | | Samphure | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **D** | **IVI** | **D** | **IVI** | **D** | **IVI** | **D** | **IVI** | **D** | **IVI** |
| **Shrubs** | | | | | | | | | | | |
| *Abelmoschus manihot* (Roxb.) Hochr. | Malvaceae | | | | | | | 50 | 2.36 | | |
| *Agapetes angulata* (Griff.) Hook.f. | Ericaceae | | | | | | | | | 150 | 4.23 |
| *Agapetes discolor* C.B. Clarke | Ericaceae | | | | | | | | | 250 | 9.77 |
| *Agapetes incurvata* (Griff.)Sleumer | Ericaceae | | | | | 200 | 8.26 | | | | |
| *Agapetes megacarpa* W.W. Sm. | Ericaceae | 100 | 4.60 | | | | | | | | |
| *Aralia armata* (Wall. ex G. Don) Seem | Araliaceae | | | | | 100 | 4.86 | | | | |
| *Ardisia humilis* Vahl | Primulaceae | 150 | 6.90 | | | | | | | | |
| *Ardisia neriifolia* Wall. ex A. DC. | Primulaceae | | | 800 | 24.86 | | | | | | |
| *Ardisia odontophylla* Wall. ex A. DC. | Primulaceae | | | | | 250 | 9.22 | | | | |
| *Artemesia nilagirica* (C.B. Clarke) Pamp. | Asteraceae | | | 250 | 9.40 | | | 250 | 7.02 | | |
| *Artemisia indica* Willd. | Asteraceae | | | | | | | 350 | 11.73 | | |
| *Berberis aristata* DC. | Berberidaceae | | | 150 | 7.38 | | | | | | |
| *Boehmeria platyphylla* D.Don | Urticaceae | 200 | 7.62 | | | 150 | 5.83 | | | | |
| *Boenninghausenia albiflora* (Hook.) Rchb. ex Meisn. | Rutaceae | 50 | 2.30 | | | | | | | | |
| *Buddleja asiatica* Lour. | Buddlejaceae | 1100 | 22.06 | 350 | 13.59 | 200 | 5.32 | | | 100 | 3.50 |
| *Callicarpa rubella* Lindl. | Verbenaceae | 300 | 10.63 | | | 250 | 9.22 | 850 | 19.43 | | |
| *Camellia kissi* Wall. | Theaceae | 50 | 2.30 | | | 150 | 7.30 | | | | |
| *Coriaria nepalensis* Wall. | Coriariaceae | 100 | 4.60 | 200 | 6.21 | 100 | 4.86 | 750 | 17.89 | | |
| *Corylopsis himalayana* Griff. | Hamamelidaceae | | | 50 | 3.18 | 50 | 2.43 | 650 | 16.35 | 150 | 4.23 |
| *Croton caudatus* Geiseler | Euphorbiaceae | | | | | | | | | 400 | 11.96 |
| *Debregeasia longifolia* (Burm.f.) Wedd. | Urticaceae | | | 100 | 4.19 | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Debregeasia saenab* (Forssk.) Hepper & J.R.I. Wood | Urticaceae | | | | | | | 150 | 5.48 | | |
| *Desmodium heterocarpon* L. DC. | Papilionaceae | | | | | | | | | 900 | 21.30 |
| *Desmodium hispidum* Franch. | Papilionaceae | | | 250 | 11.57 | | | | | | |
| *Desmodium oblongum* Benth. | Papilionaceae | | | | | | | 300 | 9.38 | | |
| *Dichroa febrifuga* Lour. | Hydrangeaceae | 50 | 2.30 | 200 | 10.56 | 150 | 7.30 | 150 | 5.48 | | |
| *Eupatorium cannabinum* L. | Asteraceae | 250 | 8.33 | | | 250 | 7.75 | | | | |
| *Eurya japonica* Thunb. | Theaceae | | | | | | | | | 350 | 11.23 |
| *Gaultheria dumicola* W. W. Smith | Ericaceae | | | | | 200 | 8.26 | | | | |
| *Gaultheria fragrantissima* Wall. | Ericaceae | 100 | 4.60 | | | | | | | | |
| *Gaultheria griffithiana* Wight | Ericaceae | 1000 | 20.63 | | | | | | | | |
| *Gaultheria hookeri* C.B. Clarke | Ericaceae | | | 150 | 9.55 | 100 | 3.39 | | | | |
| *Gaultheria nummularioides* D. Don | Ericaceae | | | 200 | 8.39 | | | | | | |
| *Gaultheria trichophylla* Royle | Ericaceae | | | | | | | | | 50 | 2.77 |
| *Glochidion lanceolarium* (Roxb.) Voigt | Euphorbiaceae | | | | | | | | | 100 | 3.50 |
| *Hydrangea heteromalla* D. Don | Hydrangeaceae | 50 | 2.30 | 50 | 3.18 | 150 | 7.30 | 200 | 7.84 | | |
| *Indigofera species* L. | Leguminosae | | | | | | | 50 | 2.36 | | |
| *Leea guineensis* G. Don | Leeaceae | | | | | | | | | 500 | 15.46 |
| *Lyonia ovalifolia* (Wall.) Drude | Ericaceae | | | 100 | 4.19 | | | 150 | 7.07 | | |
| *Maesa chisia* Buch.-Ham. ex D. Don | Myrsinaceae | | | | | | | | | 400 | 14.00 |
| *Maesa ruguso* C.B. Clarke | Myrsinaceae | | | | | | | 450 | 13.27 | | |
| *Mahonia nepalensis* DC. ex Dippel | Berberidaceae | 300 | 7.46 | 150 | 7.38 | 500 | 15.50 | 100 | 4.71 | | |
| *Osbeckia nepalensis* Hook.f. | Melastomataceae | | | | | 150 | 7.30 | | | | |
| *Osbeckia stellata* Buch.-Ham. ex Ker Gawl. | Melastomataceae | | | | | | | 350 | 8.56 | 200 | 4.96 |
| *Oxyspora cernua* (Roxb.) Hook. f. & Thomson ex Triana | Melastomataceae | | | | | | | | | 1050 | 23.49 |
| *Oxyspora paniculata* (D.Don) DC. | Melastomataceae | 50 | 2.30 | 700 | 22.84 | | | 150 | 5.48 | | |
| *Oxyspora vagans* (Roxb.) Wall. | Melastomataceae | 250 | 8.33 | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Pieris formosa* (Wall.) D. Don | Ericaceae | | | 100 | 4.19 | | | | | | |
| *Piptanthus nepalensis* (Hook.) D.Don | Papilionaceae | | | | | 100 | 4.86 | | | | |
| *Plectranthus ternifolius* D.Don | Lamiaceae | 100 | 3.02 | | | 200 | 8.26 | | | | |
| *Polygonum microcephalum* D. Don | Polygonaceae | | | | | | | 100 | 4.71 | | |
| *Polygonum molle* D. Don | Polygonaceae | 950 | 19.92 | | | | | | | 100 | 3.50 |
| *Rhamnus nepalensis* (Wall.) M.A. Lawson | Rhamnaceae | | | | | | | 100 | 4.71 | | |
| *Rhododendron lepidotum* Wall. ex G.Don | Ericaceae | | | 50 | 3.18 | | | | | | |
| *Rosa clinophylla* Redout & Thory | Rosaceae | | | | | 150 | 7.30 | | | | |
| *Rubus lineatus* Reinw. ex Blume | Rosaceae | | | | | 250 | 9.22 | | | | |
| *Rubus lucens* Focke | Rosaceae | | | | | | | 50 | 2.36 | | |
| *Rubus moluccanus* L. | Rosaceae | 50 | 2.30 | | | 400 | 13.57 | | | | |
| *Rubus niveus* Thunb. | Rosaceae | | | | | | | 50 | 2.36 | | |
| *Rubus rosifolius* Sm. | Rosaceae | 150 | 5.32 | | | | | | | 1000 | 22.76 |
| *Rubus sumatranus* Miq. | Rosaceae | 100 | 4.60 | | | | | | | | |
| *Sambucus adnata* DC. | Sambucaceae | | | | | | | | | 50 | 2.77 |
| *Sida rhombifolia* L. | Malvaceae | | | 600 | 20.82 | | | | | | |
| *Solanum aculeatissimum* Jacq. | Solanaceae | | | | | | | | | 350 | 13.27 |
| *Sophora acuminata* Benth. ex Baker | Leguminosae | 350 | 9.76 | 250 | 11.57 | 150 | 4.36 | 300 | 9.38 | 200 | 9.04 |
| *Spiraea canescens* D. Don | Rosaceae | | | | | | | 150 | 5.48 | | |
| *Spiraea japonica* L.f. | Rosaceae | 150 | 6.90 | 100 | 6.37 | | | | | 150 | 4.23 |
| *Strobilanthes denticulatus* (Wall. ex Nees) T.Anders. | Acanthaceae | | | | | | | 350 | 11.73 | | |
| *Strobilanthes discolor* (Nees) T. Anderson | Acanthaceae | 50 | 2.30 | | | | | | | | |
| *Strobilanthes hamiltoniana* (Steud.) Bosser & Heine | Acanthaceae | | | | | | | | | 100 | 3.50 |
| *Symplocos glomerata* King ex C.B. Clarke | Symplocaceae | | | | | | | | | 50 | 2.77 |
| *Symplocos lucida* (Thunb.) Siebold & Zucc. | Symplocaceae | 400 | 8.89 | | | | | | | 50 | 2.77 |
| *Symplocos paniculata* (Thunb.) Miq. | Symplocaceae | 350 | 9.76 | 150 | 7.38 | 250 | 10.69 | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Symplocos ramosissima* Wall. ex G. Don | Symplocaceae | | | | | 200 | 6.79 | | | | |
| *Tithonia diversifolia* (Hemsl.) A.Gray | Asteraceae | | | | | | | 50 | 2.36 | | |
| *Vaccinium donianum* Wight | Ericaceae | | | | | | | | | 200 | 4.96 |
| *Vernonia saligna* DC. | Compositae | 50 | 2.30 | | | | | | | | |
| *Viburnum cylindricum* Buch.-Ham. ex D. DOn | Caprifoliaceae | 200 | 7.62 | | | 300 | 11.65 | | | | |
| *Viburnum foetidum* Wall. | Caprifoliaceae | | | | | 250 | 9.22 | 400 | 12.50 | | |
| **Herbs** | | | | | | | | | | | |
| *Achyranthes bidentata* Blume | Amaranthaceae | 3125 | 5.64 | | | | | | | | |
| *Ainsliaea pteropoda* DC. | Asteraceae | 2500 | 5.04 | | | | | | | | |
| *Ajuga integrifolia* Buch.-Ham. | Lamiaceae | | | | | | | 4375 | 13.5 | | |
| *Ajuga macrosperma* Wall. ex Benth. | Lamiaceae | | | | | | | 1875 | 6.26 | | |
| *Ampelopsis rubifolia* (Wall.) Planch. | Vitaceae | | | | | | | 1250 | 5.25 | | |
| *Anaphalis adnata* Wall. ex DC. | Asteraceae | | | | | | | | | 1875 | 9.61 |
| *Anaphalis contorta* (D. Don) Hook.f. | Asteraceae | | | | | 2500 | 9.19 | | | | |
| *Anemone vitifolia* Buch.-Ham. ex DC. | Ranunculaceae | | | 3125 | 16.93 | | | | | | |
| *Arisaema tortuosum* (Wall.) Schott | Araceae | | | | | | | 625 | 2.62 | | |
| *Artemisia indica* Willd. | Asteraceae | | | 3750 | 21.32 | | | 5625 | 15.5 | | |
| *Asparagus officinalis* L. | Liliaceae | | | | | | | 625 | 2.62 | | |
| *Astilbe rivularis* Buch.-Ham. ex D. Don | Saxifragaceae | 3750 | 7.56 | | | | | | | | |
| *Begonia josephi* A.DC. | Begoniaceae | | | | | | | 1250 | 5.25 | | |
| *Begonia palmata* D. Don | Begoniaceae | | | 1250 | 6.27 | | | | | | |
| *Begonia picta* Sm. | Begoniaceae | 1875 | 3.12 | | | | | | | | |
| *Begonia roxburghii* A. DC. | Begoniaceae | | | | | | | | | 1250 | 5.48 |
| *Bidens biternata* (Lour.) Merr. & Sherff | Asteraceae | | | 1875 | 13.16 | | | | | 2500 | 13.7 |
| *Bidens pilosa* L. | Asteraceae | | | | | 11875 | 23.55 | | | | |
| *Brachystemma calycinum* D. Don | Caryophyllaceae | | | | | | | 1250 | 3.63 | 1250 | 5.48 |
| *Bulbophyllum eublepharum* Rchb.f. | Orchidaceae | | | 1250 | 8.77 | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Bulbophyllum rolfei* (Kuntze) Seidenf. | Orchidaceae | 625 | 1.92 | | | | | | | | |
| *Bulbophyllum striatum* (Griff.) Rchb.f. | Orchidaceae | | | 625 | 4.39 | | | 625 | 2.62 | | |
| *Calanthe alismifolia* Lindl. | Orchidaceae | | | | | | | 1250 | 3.63 | | |
| *Calanthe puberula* Lindl. | Orchidaceae | | | | | | | 625 | 2.62 | | |
| *Carex baccans* Nees | Cyperaceae | | | | | 1875 | 6.40 | | | | |
| *Chaerophyllum villosum* Wall. ex DC. | Apiaceae | 9375 | 14.30 | | | | | | | | |
| *Chiloschista parishii* Seidenf. | Orchidaceae | 1875 | 4.44 | | | | | | | | |
| *Cleisostoma duplicilobum* (J.J. Sm.) Garay | Orchidaceae | | | | | 625 | 2.79 | | | | |
| *Clematis buchananiana* DC. | Ranunculaceae | 1250 | 3.84 | | | | | 1250 | 3.63 | | |
| *Clematis montana* Buch.-Ham. ex DC. | Ranunculaceae | | | 625 | 4.39 | | | | | | |
| *Codonopsis javanica* (Blume) Hook.f. & Thomson | Campanulaceae | | | 2500 | 17.55 | | | | | | |
| *Coelogyne calcicola* Kerr | Orchidaceae | | | 1250 | 8.77 | | | | | | |
| *Coelogyne corymbosa* Lindl. | Orchidaceae | | | | | 1250 | 3.61 | 3125 | 8.28 | | |
| *Coelogyne flaccida* Lindl. | Orchidaceae | 3125 | 5.64 | | | | | | | | |
| *Colocasia esculenta* (L.) Schott | Araceae | 625 | 1.92 | | | | | | | | |
| *Crawfurdia campanulacea* Wall. & Griff. ex C. B. Clarke | Gentianaceae | | | | | | | 1875 | 6.26 | 625 | 4.13 |
| *Crawfurdia speciosa* C.B. Clarke | Gentianaceae | 1875 | 4.44 | | | | | | | | |
| *Cyclea peltata* Hook. f. & Thoms. | Menispermaceae | 12500 | 17.31 | | | | | | | | |
| *Cymbidium tigrinum* C.S.P.Parish ex Hook. | Orchidaceae | 3125 | 6.96 | | | | | | | | |
| *Dactylicapnos scandens* (D. Don) Hutch. | Papaveraceae | 1250 | 2.52 | | | 2500 | 7.23 | 2500 | 8.88 | | |
| *Delphinium altissimum* Wall. | Ranunculaceae | 1875 | 5.75 | | | | | 1250 | 5.25 | | |
| *Dendrobium bensoniae* Rchb. f. | Orchidaceae | 2500 | 5.04 | | | | | | | | |
| *Dendrobium bicameratum* Lindl. | Orchidaceae | | | | | | | | | 3750 | 19.2 |
| *Dendrobium chrysotoxum* Lindl. | Orchidaceae | | | | | | | | | 2500 | 11 |
| *Dendrobium pulchellum* Roxb. ex Lindl. | Orchidaceae | | | 625 | 4.39 | | | | | | |
| *Drymaria cordata* (L.) Willd. Ex Schult. | Caryophyllaceae | | | | | | | | | 1875 | 6.83 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Duchesnea indica* (Jacks.) Focke | Rosaceae | | | | | | | | | 625 | 4.13 |
| *Dysphania ambrosioides* (L.) Mosyakin & Clemants | Chenopodiaceae | | | | | 10625 | 21.89 | | | | |
| *Elatostema clarkei* Hook.f. | Urticaceae | | | | | | | | | 3125 | 12.3 |
| *Elsholtzia pilosa* (Benth.) Benth. | Lamiaceae | 3750 | 7.56 | | | | | | | | |
| *Eria biflora* Griff. | Orchidaceae | | | 1250 | 8.77 | | | | | | |
| *Eria vittata* Lindl. | Orchidaceae | | | | | | | 1875 | 6.26 | | |
| *Fagopyrum acutatum* (Lehm.) Mansf. ex K. hammer | Polygonaceae | 11250 | 16.11 | | | | | | | | |
| *Fragaria nilgerrensis* Schltdl. ex J. Gay | Rosaceae | 5625 | 10.68 | | | | | | | | |
| *Fragaria nubicola* (Lindl. ex Hook.f.) Lacaita | Rosaceae | | | | | 10000 | 21.07 | | | | |
| *Galinsoga parviflora* Cav. | Asteraceae | | | | | | | | | 1250 | 5.48 |
| *Geranium nepalense* Sweet | Geraniaceae | | | | | | | 6875 | 17.6 | 8125 | 28.7 |
| *Gynura cusimbua* (D.Don) S. Moore | Asteraceae | | | 2500 | 15.05 | | | | | | |
| *Habenaria malleifera* Hook.f. | Orchidaceae | | | | | | | 2500 | 7.27 | | |
| *Habenaria stenopetala* Lindl. | Orchidaceae | | | | | | | 2500 | 7.27 | | |
| *Hedychium coccineum* Buch.-Ham. ex D. Don | Zingiberaceae | | | | | 3125 | 8.05 | | | | |
| *Herpetospermum pedunculosum* (Ser.) C.B. Clarke | Cucurbitaceae | 1250 | 3.84 | | | | | | | | |
| *Holboellia latifolia* Wall. | Lardizabalaceae | 625 | 1.92 | | | | | | | | |
| *Hydrocotyle javanica* thunb. | Araliaceae | | | | | | | 3125 | 9.89 | | |
| *Hypericum elodeoides* Choisy | Hypericaceae | | | 1875 | 10.66 | | | | | | |
| *Impatients latiflora* Hook.f. & Thomson | Balsaminaceae | | | | | | | | | 6875 | 26 |
| *Inula nervosa* Wall. Ex DC. | Asteraceae | | | | | 1250 | 3.61 | | | | |
| *Jasminum dispermum* Wall. | Oleaceae | | | 3125 | 19.43 | | | | | | |
| *Justicia khasiana* C.B.Clarke | Acanthaceae | | | 2500 | 12.55 | | | | | | |
| *Leucas cephalotes* (Roth) Spreng | Lamiaceae | | | | | 1875 | 6.40 | | | | |
| *Leucas ciliata* Benth. | Lamiaceae | | | | | 5000 | 12.49 | | | | |
| *Lobelia zeylanica* L. | Campanulaceae | | | | | | | 1875 | 6.26 | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Luffa cylindrica* (L.) M. Roem. | Cucurbitaceae | | | | | 625 | 2.79 | | | | |
| *Lycopodium japonicum* Thunb. | Lycopodiaceae | 3125 | 6.96 | | | 1250 | 3.61 | | | | |
| *Oenanthe javanica* (Blume) DC. | Apiaceae | | | | | | | 625 | 2.62 | | |
| *Ophiorrhiza oppositiflora* Hook.f. | Rubiaceae | | | | | | | 625 | 2.62 | | |
| *Otochilus porrectus* Lindl. | Orchidaceae | 1250 | 2.52 | 1250 | 6.27 | | | | | 1250 | 5.48 |
| *Oxalis corniculata* L. | Oxalidaceae | 1250 | 2.52 | | | | | | | | |
| *Panax bipinnatifidum* (Burkill) J. Wen | Araliaceae | 2500 | 3.73 | | | | | | | | |
| *Panax pseudoginseng* Wall. | Araliaceae | 3750 | 8.88 | | | | | | | | |
| *Paris fargesii* Franch. | Trilliaceae | 625 | 1.92 | 1875 | 8.16 | | | | | | |
| *Paris polyphylla* Sm. | Trilliaceae | | | | | | | 1250 | 3.63 | | |
| *Pericampylus glaucus* (Lam.) Merr. | Orchidaceae | | | | | 4375 | 9.71 | | | | |
| *Persicaria hydropiper* (L.) Delarbre | Polygonaceae | 1875 | 4.44 | | | | | | | | |
| *Phaius flavus* (Blume) Lindl. | Orchidaceae | | | | | | | 1250 | 5.25 | | |
| *Phaius mishmensis* (Lindl. & Paxton) Rchb.f. | Orchidaceae | | | | | | | 2500 | 10.5 | | |
| *Phalaenopsis difformis* (Wall. ex Lindl.) Kocyan & Schuit. | Orchidaceae | | | | | 2500 | 5.27 | | | | |
| *Pholidota articulata* Lindl. | Orchidaceae | 3125 | 6.96 | | | | | | | | |
| *Phytolacca acinosa* Roxb. | Phytolaccaceae | 1250 | 2.52 | | | | | | | | |
| *Plantago major* L. | Plantaginaceae | | | 1250 | 8.77 | | | | | | |
| *Pleione humilis* (Sm.) D. Don | Orchidaceae | | | | | | | 1875 | 6.26 | | |
| *Pleione maculata* (Lindl.) Lindl. & Paxton | Orchidaceae | | | | | | | 3125 | 9.89 | | |
| *Polygonum pubescens* Blume | Polygonaceae | | | | | 3125 | 11.98 | | | 6250 | 24.6 |
| *Potentilla fulgens* Wall. ex Sims | Rosaceae | 1875 | 3.12 | | | | | | | | |
| *Ranunculus diffusus* DC. | Ranunculaceae | 1250 | 2.52 | | | | | | | | |
| *Ranunculus sceleratus* L. | Ranunculaceae | 625 | 3.23 | | | | | | | | |
| *Rubia cordifolia* L. | Rubiaceae | | | | | 1875 | 6.40 | | | | |
| *Rubia sikkimensis* Kurz | Rubiaceae | | | | | | | | | 625 | 4.13 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Satyrium nepalense* D. Don | Orchidaceae | | | | | | | 625 | 2.62 | | |
| *Selaginella chrysorrhizos* Spring | Selaginellaceae | | | | | 625 | 2.79 | | | | |
| *Senecio cappa* Buch.-Ham. ex D.Don | Asteraceae | | | | | 3750 | 10.84 | | | | |
| *Senecio scandens* Buch.-Ham. ex D. Don | Asteraceae | | | | | 1875 | 8.36 | | | | |
| *Sigesbeckia orientalis* L. | Asteraceae | | | 625 | 4.39 | | | | | | |
| *Silene baccifera* (L.) Roth | Caryophyllaceae | | | | | | | 1875 | 6.26 | | |
| *Stellaria wallichiana* Haines | Caryophyllaceae | | | | | | | | | 2500 | 13.7 |
| *Swertia bimaculata* Hook.f.&Thoms. | Gentianaceae | 2500 | 3.73 | | | | | | | | |
| *Trichosanthes tricuspidata* Lour. | Cucurbitaceae | 1250 | 2.52 | | | | | | | | |
| *Urtica dioica* L. | Urticaceae | | | | | 1250 | 3.61 | | | | |
| *Valeriana hardwickii* Wall. | Valerianaceae | | | | | 625 | 2.79 | | | | |
| *Vanda cristata* Wall. ex Lindl. | Orchidaceae | | | | | 1250 | 5.57 | | | | |
| *Verbena officinalis* L. | Verbenaceae | 625 | 1.92 | | | | | | | | |
| *Viola betonicifolia* Sm. | Violaceae | 3125 | 6.96 | | | | | | | | |

#### 4.2.3.2 Species diversity indices

In all the community forest, high diversity and low dominance was shown wshich is considered as the major characteristic feature of an old growth forest. In trees, Shannon diversity index (H') value ranged from 2.29 – 3.90 where Fakim WLS (3.90), Sitimi (3.69) and Chinkhu (3.43) reflected higher diversity as compared to Pungro (2.36) and Samphure CF (2.29). The Simpson dominance index (CD) in the present study ranged from 0.02 – 0.30 and the Margalef index (Dmg) of tree species ranged from 6.10 – 11.45. The Pielou’s evenness index (e) ranged from 0.66 – 0.94 where Fakim WLS, Sitimi and Chinkhu CF showed high evenness of species as compared to Pungro and Samphure community forest (Table 4.2.9).

In shrubs, the Shannon diversity index (H') in the present study ranged from 2.70 – 2.96 where the highest H' was recorded in Chinkhu CF (2.96) followed by Pungro CF (2.70), Fakim WLS (2.84), Sitimi CF (2.73) and lowest in Samphure CF (2.70). The Simpson dominance index (CD) in all the community forest ranged from 0.04 – 0.08 and as H' value increased, CD value decreased. The Margalef species richness index (Dmg) ranged from 4.35 – 5.46 and the Pielou’s evenness index (e) in the present study ranged from 0.85 – 0.91, indicating quite even species within the community (Table 4.2.9).

In herbs, the highest Shannon diversity index (H') value ranged from 2.62 – 3.27 where Fakim WLS and Pungro CF reflected higher species diversity as compared to other community forest. The Simpson dominance index (CD) ranged from 0.04 – 0.08, where highest CD value was recorded in lowest H' value. The Margalef species richness index (Dmg) ranged from 3.71 – 7.04 that corresponds well with the H' value and the Pielou’s evenness index (e) ranged from 0.87 – 0.92 indicating that even distribution of species within the community forest (Table 4.2.9).

#### 4.2.3.3 Population structure of tree species in various girth-classes

The tree density and basal area varied in different girth class distribution in all the communities. The study showed that the highest density and basal area was recorded from the younger trees (10 – 60 cm girth class) which contributed 75% of total density and 53% of total basal area in all the communities. In girth class 30 – 60 cm, Chinkhu CF recorded the highest density (268 individuals ha$^{-1}$) and basal area (17.48 m$^2$ha$^{-1}$). Similarly in older trees (90 – >150 cm girth class), Chinkhu CF recorded the highest density (23 individuals ha$^{-1}$) and basal area (8.90 m$^2$ha$^{-1}$) where as no individual in girth class >150 cm was recorded from community forest (Sitimi, Pungro, Samphure) and Fakim WLS. The overall population structure in all communities showed a reverse *J*-shaped population curve indicating a good forest health and high species richness (Figure 4.2.5).

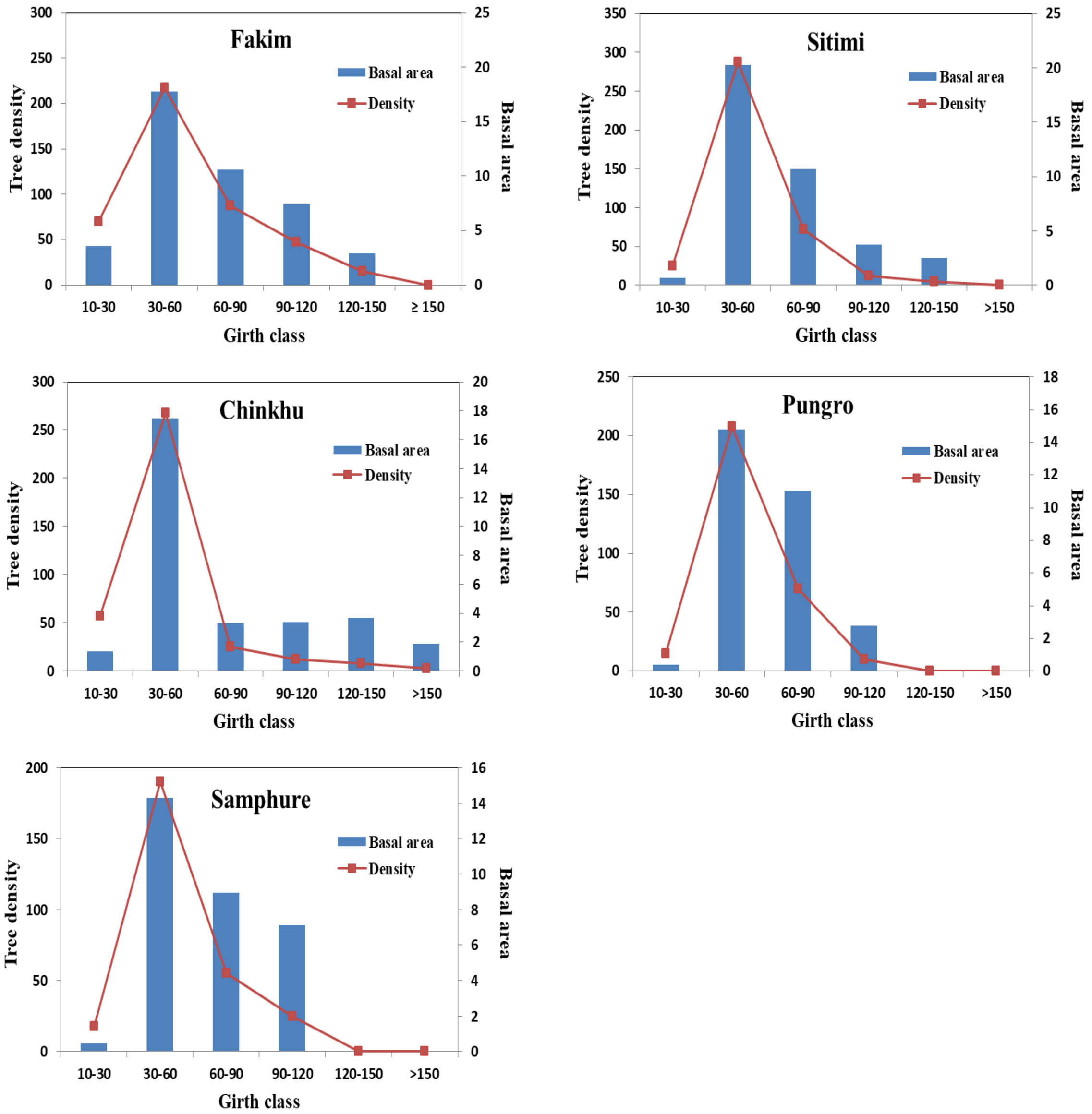
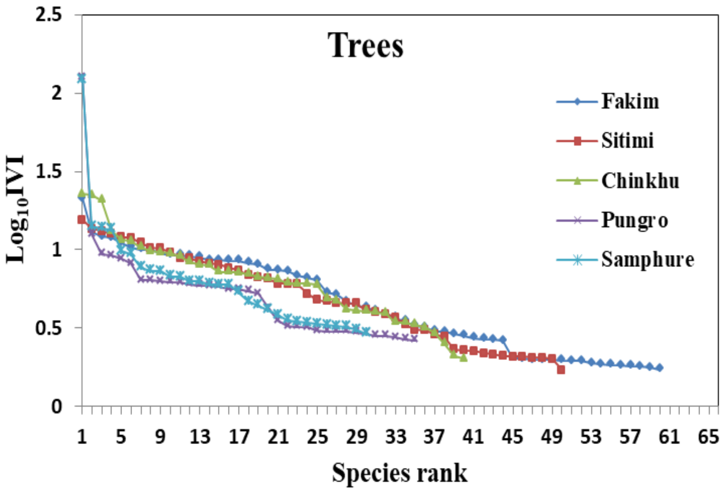
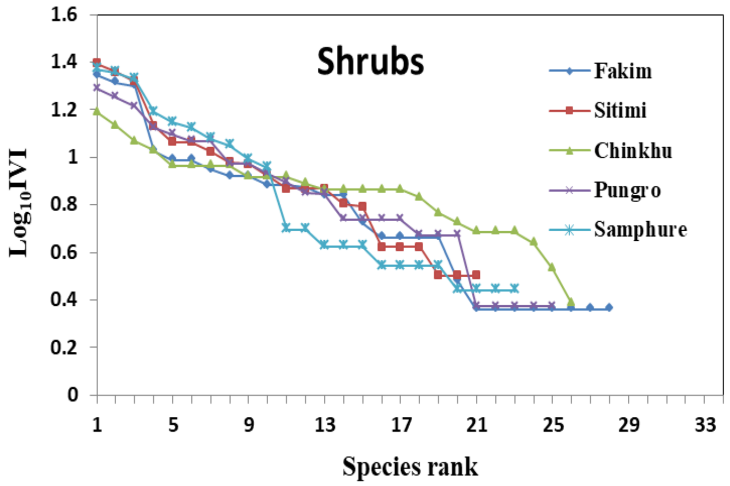



**Figure 4.2.5** Contributions of tree stand density and basal area based on girth class contribution in five study sites of Kiphire District, Nagaland

#### 4.2.3.4 Dominance-Diversity curve

Dominance-diversity curve (% IVI on log scale plotted against species rank) showed mixed nature of vegetation with site wise variations in different communities. Among tree species, the dominance-diversity curve showed high equitability and low dominance in Chinkhu CF, Sitimi CF and Fakim WLS and the dominance-diversity curve followed a log normal distribution pattern while the dominance-diversity curve of Pungro and Samphure CF showed low equitability and low dominance and the dominance-diversity curve followed a broken stick distribution pattern (Figure 5.2.6). Among Pungro and Samphure CF, *Pinus kesiya* was the dominant tree species with corresponding value 125.97 and 121.22 respectively. Other co-dominant tree species in community forest were: *Acer oblongum, Betula alnoides, Cinnamomum zeylanicum, Lithocarpus pachyphyllus, Litsea monopetala, Lithocarpus xylocarpus, Magnolia campbelli, Michelia oblong, Prunus cerasoides*, and *Quercus lamelosa* (Table 4.2.10). In shrubs and herbs species, the dominance-diversity curve showed high equitability and low dominance in all the five study sites and the dominance-diversity curve followed a log normal distribution pattern (Figure 4.2.6).





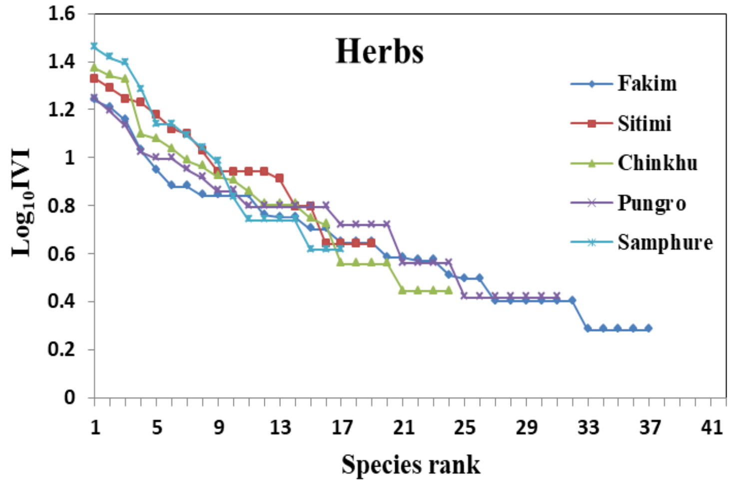




**Figure 4.2.6** Dominance-Diversity curve for trees, shrubs and herbs in five study sites of Kiphire District, Nagaland

### 4.2.3.5 Distribution pattern of tree species

The Whitford index (A/F ratio) was analysed to study the distribution pattern of tree species in all the communities. The study revealed that four out of five study sites (Fakim, Sitimi, Chingki and Samphure) showed maximum random distribution pattern (43%, 44%, 53% and 47% respectively). The highest regular distribution pattern was recorded from Pungro CF (51%) indicating high competition of species and community forest (Sitimi, Samphure and Pungro) recorded the minimum clumped distribution pattern of tree species (20%, 20% and 6 %) than other community forest. The overall study of distribution pattern of tree species in different community showed that the forest is quite even in all the community and existence of high competition between the individuals (Table 4.2.10).

#### 4.2.3.6 Sorenson's similarity for tree species

Sorenson's similarity index was analysed to study the similarity of tree species in all the community. The similarity index indicated that Sitimi and Chinkhu CF showed highest similarity os species (51%) followed by Fakim WLS and Sitimi CF (42%). The probable reason for highest similarity between the community forests maybe attributed to same range of atitude (1800 – 2500 m) and temeprate region. The study showed that Fakim WLS and Pungro CF; Pungro and Samphure CF showed same similarity of species (40% each) whereas Pungro and Sitimi CF recorded the lowest similarity index (28%) which maybe attributed to different forest type and altitudinal variant and other ecological factors (Table 4.2.12).

**Table 4.2.12** Sorenson Similarity indices for tree species between five study sites of Kiphire District, Nagaland

| Study area | Fakim | Sitimi | Chinkhu | Pungro | Samphure |
|---|---|---|---|---|---|
| **Fakim** | x | | | | |
| **Sitimi** | 0.42 | x | | | |
| **Chinkhu** | 0.37 | 0.51 | x | | |
| **Pungro** | 0.40 | 0.28 | 0.35 | x | |
| **Samphure** | 0.36 | 0.30 | 0.31 | 0.40 | x |

#### 4.2.3.7 Disturbance pattern

The disturbance index on cut stumps was highest at Samphure and Pungro CF ( 24% and 21% respectively) since the region is dominant with *Pinus kesiya* which is considered as general purpose timber and also an important NTFP species (Table 4.2.9). Oleoresin of good quality is tapped from these trees and exported commercially. Fakim WLS observed least disturbance on account of anthropogenic activity.

### 4.2.4 Tuensang district

### 4.2.4.1 Floristic structure

*Tree species composition*

In the present study, a total of 810 individuals belonging to 121 species and 74 genera belonging to 45 families were recorded from the five community forest (Helipong, Chendang, Yangli, Panso and Pangsha) of Tuensang district, Nagaland, Northeast India. Out of these, 44 species, 32 genera, 22 families and 183 individuals were recorded from Helipong; 37 species, 27 genera, 18 families and 137 individuals from Chendang; 36 species, 31 genera, 21 families and 162 individuals from Yangli; 45 species, 39 genera, 28 families and 149 individuals from Panso and 33 species, 31 genera, 27 families and 179 individuals from Samphure community forest of Nagaland respectively (Table 4.2.13). Based on IVI value, the dominant tree species in Helipong were: *Quercus lamellosa* (25.22), *Lithocarpus pachyphyllus* (18.32) and *Phoebe lanceolata* (15.75) and the co-dominant species were: *Machilus parviflora* (11.81), *Prunus ceylanica* (11.66) and *Cephalotaxus griffithii* (10.92) (Table 4.2.14). The most dominant families were: Fagaceae, Lauraceae and Rosaceae. In Chendang, the dominant tree species were: *Lithocarpus elegans* (21.26), *Phoebe lanceolata* (20.19) and *Saurauia nepalensis* (20.12) and the co-dominant species were: *Alnus nepalensis* (12.11) and *Schima Khasiana* (12.35) (Table 4.2.14). The most dominant families were: Fagaceae, Rosaceae and Theaceae. In Yangli, the dominant species were: *Alnus nepalensis* (35.12), *Terminalia myriocarpa* (22.44) and *Litsea monopetala* (18.34) and the co-dominant species were: *Prunus cerasoides* (12.69), *Xerospermum noronhianum* (11.33) and *Mallotus paniculatus* (11.30) (Table 4.2.14). The dominant families were: Fagaceae, Lauraceae and Moraceae. In Panso, the dominant species were: *Castanopsis tribuloides* (17.38), *Magnolia oblonga* (15.78) and *Trema orientalis* (14.17) and the co-dominant species were: *Schima wallichi* (11.09), *Terminalia myriocarpa* (10.52) and *Myrica esculenta* (9.82) (Table 4.2.14). The dominant families were: Euphorbiaceae, Magnoliaceae and Lauraceae. In Pangsha, the dominant species were: *Pterospermum lanceifolium* (28.09), *Duabanga grandiflora* (24.83) and *Alstonia scholaris* (21.74) and co-dominant species were: *Lindera pulcherrima* (17.84) and *Docynia indica* (15.38) (Table 4.2.14). The dominant families were: Betulaceae, Lauraceae and Theaceae. The tree stand density (individuals ha$^{-1}$) in the community forest ranged from 318 – 440 where the highest density was recorded from Helipong (440) and lowest density was recorded from Chendang (290). The basal area (m$^2$ha$^{-1}$) ranged from 27.28 – 34.18 where the highest basal area was recorded from Yangli (42.80) and the lowest basal area from Pangsha community forest (27.28) respectively (Table 4.2.13).

**Table 4.2.13** Phytosociological attributes of trees, shrubs and herbs in five study sites of Tuensang District, Nagaland

| Parameters | Helipong | Chendang | Yangli | Panso | Pangsha |
|---|---|---|---|---|---|
| **Trees** | | | | | |
| No. of species | 42 | 37 | 36 | 45 | 33 |
| No. of genera | 34 | 27 | 31 | 39 | 31 |
| Families | 22 | 18 | 21 | 28 | 27 |
| Density (individuals ha$^{-1}$) | 440 | 318 | 405 | 373 | 423 |
| Basal area (m$^2$ha$^{-1}$) | 32.90 | 28.65 | 34.18 | 33.38 | 27.28 |
| Shannon diversity index (H') | 3.49 | 3.45 | 3.31 | 3.59 | 3.26 |
| Simpson dominance index (CD) | 0.03 | 0.03 | 0.04 | 0.03 | 0.05 |
| Margalef species richness index (Dmg) | 7.87 | 7.31 | 6.88 | 8.79 | 6.16 |
| Evenness (e) | 0.92 | 0.96 | 0.90 | 0.94 | 0.93 |
| Disturbance index (%) | 8 | 17 | 11 | 9 | 6 |
| **Shrubs** | | | | | |
| No. of species | 27 | 26 | 30 | 22 | 23 |
| No. of genera | 25 | 23 | 25 | 21 | 21 |
| Families | 20 | 19 | 22 | 20 | 18 |
| Density (individuals ha$^{-1}$) | 4500 | 5550 | 6850 | 6650 | 5100 |
| Shannon diversity index (H') | 2.83 | 2.91 | 3.20 | 2.81 | 2.95 |
| Simpson dominance index (CD) | 0.05 | 0.05 | 0.04 | 0.07 | 0.06 |
| Margalef species richness index (Dmg) | 5.78 | 5.30 | 5.89 | 4.29 | 4.76 |
| Evenness (e) | 0.86 | 0.89 | 0.94 | 0.91 | 0.94 |
| **Herbs** | | | | | |
| No. of species | 23 | 30 | 33 | 25 | 26 |
| No. of genera | 20 | 28 | 31 | 22 | 23 |
| Families | 12 | 15 | 21 | 18 | 21 |
| Density (individuals ha$^{-1}$) | 48750 | 79375 | 65625 | 48125 | 53125 |
| Shannon diversity index (H') | 2.68 | 3.09 | 2.77 | 2.88 | 2.79 |
| Simpson dominance index (CD) | 0.06 | 0.04 | 0.05 | 0.05 | 0.07 |
| Margalef species richness index (Dmg) | 5.05 | 5.99 | 6.88 | 5.52 | 5.63 |
| Evenness (e) | 0.85 | 0.90 | 0.79 | 0.89 | 0.85 |

**Table 4.2.14** Density (individuals ha$^{-1}$), Basal area (m$^2$ha$^{-1}$), Important value index (IVI) and Distribution pattern (DP) of tree species in five study sites of Tuensang District, Nagaland

| Species | Family | Helipong | | | | Chendang | | | | Yangli | | | | Panso | | | | Pangsha | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP |
| *Acer laevigatum* Wall. | Aceraceae | 5 | 0.21 | 2.80 | C | 7.5 | 0.44 | 5.18 | C | | | | | | | | | | | | |
| *Acer oblongum* Wall. ex DC. | Aceraceae | 7.5 | 0.25 | 4.50 | R | 5 | 0.27 | 3.81 | C | | | | | | | | | | | | |
| *Acer pectinatum* Wall. ex G.Nicholson | Aceraceae | 5 | 0.27 | 2.98 | C | | | | | | | | | | | | | | | | |
| *Aglaia spectabilis* (Miq.) S.S.Jain & S.Bennet | Meliaceae | | | | | | | | | | | | | 10 | 0.73 | 8.06 | RE | 12.5 | 0.79 | 9.85 | RE |
| *Alangium chinense* (Lour.) Harms | Cornaceae | 10 | 0.79 | 7.71 | RE | | | | | | | | | | | | | | | | |
| *Albizia chinensis* (Osbeck) Merr. | Mimosaceae | | | | | | | | | 2.5 | 0.36 | 3.29 | R | 5 | 0.27 | 3.21 | C | | | | |
| *Albizia procera* (Roxb.)Benth. | Mimosaceae | | | | | | | | | | | | | 2.5 | 0.32 | 2.68 | R | | | | |
| *Alnus nepalensis* D.Don | Betulaceae | 5 | 0.84 | 5.71 | RE | 7.5 | 1.68 | 12.11 | C | 42.5 | 6.21 | 35.12 | R | 2.5 | 0.29 | 2.61 | R | 7.5 | 0.59 | 6.61 | R |
| *Alstonia scholaris* (L.) R. Br. | Apocynaceae | | | | | | | | | | | | | 10 | 0.86 | 7.40 | R | 30 | 2.54 | 21.74 | R |
| *Artocarpus chama* Buch.-Ham. | Moraceae | | | | | | | | | 2.5 | 0.16 | 2.70 | R | | | | | | | | |
| *Artocarpus lacucha* Buch.-Ham. | Moraceae | | | | | | | | | 10 | 1.47 | 8.37 | C | | | | | 7.5 | 0.47 | 4.85 | C |
| *Bauhinia purpurea* L. | Caesalpiniaceae | | | | | | | | | 20 | 0.49 | 9.60 | C | | | | | | | | |
| *Beilschmiedia roxburghiana* Nees | Lauraceae | | | | | | | | | | | | | 10 | 0.10 | 4.04 | C | | | | |
| *Betula alnoides* Buch.-Ham. ex. D. Don | Betulaceae | | | | | | | | | | | | | 2.5 | 1.89 | 7.41 | R | 10 | 1.67 | 12.50 | RE |
| *Betula utilis D. Don* | Betulaceae | | | | | 5 | 0.84 | 5.81 | C | | | | | | | | | | | | |
| *Boehmeria rugulosa* Wedd. | Urticaceae | | | | | | | | | | | | | 5 | 0.06 | 3.64 | RE | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Brassaiopsis hainla* (Buch.-Ham.) Seem. | Araliaceae | | | | | | | | | | | | | 12.5 | 0.42 | 8.86 | RE | | | | |
| *Bridelia glauca* Blume | Euphorbiaceae | | | | | | | | | 2.5 | 0.40 | 3.40 | R | | | | | | | | |
| *Callicarpa arborea* Roxb. | Verbenaceae | | | | | | | | | 12.5 | 0.90 | 8.94 | C | 7.5 | 0.63 | 6.03 | R | 5 | 0.30 | 3.62 | C |
| *Callicarpa macrophylla* Vahl | Verbenaceae | | | | | | | | | | | | | 5 | 0.83 | 5.96 | RE | | | | |
| *Canarium strictum* Roxb. | Burseraceae | | | | | | | | | 7.5 | 1.05 | 6.54 | C | 15 | 0.65 | 9.18 | R | 12.5 | 0.54 | 8.94 | R |
| *Castanopsis indica* (Roxb. ex Lindl.) A.DC. | Fagaceae | | | | | | | | | | | | | | | | | 7.5 | 0.58 | 5.24 | C |
| *Castanopsis lanceifolia* (Oerst.) Hickel & A.Camus | Fagaceae | | | | | | | | | 5 | 0.42 | 4.07 | C | | | | | | | | |
| *Castanopsis tribuloides* (Sm.) A.DC. | Fagaceae | | | | | | | | | | | | | 25 | 2.14 | 17.38 | RE | | | | |
| *Cephalotaxus griffithii* Hook.f. | Taxaceae | 20 | 0.76 | 10.92 | RE | 12.5 | 0.76 | 9.19 | C | | | | | | | | | | | | |
| *Choerospondias axillaris* (Roxb.) B.L. Burtt & A.W. Hill | Anacardiaceae | | | | | | | | | | | | | | | | | 15 | 0.59 | 9.70 | R |
| *Cinnamomum impressum* (Meisn,) Kosterm. | Lauraceae | 5 | 0.27 | 2.97 | C | 7.5 | 0.41 | 5.10 | C | | | | | | | | | | | | |
| *Colona floribunda* (Kurz) Craib | Tiliaceae | 7.5 | 0.32 | 4.71 | R | | | | | | | | | | | | | | | | |
| *Cyathea andersonii* (J. Scott ex Bedd.) Copel. | Cyatheaceae | | | | | | | | | | | | | | | | | 12.5 | 0.13 | 8.77 | RE |
| *Cyathea sollyana* (Griff.) Fraser-Jenkins | Cyatheaceae | | | | | | | | | | | | | | | | | 7.5 | 0.10 | 4.82 | R |
| *Dillenia indica* L. | Dilleniaceae | | | | | | | | | 7.5 | 0.98 | 6.33 | C | | | | | 12.5 | 1.69 | 11.83 | C |
| *Dimocarpus longan* Lour. | Sapindaceae | | | | | | | | | 10 | 0.39 | 5.21 | C | 2.5 | 0.32 | 2.70 | R | | | | |
| *Diospyros kaki* L.f. | Ebenaceae | 10 | 0.60 | 8.14 | RE | | | | | | | | | | | | | | | | |
| *Docynia indica* (Wallich.)Decne. | Rosaceae | | | | | | | | | 12.5 | 0.50 | 6.16 | RE | | | | | 32.5 | 1.01 | 15.38 | C |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Drimycarpus racemosus* (Roxb.) Hook. f. | Anacardiaceae | | | | | | | | | | | | | 10 | 0.60 | 7.66 | RE | | | | |
| *Duabanga grandiflora* (DC.) Walp. | Lythraceae | | | | | | | | | | | | | | | | | 35 | 3.06 | 24.83 | R |
| *Elaeocarpus braceanus* Watt ex C. B. Clarke | Elaeocarpaceae | | | | | | | | | 5 | 0.37 | 3.93 | C | | | | | | | | |
| *Elaeocarpus floribundus* Blume | Elaeocarpaceae | | | | | 10 | 0.32 | 9.45 | RE | | | | | | | | | | | | |
| *Elaeocarpus lanceifolius* Roxb. | Elaeocarpaceae | 2.5 | 0.13 | 1.97 | C | | | | | | | | | | | | | | | | |
| *Elaeocarpus serratus* L. | Elaeocarpaceae | | | | | | | | | | | | | 12.5 | 0.49 | 8.02 | R | 10 | 0.42 | 6.57 | R |
| *Elaeocarpus tectorius* (Lour.) Poir. | Elaeocarpaceae | 5 | 0.29 | 3.03 | C | 12.5 | 0.60 | 8.64 | C | | | | | | | | | | | | |
| *Engelhardia spicata* Lesch. ex Blume | Juglandaceae | 7.5 | 1.19 | 7.36 | R | | | | | | | | | 7.5 | 0.76 | 5.36 | C | 17.5 | 0.90 | 11.46 | R |
| *Eurya acuminata* DC. | Theaceae | | | | | 7.5 | 0.24 | 4.49 | C | | | | | 2.5 | 0.04 | 1.85 | R | 20 | 0.51 | 10.62 | R |
| *Eurya cerasifolia* (D. Don) Kobuski | Theaceae | 10 | 0.43 | 7.61 | RE | 12.5 | 0.40 | 10.53 | RE | | | | | | | | | | | | |
| *Exbucklandia populnea* (R.Br. ex Griff.) R.W.Br. | Hamamelidaceae | 12.5 | 0.97 | 8.85 | RE | | | | | | | | | | | | | | | | |
| *Ficus hispida* L.f. | Moraceae | | | | | | | | | 10 | 0.49 | 8.74 | RE | 10 | 0.41 | 7.10 | RE | | | | |
| *Ficus neriifolia* Sm. | Moraceae | | | | | 2.5 | 0.15 | 2.61 | R | | | | | | | | | | | | |
| *Ficus racemosa* L. | Moraceae | | | | | | | | | 15 | 0.79 | 9.25 | C | | | | | | | | |
| *Ficus semicordata* Buch.-Ham. ex Sm. | Moraceae | 2.5 | 0.12 | 1.96 | C | | | | | | | | | | | | | | | | |
| *Garcinia anomala* Planch. & Triana | Clusiaceae | | | | | | | | | | | | | 15 | 0.84 | 8.68 | C | | | | |
| *Garcinia sopsopia* (Buch. -Ham.) Mabb. | Clusiaceae | | | | | | | | | | | | | | | | | 2.5 | 0.07 | 2.18 | R |
| *Glochidion zeylanicum* (Gaertn.) A.Juss. | Euphorbiaceae | 2.5 | 0.06 | 1.75 | C | | | | | | | | | | | | | | | | |
| *Heynea trijuga* Roxb. ex Sims | Meliaceae | | | | | | | | | | | | | | | | | 15 | 0.39 | 7.65 | C |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Hibiscus macrophyllus* Roxb. ex Hornem. | Malvaceae | | | | | | | | | | | | | 2.5 | 0.08 | 1.97 | R | | | | |
| *Ilex dipyrena* Wall. | Aquifoliaceae | | | | | 15 | 0.77 | 9.99 | C | | | | | | | | | | | | |
| *Ilex excelsa* (Wall.) Hook. fil. | Aquifoliaceae | 7.5 | 0.56 | 4.45 | C | | | | | | | | | | | | | | | | |
| *Illicium griffithii* Hook. f. & Thoms. | Illiciaceae | 5 | 0.31 | 3.11 | C | 2.5 | 0.11 | 2.46 | R | | | | | | | | | | | | |
| *Juglans regia* L. | Juglandaceae | 15 | 0.62 | 8.36 | R | | | | | 5 | 0.63 | 4.69 | C | | | | | | | | |
| *Juniperus species*L. | Cupressaceae | 5 | 0.63 | 4.08 | C | 5 | 0.28 | 3.86 | C | | | | | | | | | | | | |
| *Lindera melastomacea* Fern.-Vill. | Lauraceae | 5 | 0.31 | 4.11 | RE | | | | | | | | | 10 | 0.27 | 5.63 | R | | | | |
| *Lindera nacusua* (D. Don) Merr | Lauraceae | | | | | 10 | 0.12 | 8.77 | RE | 22.5 | 0.78 | 11.07 | C | | | | | | | | |
| *Lindera pulcherrima* (Nees) Benth. | Lauraceae | 17.5 | 0.65 | 10.03 | RE | | | | | 12.5 | 0.49 | 7.76 | C | | | | | 25 | 1.80 | 17.84 | RE |
| *Lithocarpus elegans* (Blume) Hatus. ex Soepadmo | Fagaceae | 7.5 | 1.22 | 8.44 | RE | 15 | 3.25 | 21.26 | RE | 2.5 | 0.70 | 4.27 | R | 5 | 0.53 | 3.99 | C | | | | |
| *Lithocarpus pachyphyllus* (Kurz) Rehder | Fagaceae | | | | | 5 | 0.78 | 6.90 | C | | | | | | | | | | | | |
| *Lithocarpus truncatus* (King ex Hook.f.) Rehder | Fagaceae | | | | | | | | | | | | | 2.5 | 0.14 | 2.14 | R | | | | |
| *Lithocarpus xylocarpus* (Kurz) Markgr. | Fagaceae | 30 | 2.43 | 18.32 | R | 10 | 1.69 | 11.64 | C | | | | | | | | | | | | |
| *Litsea elongata* (Nees) Hook.f. | Lauraceae | | | | | | | | | 7.5 | 0.52 | 6.59 | R | 10 | 0.62 | 7.74 | RE | | | | |
| *Litsea laeta* (Wall. ex Nees) Hook.f. | Lauraceae | | | | | 7.5 | 0.20 | 4.37 | C | | | | | | | | | | | | |
| *Litsea monopetala* (Roxb.) Pers. | Lauraceae | 12.5 | 1.18 | 9.48 | RE | | | | | 27.5 | 1.74 | 18.34 | RE | | | | | | | | |
| *Litsea salicifolia* (Roxb. ex Nees) Hook.f. | Lauraceae | | | | | | | | | 5 | 0.14 | 3.26 | C | | | | | | | | |
| *Macaranga denticulata* (Blume) | Euphorbiaceae | | | | | | | | | | | | | 12.5 | 0.71 | 9.74 | RE | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Müll.Arg. | | | | | | | | | | | | | | | | | | | | | |
| *Machilus parviflora* Meisn. | Lauraceae | 20 | 1.05 | 11.81 | RE | | | | | | | | | | | | | | | | |
| *Magnolia campbellii* Hook.f.&Thomson. | Magnoliaceae | 7.5 | 1.36 | 7.86 | R | 10 | 0.98 | 11.77 | RE | | | | | | | | | | | | |
| *Magnolia cathcartii* (Hook.f.&Thomson.) Noot. | Magnoliaceae | | | | | | | | | 2.5 | 0.16 | 2.71 | R | | | | | | | | |
| *Magnolia champaca* (L.) Baill. ex Pierre | Magnoliaceae | | | | | | | | | | | | | 2.5 | 1.89 | 7.41 | R | | | | |
| *Magnolia doltsopa* (Buch.-Ham. ex DC.) Figlar | Magnoliaceae | | | | | 12.5 | 0.82 | 9.38 | C | | | | | | | | | | | | |
| *Magnolia oblonga* (Wall. ex Hook.f. & Thomson) Figlar | Magnoliaceae | 7.5 | 1.81 | 10.24 | RE | | | | | 5 | 0.87 | 5.39 | C | 17.5 | 2.28 | 15.78 | RE | 7.5 | 1.40 | 9.57 | RE |
| *Mallotus nepalensis* Müll.Arg. | Euphorbiaceae | 10 | 0.28 | 7.15 | RE | 2.5 | 0.03 | 2.18 | R | | | | | | | | | | | | |
| *Mallotus paniculatus* (Lam.) Müll.Arg. | Euphorbiaceae | | | | | | | | | 20 | 1.07 | 11.30 | C | | | | | | | | |
| *Mallotus roxburghianus* Müll.Arg. | Euphorbiaceae | | | | | | | | | | | | | 15 | 1.26 | 12.06 | RE | | | | |
| *Mangifera andamanica* King | Anacardiaceae | | | | | | | | | | | | | 2.5 | 1.30 | 5.62 | R | | | | |
| *Mangiferae sylvatica* Roxb. | Anacardiaceae | | | | | | | | | 2.5 | 1.25 | 5.89 | R | | | | | | | | |
| *Myrica esculenta* Buch.-Ham. ex D. Don | Myricaceae | | | | | | | | | 12.5 | 0.67 | 6.65 | RE | 12.5 | 1.09 | 9.82 | RE | 5 | 0.10 | 2.89 | C |
| *Nephelium lappaceum* L. | Sapindaceae | | | | | | | | | | | | | | | | | 17.5 | 0.97 | 11.69 | R |
| *Phoebe hainesiana* Brandis | Lauraceae | | | | | | | | | | | | | | | | | 7.5 | 0.31 | 6.93 | RE |
| *Phoebe lanceolata* (Nees) Nees | Lauraceae | 25 | 1.97 | 15.75 | R | 20 | 2.49 | 20.19 | C | 7.5 | 0.69 | 5.47 | C | 2.5 | 0.74 | 3.96 | R | 7.5 | 0.29 | 4.18 | C |
| *Phyllanthus reticulatus* Poir. | Euphorbiaceae | | | | | | | | | | | | | 2.5 | 0.06 | 1.91 | R | | | | |
| *Picrasma javanica* Blume | Simarubaceae | | | | | | | | | | | | | | | | | 5 | 0.07 | 2.76 | C |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Polygala arillata* Buch.-Ham. ex D. Don. | Polygalaceae | | | | | | | | | | | | | 5 | 0.08 | 3.72 | RE | | | | |
| *Prunus cerasoides* D. Don | Rosaceae | 2.5 | 0.20 | 2.19 | C | 2.5 | 0.37 | 3.37 | R | 10 | 1.29 | 12.69 | RE | | | | | 5 | 0.53 | 5.79 | RE |
| *Prunus ceylanica* (Wight) Miq. | Rosaceae | 12.5 | 1.90 | 11.66 | RE | | | | | | | | | | | | | | | | |
| *Prunus napaulensis* (Ser.) Steud. | Rosaceae | | | | | 10 | 0.89 | 8.84 | R | | | | | 7.5 | 0.78 | 6.47 | R | | | | |
| *Prunus wallichii* Steud. | Rosaceae | | | | | | | | | | | | | 2.5 | 0.69 | 3.81 | R | | | | |
| *Pterospermum lanceifolium* Roxb. | Sterculiaceae | | | | | | | | | | | | | | | | | 37.5 | 3.79 | 28.09 | R |
| *Pyrus pashia* Buch.-Ham. ex. D. Don | Rosaceae | 22.5 | 0.84 | 10.76 | R | 12.5 | 0.63 | 10.05 | RE | | | | | | | | | | | | |
| *Quercus lamellosa* Sm. | Fagaceae | 42.5 | 3.75 | 25.22 | R | 7.5 | 1.52 | 8.96 | C | 2.5 | 1.94 | 7.91 | R | | | | | | | | |
| *Quercus lineata* Blume | Fagaceae | | | | | 2.5 | 0.18 | 2.71 | R | | | | | | | | | | | | |
| *Quercus semiserrata* Roxb. | Fagaceae | 5 | 0.25 | 2.91 | C | | | | | | | | | | | | | | | | |
| *Quercus serrata* Murray | Fagaceae | 2.5 | 1.87 | 7.26 | R | 5 | 1.95 | 10.98 | RE | | | | | | | | | | | | |
| *Rhododendron arboreum* Sm. | Ericaceae | 7.5 | 0.23 | 3.44 | C | 10 | 0.21 | 6.50 | R | | | | | | | | | | | | |
| *Rhododendron elliottii* Watt ex Brandis | Ericaceae | 10 | 0.25 | 7.08 | RE | | | | | | | | | | | | | | | | |
| *Rhus griffithi* Hook.f. | Anacardiaceae | | | | | | | | | 15 | 1.22 | 8.89 | C | | | | | | | | |
| *Saurauia armata* Kurz | Actinidiaceae | | | | | 2.5 | 0.08 | 2.37 | R | | | | | | | | | 5 | 0.21 | 3.29 | C |
| *Saurauia napaulensis* DC. | Actinidiaceae | 5 | 0.30 | 4.08 | RE | 22.5 | 2.25 | 20.12 | RE | | | | | | | | | | | | |
| *Saurauia punduana* Wall. | Actinidiaceae | | | | | | | | | | | | | 7.5 | 0.88 | 7.85 | RE | | | | |
| *Saurauia roxburghii* Wall. | Actinidiaceae | | | | | | | | | 10 | 0.30 | 8.18 | RE | 2.5 | 0.08 | 1.98 | R | | | | |
| *Schefflera wallichiana* (Wight & Arn.) Harms. | Araliaceae | 12.5 | 0.35 | 7.96 | RE | 7.5 | 0.34 | 7.45 | RE | | | | | | | | | | | | |
| *Schima khasiana* Dyer | Theaceae | 7.5 | 0.60 | 6.55 | RE | 10 | 1.15 | 12.35 | RE | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Schima wallichii* Choisy | Theaceae | | | | | | | | | 7.5 | 0.72 | 5.56 | C | 15 | 1.65 | 11.09 | C | 7.5 | 0.74 | 7.17 | R |
| *Sorbus insignis* (Hook. f.) Hedl. | Rosaceae | | | | | | | | | | | | | 5 | 0.53 | 4.00 | C | | | | |
| *Sterculia versicolor* Wall. | Sterculiaceae | | | | | | | | | | | | | 7.5 | 0.27 | 3.89 | C | | | | |
| *Stereospermum chelonoides* (L.f.) DC. | Bignoniaceae | | | | | | | | | | | | | 5 | 1.67 | 8.48 | RE | | | | |
| *Syzygium cumini* (L.) Skeels | Myrtaceae | | | | | | | | | | | | | | | | | 12.5 | 0.56 | 7.67 | C |
| *Taxus wallichiana* Zucc. | Taxaceae | 10 | 0.47 | 4.75 | C | 12.5 | 0.54 | 7.10 | RE | | | | | | | | | | | | |
| *Terminalia myriocarpa* Van Heurck & Müll. Arg. | Combretaceae | | | | | | | | | 32.5 | 2.72 | 22.44 | R | 12.5 | 1.33 | 10.52 | RE | | | | |
| *Thespesia populnea* (L.) Sol. Ex correa | Malvaceae | | | | | | | | | | | | | | | | | 5 | 0.09 | 2.83 | C |
| *Toona ciliata* M. Roem | Meliaceae | | | | | 5 | 0.85 | 7.14 | RE | | | | | | | | | | | | |
| *Trema orientalis* (L.) Blume. | Ulmaceae | | | | | | | | | 12.5 | 0.56 | 7.96 | C | 20 | 1.52 | 14.17 | RE | | | | |
| *Xerospermum noronhianum* Blume | Sapindaceae | | | | | | | | | 17.5 | 0.74 | 11.33 | R | 12.5 | 0.28 | 8.45 | RE | | | | |
| *Zanthoxylum armatum* DC. | Rutaceae | | | | | | | | | | | | | | | | | 2.5 | 0.06 | 2.14 | R |
| *Zanthoxylum budrunga* Wall. | Rutaceae | | | | | 2.5 | 0.08 | 2.37 | R | | | | | | | | | | | | |

**Key to abbreviation:** RE= Regular; R= Random; C= Clumped

*Shrub species composition*

In shrubs, a total of 77 species and 52 genera representing 36 families were recorded from five community forests (Helipong, Chendang, Yangli, Panso and Pangsha) of Tuensang district, Nagaland. Out of these, 30 species, 25 genera and 22 families from Yangli followed by 27 species, 25 genera and 50 families from Helipong; 26 species, 23 genera and 19 families from Chendang; 23 species belonging to 21 genera and 18 families from Pangsha and 22 species, 21 genera and 20 families were recorded from Panso respectively (Table 4.2.13). Based on IVI value, the most dominant shrub species in Yangli were: *Eupatorium adoratum* (18.09), *Clerodendrum glandulosum* (15.90) and *Sambucus javanica* (12.98) (Table 4.2.15) and the dominant families were: Ericaceae, Myrsinaceae and Urticaceae. In Helipong, the most dominant species were: *Sophora acuminata* (17.41), *Mahonia nepalensis* (18.52) and *Agapetes incurvata* (14.07) (Table 4.2.15) and the dominant families were: Ericaceae, Melastomataceae and Rubiaceae. In Chendang, the dominant shrub species were: *Rubus acuminata* (16.77), *Viburnum corylifolium* (15.88) and *Eurya japonica* (13.20) (Table 4.2.15) and the most dominant families were: Asteraceae, Melastomataceae and Rosaceae. In Pangsha, dominant species were: *Dendrocnide sinuata* (20.87), *Truimfetta rhomboidea* (15.97) and *Boehmeria hamiltoniana* (14.01) (Table 4.2.15) and the dominant families were: Tiliaceae and Urticaceae. In Panso, the most dominant species were: *Clerodendrum infortunatum* (20.55), *Leea asiatica* (19.04) and *Boehmeria hamiltoniana* (16.79) (Table 4.2.15) and the dominant families were: Asteraceae, Rubiaceae and Urticaceae. From the present study, the highest shrub density (individuals ha$^{-1}$) was recorded from Yangli (6850) followed by Panso (6650), Chendang (5550), Pangsha (5100) and the lowest in Helipong community forest (4500) respectively (Table 4.2.13).

*Herb species composition*

In herbs, a total of 117 species, 78 genera representing 42 families were recorded from five community forest (Helipong, Chendang, Yangli, Panso and Pangsha) of Tuensang district, Nagaland. Of these, 33 species, 31 genera and 21 families were recorded from Yangli followed by 30 species, 28 genera and 15 families from Chendang; 26 species, 23 genera and 21 families from Pangsha; 25 species, 22 genera and 18 families from Panso and 23 species, 20 genera and 12 families from Pangsha community forest of Nagaland respectively (Table 4.2.13). Among the community forest, the most dominant herb species in Yangli were: *Tinospora sinensis* (19.49), *Impatients discolor* (16.63) and *Girardinia diversifolia* (13.77) (Table 4.2.15) and the dominant families were: Commelinaceae, Polygonanceae and Vitaceae. In Chendang, the most dominant species were: *Fagopyrum esculentum* (14.15), *Potentilla polyphylla* (13.37) and *Astilbe rivularis* (11.79) (Table 4.2.15) and the dominant families were: Asteraceae, Zingiberaceae and Lamiaceae. In Panso, the dominant species were: *Porana paniculata* (19.53), *Dysphania ambrosioides* (16.93) and *Dioscorea tomentosa* (14.34) (Table 4.2.15) and the dominant families were: Dioscoreaceae and Orchidaceae. In Pangsha, the dominant species were: *Desmodium microphyllum* (23.99), *Paedera foetida* (22.81) and *Dysphania ambrosioides* (19.28) (Table 4.2.15) and the most dominant families were: Vitaceae and Zingiberaceae. In Helipong, dominant species were: *Geranium nepalense* (22.82), *Leucas ciliata* (20.26) and *Senecio scandens* (17.69) (Table 4.2.15) and the dominant families were: Asteraceae and Urticaceae. The highest herb density (individuals $ha^{-1}$) was recorded from Chendang (79375) followed by Yangli (65625), Pangsha (53125), Helipong (48750) and Panso (48125) respectively (Table 4.2.13).

**Table 4.2.15** Density (individuals ha$^{-1}$) and Important value index (IVI) of shrubs and herbs species in five study sites of Tuensang District, Nagaland

| Species | Family | Helipong | | Chendang | | Yangli | | Panso | | Pangsha | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D | IVI | D | IVI | D | IVI | D | IVI | D | IVI |
| **Shrubs** | | | | | | | | | | | |
| *Abelmoschus manihot* (Roxb.) Hochr. | Malvaceae | 100 | 5.93 | 50 | 2.41 | | | | | | |
| *Abroma augusta* (L.) L. f. | Malvaceae | | | | | | | 100 | 5.01 | | |
| *Agapetes angulata* (Griff.) Hook.f. | Ericaceae | | | | | 150 | 5.76 | | | | |
| *Agapetes incurvata* (Griff.)Sleumer | Ericaceae | 300 | 14.07 | 150 | 5.71 | | | | | | |
| *Agapetes macrantha* (Hook.) Benth. & Hook.f. | Ericaceae | | | | | 100 | 5.03 | | | 200 | 7.49 |
| *Ardisia odontophylla* Wall. ex A. DC. | Myrsinaceae | 100 | 4.07 | 200 | 6.60 | | | | | | |
| *Artemesia nilagirica* (C.B. Clarke) Pamp. | Asteraceae | 50 | 2.96 | 100 | 4.82 | | | | | | |
| *Aster albescens* (DC.) Wall. ex Hand.-Mazz. | Asteraceae | | | | | | | 200 | 6.52 | | |
| *Boehmeria hamiltoniana* Wedd. | Urticaceae | | | | | | | 650 | 16.79 | 350 | 14.01 |
| *Boehmeria platyphylla* D.Don | Urticaceae | | | | | 300 | 9.74 | | | | |
| *Buddleja asiatica* Lour. | Buddlejaceae | 150 | 8.89 | | | | | | | | |
| *Calamus leptospadix* Griff. | Arecaceae | 100 | 4.07 | | | 150 | 3.98 | 250 | 9.02 | 200 | 7.49 |
| *Camellia kissi* Wall. | Theaceae | 100 | 5.93 | 250 | 9.01 | | | | | | |
| *Camellia oleifera* Abel. | Theaceae | | | | | 200 | 6.49 | | | 50 | 2.77 |
| *Casearia vareca* Roxb. | Flacourtiaceae | | | | | 250 | 7.22 | 150 | 5.76 | 100 | 5.53 |
| *Clerodendrum glandulosum* Lindl. | Verbenaceae | 250 | 11.11 | | | 600 | 15.90 | | | 300 | 11.24 |
| *Clerodendrum infortunatum* L. | Verbenaceae | | | | | 150 | 3.98 | 900 | 20.55 | | |
| *Corylopsis himalayana* Griff. | Hamamelidaceae | 150 | 7.04 | 250 | 9.01 | | | | | | |
| *Daphne bholua* (W.W. Sm. & Cave) B.L. Brutt | Thymelaeaceae | 150 | 7.04 | 150 | 5.71 | | | | | | |
| *Debregeasia longifolia* (Burm.f.) Wedd. | Urticaceae | 100 | 4.07 | | | 300 | 11.52 | 350 | 10.53 | 250 | 10.26 |
| *Debregeasia saenab* (Forssk.) Hepper & J.R.I. Wood | Urticaceae | | | 200 | 6.60 | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Dendrocnide sinuata* (Blume) Chew | Urticaceae | | | | | | | 500 | 12.78 | 700 | 20.87 |
| *Dracaena angustifolia* (Medik.) Roxb. | Dracaenaceae | 100 | 4.07 | | | 350 | 10.47 | 150 | 5.76 | 150 | 6.51 |
| *Elaeagnus caudata* Schltdl. ex Momiy. | Elaeagnaceae | | | | | 150 | 3.98 | 550 | 15.29 | | |
| *Elaeagnus parvifolia* Wall. ex Royle | Elaeagnaceae | 100 | 4.07 | | | | | | | | |
| *Elaeagnus pyriformis* Hook.f. | Elaeagnaceae | | | | | 100 | 3.25 | | | | |
| *Embelia floribunda* Wall. | Myrsinaceae | | | 50 | 2.41 | | | | | | |
| *Embelia parviflora* Wall. ex A.DC. | Myrsinaceae | | | | | 250 | 9.01 | | | | |
| *Eriobotrya bengalensis* (Roxb.) Hook.f. | Rosaceae | | | | | | | | | 100 | 5.53 |
| *Eupatorium adoratum* L. | Compositae | | | | | 750 | 18.09 | | | | |
| *Eurya japonica* Thunb. | Theaceae | | | 400 | 13.20 | | | | | | |
| *Ficus chartacea* Corner | Moraceae | | | | | 100 | 3.25 | | | | |
| *Gaultheria hookeri* C.B. Clarke | Ericaceae | 200 | 10.00 | | | | | | | | |
| *Grewia abutilifolia* Vent. ex Juss. | Tiliaceae | | | | | | | | | 250 | 10.26 |
| *Grewia sclerophylla* Roxb. | Tiliaceae | | | | | | | | | 200 | 7.49 |
| *Helwingia himalaica* J. D. Hooker & Thomson ex C. B. Clarke | Helwingiaceae | | | | | 200 | 6.49 | 50 | 2.51 | | |
| *Hibiscus sabdariffa* L. | Malvaceae | | | | | | | | | 50 | 2.77 |
| *Hypericum patulum* Thunb. | Hypericaceae | | | | | 100 | 3.25 | 100 | 3.26 | | |
| *Impatiens laevigata* Wall. ex Hook.f. & Thomson. | Balsaminaceae | | | | | | | | | 150 | 6.51 |
| *Inula cappa* (Buch.-Ham. ex D.Don) DC. | Asteraceae | | | 150 | 5.71 | | | | | | |
| *Inula eupatorioides* Wall. ex DC. | Asteraceae | | | | | 150 | 3.98 | | | | |
| *Leea alata* Edgew. | Vitaceae | | | | | 50 | 2.52 | | | | |
| *Leea asiatica* (L.) Ridsdale | Vitaceae | | | | | 150 | 3.98 | 800 | 19.05 | | |
| *Leea compactiflora* Kurz | Leeaceae | | | 300 | 9.90 | | | | | | |
| *Leea macrophylla* Roxb. ex Hornem. | Leeaceae | | | | | | | | | 300 | 11.24 |
| *Maesa chisia* Buch.-Ham. ex D. Don | Myrsinaceae | | | | | 250 | 5.44 | | | | |
| *Maesa indica* (Roxb.) A. DC. | Myrsinaceae | | | | | 300 | 6.17 | 250 | 9.02 | 150 | 6.51 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Maesa rugosa* C.B. Clarke | Myrsinaceae | 250 | 11.11 | | | | | | | | |
| *Mahonia nepalensis* DC. ex Dippel | Berberidaceae | 500 | 18.52 | 200 | 8.12 | | | | | | |
| *Mahonia pycnophylla* (Fedde) Takeda | Berberidaceae | | | 100 | 4.82 | | | | | | |
| *Musa species* L. | Musaceae | 100 | 5.93 | | | 50 | 2.52 | | | 200 | 7.49 |
| *Mussaenda frondosa* L. | Rubiaceae | | | | | 200 | 6.49 | | | 300 | 11.24 |
| *Mussaenda glabra* Vahl | Rubiaceae | | | | | | | 150 | 7.52 | | |
| *Mussaenda macrophylla* wall. | Rubiaceae | | | | | | | | | 200 | 7.49 |
| *Mussaenda roxburghii* Hook.f. | Rubiaceae | 200 | 8.15 | | | 250 | 7.22 | 300 | 9.77 | | |
| *Musseanda glabra* Vahl | Rubiaceae | 250 | 11.11 | 350 | 12.31 | | | | | | |
| *Neillia thyrsiflora* D. Don | Rosaceae | | | 150 | 5.71 | | | | | | |
| *Osbeckia crinita* Benth. ex C.B. Clarke | Melastomataceae | | | 100 | 4.82 | | | | | | |
| *Osbeckia nepalensis* Hook.f. | Melastomataceae | 150 | 7.04 | | | 300 | 6.17 | 200 | 6.52 | 150 | 8.30 |
| *Osbeckia stellata* Buch.-Ham. ex Ker Gawl. | Melastomataceae | | | 150 | 5.71 | | | | | | |
| *Oxyspora cernua* (Roxb.) Hook. f. & Thomson ex Triana | Melastomataceae | 100 | 4.07 | 150 | 5.71 | | | | | | |
| *Persicaria chinensis* (L.) H. Gross | Polygonaceae | | | | | | | 100 | 3.26 | | |
| *Phlogacanthus curviflorus* Ness | Acanthaceae | | | | | 150 | 5.76 | | | | |
| *Phrynium species* Willd. | Marantaceae | | | | | 50 | 2.52 | 350 | 10.53 | 50 | 2.77 |
| *Plectranthus ternifolius* D.Don | Lamiaceae | 100 | 4.07 | 250 | 10.52 | | | | | | |
| *Polygala arillata* Buch.-Ham. ex D. Don. | Polygalaceae | | | | | 350 | 6.90 | | | | |
| *Rhododendron vaccinioides* Hook. | Ericaceae | 100 | 4.07 | | | | | | | | |
| *Rubus acuminatus* Sm. | Rosaceae | | | 600 | 16.77 | | | | | | |
| *Rubus lucens* Focke | Rosaceae | 100 | 4.07 | | | | | | | | |
| *Rubus moluccanus* L. | Rosaceae | 150 | 7.04 | | | | | | | | |
| *Sambucus javanica* Blume | Sambucaceae | | | | | 400 | 12.98 | 400 | 13.03 | | |
| *Sophora acuminata* Baker | Leguminosae | 450 | 17.41 | 300 | 11.42 | | | | | | |
| *Strobilanthes hamiltoniana* (Steud.) Bosser & Heine | Acanthaceae | | | 200 | 8.12 | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|
| *Strobilanthes simonsii* T. Anderson | Acanthaceae | | | | | | | 50 | 2.51 | | |
| *Tithonia rotundifolia* (Miller) S.F. Blake | Asteraceae | | | | | | | 100 | 5.01 | | |
| *Triumfetta rhomboidea* Jacq. | Tiliaceae | | | | | | | | | 450 | 15.97 |
| *Viburnum corylifolium* Hook.f. & Thomson | Caprifoliaceae | | | 550 | 15.88 | | | | | | |
| *Viburnum foetidum* Wall. | Caprifoliaceae | | | 100 | 3.30 | | | | | | |
| *Zanthoxylum khasianum* Hook.f. | Rutaceae | 100 | 4.07 | 150 | 5.71 | | | | | 250 | 10.26 |
| **Herbs** | | | | | | | | | | | |
| *Aerides multiflora* Roxb. | Orchidaceae | | | | | | | | | 1250 | 4.53 |
| *Aerides odorata* Lour. | Orchidaceae | | | | | 1250 | 4.98 | | | | |
| *Aerides rosea* Lodd. ex Lindl. & Paxton | Orchidaceae | | | 1250 | 3.93 | | | | | | |
| *Aeschynanthus acuminatus* Wall. Ex A. DC. | Gesneriaceae | | | | | | | 1250 | 4.56 | | |
| *Aeschynanthus parviflorus* (D. Don) Spreng | Gesneriaceae | 1875 | 6.35 | | | | | | | | |
| *Alpinia malaccensis* (Burm.f.) Roscoe | Zingiberaceae | | | | | | | | | 625 | 3.35 |
| *Ampelocissus divaricata* (Wall. ex M.A.Lawson) Planch. | Vitaceae | | | | | 625 | 2.49 | | | 2500 | 9.05 |
| *Ampelopsis rubifolia* (Wall.) Planch. | Vitaceae | | | | | | | | | 1875 | 7.88 |
| *Anaphalis contorta* (D. Don) Hook.f. | Asteraceae | | | 3125 | 6.29 | | | | | | |
| *Anaphalis triplinervis* (Sims) Sims ex C. B. Clarke | Asteraceae | 625 | 3.78 | | | | | | | | |
| *Arachnis labrosa* (Lindl. & Paxton) Rchb.f. | Orchidaceae | | | | | | | | | 625 | 3.35 |
| *Arisaema concinnum* Schott | Araceae | | | | | 2500 | 9.96 | | | | |
| *Arisaema griffithii* Schott | Araceae | | | 1875 | 5.89 | | | | | | |
| *Aristolochia saccata* Wall. | Aristolochiaceae | | | | | | | | | 625 | 3.35 |
| *Astilbe rivularis* Buch.-Ham. ex D. Don | Saxifragaceae | | | 5625 | 11.79 | | | | | | |
| *Astilbe rubra* Hook.f. & Thomson | Saxifragaceae | 1875 | 6.35 | | | | | | | | |
| *Bauhinia vahlii* Wight & Arn. | Caesalpiniaceae | | | | | | | 3125 | 12.4 | | |
| *Begonia adscendens* C.B. Clarke | Begoniaceae | | | | | | | 2500 | 9.12 | | |
| *Begonia megaptera* A. DC. | Begoniaceae | | | | | 3750 | 7.25 | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Begonia palmata* D. Don | Begoniaceae | | | | | | | | | 3125 | 12.40 |
| *Bulbophyllum affine* Wall. ex Lindl. | Orchidaceae | | | | | 625 | 2.49 | | | | |
| *Bulbophyllum elatum* (Hook.f.) J.J.Sm. | Orchidaceae | | | | | | | 1875 | 7.82 | | |
| *Bulbophyllum helenae* (Kuntze) J.J.Sm. | Orchidaceae | | | | | | | 625 | 3.26 | | |
| *Bulbophyllum leopardinum* (Wall.) Lindl. | Orchidaceae | | | | | | | 1875 | 7.82 | | |
| *Cayratia pedata* (Lam.) Gagnep. | Vitaceae | | | | | | | 1250 | 4.56 | | |
| *Cheilocostus speciosus* (J.Koenig) C.D. Specht | Zingiberaceae | | | 1250 | 3.93 | | | | | | |
| *Cissus adnata* Roxb. | Vitaceae | | | | | 1875 | 5.93 | | | | |
| *Coelogyne calcicola* Kerr | Orchidaceae | 1875 | 8.85 | | | | | | | | |
| *Coelogyne cristata* Lindl. | Orchidaceae | 2500 | 10.13 | | | | | | | | |
| *Commelina paludosa* Blume | Commelinaceae | | | | | 1875 | 4.4 | | | | |
| *Conocephalus suaveolens* Blume | Moraceae | | | 3125 | 7.47 | | | | | | |
| *Cyanotis vaga* (Lour.) Schult. & Schult.f. | Commelinaceae | | | | | 625 | 2.49 | | | | |
| *Cymbidium tracyanum* L. Castle | Orchidaceae | | | 625 | 1.96 | | | | | | |
| *Cyperus diffusus* Vahl | Cyperaceae | | | | | 2500 | 8.42 | | | | |
| *Cyperus haspan* L. | Cyperaceae | | | | | 625 | 2.49 | | | | |
| *Cyperus rotundus* L. | Cyperaceae | | | | | | | 1250 | 4.56 | | |
| *Dendrobium fugax* Rch.f. | Orchidaceae | | | | | 1250 | 4.98 | | | | |
| *Dendrobium hookerianum* Lindl. | Orchidaceae | | | 2500 | 6.68 | | | | | | |
| *Dendrobium longicornu* Lindl | Orchidaceae | | | 1875 | 5.89 | | | | | | |
| *Dendrobium ochreatum* Lindl. | Orchidaceae | | | | | | | 1250 | 4.56 | | |
| *Dendrobium porphyrochilum* Lindl. | Orchidaceae | | | | | 1875 | 7.47 | | | | |
| *Desmodium microphyllum* (Thunb.) DC. | Papilionaceae | | | | | | | | | 8125 | 23.99 |
| *Dicranopteris linearis* (Burm.f.) Underw. | Gleicheniaceae | | | | | | | | | 1875 | 7.88 |
| *Didymocarpus acuminatus* R.Br. | Gesneriaceae | 1250 | 5.06 | | | | | | | | |
| *Didymocarpus pulcher* C.B. Clarke | Gesneriaceae | | | | | | | 1875 | 7.82 | | |
| *Dioscorea alata* L. | Dioscoreaceae | | | | | | | 625 | 3.26 | 625 | 3.35 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Dioscorea bulbifera* L. | Dioscoreaceae | | | 3750 | 8.25 | | | | | | |
| *Dioscorea tomentosa* J. Koenig ex Spreng. | Dioscoreaceae | | | | | | | 3125 | 14.3 | | |
| *Dysphania ambrosioides* (L.) Mosyakin & Clemants | Chenopodiaceae | | | | | 2500 | 6.89 | 4375 | 16.9 | 5625 | 19.28 |
| *Elsholtzia flava* Benth. | Lamiaceae | | | 1250 | 3.93 | | | | | | |
| *Elsholtzia strobilifera* (Benth.) Benth. | Lamiaceae | | | | | | | 1250 | 4.56 | | |
| *Erythropalum scandens* Blume | Olacaceae | | | | | | | | | 625 | 3.35 |
| *Fagopyrum esculentum* Moench | Polygonaceae | | | 7500 | 14.15 | 3125 | 9.38 | | | | |
| *Fragaria nubicola* (Lindl. ex Hook.f.) Lacaita | Rosaceae | 3125 | 11.41 | | | | | | | | |
| *Geranium nepalense* Sweet | Geraniaceae | 6250 | 22.82 | | | | | | | | |
| *Girardinia diversifolia* (Link) Friis | Urticaceae | 1250 | 5.06 | | | 5000 | 13.8 | 1875 | 5.86 | | |
| *Hedychium coronarium* J.Koenig | Zingiberaceae | | | | | | | | | 1875 | 7.88 |
| *Hedychium flavum* Roxb. (Min.) | Zingiberaceae | | | 1250 | 3.93 | | | | | | |
| *Hedychium villosum* Wall. | Zingiberaceae | | | | | 1875 | 5.93 | | | | |
| *Hibiscus surattensis* L. | Malvaceae | | | | | | | | | 2500 | 9.05 |
| *Hypericum elodeoides* Choisy | Hypericaceae | | | | | | | 625 | 3.26 | | |
| *Hypericum monanthemum* Hook. f. & Thomson ex Dyer | Hypericaceae | | | | | 625 | 2.49 | | | 625 | 3.35 |
| *Impatiens arguta* Hook.f. & Thomson | Balsaminaceae | | | | | | | | | 1875 | 7.88 |
| *Impatiens tropaeolifolia* Griff. ex Hook. f. | Balsaminaceae | | | | | | | 3125 | 12.4 | | |
| *Impatients discolor* DC. | Balsaminaceae | | | | | 6875 | 16.6 | | | | |
| *Inula nervosa* Wall. Ex DC. | Asteraceae | 2500 | 10.13 | 3125 | 8.64 | | | | | | |
| *Juncus effusus* L. | Juncaceae | 1250 | 5.06 | | | 625 | 2.49 | | | | |
| *Juncus minimus* Buchenau | Juncaceae | | | | | | | | | 625 | 3.35 |
| *Justicia japonica* Thunb. | Acanthaceae | | | 3125 | 8.64 | | | | | | |
| *Leucas ciliata* Benth. | Lamiaceae | 5000 | 20.26 | | | | | | | | |
| *Leucas nutans* (Roth) Spreng | Lamiaceae | | | 3750 | 9.43 | | | | | | |
| *Mikania micrantha* Kunth | Asteraceae | | | | | 1250 | 4.98 | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Mucuna macrocarpa* Wall. | Leguminosae | | | | | 625 | 2.49 | | | | |
| *Paederia foetida* L. | Rubiaceae | | | | | | | | | 7500 | 22.81 |
| *Papilionanthe teres* (Roxb.) Schltr. | Orchidaceae | | | 1250 | 3.93 | | | 1875 | 9.78 | | |
| *Papilionanthe uniflora* (Lindl.) garay | Orchidaceae | 3125 | 11.41 | | | | | | | | |
| *Peperomia reflexa* Kunth | Piperaceae | | | | | | | | | 625 | 3.35 |
| *Perilla frutescens* (L.) Britton | Lamiaceae | 625 | 3.78 | | | | | | | | |
| *Persicaria chinensis* (L.) H. Gross | Polygonaceae | | | | | 2500 | 8.42 | | | | |
| *Phalaenopsis deliciosa* Rchb.f. | Orchidaceae | | | | | 1250 | 3.44 | | | | |
| *Phragmites karka* (Retz.) Trin. ex Steud. | Poaceae | 625 | 3.78 | | | | | | | | |
| *Pilea bracteosa* Wedd. | Urticaceae | | | | | | | | | 3125 | 10.23 |
| *Pilea oxyodon* Wedd. | Urticaceae | | | | | | | 1250 | 6.52 | | |
| *Pilea scripta* (Buch.-Ham. ex D. Don) Wedd. | Urticaceae | | | 3125 | 8.64 | | | | | | |
| *Pilea umbrosa* Blume | Urticaceae | | | | | 2500 | 8.42 | | | | |
| *Plantago major* L. | Plantaginaceae | | | 2500 | 7.86 | | | | | | |
| *Pogostemon parviflorus* Benth. | Lamiaceae | | | 1250 | 3.93 | | | | | | |
| *Polygala chinensis* L. | Polygalaceae | | | | | 625 | 2.49 | | | | |
| *Polygonatum oppositifolium* (Wall.) Royle | Convallariaceae | | | | | 625 | 2.49 | | | | |
| *Polygonum campanulatum* Hook.f. | Polygonaceae | 1875 | 8.85 | | | | | | | | |
| *Polygonum pubescens* Blume | Polygonaceae | | | 3750 | 9.43 | | | | | | |
| *Porana paniculata* Roxb. | Convolvulaceae | | | 4375 | 10.22 | 1250 | 4.98 | 5625 | 19.5 | | |
| *Potentilla lineata* Trevir. | Rosaceae | 1250 | 5.06 | | | | | | | | |
| *Potentilla polyphylla* Wall. ex Lehm. | Rosaceae | | | 6875 | 13.37 | | | | | | |
| *Potentilla sundaica* (Blume) O. Kuntze | Rosaceae | | | 2500 | 6.68 | | | | | | |
| *Pothos chinensis* (Raf.) Merr. | Araceae | | | 1875 | 4.72 | | | | | | |
| *Rhynchostylis retusa* (L.) Blume | Orchidaceae | 1250 | 5.06 | 3125 | 8.64 | | | | | 1250 | 4.53 |
| *Rumex nepalensis* Spreng. | Polygonaceae | | | | | | | | | 1250 | 4.53 |
| *Selaginella wallichii* (Hook. & Grev.) Spring | Selaginellaceae | | | | | | | | | 625 | 5.52 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Senecio cappa* Buch.-Ham. ex D.Don | Asteraceae | | | | | | | 1250 | 6.52 | | |
| *Senecio scandens* Buch.-Ham. ex D. Don | Asteraceae | 3750 | 17.69 | | | | | | | | |
| *Sida acuta* Burm.f. | Malvaceae | 1250 | 5.06 | | | | | | | | |
| *Silene vagans* C.B. Clarke | Caryophyllaceae | | | | | | | 625 | 3.26 | | |
| *Smilax glabra* Roxb. | Smilacaceae | | | | | 1875 | 7.47 | | | | |
| *Solena amplexicaulis* (Lam.) Gandhi | Cucurbitaceae | 3125 | 11.41 | | | 1250 | 3.44 | | | | |
| *Sonchus arvensis* L. | Asteraceae | | | 1250 | 3.93 | | | | | | |
| *Sonchus wightianus* DC. | Asteraceae | 625 | 3.78 | | | | | | | 1250 | 4.53 |
| *Spathoglottis pubescens* Lindl. | Orchidaceae | | | 625 | 1.96 | | | | | | |
| *Spatholobus roxburghii* Benth. | Leguminosae | | | | | | | 1250 | 8.48 | | |
| *Tetrastigma lanceolarium* (Roxb.) Planch. | Vitaceae | | | 1250 | 3.93 | | | | | | |
| *Thalictrum foliolosum* DC. | Ranunculaceae | | | | | 625 | 2.49 | | | | |
| *Thunbergia coccinea* Wall. | Acanthaceae | | | 625 | 1.96 | | | | | | |
| *Thysanolaena latifolia* (Roxb. ex Hornem.) Honda | Poaceae | | | | | | | | | 1875 | 7.88 |
| *Tinospora sinensis* (Lour.) Merr. | Rutaceae | | | | | 8750 | 19.5 | 2500 | 9.12 | | |
| *Trichosanthes cordata* Roxb | Cucurbitaceae | | | | | 625 | 2.49 | | | | |
| *Urtica dioica* L. | Urticaceae | 1875 | 8.85 | | | | | | | | |
| *Zingiber chrysanthum* Roscoe | Zingiberaceae | | | | | 1875 | 5.93 | 1875 | 9.78 | 625 | 3.35 |

#### 4.2.4.2 Species diversity indices

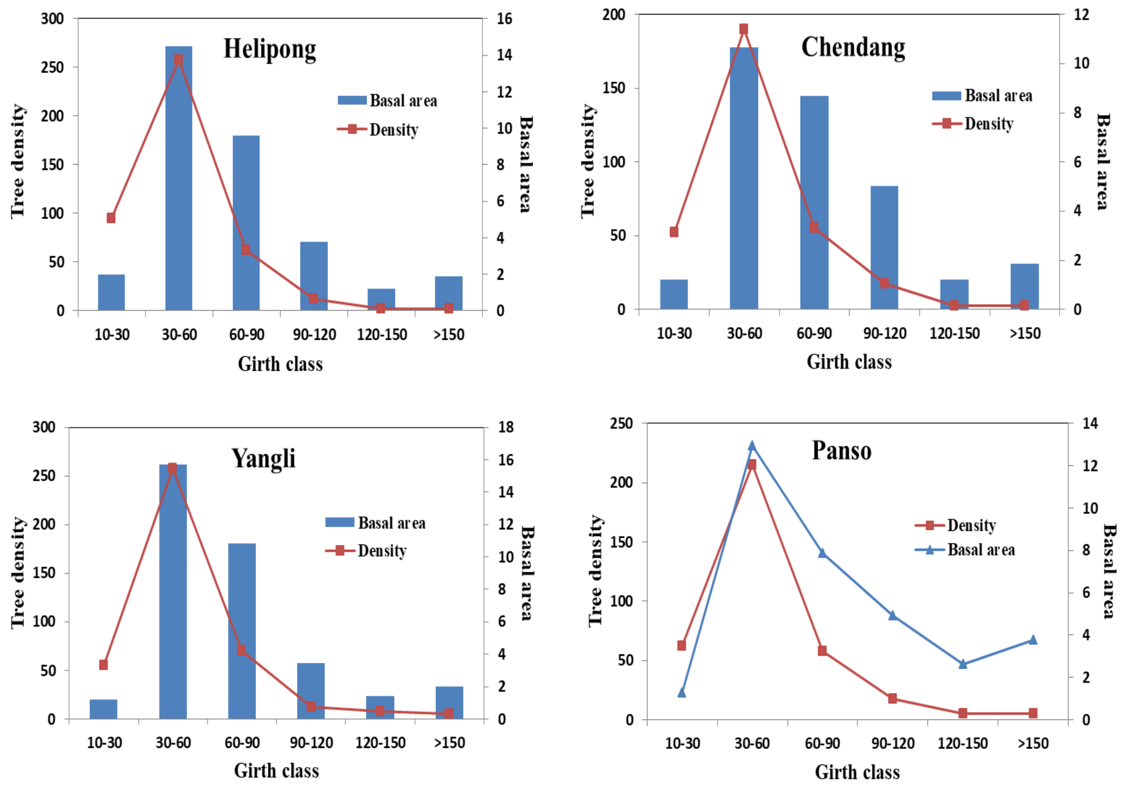
High diversity and low dominance is considered as the major characteristic feature of an old growth forest which is also shown in the present study. In trees, Shannon diversity index (H') value ranged from 3.26 – 3.59 indicating high diversity in all the community forest. Panso recorded the highest H' value (3.59) followed by Helipong (3.49), Chendang (3.45), Yangli (3.31) and Pangsha (3.26). The Simpson dominance index (CD) in the present study ranged from 0.03 – 0.05. The study observed that, higher the H' value, lower the Simpson dominance index (CD) value The Margalef index (Dmg) of tree species ranged from 6.16 – 8.79 and the Pielou's evenness index (e) ranged from 0.90 – 0.96 indicating high evenness of species in all the community forest (Table 4.2.13).

In shrubs, the Shannon diversity index (H') ranged from 2.81 – 3.20 where the highest H' value was recorded in Yangli (3.20) followed by Pangsha (2.95), Chendang (2.91), Helipong (2.83) and lowest in Panso CF (2.81). The Simpson dominance index (CD) in all the community forest ranged from 0.04 – 0.07 and as H' value increased, CD value decreased. The Margalef species richness index (Dmg) ranged from 4.29 – 5.89 and the Pielou's evenness index (e) in the present study ranged from 0.86 – 0.94, indicating quite even species in the community (Table 4.2.13).

In herbs, the highest Shannon diversity index (H') value ranged from 2.68 – 3.09 where Chendang CF exhibited the highest diversity value (3.09) as compared to other community forest. The Simpson dominance index (CD) ranged from 0.04 – 0.07 and the Margalef species richness index (Dmg) ranged from 5.05 – 6.88 where Yangli CF recorded the highest Dmg value (6.88). The Pielou's evenness index (e) ranged from 0.79 – 0.90 where Chendang CF showed the highest species evenness value indicating even distribution of species as compared to other community forest (Table 4.2.13).

### 4.2.4.3 Population structure of tree species in various girth-classes

The tree density and basal area in all the communities varied in different girth class distributions. In all the communities, the highest density was recorded from the girth class (30 – 60 cm) contributing 59% of the total tree density followed by young tress with girth class (10 – 30 cm) which contributed 21% and girth class (60 – 90 cm) which contributed 14%. In older trees (>120 cm girth class), Yangli CF recorded the the highest density (13 individuals ha$^{-1}$) followed by Panso CF (10 individuals ha$^{-1}$) whereas no individual was recorded from Pangsha CF in girth class > 150 cm. Similarly, girth class (30 – 60 cm) recorded the highest basal area contributing 42% of the total basal area followed by 60 – 90 cm girth class (26%) and 90 – 120 cm girth class (14%). The overall population structure in all communities showed a reverse *J*-shaped population curve indicating a good forest health and high species richness (Figure 4.2.7).



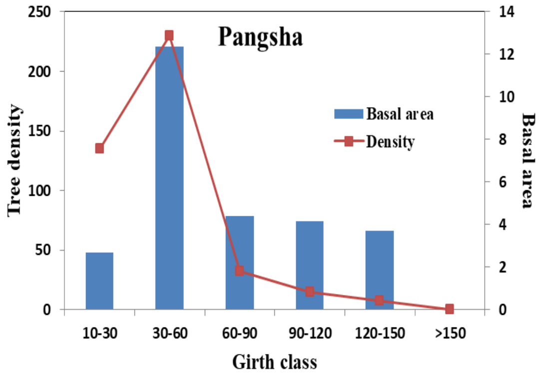
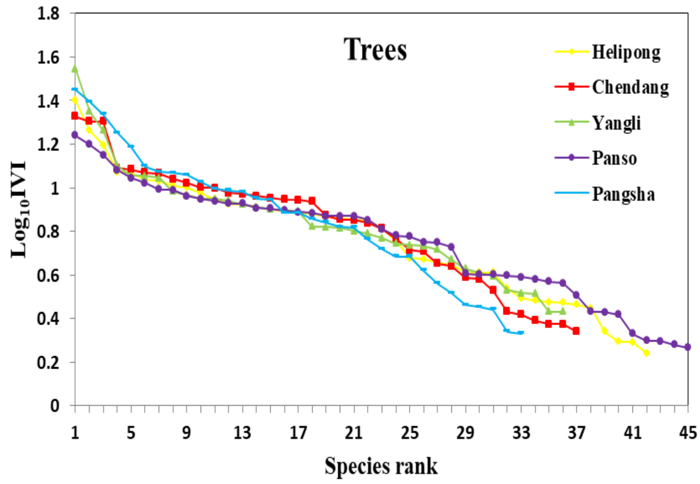
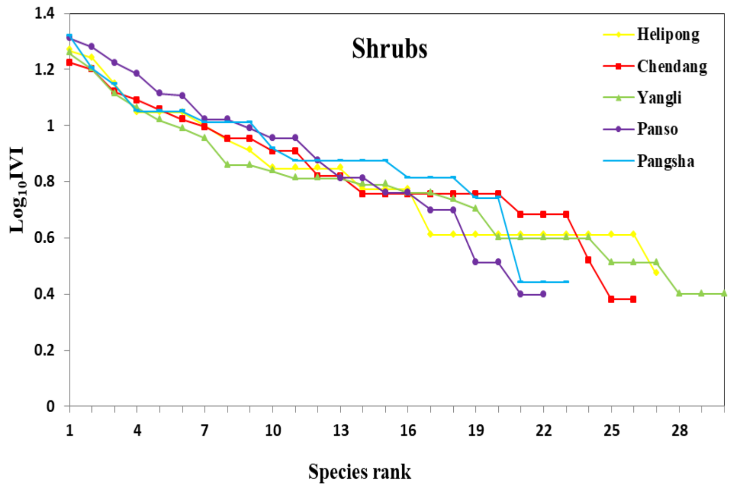



**Figure 4.2.7** Contributions of tree stand density and basal area based on girth class contribution in five study sites of Tuensang District, Nagaland

### 4.2.4.4 Dominance-Diversity curve

The study showed no significant change in the dominance-diversity curve in different community forest of Tuensang district. In all the plant communities, the dominance-diversity curve showed high equitability and low dominance and the dominance-diversity curve followed a log normal distribution pattern (Figure 4.2.8). Among the trees, the most dominant species were *Quercus lamellosa* (Helipong), *Lithocarpus elegans* (Chendang), *Alnus nepalensis* (Yangli), *Castanopsis tribuloides* (Panso) and *Pterospermum lanceifolium* (Pangsha). In shrubs, the most dominant species were *Mahonia nepalensis* (Helipong), *Rubus acuminatus* (Chendang), *Eupatorium adoratum* (Yangli), *Clerodendrum infortunatum* (Panso) and *Dendrocnide sinuata* (Pangsha). In herbs, the most dominant species were *Geranium nepalense* (Helipong), *Fagopyrum esculentum* (Chendang), *Tinospora sinensis* (Yangli), *Porana paniculata* (Panso) and *Desmodium microphyllum* (Pangsha).



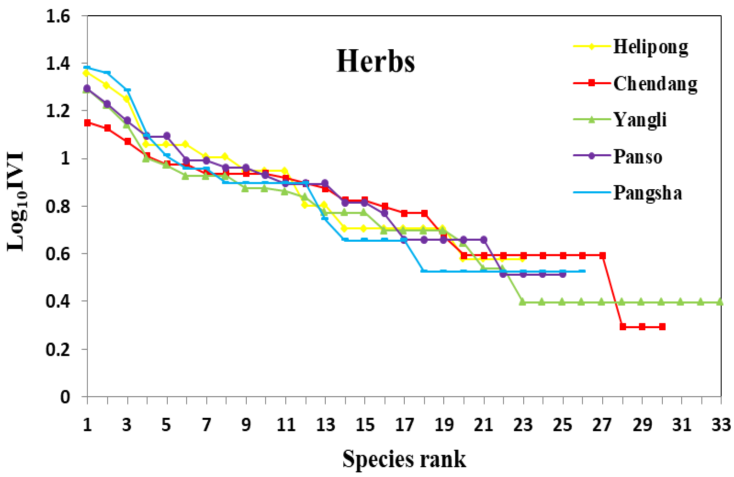




**Figure 4.2.8** Dominance-Diversity curve for trees, shrubs and herbs in five study sites of Tuensang District, Nagaland

#### 4.2.4.5 Distribution pattern of tree species

The Whitford index (A/F ratio) was analysed to study the distribution pattern of tree species in all the five community forest. The distribution pattern of species varied significantly in all the community The study showed that, the community forests (Yangli and Chendang) exhibited maximum clumbed distribution (53% and 43% respectively) revealing that the species were in patches which maybe due resulted to resources concentrated in small area within a large habitat. Where as Panso and Pangsha CF was dominated by random distribution (42% each) where individuals are arranged without any apparent pattern and Helipong CF exhibited the maximum regular distribution (43%) indicating higher competition of individuals in the forest (Table 4.2.14).

#### 4.2.4.6 Sorenson's similarity

Sorenson's similarity index was analyzed to study the similarity of tree species in all the community. The overall study showed very less similarity of species in all the community forest. The highest similarity (58%) was observed between Helipong and Chendang CF followed by Yangli and Panso CF (40%) and Yangli and Pangsha CF (35%). The other species similarity between various community forest (e.g Helipong and Yangli; Chendang and Panso; Pangsha and Chendang etc) showed no significant similarity within the species which maybe attributed to different altudinal gradient and various environmental factors (Table 4.2.16).

**Table 4.2.16** Sorenson Similarity indices for tree species between five study sites of Tuensang District, Nagaland

| Study | Helipong | Chendang | Yangli | Panso | Pangsha |
|---|---|---|---|---|---|
| **Helipong** | x | | | | |
| **Chendang** | 0.58 | x | | | |
| **Yangli** | 0.23 | 0.16 | x | | |
| **Panso** | 0.14 | 0.12 | 0.40 | x | |
| **Pangsha** | 0.16 | 0.14 | 0.35 | 0.33 | x |

### 4.2.4.7 Disturbance pattern

The highest disturbance index was observed in Chendang (17%) and Yangli (11%) which maybe attributed to extraction of timber species such as *Alnus nepalensis*, *Prunus cerasoides* and *Terminalia myriocarpa* (Table 4.2.13). The study also showed mild anthropogenic pressure on Helipong and Panso CF pressure on account of fuelwood requirements and other agricultural tools.

## 4.2.5 Phek district

### 4.2.5.1 Floristic structure

*Tree species composition*

In the present study, a total of 548 individuals belonging to 116 species and 88 genera belonging to 50 families were recorded from the four community forest (Chizami, Akhegwo, Zipu and Meluri) of Phek district, Nagaland, Northeast India. Out of these, 49 species, 46 genera, 29 families and 151 individuals were recorded from Chizami; 43 species, 39 genera, 30 families and 154 individuals from Akhegwo; 36 species, 33 genera, 24 families and 132 individuals from Zipu and 30 species, 27 genera, 23 families and 111 individuals from Meluri community forest of Nagaland respectively (Table 4.2.17). Based on IVI value, the dominant tree species in Chizami were: *Betula alnoides* (18.24), *Duabanga grandiflora* (17.30) and *Quercus lamellosa* (14.92) and the co-dominant species were: *Lithocarpus elegans* (9.88), *Stereospermum chelonoides* (9.48) and *Myrica esculenta* (9.44) (Table 4.2.18). The most dominant families were: Anacardiaceae, Fagaceae and Moraceae. In Akhegwo, the dominant tree species were: *Alstonia scholaris* (21.49), *Altingia excelsa* (19.48) and *Dillenia indica* (17.43) and the co-dominant species were: *Tetrameles nudiflora* (12.10), *Mallotus philippensis* (11.04) and *Sterculia villosa* (10.73) (Table 4.2.18). The most dominant families were: Euphorbiaceae, Moraceae and Sterculiaceae. In Zipu, the dominant species were: *Aquilaria agallocha* (24.18), *Dillenia indica* (23.57) and *Brassaiopsis hainla* (18.05) and the co-dominant species were: *Lithocarpus xylocarpus* (15.03), *Docynia indica* (13.81) and *Bischofia javanica* (12.88) (Table 4.2.18). The dominant families were: Fagaceae, Lauraceae and Moraceae. In Meluri, the most dominant species was *Pinus kesiya* (106.35) and the co-dominant species were: *Stereospermum chelonoides* (15.39) and *Alnus* *nepalensis* (14.23) (Table 4.2.18). The dominant families were: Fagaceae and Magnoliaceae. The tree stand density (individuals $ha^{-1}$) in the community forest ranged from 278 – 385 where the highest density was recorded from Akhegwo CF (385) followed by Chizami CF (378) and lowest density was recorded from Meluri (278). The basal area ($m^2ha^{-1}$) ranged from 27.96 – 35.33 where the highest basal area was recorded from Chizami CF (35.33) and the lowest from Meluri CF (27.96) respectively (Table 4.2.17).

**Table 4.2.17** Phytosociological attributes of trees, shrubs and herbs in four study sites of Phek District, Nagaland

| Parameters | Chizami | Akhegwo | Zipu | Meluri |
|---|---|---|---|---|
| **Trees** | | | | |
| No. of species | 49 | 43 | 36 | 30 |
| No. of genera | 46 | 39 | 33 | 27 |
| Families | 29 | 30 | 24 | 23 |
| Density (individuals $ha^{-1}$) | 378 | 385 | 330 | 278 |
| Basal area ($m^2ha^{-1}$) | 35.33 | 32.64 | 30.16 | 27.96 |
| Deforestation status (%) | 0.15 | 0.17 | 0.21 | 0.26 |
| Shannon diversity index (H') | 3.71 | 3.55 | 3.32 | 2.65 |
| Simpson index (CD) | 0.02 | 0.03 | 0.04 | 0.16 |
| Margalef index (Dmg) | 9.57 | 8.34 | 5.12 | 6.16 |
| Evenness (e) | 0.95 | 0.94 | 0.93 | 0.78 |
| Disturbance index (%) | 15 | 17 | 21 | 26 |
| **Shrubs** | | | | |
| No. of species | 28 | 27 | 24 | 18 |
| No. of genera | 28 | 26 | 24 | 16 |
| Families | 20 | 19 | 15 | 12 |
| Density (individuals $ha^{-1}$) | 5600 | 5850 | 6100 | 5450 |
| Shannon diversity index (H') | 2.93 | 2.84 | 2.81 | 2.43 |
| Simpson index (CD) | 0.05 | 0.08 | 0.08 | 0.11 |
| Margalef index (Dmg) | 5.72 | 5.46 | 4.79 | 3.62 |
| Evenness (e) | 0.67 | 0.86 | 0.88 | 0.84 |
| **Herbs** | | | | |
| No. of species | 30 | 22 | 25 | 20 |
| No. of genera | 26 | 20 | 23 | 19 |
| Families | 19 | 17 | 18 | 8 |
| Density (individuals $ha^{-1}$) | 58125 | 43750 | 48750 | 65000 |
| Shannon diversity index (H') | 2.89 | 2.86 | 2.93 | 2.7 |
| Simpson index (CD) | 0.05 | 0.07 | 0.07 | 0.08 |

| | | | | |
|---|---|---|---|---|
| Margalef index (Dmg) | 6.40 | 4.94 | 5.51 | 4.09 |
| Evenness (e) | 0.85 | 0.92 | 0.91 | 0.90 |

*Shrub species composition*

In shrubs, a total of 74 species and 54 genera representing 30 families were recorded from five community forest (Chizami, Akhegwo, Zipu and Meluri) of Phek district, Nagaland. Out of these, 28 species, 28 genera and 20 families were recorded from Chizami followed by 27 species, 26 genera and 19 families from Akhegwo; 24 species, 24 genera and 15 families from Zipu and 18 species, 16 genera and 12 families were recorded from Meluri respectively (Table 4.2.17). Based on IVI value, the most dominant shrub species in Chizami CF were: *Boehmeria hamiltoniana* (16.72), *Clerodendrum chinense* (15.83) and *Leea asiatica* (14.04) (Table 4.2.19) and the dominant families were: Ericaceae, Papilionaceae and Urticaceae. In Akhegwo CF, the most dominant species were: *Melastoma malabathricum* (23.55), *Morinda angustifolia* (21.84) and *Mycetia longifolia* (20.13) (Table 4.2.19) and the dominant families were: Ericaceae and Rubiaceae. In Zipu CF, the dominant shrub species were: *Mussaenda frondosa* (24.56), *Clerodendrum chinense* (22.10) and *Osbeckia nepalensis* (18.82) (Table 4.2.19) and the most dominant families were: Asteraceae and Ericaceae. In Meluri, dominant species were: *Artemesia nilagirica* (32.55), *Osbeckia stellata* (27.94) and *Polygonum microcephalum* (25.19) (Table 4.2.19) and the dominant families were: Asteraceae, Ericaceae and Rubiaceae. From the present study, the highest shrub density (individuals ha$^{-1}$) was recorded from Zipu CF (6100) followed by Akhegwo CF (5850), Chizami CF (5600) and the lowest in Meluri CF (5450) respectively (Table 4.2.17).

**Table 4.2.18** Density (individuals ha$^{-1}$), Basal area (m$^{2}$ha$^{-1}$), Important value index (IVI) and Distribution pattern (DP) of tree species in four study sites of Phek District, Nagaland

| Species | Family | Chizami | | | | Akhegwo | | | | Zipu | | | | Meluri | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP |
| *Acer laurinum* Hassk. | Aceraceae | | | | | | | | | 7.5 | 0.42 | 4.99 | C | | | | |
| *Acer thomsonii* Miq. | Aceraceae | 2.5 | 0.12 | 2.05 | C | | | | | | | | | | | | |
| *Acrocarpus fraxinifolius* Arn. | Leguminosae | | | | | 5 | 1.02 | 5.49 | C | 5 | 1.41 | 8.86 | RE | | | | |
| *Aglaia spectabilis* (Miq.) S.S.Jain & S.Bennet | Meliaceae | 5 | 0.55 | 3.92 | C | | | | | | | | | | | | |
| *Ailanthus integrifolia* Lam. | Simaroubaceae | | | | | 2.5 | 0.37 | 2.87 | R | | | | | | | | |
| *Albizia chinensis* (Osbeck) Merr. | Fabaceae | 2.5 | 0.29 | 2.55 | R | | | | | | | | | | | | |
| *Albizia procera* (Roxb.)Benth. | Mimosaceae | | | | | 5 | 0.86 | 6.09 | RE | 2.5 | 0.68 | 4.33 | R | | | | |
| *Alnus nepalensis* D.Don | Betulaceae | 7.5 | 0.93 | 7.78 | RE | | | | | | | | | 12.5 | 0.82 | 14.22 | RE |
| *Alstonia scholaris* (L.) R. Br. | Apocynaceae | | | | | 27.5 | 3.28 | 21.49 | R | | | | | | | | |
| *Altingia excelsa* Noronha | Altingiaceae | | | | | 22.5 | 3.05 | 19.48 | RE | 5 | 0.85 | 5.66 | C | | | | |
| *Aquilaria agallocha* (Lour.) Roxb. | Thymelaeaceae | | | | | 2.5 | 0.16 | 2.22 | R | 32.5 | 2.71 | 24.18 | R | | | | |
| *Artocarpus chama* Buch.-Ham. | Moraceae | 2.5 | 0.17 | 2.19 | C | 2.5 | 0.21 | 2.36 | R | | | | | | | | |
| *Artocarpus heterophyllus* Lam. | Moraceae | | | | | | | | | 2.5 | 0.15 | 2.58 | R | | | | |
| *Artocarpus lacucha* Buch.-Ham. | Moraceae | 5 | 0.76 | 4.52 | C | 5 | 0.90 | 5.12 | C | 7.5 | 1.10 | 7.25 | C | | | | |
| *Bauhinia divergens* Baker | Caesalpiniaceae | | | | | | | | | | | | | 5 | 0.36 | 4.79 | C |
| *Beilschmiedia fagifolia* Nees | Lauraceae | | | | | 7.5 | 0.14 | 4.53 | R | | | | | | | | |
| *Beilschmiedia roxburghiana* Nees | Lauraceae | 7.5 | 0.69 | 4.99 | C | | | | | | | | | | | | |
| *Betula alnoides* Buch.-Ham. ex. D. Don | Betulaceae | 25 | 2.71 | 18.49 | R | | | | | | | | | 5 | 0.84 | 8.19 | RE |
| *Betula utilis* D. Don | Betulaceae | | | | | | | | | 5 | 0.59 | 4.81 | C | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Bischofia javanica* Blume | Euphorbiaceae | | | | | | | | | 12.5 | 1.94 | 12.88 | C | | | | |
| *Bombax ceiba* L. | Malvaceae | | | | | 2.5 | 2.00 | 7.84 | R | | | | | | | | |
| *Brassaiopsis hainla* (Buch.-Ham.) Seem. | Araliaceae | 10 | 0.51 | 7.24 | RE | | | | | 25 | 1.55 | 18.05 | R | | | | |
| *Callicarpa arborea* Roxb. | Verbenaceae | | | | | | | | | | | | | 5 | 0.33 | 6.36 | RE |
| *Canarium strictum* Roxb. | Burseraceae | | | | | 12.5 | 1.30 | 10.44 | RE | 15 | 2.37 | 15.07 | C | | | | |
| *Castanopsis hystrix* Hook. f. & Thom. ex A. DC. | Fagaceae | | | | | | | | | | | | | 7.5 | 0.97 | 11.25 | RE |
| *Castanopsis indica* (Roxb. ex Lindl.) A.DC. | Fagaceae | | | | | | | | | 7.5 | 0.91 | 7.96 | R | | | | |
| *Castanopsis lanceifolia* (Oerst.) Hickel & A.Camus | Fagaceae | 5 | 0.34 | 3.35 | C | | | | | | | | | | | | |
| *Cedrela toona* Roxb. ex Rottl. & Willd. | Meliaceae | 7.5 | 1.07 | 8.17 | RE | | | | | | | | | | | | |
| *Cephalotaxus griffithii* Hook.f. | Taxaceae | 12.5 | 0.23 | 7.11 | RE | | | | | | | | | | | | |
| *Cinnamomum zeylanicum* Blume | Lauraceae | | | | | | | | | 5 | 0.23 | 4.95 | RE | | | | |
| *Colona floribunda* (Kurz) Craib | Tiliaceae | | | | | 7.5 | 0.14 | 4.52 | R | | | | | | | | |
| *Cycas species* L. | Cycadaceae | | | | | | | | | | | | | 10 | 0.24 | 7.86 | R |
| *Dalbergia mimosoides* Franch. | Papilionaceae | | | | | | | | | 15 | 0.14 | 9.00 | R | | | | |
| *Dillenia indica* L. | Dilleniaceae | | | | | 20 | 2.59 | 17.43 | RE | 30 | 2.76 | 23.57 | C | | | | |
| *Dimocarpus longan* Lour. | Sapindaceae | 10 | 0.28 | 5.54 | R | | | | | | | | | | | | |
| *Docynia indica* (Wallich.)Decne. | Rosaceae | | | | | | | | | 17.5 | 0.96 | 13.81 | RE | | | | |
| *Drimycarpus racemosus* (Roxb.) Hook. f. | Anacardiaceae | 5 | 0.89 | 4.89 | C | | | | | | | | | | | | |
| *Duabanga grandiflora* (DC.) Walp. | Lythraceae | 20 | 2.75 | 17.30 | RE | | | | | | | | | | | | |
| *Elaeocarpus aristatus* Roxb. | Elaeocarpaceae | | | | | 7.5 | 1.00 | 7.15 | R | 7.5 | 0.79 | 6.22 | C | | | | |
| *Elaeocarpus floribundus* Blume | Elaeocarpaceae | | | | | | | | | 5 | 0.61 | 4.88 | C | | | | |
| *Elaeocarpus tectorius* (Lour.) Poir. | Elaeocarpaceae | 2.5 | 0.20 | 2.29 | R | 10 | 0.46 | 7.23 | RE | | | | | 5 | 0.40 | 4.94 | C |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Engelhardia spicata* Lesch. ex Blume | Juglandaceae | 5 | 0.99 | 5.18 | C | | | | | | | | | | | | |
| *Erythrina arborescens* Roxb. | Leguminosae | 10 | 0.29 | 6.64 | RE | | | | | | | | | 2.5 | 0.08 | 2.89 | R |
| *Eurya acuminata* DC. | Theaceae | | | | | 12.5 | 0.34 | 7.52 | RE | | | | | 5 | 0.19 | 5.88 | RE |
| *Eurya cerasifolia* (D. Don) Kobuski | Theaceae | 12.5 | 0.25 | 7.19 | RE | | | | | | | | | | | | |
| *Ficus hispida* L.f. | Moraceae | | | | | 5 | 0.16 | 2.86 | C | | | | | | | | |
| *Ficus neriifolia* Sm. | Moraceae | | | | | | | | | 10 | 0.39 | 8.31 | RE | | | | |
| *Ficus semicordata* Buch.-Ham. ex Sm. | Moraceae | 2.5 | 0.11 | 2.03 | R | | | | | | | | | | | | |
| *Ficus tinctoria* (Blume) Corner | Moraceae | | | | | 7.5 | 0.19 | 5.76 | RE | | | | | | | | |
| *Firmiana colorata* (Roxb.) R.Br. | Sterculiaceae | | | | | 5 | 0.30 | 3.29 | C | | | | | | | | |
| *Firmiana fulgens* (Wall. ex Mast.) K.Schum. | Sterculiaceae | | | | | | | | | 12.5 | 0.99 | 12.40 | RE | | | | |
| *Garcinia anomala* Planch. & Triana | Clusiaceae | | | | | 15 | 0.92 | 9.94 | R | 5 | 0.17 | 4.74 | RE | | | | |
| *Garcinia pedunculata* Roxb. ex Buch.-Ham. | Clusiaceae | 2.5 | 0.17 | 2.20 | R | | | | | | | | | | | | |
| *Glochidion zeylanicum* (Gaertn.) A.Juss. | Phyllanthaceae | | | | | 10 | 0.35 | 5.83 | R | | | | | | | | |
| *Gmelina arborea* Roxb. | Verbenaceae | 10 | 1.55 | 9.15 | R | 7.5 | 0.68 | 6.18 | R | | | | | | | | |
| *Grewia serrulata* DC. | Tiliaceae | | | | | 2.5 | 0.05 | 1.87 | R | | | | | | | | |
| *Holigarna caustica* (Dennst.) Oken | Anacardiaceae | 7.5 | 0.34 | 6.11 | RE | | | | | | | | | | | | |
| *Illicium simonsii* Maxim. | Illiciaceae | | | | | | | | | 7.5 | 0.28 | 5.87 | C | | | | |
| *Itea chinensis* Hook. & Arn. | Iteaceae | | | | | | | | | | | | | 2.5 | 0.15 | 3.13 | R |
| *Itea macrophylla* Wall. | Iteaceae | | | | | | | | | | | | | 5 | 0.20 | 5.91 | RE |
| *Juglans regia* L. | Juglandaceae | 5 | 1.15 | 5.63 | C | | | | | | | | | | | | |
| *Kydia calycina* Roxb. | Malvaceae | | | | | | | | | | | | | 5 | 0.16 | 5.75 | RE |
| *Kydia glabrescens* Mast. | Malvaceae | | | | | 10 | 0.14 | 7.33 | RE | | | | | | | | |
| *Lagerstroemia speciosa* (L.) Pers. | Lythraceae | | | | | 2.5 | 0.78 | 4.10 | R | 2.5 | 1.27 | 6.32 | C | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Leea indica* (Burm.f.) Merr. | Leeaceae | 12.5 | 0.25 | 8.22 | RE | | | | | | | | | | | | |
| *Lithocarpus elegans* (Blume) Hatus. ex Soepadmo | Fagaceae | 10 | 1.81 | 9.88 | C | 5 | 0.79 | 5.87 | RE | | | | | 5 | 0.68 | 5.94 | C |
| *Lithocarpus fenestratus* (Roxb.) Rehder | Fagaceae | 2.5 | 1.90 | 7.08 | R | | | | | | | | | | | | |
| *Lithocarpus pachyphyllus* (Kurz) Rehder | Fagaceae | | | | | | | | | 5 | 0.48 | 5.77 | RE | | | | |
| *Lithocarpus xylocarpus* (Kurz) Markgr. | Fagaceae | | | | | | | | | 10 | 2.01 | 15.03 | RE | | | | |
| *Litsea glutinosa* (Lour.) C.B.Rob. | Lauraceae | | | | | | | | | 12.5 | 0.22 | 8.53 | RE | | | | |
| *Macaranga denticulata* (Blume) Müll.Arg. | Euphorbiaceae | | | | | 15 | 0.65 | 10.18 | RE | | | | | 7.5 | 0.48 | 9.49 | RE |
| *Machilus duthiei* King ex Hook.f. | Lauraceae | | | | | | | | | 2.5 | 0.09 | 2.40 | R | | | | |
| *Macropanax dispermus* (Blume) Kuntze | Araliaceae | | | | | 5 | 0.42 | 3.66 | C | | | | | 5 | 0.30 | 4.58 | C |
| *Magnolia cathcartii* (Hook.f.&Thomson.) Noot. | Magnoliaceae | | | | | 5 | 0.37 | 3.52 | C | | | | | 7.5 | 0.59 | 8.19 | R |
| *Magnolia oblonga* (Wall. ex Hook.f. & Thomson) Figlar | Magnoliaceae | 5 | 0.87 | 4.85 | C | | | | | | | | | | | | |
| *Magnolia rabaniana* (Hook.f. & Thomson) D.C.S.Raju & M.P.Nayar | Magnoliaceae | | | | | 5 | 0.36 | 3.48 | C | | | | | 5 | 0.42 | 5.01 | C |
| *Mallotus philippensis* (Lam.) Müll.Arg. | Euphorbiaceae | | | | | 17.5 | 1.07 | 11.04 | R | | | | | | | | |
| *Mansonia dipikae* Purkayastha | Malvaceae | 2.5 | 1.27 | 5.32 | R | | | | | | | | | | | | |
| *Morus laevigata* Wall. ex Brandis | Moraceae | | | | | | | | | 5 | 0.86 | 7.02 | RE | | | | |
| *Myrica esculenta* Buch.-Ham. ex D. Don | Myricaceae | 12.5 | 0.68 | 9.44 | RE | | | | | | | | | 2.5 | 0.14 | 3.10 | R |
| *Nephelium lappaceum* L. | Sapindaceae | 5 | 0.48 | 3.74 | C | | | | | | | | | | | | |
| *Parkia timoriana* (DC.)Merr. | Mimosaceae | 7.5 | 0.54 | 6.68 | RE | | | | | | | | | | | | |
| *Phoebe lanceolata* (Nees) Nees | Lauraceae | 5 | 0.30 | 3.24 | C | | | | | 7.5 | 0.54 | 5.41 | C | | | | |
| *Phoenix species* L. | Arecaceae | | | | | | | | | | | | | 2.5 | 0.11 | 2.98 | R |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Phyllanthus emblica* L. | Euphorbiaceae | | | | | 2.5 | 0.13 | 2.13 | R | | | | | | | | |
| *Pinus Kesiya* Royle ex Gordon | Pinaceae | 2.5 | 0.29 | 2.55 | C | | | | | | | | | 107.5 | 17.01 | 106.35 | C |
| *Pongamia pinnata* (L.) Pierre | Leguminosae | | | | | 10 | 0.55 | 7.52 | RE | 2.5 | 0.13 | 2.51 | C | | | | |
| *Prunus cerasoides* D. Don | Rosaceae | 5 | 0.67 | 5.32 | RE | | | | | | | | | | | | |
| *Pterospermum lanceifolium* Roxb. | Sterculiaceae | | | | | 7.5 | 0.77 | 5.38 | C | | | | | | | | |
| *Pyrularia edulis* (Wall.)A.DC. | Santalaceae | | | | | | | | | 10 | 0.11 | 7.40 | RE | | | | |
| *Pyrus pashia* Buch.-Ham. ex. D. Don | Rosaceae | 7.5 | 0.18 | 3.56 | C | | | | | | | | | | | | |
| *Quercus griffithii* Hook.f. & Thomson ex Miq. | Fagaceae | | | | | | | | | | | | | 5 | 0.47 | 6.86 | RE |
| *Quercus lamellosa* Sm. | Fagaceae | 15 | 2.38 | 14.92 | RE | | | | | 5 | 1.49 | 9.13 | RE | | | | |
| *Quercus serrata* Murray | Fagaceae | 2.5 | 0.70 | 3.69 | R | 5 | 0.44 | 4.80 | RE | | | | | 2.5 | 0.43 | 4.15 | R |
| *Rhododendron arboreum* Sm. | Ericaceae | | | | | | | | | 12.5 | 0.45 | 10.62 | RE | 7.5 | 0.35 | 7.34 | R |
| *Rhus khasiana* Hook.f. | Anacardiaceae | | | | | 15 | 0.27 | 7.95 | R | | | | | | | | |
| *Rhus succedanea* L. | Anacardiaceae | 15 | 0.38 | 8.22 | R | | | | | | | | | | | | |
| *Saurauia armata* Kurz | Actinidiaceae | | | | | | | | | | | | | 10 | 0.26 | 9.62 | RE |
| *Saurauia napaulensis* DC. | Actinidiaceae | | | | | | | | | 2.5 | 0.11 | 2.46 | R | | | | |
| *Saurauia roxburghii* Wall. | Actinidiaceae | 12.5 | 0.38 | 7.54 | RE | | | | | | | | | | | | |
| *Schefflera wallichiana* (Wight & Arn.) Harms. | Araliaceae | | | | | | | | | 5 | 0.27 | 3.75 | C | | | | |
| *Schima wallichii* Choisy | Theaceae | 7.5 | 0.88 | 5.54 | C | 5 | 0.59 | 5.24 | RE | | | | | 5 | 0.54 | 7.14 | RE |
| *Sorbus foliolosa* (Wall.) Spach | Rosaceae | | | | | | | | | | | | | 2.5 | 0.10 | 2.95 | R |
| *Spondias pinnata* (L.f.) Kurz. | Anacardiaceae | 7.5 | 0.32 | 3.93 | C | | | | | | | | | | | | |
| *Sterculia villosa* Roxb. | Sterculiaceae | | | | | 17.5 | 0.61 | 10.73 | RE | | | | | | | | |
| *Stereospermum chelonoides* (L.f.) DC. | Bignoniaceae | 5 | 2.14 | 9.48 | RE | 5 | 1.34 | 7.56 | RE | | | | | 2.5 | 0.14 | 3.08 | R |
| *Symplocos racemosa* Roxb. | Symplocaceae | 5 | 0.25 | 3.08 | C | | | | | | | | | | | | |
| *Syzygium cumini* (L.) Skeels | Myrtaceae | 15 | 0.40 | 9.30 | RE | 17.5 | 0.32 | 8.76 | R | | | | | | | | |
| *Taxus baccata* L. | Taxaceae | | | | | | | | | | | | | 15 | 0.90 | 15.39 | RE |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Taxus wallichiana* Zucc. | Taxaceae | | | | | | | | | 5 | 0.13 | 3.28 | C | | | | |
| *Tetrameles nudiflora* R. Br. | Tetramelaceae | | | | | 12.5 | 2.19 | 12.10 | C | | | | | | | | |
| *Thespesia populnea* ( L.) Sol. Ex correa | Malvaceae | 10 | 0.16 | 5.21 | R | | | | | | | | | | | | |
| *Trevesia palmata* (Roxb. ex Lindl.) Vis. | Araliaceae | 7.5 | 0.20 | 3.61 | C | | | | | | | | | | | | |
| *Turpinia pomifera* (Roxb.) DC. | Staphyleaceae | 2.5 | 0.18 | 2.23 | R | | | | | | | | | | | | |
| *Vernicia fordii* (Hemsl.) Airy Shaw | Euphorbiaceae | 10 | 0.37 | 6.85 | RE | | | | | | | | | | | | |
| *Vernonia arborea* Buch.-Ham. | Asteraceae | | | | | 10 | 0.23 | 6.54 | RE | | | | | | | | |
| *Vernonia volkameriifolia* DC. | Asteraceae | | | | | | | | | | | | | 10 | 0.18 | 11.03 | RE |
| *Wendlandia tinctoria* (Roxb.) DC. | Rubiaceae | | | | | 7.5 | 0.16 | 4.60 | R | | | | | 5 | 0.12 | 5.62 | RE |

**Key to abbreviation:** RE= Regular; R= Random; C= Clumped

*Herb species composition*

In herbs, a total of 76 species, 66 genera representing 36 families were recorded from five community forest (Chizami, Akhegwo, Zipu and Meluri) of Phek district, Nagaland. Of these, 30 species, 26 genera and 19 families were recorded from Chizami CF followed by 25 species, 23 genera and 18 families from Zipu; 22 species, 20 genera and 17 families from Akhegwo and 20 species, 19 genera and 8 families from Meluri community forest of Nagaland respectively (Table 4.2.17). In Chizami, the most dominant herb species were: *Ageratina riparia* (19.10), *Mikania micrantha* (16.95) and *Smilax myrtillus* (14.80) (Table 4.2.19) and the dominant families were: Asteraceae, Poaceae and Zingiberaceae. In Zipu, the most dominant species were: *Girardinia diversifolia* (25.97), *Cheilocostus speciosus* (20.84) and *Desmodium microphyllum* (18.28) (Table 4.2.19) and the dominant families were: Asteraceae and Zingiberaceae. In Akhegwo, the dominant species were: *Cheilocostus speciosus* (25.47), *Tinospora Sinensis* (21.18) and *Dendrobium fugax* (18.33) (Table 4.2.19) and the dominant families were: Vitaceae and Zingiberaceae. In Meluri, the dominant species were: *Ajuga macrosperma* (29.95), *Pogostemon parviflorus* (21.29) and *Dysphania ambrosioides* (19.37) (Table 4.2.19) and the most dominant families were: Asteraceae and Lamiaceae. The highest herb density (individuals ha$^{-1}$) was recorded from Meluri CF (65000) followed by Chizami CF (58125), Zipu CF (48750) and Akhegwo CF (43750) respectively (Table 4.2.17).

### 4.2.5.2 Species diversity indices

In the present study, the community forest with higher diversity index showed low dominance value which is also considered as a characteristic feature of a natural forest. In trees, Shannon diversity index (H') value ranged from 2.65 – 3.71 Where the highest diversity index was recorded from Chizami CF (3.71) followed by Akhegwo CF (3.55) and Zipu CF (3.32). The lowest diversity index was recorded from Meluri CF (2.65) which maybe attributed to lesser species richness and tree density due to higher enthropogenic pressure in the forest. The Simpson dominance index (CD) study ranged from 0.02 – 0.16, where the highest dominance index was recorded from Meluri CF (0.16) indicating lesser diversity than other community forest. The highest Margalef index (Dmg) for tree species was recorded from Chizami CF (9.57) and lowest in Zipu CF (5.12)and the Pielou's evenness index (e) ranged from 0.78 – 0.95, where Meluri CF (0.78) recorded the lowest evenness value indicating that the community is not very even as compared to other community forest (Table 4.2.17).

In shrubs, Shannon diversity index (H') value ranged from 2.43 – 2.93 indicating an average species diversity in the community forests. The Simpson dominance index (CD) in the present study ranged from 0.05 – 0.11 where the study observed that, higher the H' value, lower the dominance index value. The Margalef index (Dmg) of shrub species ranged from 3.62 – 5.72 and the Pielou's evenness index (e) ranged from 0.67 – 0.88 indicating less evenness of species in the community (Table 4.2.17).

In herbs, the highest Shannon diversity index (H') value ranged from 2.70 – 2.93 where Zipu CF recorded the highest diversity (2.93) followed by Chizami CF (2.89) and Akhegwo CF (2.86). The lowest diversity index was recorded from Meluri CF (2.70). The Simpson dominance index (CD) ranged from 0.05 – 0.08 and the Margalef species richness index (Dmg) ranged from 4.09 – 6.40. The Pielou's evenness index (e) of herbs species ranged from 0.85 – 0.92 indicating that the community is even (Table 4.2.17).

**Table 4.2.19** Density (individuals ha$^{-1}$) and Important value index (IVI) of shrubs and herbs species in four study sites of Phek District, Nagaland

| Species | Family | Chizami | | Akhegwo | | Zipu | | Meluri | |
|---|---|---|---|---|---|---|---|---|---|
| | | D | IVI | D | IVI | D | IVI | D | IVI |
| **Shrubs** | | | | | | | | | |
| *Abelmoschus manihot* (Roxb.) Hochr. | Malvaceae | 200 | 7.02 | | | | | | |
| *Acacia pennata* (L.)Willd. | Mimosaceae | | | 100 | 3.75 | | | | |
| *Acacia pruinescens* Kurz | Mimosaceae | 100 | 3.51 | | | | | | |
| *Agapetes mannii* Hemsl | Ericaceae | | | 150 | 4.60 | 200 | 5.32 | | |
| *Agapetes salicifolia* C.B. Clarke | Ericaceae | 150 | 6.13 | | | | | | |
| *Amblyanthopsis membranacea* (Wall.) Mez | Myrsinaceae | 100 | 3.51 | | | | | | |
| *Amblyanthus glandulosus* A.DC | Myrsinaceae | 250 | 7.91 | | | | | | |
| *Artemesia nilagirica* (C.B. Clarke) Pamp. | Asteraceae | | | | | 100 | 3.68 | 1150 | 32.53 |
| *Baliospermum calycinum* Müll.Arg. | Euphorbiaceae | | | 50 | 2.90 | 50 | 2.86 | | |
| *Baliospermum solanifolium* (Burm.) Suresh | Euphorbiaceae | 100 | 3.51 | | | | | | |
| *Blumea riparia* (Blume) DC. | Asteraceae | | | | | | | 150 | 8.47 |
| *Boehmeria hamiltoniana* Wedd. | Urticaceae | 550 | 16.72 | | | 250 | 10.22 | | |
| *Boehmeria japonica* (L.f.) Miq. | Urticaceae | | | 300 | 9.21 | | | | |
| *Breynia retusa* (Dennst.) Alston | Euphorbiaceae | 200 | 7.02 | | | | | | |
| *Bridelia stipularis* (L.) Blume | Euphorbiaceae | | | | | 100 | 5.72 | | |
| *Brugmansia suaveolens* (Humb. & Bonpl.) Bercht. & J. Presl. | Solanaceae | | | 50 | 2.90 | | | | |
| *Butea buteiformis* (Voigt) Mabb. | Papilionaceae | 150 | 6.13 | | | | | | |
| *Calamus erectus* Roxb. | Arecaceae | | | | | 400 | 12.68 | | |
| *Calamus leptospadix* Griff. | Arecaceae | 50 | 2.62 | | | | | | |
| *Camellia oleifera* Abel. | Theaceae | 100 | 5.23 | 200 | 7.50 | | | | |
| *Casearia vareca* Roxb. | Flacourtiaceae | 150 | 7.85 | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Cassiope fastigiata* (Wall.) D. Don | Ericaceae | | | | | 100 | 3.68 | | |
| *Chassalia curviflora* (Wall.) Thwaites | Rubiaceae | | | | | | | 100 | 4.69 |
| *Clerodendrum chinense* (Osbeck) Mabb. | Verbenaceae | 500 | 15.83 | | | 850 | 22.10 | | |
| *Clerodendrum infortunatum* L. | Verbenaceae | | | 550 | 15.52 | | | | |
| *Coriaria nepalensis* Wall. | Coriariaceae | 300 | 10.53 | | | | | | |
| *Corylopsis himalayana* Griff. | Hamamelidaceae | | | | | | | 50 | 3.77 |
| *Crotalaria juncea* L. | Papilionaceae | 250 | 9.64 | | | | | | |
| *Daphne involucrata* Wall. | Thymelaeaceae | | | 50 | 2.90 | | | | |
| *Debregeasia longifolia* (Burm.f.) Wedd. | Urticaceae | 100 | 3.51 | | | | | 200 | 6.53 |
| *Dendrocnide sinuata* (Blume) Chew | Urticaceae | | | 100 | 3.75 | 100 | 3.68 | | |
| *Desmodium hispidum* Franch. | Papilionaceae | | | 250 | 8.36 | | | | |
| *Desmodium oblongum* Benth. | Papilionaceae | | | | | 250 | 10.22 | | |
| *Dobinea vulgaris* Buch.-Ham. ex D. Don | Anacardiaceae. | 150 | 6.13 | | | | | | |
| *Dracaena angustifolia* (Medik.) Roxb. | Dracaenaceae | 300 | 10.53 | | | | | | |
| *Embelia ribes* Burm.f. | Myrsinaceae | | | | | 100 | 3.68 | | |
| *Eriobotrya bengalensis* (Roxb.) Hook.f. | Rosaceae | 100 | 3.51 | 50 | 2.90 | | | | |
| *Eupatorium adoratum* L. | Compositae | | | | | | | 600 | 22.44 |
| *Flemingia macrophylla* (Willd.) Merr. | Papilionaceae | 50 | 2.62 | | | | | | |
| *Flemingia semialata* Roxb. | Papilionaceae | | | 100 | 3.75 | 350 | 11.86 | 50 | 3.77 |
| *Gaultheria fragrantissima* Wall. | Ericaceae | | | | | 150 | 6.54 | 300 | 11.22 |
| *Hibiscus sabdariffa* L. | Malvaceae | | | 150 | 6.65 | | | | |
| *Hydrangea heteromalla* D. Don | Hydrangeaceae | 150 | 6.13 | | | | | | |
| *Indigofera* species L. | Leguminosae | 50 | 2.62 | 50 | 2.90 | | | | |
| *Inula cappa* (Buch.-Ham. ex D.Don) DC. | Asteraceae | | | | | 100 | 5.72 | | |
| *Ixora acuminata* Roxb. | Rubiaceae | | | 200 | 9.54 | | | | |
| *Jasminum caudatum* Wall. ex Lindl. | Oleaceae | | | 50 | 2.90 | | | | |
| *Jasminum laurifolium* Roxb. Ex Hornem | Oleaceae | | | | | | | 150 | 8.47 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Jasminum scandens* (Retz.) Vahl | Oleaceae | | | 50 | 2.90 | | | | |
| *Jasminum subhumile* W. W. Sm. | Oleaceae | | | | | | | 200 | 9.38 |
| *Leea asiatica* (L.) Ridsdale | Vitaceae | 400 | 14.04 | | | | | | |
| *Leea compactiflora* Kurz | Vitaceae | | | 150 | 4.60 | | | | |
| *Leycesteria formosa* Wall. | Caprifoliaceae | | | | | | | 50 | 3.77 |
| *Lycianthes biflora* (Lour.) Bitter | Solanaceae | | | | | 300 | 11.04 | | |
| *Lyonia macrocalyx* (J. Anthony) Airy Shaw | Ericaceae | | | 350 | 14.15 | 200 | 5.32 | | |
| *Lyonia ovalifolia* (Wall.) Drude | Ericaceae | 150 | 4.40 | | | | | 100 | 4.69 |
| *Maesa ramentacea* (Roxb.) A. DC. | Myrsinaceae | | | 100 | 3.75 | | | | |
| *Melastoma malabathricum* L. | Melastomataceae | | | 900 | 23.55 | | | | |
| *Melastoma napalense* Lodd. | Melastomataceae | 300 | 8.81 | | | | | | |
| *Morinda angustifolia* Roxb. | Rubiaceae | 350 | 11.42 | 800 | 21.84 | 50 | 2.86 | | |
| *Mussaenda frondosa* L. | Rubiaceae | | | 700 | 20.13 | 1000 | 24.56 | | |
| *Mycetia longifolia* (Wall.) Kuntze | Rubiaceae | | | 150 | 6.65 | | | 50 | 3.77 |
| *Osbeckia nepalensis* Hook.f. | Melastomataceae | | | | | 650 | 18.82 | | |
| *Osbeckia stellata* Buch.-Ham. ex Ker Gawl. | Melastomataceae | 200 | 7.02 | | | | | 900 | 27.94 |
| *Phrynium species* Willd. | Marantaceae | | | 100 | 5.79 | 100 | 3.68 | | |
| *Polygonum microcephalum* D. Don | Polygonaceae | | | 50 | 2.90 | | | 750 | 25.19 |
| *Spiraea canescens* D. Don | Rosaceae | | | | | | | 350 | 12.14 |
| *Spiraea japonica* L.f. | Rosaceae | | | | | 300 | 9.00 | | |
| *Vaccinium dunalianum* Wight | Ericaceae | | | | | | | 100 | 4.69 |
| *Vaccinium exaristatum* Kurz | Ericaceae | | | 100 | 3.75 | | | 200 | 6.53 |
| *Vaccinium retusum* (Griff.) J. D. Hooker ex C. B. Clarke | Ericaceae | | | | | 100 | 3.68 | | |
| *Vaccinium sprengelii* (G.Don) Sleumer | Ericaceae | 150 | 6.13 | | | | | | |
| *Vernonia blanda* (Wall.) DC. | Asteraceae | | | | | 250 | 10.22 | | |
| *Zanthoxylum oxyphyllum* Edgew. | Rutaceae | | | | | 50 | 2.86 | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Herbs** | | | | | | | | | |
| *Aerides rosea* Lodd. ex Lindl. & Paxton | Orchidaceae | | | | | 625 | 3.61 | | |
| *Aeschynanthus acuminatus* Wall. Ex A. DC. | Gesneriaceae | | | 1250 | 5.30 | | | 1250 | 4.36 |
| *Aeschynanthus parasiticus* (Roxb.) Wall. | Gesneriaceae | 1250 | 5.79 | | | | | | |
| *Ageratina riparia* (Regel) R.M. King & H. Rob. | Asteraceae | 6875 | 19.10 | | | | | | |
| *Ajuga macrosperma* Wall. ex Benth. | Lamiaceae | | | | | | | 13125 | 29.95 |
| *Ampelopsis rubifolia* (Wall.) Planch. | Vitaceae | | | 1875 | 9.16 | | | | |
| *Aster trinervius* (C.B. Clarke) Grierson | Asteraceae | | | | | 1250 | 7.22 | | |
| *Balanophora dioica* R. Br. ex Royle | Balanophoraceae | 625 | 2.89 | | | | | | |
| *Bauhinia vahlii* Wight & Arn. | Caesalpiniaceae | 1875 | 6.86 | | | | | | |
| *Bidens pilosa* L. | Asteraceae | 1250 | 5.79 | | | | | 3125 | 12.12 |
| *Blumea aromatica* DC. | Asteraceae | 1250 | 3.97 | | | | | | |
| *Brachystemma calycinum* D. Don | Caryophyllaceae | | | | | 1250 | 4.89 | | |
| *Bulbophyllum affine* Wall. ex Lindl. | Orchidaceae | 625 | 2.89 | | | | | | |
| *Bulbophyllum helenae* (Kuntze) J.J.Sm. | Orchidaceae | | | 3125 | 14.46 | | | | |
| *Calanthe clavata* Lindl. | Orchidaceae | | | | | | | 2500 | 8.72 |
| *Calanthe densiflora* Lindl. | Orchidaceae | | | | | | | 3750 | 13.09 |
| *Carex baccans* Nees | Cyperaceae | 2500 | 7.94 | 625 | 3.87 | | | | |
| *Cayratia pedata* (Lam.) Gagnep. | Vitaceae | 625 | 2.89 | | | | | | |
| *Cheilocostus speciosus* (J.Koenig) C.D. Specht | Zingiberaceae | | | 6875 | 25.47 | 5625 | 20.84 | | |
| *Cirsium interpositum* Petr. | Asteraceae | | | | | 1250 | 4.89 | | |
| *Cirsium lineare* (Thunb.)Sch.Bip. | Asteraceae | | | | | | | 1250 | 4.36 |
| *Conocephalus species* Blume | Moraceae | | | 1250 | 5.30 | | | | |
| *Curculigo orchioides* Gaertn. | Hypoxidaceae | 3125 | 10.83 | | | | | | |
| *Curcuma angustifolia* Roxb. | Zingiberaceae | 1250 | 3.97 | | | | | | |
| *Cymbidium elegans* Lindl. | Orchidaceae | | | 2500 | 10.59 | | | | |
| *Dendrobium fugax* Rch.f. | Orchidaceae | | | | 3750 | 18.33 | 8.50 | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Desmodium microphyllum* (Thunb.) DC. | Papilionaceae | 625 | 2.89 | | | 4375 | 18.28 | | |
| *Dichrocephala integrifolia* (L.f.) Kuntze | Asteraceae | | | | | | | 625 | 3.40 |
| *Dioscorea tomentosa* J. Koenig ex Spreng. | Dioscoreaceae | | | 1250 | 5.30 | | | | |
| *Drymaria cordata* (L.) Willd. Ex Schult. | Caryophyllaceae | | | | | 1250 | 4.89 | | |
| *Dysphania ambrosioides* (L.) Mosyakin & Clemants | Chenopodiaceae | 3750 | 10.09 | | | | | 6250 | 19.37 |
| *Elsholtzia blanda* (Benth.) Benth. | Lamiaceae | | | | | 1875 | 8.50 | 2500 | 6.29 |
| *Eria biflora* Griff. | Orchidaceae | | | | | | | 1250 | 6.80 |
| *Girardinia diversifolia* (Link) Friis | Urticaceae | 1250 | 5.79 | | | 8125 | 25.97 | | |
| *Habenaria dentata* (Sw.) Schltr. | Orchidaceae | | | | | 1250 | 4.89 | | |
| *Habenaria digitata* Lindl. | Orchidaceae | 1875 | 5.04 | | | | | | |
| *Habenaria intermedia* D. Don | Orchidaceae | | | | | | | 3125 | 7.25 |
| *Hedychium coccineum* Buch.-Ham. ex D. Don | Zingiberaceae | 625 | 2.89 | 1875 | 9.16 | 3125 | 13.39 | | |
| *Hypericum japonicum* Thunb. | Hypericaceae | | | | | | | 1875 | 7.76 |
| *Hypoxis aurea* Lour. | Hypoxidaceae | 1250 | 3.97 | | | | | | |
| *Impatiens arguta* Hook.f. & Thomson | Balsaminaceae | 2500 | 9.76 | | | 1875 | 8.50 | | |
| *Juncus bufonius* L. | Juncaceae | 625 | 2.89 | | | 2500 | 9.78 | | |
| *Laportea bulbifera* (Siebold & Zucc.) Wedd. | Urticaceae | | | | | | | 3750 | 8.21 |
| *Lygodium flexuosum* (L.) Sw. | Lygodiaceae | | | | | 625 | 3.61 | | |
| *Mikania micrantha* Kunth | Asteraceae | 5625 | 16.95 | | | | | | |
| *Mucuna macrocarpa* Wall. | Leguminosae | | | 625 | 3.87 | 1250 | 7.22 | | |
| *Myriopteron extensum* (Wight & Arn.) K. Schum. | Apocynaceae | | | 1250 | 5.30 | | | | |
| *Nicotiana tabacum* L. | Solanaceae | | | 625 | 3.87 | | | | |
| *Ophioglossum reticulatum* L. | Ophioglossaceae | | | | | | | 1250 | 6.80 |
| *Panicum khasianum* Munro ex Hook.f. | Poaceae | | | 1250 | 5.30 | 625 | 3.61 | | |
| *Papilionanthe teres* (Roxb.) Schltr. | Orchidaceae | | | 1875 | 9.16 | | | | |
| *Papilionanthe uniflora* (Lindl.) garay | Orchidaceae | | | | | 2500 | 9.78 | | |
| *Phaius flavus* (Blume) Lindl. | Orchidaceae | | | | | | | 4375 | 11.61 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Phragmites species* Adans | Poaceae | 625 | 2.89 | | | | | | |
| *Piper longum* L. | Piperaceae | | | 1250 | 7.74 | | | | |
| *Pleione humilis* (Sm.) D. Don. | Orchidaceae | | | | | | | 1875 | 7.76 |
| *Pleione praecox* (Sm.) D.Don | Orchidaceae | 1250 | 5.79 | | | | | | |
| *Pogostemon parviflorus* Benth. | Lamiaceae | | | | | | | 7500 | 21.29 |
| *Polygonum delicatulum* Meisn. | Polygonaceae | 625 | 2.89 | | | | | | |
| *Porana paniculata* Roxb. | Convolvulaceae | | | 2500 | 13.03 | 1250 | 4.89 | | |
| *Satyrium nepalense* D. Don | Orchidaceae | | | | | 625 | 3.61 | 1875 | 7.76 |
| *Senecio nagensium* C.B.Clarke | Asteraceae | | | 1875 | 6.72 | | | 1250 | 4.36 |
| *Senecio scandens* Buch.-Ham. ex D. Don | Asteraceae | 1250 | 5.79 | | | | | | |
| *Setaria verticillata* (L.) P.Beauv. | Poaceae | 3125 | 10.83 | | | | | | |
| *Smilax myrtillus* A.DC. | Smilacaceae | 4375 | 14.80 | | | 1250 | 4.89 | | |
| *Sonchus wightianus* DC. | Asteraceae | 1250 | 3.97 | | | | | 2500 | 8.72 |
| *Spermacoce hispida* L. | Rubiaceae | 3750 | 10.09 | 625 | 3.87 | | | | |
| *Stephania elegans* Hook.f. & thomson | Menispermaceae | 1875 | 6.86 | | | | | | |
| *Tagetes erecta* L. | Asteraceae | 625 | 2.89 | | | | | | |
| *Tetrastigma lanceolarium* (Roxb.) Planch. | Vitaceae | | | | | 1250 | 4.89 | | |
| *Tetrastigma obovatum* Gagnep | Vitaceae | | | 1250 | 7.74 | | | | |
| *Thalictrum reniforme* Wall. | Ranunculaceae | | | | | 625 | 3.61 | | |
| *Tinospora sinensis* (Lour.) Merr. | Rutaceae | | | 5000 | 21.18 | | | | |
| *Trichosanthes multiloba* Miq. | Cucurbitaceae | | | 1250 | 5.30 | | | | |
| *Triumfetta pilosa* Roth | Tiliaceae | | | | | 1250 | 4.89 | | |
| *Valeriana jatamansi* Jones | Valerianaceae | | | | | 1250 | 4.89 | | |

### 4.2.5.3 Population structure of tree species in various girth-classes

The tree density and basal cover in all the community forest varied significantly in various girth classes. The highest density and basal cover was recorded from young trees (30 – 60 cm girth class) contributing about 75% and 40 % of the total density and basal area. Akhegwo CF recorded the maximum tree density in higher girth classes (32.5 individuals ha$^{-1}$) whereas no individual was recorded from Zipu and Meluri CF. Among the the regenerating trees (10 – 30 cm girth class), Chezami CF recorded the highest density (125 individuals ha$^{-1}$) followed by Akhegwo CF (115 individuals ha$^{-1}$) indicating high regenaration potential in these forests. The study also showed that the density of tree species decreased with increase in girth class. The tree basal cover in all the communities also differed significantly. Overall, the individuals between 30 – 60 cm girth class (43.18 m$^2$ha$^{-1}$) contributed the highest basal cover followed by 60 – 90 cm girth class (40.11 m$^2$ha$^{-1}$) whereas old trees contributed only 14% of the total basal cover (Figure 4.2.9).

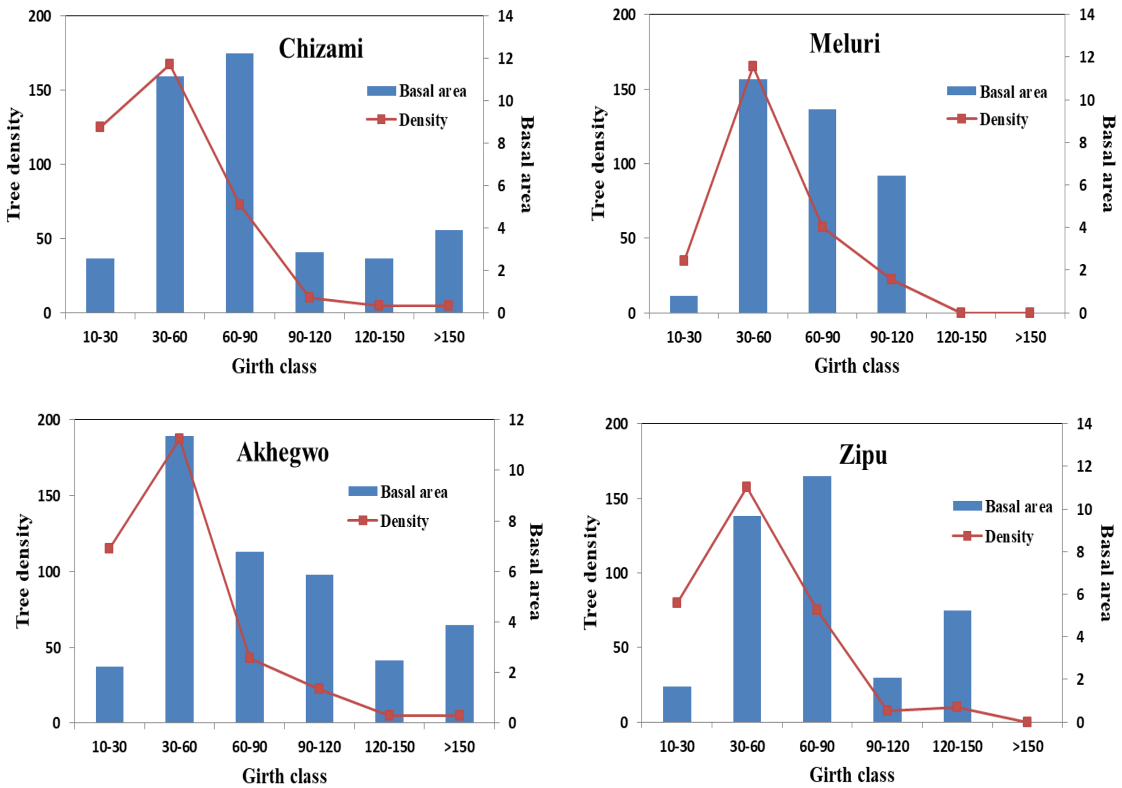
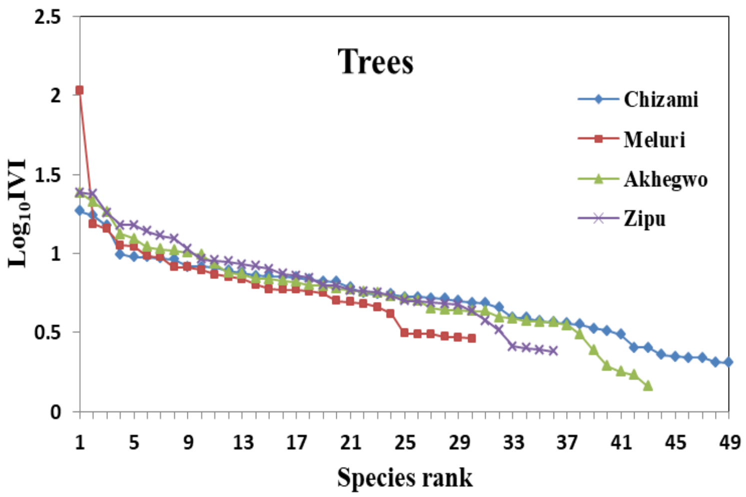
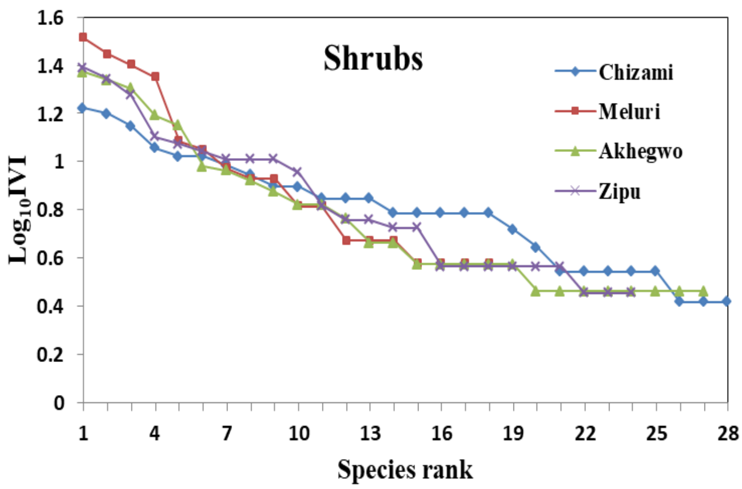



**Figure 4.2.9** Contributions of tree stand density and basal area based on girth class contribution in four study sites of Phek District, Nagaland

### 4.2.5.4 Dominance-Diversity curve

The dominance-diversity curve for the tree, shrub and herb layer showed high equitability and low dominance and the dominance-diversity curve followed a log normal distribution pattern (Figure 4.2.10). Among the trees, the most dominant species were: *Betula alnoides* (Chizami), *Alstonia scholaris* (Akhegwo), *Aquilaria agallocha* (Zipu) and *Pinus kesiya* (Meluri). In shrubs, the most dominant species were: *Boehmeria hamiltoniana* (Chizami), *Melastoma malabathricum* (Akhegwo), *Mussaenda frondosa* (Zipu) and *Artemesia nilagirica* (Meluri). In herbs, the most dominant species were: *Ageratina riparia* (Chezami), *Cheilocostus speciosus* (Akhegwo), *Girardinia diversifolia* (Zipu) and *Ajuga macrosperma* (Meluri).



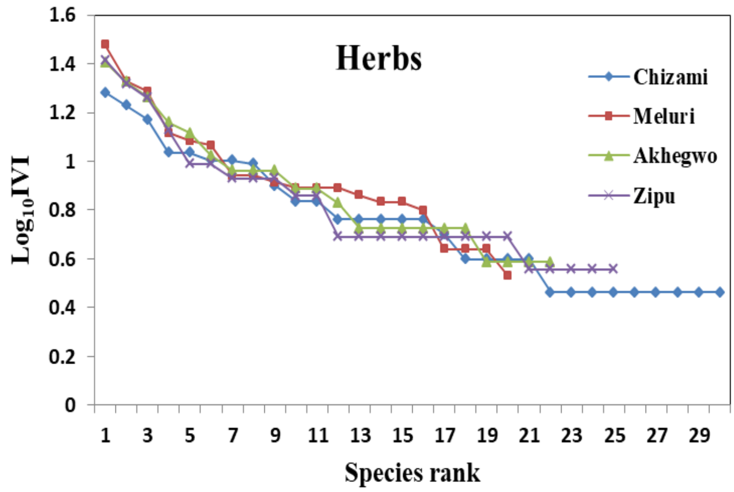



**Figure 4.2.10** Dominance-Diversity curve for trees, shrubs and herbs in four study sites of Phek District, Nagaland

### 4.2.5.5 Distribution pattern of tree species

The Whitford index (A/F ratio) was studied to analyse the distribution of tree species where the distribution pattern varied significantly in all the community. The study showed that, the community forests (Zipu and Chizami) exhibited maximum clumbed distribution (42% and 39% respectively) showing the characteristic feature of distribution pattern of species in a natural forest. Where as Akhegwo CF was dominated by random distribution (42% each) where distribution of species were atypical in nature and Meluri CF showed maximum regular distribution of species (47%) which maybe due to competition and territoriality of species in the forest (Table 4.2.18).

### 4.2.5.6 Sorenson's similarity

Sorenson's similarity index was analyzed to study the similarity of tree species in all the community. The overall study showed less similarity in all the communities. The highest similarity (30%) was observed between Akhegwo and Meluri CF followed by Akhegwo and Zipu CF (28%) and Chizami and Meluri CF (20%). Chizami and Akhegwo CF showed only 10% similarity whereas there was no significant similarity within the species between Zipu and Meluri CF (0.03%) which maybe attributed to different altudinal gradient and species composition in the forest (Table 4.2.20).

**Table 4.2.20** Sorenson Similarity indices for tree species between four study sites of Phek District, Nagaland

| Study area | Chizami | Akhegwo | Zipu | Meluri |
|---|---|---|---|---|
| **Chizami** | x | | | |
| **Akhegwo** | 0.2 | x | | |
| **Zipu** | 0.1 | 0.28 | x | |
| **Meluri** | 0.25 | 0.3 | 0.03 | x |

**4.2.5.7 Disturbance pattern**

The average disturbance index for all the study sites was 20%. The highest disturbance was observed in Meluri (26%) followed by Zipu (21%) and Akhegwo (17%). The high disturbance index in these forests maybe attributed to extraction of timber species such as *Altingia excelsa*, *Aquilaria agallocha*, *Dillenia indica* and *Pinus kesiya* by the local people (Table 4.2.17). Maximum lopping was also observed at Meluri and Zipu CF on account of fuelwood requirements and fodders for livestock.

**4.2.6 Wokha district**

**4.2.6.1 Floristic structure**

*Tree species composition*

In the present study, a total of 641 individuals belonging to 134 species and 98 genera belonging to 47 families were recorded from the three community forest (Wokha village, Tsonsa and Doyang) and Ralan plantation forest (PF) of Wokha district, Nagaland, Northeast India. Out of these, 54 species, 47 genera, 31 families and 197 individuals were recorded from Wokha village CF; 49 species, 41 genera, 30 families and 184 individuals from Tsonsa CF; 42 species, 38 genera, 25 families and 146 individuals from Doyang CF and 25 species, 22 genera, 20 families and 114 individuals from Ralan plantation forest of Nagaland respectively (Table 4.2.21). Based on IVI value, the dominant tree species in Wokha village CF were: *Cananrium strictum* (25.08), *Magnolia oblonga* (16.99) and *Alstonia scholaris* (15.32) and the co-dominant species were: *Myrica esculenta* (11.51), *Schima wallichi* (10.02) and *Dimocarpus longan* (9.95) (Table 4.2.22). The most dominant families were: Euporbiaceae, Fagaceae and Lauraceae. In Tsonsa CF, the dominant tree species were: *Engelhardtia roxburghiana* (29.25), *Alstonia scholaris* (20.27) and *Callicarpa arborea* (19.05) and the co-dominant species were: *Terminalia myriocarpa* (14.43) and *Eurya accuminata* (10.71) (Table 4.2.22). The most dominant families were: Euphorbiaceae, Lauraceae and Magnoliaceae. In Doyang, the dominant species were: *Ailanthus integrifolia* (22.65), *Dillenia pentagyna* (21.76) and *Bombax ceiba* (19.75) and the co-dominant species were: *Stereospermum chelonoides* (17.58), *Canarium strictum* (13.64) and *Melia azederach* (12.85) (Table 4.2.22). The dominant families were: Euphorbiaceae, Rubiaceae and Sterculiaceae. In Ralan, the most dominant species were: *Tectona grandis* (29.00), *Stereospermum chelonoides* (26.60) and *Pterospermum acerifolium* (22.11) and the co-dominant species were: *Canarium bengalense* (21.08), *Elaeocarpus lanceifolius* (18.19) and *Bombax ceiba* (15.11) (Table 4.2.22). The dominant families were: Burseraceae and Sterculiaceae. The tree stand density (individuals $ha^{-1}$) in the community forest ranged from 285 – 493 where the highest density was recorded from Wokha village CF (493) followed by Tsonsa CF (460) and Doyang CF (365) and the lowest density was recorded from Ralan PF (278). The basal area ($m^2ha^{-1}$) ranged from 32.47 – 41.16 where the highest basal area was recorded from Wokha village CF (41.16) and the lowest from Ralan PF (32.47) respectively (Table 4.2.21).

**Table 4.2.21** Phytosociological attributes of trees, shrubs and herbs in four study sites of Wokha District, Nagaland

| **Parameters** | **Wokha village** | **Tsonsa** | **Doyang** | **Ralan** |
|---|---|---|---|---|
| **Trees** | | | | |
| No. of species | 54 | 49 | 42 | 25 |
| No. of genera | 47 | 41 | 38 | 22 |
| Families | 31 | 30 | 25 | 20 |
| Density (individuals $ha^{-1}$) | 493 | 460 | 365 | 285 |
| Basal area ($m^2 ha^{-1}$) | 41.16 | 40.15 | 38.43 | 32.47 |
| Shannon diversity index (H') | 3.67 | 3.49 | 3.40 | 2.98 |
| Simpson index (CD) | 0.03 | 0.04 | 0.04 | 0.05 |
| Margalef index (Dmg) | 10.03 | 9.20 | 8.23 | 5.07 |
| Evenness (e) | 0.92 | 0.89 | 0.90 | 0.92 |
| Disturbance index (%) | 13 | 16 | 22 | 29 |
| **Shrubs** | | | | |
| No. of species | 20 | 23 | 24 | 30 |
| No. of genera | 19 | 23 | 21 | 25 |
| Families | 18 | 19 | 18 | 17 |
| Density (individuals $ha^{-1}$) | 6300 | 7900 | 8250 | 7550 |
| Shannon diversity index (H') | 2.63 | 2.84 | 2.95 | 2.96 |
| Simpson index (CD) | 0.09 | 0.07 | 0.06 | 0.07 |
| Margalef index (Dmg) | 5.38 | 4.35 | 4.50 | 5.78 |
| Evenness (e) | 0.88 | 0.90 | 0.93 | 0.87 |
| **Herbs** | | | | |
| No. of species | 27 | 34 | 31 | 26 |
| No. of genera | 26 | 33 | 30 | 26 |
| Families | 19 | 20 | 22 | 16 |
| Density (individuals $ha^{-1}$) | 78125 | 85625 | 85000 | 72500 |
| Shannon diversity index (H') | 3.03 | 3.27 | 3.09 | 3.01 |
| Simpson index (CD) | 0.06 | 0.04 | 0.06 | 0.05 |
| Margalef index (Dmg) | 5.38 | 6.71 | 6.11 | 5.26 |
| Evenness (e) | 0.91 | 0.93 | 0.90 | 0.92 |

**Table 4.2.22** Density (individuals $ha^{-1}$), Basal area ($m^2ha^{-1}$), Important value index (IVI) and Distribution pattern (DP) of tree species in four study sites of Wokha District, Nagaland

| Species | Family | Wokha village | | | | Tsonsa | | | | Doyang | | | | Ralan | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP |
| *Acer laurinum* Hassk. | Acearceae | 5 | 0.44 | 2.94 | C | 10 | 0.87 | 6.29 | C | | | | | | | | |
| *Actinodaphne obovata* (Nees) Blume | Lauraceae | 12.5 | 1.13 | 7.89 | RE | | | | | | | | | | | | |
| *Ailanthus integrifolia* Lam. | Simaroubaceae | | | | | | | | | 22.5 | 4.63 | 22.65 | R | 7.5 | 2.35 | 13.79 | C |
| *Alangium chinense* (Lour.) Harms | Cornaceae | 10 | 0.53 | 6.79 | RE | | | | | | | | | | | | |
| *Albizia chinensis* (Osbeck) Merr. | Mimosaceae | | | | | | | | | 7.5 | 0.69 | 7.19 | RE | | | | |
| *Albizia lebbeck* (L.) Benth. | Mimosaceae | | | | | | | | | 10 | 0.86 | 7.19 | C | | | | |
| *Alnus nepalensis* D.Don | Betulaceae | 2.5 | 0.30 | 2.09 | C | 2.5 | 0.45 | 2.65 | R | | | | | | | | |
| *Alstonia scholaris* (L.) R. Br. | Apocynaceae | 30 | 2.37 | 15.32 | R | 42.5 | 2.86 | 20.27 | R | | | | | | | | |
| *Anacardium occidentale* L. | Anacardiaceae | | | | | | | | | | | | | 5 | 0.24 | 4.12 | C |
| *Antidesma acidum* Retz. | Euphorbiaceae | | | | | | | | | 5 | 0.26 | 4.27 | RE | | | | |
| *Aporosa octandra* (Buch.-Ham. ex D.Don) Vickery | Euphorbiaceae | 2.5 | 0.22 | 1.91 | C | | | | | | | | | | | | |
| *Archidendron clypearia* (Jack) I.C.Nielsen | Mimosaceae | 2.5 | 0.20 | 1.87 | C | | | | | | | | | | | | |
| *Bauhinia purpurea* L. | Caesalpiniaceae | 2.5 | 0.11 | 1.65 | C | | | | | | | | | | | | |
| *Bauhinia variegata* L. | Caesalpiniaceae | 5 | 0.28 | 3.44 | RE | | | | | | | | | | | | |
| *Beilschmiedia brandisii* Hook. f. | Lauraceae | | | | | 5 | 0.05 | 2.18 | C | | | | | | | | |
| *Benkara griffithii* (Hook.f.) Ridsdale | Rubiaceae | | | | | | | | | 2.5 | 0.08 | 2.00 | C | | | | |
| *Bischofia javanica* Blume | Euphorbiaceae | | | | | | | | | 5 | 0.26 | 4.26 | RE | 12.5 | 0.66 | 12.82 | RE |
| *Bombax ceiba* L. | Malvaceae | | | | | | | | | 20 | 3.78 | 19.75 | C | 10 | 2.03 | 15.11 | R |
| *Byttneria aspera* Colebr. ex Wall. | Sterculiaceae | 5 | 0.23 | 2.46 | C | | | | | | | | | | | | |
| *Callicarpa arborea* Roxb. | Verbenaceae | 10 | 0.43 | 6.54 | RE | 37.5 | 2.80 | 19.05 | R | | | | | | | | |
| *Canarium bengalense* Roxb. | Burseraceae | | | | | | | | | | | | | 17.5 | 2.55 | 21.08 | RE |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Canarium strictum* Roxb. | Burseraceae | 40 | 5.55 | 25.08 | R | 10 | 0.94 | 7.45 | RE | 15 | 2.38 | 13.64 | C | 5 | 1.23 | 7.53 | C |
| *Canthium glabrum* Blume | Rubiaceae | | | | | | | | | 2.5 | 0.15 | 2.18 | C | | | | |
| *Castanopsis indica* (Roxb. ex Lindl.) A.DC. | Fagaceae | 2.5 | 0.29 | 2.09 | R | | | | | | | | | | | | |
| *Castanopsis lanceifolia* (Oerst.) Hickel & A.Camus | Fagaceae | 15 | 1.37 | 8.98 | R | | | | | | | | | | | | |
| *Choerospondias axillaris* (Roxb.) B.L. Burtt & A.W. Hill | Anacardiaceae | | | | | 15 | 0.46 | 7.35 | R | | | | | | | | |
| *Chukrasia tabularis* A. Juss. | Meliaceae | | | | | | | | | 2.5 | 0.28 | 2.52 | R | | | | |
| *Cinnamomum bejolghota* (Buch.-Ham.) Sweet | Lauraceae | 7.5 | 1.31 | 7.32 | RE | | | | | | | | | | | | |
| *Clausena anisata* (Willd.) Hook.f. ex Benth. | Rutaceae | 5 | 0.25 | 2.50 | C | | | | | | | | | | | | |
| *Cordia dichotoma* G. Frost | Boraginaceae | | | | | 2.5 | 0.06 | 1.67 | C | 12.5 | 0.33 | 7.62 | R | | | | |
| *Cordia fragrantissima* Kurz | Boraginaceae | | | | | | | | | | | | | 7.5 | 0.51 | 9.01 | RE |
| *Croton joufra* Roxb. | Euphorbiaceae | | | | | | | | | | | | | 2.5 | 0.11 | 2.78 | C |
| *Croton persimilis* Müll.Arg. | Euphorbiaceae | | | | | | | | | 2.5 | 0.13 | 2.13 | C | | | | |
| *Cryptocarya amygdalina* Nees | Lauraceae | 10 | 2.02 | 8.68 | R | | | | | | | | | | | | |
| *Dalbergia rimosa* Roxb. | Papilionaceae | | | | | 12.5 | 0.43 | 6.73 | R | | | | | | | | |
| *Dillenia pentagyna* Roxb. | Dilleniaceae | | | | | | | | | 27.5 | 3.76 | 21.76 | RE | 12.5 | 1.02 | 10.96 | C |
| *Dimocarpus longan* Lour. | Sapindaceae | 20 | 0.99 | 9.95 | RE | | | | | | | | | | | | |
| *Diospyros glandulosa* Lace. | Ebenaceae | | | | | 2.5 | 0.11 | 1.80 | C | | | | | | | | |
| *Diospyros lanceifolia* Roxb. | Ebenaceae | | | | | 10 | 0.95 | 7.49 | RE | | | | | | | | |
| *Diospyros pilosiuscula* G.Don | Ebenaceae | | | | | | | | | | | | | 2.5 | 0.08 | 2.70 | R |
| *Dipterocarpus retusus* Blume | Dipterocarpaceae | | | | | | | | | 5 | 1.52 | 6.43 | C | | | | |
| *Drimycarpus racemosus* (Roxb.) Hook. f. | Anacardiaceae | | | | | 5 | 0.47 | 3.24 | C | | | | | | | | |
| *Duabanga grandiflora* (DC.) Walp. | Lythraceae | 5 | 1.21 | 4.82 | C | | | | | | | | | | | | |
| *Echinocarpus dasycarpus* Benth. | Elaeocarpaceae | 15 | 0.75 | 7.49 | R | | | | | | | | | | | | |
| *Elaeocarpus lanceifolius* Roxb. | Elaeocarpaceae | | | | | | | | | | | | | 15 | 1.97 | 18.19 | RE |
| *Elaeocarpus prunifolius* Wall. ex | Elaeocarpaceae | | | | | 7.5 | 0.40 | 4.59 | R | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Müll.Berol. | | | | | | | | | | | | | | | | | |
| *Elaeocarpus tectorius* (Lour.) Poir. | Elaeocarpaceae | 2.5 | 0.10 | 1.62 | R | | | | | | | | | | | | |
| *Engelhardia roxburghiana* Lindl. | Juglandaceae | | | | | 60 | 4.93 | 29.25 | C | 5 | 0.65 | 5.28 | R | | | | |
| *Erythrina arborescens* Roxb. | Leguminosae | 7.5 | 0.52 | 3.65 | C | 17.5 | 0.68 | 9.41 | RE | | | | | | | | |
| *Eurya acuminata* DC. | Theaceae | 17.5 | 0.72 | 8.78 | RE | 25 | 0.54 | 10.71 | R | | | | | | | | |
| *Ficus hispida* L.f. | Moraceae | 20 | 0.61 | 9.01 | RE | 15 | 0.39 | 8.16 | RE | | | | | | | | |
| *Ficus racemosa* L. | Moraceae | | | | | 5 | 0.34 | 3.89 | RE | 12.5 | 1.20 | 10.99 | RE | | | | |
| *Gamblea ciliata* C. B. Clarke | Araliaceae | 7.5 | 0.49 | 5.31 | RE | | | | | | | | | | | | |
| *Garcinia anomala* Planch. & Triana | Clusiaceae | 5 | 0.19 | 2.35 | C | | | | | | | | | | | | |
| *Garcinia cowa* Roxb. ex Choisy | Clusiaceae | | | | | 5 | 0.25 | 3.68 | C | | | | | | | | |
| *Garcinia gummi-gutta* (L.) Roxb. | Clusiaceae | | | | | 2.5 | 0.13 | 1.84 | R | | | | | | | | |
| *Garcinia pedunculata* Roxb. ex Buch.-Ham. | Clusiaceae | 5 | 0.42 | 2.90 | C | 5 | 0.33 | 2.88 | C | | | | | | | | |
| *Garcinia sopsopia* (Buch. -Ham.) Mabb. | Clusiaceae | 5 | 0.59 | 4.19 | R | | | | | | | | | | | | |
| *Glochidion heyneanum* (Wight & Arn.) Wight | Euphorbiaceae | 2.5 | 0.10 | 1.62 | R | | | | | | | | | | | | |
| *Gmelina arborea* Roxb. | Verbenaceae | | | | | 5 | 1.00 | 5.53 | RE | 7.5 | 0.54 | 6.79 | C | | | | |
| *Goniothalamus sesquipedalis* (Wall.) Hook. f. & Thomson | Annonaceae | | | | | 7.5 | 0.08 | 4.76 | RE | | | | | | | | |
| *Heritiera acuminata* Wall. ex Kurz | Sterculiaceae | | | | | 2.5 | 0.16 | 1.93 | R | | | | | | | | |
| *Hevea brasiliensis* (A.Juss.) Meull. | Euphorbiaceae | | | | | | | | | | | | | 10 | 0.70 | 8.98 | C |
| *Holarrhena pubescens* Wall. ex G. Don | Apocynaceae | | | | | | | | | 5 | 0.13 | 2.81 | C | 17.5 | 0.40 | 13.68 | RE |
| *Hovenia dulcis* Thunb. | Rhamnaceae | 12.5 | 1.87 | 9.69 | RE | | | | | | | | | | | | |
| *Ilex embelioides* Hook.f. | Aquifoliaceae | | | | | | | | | 2.5 | 0.11 | 2.08 | R | | | | |
| *Iteadaphne caudata* (Nees) H.W. Li | Lauraceae | | | | | 5 | 0.08 | 2.25 | C | | | | | | | | |
| *Juglans regia* L. | Juglandaceae | 10 | 0.88 | 6.77 | RE | | | | | | | | | | | | |
| *Lagerstroemia speciosa* (L.) Pers. | Lythraceae | | | | | | | | | 10 | 0.53 | 6.33 | C | 12.5 | 1.31 | 13.52 | R |
| *Lithocarpus elegans* (Blume) Hatus. ex Soepadmo | Fagaceae | | | | | 5 | 1.88 | 7.74 | C | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Lithocarpus fenestratus* (Roxb.) Rehder | Fagaceae | 5 | 0.44 | 2.94 | C | | | | | | | | | | | | |
| *Litsea doshia* (D. Don) Kosterm. | Lauraceae | | | | | | | | | 2.5 | 0.27 | 2.51 | C | | | | |
| *Litsea monopetala* (Roxb.) Pers. | Lauraceae | | | | | | | | | 2.5 | 0.28 | 2.52 | R | | | | |
| *Litsea semecarpifolia* (Wall. ex Nees) Hook.f. | Lauraceae | | | | | 5 | 0.21 | 3.56 | C | | | | | | | | |
| *Macaranga denticulata* (Blume) Müll.Arg. | Euphorbiaceae | | | | | | | | | 7.5 | 0.47 | 5.49 | R | | | | |
| *Macaranga indica* Wight | Euphorbiaceae | 7.5 | 0.37 | 5.04 | RE | 7.5 | 0.25 | 5.21 | RE | | | | | | | | |
| *Machilus duthiei* King ex Hook.f. | Lauraceae | 2.5 | 0.11 | 1.65 | R | | | | | | | | | | | | |
| *Magnolia champaca* (L.) Baill. ex Pierre | Magnoliaceae | | | | | 5 | 0.26 | 3.70 | R | | | | | | | | |
| *Magnolia hookeri* (Cubitt & W.W.Sm.) D.C.S.Raju & M.P.Nayar | Magnoliaceae | | | | | 5 | 0.36 | 2.95 | C | | | | | | | | |
| *Magnolia oblonga* (Wall. ex Hook.f. & Thomson) Figlar | Magnoliaceae | 35 | 2.64 | 16.99 | R | 5 | 2.56 | 8.44 | C | | | | | | | | |
| *Mallotus paniculatus* (Lam.) Müll.Arg. | Euphorbiaceae | | | | | | | | | 5 | 0.31 | 4.41 | RE | | | | |
| *Mallotus roxburghianus* Müll.Arg. | Euphorbiaceae | | | | | 7.5 | 0.06 | 4.72 | RE | | | | | | | | |
| *Mangifera sylvatica* Roxb. | Anacardiaceae | 5 | 0.31 | 2.64 | C | | | | | | | | | | | | |
| *Maniltoa polyandra* (Roxb.) Harms | Caesalpiniaceae | | | | | 10 | 1.50 | 9.83 | RE | | | | | | | | |
| *Melia azedarach* L. | Meliaceae | | | | | | | | | 20 | 1.12 | 12.85 | RE | | | | |
| *Micromelum integerrimum* (Buch.-Ham. ex Colebr.) M. Roem. | Rutaceae | | | | | | | | | 15 | 0.54 | 8.84 | R | 7.5 | 0.13 | 7.69 | RE |
| *Miliusa macrocarpa* Hook. f. & Thomson | Annonaceae | 7.5 | 0.37 | 4.15 | R | | | | | | | | | | | | |
| *Morus laevigata* Wall. ex Brandis | Moraceae | 2.5 | 0.53 | 2.66 | C | | | | | | | | | | | | |
| *Myrica esculenta* Buch.-Ham. ex D. Don | Myricaceae | 25 | 1.22 | 11.51 | R | | | | | | | | | | | | |
| *Neolitsea zeylanica* (Nees & T. Nees) Merr. | Lauraceae | | | | | 2.5 | 1.17 | 4.45 | R | | | | | | | | |
| *Olea dioica* Roxb. | Oleaceae | | | | | 2.5 | 0.11 | 1.79 | R | | | | | | | | |
| *Olea salicifolia* Wall. ex G.Don | Oleaceae | | | | | | | | | | | | | 15 | 0.19 | 12.08 | R |
| *Ostodes paniculata* Blume | Euphorbiaceae | | | | | 2.5 | 0.69 | 3.25 | c | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Parkia timoriana* (DC.)Merr. | Mimosaceae | | | | | | | | | | | | | 10 | 1.02 | 10.09 | R |
| *Phoebe goalparensis* Hutch. | Lauraceae | | | | | | | | | 2.5 | 0.18 | 2.26 | C | | | | |
| *Phoebe lanceolata* (Nees) Nees | Lauraceae | 10 | 0.61 | 5.26 | C | 7.5 | 0.82 | 5.62 | R | | | | | | | | |
| *Pinus patula* Schiede ex Schltdl. & Cham. | Pinaceae | | | | | 2.5 | 0.58 | 2.98 | c | | | | | | | | |
| *Prismatomeris tetrandra* (Roxb.) K.Schum. | Rubiaceae | 2.5 | 0.11 | 1.63 | C | | | | | | | | | | | | |
| *Prunus cerasoides* D. Don | Rosaceae | 2.5 | 0.69 | 3.06 | C | | | | | | | | | | | | |
| *Prunus jenkinsii* Hook.f. & Thomson | Rosaceae | 2.5 | 0.77 | 3.24 | R | | | | | | | | | | | | |
| *Pterospermum acerifolium* (L.) Willd. | Sterculiaceae | | | | | | | | | 7.5 | 0.82 | 7.53 | RE | 20 | 2.60 | 22.11 | C |
| *Quercus lamellosa* Sm. | Fagaceae | 5 | 1.04 | 5.29 | RE | 10 | 2.32 | 9.92 | C | | | | | | | | |
| *Quercus serrata* Murray | Fagaceae | | | | | 5 | 2.54 | 9.37 | RE | | | | | | | | |
| *Reevesia wallichii* R. Br. | Malvaceae | | | | | 5 | 0.30 | 2.81 | C | | | | | | | | |
| *Rhus succedanea* L. | Anacardiaceae | | | | | | | | | 22.5 | 1.07 | 13.40 | C | | | | |
| *Sapindus mukorossi* Gaertn. | Sapindaceae | | | | | | | | | 2.5 | 0.76 | 3.76 | R | | | | |
| *Saurauia napaulensis* DC. | Actinidiaceae | | | | | 2.5 | 0.08 | 1.71 | C | 7.5 | 0.54 | 6.79 | RE | | | | |
| *Schefflera hypoleuca* (Kurz) Harms | Araliaceae | 2.5 | 0.11 | 1.65 | R | | | | | | | | | | | | |
| *Schima wallichii* Choisy | Theaceae | 12.5 | 1.65 | 10.02 | RE | | | | | | | | | | | | |
| *Sterculia coccinea* Roxb. | Sterculiaceae | | | | | | | | | 5 | 0.27 | 3.19 | C | 15 | 0.76 | 10.94 | C |
| *Sterculia guttata* Roxb. | Sterculiaceae | | | | | | | | | 2.5 | 0.26 | 2.48 | R | 10 | 1.07 | 11.81 | RE |
| *Sterculia versicolor* Wall. | Sterculiaceae | 5 | 0.19 | 2.34 | C | 5 | 0.26 | 3.69 | RE | | | | | | | | |
| *Sterculia villosa* Roxb. | Sterculiaceae | | | | | | | | | 10 | 0.94 | 7.42 | C | 5 | 0.17 | 3.87 | C |
| *Stereospermum chelonoides* (L.f.) DC. | Bignoniaceae | | | | | | | | | 17.5 | 3.63 | 17.58 | RE | 25 | 3.39 | 26.60 | RE |
| *Stereospermum tetragonum* DC. | Bignoniaceae | | | | | 2.5 | 0.09 | 1.76 | R | | | | | | | | |
| *Sumbaviopsis albicans* (Blume) J.J.Sm. | Euphorbiaceae | | | | | 5 | 0.03 | 3.13 | RE | | | | | | | | |
| *Syzygium cumini* (L.) Skeels | Myrtaceae | 15 | 0.52 | 7.80 | RE | 10 | 0.28 | 5.80 | RE | | | | | | | | |
| *Syzygium jambos* (L.) Alston. | Myrtaceae | | | | | 5 | 0.06 | 2.22 | C | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Syzygium reticulatum* (Wight) Walp. | Myrtaceae | 5 | 0.12 | 2.19 | C | | | | | | | | | | | | |
| *Tectona grandis* L.f. | Lamiaceae | | | | | | | | | | | | | 7.5 | 0.94 | 8.96 | C |
| *Terminalia bellerica* (Gaertn.) Roxb. | Combretaceae | | | | | | | | | 2.5 | 0.54 | 3.21 | R | | | | |
| *Terminalia myriocarpa* Van Heurck & Müll. Arg. | Combretaceae | 10 | 1.89 | 9.23 | RE | 17.5 | 3.09 | 14.43 | R | | | | | | | | |
| *Tetrameles nudiflora* R. Br. | Tetramelaceae | | | | | | | | | 7.5 | 1.20 | 7.40 | R | 30 | 3.58 | 29.00 | C |
| *Trema cannabina* Lour. | Ulmaceae | 5 | 0.31 | 2.65 | C | | | | | | | | | | | | |
| *Triadica cochinchinensis* Lour. | Euphorbiaceae | | | | | | | | | 10 | 0.73 | 9.08 | RE | | | | |
| *Vernicia fordii* (Hemsl.) Airy Shaw | Euphorbiaceae | 12.5 | 0.46 | 7.15 | RE | | | | | | | | | | | | |
| *Vitex quinata* (Lour.) F.N.Williams | Lamiaceae | 5 | 0.18 | 3.19 | RE | | | | | | | | | | | | |
| *Wendlandia bicuspidata* Wight & Arn. | Rubiaceae | | | | | | | | | 5 | 0.18 | 2.96 | C | | | | |
| *Wendlandia budleioides* Wall. ex Wight & Arn. | Rubiaceae | | | | | | | | | | | | | 2.5 | 0.05 | 2.58 | C |
| *Wendlandia coriacea* (Wall.) DC. | Rubiaceae | | | | | 7.5 | 0.90 | 5.84 | R | | | | | | | | |
| *Wrightia arborea* (Dennst.) Mabb. | Apocynaceae | | | | | | | | | 5 | 0.52 | 3.83 | C | | | | |
| *Wrightia coccinea* (Roxb. ex Hornem.) Sims | Apocynaceae | 5 | 0.09 | 2.09 | C | | | | | | | | | | | | |
| *Wrightia tinctoria* R. Br. | Apocynaceae | | | | | | | | | 7.5 | 0.63 | 5.91 | C | | | | |
| *Zanthoxylum rhetsa* DC. | Rutaceae | | | | | | | | | 15 | 0.91 | 10.93 | RE | | | | |

**Key to abbreviation:** RE= Regular; R= Random; C= Clumped

*Shrub species composition*

In shrubs, a total of 78 species and 58 genera representing 38 families were recorded from three community forest (Wokha village, Tsonsa and Doyang) and Ralan plantation forest (PF) of Wokha district, Nagaland. Out of these, 30 species, 25 genera and 17 families were recorded from Ralan PF followed by 24 species, 21 genera and 18 families were recorded from Doyang CF; 23 species, 23 genera and 19 families from Tsonsa CF and 20 species, 19 genera and 18 families were recorded from Wokha village CF respectively (Table 4.2.21). Based on IVI value, the most dominant shrub species in Ralan PF were: *Boehmeria japonica* (22.04), *Leea macrophylla* (20.05) and *Maesa indica* (18.72) (Table 4.2.23) and the dominant families were: Myrsinaceae, Papilionaceae and Rubiaceae. In Doyang CF, the most dominant species were: *Viburnum corylifolium* (16.99), *Eleutherococcus trifoliatus* (15.18) and *Clerodendrum laevifolium* (13.96) (Table 4.2.23) and the dominant families were: Asteraceae, Papilionaceae and Rubiaceae. In Tsonsa CF, the dominant shrub species were: *Maesa indica* (20.90), *Caearia vareca* (19.01) and *Clerodendrum glandulosum* (17.11) (Table 4.2.23) and the most dominant families were: Rubiaceae and Verbenaceae. In Wokha village CF, dominant species were: *Boehmeria platyphylla* (25.95), *Eupatorium adoratum* (22.77) and *Maesa ramentacea* (21.18) (Table 4.2.23) and the dominant families were: Rutaceae and Urticaceae. From the present study, the highest shrub density (individuals $ha^{-1}$) was recorded from Doyang CF (8250) followed by Tsonsa CF (7900), Ralan PF (7550) and the lowest in Wokha village CF (6300) respectively (Table 4.2.21).

*Herb species composition*

In herbs, a total of 99 species, 89 genera representing 40 families were recorded from three community forest (Wokha village, Tsonsa and Doyang) and Ralan plantation forest (PF) of Wokha district, Nagaland. Of these, 34 species, 33 genera and 20 families were recorded from Tsonsa CF followed by 31 species, 30 genera and 22 families from Doyang CF; 27 species, 26 genera and 19 families from Wokha village CF and 26 species, 26 genera and 19 families from Ralan CF of Wokha district, Nagaland respectively (Table 4.2.21). In Tsonsa CF, the most dominant herb species were: *Cayradia pedata* (15.77), *Girardinia diversifolia* (14.31) and *Porana paniculata* (12.12) (Table 4.2.23) and the dominant families were: Asteraceae, Papilionaceae and Vitaceae. In Doyang CF, the most dominant species were: *Desmodium microphyllum* (20.26), *Cyanotis axillaris* (18.79) and *Justicia japonica* (17.32) (Table 4.2.23) and the dominant families were: Apocynaceae and Commelinaceae. In Wokha village CF, the dominant species were: *Dioscorea glabra* (19.48), *Euphorbia hirta* (17.08) and *Smithia ciliata* (14.68) (Table 4.2.23) and the dominant families were: Asteraceae and Papilionaceae. In Ralan PF, the dominant species were: *Adenostemma viscosum* (15.68), *Boehmeria clidemioides* (13.09) and *Leucas ciliata* (12.23) (Table 4.2.23) and the most dominant families were: Asteraceae and Rubiaceae. The highest herb density (individuals $ha^{-1}$) was recorded from Tsonsa CF (85625) followed by Doyang CF (85000), Wokha village CF (78125) and lowest in Ralan PF (72500) respectively (Table 4.2.21).

**Table 4.3.23** Density (individuals ha$^{-1}$) and Important value index (IVI) of shrubs and herbs species in four study sites of Wokha District, Nagaland

| Species | Family | Wokha village | | Tsonsa | | Doyang | | Ralan | |
|---|---|---|---|---|---|---|---|---|---|
| | | D | IVI | D | IVI | D | IVI | D | IVI |
| **Shrubs** | | | | | | | | | |
| *Acacia pennata* (L.)Willd. | Mimosaceae | | | | | | | 150 | 4.73 |
| *Agapetes lobbii* Airy Shaw | Ericaceae | | | 200 | 8.25 | | | | |
| *Allophylus zeylanicus* L. | Sapindaceae | | | | | | | 250 | 8.79 |
| *Aralia thomsonii* Seem. ex C.B. Clarke | Araliaceae | | | | | | | 100 | 2.69 |
| *Artemisia indica* Willd. | Asteraceae | | | | | | | 100 | 4.06 |
| *Bauhinia acuminata* L. | Caesalpiniaceae | | | | | | | 150 | 3.36 |
| *Bauhinia glauca* (Benth.) Benth. | Caesalpiniaceae | | | 150 | 6.18 | | | | |
| *Boehmeria hamiltoniana* Wedd. | Urticaceae | | | 550 | 12.68 | | | | |
| *Boehmeria japonica* (L.f.) Miq. | Urticaceae | | | | | | | 1250 | 22.04 |
| *Boehmeria platyphylla* D.Don | Urticaceae | 1150 | 25.95 | | | | | | |
| *Brugmansia suaveolens* (Humb. & Bonpl.) Bercht. & J. Presl. | Solanaceae | 300 | 10.53 | | | | | | |
| *Buddleja macrostachya* Benth. | Buddlejaceae | | | | | 500 | 11.54 | | |
| *Calamus leptospadix* Griff. | Acoraceae | 100 | 3.51 | 100 | 2.69 | | | | |
| *Calliandra umbrosa* (Wall.)Benth. | Mimosaceae | | | | | | | 200 | 5.39 |
| *Casearia vareca* Roxb. | Flacourtiaceae | 400 | 12.12 | 1050 | 19.01 | | | | |
| *Clerodendrum glandulosum* Lindl. | Verbenaceae | | | 900 | 17.11 | | | | |
| *Clerodendrum japonicum* (Thunb.) Sweet | Verbenaceae | | | | | | | 150 | 3.36 |
| *Clerodendrum laevifolium* Blume | Verbenaceae | | | | | 700 | 13.96 | | |
| *Crotalaria juncea* L. | Papilionaceae | | | | | 50 | 1.98 | | |
| *Daphne involucrata* Wall. | Thymelaeaceae | | | | | 350 | 9.72 | 100 | 4.06 |
| *Dendrocnide sinuata* (Blume) Chew | Urticaceae | 500 | 15.63 | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Dendrotrophe granulata* (Hook. f. & Thomson ex A. DC.) Henry & B. Roy | Santalaceae | 100 | 5.43 | | | | | | |
| *Desmodium heterocarpon* (L.)DC. | Papilionaceae | | | | | | | 200 | 6.76 |
| *Desmodium sequax* Wall. | Papilionaceae | | | | | 200 | 7.90 | | |
| *Desmodium teres* Benth. | Papilionaceae | | | 250 | 8.88 | | | | |
| *Desmodium velutinum* (Willd.)DC. | Papilionaceae | | | | | | | 200 | 8.13 |
| *Diplopterygium giganteum* (Wall. ex Hook.) Nakai | Gleicheniaceae | | | 150 | 3.33 | | | | |
| *Dracaena angustifolia (*Medik.) Roxb. | Dracaenaceae | 250 | 9.74 | | | | | | |
| *Eleutherococcus trifoliatus* (L.)S.Y.Hu. | Araliaceae | | | | | 800 | 15.18 | 150 | 4.73 |
| *Embelia nutans* Wall. | Myrsinaceae | | | | | | | 200 | 6.76 |
| *Eriobotrya bengalensis* (Roxb.) Hook.f. | Rosaceae | 150 | 6.23 | | | | | | |
| *Eupatorium adoratum* L. | Compositae | 950 | 22.77 | | | | | | |
| *Eurya japonica* Thunb. | Theaceae | | | | | 550 | 12.15 | | |
| *Grewia sclerophylla* Roxb. | Tiliaceae | | | | | | | 100 | 4.06 |
| *Jasminum scandens* (Retz.) Vahl | Oleaceae | | | | | | | 100 | 2.69 |
| *Lantana camara* L. | Verbenaceae | | | 100 | 4.12 | | | | |
| *Lasianthus cyanocarpus* Jack | Rubiaceae | | | | | | | 250 | 8.79 |
| *Lasianthus hookeri* C.B.Clarke ex Hook.f. | Rubiaceae | | | | | 250 | 7.14 | 100 | 4.06 |
| *Lasianthus lucidus* Blume | Rubiaceae | 100 | 3.51 | | | | | | |
| *Leea asiatica* (L.) Ridsdale | Leeaceae | 200 | 7.02 | 300 | 8.08 | | | | |
| *Leea guineensis* G. Don | Leeaceae | | | | | | | 50 | 2.03 |
| *Leea macrophylla* Roxb. ex Hornem. | Vitaceae | | | | | 400 | 10.33 | 1100 | 20.05 |
| *Litsea lancifolia* (Roxb. ex Nees in Wall.) Benth. & Hook. fil. ex Villar | Lauraceae | | | 150 | 4.76 | 300 | 9.12 | | |
| *Luculia pinceana* Hook. | Rubiaceae | | | 250 | 7.45 | | | | |
| *Maesa indica* (Roxb.) A. DC. | Myrsinaceae | | | 1200 | 20.90 | 450 | 10.93 | 1000 | 18.72 |
| *Maesa ramentacea* (Roxb.) A. DC. | Myrsinaceae | 850 | 21.18 | | | | | 100 | 2.69 |
| *Medinilla rubicunda* (Jack) Bl. | Melastomataceae | | | 200 | 6.82 | | | | |

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|---|---|---|---|---|---|---|---|---|---|
| *Millettia pachycarpa* Benth. | Papilionaceae | | | | | 250 | 7.14 | 150 | 4.73 |
| *Musa species* L. | Musaceae | | | | | | | 150 | 6.10 |
| *Mussaenda frondosa* L. | Rubiaceae | | | | | | | 300 | 9.45 |
| *Mussaenda macrophylla* wall. | Rubiaceae | | | | | 300 | 7.75 | | |
| *Mussaenda macrophylla* wall. | Rubiaceae | | | 350 | 10.14 | | | 100 | 2.69 |
| *Mycetia longifolia* (Wall.) Kuntze | Rubiaceae | | | 450 | 11.41 | | | | |
| *Neillia thyrsiflora* D. Don | Rosaceae | | | | | 150 | 4.56 | | |
| *Osbeckia nepalensis* Hook.f. | Melastomataceae | 200 | 7.02 | | | | | | |
| *Phlogacanthus tubiflorus* Ness | Acanthaceae | | | 400 | 10.78 | 150 | 4.56 | | |
| *Phyllanthus clarkei* Hook.f. | Euphorbiaceae | | | | | 350 | 8.35 | | |
| *Phyllanthus urinaria* L. | Euphorbiaceae | 100 | 5.43 | | | | | | |
| *Pittosporum glabratum* Lindl. | Pittosporaceae | | | 300 | 9.51 | | | | |
| *Premna cordifolia* Roxb. | Lamiaceae | | | | | | | 150 | 4.73 |
| *Pseudocaryopteris foetida* (D.Don) P.D.Cantino | Verbenaceae | 200 | 10.87 | | | | | | |
| *Psychotria erratica* Hook.f. | Rubiaceae | | | 150 | 4.76 | | | | |
| *Rhamnus napalensis* (Wall.) M.A. Lawson | Rhamnaceae | | | | | 250 | 7.14 | | |
| *Sambucus javanica* Blume | Sambucaceae | 250 | 11.66 | | | | | | |
| *Sauropus androgynus* (L.) Merr. | Euphorbiaceae | | | | | 50 | 1.98 | | |
| *Skimmia laureola* Franch. | Rutaceae | 200 | 8.94 | | | | | | |
| *Solanum ferox* L. | Solanaceae | | | 100 | 4.12 | | | | |
| *Solanum indicum* L. | Solanaceae | | | | | 150 | 4.56 | | |
| *Sphenodesme involucrata* (C.Presl) B.L.Rob. | Verbenaceae | | | | | | | 200 | 6.76 |
| *Tadehagi triquetrum* (L.) H.Ohashi | Papilionaceae | | | | | 100 | 3.95 | | |
| *Tithonia rotundifolia* (Miller) S.F. Blake | Asteraceae | | | | | 50 | 1.98 | | |
| *Urena callifera* C.B. Clarke | Malvaceae | | | 200 | 5.39 | | | 100 | 4.06 |
| *Urena labota* L. | Malvaceae | | | | | 500 | 10.17 | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Vernonia cylindriceps*C.B. Clarke | Asteraceae | 150 | 4.30 | | | | | | |
| *Vernonia mastersii* Watt. | Asteraceae | | | 150 | 4.76 | 450 | 10.93 | 300 | 9.45 |
| *Viburnum corylifolium* Hook.f. & Thomson | Caprifoliaceae | | | | | 950 | 16.99 | | |
| *Zanthoxylum acanthopodium* DC. | Rutaceae | 100 | 5.43 | 250 | 8.88 | | | | |
| *Zanthoxylum armatum* DC. | Rutaceae | 50 | 2.72 | | | | | 100 | 4.06 |
| **Herbs** | | | | | | | | | |
| *Acanthus leucostachyus* Wall. | Acanthaceae | | | 1875 | 4.60 | | | | |
| *Acmella paniculata* (Wall. ex DC.) R.K.Jansen | Asteraceae | | | 1250 | 2.66 | | | | |
| *Adenostemma viscosum* J.R.Forst. & G.Forst. | Asteraceae | | | | | | | 7500 | 15.68 |
| *Aerides odorata* Lour. | Orchidaceae | | | | | 1875 | 6.37 | | |
| *Ageratina adenophora* (Spreng.) R.M.King & H.Rob. | Asteraceae | 5000 | 12.28 | | | | | | |
| *Ageratum conyzoides* (L.) L. | Asteraceae | | | 3125 | 8.47 | | | | |
| *Agrimonia pilosa* Ledeb. | Rosaceae | | | 1250 | 3.87 | | | | |
| *Ampelopsis rubifolia* (Wall.) Planch. | Vitaceae | | | | | 3125 | 6.45 | | |
| *Bauhinia vahlii* Wight & Arn. | Caesalpiniaceae | 1250 | 4.54 | | | | | | |
| *Bidens bipinnata* L. | Compositae | | | | | 2500 | 8.50 | | |
| *Bidens pilosa* L. | Asteraceae | | | 3750 | 9.20 | | | | |
| *Blumea aromatica* DC. | Asteraceae | | | | | | | 2500 | 8.78 |
| *Boehmeria clidemioides* Miq. | Urticaceae | | | | | | | 5625 | 13.09 |
| *Bulbophyllum roxburghii* (Lindl.) Rchb.f. | Orchidaceae | | | | | 3125 | 7.84 | | |
| *Calanthe alismifolia* Lindl. | Orchidaceae | 1250 | 4.54 | | | | | | |
| *Cayratia japonica* (Thunb.) Gagnep. | Vitaceae | | | 1250 | 2.66 | | | | |
| *Cayratia pedata* (Lam.) Gagnep. | Vitaceae | | | 9375 | 15.77 | | | | |
| *Chonemorpha fragrans* (Moon) Alst. | Apocynaceae | | | | | 625 | 2.12 | | |
| *Chrysanthemum indicum* L. | Asteraceae | | | 1250 | 3.87 | | | 1875 | 5.25 |
| *Cirsium lineare* (Thunb.)Sch.Bip. | Asteraceae | | | 1875 | 5.80 | | | | |

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|---|---|---|---|---|---|---|---|---|---|
| *Cissus adnata* Roxb. | Vitaceae | | | | | | | 1250 | 3.06 |
| *Cissus repens* Lam. | Vitaceae | | | | | 1250 | 4.25 | | |
| *Clematis acuminata* DC. | Ranunculaceae | | | 1250 | 2.66 | | | | |
| *Clinopodium umbrosum* (M.Bieb.) Kuntze | Lamiaceae | | | 3750 | 7.99 | | | | |
| *Clitoria mariana* L. | Papilionaceae | | | | | | | 3125 | 8.31 |
| *Combretum wallichii* DC. | Combretaceae | | | | | 2500 | 8.50 | | |
| *Commelina paludosa* Blume | Commelinaceae | | | 2500 | 5.33 | | | | |
| *Corydalis leptocarpa* Hook.f. & Thomson | Fumariaceae | | | 1250 | 3.87 | | | | |
| *Crotalaria sessiliflora* L. | Papilionaceae | 2500 | 7.61 | | | | | | |
| *Cryptolepis sinensis* (Lour.) Merr. | Apocynaceae | | | | | | | 1250 | 3.06 |
| *Curculigo orchioides* Gaertn. | Hypoxidaceae | | | 1875 | 5.80 | | | | |
| *Cyanotis axillaris* (L.) D. Don ex Sweet | Commelinaceae | | | | | 11250 | 18.79 | 2500 | 7.45 |
| *Cynoglossum zeylanicum* (Vahl) Brand | Boraginaceae | | | | | 2500 | 7.11 | | |
| *Dalbergia rimosa* Roxb. | Papilionaceae | 1250 | 4.54 | | | | | | |
| *Decaloba leschenaultii* (DC.) M. Roem. | Passifloraceae | | | 5000 | 10.66 | | | | |
| *Dendrobium bensoniae* Rchb. f. | Orchidaceae | | | | | 3125 | 7.84 | | |
| *Desmodium microphyllum* (Thunb.) DC. | Papilionaceae | | | | | 12500 | 20.26 | | |
| *Didymocarpus aurantiacus* C.B. Clarke | Gesneriaceae | | | 3125 | 8.47 | | | | |
| *Dinetus racemosus* (Roxb.) Buch.-Ham. ex Sweet | Convolvulaceae | | | | | | | 1875 | 6.59 |
| *Dioscorea glabra* Roxb. | Dioscoreaceae | 10625 | 19.48 | | | | | | |
| *Dioscorea pentaphylla* L. | Dioscoreaceae | | | | | | | 3125 | 8.31 |
| *Dipsacus inermis* Wall. | Dipsacaceae | 1250 | 3.07 | | | | | | |
| *Eclipta prostrata* (L.) L. | Asteraceae | | | 1250 | 2.66 | | | | |
| *Elephantopus scaber* L. | Asteraceae | | | 625 | 1.93 | | | 3750 | 10.51 |
| *Entada rheedei* Spreng. | Papilionaceae | | | 1250 | 3.87 | | | 1250 | 4.39 |
| *Eria biflora* Griff. | Orchidaceae | | | | | 2500 | 8.50 | | |

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|---|---|---|---|---|---|---|---|---|---|
| *Euphorbia hirta* L. | Euphorbiaceae | 8750 | 17.08 | | | | | | |
| *Euphorbia sikkimensis* Boiss. | Euphorbiaceae | | | | | 1250 | 2.86 | | |
| *Girardinia diversifolia* (Link) Friis | Urticaceae | | | 8125 | 14.31 | | | | |
| *Gomphostemma strobilinum* Wall. ex Benth. | Lamiaceae | | | 2500 | 6.53 | | | | |
| *Gouania microcarpa* DC. | Rhamnaceae | | | | | 625 | 2.12 | | |
| *Gynura angulosa* (Wall.) DC. | Asteraceae | | | 625 | 1.93 | | | | |
| *Heterostemma wallichii* Wight & Arn. | Asclepiadaceae | | | | | 1250 | 4.25 | | |
| *Hodgsonia macrocarpa* (Blume) Cogn. | Cucurbitaceae | 1250 | 3.07 | | | 1875 | 4.98 | 1875 | 6.59 |
| *Ichnocarpus frutescens* (L.) W.T. Aiton | Apocynaceae | | | | | 625 | 2.12 | | |
| *Impatiens arguta* Hook.f. & Thomson | Balsaminaceae | | | 3750 | 7.99 | | | | |
| *Ipomoea pileata* Roxb. | Convolvulaceae | | | | | | | 2500 | 7.45 |
| *Ipomoea purpurea* (L.) Roth | Convolvulaceae | | | 1875 | 4.60 | | | | |
| *Justicia japonica* Thunb. | Acanthaceae | | | | | 10000 | 17.32 | | |
| *Laportea bulbifera* (Siebold & Zucc.) Wedd. | Urticaceae | 2500 | 6.14 | | | | | | |
| *Leucas ciliata* Benth. | Lamiaceae | | | | | | | 5000 | 12.23 |
| *Lonicera acuminata* Wall. | Caprifoliaceae | 3750 | 10.68 | | | | | | |
| *Mikania micrantha* Kunth | Asteraceae | 1875 | 5.34 | 3125 | 7.26 | | | | |
| *Mitreola petiolata* (J.F.Gmel.) Torr. | Loganiaceae | | | | | 1250 | 2.86 | | |
| *Mucuna macrocarpa* Wall. | Leguminosae | 625 | 2.27 | 1250 | 3.87 | | | | |
| *Neanotis wightiana* (Wall. ex Wight & Arn.) | Rubiaceae | 1875 | 3.87 | | | | | | |
| *Oldenlandia auricularia* (L.) K.Schum. | Rubiaceae | | | | | | | 3750 | 10.51 |
| *Ophiorrhiza pauciflora* Hook.f. | Rubiaceae | 2500 | 7.61 | | | | | | |
| *Papilionanthe teres* (Roxb.) Schltr. | Orchidaceae | | | | | 1875 | 4.98 | | |
| *Papilionanthe uniflora* (Lindl.) garay | Orchidaceae | | | | | | | 3125 | 9.64 |
| *Parochetus communis* D.Don | Papilionaceae | 1875 | 5.34 | | | | | | |
| *Passiflora edulis* Sims | Passifloraceae | | | | | 1250 | 2.86 | | |
| *Polygala persicariifolia* DC. | Polygalaceae | | | | | 625 | 2.12 | 1875 | 6.59 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Porana paniculata* Roxb. | Convolvulaceae | | | 6250 | 12.12 | 1875 | 6.37 | | |
| *Potentilla sundaica* (Blume) O. Kuntze | Rosaceae | 2500 | 7.61 | | | | | | |
| *Pueraria peduncularis* (Graham ex Benth.) | Papilionaceae | | | 2500 | 6.53 | | | | |
| *Rhynchostylis retusa* (L.) Blume | Orchidaceae | | | | | 1250 | 2.86 | 1250 | 4.39 |
| *Sabia purpurea* Hook.f. & Thom. | Sabiaceae | | | | | | | 625 | 2.20 |
| *Salomonia cantoniensis* Lour. | Polygalaceae | | | 625 | 1.93 | | | | |
| *Senecio nagensium* C.B.Clarke | Asteraceae | | | | | | | 3125 | 8.31 |
| *Setaria palmifolia* (J.Koenig) Stapf | Poaceae | 3750 | 7.74 | | | | | | |
| *Shuteria involucrata* (Wall.) Wight & Arn. | Papilionaceae | 1875 | 5.34 | | | | | | |
| *Smilax perfoliata* Lour. | Smilacaceae | | | | | 1875 | 6.37 | | |
| *Smithia ciliata* Royle | Papilionaceae | 6875 | 14.68 | 1875 | 5.80 | | | | |
| *Sonerila khasiana* C. B. Clarke | Melastomataceae | 1875 | 6.81 | | | | | | |
| *Sonerila maculata* Roxb. | Melastomataceae | | | | | 3750 | 8.58 | 1250 | 3.06 |
| *Spatholobus roxburghii* Benth. | Leguminosae | 625 | 2.27 | | | | | | |
| *Spermacoce hispida* L. | Rubiaceae | | | | | 1875 | 3.59 | | |
| *Spermacoce ocymoides* Burm.f. | Rubiaceae | | | | | | | 4375 | 10.03 |
| *Spiradiclis bifida* Kurz | Rubiaceae | | | | | | | 3750 | 10.51 |
| *Stachytarpheta jamaicensis* (L.) Vahl | Verbenaceae | 3125 | 8.41 | | | 1250 | 4.25 | | |
| *Thunbergia grandiflora* (Roxb. ex Rottl.) | Acanthaceae | 1250 | 4.54 | 1250 | 3.87 | | | | |
| *Tinospora sinensis* (Lour.) Merr. | Menispermaceae | | | 625 | 1.93 | 1250 | 2.86 | 1875 | 6.59 |
| *Toddalia asiatica* (L.) Lam. | Rutaceae | 3750 | 10.68 | | | | | | |
| *Trichosanthes cucumerina* L. | Cucurbitaceae | | | 2500 | 6.53 | | | | |
| *Trichosanthes lepiniana* (Naudin) Cogn. | Cucurbitaceae | | | | | 3125 | 7.84 | | |
| *Triumfetta pilosa* Roth | Tiliaceae | 1875 | 6.81 | 1875 | 4.60 | | | | |
| *Vanda tessellata* (Roxb.) Hook. ex G.Don | Orchidaceae | | | | | 1250 | 4.25 | 2500 | 7.45 |
| *Wedelia montana* (Blume) Boerl. | Asteraceae | 2500 | 7.61 | | | | | | |

#### 4.2.6.2 Species diversity indices

Higher diversity index with low dominance value is considered as a distinctive feature of a natural forest, which was also shown in the present study. In trees, Shannon diversity index (H') value ranged from 2.98 – 3.67 and Simpson dominance index (CD) ranged from 0.03 – 0.05. The highest diversity index was recorded from Wokha village CF (3.67) followed by Tsonsa CF (3.49) and Doyang CF (3.40). The lowest diversity index was recorded from Ralan PF (2.98) which maybe attributed to lesser species richness and density due to various enthropogenic activities. The Simpson dominance index value increased as diversity index decreased. Similarly, the highest Margalef index (Dmg) for tree species was recorded from Wokha village CF (10.03) and lowest in Ralan PF (5.07). The Pielou's evenness index (e) ranged from 0.89 – 0.92, indicating quite even of species in the community (Table 4.2.21).

In shrubs, Shannon diversity index (H') value ranged from 2.63 – 2.96 indicating an average species diversity in the community. The Simpson dominance index (CD) ranged from 0.06 – 0.09 which was inversely proportional to Shannon diversity index (H'). The Margalef index (Dmg) ranged from 4.35 – 5.78 and the Pielou's evenness index (e) ranged from 0.87 – 0.93 indicating high evenness of species in the community (Table 4.2.21).

In herbs, the Shannon diversity index (H') value ranged from 3.01 – 3.27 and the Simpson dominance index (CD) ranged from 0.04 – 0.06. The highest diversity index was recorded from Tsonsa CF (3.27) followed by Doyang CF (3.09) and Wokha village CF (3.03). The lowest diversity index was recorded from Ralan PF (3.01). The Margalef species richness index (Dmg) ranged from 5.26 – 6.71. The Pielou's evenness index (e) of herbs species ranged from 0.90 – 0.93 indicating that species distribution in the community is quite even (Table 4.2.21).

#### 4.2.6.3 Population structure of tree species in various girth-classes

The tree density and basal area in all the community varied significantly in different girth classes. The highest density and basal cover was recorded from young and regenerating trees (10 – 60 cm girth class) contributing about 77% and 44 % of the total density and basal area. Older trees with higher girth class contributed 8%

(density) and 30% (basal area) of the total population structure in various girth class distributions. In regenerating trees, Tsonsa CF recorded the highest density (138 individuals ha$^{-1}$) with basal area (2.97 m$^2$ha$^{-1}$) whereas in mature trees, Doyang CF recorded the highest density (13 individuals ha$^{-1}$) with basal area (7.31 m$^2$ha$^{-1}$). In Wokha village CF, no individual was recorded in the girth class >150 cm. The study showed that the density of tree species decreased with increase in girth class. The tree basal area in all the communities also differed significantly in each girth classes (Figure 4.2.11).

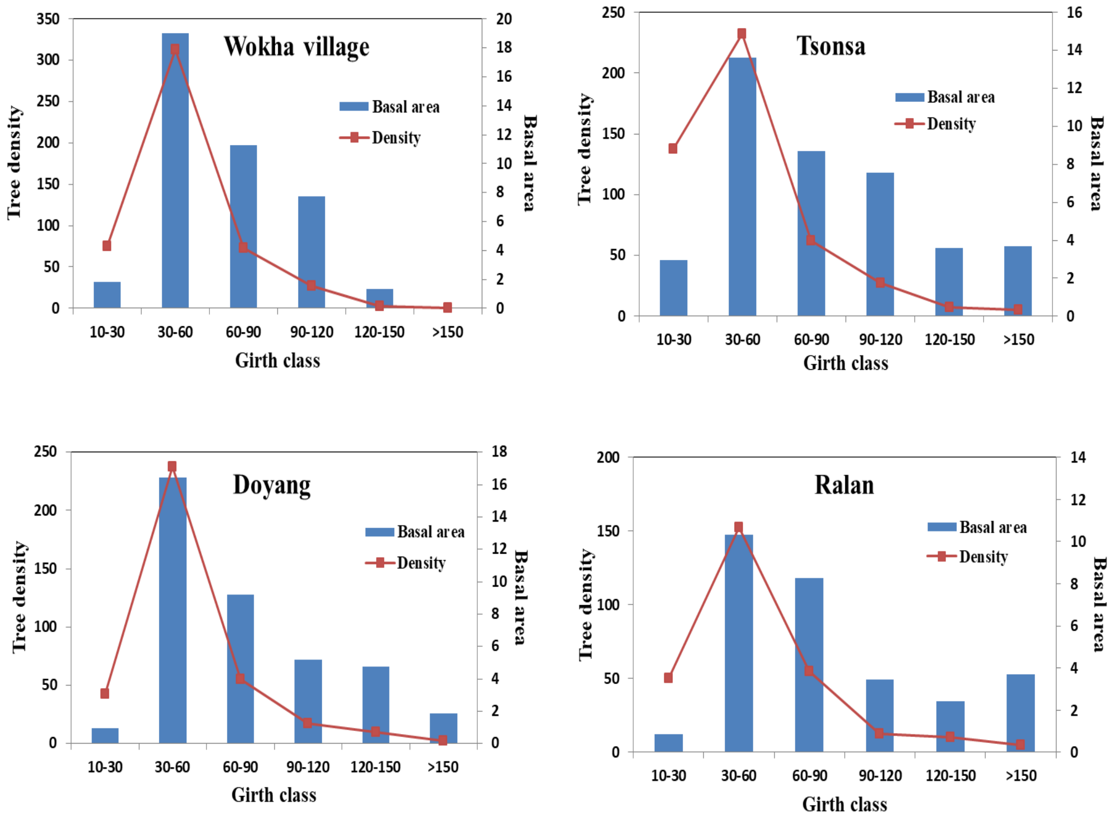
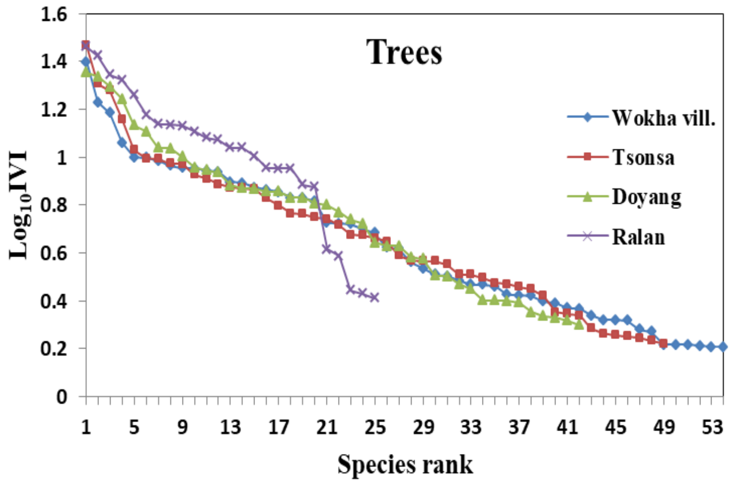
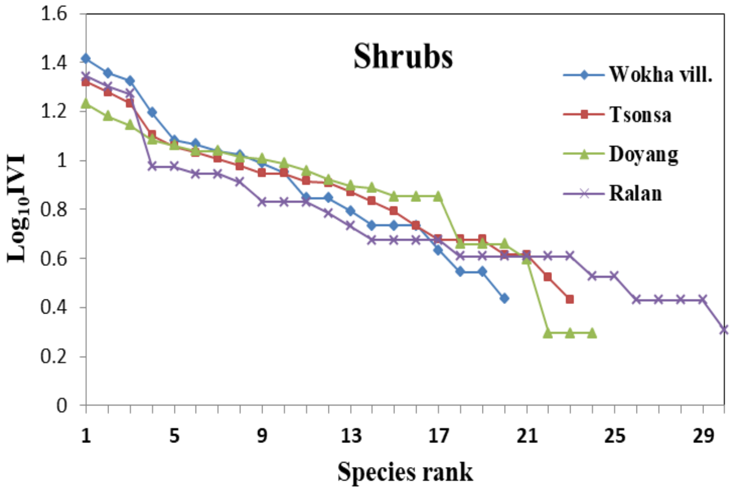



**Figure 4.2.11** Contributions of tree stand density and basal area based on girth class contribution in four study sites of Wokha District, Nagaland

### 4.2.6.4 Dominance-Diversity curve

The dominance-diversity curve showed species richness and equitability of species in various communities. In trees, the dominance-diversity curve showed high species richness with higher evenness in all the community forest (Wokha village, Tsonsa and Doyang) and the dominance-diversity curve followed a log normal distribution pattern. Whereas the dominance-diversity curve of Ralan PF showed steep slope indicating lower species richness and evenness and the dominance-diversity curve followed a broken stick distribution pattern. In shrubs, the dominance-diversity curve in the community forest (Tsonsa and Doyang) and Ralan PF showed shallow slope indicating high species richness and equitability and the the dominance-diversity curve followed log normal distribution. Where as the dominance-diversity curve in Wokha village CF showed relatively low equitability and high dominance as compared to other community forest and followed a broken stick distribution pattern. In herbs, there was no significant change in the dominance-diversity curve in all the community and showed high species richness and equal distribution of species. The dominance-diversity curve followed a log normal distribution pattern (Figure 4.2.12). Among the trees, the most dominant species were: *Cananrium strictum* (Wokha village CF), *Engelhardtia roxburghiana* (Tsonsa CF), *Ailanthus integrifolia* (Doyang CF) and *Tectona grandis* (Ralan PF). In shrubs, the most dominant species were: *Boehmeria platyphylla* (Wokha village CF), *Maesa indica* (Tsonsa CF), *Viburnum corylifolium* (Doyang CF) and *Boehmeria japonica* (Ralan PF). In herbs, the most dominant species were: *Dioscorea glabra* (Wokha village CF), *Cayradia pedata* (Tsonsa CF), *Desmodium microphyllum* (Doyang CF) and *Adenostemma viscosum* (Ralan PF).





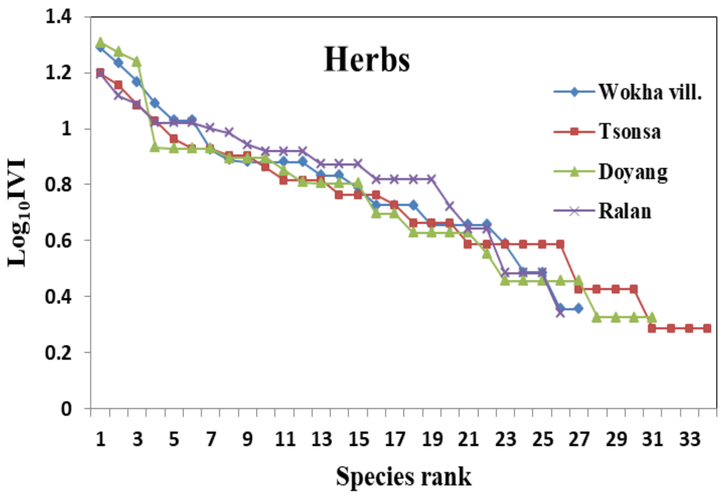




**Figure 4.2.12** Dominance-Diversity curve for trees, shrubs and herbs in four study sites of Wokha District, Nagaland

### 4.2.6.5 Distribution pattern of tree species

The Whitford index (A/F ratio) revealed that most of the plant species in all the community had clumped distribution pattern followed by regular and random distribution. Tsonsa CF recorded the highest clumped distribution (50%) followed by Doyang CF and Ralan PF (48% each). About 31 – 35 % of the species showed regular distribution in all the communities which may be result due to various interactions between individuals such as competition, allelopathy, root interaction etc. and only 26% of the total plant species exhibited random distribution pattern (Table 4.2.22).

#### 4.2.6.6 Sorenson's similarity

Similarity and dissimilarity of species in community composition is one of the most fundamental and conspicuous features by which different forest ecosystems may be distinguished. In the present study, Sorenson's similarity showed very less similarity of species in all the communities. The highest similarity (42%) was observed between Doyang CF and Ralan PF followed by Wokha village and Tsonsa CF (31%). Less similarity of species in community forests (e.g. Wokha village and Doyang CF; Ralan and Wokha village CF; Tsonsa CF and Ralan PF) maybe attributed to different altudinal gradient, selective tree harvesting or effects of climate change on species composition and various edaphic factors. Detailed analysis of species similarity between communities is shown in table 4.2.24.

**Table 4.2.24** Sorenson Similarity indices for tree species four study sites of Wokha District, Nagaland

| Study area | Wokha village | Tsonsa | Doyang | Ralan |
|---|---|---|---|---|
| **Wokha village** | x | | | |
| **Tsonsa** | 0.31 | x | | |
| **Doyang** | 0.04 | 0.13 | x | |
| **Ralan** | 0.03 | 0.06 | 0.42 | x |

#### 4.2.6.7 Disturbance pattern

The average disturbance index for all the study sites was 20% (Table 4.2.21). The highest disturbance index based on cut sumps was observed at Ralan PF (29%) followed by Doyang (22%), Tsonsa (16%) and Wokha village CF (13%). High disturbance in these regions maybe attributed due to extreme anthropogenic pressure on account of timber extraction, fuelwood collection, non timber forest products and grazing. Maximum disturbance index in Ralan forest may also attributed due to various encroachment activities as the region is located in the interstate border area hence increasing the rate of deforestation.

### 4.2.7 Zunhebhoto district

### 4.2.7.1 Floristic structure

*Tree species composition*

In the present study, a total of 686 individuals belonging to 151 species and 102 genera belonging to 54 families were recorded from the five community forest (Lumami, Luvishe, Akuhaito, Aichisanghemi and Satakha) of Zunhebhoto district, Nagaland, Northeast India. Out of these, 48 species, 41 genera, 28 families and 150 individuals were recorded from Lumami CF followed by 44 species, 42 genera, 30 families and 141 individuals from Luvishe CF; 41 species, 35 genera, 26 families and 139 individuals from Akuhaito CF; 38 species, 35 genera, 28 families and 133 individuals from Aichisanghemi CF and 36 species, 33 genera, 24 families and 124 individuals from Satakha CF of Nagaland respectively (Table 4.2.25). Based on IVI value, the dominant tree species in Lumami CF were: *Tetrameles nudiflora* (20.10), *Elaeocarpus lanceifolius* (17.39) and *Acrocarpus fraxinifolius* (16.39) and the co-dominant species were: *Sapium baccatum* (12.50), *Stereospermum chelonoides* (11.18) and *Canarium bengalense* (10.25) (Table 4.2.26). The most dominant families were: Euporbiaceae, Lauraceae, Moraceae and Sterculiaceae. In Luvishe CF, the dominant tree species were: *Quercus serrata* (23.20), *Firmiana colorata* (17.44) and *Erythrina stricta* (15.07) and the co-dominant species were: *Dysoxylum procerum* (13.65), *Salix tetrasperma* (13.32) and *Terminalia myriocarpa* (12.74) (Table 4.2.26). The most dominant families were: Euphorbiaceae, Lauraceae and Meliaceae. In Akuhaito CF, the dominant species were: *Lithocarpus elegans* (23.97), *Choerospondias axillaris* (22.82) and *Ailanthus integrifolia* (20.37) and the co-dominant species were: *Nephelium lappaceum* (12.32), *Schima wallichii* (11.70) and *Dimocarpus longan* (11.57) (Table 4.2.26). The dominant families were: Anacardiaceae, Fagaceae and Sterculiaceae. In Aichisanghemi CF, the most dominant species were: *Bombax ceiba* (21.92), *Canarium strictum* (19.15) and *Gmelina arborea* (18.88) and the co-dominant species were: *Tetrameles nudiflora* (13.25), *Acrocarpus fraxinifolius* (12.83) and *Ailanthus integrifolia* (12.54) (Table 4.2.26). The dominant families were: Euphorbiaceae, Lauraceae and Moraceae. In Satakha CF, the most dominant species were: *Pongamia pinnata* (14.66), *Aquilaria agallocha* (14.24) and *Pterospermum lanceifolium* (13.70) and the co-dominant species were: *Alstonia scholaris* (12.37), *Albizia procera* (12.09) and *Mahonia napaulensis* (11.46) (Table 4.2.26). The dominant families were: Anacardiaceae, Leguminosae and Mimosaceae. The tree stand density (individuals $ha^{-1}$) in the community forest ranged from 310 – 378 where the highest density was recorded from Lumami CF (378) followed by Luvishe CF (353), Akuhaito CF (348) and Aichisanghemi CF (333). The lowest tree density was recorded from Satakha CF (310). The basal area ($m^2ha^{-1}$) ranged from 25.83 – 34.45 where the highest basal area was recorded from Lumami CF (34.45) followed by Aichisanghemi CF (32.02) and the lowest basal area were recorded from Satakha CF (25.83) respectively (Table 4.2.25).

**Table 4.2.25** Phytosociological attributes of trees, shrubs and herbs in five study sites of Zunhebhoto District, Nagaland

| Parameters | Lumami | Luvishe | Akuhaito | Aichisanghemi | Satakha |
|---|---|---|---|---|---|
| **Trees** | | | | | |
| No. of species | 48 | 44 | 41 | 38 | 36 |
| No. of genera | 41 | 42 | 35 | 35 | 33 |
| Families | 28 | 30 | 26 | 28 | 24 |
| Density (individuals $ha^{-1}$) | 378 | 353 | 348 | 333 | 310 |
| Basal area ($m^2ha^{-1}$) | 34.45 | 27.84 | 28.74 | 32.02 | 25.83 |
| Shannon diversity index (H') | 3.66 | 3.57 | 3.45 | 3.21 | 3.12 |
| Simpson index (CD) | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 |
| Margalef index (Dmg) | 9.38 | 8.69 | 8.11 | 7.57 | 7.26 |
| Evenness (e) | 0.95 | 0.94 | 0.92 | 0.88 | 0.87 |
| Disturbance index (%) | 12 | 18 | 16 | 20 | 23 |
| **Shrubs** | | | | | |
| No. of species | 28 | 23 | 26 | 22 | 30 |
| No. of genera | 25 | 20 | 24 | 19 | 19 |
| Families | 20 | 17 | 16 | 15 | 15 |
| Density (individuals $ha^{-1}$) | 5750 | 6150 | 7200 | 5150 | 8050 |
| Shannon diversity index (H') | 3.02 | 2.91 | 2.98 | 2.61 | 3.24 |
| Simpson index (CD) | 0.04 | 0.06 | 0.05 | 0.06 | 0.04 |
| Margalef index (Dmg) | 5.69 | 4.57 | 5.03 | 4.53 | 5.71 |
| Evenness (e) | 0.91 | 0.92 | 0.91 | 0.84 | 0.95 |
| **Herbs** | | | | | |
| No. of species | 19 | 22 | 29 | 31 | 24 |
| No. of genera | 18 | 20 | 26 | 28 | 21 |
| Families | 11 | 17 | 22 | 19 | 12 |

| | | | | | |
|---|---|---|---|---|---|
| Density (individuals ha$^{-1}$) | 46875 | 49375 | 54375 | 50625 | 45000 |
| Shannon diversity index (H') | 2.65 | 2.75 | 3.14 | 3.17 | 2.96 |
| Simpson index (CD) | 0.06 | 0.07 | 0.05 | 0.04 | 0.08 |
| Margalef index (Dmg) | 4.20 | 5.26 | 6.27 | 6.37 | 5.38 |
| Evenness (e) | 0.90 | 0.86 | 0.93 | 0.94 | 0.93 |

*Shrub species composition*

In shrubs, a total of 87 species and 65 genera representing 35 families were recorded from five community forest (Lumami, Luvishe, Akuhaito, Aichisanghemi and Satakha) of Zunhebhoto district, Nagaland, Northeast India. Out of these, 30 species, 19 genera and 15 families were recorded from Satakha CF followed by 28 species, 25 genera and 20 families were recorded from Lumami CF; 26 species, 24 genera and 16 families from Akuhaito CF; 23 species, 20 genera and 17 families from Luvishe CF and 22 species, 19 genera and 15 families were recorded from Aichisanghemi CF respectively (Table 4.2.25). Based on IVI value, the most dominant shrub species in Satakha CF were: *Clerodendrum infortunatum* (12.82), *Dendrocnide sinuata* (10.96) and *Zanthoxylum acanthopodium* (10.33) (Table 4.2.27) and the dominant families were: Euphorbiaceae, Urticaceae and Verbenaceae. In Lumami CF, the most dominant species were: *Maesa indica* (13.02), *Mussaenda frondosa* (12.15), *Boehmeria japonica* (11.28) and *Clerodendrum japonicum* (10.41) (Table 4.2.27) and the dominant families were: Melastomataceae, Rosaceae and Rubiaceae. In Akuhaito CF, the dominant shrub species were: *Maesa indica* (15.28), *Debregeasia longifolia* (13.89) and *Melastoma malabathricum* (12.50) (Table 4.2.27) and the most dominant families were: Melastomataceae, Rubiaceae and Urticaceae. In Luvishe CF, dominant species were: *Leea compactiflora* (18.75), *Daphne involucrata* (17.13) and *Viburnum corylifolium* (15.50) (Table 4.2.27) and the dominant families were: Ericaceae, Melastomataceae and Verbenaceae. In Aichisanghemi CF, dominant species were: *Amomum pterocarpum* (18.10), *Clerodendrum laevifolium* (16.16) and *Embelia ribes* (15.19) (Table 4.2.27) and the dominant families were: Rubiaceae and Zingiberaceae. From the present study, the highest shrub density (individuals ha$^{-1}$) was recorded from Satakha CF (8050) followed by Akuhaito CF (7200), Luvishe CF (6150), Lumami CF (5750) and the lowest in Aichisanghemi CF (5150) respectively (Table 4.2.25).

**Table 4.2.26** Density (individuals ha$^{-1}$), Basal area (m$^{2}$ha$^{-1}$), Important value index (IVI) and Distribution pattern (DP) of tree species in five study sites of Zunhebhoto District, Nagaland

| Species | Family | Lumami | | | | Luvishe | | | | Akuhaito | | | | Aichisanghemi | | | | Satakha | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP | D | BA | IVI | DP |
| *Acer sikkimense* Miq. | Aceraceae | | | | | 2.5 | 0.18 | 2.50 | C | | | | | | | | | | | | |
| *Acer sterculiaceum* Wall. | Aceraceae | | | | | | | | | 2.5 | 0.13 | 2.33 | C | | | | | | | | |
| *Acrocarpus fraxinifolius* Arn. | Leguminosae | 20 | 2.90 | 16.39 | R | | | | | | | | | 10 | 1.69 | 12.83 | C | 2.5 | 1.21 | 6.73 | R |
| *Actinodaphne obovata* (Nees) Blume | Lauraceae | 5 | 0.57 | 4.75 | C | | | | | | | | | | | | | | | | |
| *Aglaia spectabilis* (Miq.) S.S.Jain & S.Bennet | Meliaceae | | | | | 5 | 0.32 | 4.83 | C | | | | | 7.5 | 1.05 | 8.95 | RE | | | | |
| *Ailanthus integrifolia* Lam. | Simaroubaceae | 10 | 1.02 | 8.27 | C | | | | | 22.5 | 2.66 | 20.37 | C | 12.5 | 1.72 | 12.54 | C | | | | |
| *Alangium chinense* (Lour.) Harms | Cornaceae | 5 | 0.65 | 4.98 | C | | | | | | | | | | | | | 5 | 0.22 | 4.96 | R |
| *Albizia chinensis* (Osbeck) Merr. | Mimosaceae | 2.5 | 0.40 | 2.70 | R | 2.5 | 0.22 | 2.62 | C | 2.5 | 0.29 | 2.89 | C | | | | | 7.5 | 1.03 | 7.67 | C |
| *Albizia lucidior* (Steud.) I.C.Nielsen | Mimosaceae | | | | | | | | | 7.5 | 0.81 | 7.30 | C | | | | | 5 | 0.70 | 6.82 | R |
| *Albizia procera* (Roxb.)Benth. | Mimosaceae | | | | | 7.5 | 0.76 | 8.23 | RE | | | | | 5 | 0.52 | 4.27 | C | 10 | 1.32 | 12.09 | RE |
| *Alchornea tiliifolia* (Benth.) Müll.Arg. | Euphorbiaceae | | | | | 2.5 | 0.16 | 2.42 | R | | | | | | | | | | | | |
| *Alnus nepalensis* D.Don | Betulaceae | | | | | | | | | 5 | 0.77 | 5.28 | C | 10 | 1.23 | 11.40 | RE | | | | |
| *Alseodaphne dumicola* W.W.Sm. | Lauraceae | | | | | 2.5 | 0.13 | 2.29 | R | | | | | | | | | | | | |
| *Alstonia scholaris* (L.) R. Br. | Apocynaceae | | | | | | | | | 10 | 1.62 | 13.16 | RE | 2.5 | 0.69 | 4.05 | R | 10 | 1.39 | 12.37 | R |
| *Antidesma bunius* (L.) Spreng. | Euphorbiaceae | | | | | | | | | | | | | 7.5 | 0.12 | 6.05 | C | | | | |
| *Aquilaria agallocha* (Lour.) Roxb. | Thymelaceae | | | | | | | | | | | | | 12.5 | 1.61 | 11.06 | C | 15 | 1.14 | 14.24 | R |
| *Artocarpus lacucha* Buch.-Ham. | Moraceae | 5 | 0.57 | 4.74 | RE | | | | | 5 | 0.74 | 5.16 | C | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Bauhinia variegata* L. | Caesalpiniaceae | | | | | 10 | 0.24 | 7.07 | RE | | | | | | | | | | | | |
| *Betula alnoides* Buch.-Ham. ex. D. Don | Betulaceae | | | | | | | | | 2.5 | 0.43 | 3.37 | C | | | | | | | | |
| *Bischofia javanica* Blume | Euphorbiaceae | 2.5 | 0.44 | 2.82 | R | 2.5 | 0.15 | 2.38 | C | | | | | 5 | 0.45 | 4.04 | C | | | | |
| *Bombax ceiba* L. | Malvaceae | | | | | 5 | 1.00 | 7.27 | RE | | | | | 17.5 | 3.88 | 21.92 | RE | 2.5 | 1.40 | 7.46 | R |
| *Brassaiopsis hainla* (Buch.-Ham.) Seem. | Araliaceae | | | | | 7.5 | 0.30 | 4.33 | C | | | | | | | | | 12.5 | 0.71 | 10.54 | RE |
| *Callicarpa arborea* Roxb. | Verbenaceae | | | | | 5 | 0.21 | 3.30 | C | 12.5 | 0.47 | 8.72 | RE | | | | | | | | |
| *Canarium bengalense* Roxb. | Burseraceae | 12.5 | 1.17 | 10.25 | RE | | | | | | | | | | | | | | | | |
| *Canarium strictum* Roxb. | Burseraceae | | | | | | | | | | | | | 22.5 | 2.87 | 19.15 | C | 5 | 1.10 | 7.14 | C |
| *Canthium dicoccum* (Gaertn.) Merr. | Rubiaceae | 7.5 | 0.18 | 5.16 | RE | | | | | | | | | | | | | | | | |
| *Castanopsis hystrix* Hook. f. & Thom. ex A. DC. | Fagaceae | | | | | | | | | | | | | | | | | 7.5 | 0.61 | 7.27 | R |
| *Castanopsis indica* (Roxb. ex Lindl.) A.DC. | Fagaceae | | | | | 2.5 | 0.66 | 4.19 | R | | | | | | | | | | | | |
| *Celtis australis* L. | Ulmaceae | 5 | 0.18 | 3.60 | C | | | | | | | | | | | | | | | | |
| *Choerospondias axillaris* (Roxb.) B.L. Burtt & A.W. Hill | Anacardiaceae | | | | | | | | | 25 | 3.15 | 22.82 | C | | | | | 10 | 0.39 | 8.48 | R |
| *Chukrasia tabularis* A. Juss. | Meliaceae | | | | | 5 | 0.94 | 5.93 | C | | | | | | | | | | | | |
| *Cinnamomum impressinervium* Meisn. | Lauraceae | | | | | | | | | 7.5 | 0.71 | 5.79 | C | | | | | | | | |
| *Cordia myxa* L. | Boraginaceae | | | | | | | | | | | | | | | | | 7.5 | 0.28 | 6.00 | R |
| *Croton joufra* Roxb. | Euphorbiaceae | 10 | 0.31 | 7.08 | RE | | | | | | | | | | | | | | | | |
| *Cryptomeria japonica* (Thunb. ex L.f.) D. Don | Cupressaceae | | | | | | | | | | | | | 5 | 0.47 | 4.10 | C | | | | |
| *Cyathea brunoniana* Wall. ex Hook. | Cyatheaceae | | | | | | | | | 2.5 | 0.03 | 1.98 | C | | | | | | | | |
| *Dillenia indica* L. | Dilleniaceae | | | | | | | | | | | | | 7.5 | 1.00 | 7.65 | C | | | | |
| *Dillenia pentagyna* Roxb. | Dilleniaceae | 5 | 0.44 | 3.49 | C | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Dimocarpus longan* Lour. | Sapindaceae | | | | | | | | | 15 | 0.75 | 11.57 | RE | | | | | | | | |
| *Dipterocarpus retusus* Blume | Dipterocarpaceae | | | | | | | | | 5 | 1.01 | 7.27 | C | | | | | | | | |
| *Drimycarpus racemosus* (Roxb.) Hook. f. | Anacardiaceae | | | | | | | | | 12.5 | 0.46 | 8.69 | C | | | | | | | | |
| *Duabanga grandiflora* (DC.) Walp. | Lythraceae | | | | | | | | | 2.5 | 0.29 | 2.89 | R | | | | | | | | |
| *Dysoxylum binectariferum* Hiern. | Meliaceae | | | | | | | | | | | | | | | | | 12.5 | 1.16 | 11.00 | C |
| *Dysoxylum procerum* Hiern. | Meliaceae | | | | | 15 | 1.68 | 13.65 | C | | | | | | | | | | | | |
| *Elaeocarpus aristatus* Roxb. | Elaeocarpaceae | | | | | 12.5 | 1.56 | 12.54 | C | | | | | 5 | 0.49 | 4.18 | C | | | | |
| *Elaeocarpus floribundus* Blume | Elaeocarpaceae | 2.5 | 0.26 | 2.30 | R | | | | | | | | | | | | | | | | |
| *Elaeocarpus lanceifolius* Roxb. | Elaeocarpaceae | 20 | 2.94 | 17.39 | C | | | | | | | | | | | | | | | | |
| *Elaeocarpus prunifolius* Wall. ex Müll.Berol. | Elaeocarpaceae | | | | | | | | | | | | | | | | | 5 | 1.01 | 6.76 | C |
| *Engelhardia roxburghiana* Lindl. | Juglandaceae | 5 | 0.82 | 5.46 | C | | | | | | | | | | | | | | | | |
| *Engelhardia spicata* Lesch. ex Blume | Juglandaceae | | | | | | | | | 5 | 0.67 | 4.92 | C | | | | | 7.5 | 0.67 | 8.77 | RE |
| *Erythrina arborescens* Roxb. | Leguminosae | | | | | | | | | 7.5 | 0.34 | 5.67 | R | | | | | | | | |
| *Erythrina stricta* Roxb. | Leguminosae | | | | | 17.5 | 1.56 | 15.07 | RE | | | | | | | | | 12.5 | 0.43 | 10.71 | R |
| *Erythrina variegata* Lam. | Leguminosae | | | | | 7.5 | 0.17 | 4.97 | R | | | | | | | | | | | | |
| *Eurya acuminata* DC. | Theaceae | | | | | | | | | 15 | 0.37 | 9.08 | R | | | | | | | | |
| *Ficus auriculata* Lour. | Moraceae | | | | | | | | | 2.5 | 0.02 | 1.97 | C | | | | | | | | |
| *Ficus curtipes* Corner | Moraceae | 10 | 0.35 | 7.20 | C | | | | | | | | | | | | | | | | |
| *Ficus gasparriniana* Miq. | Moraceae | | | | | | | | | | | | | 10 | 0.53 | 9.20 | C | | | | |
| *Ficus hispida* L.f. | Moraceae | | | | | | | | | | | | | 2.5 | 0.10 | 2.20 | C | | | | |
| *Ficus racemosa* L. | Moraceae | 5 | 1.03 | 6.07 | C | | | | | | | | | | | | | | | | |
| *Ficus semicordata* Buch.-Ham. ex Sm. | Moraceae | 2.5 | 0.22 | 2.19 | R | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ficus subincisa* Buch.-Ham. ex Sm. | Moraceae | | | | | 5 | 0.31 | 4.79 | C | | | | | | | | | | | | |
| *Firmiana colorata* (Roxb.) R.Br. | Sterculiaceae | 7.5 | 0.66 | 6.55 | C | 22.5 | 1.83 | 17.44 | RE | | | | | 5 | 0.45 | 4.05 | C | 5 | 0.42 | 4.48 | C |
| *Garcinia anomala* Planch. & Triana | Clusiaceae | | | | | | | | | | | | | | | | | 10 | 0.22 | 7.83 | R |
| *Garcinia gummi-gutta* (L.) Roxb. | Clusiaceae | | | | | | | | | | | | | | | | | 5 | 0.28 | 3.94 | C |
| *Garcinia pedunculata* Roxb. ex Buch.-Ham. | Clusiaceae | | | | | | | | | 5 | 0.35 | 3.82 | C | | | | | | | | |
| *Glochidion assamicum* (Müll.Arg.) Hook.f. | Euphorbiaceae | | | | | | | | | | | | | | | | | 15 | 0.40 | 8.90 | C |
| *Glochidion sphaerogynum* (Müll.Arg.) Kurz | Euphorbiaceae | 12.5 | 0.69 | 8.85 | C | | | | | | | | | | | | | | | | |
| *Gmelina arborea* Roxb. | Verbenaceae | | | | | | | | | | | | | 22.5 | 2.42 | 18.88 | R | | | | |
| *Grewia optiva* J. R. Drumm. ex Burret | Tiliaceae | | | | | | | | | 12.5 | 0.40 | 8.47 | C | 5 | 0.17 | 3.17 | C | | | | |
| *Gynocardia odorata* R. Br. | Flacourtiaceae | | | | | 10 | 0.45 | 6.70 | R | | | | | | | | | 10 | 0.69 | 7.15 | C |
| *Heynea trijuga* Roxb. ex Sims | Meliaceae | 2.5 | 0.14 | 1.96 | R | 5 | 0.25 | 3.45 | C | 2.5 | 0.15 | 2.41 | R | | | | | | | | |
| *Holarrhena pubescens* Wall. ex G. Don | Apocynaceae | 7.5 | 0.14 | 4.15 | R | | | | | | | | | | | | | | | | |
| *Illicium simonsii* Maxim. | Illiciaceae | 15 | 0.56 | 9.14 | RE | 2.5 | 0.18 | 2.47 | R | | | | | | | | | | | | |
| *Juglans regia* L. | Juglandaceae | | | | | | | | | 5 | 0.82 | 5.44 | C | | | | | | | | |
| *Kydia calycina* Roxb. | Malvaceae | | | | | 15 | 0.65 | 9.96 | R | | | | | | | | | | | | |
| *Lagerstroemia speciosa* (L.) Pers. | Lythraceae | 7.5 | 0.78 | 6.02 | R | | | | | | | | | 2.5 | 0.37 | 3.03 | R | | | | |
| *Ligustrum robustum* (Roxb.) Blume | Oleaceae | | | | | | | | | | | | | 10 | 0.28 | 6.16 | C | | | | |
| *Lindera melastomacea* Fern.-Vill. | Lauraceae | 5 | 0.19 | 3.65 | C | | | | | | | | | | | | | | | | |
| *Lithocarpus elegans* (Blume) Hatus. ex Soepadmo | Fagaceae | | | | | | | | | 27.5 | 3.28 | 23.97 | R | | | | | | | | |
| *Lithocarpus fenestratus* | Fagaceae | | | | | | | | | 5 | 0.44 | 4.12 | C | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (Roxb.) Rehder | | | | | | | | | | | | | | | | | | | | | |
| *Litsea cubeba (Lour.) Pers.* | Lauraceae | | | | | 7.5 | 0.80 | 8.38 | RE | | | | | 15 | 0.52 | 10.69 | RE | | | | |
| *Litsea glutinosa* (Lour.) C.B.Rob. | Lauraceae | | | | | | | | | | | | | 7.5 | 0.19 | 6.27 | RE | | | | |
| *Litsea khasyana* Meisn. | Lauraceae | | | | | | | | | 2.5 | 0.08 | 2.17 | R | | | | | | | | |
| *Litsea monopetala* (Roxb.) Pers. | Lauraceae | 2.5 | 0.21 | 2.14 | R | | | | | | | | | | | | | | | | |
| *Litsea salicifolia* (Roxb. ex Nees) Hook.f. | Lauraceae | | | | | | | | | | | | | 2.5 | 0.11 | 2.22 | C | | | | |
| *Macaranga denticulata* (Blume) Müll.Arg. | Euphorbiaceae | | | | | 10 | 0.44 | 6.65 | R | | | | | | | | | | | | |
| *Macaranga indica* Wight | Euphorbiaceae | | | | | | | | | 7.5 | 0.26 | 5.41 | R | 17.5 | 1.03 | 11.88 | R | 7.5 | 0.41 | 7.75 | R |
| *Machilus duthiei* King ex Hook.f. | Lauraceae | 7.5 | 1.46 | 8.88 | RE | | | | | | | | | | | | | | | | |
| *Magnolia champaca* (L.) Baill. ex Pierre | Magnoliaceae | 2.5 | 0.36 | 2.59 | R | | | | | 10 | 0.75 | 8.98 | C | | | | | | | | |
| *Magnolia doltsopa* (Buch.-Ham. ex DC.) Figlar | Magnoliaceae | | | | | | | | | | | | | 12.5 | 0.79 | 10.78 | RE | | | | |
| *Magnolia hodgsonii* (Hook.f. & Thomson) H.Keng | Magnoliaceae | | | | | 2.5 | 0.15 | 2.38 | C | | | | | | | | | | | | |
| *Mahonia napaulensis* DC. | Magnoliaceae | | | | | 2.5 | 0.18 | 2.48 | C | 17.5 | 0.45 | 11.24 | RE | | | | | 12.5 | 0.95 | 11.46 | R |
| *Mallotus tetracoccus* (Roxb.) Kurz | Euphorbiaceae | 10 | 0.68 | 6.40 | R | | | | | | | | | | | | | | | | |
| *Mangifera indica* L. | Anacardiaceae | | | | | | | | | 2.5 | 0.20 | 2.58 | R | 2.5 | 0.17 | 2.42 | C | | | | |
| *Mangifera sylvatica* Roxb. | Anacardiaceae | | | | | | | | | 2.5 | 0.15 | 2.39 | R | | | | | | | | |
| *Micromelum integerrimum* (Buch.-Ham. ex DC.) Wight & Arn. ex M. Roem. | Rutaceae | 15 | 0.28 | 8.31 | C | | | | | | | | | | | | | | | | |
| *Morus australis* Poir. | Moraceae | | | | | 2.5 | 0.22 | 2.61 | C | | | | | | | | | | | | |
| *Morus laevigata* Wall. ex Brandis | Moraceae | | | | | | | | | | | | | 10 | 1.10 | 8.71 | C | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Myrsine semiserrata* Wall. | Myrsinaceae | | | | | 10 | 0.31 | 8.44 | RE | | | | | | | | | | | | |
| *Nephelium lappaceum* L. | Sapindaceae | | | | | | | | | 15 | 0.96 | 12.32 | RE | | | | | | | | |
| *Oreocnide integrifolia* (Gaud.) Miq. | Urticaceae | | | | | | | | | | | | | 15 | 0.21 | 8.58 | C | | | | |
| *Oroxylum indicum* (L.) Kurz | Bignoniaceae | 12.5 | 0.45 | 8.16 | RE | 5 | 0.19 | 3.22 | C | | | | | | | | | | | | |
| *Persea odoratissima* (Nees) Kosterm. | Lauraceae | | | | | 12.5 | 1.11 | 10.92 | RE | | | | | | | | | | | | |
| *Phoebe lanceolata* (Nees) Nees | Lauraceae | | | | | | | | | 5 | 0.28 | 3.59 | C | | | | | | | | |
| *Pongamia pinnata* (L.) Pierre | Fabaceae | | | | | | | | | | | | | 7.5 | 0.65 | 6.56 | C | 15 | 1.25 | 14.66 | R |
| *Premna latifolia* Roxb. | Lamiaceae | | | | | 10 | 0.27 | 6.05 | R | | | | | | | | | | | | |
| *Prunus cerasoides* D. Don | Rosaceae | 2.5 | 0.29 | 2.39 | R | | | | | | | | | | | | | | | | |
| *Prunus ceylanica* (Wight) Miq. | Rosaceae | | | | | | | | | | | | | | | | | 10 | 0.70 | 10.94 | RE |
| *Prunus cornuta* (Wall. ex Royle) Steud. | Rosaceae | | | | | 7.5 | 0.70 | 8.03 | RE | | | | | | | | | | | | |
| *Pterospermum acerifolium* (L.) Willd. | Sterculiaceae | 10 | 0.91 | 8.82 | C | | | | | | | | | | | | | 12.5 | 1.53 | 13.70 | R |
| *Pyrularia edulis* (Wall.) A.DC. | Santalaceae | | | | | | | | | | | | | | | | | 5 | 0.31 | 5.32 | R |
| *Pyrus communis* L. | Rosaceae | 2.5 | 0.12 | 1.90 | R | | | | | | | | | | | | | | | | |
| *Quercus lamellosa* Sm. | Fagaceae | | | | | | | | | 7.5 | 1.50 | 9.70 | R | | | | | | | | |
| *Quercus serrata* Murray | Fagaceae | 5 | 0.47 | 4.45 | C | 27.5 | 3.04 | 23.20 | R | | | | | | | | | | | | |
| *Rhus chinensis* Mill. | Anacardiaceae | | | | | | | | | | | | | | | | | 2.5 | 0.10 | 2.46 | R |
| *Salix tetrasperma* Roxb. | Salicaceae | | | | | 12.5 | 1.78 | 13.32 | RE | | | | | | | | | | | | |
| *Sapindus mukorossi* Gaertn. | Sapindaceae | | | | | 5 | 0.60 | 4.68 | C | | | | | | | | | | | | |
| *Sapium baccatum* Roxb. | Euphorbiaceae | 17.5 | 1.49 | 12.50 | RE | | | | | | | | | | | | | | | | |
| *Sapium euginiaefolium* Buch.-Ham. | Euphorbiaceae | 7.5 | 0.95 | 7.39 | RE | | | | | | | | | | | | | | | | |
| *Saurauia cerea* Griff. ex Dyer | Actinidiaceae | | | | | 15 | 0.67 | 10.02 | R | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Saurauia napaulensis* DC. | Actinidiaceae | | | | | | | | | | | | | | | | | 7.5 | 0.71 | 8.93 | R |
| *Saurauia punduana* Wall. | Actinidiaceae | | | | | | | | | 2.5 | 0.22 | 2.64 | R | | | | | | | | |
| *Schefflera shweliensis* W.W.Sm | Araliaceae | | | | | | | | | | | | | 5 | 1.09 | 6.05 | C | | | | |
| *Schefflera venulosa* (Wight & Arn.) Harms | Araliaceae | | | | | | | | | | | | | | | | | 15 | 0.73 | 10.18 | C |
| *Schima khasiana* Dyer | Theaceae | 2.5 | 0.06 | 1.72 | R | | | | | | | | | | | | | | | | |
| *Schima wallichii* Choisy | Theaceae | | | | | | | | | 10 | 1.20 | 11.70 | RE | 10 | 0.98 | 10.61 | RE | | | | |
| *Spondias pinnata* (L.f.) Kurz. | Anacardiaceae | | | | | 5 | 0.18 | 3.20 | C | | | | | 2.5 | 0.06 | 2.09 | C | 5 | 0.57 | 6.30 | R |
| *Sterculia guttata* Roxb. | Sterculiaceae | 5 | 0.35 | 3.23 | C | | | | | | | | | | | | | | | | |
| *Sterculia hamiltonii* (Kuntze) Adelb. | Sterculiaceae | | | | | | | | | 12.5 | 0.88 | 11.32 | C | 2.5 | 0.23 | 2.59 | C | | | | |
| *Sterculia versicolor* Wall. | Sterculiaceae | | | | | | | | | 2.5 | 0.08 | 2.18 | C | | | | | | | | |
| *Sterculia villosa* Roxb. | Sterculiaceae | 2.5 | 0.36 | 2.59 | R | | | | | | | | | | | | | | | | |
| *Stereospermum chelonoides* (L.f.) DC. | Bignoniaceae | 7.5 | 2.26 | 11.18 | C | | | | | | | | | | | | | | | | |
| *Styrax serrulatus* Roxb. | Styracaceae | 12.5 | 0.61 | 8.61 | RE | | | | | | | | | | | | | | | | |
| *Symplocos dryophila* C.B. Clarke | Symplocaceae | | | | | 7.5 | 0.14 | 5.99 | RE | | | | | | | | | | | | |
| *Symplocos racemosa* Roxb. | Symplocaceae | | | | | | | | | | | | | | | | | 10 | 0.64 | 9.44 | R |
| *Syzygium cumini* (L.) Skeels | Myrtaceae | 10 | 0.28 | 6.12 | RE | | | | | | | | | | | | | 7.5 | 0.35 | 5.02 | C |
| *Syzygium reticulatum* (Wight) Walp. | Myrtaceae | 2.5 | 0.07 | 1.75 | R | | | | | | | | | | | | | | | | |
| *Syzygium syzygioides* (Miq.) Merr. & L.M.Perry | Myrtaceae | | | | | | | | | 17.5 | 0.38 | 9.83 | C | | | | | | | | |
| *Terminalia chebula* Retz. | Combretaceae | 5 | 0.52 | 4.59 | C | | | | | | | | | | | | | | | | |
| *Terminalia myriocarpa* Van Heurck & Müll. Arg. | Combretaceae | | | | | 12.5 | 1.93 | 12.74 | C | | | | | | | | | | | | |
| *Tetrameles nudiflora* R. | Tetramelaceae | 27.5 | 3.19 | 20.10 | R | | | | | | | | | | | | | 12.5 | 1.58 | 13.25 | C | | | | |

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| Br. | | | | | | | | | | | | | | | | | | | | | |
| *Toona ciliata* M. Roem | Meliaceae | | | | | 2.5 | 0.31 | 2.95 | C | | | | | 10 | 0.81 | 10.09 | RE | 5 | 0.51 | 4.83 | C |
| *Trema orientalis* (L.) Blume. | Ulmaceae | | | | | | | | | | | | | 7.5 | 0.30 | 5.45 | C | | | | |
| *Trema politoria* (Planch.) Blume | Ulmaceae | | | | | | | | | 5 | 0.21 | 4.51 | C | | | | | | | | |
| *Trevesia palmata* (Roxb. ex Lindl.) Vis. | Araliaceae | | | | | | | | | | | | | | | | | 12.5 | 0.31 | 7.73 | C |
| *Turpinia pomifera* (Roxb.) DC. | Staphyleaceae | 5 | 0.73 | 4.32 | C | | | | | | | | | | | | | | | | |
| *Vatica lanceifolia* (Roxb.) Blume | Dipterocarpaceae | | | | | 10 | 0.55 | 7.05 | C | | | | | | | | | | | | |
| *Wendlandia glabrata* DC. | Rubiaceae | | | | | | | | | | | | | 5 | 0.08 | 2.88 | C | | | | |
| *Wrightia arborea* (Dennst.) Mabb. | Apocynaceae | | | | | 7.5 | 0.23 | 6.32 | RE | | | | | | | | | | | | |
| *Zanthoxylum armatum* DC. | Rutaceae | | | | | 5 | 0.11 | 2.94 | C | | | | | | | | | | | | |
| *Zanthoxylum rhetsa* DC. | Rutaceae | 7.5 | 0.71 | 6.70 | RE | | | | | | | | | | | | | | | | |

**Key to abbreviation:** RE= Regular; R= Random; C= Clumped

*Herb species composition*

In herbs, a total of 103 species, 81 genera representing 32 families were recorded from five community forest (Lumami, Luvishe, Akuhaito, Aichisanghemi and Satakha) of Zunhebhoto district, Nagaland, Northeast India. Of these, 31 species, 28 genera and 19 families were recorded from Aichisanghemi CF followed by 29 species, 26 genera and 22 families from Akuhaito CF; 24 species, 21 genera and 12 families from Satakha CF; 22 species, 20 genera and 17 families from Luvishe CF and 19 species, 18 genera and 11 families from Lumami CF of Zunhebhoto district, Nagaland respectively (Table 4.2.25). In Aichisanghemi CF, the most dominant herb species were: *Cheilocostus speciosus* (16.66), *Hedychium flavescens* (15.41) and *Cissus javana* (14.19) (Table 4.2.27) and the dominant families were: Asteraceae, Urticaceae and Zingiberaceae. In Akuhaito CF, the most dominant species were: *Girardinia diversifolia* (16.69), *Mikania micrantha* (14.40) and *Porana paniculata* (13.25) (Table 4.2.27) and the dominant families were: Asteraceae and Papilionaceae. In Satakha CF, the dominant species were: *Cheilocostus speciosus* (20.05), *Bidens pilosa* (17.27) and *Commelina paludosa* (15.88) (Table 4.2.27) and the dominant families were: Asteraceae, Commelinaceae and Zingiberaceae. In Luvishe CF, the dominant species were: *Clinopodium umbrosum* (21.20), *Elatostema hookerianum* (19.93) and *Achyranthes bidentata* (14.87) (Table 4.2.27) and the most dominant families were: Convolvulaceae and Orchidaceae. In Lumami CF, the dominant species were: *Bidens bipinnata* (26.22), *Galinsoga parviflora* (23.56) and *Tinospora sinensis* (19.56) (Table 4.2.27) and the most dominant families were: Asteraceae and Lamiaceae. The highest herb density (individuals $ha^{-1}$) was recorded from Akuhaito CF (54375) followed by Aichisanghemi CF (50625), Luvishe CF (49375) and Lumami CF (46875). The lowest herb density was recorded from Satakha CF (45000) respectively (Table 4.2.25).

**Table 4.2.27** Density (individuals ha$^{-1}$) and Important value index (IVI) of shrubs and herbs species in five study sites of Zunhebhoto District, Nagaland

| Species | Family | Lumami | | Luvishe | | Akuhaito | | Aichisanghemi | | Satakha | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D | IVI | D | IVI | D | IVI | D | IVI | D | IVI |
| **Shrubs** | | | | | | | | | | | |
| *Agapetes macrantha* (Hook.) Benth. & Hook.f. | Ericaceae | 150 | 3.91 | 250 | 8.98 | | | | | | |
| *Amomum pterocarpum* Thwaites | Zingiberaceae | | | | | | | 600 | 18.10 | | |
| *Baliospermum calycinum* Müll.Arg. | Euphorbiaceae | | | | | | | | | 350 | 8.47 |
| *Baliospermum solanifolium* (Burm.) Suresh | Euphorbiaceae | 100 | 4.34 | 150 | 5.72 | | | | | | |
| *Boehmeria glomerulifera* Miq. | Urticaceae | | | | | | | 200 | 8.72 | 400 | 9.09 |
| *Boehmeria hamiltoniana* Wedd. | Urticaceae | | | | | 450 | 11.81 | | | | |
| *Boehmeria japonica* (L.f.) Miq. | Urticaceae | 350 | 11.28 | | | | | | | | |
| *Calamus leptospadix* Griff. | Arecaceae | | | | | 150 | 3.47 | | | 250 | 6.20 |
| *Callicarpa rubella* Lindl. | Verbenaceae | | | 200 | 8.17 | | | 150 | 6.14 | 300 | 6.82 |
| *Camellia sinensis* (L.) Kuntze | Theaceae | | | 50 | 2.45 | | | | | | |
| *Carlemannia tetragona* Hook.f. | Carlemanniaceae | | | | | | | 50 | 2.58 | | |
| *Casearia vareca* Roxb. | Flacourtiaceae | | | | | 100 | 2.78 | 100 | 5.17 | 200 | 5.58 |
| *Cautleya gracilis* (Smith) Dandy | Zingiberaceae | 200 | 8.67 | | | | | | | | |
| *Chassalia curviflora* (Wall.) Thwaites | Rubiaceae | | | | | 200 | 8.33 | | | | |
| *Clerodendrum chinense* (Osbeck) Mabb. | Verbenaceae | | | | | | | | | 450 | 9.71 |
| *Clerodendrum infortunatum* L. | Verbenaceae | | | 500 | 14.69 | 400 | 11.11 | | | 700 | 12.82 |
| *Clerodendrum japonicum* (Thunb.) Sweet | Verbenaceae | 300 | 10.41 | 350 | 12.25 | | | | | | |
| *Clerodendrum laevifolium* Blume | Verbenaceae | | | | | | | 500 | 16.16 | | |
| *Croton caudatus* Geiseler | Euphorbiaceae | 100 | 4.34 | | | 100 | 2.78 | | | | |
| *Daphne involucrata* Wall. | Thymelaeaceae | 150 | 5.21 | 650 | 17.13 | | | | | 100 | 3.30 |
| *Debregeasia longifolia* (Burm.f.) Wedd. | Urticaceae | | | | | 600 | 13.89 | 100 | 5.17 | 50 | 1.65 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Dendrocnide sinuata* (Blume) Chew | Urticaceae | | | 300 | 11.44 | | | | | 550 | 10.96 |
| *Desmodium concinnum* DC. | Papilionaceae | | | | | | | | | 300 | 7.85 |
| *Dicranopteris splendida* (Hand.-Mazz.) Ching | Gleicheniaceae | | | | | | | | | 150 | 4.96 |
| *Diflugossa colorata* (Nees) Bremek. | Acanthaceae | 50 | 2.17 | | | | | | | | |
| *Dracaena angustifolia* (Medik.) Roxb. | Dracaenaceae | | | | | | | 250 | 11.31 | | |
| *Embelia floribunda* Wall. | Myrsinaceae | | | 50 | 2.45 | | | | | | |
| *Embelia nutans* Wall. | Myrsinaceae | | | 200 | 6.53 | 150 | 3.47 | 150 | 7.75 | | |
| *Embelia ribes* Burm.f. | Myrsinaceae | | | | | | | 450 | 15.19 | | |
| *Eriobotrya bengalensis* (Roxb.) Hook.f. | Rosaceae | | | | | | | | | 50 | 1.65 |
| *Etlingera linguiformis* (Roxb.) R.M.Sm. | Zingiberaceae | | | | | | | | | 250 | 7.23 |
| *Hedychium marginatum* C.B.Clarke | Zingiberaceae | | | | | | | 300 | 12.28 | | |
| *Hedychium rubrum* A.S. Rao & D.M. Verma | Zingiberaceae | | | | | | | 100 | 5.17 | | |
| *Hymenandra wallichii* A. DC. | Myrsinaceae | | | | | | | | | 150 | 4.96 |
| *Impatiens laevigata* Wall. ex Hook.f. & Thomson. | Balsaminaceae | | | 150 | 5.72 | | | 200 | 8.72 | | |
| *Ixora acuminata* Roxb. | Rubiaceae | | | | | | | | | 200 | 6.61 |
| *Jasminum lanceolaria* Roxb. | Oleaceae | | | | | | | | | 250 | 7.23 |
| *Justicia vasculosa* Wall. | Acanthaceae | | | | | 200 | 4.17 | | | | |
| *Lasianthus biermannii* King ex Hook.f. | Rubiaceae | | | | | | | 250 | 8.08 | | |
| *Leea asiatica* (L.) Ridsdale | Leeaceae | | | | | 450 | 10.42 | | | | |
| *Leea compactiflora* Kurz | Leeaceae | 300 | 10.41 | 750 | 18.75 | 250 | 9.03 | | | 350 | 8.47 |
| *Leea macrophylla* Roxb. ex Hornem. | Leeaceae | | | | | | | 400 | 14.22 | | |
| *Leptopus clarkei* (Hook.f.) Pojark. | Euphorbiaceae | | | | | | | | | 150 | 3.93 |
| *Leucoceptrum canum* Sm. | Lamiaceae | 200 | 7.37 | | | | | | | | |
| *Lobelia nicotianifolia* Roth | Campanulaceae | 250 | 8.24 | 100 | 3.27 | 100 | 4.17 | | | | |
| *Luculia pinceana* Hook. | Rubiaceae | | | | | | | | | 200 | 5.58 |
| *Lyonia macrocalyx* (J. Anthony) Airy Shaw | Ericaceae | 100 | 3.04 | | | | | | | 100 | 3.30 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Maesa indica* (Roxb.) A. DC. | Myrsinaceae | 450 | 13.02 | | | 700 | 15.28 | | | | |
| *Maoutia puya* (Hook.) Wedd. | Urticaceae | | | | | | | | | 150 | 4.96 |
| *Melastoma malabathricum* L. | Melastomataceae | 250 | 8.24 | | | 500 | 12.50 | | | | |
| *Musa species* L. | Musaceae | | | | | 150 | 6.25 | | | | |
| *Mussaenda frondosa* L. | Rubiaceae | 400 | 12.15 | 400 | 13.06 | | | 150 | 6.14 | | |
| *Mussaenda macrophylla* wall. | Rubiaceae | 200 | 7.37 | | | | | | | | |
| *Mussaenda roxburghii* Hook.f. | Rubiaceae | | | | | 300 | 9.72 | 300 | 12.28 | | |
| *Neillia thyrsiflora* D. Don | Rosaceae | 150 | 5.21 | | | | | | | | |
| *Oenanthe javanica* (Blume) DC. | Apiaceae | | | | | 200 | 4.17 | | | | |
| *Ophiorrhiza griffithii* Hook.f. | Rubiaceae | | | | | 250 | 7.64 | | | 250 | 7.23 |
| *Ophiorrhiza repens* (Wall. ex G.Don) Bennet | Rubiaceae | | | 150 | 5.72 | | | | | | |
| *Osbeckia nepalensis* Hook.f. | Melastomataceae | 300 | 10.41 | 250 | 8.98 | 400 | 11.11 | 250 | 9.69 | 400 | 9.09 |
| *Osbeckia stellata* Buch.-Ham. ex Ker Gawl. | Melastomataceae | 250 | 8.24 | | | 350 | 10.42 | | | 350 | 8.47 |
| *Osyris lanceolata* Hochst. & Steud. (Keep it min.) | Santalaceae | | | | | | | 50 | 2.58 | | |
| *Phlogacanthus tubiflorus* Ness | Acanthaceae | 50 | 2.17 | | | 250 | 7.64 | | | | |
| *Phrynium species* Willd. | Marantaceae | | | | | | | 100 | 5.17 | 150 | 3.93 |
| *Plagiopetalum esquirolii* (H. Lév.) Rehder | Melastomataceae | | | 200 | 6.53 | | | | | | |
| *Polygonum microcephalum* D. Don | Polygonaceae | 150 | 5.21 | | | | | | | | |
| *Pouzolzia viminea* Wedd. | Urticaceae | | | | | 100 | 2.78 | | | | |
| *Premna pinguis* C.B.Clarke | Lamiaceae | | | | | 350 | 10.42 | | | | |
| *Psychotria calocarpa* Kurz | Rubiaceae | | | | | 150 | 4.86 | | | | |
| *Psychotria thomsonii* Hook.f. | Rubiaceae | | | | | | | 350 | 13.25 | | |
| *Rhamnus napalensis* (Wall.) M.A. Lawson | Rhamnaceae | 250 | 8.24 | | | | | | | | |
| *Rubus alpestris* Blume | Rosaceae | | | | | | | 150 | 6.14 | | |
| *Rubus barbatus* Edgew. | Rosaceae | 200 | 7.37 | | | | | | | | |
| *Rubus ferox* Vest | Rosaceae | 100 | 4.34 | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Rubus rugosus* Sm. | Rosaceae | | | 150 | 5.72 | | | | | | |
| *Rubus wardii* Merr | Rosaceae | | | 250 | 8.98 | | | | | | |
| *Sarcococca pruniformis* Lindl. | Buxaceae | | | 150 | 5.72 | | | | | | |
| *Solanum indicum* L. | Solanaceae | 150 | 5.21 | | | | | | | | |
| *Sphenodesme pentandra* Jack (Large Climber) | Verbenaceae | | | | | 50 | 2.08 | | | | |
| *Strobilanthes denticulatus* (Wall. ex Nees) T.Anders. | Acanthaceae | | | | | | | | | 200 | 5.58 |
| *Symplocos ramosissima* Wall. ex G. Don | Symplocaceae | 200 | 8.67 | | | | | | | | |
| *Synotis auriculata* C. Jeffrey & Y. L. Chen | Asteraceae | | | 50 | 2.45 | | | | | | |
| *Synotis triligulata* (Buch.-Ham. ex D.Don) C.Jeffrey & Y.L. Chen | Asteraceae | | | | | | | | | 150 | 4.96 |
| *Tadehagi triquetrum* (L.) H.Ohashi | Papilionaceae | 150 | 5.21 | | | | | | | | |
| *Vaccinium nummularia* Hook.f. & Thomson ex C.B.Clarke | Ericaceae | | | 300 | 9.80 | | | | | | |
| *Vaccinium vacciniaceum* (Roxb.) Sleumer | Ericaceae | | | | | 300 | 9.72 | | | | |
| *Viburnum corylifolium* Hook.f. & Thomson | Caprifoliaceae | 250 | 9.54 | 550 | 15.50 | | | | | | |
| *Zanthoxylum acanthopodium* DC. | Rutaceae | | | | | | | | | 500 | 10.33 |
| **Herbs** | | | | | | | | | | | |
| *Acampe ochracea* (Lindl.) Hochr. | Orchidaceae | | | 1875 | 9.25 | | | | | | |
| *Acampe praemorsa* (Roxb.) Blatt. & McCann | Orchidaceae | | | 625 | 3.08 | | | | | | |
| *Acampe rigida* (Buch.-Ham. ex Sm.) P.F.Hunt | Orchidaceae | | | | | | | | | 1250 | 6.55 |
| *Achyranthes aspera* L. | Amaranthaceae | 1250 | 7.11 | | | 625 | 2.74 | | | | |
| *Achyranthes bidentata* Blume | Amaranthaceae | | | 3750 | 14.87 | | | | | | |
| *Aerides crassifolia* Parish & Rchb.f | Orchidaceae | 1875 | 8.44 | 1250 | 6.17 | | | | | | |
| *Aerides odorata* Lour. | Orchidaceae | | | | | | | 1875 | 8.79 | 3125 | 12.60 |
| *Aeschynanthus parasiticus* (Roxb.) Wall. | Gesneriaceae | | | 2500 | 8.70 | | | | | | |
| *Ageratina riparia* (Regel) R.M. King & H. Rob. | Asteraceae | | | | | 3125 | 12.10 | | | | |
| *Aletris glabra* Bureau & Franch. | Haemodoraceae | | | | | | | 1250 | 4.16 | | |
| *Amaranthus viridis* L. | Amaranthaceae | | | | | | | 625 | 2.93 | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ampelocissus divaricata* (Wall. ex M.A.Lawson) Planch. | Vitaceae | | | | | 1875 | 5.04 | | | | |
| *Anaphalis adnata* Wall. ex DC. | Asteraceae | | | | | | | | | 625 | 3.28 |
| *Anaphalis grifithii* Hook.f. | Asteraceae | | | | | | | 1875 | 7.09 | | |
| *Arisaema concinnum* Schott | Araceae | | | 1250 | 6.17 | | | | | | |
| *Arthraxon nudum* (Nees) Benth. ex C.B.Clarke | Poaceae | | | 1250 | 4.35 | | | | | | |
| *Bauhinia vahlii* Wight & Arn. | Caesalpiniaceae | | | | | 2500 | 9.36 | | | | |
| *Bidens bipinnata* L. | Asteraceae | 8125 | 26.2 | | | | | | | | |
| *Bidens pilosa* L. | Asteraceae | | | 1875 | 9.25 | | | | | 4375 | 17.27 |
| *Blumea repanda* (Roxb.) Hand. Mazz. | Asteraceae | | | | | | | | | 1250 | 4.66 |
| *Bulbophyllum acutiflorum* A.Rich. | Orchidaceae | | | 2500 | 10.52 | | | | | | |
| *Bulbophyllum affine* Wall. ex Lindl. | Orchidaceae | | | | | | | 1250 | 5.86 | | |
| *Bulbophyllum andersonii* (Hook. f.) J.J. Sm. | Orchidaceae | 2500 | 9.78 | | | | | | | | |
| *Bulbophyllum candidum* Hook.f. | Orchidaceae | | | | | | | | | 1875 | 9.83 |
| *Bulbophyllum hirtum* (Sm.) Lindl. | Orchidaceae | 625 | 3.56 | | | | | | | | |
| *Bulbophyllum odoratissimum* (Sm.) Lindl. | Orchidaceae | | | | | | | 625 | 2.93 | | |
| *Calamus floribundus* Griff. | Arecaceae | | | | | 625 | 2.74 | | | | |
| *Calanthe mannii* Hook.f. | Orchidaceae | | | | | | | | | 1250 | 6.55 |
| *Carex speciosa* Kunth | Cyperaceae | | | | | | | 1250 | 4.16 | | |
| *Cheilocostus speciosus* (J.Koenig) C.D. Specht | Zingiberaceae | | | | | | | 5000 | 16.66 | 5625 | 20.05 |
| *Chlorophytum nepalense* Lindl. Baker | Liliaceae | | | 1250 | 6.17 | | | | | | |
| *Cissampelos pareira* L. | Menispermaceae | | | | | 1875 | 6.62 | | | | |
| *Cissus javana* DC. | Vitaceae | | | | | | | 3750 | 14.19 | | |
| *Clematis puberula* Hook. f. & Thoms. | Ranunculaceae | | | | | 1250 | 5.47 | | | | |
| *Clinopodium umbrosum* (M.Bieb.) Kuntze | Lamiaceae | 1250 | 7.11 | 6875 | 21.20 | | | 1875 | 7.09 | 1875 | 7.94 |
| *Coelogyne micrantha* Lindl. | Orchidaceae | | | | | | | 1250 | 5.86 | | |
| *Coelogyne punctulata* Lindl. | Orchidaceae | | | | | | | | | 1250 | 6.55 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Commelina paludosa* Blume | Commelinaceae | | | | | 625 | 2.74 | | | 3750 | 15.88 |
| *Crotalaria occulta* Graham ex Benth | Papilionaceae | | | | | 1250 | 5.47 | | | | |
| *Curculigo orchioides* Gaertn. | Hypoxidaceae | | | | | 2500 | 10.95 | | | | |
| *Curcuma aromatica* Salisb. | Zingiberaceae | | | | | 625 | 2.74 | | | | |
| *Curcuma montana* Roxb. | Zingiberaceae | | | 625 | 3.08 | | | | | | |
| *Cyanthillium cinereum* (L.) H. Rob. | Asteraceae | 1875 | 8.44 | | | | | | | | |
| *Cyclocodon parviflorus* (Wall. ex A.DC.) Hook.f. & Thomson | Campanulaceae | | | | | 625 | 2.74 | | | | |
| *Cymbidium devonianum* Paxton | Orchidaceae | | | | | | | 2500 | 10.02 | 625 | 3.28 |
| *Dendrobium fugax* Rch.f. | Orchidaceae | | | 2500 | 10.52 | | | | | 1875 | 9.83 |
| *Dendrobium heterocarpum* Wall. | Orchidaceae | | | | | | | 1875 | 8.79 | | |
| *Dendrobium hookerianum* Lindl. | Orchidaceae | 625 | 3.56 | | | | | | | | |
| *Desmodium microphyllum* (Thunb.) DC. | Papilionaceae | | | | | | | 3125 | 11.26 | | |
| *Dianella ensifolia* (L.) DC. | Liliaceae | | | | | 1875 | 8.21 | | | | |
| *Didymocarpus pulcher* C.B. Clarke | Gesneriaceae | | | | | | | | | 2500 | 11.22 |
| *Digitaria ciliaris* (Retz.) Koeler | Poaceae | 2500 | 9.78 | | | | | | | | |
| *Digitaria stricta* Roth | Poaceae | | | | | | | | | 625 | 3.28 |
| *Dinetus racemosus* (Roxb.) Buch.-Ham. ex Sweet | Convolvulaceae | | | 1875 | 9.25 | | | | | | |
| *Dioscorea bulbifera* L. | Dioscoreaceae | | | 625 | 3.08 | | | | | | |
| *Dioscorea glabra* Roxb. | Dioscoreaceae | | | | | 2500 | 7.77 | | | | |
| *Dioscorea tomentosa* J. Koenig ex Spreng. | Dioscoreaceae | | | | | | | 625 | 2.93 | | |
| *Elatostema acuminatum* (Poir.) Brongn. | Urticaceae | | | | | | | 1250 | 4.16 | | |
| *Elatostema hookerianum* Wedd. | Urticaceae | | | 6250 | 19.93 | | | | | | |
| *Entada rheedei* Spreng. | Papilionaceae | | | | | 625 | 2.74 | | | | |
| *Eria biflora* Griff. | Orchidaceae | | | 1250 | 6.17 | | | 1875 | 7.09 | | |
| *Erythropalum scandens* Blume | Olacaceae | | | | | | | 625 | 2.93 | | |
| *Ficus nigrescens* King. | Moraceae | | | | | 625 | 2.74 | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Fimbristylis bisumbellata* (Forssk.) Bubani | Cyperaceae | | | 3125 | 13.60 | | | | | | |
| *Floscopa scandens* Lour. | Commelinaceae | | | | | | | | | 3125 | 12.60 |
| *Galinsoga parviflora* Cav. | Asteraceae | 6875 | 23.6 | | | | | | | | |
| *Girardinia diversifolia* (Link) Friis | Urticaceae | | | | | 5625 | 16.69 | | | | |
| *Gouania microcarpa* DC. | Rhamnaceae | 625 | 3.56 | | | | | | | | |
| *Gynura nepalensis* DC. | Asteraceae | | | | | | | 2500 | 8.33 | | |
| *Hedychium flavescens* Carey ex Roscoe | Zingiberaceae | | | | | | | 4375 | 15.42 | 2500 | 9.33 |
| *Hedyotis scandens* Roxb. | Rubiaceae | | | 625 | 3.08 | | | | | | |
| *Herpetospermum pedunculosum* (Ser.) C.B. Clarke | Cucurbitaceae | | | | | 1875 | 6.62 | | | | |
| *Hodgsonia macrocarpa* (Blume) Cogn. | Cucurbitaceae | | | | | 1250 | 3.89 | | | | |
| *Holboellia latifolia* Wall. | Lardizabalaceae | | | | | | | 625 | 2.93 | | |
| *Ipomoea pileata* Roxb. | Convolvulaceae | | | 1875 | 7.43 | | | | | | |
| *Ipomoea quamoclit* L. | Convolvulaceae | | | | | | | 625 | 2.93 | | |
| *Lasia spinosa* (L.) Thwaites | Araceae | | | | | 2500 | 9.36 | | | | |
| *Maranta species* L. | Marantaceae | | | | | | | 1250 | 5.86 | 1250 | 6.55 |
| *Mikania micrantha* Kunth | Asteraceae | | | | | 4375 | 14.40 | | | | |
| *Mucuna macrocarpa* Wall. | Leguminosae | | | | | | | | | 1875 | 9.83 |
| *Mukia maderaspatana* (L.) M. Roem. | Cucurbitaceae | 1250 | 7.11 | | | 625 | 2.74 | | | | |
| *Ocimum basilicum* L. (Cultivated) | Lamiaceae | 1875 | 10.7 | | | | | | | | |
| *Ophiorrhiza ochroleuca* Hook.f. | Rubiaceae | 3125 | 13.3 | | | | | | | | |
| *Papilionanthe teres* (Roxb.) Schltr. | Orchidaceae | | | 3125 | 11.78 | | | | | | |
| *Papilionanthe uniflora* (Lindl.) garay | Orchidaceae | | | | | 1875 | 8.21 | | | | |
| *Paris polyphylla* Sm. | Trilliaceae | | | | | | | 1875 | 7.09 | | |
| *Parthenocissus semicordata* (Wall.) Planch. | Vitaceae | | | 1250 | 6.17 | | | | | | |
| *Passiflora adenophylla* Mast. | Passifloraceae | | | | | 1250 | 5.47 | | | | |
| *Passiflora stipulata* Aubl. | Passifloraceae | 625 | 3.56 | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Phragmites karka* (Retz.) Trin. ex Steud. | Poaceae | | | | | | | 625 | 2.93 | | |
| *Pollia secundiflora* (Blume) Bakh.f. | Commelinaceae | | | | | | | | | 625 | 3.28 |
| *Polygonatum cathcartii* Baker | Convallariaceae | | | | | | | | | 1250 | 6.55 |
| *Porana paniculata* Roxb. | Convolvulaceae | | | | | 3750 | 13.25 | 1250 | 5.86 | 625 | 3.28 |
| *Remusatia vivipara* (Roxb.) Schott | Araceae | | | | | | | 1875 | 7.09 | | |
| *Rhynchostylis retusa* (L.) Blume | Orchidaceae | 1875 | 10.7 | 625 | 3.08 | | | | | 625 | 3.28 |
| *Scleria terrestris* (L.) Fassett | Cyperaceae | 3750 | 16.9 | | | | | 2500 | 11.72 | | |
| *Sigesbeckia orientalis* L. | Asteraceae | 1250 | 7.11 | | | 3125 | 10.51 | | | | |
| *Spatholobus roxburghii* Benth. | Leguminosae | | | 625 | 3.08 | 625 | 2.74 | | | | |
| *Spilanthes acmella* (L.) L. | Asteraceae | | | | | 625 | 2.74 | | | | |
| *Sporobolus piliferus* (Trin.) Kunth | Poaceae | | | | | | | | | 1250 | 6.55 |
| *Synedrella nodiflora* (L.) Gaertn. | Asteraceae | | | | | 3750 | 13.25 | | | | |
| *Tinospora sinensis* (Lour.) Merr. | Menispermaceae | 5000 | 19.6 | | | | | | | | |
| *Urtica parviflora* Roxb. | Urticaceae | | | | | | | 625 | 2.93 | | |

#### 4.2.7.2 Species diversity indices

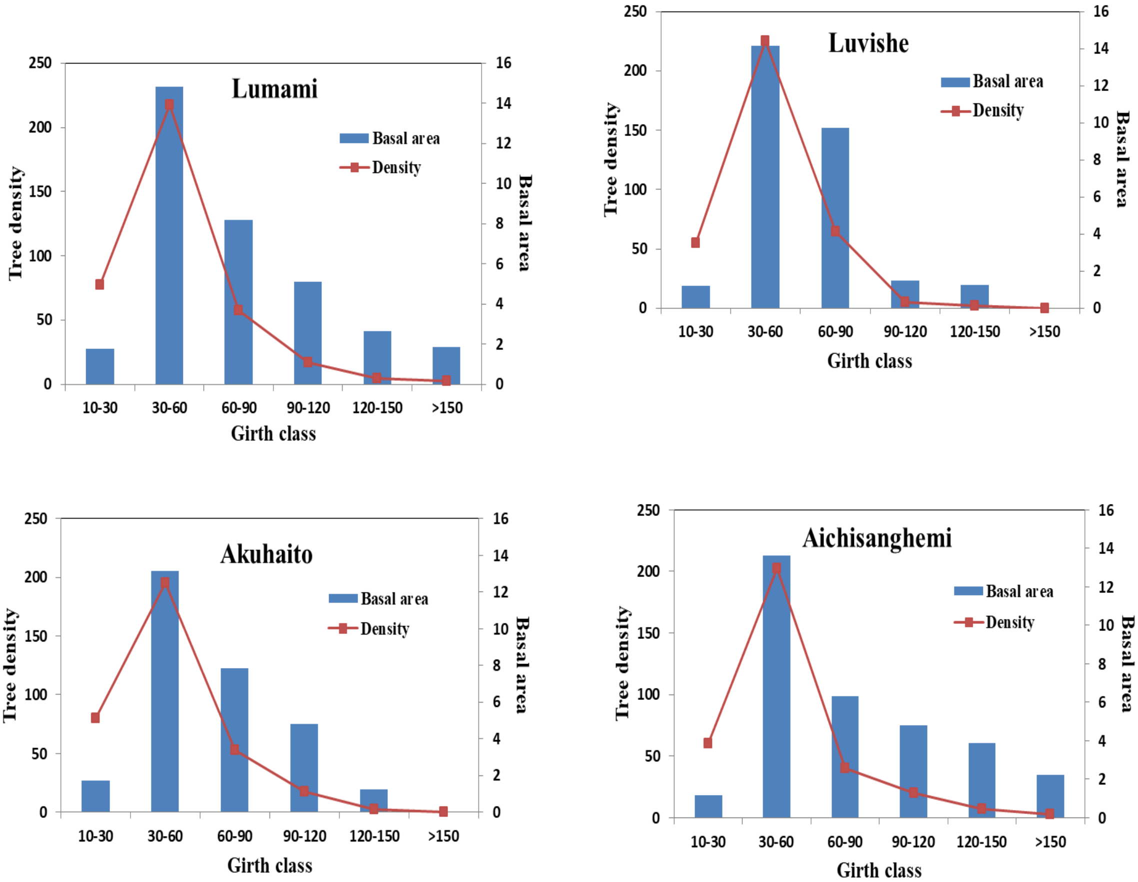
In the present study, the diversity index (H') of tree species ranged from 3.12 – 3.66 and dominance index (CD) ranged from 0.02 – 0.04. The highest diversity index was recorded from Lumami CF (3.66) followed by Luvishe CF (3.57), Akuhaito CF (3.45) and Aichisanghemi CF (3.21). The lowest diversity index was recorded from Satakha CF (3.12). The overall diversity index in all the community forest showed high species diversity and the dominance index value increased as diversity index decreased. Similarly, the highest Margalef index (Dmg) for tree species was recorded from Lumami CF (9.38) and lowest in Satakha CF (3.12) and the Pielou's evenness index (e) ranged from 0.87 – 0.95, indicating quite even of species in the community (Table 4.2.25).

In shrubs, Shannon diversity index (H') value ranged from 2.61 – 3.24 where Satakha and Lumami CF recorded the highest H' value (3.24 and 3.02). The other community forest (Luvishe, Akuhaito and Aichisanghemi) comparatively showed lower diversity (2.91, 2.98 and 2.61 respectively) indicating an average species distribution in the community. The Simpson dominance index (CD) ranged from 0.04 – 0.06 where the study observed as diversity index increased dominance index decrease. The Margalef index (Dmg) ranged from 4.53 – 5.71 and the Pielou's evenness index (e) ranged from 0.84 – 0.95 indicating evenness of species in the community (Table 4.2.25).

In herbs, the highest Shannon diversity index (H') value ranged from 2.65 – 3.17 and the Simpson dominance index (CD) ranged from 0.04 – 0.08. The highest diversity index was recorded from Aichisanghemi CF (3.17) followed by Akuhaito CF (3.14), Satakha CF (2.96) and Luvishe CF (2.75). The lowest diversity index was recorded from Lumami CF (2.65). Similarly the Margalef species richness index (Dmg) ranged from 4.20 – 6.37 where Aichisanghemi and Akuhaito CF recorded the highest Margalef index (6.37 and 6.27) and lowest in Lumami CF (4.20). The Pielou's evenness index (e) of herbs species ranged from 0.86 – 0.94 indicating that species distribution in the community is quite even (Table 4.2.25).

### 4.2.7.3 Population structure of tree species in various girth-classes

The tree density and basal area in all the community forest varied in different girth classes. The study showed that the young trees (30 – 60 cm girth class) contributed the maximum density (60%) and basal area (40%) followed by mid girth class (60 – 90 cm) contributing 15% and 26% of the total density and basal area as compared to other community forest. The young regenerating trees (10 – 30 cm girth class) also contributed tree density (19%) where as the mature trees contributed only 5% of the total tree density. Old trees (>120 cm girth class) recorded in the present study contributed 12% of the total basal area whereas regenerating trees contributed only 5%. No individuals were recorded from the community (e.g. Luvishe, Akuhaito and Satakha) in girth class (> 150 cm). Contributions of tree stand density and basal area based on girth class distribution in all the community is also shown in figure 4.2.13.



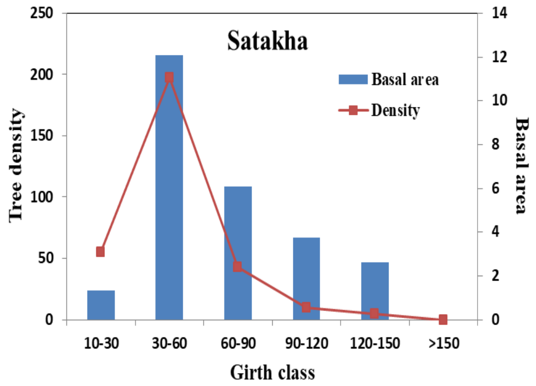



**Figure 4.2.13** Contributions of tree stand density and basal area based on girth class contribution in five study sites of Zunhebhoto District, Nagaland

### 4.2.7.4 Dominance-Diversity curve

Dominance-diversity curve of tree, shrub and herb layer showed variations in species richness and evenness in all the study sites. In trees, the dominance-diversity curve of community forests (e.g. Lumami, Luvishe and Akuhaito) showed shallow gradient indicating high species richness and evenness and the dominance-diversity curve followed a log normal distribution pattern. Whereas the dominance-diversity curve of Aichisanghemi and Satakha CF comparatively showed lower species richness and evenness and followed a broken stick distribution pattern. In shrubs, the dominance-diversity curve of community forest (e.g. Lumami, Akuhaito and Satakha) showed high species richness, equitability and low dominance and the dominance-diversity curve followed a log normal distribution pattern. Whereas the dominance-diversity curve in the community forest (e.g. Luvishe and Aichisanghemi) showed steep gradient curve indicating low equitability and high dominance of species following broken stick distribution pattern. In herbs, the dominance-diversity curve of Luvishe CF showed a broken stick series of distribution pattern indicating low species richness and species evenness in the forest (Figure 4.2.14). Among the trees, the most dominant species were: *Tetrameles nudiflora* (Lumami CF), *Quercus serrata* (Luvishe CF), *Lithocarpus elegans* (Akuhaito CF), *Bombax ceiba* (Aichisanghemi CF) and *Pongamia pinnata* (Satakha CF). In shrubs, the most dominant species were: *Clerodendrum infortunatum* (Satakha CF), *Maesa indica* (Lmuami CF), *Maesa indica* (Akuhaito CF), *Leea compactiflora* (Luvishe CF) and *Amomum pterocarpum* (Aichisanghemi CF). In herbs, the most dominant species were: *Cheilocostus speciosus* (Aichisanghemi CF), *Girardinia diversifolia* (Akuhaito CF), *Cheilocostus speciosus* (Satakha CF), *Clinopodium umbrosum* (Lusvishe CF) and *Bidens bipinnata* (Lumami CF).

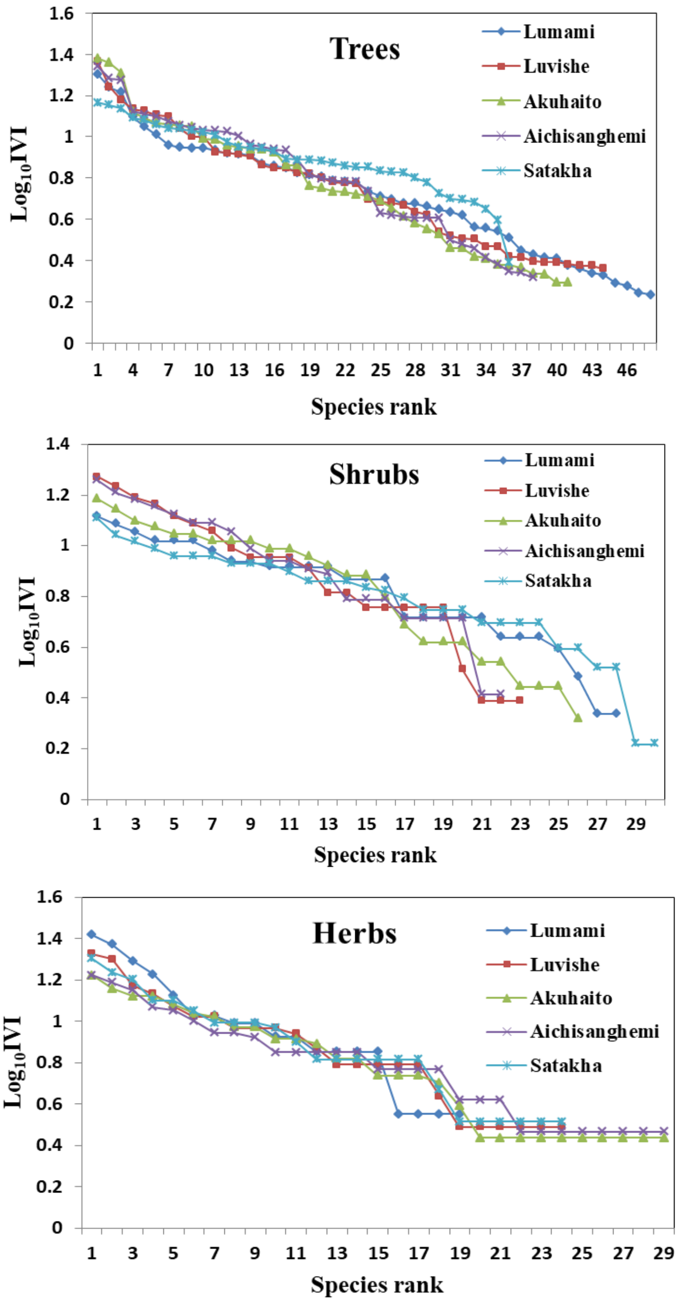



**Figure 4.2.14** Dominance-Diversity curve for trees, shrubs and herbs in five study sites of Zunhebhoto District, Nagaland

#### 4.2.7.5 Distribution pattern of tree species

The Whitford index (A/F ratio) revealed that 50% of all the plant species in the community exhibited clumped distribution pattern followed by random (30%) and regular distribution (20%) which is also a characteristic feature of a natural forest. Aichisanghemi CF recorded the highest clumped distribution (68%) followed by Akuhaito CF (59%), Luvishe CF (48%) and Lumami CF (42%) whereas in Satakha CF, maximum number of plant species exhibited random distribution (56%) followed by clumped distribution (33%) and regular distribution pattern (11%). About 11 – 27 % of the total species exhibited regular distribution in all the communities which may be resulted due to various interactions between individuals such as competition, allelopathy, root interaction etc. (Table 4.2.26).

#### 4.2.7.6 Sorenson's similarity

In the present study, Sorenson's similarity index showed higher percentage of low similarity of species content in all the communities. Gradual change in species composition and diversity was observed in the community. The Sorenson's similarity index between all the communities varied from 0.10 – 0.30 with an average of 0.18. The highest similarity (30%) was observed between Aichisanghemi CF and Satakha CF followed by Luvishe and Satakha CF (25%) and Luvishe and Aichisanghemi CF (22%), whereas the lowest Sorenson's similarity index was observed between Luvishe and Akuhaito CF (10%) and Lumami and Akuhaito CF (11%). The study showed that communities with similar altitudinal gradient have more species in common than communities occupying different altitude. Less similarity of species may also due to different anthropogenic pressures on the forest, climatic variations, species composition and various edaphic factors. Detailed analysis of species similarity between communities is shown in Table 4.2.28.

**Table 4.2.28** Sorenson Similarity indices for tree species between five study sites of Zunhebhoto District, Nagaland

| Study area | Lumami | Luvishe | Akuhaito | Aichisanghemi | Satakha |
|---|---|---|---|---|---|
| **Lumami** | x | | | | |
| **Luvishe** | 0.15 | x | | | |
| **Akuhaito** | 0.11 | 0.10 | x | | |
| **Aichisanghemi** | 0.16 | 0.22 | 0.20 | | |
| **Satakha** | 0.14 | 0.25 | 0.18 | 0.30 | x |

#### 4.2.7.7 Disturbance pattern

The average disturbance index based on cut sumps on all the study sites was 18%. The highest disturbance index was Satakha (23%) followed by Aichisanghemi (20%), Luvishe (18%), Akuhaito (16%) and only 12% in Lumami CF (Table 4.2.25). Maximum intensity of disturbances in all these regions maybe attributed to various anthropogenic pressures on account of fuelwood requirements by the local people, tree felling for timber and agriculture tools. Lopping of tree branches was also observed in Akuhaito and Lumami CF on account of fodder requirements for livestock.

### 4.2.8 Longleng district

#### 4.2.8.1 Floristic structure

*Tree species composition*

In the present study, a total of 644 individuals belonging to 98 species and 67 genera belonging to 42 families were recorded from the four community forest (Yongphang, Mongtikong, Dikhu and Yongam) of Longleng district, Nagaland, Northeast India. Out of these, 50 species, 38 genera, 29 families and 164 individuals were recorded from Yongphang; 49 species, 38 genera, 28 families and 163 individuals from Mongtikong; 47 species, 36 genera, 27 families and 159 individuals from Dikhu and 43 species, 33 genera, 25 families and 158 individuals from Yongam community forest of Nagaland respectively (Table 4.2.29). Based on IVI value, the most dominant tree species in Yongphang CF were: *Albizia procera* (13.45), *Acrocarpus fraxinifolius* (12.46) and *Tetrameles nudiflora* (11.23) and the co-dominant species were: *Ficus silhetensis* (10.97), *Litsea laeta* (10.35) and *Bombax ceiba* (10.36) (Table 4.2.30). The most dominant families were: Euphorbiaceae, Magnoliaceae and Moraceae. In Mongtikong CF, the dominant tree species were: *Spondias pinnata* (20.57), *Firmiana colorata* (20.10) and *Canarium strictum* (18.70) and the co-dominant species were: *Morus laevigata* (11.96), *Albizia procera* (11.07) *and Altingia excelsa* (10.76) (Table 4.2.30). The most dominant families were: Clusiaceae, Magnoliaceae and Sterculiaceae. In Dikhu, the dominant species were: *Gmelina arborea* (18.05), *Drimycarpus racemosus* (17.38) and *Magnolia champaca* (15.17) and the co-dominant species were: *Canarium bengalense* (12.30), *Morus laevigata* (11.22) and *Pterospermum lanceifolium* (10.88) (Table 4.2.30). The dominant families were: Clusiaceae, Euphorbiaceae and Moraceae. In Yongam, the most dominant species were: *Ailanthus integrifolia* (20.19), *Altingia excelsa* (20.04) and *Lagerstroemia speciosa* (19.00) and the co-dominant species were: *Stereospermum chelonoides* (15.99), *Bischofia javanica* (14.33) and *Garcinia cowa* (14.23) (Table 4.2.30). The dominant families were: Euphorbiaceae, Magnoliaceae and Magnoliaceae. The tree stand density (individuals $ha^{-1}$) in the community forest ranged from 395 – 410 where Yongphang and Mongtikong CF (410 and 408) comparatively recorded higher density than Dikhu and Yongam CF (398 and 395). The basal area ($m^2 ha^{-1}$) ranged from 36.26 – 39.22 where the highest basal area was recorded from Mongtikong CF (39.22) followed by Dikhu CF (38.37) and Yongphang CF (37.78) and the lowest from Yongam CF (36.26) (Table 4.2.29).

**Table 4.2.29** Phytosociological attributes of trees, shrubs and herbs in four study sites of Longleng District, Nagaland

| Parameters | Yongphang | Mongtikong | Dikhu | Yongam |
|---|---|---|---|---|
| **Trees** | | | | |
| No. of species | 50 | 49 | 47 | 43 |
| No. of genera | 38 | 38 | 36 | 33 |
| Families | 29 | 28 | 27 | 25 |
| Density (individuals $ha^{-1}$) | 410 | 408 | 398 | 395 |
| Basal area ($m^2 ha^{-1}$) | 37.78 | 39.22 | 38.37 | 36.26 |
| Shannon diversity index (H') | 3.79 | 3.71 | 3.68 | 3.48 |
| Simpson index (CD) | 0.02 | 0.03 | 0.03 | 0.04 |
| Margalef index (Dmg) | 9.61 | 9.42 | 9.07 | 8.30 |
| Evenness (e) | 0.97 | 0.95 | 0.96 | 0.92 |
| Disturbance index (%) | 9 | 11 | 13 | 15 |

| | | | | |
|---|---|---|---|---|
| **Shrubs** | | | | |
| No. of species | 18 | 19 | 24 | 20 |
| No. of genera | 16 | 19 | 24 | 19 |
| Families | 14 | 16 | 19 | 14 |
| Density (individuals $ha^{-1}$) | 5650 | 5500 | 7100 | 5900 |
| Shannon diversity index (H') | 2.40 | 2.63 | 2.79 | 2.65 |
| Simpson index (CD) | 0.12 | 0.09 | 0.07 | 0.09 |
| Margalef index (Dmg) | 3.60 | 3.83 | 4.64 | 3.98 |
| Evenness (e) | 0.83 | 0.89 | 0.88 | 0.88 |
| **Herbs** | | | | |
| No. of species | 34 | 28 | 21 | 26 |
| No. of genera | 31 | 24 | 20 | 24 |
| Families | 19 | 14 | 10 | 18 |
| Density (individuals $ha^{-1}$) | 83750 | 70625 | 57500 | 69375 |
| Shannon diversity index (H') | 3.21 | 3.09 | 2.95 | 3.00 |
| Simpson index (CD) | 0.05 | 0.06 | 0.07 | 0.06 |
| Margalef index (Dmg) | 6.74 | 5.71 | 4.42 | 5.31 |
| Evenness (e) | 0.91 | 0.92 | 0.97 | 0.92 |

*Shrub species composition*

In shrubs, a total of 46 species and 35 genera representing 24 families were recorded from four community forest (Yongphang, Mongtikong, Dikhu and Yongam) of Longleng district, Nagaland. Out of these, 24 species, 24 genera and 19 families were recorded from Dikhu CF followed by 20 species, 19 genera and 14 families from Yongam CF; 19 species, 19 genera and 16 families from Mongtikong CF and 18 species, 16 genera and 14 families were recorded from Yongphang CF respectively (Table 4.2.29). Based on IVI value, the most dominant shrub species in Dikhu CF were: *Clerodendrum infortunatum* (24.76), *Mussaenda frondosa* (22.65) and *Dendrocnide sinuata* (19.13) (Table 4.2.31) and the dominant families were: Malvaceae and Rubiaceae. In Yongam CF, the most dominant species were: *Osbeckia nepalensis* (20.76), *Mussaenda frondosa* (19.06) and *Melastoma nepalense* (16.52) (Table 4.2.31) and the dominant families were: Melastomataceae, Rubiaceae and Urticaceae. In Mongtikong CF, the dominant shrub species were: *Boehmeria glomerulifera* (25.20), *Osbeckia nepalensis* (22.47) and *Strobilanthes adnata* (20.65) (Table 4.2.31) and the most dominant families were: Myrsinaceae and Urticaceae. In Yongphang CF, dominant species were: *Croton caudatus* (30.29), *Dendrocnide* *sinuata* (26.75) and *Casearia vareca* (24.98) (Table 4.2.31) and the dominant families were: Rubiaceae, Urticaceae and Zingiberaceae. From the present study, the highest shrub density (individuals $ha^{-1}$) was recorded from Dikhu CF (7100) followed by Yongam CF (5900), Yongphang CF (5650) and the lowest in Mongtikong CF (5500) respectively (Table 4.2.29).

*Herb species composition*

In herbs, a total of 79 species, 63 genera representing 31 families were recorded from four community forest (Yongphang, Mongtikong, Dikhu and Yongam) of Longleng district, Nagaland. Out of these, 34 species, 31 genera and 19 families were recorded from Yongphang CF followed by 28 species, 24 genera and 14 families from Mongtikong CF; 26 species, 24 genera and 14 families from Yongam CF and 21 species, 20 genera and 10 families from Dikhu CF of Nagaland respectively (Table 4.2.29). In Yongphang CF, the most dominant herb species were: *Cheilocostus speciosus* (17.95), *Dysphania ambrosioides* (16.46) and *Dioscorea tomentosa* (14.96) (Table 4.2.31) and the dominant families were: Asteraceae, Cyperaceae and Poaceae. In Mongtikong CF, the most dominant species were: *Pouzolzia hirta* (17.87), *Cyanotis cristata* (16.10) and *Mikania micrantha* (13.44) (Table 4.2.31) and the dominant families were: Asteraceae, Poaceae and Zingiberaceae. In Yongam CF, the dominant species were: *Gonostegia pentandra* (21.08), *Aeschyanthus acuminatus* (16.58) and *Tinospora sinensis* (14.91) (Table 4.2.31) and the dominant families were: Asteraceae, Menispermaceae and Vitaceae. In Dikhu CF, the dominant species were: *Dioscorea tomentosa* (18.01), *Cheilocostus speciosus* (15.84) and *Sonchus wightianus* (13.66) (Table 4.2.31) and the most dominant families were: Asteraceae, Vitaceae and Zingiberaceae. The highest herb density (individuals $ha^{-1}$) was recorded from Yongphang CF (83750) followed by Mongtikong CF (70625), Yongam CF (69375) and Dikhu CF (57500) respectively (Table 4.2.29).

**Table 4.2.30** Density (individuals $ha^{-1}$), Basal area ($m^2ha^{-1}$), Important value index (IVI) and Distribution pattern (DP) of tree species in four study sites of Longleng District, Nagaland

| **Species** | **Family** | **Yongphang** | | | | **Mongtikong** | | | | **Dikhu** | | | | **Yongam** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** |
| *Acrocarpus fraxinifolius* Arn. | Leguminosae | 12.5 | 2.41 | 12.46 | RE | | | | | 7.5 | 1.00 | 6.53 | R | | | | |
| *Ailanthus integrifolia* Lam. | Simaroubaceae | 5 | 0.56 | 3.70 | C | 10 | 0.79 | 7.38 | C | 2.5 | 1.25 | 4.91 | C | 30 | 3.06 | 20.19 | C |
| *Albizia procera* (Roxb.) Benth. | Mimosaceae | 17.5 | 1.94 | 13.45 | RE | 12.5 | 1.62 | 11.07 | C | 10 | 1.10 | 8.45 | C | 5 | 0.66 | 4.14 | C |
| *Alstonia scholaris* (L.) R. Br. | Apocynaceae | | | | | 7.5 | 0.88 | 6.98 | RE | 5 | 0.65 | 3.98 | C | | | | |
| *Altingia excelsa* Noronha | Altingiaceae | 5 | 0.96 | 4.76 | C | 12.5 | 1.49 | 10.76 | C | | | | | 35 | 2.54 | 20.04 | C |
| *Aphananthe cuspidata* (Bl.) Planch. | Ulmaceae | | | | | 5 | 0.55 | 4.57 | C | 12.5 | 1.64 | 9.46 | C | | | | |
| *Aquilaria agallocha* (Lour.) Roxb. | Thymelaeaceae | 5 | 0.76 | 4.25 | C | | | | | | | | | 10 | 0.92 | 8.20 | RE |
| *Artocarpus chama* Buch.-Ham. | Moraceae | 2.5 | 0.14 | 1.98 | R | | | | | | | | | | | | |
| *Artocarpus lacucha* Buch.-Ham. | Moraceae | | | | | | | | | 10 | 1.11 | 8.48 | RE | 5 | 0.59 | 4.97 | C |
| *Bauhinia divergens* Baker | Caesalpiniaceae | 5 | 0.41 | 3.33 | C | | | | | | | | | | | | |
| *Bauhinia purpurea* L. | Caesalpiniaceae | 5 | 0.46 | 3.44 | C | 2.5 | 0.06 | 1.75 | R | | | | | 2.5 | 0.22 | 2.29 | C |
| *Bauhinia variegata* L. | Caesalpiniaceae | 7.5 | 0.64 | 5.54 | R | | | | | | | | | | | | |
| *Bischofia javanica* Blume | Euphorbiaceae | 5 | 0.68 | 4.02 | C | 7.5 | 0.97 | 7.23 | RE | 15 | 1.13 | 9.77 | R | 22.5 | 1.62 | 14.33 | C |
| *Bombax ceiba* L. | Malvaceae | 10 | 2.12 | 10.06 | R | 2.5 | 1.94 | 6.54 | R | 2.5 | 1.89 | 6.58 | C | | | | |
| *Brassaiopsis mitis* C.B.Clarke | Araliaceae | 7.5 | 0.65 | 5.58 | R | | | | | | | | | | | | |
| *Canarium bengalense* Roxb. | Burseraceae | | | | | | | | | 15 | 2.10 | 12.30 | R | | | | |
| *Canarium strictum* Roxb. | Burseraceae | 12.5 | 1.49 | 9.01 | C | 27.5 | 3.16 | 18.70 | R | | | | | 7.5 | 1.30 | 7.56 | C |
| *Caryota obtusa* Griff. | Arecaceae | 5 | 0.61 | 3.84 | C | | | | | | | | | | | | |
| *Caryota Urens* L. | Arecaceae | 5 | 0.48 | 3.51 | C | | | | | | | | | | | | |
| *Claoxylon khasianum* Hook.f. | Euphorbiaceae | 10 | 0.14 | 5.83 | RE | | | | | | | | | | | | |
| *Cleistanthus monoicus* Lour. | Euphorbiaceae | | | | | | | | | 5 | 0.37 | 3.25 | C | | | | |
| *Dalbergia mimosoides* Franch. | Papilionaceae | 7.5 | 0.21 | 4.40 | R | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Dillenia indica* L. | Dilliniaceae | 10 | 1.72 | 10.03 | RE | 5 | 0.40 | 4.18 | RE | 7.5 | 1.39 | 8.56 | RE | 5 | 0.55 | 3.83 | C |
| *Dillenia pentagyna* Roxb. | Dilliniaceae | 7.5 | 0.91 | 6.25 | R | | | | | | | | | | | | |
| *Dimocarpus longan* Lour. | Sapindaceae | | | | | | | | | 5 | 0.47 | 4.52 | C | | | | |
| *Dipterocarpus retusus* Blume | Dipterocarpaceae | 5 | 0.49 | 3.51 | C | 5 | 1.04 | 4.86 | C | | | | | 5 | 0.65 | 4.10 | C |
| *Drimycarpus racemosus* (Roxb.) Hook. f. | Anacardiaceae | | | | | | | | | 20 | 3.17 | 17.38 | C | | | | |
| *Duabanga grandiflora* (DC.) Walp. | Lythraceae | | | | | 15 | 1.90 | 12.41 | RE | | | | | 12.5 | 1.88 | 12.51 | RE |
| *Elaeocarpus aristatus* Roxb. | Elaeocarpaceae | 12.5 | 0.76 | 9.09 | RE | | | | | | | | | | | | |
| *Elaeocarpus braceanus* Watt ex C. B. Clarke | Elaeocarpaceae | | | | | | | | | 5 | 0.37 | 3.25 | C | | | | |
| *Elaeocarpus floribundus* Blume | Elaeocarpaceae | | | | | 5 | 0.39 | 4.15 | C | | | | | 10 | 0.71 | 7.62 | RE |
| *Elaeocarpus lanceifolius* Roxb. | Elaeocarpaceae | 10 | 0.96 | 7.00 | R | 7.5 | 0.46 | 5.93 | RE | 5 | 0.83 | 5.47 | RE | | | | |
| *Elaeocarpus tectorius* (Lour.) Poir. | Elaeocarpaceae | | | | | 5 | 0.52 | 3.52 | C | 5 | 0.58 | 3.79 | C | 7.5 | 0.71 | 5.95 | C |
| *Eurya acuminata* DC. | Theaceae | 5 | 0.24 | 2.85 | C | 17.5 | 0.50 | 9.44 | RE | 5 | 0.13 | 3.63 | RE | 5 | 0.22 | 3.97 | RE |
| *Ficus benghalensis* L. | Moraceae | 7.5 | 0.69 | 5.68 | R | | | | | | | | | | | | |
| *Ficus hispida* L.f. | Moraceae | 5 | 0.26 | 2.93 | C | 7.5 | 0.39 | 4.77 | R | | | | | | | | |
| *Ficus lamponga* Miq. | Moraceae | | | | | 2.5 | 1.30 | 4.89 | R | 5 | 0.86 | 4.51 | C | 2.5 | 0.14 | 2.07 | RE |
| *Ficus racemosa* L. | Moraceae | 5 | 0.36 | 3.19 | C | | | | | 5 | 0.29 | 3.04 | C | 5 | 0.32 | 4.24 | C |
| *Ficus semicordata* Buch.-Ham. ex Sm. | Moraceae | | | | | 10 | 0.84 | 7.50 | C | | | | | | | | |
| *Ficus silhetensis* Miq. | Moraceae | 22.5 | 0.54 | 10.97 | R | | | | | | | | | | | | |
| *Ficus subincisa* Buch.-Ham. ex Sm. | Moraceae | | | | | | | | | 5 | 0.08 | 2.50 | C | | | | |
| *Firmiana colorata* (Roxb.) R.Br. | Sterculiaceae | 10 | 1.07 | 8.30 | RE | 32.5 | 3.23 | 20.10 | R | 12.5 | 1.09 | 9.04 | RE | 5 | 0.50 | 3.69 | C |
| *Garcinia anomala* Planch. & Triana | Clusiaceae | 7.5 | 0.34 | 4.75 | R | 2.5 | 0.06 | 1.72 | C | 5 | 0.19 | 3.79 | C | 2.5 | 0.19 | 2.19 | R |
| *Garcinia cowa* Roxb. ex Choisy | Clusiaceae | 15 | 1.15 | 9.74 | R | 5 | 0.51 | 3.51 | C | 5 | 0.18 | 2.75 | C | 27.5 | 1.13 | 14.23 | R |
| *Garcinia sopsopia* Buch. -Ham. | Clusiaceae | 5 | 0.40 | 3.30 | C | 2.5 | 0.19 | 2.06 | C | 5 | 0.11 | 2.57 | C | 5 | 0.40 | 4.46 | RE |
| *Garcinia xanthochymus* Hook.f. | Clusiaceae | | | | | | | | | 5 | 0.13 | 3.64 | RE | 12.5 | 0.97 | 8.96 | C |
| *Glochidion zeylanicum* Gaertn. | Euphorbiaceae | | | | | | | | | | | | | 17.5 | 0.37 | 9.62 | RE |
| *Gmelina arborea* Roxb. | Verbenaceae | | | | | 10 | 1.03 | 7.02 | R | 30 | 2.46 | 18.05 | R | 7.5 | 0.99 | 6.72 | R |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Grewia optiva* J. R. Drumm. | Tiliaceae | | | | | 7.5 | 0.63 | 5.39 | R | 5 | 0.12 | 2.60 | C | | | | |
| *Grewia serrulata* DC. | Tiliaceae | 7.5 | 0.68 | 5.66 | R | | | | | | | | | | | | |
| *Hydnocarpus kurzii* (King) Warb. | Flacourtiaceae | 5 | 0.50 | 3.56 | C | 7.5 | 0.41 | 5.80 | RE | 7.5 | 0.65 | 5.62 | C | 5 | 0.34 | 3.24 | C |
| *Lagerstroemia speciosa* (L.) Pers. | Lythraceae | 10 | 1.27 | 7.81 | R | 10 | 1.13 | 7.28 | R | 12.5 | 1.74 | 9.71 | C | 25 | 3.08 | 19.00 | R |
| *Lindera latifolia* Hook. fil. | Lauraceae | 7.5 | 0.25 | 4.51 | R | | | | | | | | | | | | |
| *Litsea laeta* (Wall. ex Nees) Hook.f. | Lauraceae | 20 | 0.54 | 10.35 | RE | | | | | | | | | | | | |
| *Litsea monopetala* (Roxb.) Pers. | Lauraceae | | | | | 5 | 0.42 | 3.28 | C | | | | | | | | |
| *Litsea salicifolia* (Roxb. ex Nees) | Lauraceae | | | | | 5 | 0.37 | 3.15 | C | 2.5 | 0.10 | 1.92 | C | | | | |
| *Livistona jenkinsiana* Griff. | Arecaceae | | | | | | | | | 7.5 | 0.56 | 6.42 | RE | | | | |
| *Macaranga denticulata* (Blume) Müll.Arg. | Euphorbiaceae | | | | | 10 | 0.65 | 7.01 | RE | 15 | 0.84 | 9.03 | R | 7.5 | 0.50 | 6.41 | RE |
| *Macaranga indica* Wight | Euphorbiaceae | | | | | 2.5 | 0.18 | 2.05 | R | | | | | 7.5 | 0.42 | 5.15 | R |
| *Macropanax dispermus* (Blume) Kuntze | Araliaceae | 5 | 0.44 | 3.39 | C | | | | | 5 | 0.35 | 3.20 | C | 2.5 | 0.16 | 2.13 | C |
| *Magnolia cathcartii* (Hook.f.&Thomson.) Noot. | Magnoliaceae | 2.5 | 0.14 | 2.00 | R | | | | | 10 | 0.70 | 8.43 | RE | 2.5 | 0.23 | 2.32 | RE |
| *Magnolia champaca* (L.) Baill. | Magnoliaceae | | | | | 5 | 0.42 | 3.27 | C | 17.5 | 2.57 | 15.17 | C | 5 | 0.40 | 4.45 | RE |
| *Magnolia insignis* Wall. | Magnoliaceae | 7.5 | 1.59 | 9.06 | RE | 2.5 | 0.20 | 2.11 | C | 7.5 | 0.65 | 5.62 | R | 7.5 | 0.65 | 5.78 | C |
| *Magnolia rabaniana* (Hook.f. & Thomson) D.C.S.Raju & M.P.Nayar | Magnoliaceae | 5 | 0.27 | 2.96 | C | 2.5 | 0.17 | 2.02 | C | 7.5 | 0.47 | 5.16 | R | | | | |
| *Mallotus paniculatus* Lam. | Euphorbiaceae | | | | | | | | | 2.5 | 0.15 | 2.03 | R | | | | |
| *Melia azedarach* L. | Meliaceae | | | | | 12.5 | 1.34 | 10.36 | RE | | | | | | | | |
| *Meliosma simplicifolia* (Roxb.) | Sabiaceae | | | | | | | | | | | | | 10 | 0.22 | 6.28 | RE |
| *Mesua ferrea* L. | Clusiaceae | | | | | 5 | 0.38 | 3.16 | C | 5 | 0.30 | 3.05 | C | 5 | 0.41 | 3.43 | C |
| *Morus laevigata* Wall. ex Brandis | Moraceae | 7.5 | 0.92 | 6.28 | R | 15 | 1.72 | 11.96 | RE | 12.5 | 1.53 | 11.22 | RE | 10 | 1.42 | 9.57 | C |
| *Myrica esculenta* Buch.-Ham. ex D. | Myricaceae | | | | | | | | | | | | | 5 | 0.43 | 3.49 | C |
| *Myrica fraquhariana* Wall. | Myricaceae | | | | | | | | | | | | | 7.5 | 0.19 | 5.55 | RE |
| *Oroxylum indicum* (L.) Kurz | Bignoniaceae | | | | | 10 | 0.15 | 4.77 | R | | | | | | | | |
| *Persea gamblei* King ex Hook. f. | Lauraceae | | | | | | | | | | | | | 2.5 | 0.60 | 3.32 | C |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Phoebe lanceolata* (Nees) Nees | Lauraceae | 10 | 1.33 | 10.00 | RE | | | | | | | | | | | | |
| *Phyllanthus reticulatus* Poir. | Euphorbiaceae | 12.5 | 0.39 | 8.12 | RE | | | | | | | | | | | | |
| *Pongamia pinnata* (L.) Pierre | Leguminosae | 7.5 | 0.99 | 5.47 | C | | | | | | | | | | | | |
| *Premna latifolia* Roxb. | Lamiaceae | | | | | | | | | 10 | 0.29 | 5.31 | R | | | | |
| *Prunus ceylanica* (Wight) Miq. | Rosaceae | 5 | 0.59 | 3.79 | C | | | | | | | | | | | | |
| *Pterospermum lanceifolium* Roxb. | Sterculiaceae | | | | | 7.5 | 0.79 | 6.76 | C | 15 | 1.55 | 10.88 | C | | | | |
| *Quercus griffithii* Hook.f. | Fagaceae | | | | | 2.5 | 0.18 | 2.04 | R | | | | | | | | |
| *Reevesia wallichii* R. Br. | Malvaceae | | | | | 5 | 0.32 | 3.01 | C | | | | | | | | |
| *Rhus chinensis* Mill. | Anacardiaceae | 2.5 | 0.18 | 2.09 | R | | | | | | | | | | | | |
| *Rhus succedanea* L. | Anacardiaceae | | | | | 2.5 | 0.25 | 2.22 | R | | | | | | | | |
| *Saurauia armata* Kurz | Actinidiaceae | | | | | 7.5 | 0.32 | 4.59 | R | | | | | | | | |
| *Schefflera wallichiana* (Wight & Arn.) Harms. | Araliaceae | | | | | | | | | 5 | 0.10 | 2.54 | C | | | | |
| *Spondias pinnata* (L.f.) Kurz. | Anacardiaceae | 12.5 | 0.54 | 7.51 | RE | 37.5 | 2.93 | 20.57 | R | | | | | | | | |
| *Sterculia coccinea* Roxb. | Malvaceae | 5 | 0.43 | 3.37 | C | 5 | 0.27 | 2.90 | C | | | | | 2.5 | 0.23 | 2.32 | C |
| *Sterculia villosa* Roxb. | Sterculiaceae | | | | | 5 | 0.33 | 4.01 | C | 5 | 0.26 | 2.95 | C | 7.5 | 0.60 | 6.68 | RE |
| *Stereospermum chelonoides* L.f. | Bignoniaceae | | | | | | | | | | | | | 15 | 2.91 | 15.99 | C |
| *Styrax serrulatus* Roxb. | Styracaceae | | | | | | | | | 12.5 | 0.37 | 7.16 | C | | | | |
| *Syzygium cumini* (L.) Skeels | Myrtaceae | | | | | | | | | 12.5 | 0.27 | 7.94 | RE | | | | |
| *Syzygium reticulatum* (Wight) Walp. | Myrtaceae | | | | | | | | | 5 | 0.20 | 3.81 | C | | | | |
| *Talauma hodgsonii* J. D. Hooker & Thomson | Magnoliaceae | | | | | 5 | 0.39 | 3.18 | C | | | | | | | | |
| *Terminalia myriocarpa* Van Heurck & Müll. Arg. | Combretaceae | | | | | | | | | | | | | 10 | 1.67 | 10.27 | C |
| *Tetrameles nudiflora* R. Br. | Tetramelaceae | 12.5 | 1.95 | 11.23 | RE | 5 | 0.66 | 3.87 | C | | | | | 5 | 1.05 | 6.23 | C |
| *Toona sureni* (Blume) Merr. | Meliaceae | | | | | 5 | 0.38 | 4.15 | C | | | | | | | | |
| *Trevesia palmata* (Roxb. ex Lindl.) | Araliaceae | | | | | | | | | | | | | 5 | 0.08 | 2.53 | C |
| *Wendlandia wallichii* Wight & Arn. | Rubiaceae | 10 | 0.23 | 6.08 | RE | | | | | | | | | | | | |

**Key to abbreviation:** RE= Regular; R= Random; C= Clumped

#### 4.2.8.2 Species diversity indices

In the present study, the community forest with higher diversity index showed low dominance value which is also considered as a characteristic feature of a natural forest. In trees, the highest diversity index (H') was recorded from Yongphang CF (3.79) followed by Mongtikong CF (3.71) and Dikhu CF (3.68). The lowest diversity index was recorded from Yongam CF (3.48). The Simpson dominance index (CD) ranged from 0.02 – 0.04, where the highest dominance index was recorded from Yongam CF (0.04) and as dominance index value increased, diversity index decrease. The Margalef index (Dmg) for tree species ranged from 8.30 – 9.61 where Yongphang CF recorded the highest species richness value (9.61) followed by Mongtikong CF (9.42), Dikhu CF (9.07) and Yongam CF (8.30). The Pielou's evenness index (e) ranged from 0.92 – 0.97 indicating quite even of species in the community (Table 4.2.29).

In shrubs, Shannon diversity index (H') value ranged from 2.40 – 2.79 where the highest diversity index (H') was recorded from Dikhu CF (2.79) followed by Yongam CF (2.65), Mongtikong CF (2.63) and lowest in Yongphang CF (2.40). The Simpson dominance index (CD) ranged from 0.07 – 0.12 and the Margalef index (Dmg) of ranged from 3.60 – 3.98 indicating low species richness in the community. The Pielou's evenness index (e) ranged from 0.83 – 0.89 showing less evenness of species in the community (Table 4.2.29).

In herbs, the highest Shannon diversity index (H') value ranged from 2.95 – 3.21 where Yongphang CF (3.21) recorded the highest diversity and lowest in Dikhu CF (2.95). The Simpson dominance index (CD) ranged from 0.05 – 0.07 where the study showed that the dominance index value was inversely proportional to diversity index value. The Margalef species richness index (Dmg) ranged from 4.42 – 6.74 and the Pielou's evenness index (e) ranged from 0.91 – 0.97 indicating high equitability of species in the community (Table 4.2.29).

**Table 4.2.31** Density (individuals ha$^{-1}$) and Important value index (IVI) of shrubs and herbs species in four study sites of Longleng District, Nagaland

| Species | Family | Yongphang | | Mongtikong | | Dikhu | | Yongam | |
|---|---|---|---|---|---|---|---|---|---|
| | | D | IVI | D | IVI | D | IVI | D | IVI |
| **Shrubs** | | | | | | | | | |
| *Abroma augusta* (L.) L.f. | Malvaceae | | | 200 | 10.65 | 200 | 9.27 | | |
| *Abutilon indicum* (L.) Sweet | Malvaceae | | | | | | | 150 | 5.72 |
| *Agapetes angulata* (Griff.) Hook.f. | Ericaceae | 150 | 6.74 | 100 | 5.33 | | | | |
| *Amischotolype hookeri* (Hassk.) H.Hara | Commelinaceae | | | | | | | 250 | 9.00 |
| *Amomum koenigii* J. F. Gmelin | Zingiberaceae | | | 250 | 11.56 | | | | |
| *Amomum pterocarpum* Thwaites | Zingiberaceae | 100 | 3.81 | | | | | | |
| *Amomum subulatum* Roxb. | Zingiberaceae | 150 | 8.78 | | | 150 | 5.34 | | |
| *Boehmeria glomerulifera* Miq. | Urticaceae | | | 1000 | 25.20 | 300 | 9.06 | 300 | 11.43 |
| *Boehmeria japonica* (L.f.) Miq. | Urticaceae | 300 | 13.47 | | | | | | |
| *Calamus erectus* Roxb. | Acoraceae | | | 100 | 5.33 | | | 200 | 9.74 |
| *Calamus leptospadix* Griff. | Arecaceae | 200 | 9.66 | | | 150 | 5.34 | | |
| *Casearia vareca* Roxb. | Flacourtiaceae | 950 | 24.98 | 200 | 8.90 | 100 | 3.02 | 250 | 10.59 |
| *Clerodendrum glandulosum* Lindl. | Verbenaceae | | | 300 | 10.72 | | | | |
| *Clerodendrum infortunatum* L. | Verbenaceae | | | | | 1300 | 24.76 | 450 | 13.98 |
| *Crotalaria juncea* L. | Papilionaceae | | | 150 | 6.24 | | | | |
| *Croton caudatus* Geiseler | Euphorbiaceae | 1250 | 30.29 | | | 150 | 5.34 | | |
| *Daphne involucrata* Wall. | Thymelaeaceae | | | | | 150 | 5.34 | | |
| *Debregeasia longifolia* (Burm.f.) Wedd. | Urticaceae | | | 100 | 5.33 | | | 100 | 4.87 |
| *Dendrocnide sinuata* (Blume) Chew | Urticaceae | 1050 | 26.75 | 200 | 8.90 | 900 | 19.13 | 250 | 9.00 |
| *Desmodium teres* Benth. | Papilionaceae | | | | | | | 150 | 5.72 |
| *Desmodium triquetrum* (L.) DC. | Papilionaceae | 100 | 5.85 | | | 100 | 3.02 | 200 | 9.74 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Dracaena angustifolia* (Medik.) Roxb. | Dracaenaceae | 200 | 9.66 | 250 | 11.56 | 150 | 5.34 | | |
| *Embelia ribes* Burm.f. | Myrsinaceae | | | 300 | 12.47 | | | 150 | 5.72 |
| *Eriobotrya bengalensis* (Roxb.) Hook.f. | Rosaceae | 250 | 10.55 | | | 150 | 6.95 | | |
| *Eurya japonica* Thunb. | Theaceae | | | | | | | 300 | 11.43 |
| *Glochidion lanceolarium* (Roxb.) Voigt | Euphorbiaceae | | | | | | | 150 | 5.72 |
| *Hibiscus sabdariffa* L. | Malvaceae | | | | | 200 | 6.04 | | |
| *Leea compactiflora* Kurz | Leeaceae | | | | | 200 | 6.04 | | |
| *Leea macrophylla* Roxb. ex Hornem. | Leeaceae | | | 200 | 8.90 | | | | |
| *Maesa ramentacea* (Roxb.) A. DC. | Myrsinaceae | | | 150 | 7.99 | 150 | 5.34 | 150 | 7.30 |
| *Melastoma napalense* Lodd. | Melastomataceae | 300 | 13.47 | | | 250 | 9.97 | 600 | 16.52 |
| *Morinda angustifolia* Roxb. | Rubiaceae | 50 | 2.93 | | | 200 | 7.66 | 250 | 7.41 |
| *Mussaenda frondosa* L. | Rubiaceae | 50 | 2.93 | | | 1150 | 22.65 | 750 | 19.06 |
| *Mussaenda roxburghii* Hook.f. | Rubiaceae | 200 | 9.66 | | | | | | |
| *Nostolachma khasiana* (Korth.) Deb & Lahiri | Rubiaceae | | | | | 100 | 4.63 | | |
| *Osbeckia nepalensis* Hook.f. | Melastomataceae | | | 850 | 22.47 | | | 850 | 20.76 |
| *Phrynium capitatum* Willd. | Marantaceae | | | 100 | 5.33 | | | | |
| *Phrynium rheedei* Suresh & Nicolson | Marantaceae | | | | | 200 | 7.66 | | |
| *Phrynium species* L. | Marantaceae | 100 | 5.85 | | | | | | |
| *Sambucus javanica* Blume | Sambucaceae | 150 | 8.78 | 200 | 8.90 | 250 | 8.36 | 250 | 9.00 |
| *Scutellaria discolor* Colebr. | Lamiaceae | | | | | | | 150 | 7.30 |
| *Solanum nigrum* L. | Solanaceae | | | | | 200 | 6.04 | | |
| *Strobilanthes adnata* C.B.Clarke | Acanthaceae | 100 | 5.85 | 750 | 20.65 | | | | |
| *Strobilanthes hamiltoniana* (Steud.) Bosser & Heine | Acanthaceae | | | | | 200 | 7.66 | | |
| *Urena labota* L. | Malvaceae | | | | | 200 | 6.04 | | |
| *Wallichia oblongifolia* Griff. | Arecaceae | | | 100 | 3.57 | | | | |
| **Herbs** | | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Acampe ochracea* (Lindl.) Hochr. | Orchidaceae | | | 625 | 2.25 | | | | |
| *Acanthephippium striatum* Lindl. | Orchidaceae | 2500 | 5.62 | | | | | | |
| *Acanthephippium sylhetense* Lindl. | Orchidaceae | | | | | | | 1250 | 3.46847 |
| *Acmella paniculata* (Wall. ex DC.) R.K.Jansen | Asteraceae | 3125 | 7.68 | | | | | | |
| *Aerides crassifolia* Parish & Rchb.f | Orchidaceae | | | 3125 | 9.90 | | | 1875 | 6.03604 |
| *Aerides odorata* Lour. | Orchidaceae | 1875 | 4.87 | | | | | | |
| *Aerides rosea* Lodd. ex Lindl. & Paxton | Orchidaceae | | | | | 3125 | 9.01 | | |
| *Aeschynanthus acuminatus* Wall. Ex A. DC. | Gesneriaceae | | | 1875 | 6.76 | 1250 | 5.75 | 6875 | 16.5766 |
| *Aeschynanthus parasiticus* (Roxb.) Wall. | Gesneriaceae | | | | | | | 3750 | 12.0721 |
| *Alpinia malaccensis* (Burm.f.) Roscoe | Zingiberaceae | | | 1250 | 4.51 | | | | |
| *Ampelopsis rubifolia* (Wall.) Planch. | Vitaceae | | | | | | | 1875 | 6.03604 |
| *Andropogon chinensis* (Nees) Merr. | Poaceae | 1250 | 2.81 | | | | | | |
| *Begonia palmata* D. Don | Begoniaceae | 3750 | 9.74 | | | 3750 | 13.66 | 1250 | 3.46847 |
| *Bidens pilosa* L. | Asteraceae | 1250 | 2.81 | | | | | | |
| *Blumea densiflora* (Wall.) DC. | Asteraceae | | | 3750 | 10.79 | 2500 | 11.49 | | |
| *Bothriochloa pertusa* (L.) A.Camus | Poaceae | | | 1250 | 4.51 | | | | |
| *Brachiaria villosa* (Lam.) A.Camus | Poaceae | | | | | 1875 | 6.83 | | |
| *Brachystemma calycinum* D. Don | Caryophyllaceae | 1875 | 6.19 | | | | | | |
| *Bryophyllum pinnatum* (Lam.) Oken | Crassulaceae | | | | | | | 1875 | 6.03604 |
| *Bulbophyllum affine* Wall. ex Lindl. | Orchidaceae | 625 | 2.06 | | | 3125 | 12.58 | | |
| *Bulbophyllum andersonii* (Hook. f.) J.J. Sm. | Orchidaceae | | | | | | | 625 | 2.56757 |
| *Bulbophyllum cauliflorum* Hook.f. | Orchidaceae | | | 2500 | 6.28 | | | | |
| *Bulbophyllum striatum* (Griff.) Rchb.f. | Orchidaceae | | | | | | | 1875 | 6.03604 |
| *Carex baccans* Nees | Cyperaceae | 1250 | 4.12 | | | | | | |
| *Carex cruciata* Wahlenb. | Cyperaceae | | | 1875 | 5.39 | | | | |
| *Cheilocostus speciosus* (J.Koenig) C.D. Specht | Zingiberaceae | 10625 | 17.95 | | | 5000 | 15.84 | 3750 | 12.0721 |
| *Cissus javana* DC. (Climber) | Vitaceae | 2500 | 8.25 | 1250 | 4.51 | 1875 | 6.83 | 2500 | 6.93694 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Cleisostoma subulatum* Blume | Orchidaceae | 1250 | 2.81 | | | | | | |
| *Commelina benghalensis* L. | Commelinaceae | 1250 | 4.12 | 625 | 2.25 | | | 1250 | 5.13514 |
| *Cyanotis cristata* (L.) D.Don | Commelinaceae | | | 7500 | 16.10 | | | | |
| *Cyclea peltata* Hook. f. & Thoms. | Menispermaceae | 1250 | 4.12 | | | | | 3125 | 11.1712 |
| *Cymbidium ensifolium* (L.) Sw. | Orchidaceae | | | 3750 | 10.79 | 1250 | 5.75 | | |
| *Cyperus nutans* Vahl | Cyperaceae | | | 3125 | 9.90 | | | | |
| *Cyperus rotundus* L. | Cyperaceae | | | | | | | 1875 | 4.36937 |
| *Datura stramonium* L. | Solanaceae | 1875 | 6.19 | | | | | | |
| *Dendrobium bensoniae* Rchb. f. | Orchidaceae | 1875 | 4.87 | | | | | | |
| *Dendrobium chrysotoxum* Lindl. | Orchidaceae | | | 3125 | 9.90 | | | 1875 | 7.7027 |
| *Dendrobium heterocarpum* Wall. | Orchidaceae | | | | | 2500 | 9.70 | | |
| *Desmodium microphyllum* (Thunb.) DC. | Papilionaceae | | | | | 3125 | 10.79 | | |
| *Digitaria violascens* Link | Poaceae | | | 1875 | 5.39 | | | | |
| *Dinetus racemosus* (Roxb.) Buch.-Ham. ex Sweet | Convolvulaceae | | | | | | | 1250 | 3.46847 |
| *Dioscorea tomentosa* J. Koenig ex Spreng. | Dioscoreaceae | 8125 | 14.96 | | | 6250 | 18.01 | | |
| *Dysphania ambrosioides* (L.) Mosyakin & Clemants | Chenopodiaceae | 9375 | 16.46 | | | | | 3750 | 12.0721 |
| *Elatostema sessile* J.R. Forster & G. Forster | Urticaceae | | | | | 2500 | 9.70 | | |
| *Eria biflora* Griff. | Orchidaceae | | | | | 1875 | 5.05 | | |
| *Eria vittata* Lindl. | Orchidaceae | | | 1250 | 3.14 | | | | |
| *Gonostegia pentandra* (Roxb.) Miq. | Urticaceae | | | | | | | 10000 | 21.0811 |
| *Gynura cusimbua* (D.Don) S. Moore | Asteraceae | 1250 | 2.81 | | | | | | |
| *Hedychium coccineum* Buch.-Ham. ex D. Don | Zingiberaceae | | | | | 3125 | 9.01 | | |
| *Hedychium villosum* Wall. | Zingiberaceae | 3125 | 8.99 | 2500 | 7.65 | | | | |
| *Hibiscus species* L. | Malvaceae | 2500 | 6.93 | | | | | | |
| *Hibiscus surattensis* L. | Malvaceae | | | | | | | 1875 | 6.03604 |
| *Hydrangea anomala* D. Don | Hydrangeaceae | | | | | | | 625 | 2.56757 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Impatiens stenantha* Hook. f. | Balsaminaceae | 1250 | 2.81 | | | | | | |
| *Maranta species* L. | Marantaceae | 2500 | 6.93 | | | | | | |
| *Mikania micrantha* Kunth | Asteraceae | 3750 | 9.74 | 5625 | 13.44 | | | 1250 | 3.46847 |
| *Mimosa pudica* L. | Mimosaceae | | | 625 | 2.25 | | | | |
| *Mucuna macrocarpa* Wall. | Leguminosae | | | 3125 | 9.90 | | | | |
| *Panicum brevifolium* L. | Poaceae | 1250 | 4.12 | | | | | | |
| *Papilionanthe teres* (Roxb.) Schltr. | Orchidaceae | | | 1875 | 5.39 | | | | |
| *Papilionanthe uniflora* (Lindl.) garay | Orchidaceae | 2500 | 5.62 | | | 1250 | 5.75 | | |
| *Persicaria chinensis* (L.) H. Gross | Polygonaceae | | | | | | | 2500 | 8.6036 |
| *Phragmites karka* (Retz.) Trin. ex Steud. | Poaceae | 1875 | 4.87 | 2500 | 7.65 | 2500 | 7.92 | | |
| *Pogostemon auricularius* (L.) Hassk. | Lamiaceae | | | | | | | 1875 | 6.03604 |
| *Pouzolzia hirta* (Blume) Hassk. | Urticaceae | | | 8750 | 17.87 | | | | |
| *Rhynchostylis retusa* (L.) Blume | Orchidaceae | | | | | 1875 | 5.05 | | |
| *Scirpus ternatanus* Reinw. ex Miq. | Cyperaceae | 625 | 2.06 | | | | | | |
| *Scleria lithosperma* (L.) Sw. | Cyperaceae | 1875 | 4.87 | | | | | | |
| *Senecio nagensium* C.B.Clarke | Asteraceae | | | | | 1875 | 6.83 | 1250 | 3.46847 |
| *Smilax glabra* Roxb. | Smilacaceae | 625 | 2.06 | | | | | | |
| *Sonchus wightianus* DC. | Asteraceae | 1250 | 4.12 | 1875 | 5.39 | 3750 | 13.66 | | |
| *Sporobolus fertilis* (Steud.) Clayton | Poaceae | 1875 | 3.55 | | | | | | |
| *Strychnos aenea* A.W.Hill | Loganiaceae | | | 1250 | 4.51 | | | | |
| *Tetrastigma lanceolarium* (Roxb.) Planch. | Vitaceae | 1250 | 2.81 | | | | | | |
| *Tetrastigma obovatum* Gagnep | Vitaceae | | | 625 | 2.25 | 3125 | 10.79 | | |
| *Thalictrum foliolosum* DC. | Ranunculaceae | | | | | | | 2500 | 8.6036 |
| *Thunbergia grandiflora* (Roxb. ex Rottl.) Roxb. | Acanthaceae | | | 1250 | 4.51 | | | | |
| *Tinospora sinensis*(Lour.) Merr. | Menispermaceae | | | | | | | 6875 | 14.9099 |
| *Trichosanthes cordata* Roxb | Cucurbitaceae | 625 | 2.06 | 1875 | 6.76 | | | | |

### 4.2.8.3 Population structure of tree species in various girth-classes

The tree density and basal cover in all the community forest varied significantly in various girth class distributions. The highest density and basal cover was recorded from young and regenerating trees (10 – 60 cm girth class) contributing about 77% and 47 % followed by mid girth class (60 – 90 cm) contributing 22% and 33% of the total density and basal area. Trees in higher girth classes contributed only 5% and 21% of the total density and basal area in all the community. Overall population structure of all communities showed a reverse *J*-shaped population curve indicating a good forest health and high species richness.The study also showed higher density in the lower girth class indicating good regeneration potential in the forest. Contributions of tree stand density and basal area based on girth class distribution in all the communities is shown in figure 4.2.15.

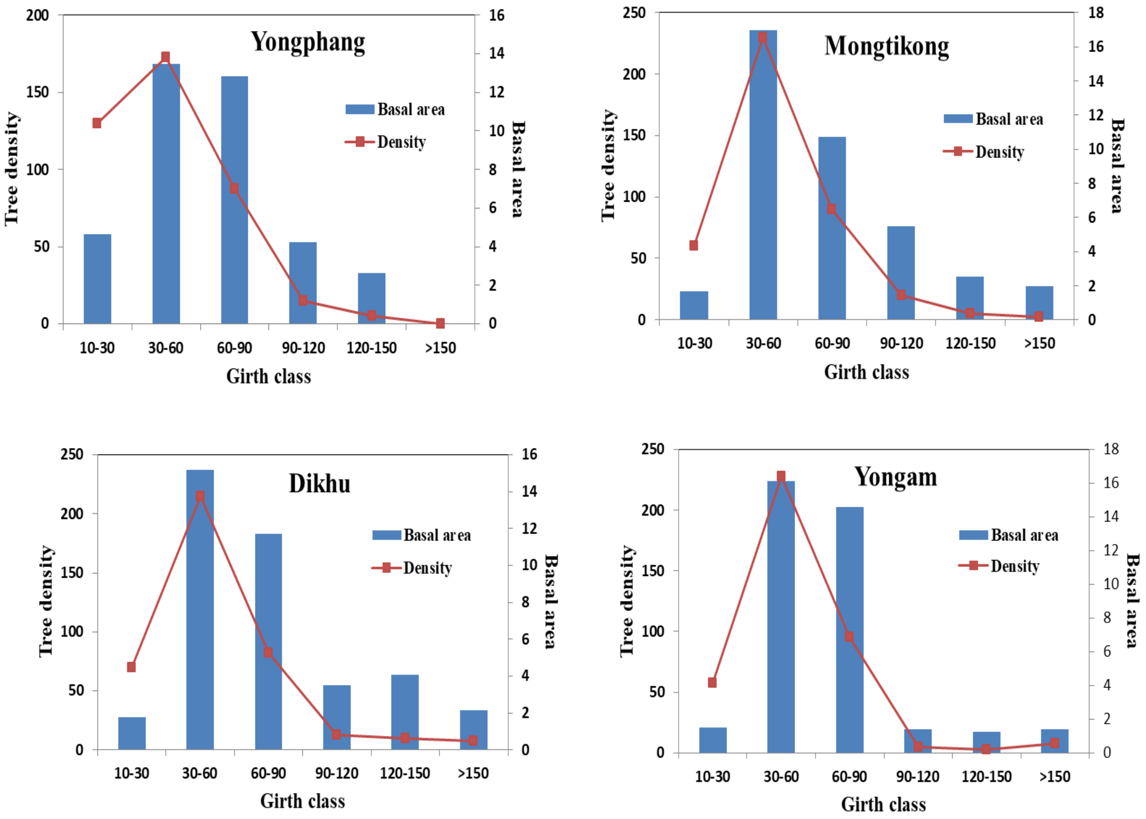
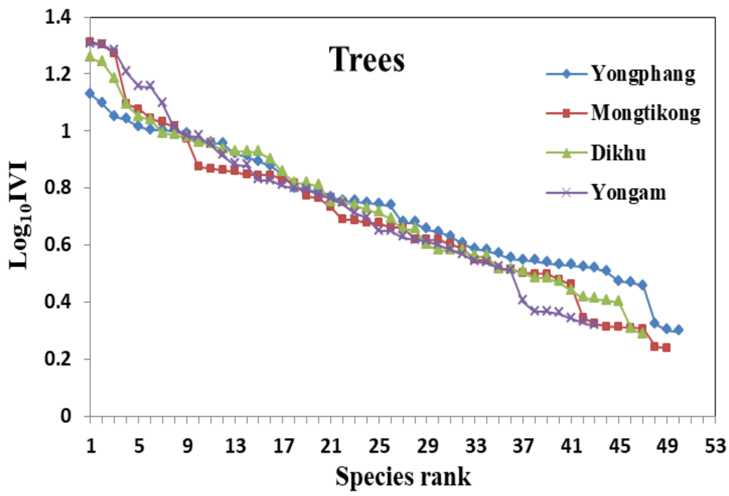



**Figure 4.2.15** Contributions of tree stand density and basal area based on girth class contribution in four study sites of Longleng District, Nagaland

#### 4.2.8.4 Dominance-Diversity curve

Dominance-diversity curve of tree, shrub and heb layer showed wide variations in species richness and evenness in all community forest of Longleng district, Nagaland. In trees, the dominance-diversity curve of all community forest showed shallow gradient slope indicating high species richness in the community. The dominance-diversity curve study also revealed high equitability and low dominance of species and followed a log normal distribution pattern. In shrubs, the dominance-diversity curve of Dikhu and Yongphang CF showed log normal distribution indicating mixed nature of vegetation and higher species richness as compared to Mongtikong and Yongam CF which reflected broken stick distribution pattern. In herbs, the dominance-diversity curve in all the community forest showed log normal series model except Dikhu CF which exhibited broken stick model indicating lower species richness and evenness (Figure 4.2.16). Among trees, the most dominant species were: *Albizia procera* (Yongphang CF), *Spondias pinnata* (Mongtikong CF), *Gmelina arborea* (Dikhu CF) and *Ailanthus integrifolia* (Yongam CF). In shrubs, the most dominant species were: *Clerodendrum infortunatum* (Dikhu CF), *Osbeckia nepalensis* (Yongam CF), *Boehmeria glomerulifera* (Mongtikong CF) and *Croton caudatus* (Yongphang CF). In herbs, the most dominant species were: *Cheilocostus speciosus* (Yongphang CF), *Pouzolzia hirta* (Mongtikong CF), *Gonostegia pentandra* (Yongam CF) and *Dioscorea tomentosa* (Dikhu CF).



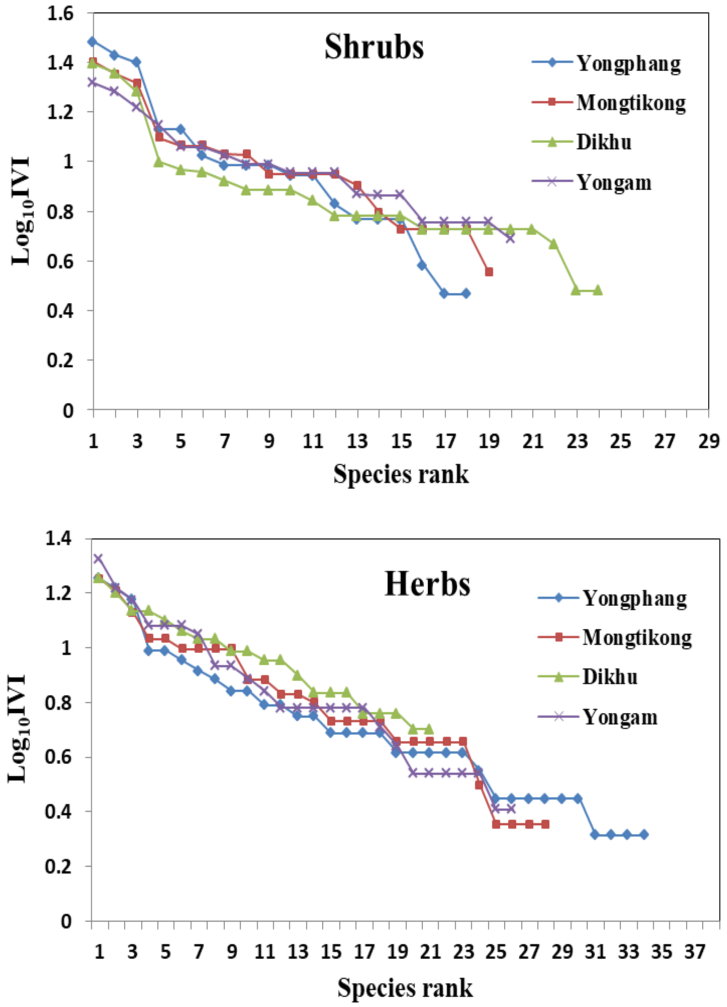



**Figure 4.2.16** Dominance-Diversity curve for trees, shrubs and herbs in four study sites of Longleng District, Nagaland

### 4.2.8.5 Distribution pattern of tree species

The distribution pattern of species varied significantly in all the community. The study showed that 40 – 60% of species exhibited clumped/contagious distribution in all the communties which is also a distinctive feature of a natural forest. Community forest (e.g. Dikhu and Yongam) exhibited the maximum clumped/contagious distribution (60% and 58%) of total species whereas Mongtikong and Yongphang CF exhibited maximum random distribution pattern with 36% and 34% respectively. The study also showed that about 20 – 28% of species exhibited regular distribution in all the community forest (Table 4.2.30).

#### 4.2.8.6 Sorenson's similarity

Sorenson's similarity index was analyzed to study the similarity of tree species in all the communities. An average of 53% similarity was observed in all the communities. The highest similarity (63%) was observed between Mongtikong and Yongam CF, followed by Mongtikong and Dikhu CF (58%) and Dikhu and Yongam CF (56%). The high similarity of species between various communities may be due to similar types of micro-habitat conditions, similar altitudinal gradients and forest vegetation, and climatic and edaphic factors (Table 4.2.32).

**Table 4.2.32** Sorenson Similarity indices for tree species between four study sites of Longleng District, Nagaland

| Study area | Yongphang | Mongtikong | Dikhu | Yongam |
|---|---|---|---|---|
| **Yongphang** | x | | | |
| **Mongtikong** | 0.46 | x | | |
| **Dikhu** | 0.41 | 0.58 | x | |
| **Yongam** | 0.49 | 0.65 | 0.56 | x |

#### 4.2.8.7 Disturbance pattern

The average disturbance index for all the study sites was 12% (Table 4.2.29). The disturbance index based on cut sumps was highest at Yongam (15%), followed by Dikhu (13%) and Mongtikong (11%). Since the region is dominated by important timber species such as *Ailanthus integrifolia, Gmelina arborea* and *Lagerstroemia speciosa*, there is high anthropogenic pressure on the local people living near the forest. The presence of tree stumps in the forest can also be attributed to natural disasters (e.g., storms, lightning, high-speed winds, etc.) that result in the felling of trees in the forest.

### 4.2.9 Kohima district

#### 4.2.9.1 Floristic structure

*Tree species composition*

In the present study, a total of 516 individuals belonging to 117 species and 86 genera belonging to 45 families were recorded from the four community forest (Peducha, Khonoma, Touphema and Longwesunyu) of Kohima district, Nagaland, Northeast India. Out of these, 50 species, 39 genera, 25 families and 159 individuals were recorded from Peducha CF; 37 species, 32 genera, 25 families and 115 individuals from Khonoma CF; 35 species, 28 genera, 23 families and 110 individuals from Touphema CF and 29 species, 25 genera, 20 families and 132 individuals from Longwesunyu CF of Nagaland respectively (Table 4.2.33). Based on IVI value, the most dominant tree species in Peducha CF were: *Quercus serrata* (19.73), *Castonopsis indica* (19.38) and *Wrightia arborea* (16.93) and the co-dominant species were: *Rhus chinensis* (11.25), *Erythrina arborescens* (11.18) and *Sterculia urens* (11.13) (Table 4.2.34). The most dominant families were: Euphorbiaceae, Meliaceae and Mimosaceae. In Khonoma CF, the dominant tree species were: *Acer oblongum* (21.61), *Prunus napaulensis* (21.58) and *Hovenia dulcis* (20.68) and the co-dominant species were: *Toona ciliata* (17.59), *Magnolia oblonga* (11.83) and *Morus laevigata* (11.58) (Table 4.2.34). The most dominant families were: Aceraceae, Fagaceae, Lauraceae and Magnoliaceae. In Touphema CF, the dominant species were: *Cedrella toona* (23.83), *Erythrina arborescens* (19.36) and *Vernonia arborea* (17.12) (15.17) and the co-dominant species were: *Bombax ceiba* (15.58), *Alnus nepalensis* (13.04) and *Betula alnoides* (12.79) (Table 4.2.34). The dominant families were: Betulaceae, Ebenaceae and Leguminosae. In Longwesunyu CF, the most dominant species were: *Ailanthus integrifolia* (29.65), *Dipterocarpus retusus* (25.87) and *Duabanga grandiflora* (20.72) and the co-dominant species were: *Sapindus mukorossi* (19.13), *Magnolia champaca* (18.55) and *Talauma hodgsonii* (17.45) (Table 4.2.34). The dominant families were: Euphorbiaceae, Lauraceae and Moraceae. The tree stand density (individuals $ha^{-1}$) in the community forest ranged from 228 – 398 where Peducha CF (398) recorded the highest density followed by Longwesunyu CF (330) and Khonoma CF (288). The lowest tree density was recorded from Touphema CF (228). The basal area ($m^2ha^{-1}$) ranged from 22.32 – 29.19 where the highest basal area was recorded from Peducha CF (29.19) followed by Longwesunyu CF (27.55) and Khonoma CF (26.49) and the lowest from Touphema CF (22.32) (Table 4.2.33).

**Table 4.2.33** Phytosociological attributes of trees, shrubs and herbs in four study sites of Kohima District, Nagaland

| Parameters | Peducha | Khonoma | Touphema | Longwesunyu |
|---|---|---|---|---|
| **Trees** | | | | |
| No. of species | 50 | 37 | 35 | 29 |
| No. of genera | 39 | 32 | 28 | 25 |
| Families | 27 | 25 | 23 | 20 |
| Density (individuals $ha^{-1}$) | 398 | 288 | 228 | 330 |
| Basal area ($m^2 ha^{-1}$) | 29.19 | 26.49 | 22.32 | 27.55 |
| Shannon diversity index (H') | 3.68 | 3.15 | 3.38 | 2.97 |
| Simpson index (CD) | 0.02 | 0.04 | 0.03 | 0.05 |
| Margalef index (Dmg) | 9.67 | 7.59 | 7.23 | 5.73 |
| Evenness (e) | 0.94 | 0.87 | 0.95 | 0.88 |
| Disturbance index (%) | 21 | 23 | 14 | 12 |
| **Shrubs** | | | | |
| No. of species | 30 | 21 | 24 | 26 |
| No. of genera | 27 | 18 | 21 | 20 |
| Families | 19 | 13 | 18 | 17 |
| Density (individuals $ha^{-1}$) | 6600 | 7950 | 7650 | 6250 |
| Shannon diversity index (H') | 3.17 | 2.62 | 2.85 | 2.78 |
| Simpson index (CD) | 0.06 | 0.09 | 0.07 | 0.08 |
| Margalef index (Dmg) | 5.94 | 3.95 | 4.57 | 5.18 |
| Evenness (e) | 0.93 | 0.86 | 0.89 | 0.85 |
| **Herbs** | | | | |
| No. of species | 27 | 35 | 30 | 28 |
| No. of genera | 24 | 32 | 27 | 23 |
| Families | 18 | 23 | 19 | 14 |
| Density (individuals $ha^{-1}$) | 42500 | 110625 | 67500 | 73125 |
| Shannon diversity index (H') | 2.62 | 3.35 | 3.01 | 3.06 |
| Simpson index (CD) | 0.07 | 0.04 | 0.06 | 0.05 |
| Margalef index (Dmg) | 6.16 | 6.57 | 6.19 | 5.67 |
| Evenness (e) | 0.79 | 0.94 | 0.88 | 0.91 |

**Table 4.2.34** Density (individuals ha$^{-1}$), Basal area (m$^2$ha$^{-1}$), Important value index (IVI) and Distribution pattern (DP) of tree species in four study sites of Kohima District, Nagaland

| Species | Family | Peducha | | | | Khonoma | | | | Touphema | | | | Longwesunyu | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** |
| *Acer caudatum* Wall. | Aceraceae | | | | | | | | | 2.5 | 0.15 | 3.49 | R | | | | |
| *Acer laevigatum* Wall. | Aceraceae | | | | | 5 | 0.41 | 4.91 | C | | | | | | | | |
| *Acer oblongum* Wall. ex DC. | Aceraceae | 5 | 0.27 | 3.39 | C | 30 | 1.25 | 21.61 | R | | | | | | | | |
| *Acer sterculiaceum* Wall. | Aceraceae | | | | | | | | | 2.5 | 0.15 | 3.49 | R | | | | |
| *Aglaia spectabilis* (Miq.) S.S.Jain & S.Bennet | Meliaceae | | | | | 7.5 | 1.32 | 9.19 | C | | | | | | | | |
| *Ailanthus integrifolia* Lam. | Simaroubaceae | | | | | | | | | | | | | 35 | 3.38 | 29.65 | C |
| *Alangium chinense* (Lour.) Harms | Cornaceae | | | | | 10 | 0.65 | 9.16 | R | 5 | 0.24 | 6.71 | RE | | | | |
| *Albizia chinensis* (Osbeck) Merr. | Mimosaceae | 7.5 | 0.52 | 7.33 | RE | | | | | | | | | | | | |
| *Albizia lebbeck* (L.) Benth. | Mimosaceae | 5 | 0.78 | 5.16 | C | | | | | | | | | | | | |
| *Albizia lucidior* (Steud.) I.C.Nielsen | Mimosaceae | 5 | 0.48 | 4.14 | C | | | | | | | | | | | | |
| *Albizia odoratissima* (L.f.)Benth. | Mimosaceae | 5 | 0.30 | 4.73 | RE | | | | | | | | | | | | |
| *Alchornea tiliifolia* (Benth.) Müll.Arg. | Euphorbiaceae | | | | | | | | | | | | | 2.5 | 0.06 | 2.66 | R |
| *Alnus nepalensis* D.Don | Betulaceae | | | | | 2.5 | 0.69 | 5.09 | C | 7.5 | 1.02 | 13.04 | RE | | | | |
| *Alseodaphne dumicola* W.W.Sm. | Lauraceae | | | | | | | | | 5 | 0.24 | 5.01 | C | | | | |
| *Alstonia scholaris* (L.) R. Br. | Apocynaceae | | | | | 5 | 0.69 | 5.94 | C | | | | | 7.5 | 0.76 | 6.74 | C |
| *Archidendron clypearia* (Jack) I.C.Nielsen | Mimosaceae | | | | | | | | | | | | | 2.5 | 0.08 | 2.75 | C |
| *Artocarpus lacucha* Buch.-Ham. | Moraceae | | | | | 7.5 | 1.04 | 8.15 | C | | | | | 5 | 2.66 | 12.86 | C |
| *Bauhinia variegata* L. | Caesalpiniaceae | 12.5 | 0.74 | 8.11 | C | | | | | | | | | | | | |
| *Betula alnoides* Buch.-Ham. ex. D. Don | Betulaceae | 2.5 | 0.20 | 2.52 | C | | | | | 5 | 1.59 | 12.79 | RE | | | | |
| *Betula cylindrostachya* Wall. | Betulaceae | | | | | | | | | 2.5 | 0.12 | 3.38 | R | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Bischofia javanica* Blume | Euphorbiaceae | 10 | 0.51 | 6.70 | C | | | | | | | | | | | | |
| *Boehmeria rugulosa* Wedd. | Urticaceae | | | | | | | | | | | | | 7.5 | 0.31 | 6.77 | C |
| *Bombax ceiba* L. | Malvaceae | 10 | 1.31 | 9.45 | R | | | | | 5 | 2.60 | 15.58 | C | | | | |
| *Brassaiopsis hainla* (Buch.-Ham.) Seem. | Araliaceae | | | | | 7.5 | 0.33 | 5.48 | C | | | | | | | | |
| *Brassaiopsis mitis* C.B.Clarke | Araliaceae | 2.5 | 0.15 | 2.36 | R | 2.5 | 0.13 | 2.98 | C | 5 | 0.38 | 5.64 | C | | | | |
| *Bridelia glauca* Blume | Euphorbiaceae | | | | | 5 | 0.44 | 6.62 | C | | | | | | | | |
| *Broussonetia species* L'Hér. ex Vent. | Moraceae | | | | | | | | | | | | | 5 | 0.18 | 5.55 | RE |
| *Callicarpa arborea* Roxb. | Verbenaceae | 7.5 | 0.41 | 4.51 | C | 7.5 | 0.58 | 6.40 | C | | | | | | | | |
| *Careya arborea* Roxb. | Lecythidaceae | 10 | 0.84 | 7.84 | C | | | | | | | | | | | | |
| *Castanopsis indica* (Roxb. ex Lindl.) A.DC. | Fagaceae | 25 | 2.40 | 19.38 | R | | | | | 5 | 1.22 | 9.37 | C | | | | |
| *Castanopsis lanceifolia* (Oerst.) Hickel & A.Camus | Fagaceae | | | | | 5 | 0.19 | 4.06 | C | | | | | | | | |
| *Cedrela toona* Roxb. ex Rottl. & Willd. | Meliaceae | | | | | | | | | 20 | 1.82 | 23.83 | R | | | | |
| *Choerospondias axillaris* (Roxb.) B.L. Burtt & A.W. Hill | Anacardiaceae | | | | | 5 | 0.20 | 4.12 | C | | | | | | | | |
| *Chukrasia tabularis* A. Juss. | Meliaceae | 10 | 1.13 | 8.83 | C | | | | | | | | | | | | |
| *Claoxylon khasianum* Hook.f. | Euphorbiaceae | | | | | | | | | | | | | 2.5 | 0.10 | 2.81 | R |
| *Clausena anisata* (Willd.) Hook.f. | Rutaceae | | | | | | | | | | | | | 7.5 | 0.19 | 4.66 | C |
| *Cleistanthus monoicus* (Lour.) Müll.Arg. | Euphorbiaceae | | | | | | | | | | | | | 7.5 | 0.28 | 4.98 | C |
| *Colona floribunda* (Kurz) Craib | Tiliaceae | | | | | | | | | | | | | 2.5 | 0.08 | 2.75 | C |
| *Cyathea spinulosa* Wall. | Cyatheaceae | | | | | | | | | | | | | 10 | 0.32 | 7.58 | C |
| *Cycas species* L. | Cycadaceae | | | | | | | | | | | | | 5 | 0.18 | 3.85 | C |
| *Dimocarpus longan* Lour. | Sapindaceae | | | | | 7.5 | 1.20 | 8.75 | C | | | | | | | | |
| *Diospyros glandulosa* Lace. | Ebenaceae | 2.5 | 0.12 | 2.27 | R | 2.5 | 0.13 | 2.97 | R | 5 | 0.33 | 5.40 | C | | | | |
| *Diospyros kaki* L.f. | Ebenaceae | | | | | | | | | 7.5 | 0.38 | 8.46 | R | | | | |
| *Diospyros pilosiuscula* G.Don | Ebenaceae | 2.5 | 0.12 | 2.27 | C | | | | | 2.5 | 0.16 | 3.55 | R | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Dipterocarpus retusus* Blume | Dipterocarpaceae | | | | | | | | | | | | | 32.5 | 2.55 | 25.87 | C |
| *Drimycarpus racemosus* (Roxb.) Hook. f. | Anacardiaceae | | | | | 7.5 | 0.92 | 7.70 | C | | | | | | | | |
| *Duabanga grandiflora* (DC.) Walp. | Lythraceae | | | | | | | | | | | | | 27.5 | 1.55 | 20.72 | C |
| *Dysoxylum procerum* Hiern. | Meliaceae | 10 | 0.54 | 6.80 | C | | | | | | | | | | | | |
| *Elaeocarpus lanceifolius* Roxb. | Elaeocarpaceae | | | | | | | | | | | | | 10 | 0.78 | 10.93 | RE |
| *Elaeocarpus serratus* L. | Elaeocarpaceae | 5 | 0.59 | 4.49 | C | 2.5 | 0.20 | 3.24 | R | | | | | | | | |
| *Engelhardia spicata* Lesch. ex Blume | Juglandaceae | | | | | | | | | 2.5 | 0.49 | 5.01 | R | | | | |
| *Erythrina arborescens* Roxb. | Leguminosae | 10 | 1.46 | 11.18 | RE | | | | | 15 | 1.31 | 19.36 | RE | | | | |
| *Erythrina stricta* Roxb. | Leguminosae | 15 | 0.89 | 9.25 | C | | | | | 5 | 0.20 | 4.80 | C | | | | |
| *Ficus hispida* L.f. | Moraceae | | | | | | | | | 5 | 0.19 | 4.79 | C | | | | |
| *Ficus racemosa* L. | Moraceae | 2.5 | 0.10 | 2.19 | R | | | | | | | | | | | | |
| *Ficus semicordata* Buch.-Ham. ex Sm. | Moraceae | 2.5 | 0.12 | 2.28 | C | | | | | | | | | | | | |
| *Ficus silhetensis* Miq. | Moraceae | 2.5 | 0.11 | 2.23 | C | | | | | 2.5 | 0.11 | 3.33 | R | 2.5 | 0.07 | 2.70 | C |
| *Firmiana colorata* (Roxb.) R.Br. | Sterculiaceae | 5 | 0.29 | 3.48 | C | | | | | | | | | | | | |
| *Garcinia pedunculata* Roxb. ex Buch.-Ham. | Clusiaceae | | | | | 5 | 0.31 | 4.52 | C | | | | | | | | |
| *Gmelina arborea* Roxb. | Verbenaceae | 5 | 0.65 | 4.70 | C | | | | | | | | | | | | |
| *Grewia optiva* J. R. Drumm. ex Burret | Tiliaceae | | | | | | | | | 2.5 | 0.13 | 3.41 | R | | | | |
| *Gynocardia odorata* R. Br. | Flacourtiaceae | 10 | 0.71 | 7.38 | C | | | | | 10 | 0.91 | 11.94 | R | | | | |
| *Holarrhena pubescens* Wall. ex G. Don | Apocynaceae | 5 | 0.13 | 2.91 | C | | | | | | | | | | | | |
| *Hovenia dulcis* Thunb. | Rhamnaceae | | | | | 22.5 | 1.68 | 20.62 | C | | | | | | | | |
| *Ilex embelioides* Hook.f. | Aquifoliaceae | | | | | 7.5 | 0.64 | 9.86 | RE | | | | | 2.5 | 0.32 | 3.61 | C |
| *Kydia calycina* Roxb. | Malvaceae | 7.5 | 0.14 | 4.81 | R | | | | | 10 | 0.64 | 10.70 | R | | | | |
| *Lithocarpus elegans* (Blume) Hatus. ex Soepadmo | Fagaceae | | | | | 7.5 | 0.88 | 7.56 | C | | | | | | | | |
| *Lithocarpus fenestratus* (Roxb.) Rehder | Fagaceae | | | | | 7.5 | 0.53 | 6.20 | C | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Litsea cubeba* (Lour.) Pers. | Lauraceae | 5 | 0.21 | 3.19 | C | | | | | | | | | | | | |
| *Litsea elongata* (Nees) Hook.f. | Lauraceae | | | | | | | | | | | | | 12.5 | 0.48 | 10.63 | RE |
| *Litsea monopetala* (Roxb.) Pers. | Lauraceae | | | | | | | | | 10 | 1.10 | 12.79 | R | | | | |
| *Macaranga denticulata* (Blume) Müll.Arg. | Euphorbiaceae | 7.5 | 0.75 | 5.67 | C | | | | | | | | | 20 | 0.72 | 15.47 | RE |
| *Macaranga pustulata* King ex J. D. | Euphorbiaceae | 7.5 | 0.26 | 4.01 | C | | | | | | | | | | | | |
| *Machilus duthiei* King ex Hook.f. | Lauraceae | | | | | 7.5 | 0.55 | 7.90 | C | | | | | | | | |
| *Magnolia champaca* (L.) Baill. ex Pierre | Magnoliaceae | | | | | | | | | | | | | 17.5 | 2.25 | 18.55 | C |
| *Magnolia doltsopa* (Buch.-Ham. ex DC.) Figlar | Magnoliaceae | 2.5 | 0.23 | 2.62 | R | | | | | 2.5 | 0.32 | 4.25 | R | | | | |
| *Magnolia hodgsonii* (Hook.f. & Thomson) H.Keng | Magnoliaceae | 7.5 | 0.45 | 4.65 | C | 2.5 | 0.28 | 3.55 | R | | | | | | | | |
| *Magnolia oblonga* (Wall. ex Hook.f. & Thomson) Figlar | Magnoliaceae | | | | | 5 | 2.25 | 11.83 | C | | | | | | | | |
| *Melia azedarach* L. | Meliaceae | 7.5 | 0.69 | 5.47 | C | | | | | | | | | | | | |
| *Morus laevigata* Wall. ex Brandis | Moraceae | | | | | 10 | 0.87 | 11.58 | C | | | | | | | | |
| *Myrica esculenta* Buch.-Ham. ex D. Don | Myricaceae | | | | | 5 | 0.22 | 4.19 | C | | | | | | | | |
| *Nephelium lappaceum* L. | Sapindaceae | | | | | 5 | 0.66 | 5.83 | C | | | | | | | | |
| *Oroxylum indicum* (L.) Kurz | Bignoniaceae | 2.5 | 0.09 | 2.14 | R | | | | | 10 | 0.36 | 11.17 | RE | | | | |
| *Parkia timoriana* (DC.) Merr. | Mimosaceae | 5 | 0.33 | 3.60 | C | | | | | | | | | | | | |
| *Phoebe goalparensis* Hutch. | Lauraceae | | | | | | | | | | | | | 15 | 1.78 | 14.38 | C |
| *Phoebe lanceolata* (Nees) Nees | Lauraceae | | | | | 7.5 | 0.63 | 6.61 | C | | | | | | | | |
| *Pinus roxburghii* Sarg. | Pinaceae | | | | | | | | | 5 | 0.38 | 5.62 | C | | | | |
| *Pongamia pinnata* (L.) Pierre | Leguminosae | | | | | | | | | | | | | 7.5 | 1.21 | 8.38 | C |
| *Premna latifolia* Roxb. | Lamiaceae | | | | | | | | | 10 | 0.32 | 9.29 | R | | | | |
| *Prunus napaulensis* (Ser.) Steud. | Rosaceae | | | | | 20 | 2.17 | 21.58 | C | | | | | | | | |
| *Prunus rufa* Wall. ex Hook.f. | Rosaceae | | | | | 5 | 0.37 | 4.74 | C | | | | | | | | |
| *Pterospermum lanceifolium* Roxb. | Sterculiaceae | 2.5 | 0.27 | 2.78 | C | | | | | | | | | | | | |
| *Quercus lanceifolia* Roxb. | Fagaceae | 5 | 0.19 | 3.13 | C | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Quercus serrata* Murray | Fagaceae | 20 | 2.87 | 19.73 | RE | | | | | 5 | 1.42 | 11.99 | RE | | | | |
| *Rhus chinensis* Mill. | Anacardiaceae | 17.5 | 0.93 | 11.25 | R | | | | | 10 | 0.47 | 9.94 | R | | | | |
| *Rhus griffithi* Hook.f. | Anacardiaceae | 5 | 0.16 | 3.03 | C | 7.5 | 0.36 | 7.19 | C | 5 | 0.17 | 6.39 | RE | | | | |
| *Salix tetrasperma* Roxb. | Salicaceae | 2.5 | 0.11 | 2.21 | R | | | | | | | | | | | | |
| *Sapindus mukorossi* Gaertn. | Sapindaceae | | | | | | | | | | | | | 20 | 2.20 | 19.13 | C |
| *Saurauia cerea* Griff. ex Dyer | Actinidiaceae | | | | | | | | | 5 | 0.25 | 6.78 | RE | | | | |
| *Schima khasiana* Dyer | Theaceae | 5 | 0.65 | 4.69 | C | | | | | | | | | | | | |
| *Shorea assamica* Dyer | Dipterocarpaceae | | | | | | | | | | | | | 17.5 | 1.92 | 17.36 | C |
| *Sorbus foliolosa* (Wall.) Spach | Rosaceae | 5 | 0.19 | 3.11 | C | | | | | | | | | | | | |
| *Spondias pinnata* (L.f.) Kurz. | Anacardiaceae | 12.5 | 0.50 | 7.28 | C | | | | | | | | | | | | |
| *Sterculia urens* Roxb. | Sterculiaceae | 12.5 | 0.91 | 11.13 | RE | | | | | | | | | | | | |
| *Sterculia versicolor* Wall. | Sterculiaceae | | | | | 7.5 | 0.37 | 7.24 | C | | | | | | | | |
| *Stereospermum chelonoides* (L.f.) DC. | Bignoniaceae | | | | | | | | | 2.5 | 1.29 | 8.62 | R | | | | |
| *Syzygium reticulatum* (Wight) Walp. | Myrtaceae | | | | | | | | | | | | | 5 | 0.18 | 5.54 | RE |
| *Talauma hodgsonii* J. D. Hooker & Thomson | Magnoliaceae | | | | | | | | | | | | | 22.5 | 1.53 | 17.45 | C |
| *Terminalia bellerica* (Gaertn.) Roxb. | Combretaceae | | | | | | | | | | | | | 15 | 1.31 | 12.70 | C |
| *Terminalia myriocarpa* Van Heurck & Müll. Arg. | Combretaceae | 7.5 | 0.94 | 7.54 | R | 5 | 0.72 | 7.67 | C | | | | | | | | |
| *Toona ciliata* M. Roem | Meliaceae | 10 | 0.97 | 8.26 | C | 12.5 | 1.80 | 17.59 | RE | | | | | | | | |
| *Trema cannabina* Lour. | Ulmaceae | | | | | 7.5 | 0.27 | 6.87 | C | 7.5 | 0.48 | 7.15 | C | | | | |
| *Vernonia arborea* Buch.-Ham. | Asteraceae | | | | | | | | | 15 | 1.20 | 17.12 | R | | | | |
| *Vitex quinata* (Lour.) F.N.Williams | Lamiaceae | | | | | 10 | 0.58 | 10.50 | C | | | | | 2.5 | 0.14 | 2.96 | C |
| *Wrightia arborea* (Dennst.) Mabb. | Apocynaceae | 32.5 | 1.13 | 16.93 | R | | | | | | | | | | | | |
| *Zanthoxylum armatum* DC. | Rutaceae | | | | | | | | | 7.5 | 0.17 | 5.79 | C | | | | |
| *Zanthoxylum rhetsa* DC. | Rutaceae | 12.5 | 0.38 | 6.88 | C | | | | | | | | | | | | |

**Key to abbreviation:** RE= Regular; R= Random; C= Clumped

*Shrub species composition*

In shrubs, a total of 76 species and 53 genera representing 31 families were recorded from the four community forest (Peducha, Khonoma, Touphema and Longwesunyu) of Kohima district, Nagaland. Out of these, 30 species, 27 genera and 19 families were recorded from Peducha CF followed by 26 species, 20 genera and 17 families from Longwesunyu CF; 24 species, 21 genera and 18 families from Touphema CF and 21 species, 18 genera and 13 families were recorded from Khonoma CF respectively (Table 4.2.33). Based on IVI value, the most dominant shrub species in Peducha CF were: *Boehmeria japonica* (19.52), *Clerodendrum japonicum* (15.73) and *Leea macrophylla* (14.22) (Table 4.10.35) and the dominant families were: Melastomataceae, Papilionaceae and Tiliaceae. In Longwesunyu CF, the most dominant species were: *Phrynium capitatum* (24.87), *Eupatorium adoratum* (21.67) and *Boehmeria glomerulifera* (20.07) (Table 4.2.35) and the dominant families were: Rubiaceae, Urticaceae and Verbenaceae. In Touphema CF, the dominant shrub species were: *Amomum subulatum* (20.83), *Clerodendrum infortunatum* (19.52) and *Mussaenda frondosa* (16.91) (Table 4.2.35) and the most dominant families were: Leeaceae, Myrsinaceae and Rubiaceae. In Khonoma CF, dominant species were: *Clerodendrum chinense* (25.02), *Maesa montana* (22.50) and *Hedychium marginatum* (21.87) (Table 4.2.35) and the dominant families were: Rubiaceae, Verbenaceae and Zingiberaceae. From the present study, the highest shrub density (individuals ha$^{-1}$) was recorded from Khonoma CF (7950) followed by Touphema CF (7650), Peducha CF (6600) and the lowest in Logwesunyu CF (6250) respectively (Table 4.2.33).

*Herb species composition*

In herbs, a total of 99 species, 83 genera representing 38 families were recorded four community forest (Peducha, Khonoma, Touphema and Longwesunyu) of Kohima district, Nagaland. Out of these, 35 species, 32 genera and 23 families were recorded from Khonoma CF followed by 30 species, 27 genera and 19 families from Touphema CF; 28 species, 23 genera and 14 families from Longwesunyu CF and 27 species, 24 genera and 18 families from Peducha CF of Nagaland respectively (Table 4.2.33). In Khonoma CF, the most dominant herb species were: *Chinopodium umbrosum* (13.47), *Porana paniculata* (12.34) and *Impatients latiflora* (11.21)

(Table 4.2.35) and the dominant families were: Asteraceae and Lamiaceae. In Touphema CF, the most dominant species were: *Ageratina riparia* (21.59), *Blumea repanda* (19.74) and *Galinsoga parviflora* (16.04) (Table 4.2.35) and the dominant families were: Asteraceae, Commelinaceae and Cyperaceae. In Longwesunyu CF, the dominant species were: *Galinsoga parviflora* (18.80), *Lasia spinosa* (17.09) and *Ageratum conyzoides* (15.38) (Table 4.2.35) and the dominant families were: Asteraceae, Menispermaceae and Vitaceae. In Peducha CF, the dominant species were: *Bauhinia vahlii* (19.18), *Chrysanthemum indicum* (17.71) and *Elatostema platyphyllum* (16.24) (Table 4.2.35) and the most dominant families were: Asteraceae, Poaceae and Urticaceae. The highest herb density (individuals $ha^{-1}$) was recorded from Khonoma CF (110625) followed by Longwesunyu CF (73125), Touphema CF (67500) and Peducha CF (42500) respectively (Table 4.2.33).

**Table 4.2.35** Density (individuals ha$^{-1}$) and Important value index (IVI) of shrubs and herbs species in four study sites of Kohima District, Nagaland

| Species | Family | Peducha | | Khonoma | | Touphema | | Longwesunyu | |
|---|---|---|---|---|---|---|---|---|---|
| | | D | IVI | D | IVI | D | IVI | D | IVI |
| **Shrubs** | | | | | | | | | |
| *Agapetes odontocera* (Wight) Hook.f. | Ericaceae | 200 | 5.97 | | | 200 | 5.84 | | |
| *Amischotolype mollissima* (Blume) Hassk. | Commelinaceae | | | | | 150 | 3.57 | | |
| *Amomum subulatum* Roxb. | Zingiberaceae | 150 | 6.68 | 100 | 3.11 | 1100 | 20.83 | 50 | 2.62 |
| *Boehmeria glomerulifera* Miq. | Urticaceae | | | | | | | 800 | 20.07 |
| *Boehmeria hamiltoniana* Wedd. | Urticaceae | | | | | 550 | 12.03 | 150 | 6.04 |
| *Boehmeria japonica* (L.f.) Miq. | Urticaceae | 900 | 19.52 | | | | | | |
| *Boesenbergia longiflora* (Wall.) Kuntze | Zingiberaceae | | | 200 | 8.07 | | | | |
| *Butea buteiformis* Voigt | Papilionaceae | | | 400 | 8.74 | | | | |
| *Calamus erectus* Roxb. | Arecaceae | 150 | 5.21 | | | | | 50 | 2.62 |
| *Casearia vareca* Roxb. | Flacourtiaceae | | | | | | | 100 | 5.24 |
| *Clerodendrum chinense* (Osbeck) Mabb. | Verbenaceae | | | 1400 | 25.02 | | | | |
| *Clerodendrum infortunatum* L. | Verbenaceae | | | 600 | 14.95 | 1000 | 19.52 | | |
| *Clerodendrum japonicum* (Thunb.) Sweet | Verbenaceae | 650 | 15.73 | | | | | 250 | 9.45 |
| *Clerodendrum laevifolium* Blume | Verbenaceae | | | | | | | 100 | 3.42 |
| *Crotalaria assamica* Benth. | Papilionaceae | 150 | 5.21 | | | | | | |
| *Daphne involucrata* Wall. | Thymelaeaceae | 100 | 4.46 | | | 200 | 7.45 | | |
| *Daphne papyraceae* Wallich ex G. Don | Thymelaeaceae | | | 100 | 4.96 | | | | |
| *Debregeasia saenab* (Forssk.) Hepper & J.R.I. Wood | Urticaceae | 200 | 7.44 | | | | | | |
| *Dendrocnide sinuata* (Blume) Chew | Urticaceae | | | | | | | 150 | 7.85 |
| *Desmodium triquetrum* (L.) DC. | Papilionaceae | 300 | 10.43 | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Desmodium velutinum* (Willd.)DC. | Papilionaceae | | | | | 100 | 4.53 | | |
| *Dichroa febrifuga* Lour. | Hydrangeaceae | | | 150 | 7.44 | | | | |
| *Dracaena angustifolia* (Medik.) Roxb. | Dracaenaceae | | | | | | | 200 | 6.84 |
| *Elaeagnus umbellata* Thunb. | Elaeagnaceae | | | 50 | 2.48 | 50 | 2.27 | | |
| *Eupatorium adoratum* L. | Compositae | 500 | 13.46 | | | | | 900 | 21.67 |
| *Eupatorium cannabinum* L. | Compositae | | | | | 700 | 15.60 | 350 | 11.05 |
| *Ficus hirta* Vahl. | Moraceae | 50 | 2.23 | | | | | | |
| *Gomphocarpus physocarpus* E. Mey. | Apocynaceae | | | | | 150 | 6.80 | | |
| *Grewia abutilifolia* Vent. ex Juss. | Tiliaceae | 100 | 2.99 | | | | | | |
| *Grewia sclerophylla* Roxb. | Tiliaceae | 50 | 2.23 | | | | | | |
| *Hedychium marginatum* C.B.Clarke | Zingiberaceae | 100 | 2.99 | 1150 | 21.87 | | | | |
| *Hedychium spicatum* Buch.-Ham. | Zingiberaceae | | | 350 | 8.11 | | | | |
| *Holmskioldia sanguinea* Retz. | Verbenaceae | | | | | | | 50 | 2.62 |
| *Hypericum oblongifolium* Choisy | Hypericaceae | | | 250 | 6.85 | | | 100 | 5.24 |
| *Impatiens laevigata* Wall. ex Hook.f. & Thomson. | Balsaminaceae | | | | | | | 200 | 8.65 |
| *Lasianthus biermannii* King ex Hook.f. | Rubiaceae | | | | | 400 | 8.45 | | |
| *Leea asiatica* (L.) Ridsdale | Leeaceae | | | | | | | 100 | 5.24 |
| *Leea compactiflora* Kurz | Leeaceae | | | | | 250 | 9.72 | | |
| *Leea macrophylla* Roxb. ex Hornem. | Leeaceae | 550 | 14.22 | | | 300 | 10.37 | | |
| *Lespedeza cuneata* (Dum.Cours.) G.Don | Papilionaceae | | | 50 | 2.48 | | | | |
| *Leycesteria formosa* Wall. | Caprifoliaceae | 50 | 2.23 | | | | | | |
| *Maesa indica* (Roxb.) A. DC. | Myrsinaceae | 250 | 8.20 | | | 150 | 5.19 | | |
| *Maesa montana* A. DC. | Myrsinaceae | 200 | 7.44 | 1200 | 22.50 | | | 400 | 13.67 |
| *Maesa rugosa* C.B. Clarke | Myrsinaceae | | | | | 150 | 5.19 | | |
| *Melastoma napalense* Lodd. | Melastomataceae | 300 | 8.96 | | | | | | |
| *Mussaenda frondosa* L. | Rubiaceae | 150 | 5.21 | | | 800 | 16.91 | | |
| *Mussaenda glabra* Vahl | Rubiaceae | | | | | | | 150 | 4.22 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Mussaenda macrophylla* wall. | Rubiaceae | | | | | 150 | 6.80 | 400 | 10.04 |
| *Mussaenda roxburghii* Hook.f. | Rubiaceae | | | 400 | 12.44 | | | | |
| *Mycetia mukerjiana* Deb & Ratna Dutta | Rubiaceae | | | 150 | 3.74 | | | | |
| *Neillia thyrsiflora* D. Don | Rosaceae | | | | | 100 | 4.53 | | |
| *Ocimum sanctum* L. | Lamiaceae | 50 | 2.23 | | | | | | |
| *Ophiorrhiza repens* (Wall. ex G.Don) Bennet | Rubiaceae | 150 | 5.21 | | | | | 200 | 8.65 |
| *Osbeckia nepalensis* Hook.f. | Melastomataceae | 200 | 7.44 | 200 | 6.22 | 200 | 7.45 | | |
| *Osbeckia stellata* Buch.-Ham. ex Ker Gawl. | Melastomataceae | 100 | 2.99 | | | | | | |
| *Pavetta indica* L. | Rubiaceae | | | 150 | 7.44 | | | | |
| *Phlogacanthus curviflorus* Ness | Acanthaceae | | | | | | | 100 | 5.24 |
| *Phlogacanthus tubiflorus* Ness | Acanthaceae | 150 | 3.74 | | | 250 | 4.88 | 50 | 2.62 |
| *Phrynium capitatum* Willd. | Marantaceae | | | | | | | 1100 | 24.87 |
| *Phrynium rheedei* Suresh & Nicolson | Marantaceae | | | | | | | 100 | 3.42 |
| *Phyllanthus leschenaultii* Müll.Arg. | Euphorbiaceae | | | | | | | 50 | 2.62 |
| *Pouzolzia sanguinea* (Blume) Merr. | Urticaceae | | | 100 | 3.11 | | | | |
| *Pseudocaryopteris bicolor* (Roxb. ex Hardw.) P.D.Cantino | Verbenaceae | | | 250 | 8.70 | | | | |
| *Psychotria denticulata* Wall. | Rubiaceae | | | | | | | 100 | 3.42 |
| *Psychotria symplocifolia* Kurz | Rubiaceae | | | | | 150 | 5.19 | | |
| *Rhynchotechum alternifolium* C.B. Clarke | Gesneriaceae | | | | | 100 | 4.53 | | |
| *Rhynchotechum ellipticum* (Wall. ex Dietrich) A. DC. | Gesneriaceae | 150 | 5.21 | | | | | | |
| *Rotheca serrata* (L.) Steane & Mabb. | Verbenaceae | 100 | 4.46 | | | | | | |
| *Rubus kurzii* Balsk | Rosaceae | | | | | 300 | 5.53 | | |
| *Rubus pedunculosus* D. Don | Rosaceae | | | 500 | 13.70 | | | | |
| *Solanum indicum* L. | Solanaceae | 200 | 5.97 | | | | | | |
| *Tadehagi triquetrum* (L.) H.Ohashi | Papilionaceae | 100 | 4.46 | | | | | | |
| *Triumfetta rhomboidea* Jacq. | Tiliaceae | 300 | 7.49 | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|
| *Urena callifera* C.B. Clarke | Malvaceae | | | | | | | 50 | 2.62 |
| *Vernonia mastersii* Watt. | Asteraceae | | | 200 | 8.07 | | | | |
| *Viburnum corylifolium* Hook.f. & Thomson | Caprifoliaceae | | | | | 150 | 6.80 | | |
| **Herbs** | | | | | | | | | |
| *Acampe ochracea* (Lindl.) Hochr. | Orchidaceae | 625 | 3.69 | | | | | | |
| *Aconitum palmatum* D. Don | Ranunculaceae | | | 1875 | 2.94 | | | | |
| *Ageratina riparia* (Regel) R.M. King & H. Rob. | Asteraceae | | | | | 10000 | 21.59 | | |
| *Ageratum conyzoides* (L.) L. | Asteraceae | | | | | | | 5625 | 15.38 |
| *Agrostophyllum callosum* Rchb.f. | Orchidaceae | | | 1250 | 3.63 | | | 3125 | 8.12 |
| *Agrostophyllum planicaule* (Wall. ex Lindl.) Rchb.f. | Orchidaceae | | | | | 2500 | 8.79 | | |
| *Albizia myriophylla* Benth. | Mimosaceae | | | | | | | 2500 | 7.26 |
| *Alpinia species* Roxb. | Zingiberaceae | | | | | | | 625 | 2.78 |
| *Ammannia baccifera* L. | Lythraceae | 1875 | 8.86 | | | | | | |
| *Anaphalis adnata* Wall. ex DC. | Asteraceae | | | 2500 | 3.51 | 1250 | 5.24 | | |
| *Anaphalis araneosa* DC. | Asteraceae | 1250 | 7.39 | | | | | | |
| *Anplectrum species* A. Gray. | Melastomataceae | | | 625 | 1.81 | | | | |
| *Anthogonium gracile* Wall. ex Lindl. | Orchidaceae | | | | | 1875 | 6.17 | | |
| *Aphyllorchis montana* Rchb.f. | Orchidaceae | | | 3125 | 7.82 | | | | |
| *Artemisia parviflora* Roxb. Ex D. Don | Asteraceae | | | 1875 | 4.19 | | | | |
| *Arundina graminifolia* (D. Don) Hochr. | Orchidaceae | | | | | | | 2500 | 9.19 |
| *Asparagus filicinus* Buch.-Ham. ex D.Don | Liliaceae | | | | | 2500 | 7.09 | | |
| *Asparagus racemosus* Willd. | Liliaceae | | | | | | | 1250 | 5.56 |
| *Bauhinia vahlii* Wight & Arn. | Caesalpiniaceae | 4375 | 19.2 | | | | | | |
| *Bidens bipinnata* L. | Asteraceae | 1875 | 6.63 | | | | | | |
| *Bidens tripartita* L. | Asteraceae | | | 2500 | 3.51 | | | | |
| *Blumea repanda* (Roxb.) Hand. Mazz. | Asteraceae | | | | | 8750 | 19.74 | | |
| *Bulbophyllum gamblei* (Hook.f.) Hook.f. | Orchidaceae | | | | | 1250 | 3.55 | | |

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|---|---|---|---|---|---|---|---|---|---|
| *Bulbophyllum wallichii* Rchb.f. | Orchidaceae | | | 1250 | 2.38 | | | | |
| *Chrysanthemum indicum* L. | Asteraceae | 3750 | 17.7 | | | 625 | 2.62 | 625 | 2.78 |
| *Cirsium interpositum* Petr. | Asteraceae | | | | | 1250 | 5.24 | | |
| *Cleisostoma simondii* (Gagnep.) Seidenf. | Orchidaceae | 1250 | 5.16 | | | | | | |
| *Clinopodium umbrosum* (M.Bieb.) Kuntze | Lamiaceae | | | 9375 | 13.5 | | | | |
| *Coelogyne fimbriata* Lindl. | Orchidaceae | | | | | 1875 | 6.17 | | |
| *Coelogyne griffithii* Hook.f. | Orchidaceae | | | 1875 | 4.19 | | | | |
| *Cryptolepis dubia* (Burm.f.) M.R.Almeida | Apocynaceae | | | 1250 | 2.38 | 1250 | 5.24 | | |
| *Cryptolepis grandiflora* Wight | Apocynaceae | 1875 | 6.63 | | | | | | |
| *Cuphea carthagenensis* (Jacq.) J.F.Macbr. | Lythraceae | | | | | 2500 | 8.79 | | |
| *Curculigo orchioides* Gaertn. | Hypoxidaceae | | | 2500 | 3.51 | | | | |
| *Curcuma angustifolia* Roxb. | Zingiberaceae | | | | | | | 1250 | 3.63 |
| *Curcuma montana* Roxb. | Zingiberaceae | 625 | 3.69 | | | | | | |
| *Cyanotis barbata* D. Don | Commelinaceae | | | | | | | 2500 | 5.34 |
| *Cyanotis cristata* (L.) D.Don | Commelinaceae | 1875 | 8.86 | | | 625 | 2.62 | | |
| *Cyclea peltata* Hook. f. & Thoms. | Menispermaceae | | | | | 3125 | 9.71 | | |
| *Cymbopogon flexuosus* (Nees ex Steud.) W.Watson | Poaceae | 1250 | 5.16 | | | | | | |
| *Cymbopogon schoenanthus* (L.) Spreng. | Poaceae | 625 | 3.69 | | | | | | |
| *Datura stramonium* L. | Solanaceae | | | 1875 | 4.19 | 1250 | 3.55 | | |
| *Decaloba leschenaultii* (DC.) M. Roem. | Passifloraceae | | | 3750 | 5.89 | | | | |
| *Dichrocephala integrifolia* (L.f.) Kuntze | Asteraceae | | | 2500 | 4.76 | | | 625 | 2.78 |
| *Digitaria ciliaris* (Retz.) Koeler | Poaceae | 1250 | 5.16 | | | | | | |
| *Dioscorea glabra* Roxb. | Dioscoreaceae | | | 1875 | 2.94 | | | | |
| *Disporum calcaratum* D. Don | Convallariaceae | | | 3125 | 5.32 | | | | |
| *Elatostema integrifolium* (D. Don) Wedd. | Urticaceae | | | 625 | 1.81 | | | | |
| *Elatostema monandrum* (Buch.-Ham. ex D. Don) H. Hara | Urticaceae | | | | | | | 3125 | 6.20 |
| *Elatostema platyphyllum* Wedd. | Urticaceae | 3125 | 16.2 | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|
| *Elephantopus scaber* L. | Asteraceae | 1875 | 8.86 | | | | | | |
| *Entada rheedei* Spreng. | Papilionaceae | | | | | | | 1250 | 5.56 |
| *Fimbristylis complanata* (Retz.) Link | Cyperaceae | | | | | 625 | 2.62 | | |
| *Galinsoga parviflora* Cav. | Asteraceae | | | | | 6250 | 16.04 | 8125 | 18.80 |
| *Galium asperifolium* Wall. | Rubiaceae | | | | | 3750 | 8.95 | | |
| *Galium elegans* Wall. ex Roxb. | Rubiaceae | | | | | | | 5000 | 12.61 |
| *Girardinia diversifolia* (Link) Friis | Urticaceae | 1250 | 7.39 | | | 1250 | 5.24 | | |
| *Gomphostemma strobilinum* Wall. ex Benth. | Lamiaceae | | | 6250 | 10.6 | | | | |
| *Gouania napalensis* Wall. | Rhamnaceae | | | 2500 | 6.01 | | | | |
| *Gouania tiliifolia* Lam. | Rhamnaceae | 625 | 3.69 | | | | | | |
| *Holboellia latifolia* Wall. | Lardizabalaceae | 1875 | 6.63 | | | | | | |
| *Hypoxis aurea* Lour. | Hypoxidaceae | | | | | 2500 | 8.79 | | |
| *Impatients latiflora* Hook.f. & Thomson | Balsaminaceae | | | 6875 | 11.2 | | | | |
| *Justicia anfractuous* C.B. Clarke | Acanthaceae | 2500 | 10.3 | | | 625 | 2.62 | 1875 | 4.49 |
| *Lasia spinosa* (L.) Thwaites | Araceae | | | | | | | 6875 | 17.09 |
| *Luffa acutangula* (L.) Roxb. | Cucurbitaceae | | | 1875 | 5.44 | | | | |
| *Lygodium flexuosum* (L.) Sw. | Lygodiaceae | 1250 | 5.16 | | | 2500 | 7.09 | | |
| *Mikania cordata* (Burm.f.) B.L. Rob | Asteraceae | | | | | | | 5625 | 11.54 |
| *Mikania micrantha* Kunth | Asteraceae | | | | | | | 3750 | 7.05 |
| *Molineria crassifolia* Baker | Hypoxidaceae | | | 5000 | 7.02 | | | | |
| *Mucuna macrocarpa* Wall. | Leguminosae | 1875 | 8.86 | 2500 | 6.01 | | | | |
| *Mukia maderaspatana* (L.) M. Roem. | Cucurbitaceae | | | | | 1875 | 7.86 | | |
| *Murdannia nudiflora* (L.) Brenan | Commelinaceae | | | | | | | 625 | 2.78 |
| *Pentasachme caudatum* Wall. ex Wight | Apocynaceae | | | 3750 | 7.14 | | | | |
| *Pilea melastomoides* (Poir.) Wedd. | Urticaceae | | | | | | | 1250 | 5.56 |
| *Pimpinella diversifolia* DC. | Apiaceae | | | 1250 | 3.63 | | | | |
| *Pollia hasskarlii* R.S.Rao | Commelinaceae | | | | | 1250 | 3.55 | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Polygonatum cathcartii* Baker | Convallariaceae | | | 625 | 1.81 | | | | |
| *Porana paniculata* Roxb. | Convolvulaceae | 625 | 3.69 | 8125 | 12.3 | | | 3125 | 8.12 |
| *Pothos scandens* L. | Araceae | | | | | | | 2500 | 7.26 |
| *Pouzolzia zeylanica* (L.) Benn. | Urticaceae | 1250 | 7.39 | | | | | | |
| *Pycreus flavidus* (Retz.) T.Koyama | Cyperaceae | | | | | 1875 | 4.47 | | |
| *Pycreus sanguinolentus* (Vahl) Nees | Cyperaceae | | | 5000 | 8.27 | | | | |
| *Remusatia hookeriana* Schott | Araceae | | | 4375 | 7.7 | | | | |
| *Rhaphidophora species* Hassk. | Araceae | | | | | | | 625 | 2.78 |
| *Rubia sikkimensis* Kurz | Rubiaceae | | | | | | | 3750 | 8.97 |
| *Saccharum arundinaceum* Retz. | Poaceae | | | | | 625 | 2.62 | | |
| *Sedum multicaule* Wall. ex Lindl. | Crassulaceae | | | 2500 | 6.01 | | | | |
| *Sigesbeckia orientalis* L. | Asteraceae | 1875 | 8.86 | 5625 | 8.83 | | | 1875 | 6.41 |
| *Smilax glabra* Roxb. | Smilacaceae | | | | | 1250 | 5.24 | | |
| *Smithia ciliata* Royle | Papilionaceae | | | 1875 | 4.19 | | | | |
| *Spathoglottis pubescens* Lindl. | Orchidaceae | 625 | 3.69 | | | | | | |
| *Spatholobus roxburghii* Benth. | Leguminosae | | | | | | | 625 | 2.78 |
| *Spiradiclis cylindrica* Wall. ex Hook.f. | Rubiaceae | | | | | 625 | 2.62 | | |
| *Stellaria vestita* Kurz | Caryophyllaceae | | | 3750 | 7.14 | | | | |
| *Synotis tetrantha* (DC.) C.Jeffrey & Y.L.Chen | Asteraceae | | | 5000 | 8.27 | | | | |
| *Tetrastigma obovatum* Gagnep | Vitaceae | 625 | 3.69 | | | 625 | 2.62 | 1250 | 5.56 |
| *Tinospora cordifolia* (Willd.) Miers. | Menispermaceae | 625 | 3.69 | | | | | | |
| *Viola hamiltoniana* D. Don | Violaceae | | | | | 1250 | 3.55 | | |

#### 4.2.9.2 Species diversity indices

In the present study, tree species showed higher diversity index than shrub and herb species in all the community forest. In trees, Shannon diversity index (H') ranged from 2.97 – 3.68 where the highest diversity index was recorded from Peducha CF (3.68) followed by Touphema CF (3.38) and Khonoma CF (3.15) the lowest was recorded from Longwesunyu CF (2.97). The Simpson dominance index (CD) value in all community showed inversely proportional to Shannon's diversity index (H'). The Margalef index (Dmg) ranged from 5.73 – 9.67 which correspond well with the Shannon's diversity index (H') value. The Pielou's evenness index (e) ranged from 0.88 – 0.94 indicating quite even of species in the community (Table 4.2.33).

In shrubs, Shannon diversity index (H') value ranged from 2.62 – 3.17 and the Simpson dominance index (CD) ranged from 0.06 – 0.09. The study showed that the dominance index value was inversely proportional to diversity index. The Margalef index (Dmg) ranged from 3.95 – 5.94 indicating low species richness in the community. The Pielou's evenness index (e) ranged from 0.85 – 0.93 indicating high species evenness in the community (Table 4.2.33).

In herbs, the highest Shannon diversity index (H') was recorded from Khonoma CF (3.35) followed by Longwesunyyu CF (3.06), Touphema CF (3.01) and lowest in Peducha CF (2.62). The Simpson dominance index (CD) ranged from 0.04 – 0.07 was inversely proportional to Shannon diversity index. The Margalef species richness index (Dmg) ranged from 5.67 – 6.57 and the Pielou's evenness index (e) ranged from 0.88 – 0.91 indicating high evenness of species in the community (Table 4.2.33).

#### 4.2.9.3 Population structure of tree species in various girth-classes

The tree density and basal area varied with girth classes in different communities. The highest density and basal area was recorded from younger trees (10 – 60 cm girth class) contributing 80% and 51% of the total tree density and basal area in all the community. The regenerating trees contributed 16% where as mature trees contributed only 5% of the total tree density indicating good regeneration potential in the community. The contribution of older trees density was highest in

Peducha and Khonoma CF (5% and 6%) whereas, no older individuals were recorded in Longwesunyu CF. The contribution of basal cover by older tree followed the pattern similar to that of tree density. Overall population structure of all communities showed a reverse *J*-shaped population curve indicating a good forest health and high species richness (Figure 4.2.17). Higher density in lower girth classes indicated a good regeneration potential of the forest indicating that future plant communities can be sustained unless there is any major biotic or abiotic changes.

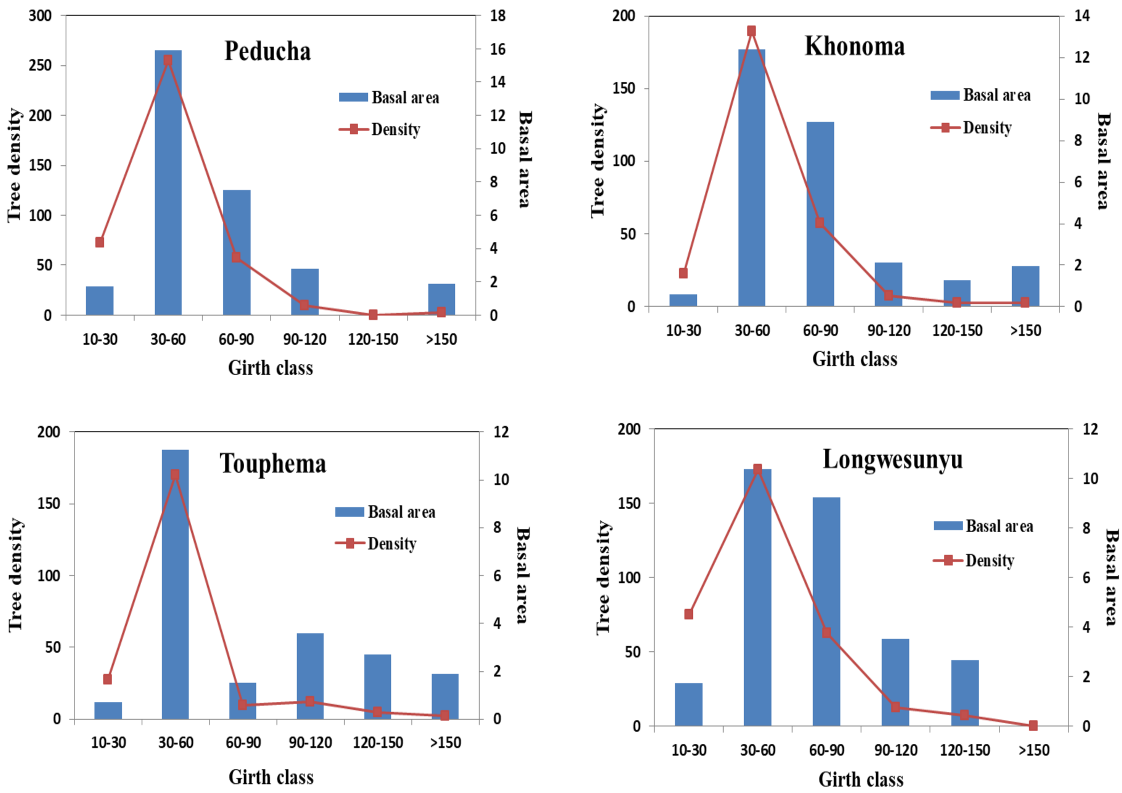
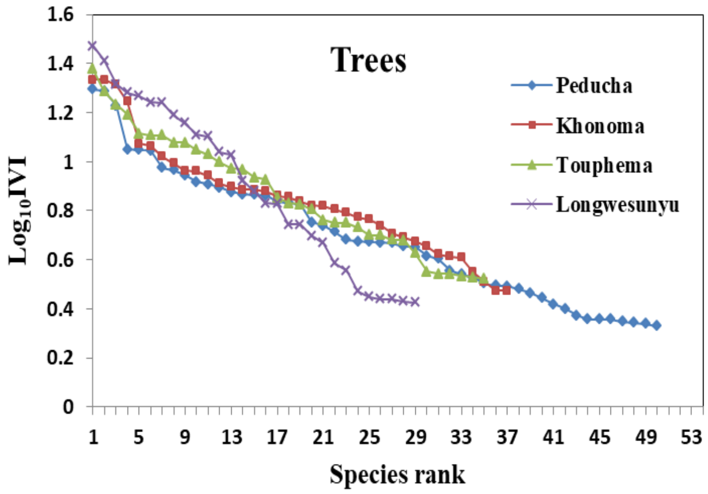
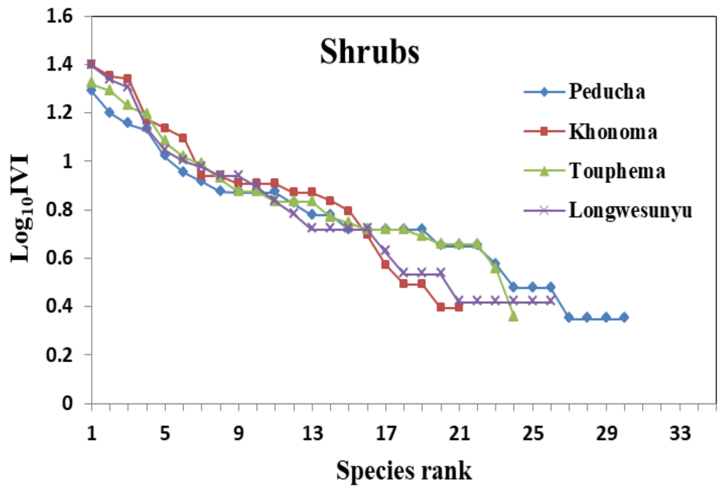



**Figure 4.2.17** Contributions of tree stand density and basal area based on girth class contribution in four study sites of Kohima District, Nagaland

### 4.2.9.4 Dominance-Diversity curve

Dominance-diversity curve (% IVI on log scale plotted against species rank) showed different species distribution with site wise variations in different forest communities. The present study showed that the dominance-diversity curve for tree, shrub and herb layer followed log normal distribution pattern indicating high equitability and low dominance of species in the community (Figure 4.2.18). Among trees, the most dominant species were: *Quercus serrata* (Peducha CF), *Acer oblongum* (Khonoma CF), *Cedrella toona* (Touphema CF) and *Ailanthus integrifolia* (Longwesunyu CF). In shrubs, the most dominant species were: *Boehmeria japonica* (Peducha CF), *Clerodendrum chinense* (Khonoma CF), *Amomum subulatum* (Touphema CF) and *Phrynium capitatum* (Longwesunyu CF). In herbs, the most dominant species were: *Bauhinia vahlii* (Peducha CF), *Chinopodium umbrosum* (Khonoma CF), *Ageratina riparia* (Touphema CF) and *Galinsoga parviflora* (Longwesunyu CF).



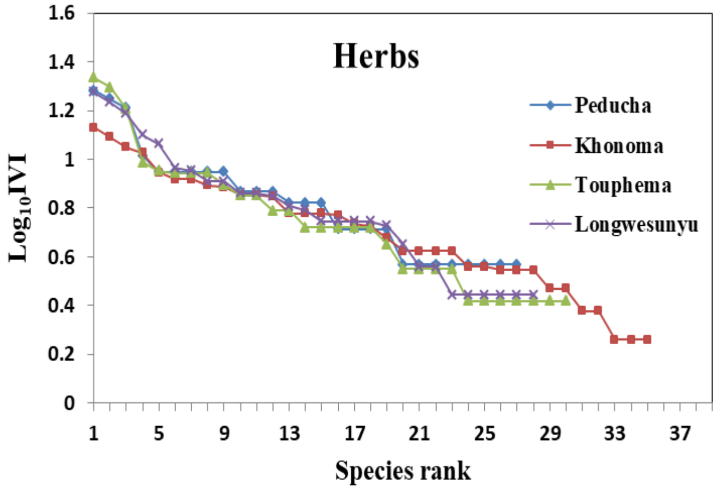



**Figure 4.2.18** Dominance-Diversity curve for trees, shrubs and herbs in four study sites of Kohima District, Nagaland

### 4.2.9.5 Distribution pattern of tree species

Whitford index (A/F ratio) was used to express the distribution pattern of species in all the communities. The distribution pattern of species in the study sites was classified into regular, random and clumped/contagious, which showed a mixed type of distribution pattern. More than 50% of the species exhibited clumped or contagious distribution in Peducha, Khonoma and Longwesunyu CF whereas in Touphema CF, 46% showed random distribution followed by 31% clumped or contagious and only 23% exhibited regular distribution pattern (Table 4.2.34).

### 4.2.9.6 Sorenson's similarity

Sorenson's similarity index reflects the inter-relationship of different forest types. An average of only 16% similarity was observed in all the community. Maximum dissimilarity of tree species was observed in Peducha and Longwesunyu (3%) and Touphema and Longwesunyu CF (5%) and highest similarity was observed in Peducha and Touphema CF (38%) and Peducha and Khonoma CF (21%). The high dissimilarity of species in the community may be attributed to different micro-habitat conditions, altitudinal gradient and species compostion, climatic and various edaphic factors (Table 4.2.36).

**Table 4.2.36** Sorenson Similarity indices for tree species between four study sites of Kohima District, Nagaland

| Study area | Peducha | Khonoma | Touphema | Longwesunyu |
|---|---|---|---|---|
| **Peducha** | x | | | |
| **Khonoma** | 0.21 | x | | |
| **Touphema** | 0.38 | 0.17 | x | |
| **Longwesunyu** | 0.05 | 0.12 | 0.03 | x |

### 4.2.9.7 Disturbance index

The average disturbance index for all the study sites was 18% (Table 4.2.33). The highest disturbance index was recorded at Khonoma CF (23%) followed by Peducha CF (21%), Touphema CF (14%) and lowest in Longwesunyu CF (12%). The study showed that local people extract tree species such as *Acer oblongum*, *Castanopsis indica*, *Prunus napaulensis*, *Quercus serrata* etc. for various construction purposes and agricultural implements. High disturbance index in Khonoma and Peducha CF may also attribute to various developmental works (e.g road construction and drainaige system) initiated by the local people around the forest.

## 4.2.10 Peren district

### 4.2.10.1 Floristic structure

*Tree species composition*

In the present study, a total of 737 individuals belonging to 136 species and 97 genera representing 48 families were recorded from the five community forest (Athibung, Dunki, Benreu, Tesen and New Jalukie) of Peren district, Nagaland, Northeast India. Out of these, 47 species belonging to 39 genera, 28 families and 168 individuals from Dunki CF followed by 42 species belonging to 38 genera, 30 families and 147 individuals from Benreu CF; 40 species belonging to 33 genera, 25 families and 145 individuals were recorded from Athibung CF; 36 species belonging to 32 genera, 24 families and 141 individuals from Tesen CF and 34 species belonging to 32 genera, 24 families and 136 individuals from New Jalukie CF of Nagaland respectively (Table 4.2.37). In Athibung CF, the most dominant tree species were: *Choerospondias axillaris* (16.75), *Sapium baccatum* (15.78) and

*Albizia chinensis* (14.12) and the co-dominant species were: *Firmiana colorata* (13.2), *Sapium mukorossi* (13.05) and *Chukrasia tabularis* (12.84) (Table 4.2.38). The most dominant families from this community were: Anacardiaceae, Euphorbiaceae, Fagaceae and Lauraceae. In Dunki CF, the dominant tree species were: *Careya arborea* (14.44), *Lagerstroemia parviflora* (12.50) and *Bombax ceiba* (11.61) and the co-dominant species were: *Ailanthus integrifolia* (12.02) and *Tectona grandis* (10.54) (Table 4.2.38). The most dominant families were: Euphorbiaceae, Fagaceae and Sterculiaceae. In Benreu CF, the dominant species were: *Alnus nepalensis* (24.65), *Prunus cerasoides* (16.68) and *Erythrina arborescens* (14.21) and the co-dominant species were: *Lithocarpus pachyphyllus* (10.44), *Ilex dipyrena* (9.96) and *Lithocarpus polystachyus* (9.43) (Table 4.2.38). The dominant families were: Fagaceae, Lauraceae and Rosaceae. In Tesen CF, The dominant species were: *Garcinia pedunculata* (21.93), *Phoebe lanceolata* (21.03) and *Schima wallichii* (17.09) and the co-dominant species were: *Drimycarpus racemosus* (16.15), *Terminalia myriocarpa* (14.30) and *Lithorcarpus elegans* (12.62) (Table 4.2.38). The dominant families were: Fabaceae, Lauraceae and Magnoliaceae. In New Jalukie CF, the dominant species were: *Duabanga grandiflora* (24.21), *Stereospermum chelonoides* (21.79) and *Lagerstroemia speciosa* (16.97) and the co-dominant species were: *Careya arborea* (15.00), *Magnolia hodgsonii* (14.31) and *Morus laevigata* (13.44) (Table 4.2.38). The most dominant families from this study site were: Lauraceae, Lythraceae and Moraceae. The highest tree density (individuals $ha^{-1}$) and basal area ($m^2ha^{-1}$) was recorded from Dunki (420 and 40.57) and New Jalukie and Tesen CF recorded the lowest density and basal area (340 and 31.8 respectively) (Table 4.2.37).

**Table 4.2.37** Phytosociological attributes of trees, shrubs and herbs in five study sites of Peren District, Nagaland

| Parameters | Dunki | Benreu | Athibung | Tesen | New Jalukie |
|---|---|---|---|---|---|
| **Trees** | | | | | |
| No. of species | 47 | 42 | 40 | 36 | 34 |
| No. of genera | 39 | 38 | 33 | 32 | 32 |
| Families | 28 | 30 | 25 | 24 | 24 |
| Density (individuals $ha^{-1}$) | 420 | 368 | 363 | 353 | 340 |
| Basal area ($m^2ha^{-1}$) | 40.57 | 38.09 | 35.47 | 31.18 | 32.25 |
| Shannon diversity index (H') | 3.73 | 3.52 | 3.50 | 3.45 | 3.40 |
| Simpson index (CD) | 0.02 | 0.03 | 0.03 | 0.04 | 0.03 |
| Margalef index (Dmg) | 8.98 | 8.22 | 7.84 | 7.07 | 6.72 |
| Evenness (e) | 0.96 | 0.94 | 0.95 | 0.95 | 0.96 |
| Disturbance index (%) | 10 | 13 | 18 | 16 | 22 |
| **Shrubs** | | | | | |
| No. of species | 25 | 30 | 33 | 21 | 23 |
| No. of genera | 24 | 23 | 30 | 19 | 20 |
| Families | 19 | 18 | 19 | 17 | 18 |
| Density (individuals $ha^{-1}$) | 6400 | 8600 | 9250 | 7300 | 7550 |
| Shannon diversity index (H') | 3.08 | 3.29 | 3.31 | 2.81 | 2.86 |
| Simpson index (CD) | 0.05 | 0.04 | 0.04 | 0.06 | 0.07 |
| Margalef index (Dmg) | 4.95 | 5.63 | 6.13 | 4.01 | 4.38 |
| Evenness (e) | 0.95 | 0.98 | 0.94 | 0.90 | 0.91 |
| **Herbs** | | | | | |
| No. of species | 28 | 29 | 22 | 35 | 27 |
| No. of genera | 27 | 28 | 21 | 30 | 23 |
| Families | 19 | 21 | 16 | 26 | 19 |
| Density (individuals $ha^{-1}$) | 66875 | 70000 | 60000 | 87500 | 77500 |
| Shannon diversity index (H') | 3.19 | 3.05 | 2.73 | 3.44 | 3.10 |
| Simpson index (CD) | 0.04 | 0.06 | 0.07 | 0.03 | 0.05 |
| Margalef index (Dmg) | 5.78 | 5.93 | 4.60 | 6.88 | 5.39 |
| Evenness (e) | 0.95 | 0.90 | 0.88 | 0.96 | 0.94 |

**Table 4.2.38** Density (individuals $ha^{-1}$), Basal area ($m^2ha^{-1}$), Important value index (IVI) and Distribution pattern (DP) of tree species in five study sites of Peren District, Nagaland

| Species | Family | Dunki | | | | Benreu | | | | Athibung | | | | Tesen | | | | New Jalukie | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** |
| *Actinodaphne obovata* (Nees) Blume | Lauraceae | 5 | 0.67 | 3.73 | C | | | | | 10 | 1.47 | 10.28 | RE | | | | | | | | |
| *Aglaia spectabilis* (Miq.) S.S.Jain & S.Bennet | Meliaceae | | | | | 5 | 0.67 | 5.19 | R | | | | | 5 | 0.44 | 3.98 | C | | | | |
| *Ailanthus integrifolia* Lam. | Simaroubaceae | 15 | 1.98 | 12.02 | C | | | | | | | | | | | | | | | | |
| *Albizia chinensis* (Osbeck) Merr. | Mimosaceae | 2.5 | 0.37 | 2.41 | C | | | | | 20 | 1.46 | 14.12 | C | 7.5 | 1.12 | 9.14 | C | 10 | 1.02 | 10.15 | RE |
| *Albizia lebbeck* (L.) Benth. | Mimosaceae | 5 | 1.05 | 5.56 | C | | | | | 5 | 0.92 | 5.10 | C | | | | | | | | |
| *Albizia procera* (Roxb.)Benth. | Mimosaceae | | | | | | | | | | | | | | | | | 12.5 | 0.89 | 11.85 | RE |
| *Alnus nepalensis* D.Don | Betulaceae | | | | | 30 | 4.71 | 24.65 | C | | | | | | | | | | | | |
| *Alphonsea ventricosa* (Roxb.) Hook. f. & Thomson | Annonaceae | 7.5 | 1.54 | 7.36 | R | | | | | | | | | | | | | | | | |
| *Alseodaphne khasyana* (Meisn.) Kosterm. | Lauraceae | | | | | 2.5 | 0.79 | 3.80 | C | | | | | | | | | | | | |
| *Alstonia scholaris* (L.) R. Br. | Apocynaceae | | | | | 7.5 | 0.73 | 6.03 | C | | | | | 7.5 | 0.62 | 6.39 | R | | | | |
| *Artocarpus lacucha* Buch.-Ham. | Moraceae | | | | | 7.5 | 0.79 | 7.22 | C | | | | | 7.5 | 0.75 | 5.68 | C | 5 | 0.52 | 4.43 | C |
| *Bauhinia purpurea* L. | Caesalpiniaceae | | | | | 7.5 | 0.20 | 3.59 | C | | | | | 7.5 | 0.72 | 6.71 | C | 15 | 0.59 | 11.64 | RE |
| *Bauhinia variegata* L. | Caesalpiniaceae | | | | | | | | | 7.5 | 0.16 | 4.76 | R | | | | | | | | |
| *Beilschmiedia roxburghiana* Nees | Lauraceae | | | | | | | | | | | | | | | | | 7.5 | 0.71 | 5.75 | C |
| *Betula alnoides* Buch.-Ham. ex. D. Don | Betulaceae | | | | | 5 | 1.04 | 6.16 | C | | | | | | | | | | | | |
| *Bischofia javanica* Blume | Euphorbiaceae | 7.5 | 0.84 | 4.75 | C | | | | | | | | | | | | | | | | |
| *Bombax ceiba* L. | Malvaceae | 12.5 | 2.06 | 11.61 | C | | | | | 2.5 | 1.29 | 5.46 | C | | | | | | | | |
| *Brassaiopsis hainla* (Buch.-Ham.) Seem. | Araliaceae | | | | | 10 | 0.30 | 6.61 | C | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Callicarpa arborea* Roxb. | Verbenaceae | | | | | | | | | 10 | 0.34 | 5.96 | C | | | | | 7.5 | 0.39 | 4.76 | C |
| *Canarium bengalense* Roxb. | Burseraceae | 20 | 1.51 | 12.06 | C | 5 | 2.56 | 9.11 | C | | | | | | | | | | | | |
| *Canarium strictum* Roxb. | Burseraceae | 5 | 0.83 | 5.03 | C | | | | | | | | | 2.5 | 1.87 | 7.84 | C | 10 | 0.63 | 8.95 | RE |
| *Careya arborea* Roxb. | Lecythidaceae | 17.5 | 2.72 | 14.44 | C | | | | | | | | | | | | | 20 | 2.07 | 15.00 | C |
| *Cassia fistula* L. | Leguminosae | 15 | 1.01 | 7.84 | C | | | | | | | | | | | | | | | | |
| *Castanopsis indica* (Roxb. ex Lindl.) A.DC. | Fagaceae | 7.5 | 0.99 | 6.90 | C | | | | | | | | | 10 | 0.68 | 9.58 | C | | | | |
| *Castanopsis lanceifolia* (Oerst.) Hickel & A.Camus | Fagaceae | | | | | | | | | | | | | 5 | 0.13 | 2.96 | C | 5 | 0.14 | 3.27 | C |
| *Castanopsis tribuloides* (Sm.) A.DC. | Fagaceae | 12.5 | 0.81 | 6.76 | C | | | | | | | | | | | | | | | | |
| *Cedrela toona* Roxb. ex Rottl. & Willd. | Meliaceae | | | | | | | | | 12.5 | 0.74 | 7.79 | C | | | | | | | | |
| *Choerospondias axillaris* (Roxb.) B.L. Burtt & A.W. Hill | Anacardiaceae | | | | | | | | | 22.5 | 2.14 | 16.75 | R | | | | | | | | |
| *Chukrasia tabularis* A. Juss. | Meliaceae | | | | | | | | | 15 | 1.49 | 12.84 | RE | | | | | | | | |
| *Cinnamomum zeylanicum* Blume | Lauraceae | | | | | 7.5 | 0.27 | 5.84 | C | | | | | | | | | | | | |
| *Colona floribunda* (Kurz) Craib | Tiliaceae | 10 | 0.43 | 5.22 | R | | | | | 10 | 0.41 | 6.17 | R | | | | | | | | |
| *Croton joufra* Roxb. | Euphorbiaceae | 7.5 | 0.21 | 4.99 | C | | | | | | | | | | | | | | | | |
| *Croton tiglium* L. | Euphorbiaceae | 5 | 0.25 | 3.60 | C | | | | | | | | | | | | | | | | |
| *Dillenia pentagyna* Roxb. | Dilleniaceae | 10 | 1.06 | 6.78 | C | | | | | | | | | | | | | 12.5 | 1.61 | 12.72 | RE |
| *Dimocarpus longan* Lour. | Sapindaceae | | | | | | | | | | | | | 5 | 0.48 | 4.11 | C | | | | |
| *Diospyros kaki* L.f. | Ebenaceae | | | | | 10 | 0.78 | 6.84 | R | | | | | | | | | | | | |
| *Docynia indica* (Wallich.)Decne. | Rosaceae | | | | | 7.5 | 0.99 | 5.66 | C | | | | | 5 | 0.11 | 4.05 | C | | | | |
| *Drimycarpus racemosus* (Roxb.) Hook. f. | Anacardiaceae | | | | | 7.5 | 0.33 | 4.98 | C | | | | | 20 | 1.85 | 16.15 | RE | 7.5 | 0.75 | 5.90 | C |
| *Duabanga grandiflora* (DC.) Walp. | Lythraceae | | | | | | | | | | | | | | | | | 22.5 | 3.93 | 24.21 | R |
| *Elaeocarpus braceanus* Watt ex C. B. Clarke | Elaeocarpaceae | | | | | 5 | 0.09 | 2.64 | C | 10 | 1.39 | 10.06 | RE | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Elaeocarpus floribundus* Blume | Elaeocarpaceae | 7.5 | 1.04 | 7.03 | C | | | | | | | | | | | | | | | | |
| *Elaeocarpus tectorius* (Lour.) Poir. | Elaeocarpaceae | | | | | | | | | 2.5 | 0.23 | 2.48 | R | 7.5 | 0.46 | 7.00 | C | 2.5 | 0.10 | 2.40 | R |
| *Engelhardia spicata* Lesch. ex Blume | Juglandaceae | | | | | | | | | | | | | 7.5 | 0.94 | 6.27 | C | 5 | 0.65 | 4.84 | C |
| *Erythrina arborescens* Roxb. | Leguminosae | | | | | 25 | 1.25 | 14.21 | R | | | | | 7.5 | 0.24 | 5.17 | R | 10 | 0.66 | 7.69 | R |
| *Erythrina stricta* Roxb. | Leguminosae | | | | | | | | | 7.5 | 0.30 | 4.05 | C | | | | | | | | |
| *Eucalyptus species* L. Hér. | Myrtaceae | | | | | | | | | | | | | | | | | 10 | 0.96 | 11.31 | RE |
| *Eurya acuminata* DC. | Theaceae | | | | | 7.5 | 0.28 | 4.84 | R | | | | | 5 | 0.10 | 4.00 | RE | | | | |
| *Exbucklandia populnea* (R.Br. ex Griff.) R.W.Br. | Hamamelidaceae | | | | | 5 | 1.88 | 7.33 | C | | | | | 10 | 0.69 | 7.33 | C | | | | |
| *Ficus racemosa* L. | Moraceae | 7.5 | 0.66 | 4.31 | C | | | | | | | | | | | | | | | | |
| *Firmiana colorata* (Roxb.) R.Br. | Sterculiaceae | 5 | 0.37 | 2.99 | C | | | | | 17.5 | 1.38 | 13.20 | RE | | | | | | | | |
| *Garcinia pedunculata* Roxb. ex Buch.-Ham. | Clusiaceae | | | | | | | | | | | | | 32.5 | 2.54 | 21.93 | R | 5 | 0.23 | 3.53 | C |
| *Gmelina arborea* Roxb. | Verbenaceae | 7.5 | 1.66 | 8.55 | RE | | | | | | | | | | | | | 5 | 0.52 | 5.79 | RE |
| *Grewia tiliifolia* Vahl | Tiliaceae | | | | | | | | | 7.5 | 0.36 | 6.46 | RE | | | | | | | | |
| *Gynocardia odorata* R. Br. | Flacourtiaceae | | | | | | | | | 7.5 | 0.18 | 4.81 | C | | | | | | | | |
| *Hevea brasiliensis* (A.Juss.) Meull. | Euphorbiaceae | | | | | | | | | | | | | | | | | 5 | 0.60 | 6.04 | RE |
| *Heynea trijuga* Roxb. ex Sims | Meliaceae | 15 | 0.48 | 8.32 | C | | | | | | | | | | | | | | | | |
| *Holarrhena pubescens* Wall. ex G. Don | Apocynaceae | 15 | 0.42 | 7.28 | R | | | | | | | | | | | | | | | | |
| *Ilex dipyrena* Wall. | Aquifoliaceae | | | | | 17.5 | 0.41 | 9.96 | C | | | | | | | | | | | | |
| *Iteadaphne caudata* (Nees) H.W. Li | Lauraceae | 5 | 0.09 | 3.19 | RE | | | | | | | | | | | | | | | | |
| *Juglans regia* L. | Juglandaceae | | | | | 5 | 0.41 | 3.48 | C | | | | | | | | | | | | |
| *Kydia calycina* Roxb. | Malvaceae | 5 | 0.53 | 4.29 | C | | | | | | | | | | | | | | | | |
| *Lagerstroemia parviflora* Roxb. | Lythraceae | 17.5 | 1.93 | 12.50 | C | | | | | | | | | | | | | | | | |
| *Lagerstroemia speciosa* (L.) | Lythraceae | 5 | 0.54 | 3.42 | C | | | | | | | | | | | | | 17.5 | 2.50 | 16.97 | R |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pers. | | | | | | | | | | | | | | | | | | | | | |
| *Lindera nacusua* (D. Don) Merr | Lauraceae | | | | | | | | | | | | | 17.5 | 0.48 | 11.06 | C | | | | |
| *Lindera pulcherrima* (Nees) Benth. | Lauraceae | | | | | 15 | 0.47 | 9.44 | C | | | | | | | | | 7.5 | 0.12 | 3.94 | C |
| *Lithocarpus elegans* (Blume) Hatus. ex Soepadmo | Fagaceae | | | | | | | | | | | | | 12.5 | 1.41 | 12.62 | RE | | | | |
| *Lithocarpus fenestratus* (Roxb.) Rehder | Fagaceae | | | | | | | | | | | | | 7.5 | 0.50 | 7.15 | C | | | | |
| *Lithocarpus pachyphyllus* (Kurz) Rehder | Fagaceae | | | | | 12.5 | 1.11 | 10.44 | C | | | | | | | | | | | | |
| *Lithocarpus polystachyus* (Wall. ex A.DC.) Rehder | Fagaceae | | | | | 10 | 1.38 | 9.43 | C | | | | | | | | | | | | |
| *Litsea cubeba* (Lour.) Pers. | Lauraceae | | | | | | | | | 2.5 | 0.08 | 2.05 | C | | | | | | | | |
| *Litsea laeta* (Wall. ex Nees) Hook.f. | Lauraceae | | | | | | | | | | | | | | | | | 5 | 0.05 | 2.99 | C |
| *Litsea salicifolia* (Roxb. ex Nees) Hook.f. | Lauraceae | | | | | | | | | | | | | 2.5 | 0.08 | 2.11 | R | | | | |
| *Macaranga denticulata* (Blume) Müll.Arg. | Euphorbiaceae | 2.5 | 0.10 | 1.74 | R | | | | | 5 | 0.24 | 4.31 | C | | | | | | | | |
| *Macaranga indica* Wight | Euphorbiaceae | 7.5 | 0.42 | 5.49 | RE | | | | | 7.5 | 0.26 | 3.92 | C | | | | | | | | |
| *Macaranga pustulata* King ex J. D. Hook. | Euphorbiaceae | | | | | 10 | 0.28 | 7.58 | C | | | | | | | | | | | | |
| *Magnolia campbellii* Hook.f.&Thomson. | Magnoliaceae | | | | | 7.5 | 0.95 | 7.62 | RE | | | | | | | | | | | | |
| *Magnolia champaca* (L.) Baill. ex Pierre | Magnoliaceae | | | | | | | | | 7.5 | 0.97 | 8.18 | C | | | | | | | | |
| *Magnolia doltsopa* (Buch.-Ham. ex DC.) Figlar | Magnoliaceae | | | | | 7.5 | 0.37 | 5.06 | R | | | | | | | | | | | | |
| *Magnolia hodgsonii* (Hook.f. & Thomson) H.Keng | Magnoliaceae | | | | | | | | | | | | | 7.5 | 1.45 | 10.20 | C | 25 | 0.50 | 14.31 | R |
| *Magnolia oblonga* (Wall. ex Hook.f. & Thomson) Figlar | Magnoliaceae | | | | | 7.5 | 1.49 | 8.02 | C | | | | | 5 | 1.87 | 9.69 | C | | | | |
| *Mallotus paniculatus* (Lam.) Müll.Arg. | Euphorbiaceae | 7.5 | 0.35 | 4.44 | C | | | | | 7.5 | 1.50 | 9.67 | C | | | | | | | | |
| *Mangifera sylvatica* Roxb. | Anacardiaceae | | | | | | | | | | | | | 5 | 0.47 | 4.06 | C | | | | |
| *Melia azedarach* L. | Meliaceae | | | | | | | | | | | | | | | | | 10 | 0.75 | 6.62 | C |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Micromelum integerrimum* (Buch.-Ham. ex Colebr.) M. Roem. | Rutaceae | 12.5 | 0.31 | 5.53 | C | | | | | | | | | | | | | | | | |
| *Morus laevigata* Wall. ex Brandis | Moraceae | | | | | 12.5 | 1.20 | 9.65 | C | | | | | | | | | 12.5 | 2.28 | 13.44 | C |
| *Murraya koenigii* (L.) Spreng. | Rutaceae | | | | | | | | | 10 | 0.31 | 7.02 | RE | | | | | | | | |
| *Myrica esculenta* Buch.-Ham. ex D. Don | Myricaceae | | | | | | | | | | | | | 5 | 0.09 | 3.98 | C | 7.5 | 0.28 | 4.43 | C |
| *Neolitsea umbrosa* (Nees) Gamble | Lauraceae | | | | | 7.5 | 0.39 | 5.13 | C | | | | | | | | | | | | |
| *Nephelium lappaceum* L. | Sapindaceae | | | | | 5 | 0.38 | 3.39 | C | | | | | 7.5 | 0.52 | 6.08 | R | | | | |
| *Parkia timoriana* (DC.) Merr. | Mimosaceae | | | | | | | | | 12.5 | 1.20 | 11.32 | C | | | | | | | | |
| *Phoebe lanceolata* (Nees) Nees | Lauraceae | | | | | | | | | | | | | 27.5 | 2.71 | 21.03 | R | | | | |
| *Pinus roxburghii* Sarg. | Pinaceae | | | | | | | | | | | | | 12.5 | 1.27 | 12.16 | RE | | | | |
| *Premna longifolia* Roxb. | Lamiaceae | | | | | | | | | 7.5 | 0.24 | 3.88 | C | | | | | | | | |
| *Prismatomeris tetrandra* (Roxb.) K.Schum. | Rubiaceae | | | | | | | | | | | | | 15 | 0.48 | 10.35 | C | | | | |
| *Prunus cerasoides* D. Don | Rosaceae | | | | | 15 | 3.23 | 16.68 | RE | | | | | | | | | | | | |
| *Prunus ceylanica* (Wight) Miq. | Rosaceae | | | | | | | | | 10 | 1.90 | 11.48 | RE | | | | | | | | |
| *Prunus napaulensis* (Ser.) Steud. | Rosaceae | | | | | 7.5 | 1.73 | 9.68 | RE | | | | | 7.5 | 0.79 | 6.94 | R | | | | |
| *Pterospermum acerifolium* (L.) Willd. | Sterculiaceae | 10 | 1.49 | 8.73 | C | | | | | | | | | | | | | | | | |
| *Quercus griffithii* Hook.f. & Thomson ex Miq. | Fagaceae | 5 | 0.72 | 4.76 | C | | | | | | | | | 7.5 | 0.67 | 6.54 | R | | | | |
| *Quercus lamellosa* Sm. | Fagaceae | | | | | 5 | 2.22 | 8.23 | C | | | | | | | | | | | | |
| *Quercus lanceifolia* Roxb. | Fagaceae | | | | | | | | | 10 | 1.10 | 9.22 | C | | | | | | | | |
| *Quercus obtusata* Bonpl. | Fagaceae | | | | | | | | | | | | | 7.5 | 0.72 | 7.83 | C | | | | |
| *Quercus semiserrata* Roxb. | Fagaceae | | | | | | | | | 5 | 0.98 | 6.39 | RE | | | | | | | | |
| *Quercus serrata* Murray | Fagaceae | | | | | | | | | 5 | 1.11 | 5.64 | C | | | | | | | | |
| *Rhus chinensis* Mill. | Anacardiaceae | 7.5 | 0.37 | 4.49 | R | | | | | 7.5 | 0.70 | 6.29 | R | | | | | 10 | 0.33 | 8.01 | RE |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Salix psilostigma* Andersson | Salicaceae | | | | | 7.5 | 0.17 | 4.54 | C | | | | | | | | | | | | |
| *Sapindus mukorossi* Gaertn. | Sapindaceae | | | | | | | | | 17.5 | 1.32 | 13.05 | RE | | | | | | | | |
| *Sapium baccatum* Roxb. | Euphorbiaceae | 10 | 1.44 | 8.62 | RE | | | | | 15 | 2.86 | 15.58 | R | | | | | | | | |
| *Saurauia armata* Kurz | Actinidiaceae | | | | | | | | | 7.5 | 0.27 | 3.95 | C | | | | | | | | |
| *Saurauia cerea* Griff. ex Dyer | Actinidiaceae | | | | | | | | | 5 | 0.40 | 3.64 | C | | | | | | | | |
| *Schima khasiana* Dyer | Theaceae | | | | | | | | | 10 | 1.31 | 8.69 | R | | | | | | | | |
| *Schima wallichii* Choisy | Theaceae | | | | | 7.5 | 1.00 | 6.73 | C | | | | | 22.5 | 1.92 | 17.09 | C | 12.5 | 1.82 | 12.01 | C |
| *Spondias pinnata* (L.f.) Kurz. | Anacardiaceae | | | | | | | | | 7.5 | 0.41 | 5.46 | C | | | | | | | | |
| *Sterculia guttata* Roxb. | Sterculiaceae | 7.5 | 0.39 | 4.54 | R | | | | | | | | | | | | | | | | |
| *Sterculia lanceifolia* Roxb. | Sterculiaceae | 5 | 0.23 | 3.53 | C | | | | | | | | | | | | | | | | |
| *Sterculia urens* Roxb. | Sterculiaceae | 7.5 | 0.82 | 6.50 | RE | | | | | | | | | | | | | 5 | 0.54 | 5.86 | RE |
| *Sterculia versicolor* Wall. | Sterculiaceae | | | | | | | | | | | | | | | | | 7.5 | 0.15 | 4.03 | C |
| *Stereospermum chelonoides* (L.f.) DC. | Bignoniaceae | 5 | 2.04 | 8.00 | C | | | | | 2.5 | 1.21 | 5.21 | C | | | | | 15 | 3.86 | 21.79 | RE |
| *Stereospermum tetragonum* DC. | Bignoniaceae | | | | | 7.5 | 0.10 | 3.32 | C | | | | | | | | | | | | |
| *Styrax serrulatus* Roxb. | Styracaceae | 2.5 | 0.06 | 1.62 | R | | | | | | | | | | | | | | | | |
| *Symplocos racemosa* Roxb. | Symplocaceae | | | | | | | | | | | | | 7.5 | 0.23 | 5.15 | R | | | | |
| *Syzygium cumini* (L.) Skeels | Myrtaceae | 17.5 | 0.52 | 9.03 | RE | 7.5 | 0.29 | 4.86 | C | | | | | 5 | 0.25 | 3.37 | C | 10 | 1.39 | 9.95 | R |
| *Tectona grandis* L.f. | Lamiaceae | 12.5 | 1.98 | 10.54 | C | | | | | | | | | | | | | 5 | 0.40 | 5.42 | RE |
| *Terminalia chebula* Retz. | Combretaceae | 12.5 | 1.31 | 8.88 | C | | | | | 5 | 0.75 | 4.63 | C | | | | | | | | |
| *Terminalia myriocarpa* Van Heurck & Müll. Arg. | Combretaceae | | | | | 7.5 | 1.50 | 8.03 | C | 7.5 | 0.78 | 5.41 | C | 17.5 | 1.49 | 14.30 | C | | | | |
| *Tetrameles nudiflora* R. Br. | Tetramelaceae | 5 | 0.90 | 4.29 | C | | | | | | | | | | | | | | | | |
| *Trema amboinensis* (Willd.) Bl. | Ulmaceae | 7.5 | 0.32 | 4.36 | R | | | | | 10 | 1.01 | 7.86 | R | | | | | | | | |
| *Trema orientalis* (L.) Blume. | Ulmaceae | | | | | 7.5 | 0.41 | 6.20 | C | | | | | | | | | | | | |
| *Triadica cochinchinensis* Lour. | Euphorbiaceae | 7.5 | 0.16 | 4.87 | C | | | | | | | | | | | | | | | | |
| *Tsuga dumosa* (D.Don) | Pinaceae | | | | | 5 | 0.49 | 4.72 | C | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eichler | | | | | | | | | | | | | | | | | | | | | |
| *Vernonia volkameriifolia* DC. | Asteraceae | | | | | 5 | 0.07 | 3.61 | C | | | | | | | | | | | | |
| *Vitex canescens* Kurz | Lamiaceae | | | | | 5 | 0.11 | 3.72 | C | | | | | | | | | | | | |
| *Wendlandia bicuspidata* Wight & Arn. | Rubiaceae | | | | | | | | | 10 | 0.26 | 6.85 | C | | | | | | | | |
| *Wendlandia coriacea* (Wall.) DC. | Rubiaceae | | | | | | | | | | | | | | | | | 12.5 | 0.31 | 10.03 | RE |
| *Wrightia tinctoria* R. Br. | Apocynaceae | 12.5 | 0.59 | 7.12 | C | | | | | | | | | | | | | | | | |
| *Zanthoxylum armatum* DC. | Rutaceae | | | | | 7.5 | 0.25 | 5.80 | C | | | | | | | | | | | | |

**Key to abbreviation:** RE= Regular; R= Random; C= Clumped

*Shrub species composition*

In shrubs, a total of 80 species and 53 genera representing 33 families were recorded from five community forest of Peren district, Nagaland, Northeast India.Out of these, 33 species belonging to 30 genera and 19 families were recorded from Athibung CF followed by 30 species belonging to 23 genera and 18 families from Benreu CF; 25 species, 24 genera and 19 families from Dunki CF; 23 species, 20 genera and 18 families from New Jalukie CF and 21 species, 19 genera and 17 families from Tesen CF (Table 4.2.37). Based on IVI value, the most dominant shrub species in Athibung CF were: *Dendrocnide sinuata* (15.48), *Artemisia indica* (12.77) and *Eupatorium adoratum* (11.69) (Table 4.2.39) and the dominant families were: Malvaceae, Rubiaceae and Zingiberaceae. In Benreu CF, the most dominant species were: *Rubus calycinus* (12.26), *Boehmeria hamiltoniana* (11.68) and *Maesa chisia* (11.10) (Table 4.2.39) and the dominant families were: Myrsinaceae, Rosaceae, and Rubiaceae. In Dunki CF, the most dominant species were: *Baliospermum solanifolium* (15.35), *Boehmeria japonica* (14.57) and *leea macrophylla* (13.01) (Table 4.2.39) and the dominant families were: Euphorbiaceae and Papilionaceae. In New Jalukie CF, the dominant shrub species were: *Eupatorium adoratum* (21.03), *Leea compactiflora* (17.99) and *Osbeckia nepalensis* (15.34) (Table 4.2.39) and the most dominant families were: Compositae, Leeaceae and Rubiaceae. In Tesen CF, dominant species were: *Mussaenda roxburghii* (20.62), *Clerodendrum chinense* (17.88) and *Leea asiatica* (13.09) (Table 4.2.39) and the dominant families were: Rubiaceae, Urticaceae and Verbenaceae. The highest shrub density (individuals ha$^{-1}$) was recorded from Athibung (9250) and the lowest density was recorded from Dunki (6400) respectively (Table 4.2.37).

*Herb species composition*

In herbs, a total of 102 species, 81 genera representing 43 families were recorded from five community of Peren district, Nagaland, Northeast India. Of these, 35 species belonging to 30 genera and 26 families were recorded from Tesen CF followed by 29 species belonging to 28 genera and 21 families from Benreu CF; 28 species, 27 genera and 28 families from Dunki CF; 27 species, 23 genera and 19 families from New Jalukie CF and 22 species, 21 genera and 16 families from Athibung CF, Nagaland respectively (Table 4.2.37). Based on IVI value, the most dominant herb species in Tesen CF were: *Bidens pilosa* (13.22), *Dioscorea tomentosa* (12.51) and *Sida acuta* (12.06) (Table 4.2.39) and the dominant families were: Balsaminaceae, Caesalpinaceae and Gesneriaceae. In Benreu CF, the most dominant species were: *Triumfetta pilosa* (18.13), *Inula nervosa* (16.35) and *Cyanotis axillaris* (15.46) (Table 4.2.39) and the dominant families were: Asteraceae, Commelinaceae and Rubiaceae. In Dunki CF, the dominant species were: *Cyanotis axillaris* (13.67), *Dioscorea* pentaphylla (12.74) and *Spermacoce hispida* (11.81) (Table 4.2.39) and the dominant families were: Cyperaceae, Poaceae and Rubiaceae. In New Jalukie CF, the dominant herb species were: *Mikania micrantha* (17.15), *Stixis suaveolens* (15.54) and *Porana paniculata* (12.20) (Table 4.2.39) and the most dominant families were: Asteraceae, Leguminosae and Papilionaceae. In Athibung CF, dominant species were: *Lygodium flexuosum* (16.57), *Blumea aromatica* (14.49) and *Justicia japonica* (13.45) (Table 4.2.39) and the dominant families were: Asteraceae, Caryophyllaceae and Cyperaceae. The highest herb density (individuals ha$^{-1}$) was recorded from Tesen CF (87500) and lowest in Athibung CF (60000) respectively (Table 4.2.37).

**4.2.10.2 Species diversity indices**

Shannon-Wiener index in all the community (trees, shrubs and herbs) showed high diversity and Simpson dominance index value were inversely proportional to the Shannon’s diversity index. In trees, Dunki CF (3.73) recorded the highest Shannon diversity whereas New Jalukie CF (3.40) recorded the lowest diversity index. In shrubs, Athibung CF (3.31) recorded the highest diversity index whereas in herbs, Tesen CF (3.44) recorded the highest diversity index. The Margalef species richness index value corresponds well with the Shannon’s diversity index and Pielou’s evenness index showed high evenness of species in all the community (Table 4.2.37).

**Table 4.2.39** Density (individuals ha$^{-1}$) and Important value index (IVI) of shrubs and herbs species in five study sites of Peren District, Nagaland

| Species | Family | Dunki | | Benreu | | Athibung | | Tesen | | New Jalukie | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D | IVI | D | IVI | D | IVI | D | IVI | D | IVI |
| **Shrubs** | | | | | | | | | | | |
| *Acacia pennata* (L.)Willd. | Mimosaceae | 250 | 7.80 | | | 100 | 3.14 | | | 100 | 4.03 |
| *Acacia pruinescens* Kurz | Mimosaceae | | | 150 | 4.84 | | | 200 | 5.52 | | |
| *Agapetes angulata* (Griff.) Hook.f. | Ericaceae | | | | | 200 | 6.29 | | | | |
| *Agapetes salicifolia* C.B. Clarke | Ericaceae | | | 250 | 7.03 | | | | | 200 | 6.70 |
| *Amomum pterocarpum* Thwaites | Zingiberaceae | 300 | 9.88 | | | | | | | | |
| *Amomum subulatum* Roxb. | Zingiberaceae | | | | | 250 | 6.83 | | | 350 | 10.04 |
| *Ardisia griffithii* C.B. Clarke | Myrsinaceae | | | 200 | 5.42 | | | | | | |
| *Ardisia neriifolia* Wall. ex A. DC. | Myrsinaceae | | | | | 150 | 3.68 | | | | |
| *Artemisia indica* Willd. | Asteraceae | | | | | 800 | 12.77 | | | | |
| *Baliospermum solanifolium* (Burm.) Suresh | Euphorbiaceae | 650 | 15.35 | | | 200 | 4.22 | | | | |
| *Boehmeria hamiltoniana* Wedd. | Urticaceae | | | 650 | 11.68 | | | 250 | 8.98 | 150 | 4.69 |
| *Boehmeria japonica* (L.f.) Miq. | Urticaceae | 600 | 14.57 | 150 | 2.78 | 250 | 6.83 | 300 | 9.67 | | |
| *Boenninghausenia albiflora* (Hook.) Rchb. ex Meisn. | Rutaceae | | | | | 300 | 6.34 | | | | |
| *Breynia retusa* (Dennst.) Alston | Euphorbiaceae | 150 | 6.24 | | | | | | | | |
| *Buddleja macrostachya* Benth. | Buddlejaceae | 200 | 7.02 | | | | | | | | |
| *Calamus erectus* Roxb. | Arecaceae | | | | | 200 | 5.25 | | | | |
| *Calamus leptospadix* Griff. | Arecaceae | | | 250 | 6.00 | 150 | 3.68 | | | | |
| *Casearia vareca* Roxb. | Flacourtiaceae | | | | | 250 | 5.80 | | | 400 | 10.70 |
| *Cibotium barometz* (L.) J.Sm | Dicksoniaceae | | | | | | | | | 300 | 8.03 |
| *Clerodendrum bracteatum* Wall. ex Walp. | Verbenaceae | | | | | 350 | 7.91 | 400 | 11.04 | | |
| *Clerodendrum chinense* (Osbeck) Mabb. | Verbenaceae | | | | | | | 900 | 17.88 | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Clerodendrum glandulosum* Lindl. | Verbenaceae | | | 300 | 7.61 | | | | | | |
| *Clerodendrum infortunatum* L. | Verbenaceae | | | 100 | 3.22 | | | | | 250 | 8.72 |
| *Clerodendrum japonicum* (Thunb.) Sweet | Verbenaceae | 400 | 11.44 | | | | | | | | |
| *Corylopsis himalayana* Griff. | Hamamelidaceae | | | | | 150 | 3.68 | | | | |
| *Croton caudatus* Geiseler | Euphorbiaceae | | | | | 200 | 4.22 | | | 150 | 4.69 |
| *Daphne bholua* (W.W. Sm. & Cave) B.L. Brutt | Thymelaeaceae | | | 250 | 6.00 | | | | | | |
| *Daphne involucrata* Wall. | Thymelaeaceae | 100 | 2.86 | | | 250 | 6.83 | 150 | 3.44 | | |
| *Dendrocnide sinuata* (Blume) Chew | Urticaceae | | | | | 1050 | 15.48 | | | | |
| *Desmodium hispidum* Franch. | Papilionaceae | | | | | | | 250 | 7.59 | | |
| *Desmodium oblongum* Benth. | Papilionaceae | | | 250 | 7.03 | | | | | | |
| *Desmodium sequax* Wall. | Papilionaceae | | | | | 200 | 5.25 | | | | |
| *Desmodium teres* Benth. | Papilionaceae | | | | | | | | | 100 | 2.68 |
| *Desmodium triquetrum* (L.) DC. | Papilionaceae | 200 | 7.02 | | | | | | | | |
| *Dracaena angustifolia* (Medik.) Roxb. | Dracaenaceae | | | 250 | 6.00 | | | 300 | 9.67 | | |
| *Eriobotrya bengalensis* (Roxb.) Hook.f. | Rosaceae | | | 250 | 6.00 | | | 250 | 8.98 | | |
| *Etlingera linguiformis* (Roxb.) R.M.Sm. | Zingiberaceae | | | | | 150 | 3.68 | | | | |
| *Eupatorium adoratum* L. | Compositae | | | 250 | 6.00 | 700 | 11.69 | 350 | 10.35 | 1200 | 21.30 |
| *Eupatorium cannabinum* L. | Compositae | | | | | | | | | 250 | 8.72 |
| *Ficus hirta* Vahl. | Moraceae | 150 | 4.94 | 200 | 5.42 | | | 200 | 6.91 | 300 | 9.38 |
| *Flemingia macrophylla* (Willd.) Merr. | Papilionaceae | 200 | 7.02 | | | | | | | | |
| *Gossypium herbaceum* L. | Malvaceae | | | | | 100 | 3.14 | | | | |
| *Hedychium marginatum* C.B.Clarke | Zingiberaceae | | | | | 200 | 5.25 | | | | |
| *Hedychium rubrum* A.S. Rao & D.M. Verma | Zingiberaceae | | | | | | | 250 | 7.59 | | |
| *Hibiscus sabdariffa* L. | Malvaceae | | | | | 150 | 4.71 | | | 150 | 6.04 |
| *Hypericum hookerianum* Wight & Arn. | Hypericaceae | | | 300 | 7.61 | | | | | | |
| *Ixora subsessilis* Wall. ex G.Don | Rubiaceae | | | | | | | 300 | 9.67 | | |
| *Jasminum duclouxii* (H. Lév.) Rehder | Oleaceae | | | | | | | 150 | 6.22 | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Lasianthus hookeri* C.B.Clarke ex Hook.f. | Rubiaceae | | | | | 200 | 5.25 | | | | |
| *Leea asiatica* (L.) Ridsdale | Leeaceae | | | 350 | 8.19 | 350 | 7.91 | 550 | 13.09 | 400 | 10.70 |
| *Leea compactiflora* Kurz | Leeaceae | | | 150 | 3.81 | 150 | 3.68 | | | 950 | 17.99 |
| *Leea macrophylla* Roxb. ex Hornem. | Leeaceae | 500 | 13.01 | 250 | 6.00 | | | | | | |
| *Lyonia macrocalyx* (J. Anthony) Airy Shaw | Ericaceae | 150 | 6.24 | | | | | | | | |
| *Maesa chisia* Buch.-Ham. ex D. Don | Myrsinaceae | | | 600 | 11.10 | 750 | 12.23 | | | | |
| *Maesa indica* (Roxb.) A. DC. | Myrsinaceae | 250 | 7.80 | 250 | 6.00 | 150 | 3.68 | 150 | 6.22 | 100 | 4.03 |
| *Melastoma malabathricum* L. | Melastomataceae | | | | | | | | | 250 | 8.72 |
| *Melastoma napalense* Lodd. | Melastomataceae | 200 | 7.02 | 250 | 6.00 | 200 | 4.22 | | | | |
| *Morinda angustifolia* Roxb. | Rubiaceae | 150 | 4.94 | 350 | 8.19 | 300 | 7.37 | 350 | 10.35 | 150 | 4.69 |
| *Mussaenda glabra* Vahl | Rubiaceae | | | | | | | | | 500 | 12.03 |
| *Mussaenda macrophylla* wall. | Rubiaceae | 350 | 10.66 | | | 150 | 3.68 | | | | |
| *Mussaenda roxburghii* Hook.f. | Rubiaceae | | | 100 | 3.22 | | | 1100 | 20.62 | 200 | 8.05 |
| *Musseanda glabra* Vahl | Rubiaceae | | | 400 | 8.77 | | | | | | |
| *Osbeckia nepalensis* Hook.f. | Melastomataceae | | | 200 | 5.42 | 400 | 8.45 | 200 | 5.52 | 750 | 15.34 |
| *Phlogacanthus curviflorus* Ness | Acanthaceae | | | | | | | | | 200 | 6.70 |
| *Phlogacanthus tubiflorus* Ness | Acanthaceae | 200 | 7.02 | 200 | 4.39 | | | | | | |
| *Phrynium species* Willd. | Marantaceae | | | 300 | 7.61 | | | | | | |
| *Rosa sericea* Wall. ex Lindl. | Rosaceae | | | 400 | 8.77 | | | | | | |
| *Rubus calycinus* Wall. ex D.Don | Rosaceae | | | 700 | 12.26 | | | | | | |
| *Rubus pedunculosus* D. Don | Rosaceae | | | 300 | 7.61 | | | | | | |
| *Sambucus wightiana* Wall. | Sambucaceae | | | | | | | 400 | 11.04 | | |
| *Senna alata* (L.) Roxb. | Leguminosae | 250 | 9.10 | | | | | | | | |
| *Sterculia hamiltonii* (Kuntze) Adelb. | Sterculiaceae | 100 | 4.16 | | | | | | | | |
| *Symplocos lucida* (Thunb.) Siebold & Zucc. | Symplocaceae | 350 | 9.36 | | | | | | | | |
| *Symplocos paniculata* (Thunb.) Miq. | Symplocaceae | 100 | 4.16 | | | | | | | | |
| *Tadehagi triquetrum* (L.) H.Ohashi | Papilionaceae | 150 | 6.24 | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Urena labota* L. | Malvaceae | | | | | 100 | 3.14 | | | | |
| *Vaccinium exaristatum* Kurz | Ericaceae | 200 | 7.02 | | | | | | | | |
| *Vernonia mastersii* Watt. | Asteraceae | | | | | | | | | 150 | 6.04 |
| *Viburnum corylifolium* Hook.f. & Thomson | Caprifoliaceae | 250 | 9.10 | | | 150 | 3.68 | | | | |
| *Zanthoxylum khasianum* Hook.f. | Rutaceae | | | | | | | 300 | 9.67 | | |
| **Herbs** | | | | | | | | | | | |
| *Acampe ochracea* (Lindl.) Hochr. | Orchidaceae | 3750 | 10.87 | | | 1875 | 7.74 | | | | |
| *Actinidia callosa* Lindl. | Actinidiaceae | 2500 | 7.69 | | | | | 1875 | 4.47 | | |
| *Aerides rosea* Lodd. ex Lindl. & Paxton | Orchidaceae | 1250 | 4.50 | | | | | | | | |
| *Aeschynanthus acuminatus* Wall. Ex A. DC. | Gesneriaceae | | | 1250 | 4.60 | | | | | 2500 | 6.56 |
| *Aeschynanthus bracteatus* Wall. ex A.DC. | Gesneriaceae | | | | | | | 2500 | 6.35 | | |
| *Ageratum conyzoides* (L.) L. | Asteraceae | | | | | | | | | 3750 | 9.84 |
| *Alpinia species* Roxb. | Zingiberaceae | | | | | | | | | 1875 | 5.75 |
| *Ampelocissus divaricata* (Wall. ex M.A.Lawson) Planch. | Vitaceae | 625 | 2.25 | | | | | | | | |
| *Ampelopsis rubifolia* (Wall.) Planch. | Vitaceae | | | | | | | | | 3125 | 10.70 |
| *Arthraxon lancifolius* (Trin.) Hochst. | Poaceae | 1875 | 6.75 | | | | | | | | |
| *Bauhinia vahlii* Wight & Arn. | Caesalpiniaceae | | | 1875 | 6.90 | 3125 | 11.36 | 1250 | 2.59 | | |
| *Begonia josephi* A.DC. | Begoniaceae | | | 625 | 2.30 | | | | | | |
| *Begonia megaptera* A. DC. | Begoniaceae | | | | | | | 3750 | 8.94 | | |
| *Bidens pilosa* L. | Asteraceae | | | | | | | 7500 | 13.22 | | |
| *Blumea aromatica* DC. | Asteraceae | | | | | 5000 | 14.49 | | | | |
| *Blumea densiflora* (Wall.) DC. | Asteraceae | | | | | | | | | 2500 | 8.23 |
| *Blumea repanda* (Roxb.) Hand. Mazz. | Asteraceae | | | 2500 | 6.39 | | | | | | |
| *Brachystemma calycinum* D. Don | Caryophyllaceae | 3125 | 8.62 | | | 1875 | 7.74 | | | 1875 | 4.09 |
| *Caesalpinia cucullata* Roxb. | Caesalpiniaceae | 1250 | 4.50 | | | | | | | | |
| *Caesalpinia enneaphylla* Roxb. | Caesalpiniaceae | | | | | | | 1875 | 4.47 | | |
| *Calanthe biloba* Lindl. | Orchidaceae | | | | | | | 625 | 1.88 | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Calanthe mannii* Hook.f. | Orchidaceae | | | | | | | 2500 | 6.35 | | |
| *Calanthe sylvatica* (Thouars) Lindl. | Orchidaceae | | | | | | | 1875 | 4.47 | | |
| *Cayratia japonica* (Thunb.) Gagnep. | Vitaceae | | | | | | | | | 1250 | 3.28 |
| *Cheilocostus speciosus* (J.Koenig) C.D. Specht | Zingiberaceae | 1875 | 5.44 | | | | | | | | |
| *Cissus javana* DC. | Vitaceae | 3125 | 8.62 | | | 2500 | 10.32 | | | | |
| *Cissus repens* Lam. | Vitaceae | | | | | 3125 | 9.82 | | | | |
| *Crepidium biauritum* (Lindl.) Szlach. | Orchidaceae | | | | | | | 1250 | 3.75 | | |
| *Cyanotis axillaris* (L.) D. Don ex Sweet | Commelinaceae | 5625 | 13.67 | 6875 | 15.46 | | | | | | |
| *Cyanotis vaga* (Lour.) Schult. & Schult.f. | Commelinaceae | | | 1250 | 4.60 | | | | | | |
| *Cynoglossum lanceolatum* Forssk. | Boraginaceae | | | | | | | 625 | 1.88 | | |
| *Cyperus rotundus* L. | Cyperaceae | | | | | | | 3750 | 7.77 | 1875 | 4.09 |
| *Desmodium microphyllum* (Thunb.) DC. | Papilionaceae | 2500 | 6.37 | | | | | | | 4375 | 8.98 |
| *Didymocarpus pedicellata* R.Br. | Gesneriaceae | | | | | | | 1875 | 4.47 | | |
| *Dioscorea glabra* Roxb. | Dioscoreaceae | | | | | | | 2500 | 5.18 | 1875 | 5.75 |
| *Dioscorea pentaphylla* L. | Dioscoreaceae | 5000 | 12.74 | | | | | | | | |
| *Dioscorea tomentosa* J. Koenig ex Spreng. | Dioscoreaceae | | | | | | | 6875 | 12.51 | | |
| *Disporum cantoniense* (Lour.) Merr. | Convallariaceae | | | 625 | 2.30 | | | | | | |
| *Drymaria cordata* (L.) Willd. Ex Schult. | Caryophyllaceae | | | 1875 | 6.90 | 1875 | 4.66 | | | 3750 | 9.84 |
| *Dysphania ambrosioides* (L.) Mosyakin & Clemants | Chenopodiaceae | | | 5000 | 12.78 | | | | | | |
| *Entada rheedei* Spreng. | Papilionaceae | | | | | | | 2500 | 6.35 | 625 | 2.47 |
| *Eryngium foetidum* L. | Apiaceae | | | 1250 | 4.60 | | | | | | |
| *Gentiana sikkimensis* C. B. Clarke | Gentianaceae | | | 1250 | 3.19 | | | | | | |
| *Girardinia diversifolia* (Link) Friis | Urticaceae | 1875 | 5.44 | 3750 | 9.58 | 1875 | 7.74 | 2500 | 6.35 | | |
| *Gonatanthus pumilus* (D.Don) Engl. & K.Krause | Araceae | | | | | | | 1875 | 4.47 | | |
| *Hedera nepalensis* K. Koch | Araliaceae | | | 625 | 2.30 | | | | | | |
| *Hedyotis vestita* R. Br. ex G. Don | Rubiaceae | | | 1875 | 6.90 | | | | | | |
| *Hodgsonia macrocarpa* (Blume) Cogn. | Cucurbitaceae | | | | | 1250 | 5.16 | | | 2500 | 6.56 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Hypericum japonicum* Thunb. | Hypericaceae | | | 1250 | 4.60 | | | | | | |
| *Impatiens bracteolata* Hook. f. | Balsaminaceae | | | | | | | 625 | 1.88 | | |
| *Impatiens graciliflora* Hook. f. | Balsaminaceae | | | | | | | 1875 | 4.47 | | |
| *Impatients latiflora* Hook.f. & Thomson | Balsaminaceae | | | | | 2500 | 8.78 | | | | |
| *Inula nervosa* Wall. Ex DC. | Asteraceae | | | 7500 | 16.35 | | | | | | |
| *Jasminum attenuatum* Roxb. ex G. Don | Oleaceae | | | 1250 | 3.19 | | | | | | |
| *Juncus bufonius* L. | Juncaceae | | | 1250 | 4.60 | | | | | | |
| *Juncus clarkei* Buchenau | Commelinaceae | | | | | | | 2500 | 5.18 | | |
| *Justicia japonica* Thunb. | Acanthaceae | | | | | 4375 | 13.45 | | | | |
| *Kyllinga brevifolia* Rottb. | Cyperaceae | | | | | 1875 | 6.20 | | | | |
| *Laphangium luteoalbum* (L.) Tzvelev | Asteraceae | | | 625 | 2.30 | | | | | | |
| *Lobelia heyneana* Schult. | Campanulaceae | | | 2500 | 9.21 | | | | | | |
| *Lobelia zeylanica* L. | Campanulaceae | 1250 | 4.50 | | | | | | | 3125 | 9.03 |
| *Lygodium flexuosum* (L.) Sw. | Lygodiaceae | 625 | 2.25 | | | 6250 | 16.57 | | | 2500 | 8.23 |
| *Mikania cordata* (Burm.f.) B.L. Rob | Asteraceae | 3125 | 9.94 | | | | | | | | |
| *Mikania micrantha* Kunth | Asteraceae | | | | | 3125 | 9.82 | | | 8125 | 17.15 |
| *Mimosa pudica* L. | Mimosaceae | | | | | | | | | 1875 | 4.09 |
| *Mucuna macrocarpa* Wall. | Leguminosae | | | 625 | 2.30 | | | 3125 | 8.22 | 1250 | 4.95 |
| *Neanotis calycina* (Wall. ex Hook.f.) W.H.Lewis | Rubiaceae | | | 1875 | 6.90 | | | | | | |
| *Oenanthe benghalensis* Benth. & Hook. f. | Apiaceae | | | | | | | | | 625 | 2.47 |
| *Ophiorrhiza succirubra* King ex Hook.f. | Rubiaceae | | | | | | | 625 | 1.88 | | |
| *Oxalis acetosella* L. | Oxalidaceae | | | | | | | 2500 | 7.51 | | |
| *Pholidota articulata* Lindl. | Orchidaceae | 1875 | 6.75 | | | | | | | | |
| *Pilea melastomoides* (Poir.) Wedd. | Urticaceae | 3750 | 10.87 | | | | | | | | |
| *Pogostemon auricularius* (L.) Hassk. | Lamiaceae | | | | | 1875 | 6.20 | | | | |
| *Porana paniculata* Roxb. | Convolvulaceae | | | 3125 | 8.69 | 1250 | 5.16 | 1250 | 3.75 | 6875 | 12.20 |
| *Pothos chinensis* (Raf.) Merr. | Araceae | | | | | | | 1875 | 4.47 | | |

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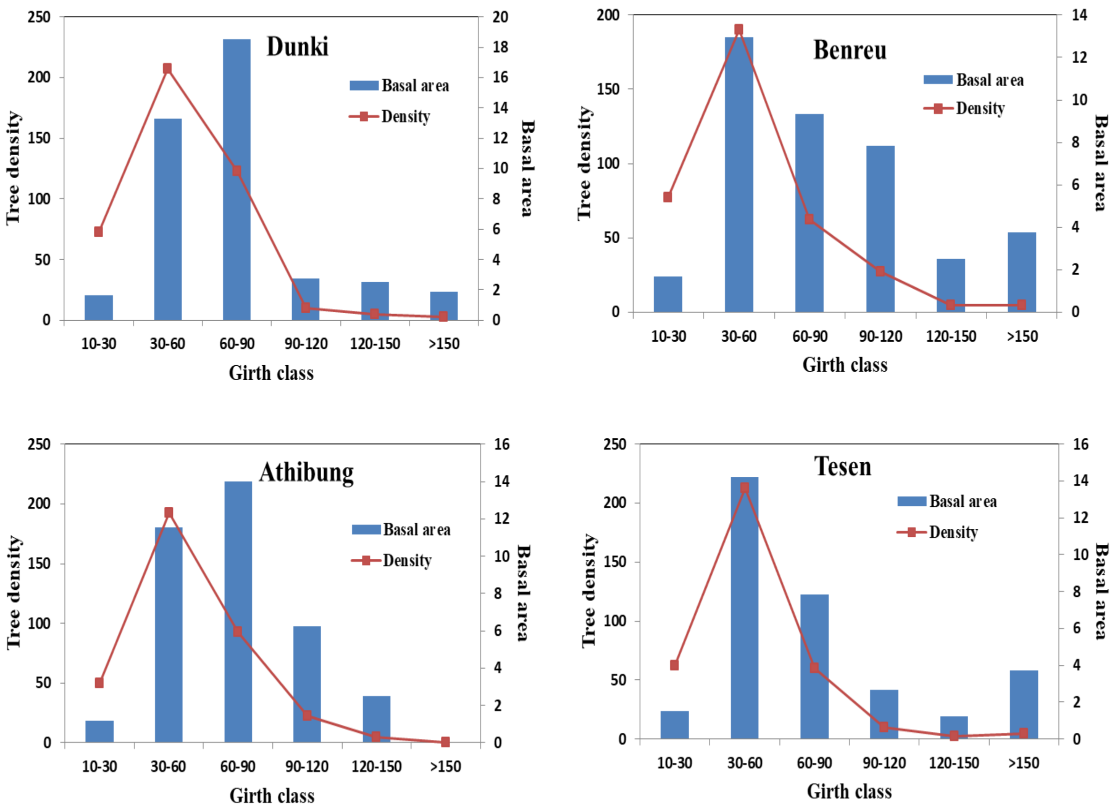
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Rhopalephora scaberrima* (Blume) Faden | Commelinaceae | | | | | | | 2500 | 6.35 | | |
| *Rhynchospora rubra* (Lour.) Makino | Cyperaceae | 2500 | 6.37 | | | | | | | | |
| *Rhynchostylis retusa* (L.) Blume | Orchidaceae | 3125 | 9.94 | | | | | | | | |
| *Rubia cordifolia* L. | Rubiaceae | | | 2500 | 9.21 | | | | | | |
| *Scleria lithosperma* (L.) Sw. | Cyperaceae | 1875 | 5.44 | | | | | | | | |
| *Scleria parvula* Steud. | Cyperaceae | | | | | 3125 | 11.36 | | | | |
| *Senecio scandens* Buch.-Ham. ex D. Don | Asteraceae | | | 1875 | 6.90 | | | | | | |
| *Sesamum indicum* L. | Pedaliaceae | | | | | | | 625 | 1.88 | | |
| *Sida acuta* Burm.f. | Malvaceae | | | 1250 | 4.60 | | | 7500 | 12.06 | 5000 | 11.45 |
| *Smilax glabra* Roxb. | Smilacaceae | | | | | | | 1875 | 5.63 | | |
| *Smilax perfoliata* Lour. | Smilacaceae | 2500 | 9.00 | | | 1875 | 6.20 | | | | |
| *Smithia ciliata* Royle | Papilionaceae | | | | | | | | | 2500 | 6.56 |
| *Sonchus wightianus* DC. | Asteraceae | | | | | | | | | 3125 | 9.03 |
| *Spermacoce hispida* L. | Rubiaceae | 4375 | 11.81 | | | 3750 | 10.87 | | | 1875 | 5.75 |
| *Spermacoce ocymoides* Burm.f. | Rubiaceae | 1250 | 4.50 | | | | | | | | |
| *Spilanthes acmella* (L.) L. | Asteraceae | | | | | 2500 | 8.78 | | | 625 | 2.47 |
| *Sporobolus indicus* (L.) R.Br. | Poaceae | 625 | 2.25 | | | | | | | | |
| *Stellaria vestita* Kurz | Caryophyllaceae | | | 4375 | 11.88 | | | 3750 | 6.61 | | |
| *Stemona tuberosa* Lour. | Stemonaceae | 1875 | 6.75 | | | | | | | | |
| *Stephania glandulifera* Miers | Menispermaceae | | | | | | | 2500 | 6.35 | | |
| *Stixis suaveolens* (Roxb.) Pierre | Capparaceae | | | | | | | | | 6875 | 15.54 |
| *Tetrastigma lanceolarium* (Roxb.) Planch. | Vitaceae | | | | | | | 3125 | 8.22 | | |
| *Thunbergia grandiflora* (Roxb. ex Rottl.) Roxb. | Acanthaceae | | | | | | | 2500 | 6.35 | | |
| *Tinospora sinensis* (Lour.) Merr. | Menispermaceae | 2500 | 7.69 | | | 3125 | 9.82 | | | 1250 | 4.95 |
| *Triumfetta pilosa* Roth | Tiliaceae | | | 8750 | 18.13 | | | 1250 | 3.75 | | |
| *Vanda tessellata* (Roxb.) Hook. ex G.Don | Orchidaceae | 1250 | 4.50 | | | 1875 | 7.74 | | | | |
| *Wollastonia biflora* (L.) DC. | Asteraceae | | | 625 | 2.30 | | | | | | |

### 4.2.10.3 Population structure of tree species in various girth-classes

The tree density and basal area varied with girth classes in different communities. The density of younger trees (10 – 60 cm girth class) contributed 66% (Dunki CF) to 78% (Tesen CF) of the total tree density in all the community. Similarly the contribution of basal area varied from 36 – 51% in these communities (Figure 4.2.19). The contribution of older trees density was highest (3% of the total) in New Jalukie CF, whereas, no older individuals were recorded in Athibung CF. The contribution of basal cover by older tree followed the pattern similar to that of tree density. Overall population structure of all communities showed a reverse *J*-shaped population curve indicating a good forest health and high species richness. Higher density in lower girth classes indicated a good regeneration potential of the forest indicating that future plant communities can be sustained unless there is any major biotic or abiotic changes.



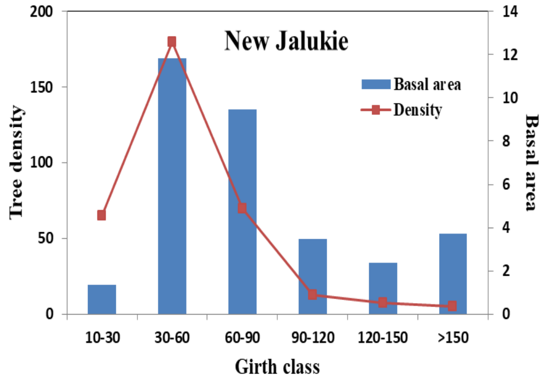



**Figure 4.2.19** Contributions of tree stand density and basal area based on girth class contribution in five study sites of Peren District, Nagaland

### 4.2.10.4 Dominance-diversity curve

The present study showed that the dominance-diversity curve of all the community (trees, shrubs and herbs) showed log normal distribution indicating high species richness and high equitability in the forest except herb vegetation in Athibung CF which reflected broken stick distribution pattern (Figure 4.2.20). In trees, the most dominant species were: *Choerospondias axillaris* (Athibung CF), *Careya arborea* (Dunki CF), *Alnus nepalensis* (Benreu CF), *Garcinia pedunculata* (Tesen CF) and *Duabanga grandiflora* (New Jalukie CF). In shrubs, the most dominant species were: *Dendrocnide sinuata* (Athibung CF), *Rubus calycinus* (Benreu CF), *Baliospermum solanifolium* (Dunki CF), *Eupatorium adoratum* (New Jalukie CF) and *Mussaenda roxburghii* (Tesen CF). In herbs, the dominant species were: *Bidens pilosa* (Tesen CF), *Triumfetta pilosa* (Benreu CF), *Cyanotis axillaris* (Dunki CF), *Mikania micrantha* (New Jalukie CF) and *Lygodium flexuosum* (Athibung CF).

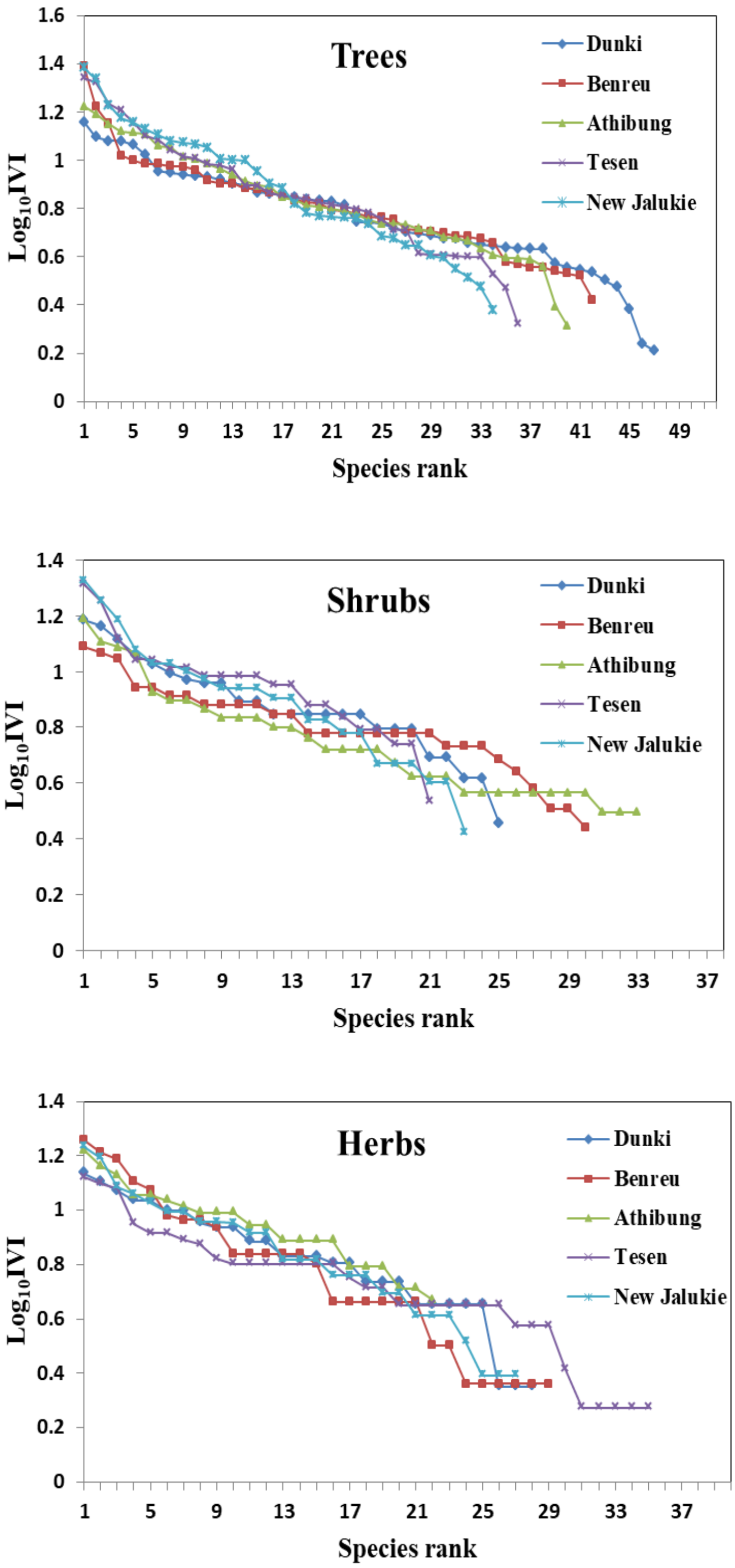



**Figure 4.2.20** Dominance-Diversity curve for trees, shrubs and herbs in five study sites of Peren District, Nagaland

#### 4.2.10.5 Distribution pattern of tree species

The Whitford similarity index showed that the woody species exhibited maximum clumped distribution in all the five study sites. The study showed that, about 65% of the total species exhibited clumped/contagious distribution followed by random and regular distribution pattern (15 % and 20%). Benreu CF (81%) exhibited the maximum clumped/contagious distribution whereas Tesen (25%) and New Jalukie CF (38%) exhibited the maximum random and regular distribution pattern (Table 4.2.38).

#### 4.2.10.6 Sorenson's similarity indices for tree species

Sorenson's similarity showed low similarity of species in all the study sites. An average of only 19% similarilty of species was observed in all the community forest. The highest similarity (38%) was recorded between Benreu and Tesen CF followed by Dunki and New Jalukie CF (26%) and Dunki and Athibiung CF (25%) whereas the lowest similarity of species was observed between Dunki and Benreu CF (4%) and Benreu and Athibung CF (5%) (Table 4.2.40).

**Table 4.2.40** Sorenson Similarity indices for tree species between five study sites of Peren District, Nagaland

| Study area | Dunki | Benreu | Athibung | Tesen | New Jalukie |
|---|---|---|---|---|---|
| **Dunki** | x | | | | |
| **Benreu** | 0.04 | x | | | |
| **Athibung** | 0.25 | 0.05 | x | | |
| **Tesen** | 0.10 | 0.38 | 0.08 | x | |
| **New Jalukie** | 0.26 | 0.21 | 0.14 | 0.40 | x |

#### 4.2.10.7 Disturbance pattern

The average disturbance index for all the study site was 16%. The highest disturbance index was recorded from New Jalukie (22%) followed by Athibung (18%), Tesen (16%), Benreu (13%) and lowest undisturbed forest was Dunki (10%) community forest (Table 4.2.38). The higher disturbance index in New Jalukie CF maybe attributed to various construction activities near the forest vicinity resulting to higher deforestation as compared to other community forest. The villages established around the forest also depend on the natural resources on account of fuelwood requirements, timbers and agricultural implements.

**4.2.11 Dimapur district**

**4.2.11.1 Floristic structure**

*Tree species composition*

In the present study, a total of 619 individuals belonging to 85 species and 64 genera representing 36 families were recorded from the five study sites (New Chumukedima PF, Medziphema CF, Hovukhu CF, Dhansiripar PF and Kashiram PF) of Dimapur district, Nagaland, Northeast India. Out of these, 39 species belonging to 35 genera, 224 families and 144 individuals from New Chumukedima PF, followed by 37 species belonging to 36 genera, 25 families and 146 individuals from Medziphema CF; 35 species belonging to 30 genera, 24 families and 143 individuals were recorded from Hovukhu CF; 27 species belonging to 25 genera, 17 families and 99 individuals from Dhansiripar PF and 25 species belonging to 24 genera, 20 families and 87 individuals from Kashiram PF (plantation forest) of Nagaland respectively (Table 4.2.41). In New Chumukedima, the most dominant tree species were: *Tectona grandis* (25.32), *Melia azaderach* (16.04) and *Tetrameles nudiflora* (14.24) and the co-dominant species were: *Dillenia pentagyna* (13.95), *Pterospermum acerifolium* (13.55) and *Ailanthus integrifolia* (13.10) (Table 4.2.42). The most dominant families from this community were: Mimosaceae, Moraceae and Sterculiaceae. In Medziphema, the dominant tree species were: *Bischofia javanica* (21.61), *Elaeocarpus aristatus* (19.82) and *Firmiana colorata* (19.21) and the co-dominant species were: *Grevillea robusta* (13.80), *Spondias pinnata* (12.53) and *Sterculia villosa* (12.41) (Table 4.2.42). The most dominant families were: Leguminosae, Mimosaceae and Sterculiaceae. In Hovukhu, the dominant species were: *Lagerstroemia speciosa* (22.59), *Melia azaderach* (19.84) and *Tectona grandis* (17.75) and the co-dominant species were: *Neolamarckia cadamba* (15.11), *Micromelus integerrimum* (14.77) and *Elaeocarpus lanceifolius* (14.18) (Table 4.2.42). The dominant families were: Leguminosae, Moraceae and Sterculiaceae. In Dhansiripar, The dominant species were: *Ficus rumphii* (27.97), *Dillenia indica* (20.77) and *Spondias pinnata* (18.64) and the co-dominant species were: *Bischofia javanica* (18.20), *Cassia siamea* (17.35) and *Lagerstroemia speciosa* (17.18) (Table

4.2.42). The dominant families were: Leguminosae, Moraceae and Sterculiaceae. In Kashiram, the dominant species were: *Gmelina arborea* (24.75), *Ailanthus integrifolia* (22.52) and *Albizia lebbeck* (21.78) and the co-dominant species were: *Pterospermum lanceifolium* (19.46), *Firmiana colorata* (16.00) and *Sterculia villosa* (15.86) (Table 4.2.42). The most dominant families from this study site were: Clusiaceae, Magnoliaceae and Sterculiaceae. The highest tree density (individuals $ha^{-1}$) and basal area ($m^2ha^{-1}$) was recorded from Medziphema CF (367 and 34.87) and the lowest from Dhansiripar PF (218 and 21.07 respectively) (Table 4.2.41).

*Shrub diversity*

In shrubs, a total of 54 species and 43 genera representing 27 families were recorded from the five study sites of Dimapur district, Nagaland, Northeast India. Out of these, 21 species belonging to 15 genera and 18 families were recorded from New Chumukedima PF followed by 20 species belonging to 17 genera and 14 families from Kashiram PF; 18 species, 14 genera and 16 families from Hovukhu CF; 16 species, 13 genera and 11 families from Medziphema CF and 15 species, 11 genera and 11 families from Dhansiripar PF (Table 4.2.41). Based on IVI value, the most dominant shrub species in New Chumukedima CF were: *Boehmeria glomerulifera* (22.59), *Dendrocnide sinuata* (19.39) and *Maesa indica* (16.20) (Table 4.2.43) and the dominant families were: Papilionaceae, Rubiaceae and Verbenaceae. In Kashiram PF, the most dominant species were: *Clerodendrum infortunatum* (20.20), *Casearia vareca* (18.98) and *Lantana camara* (17.76) (Table 4.2.43) and the dominant families were: Melastomataceae, Convolvulaceae and Menispermaceae. In Hovukhu CF, the most dominant species were: *Leea macrophylla* (20.32), *Maesa indica* (19.16) and *Boehmeria japonica* (16.84) (Table 4.2.43) and the dominant families were: Euphorbiaceae and Malvaceae. In Medziphema CF, the dominant shrub species were: *Clerodendrum glandulosum* (25.48), *Debregeasia longifolia* (24.29) and *Leea asiatica* (18.33) (Table 4.2.43) and the most dominant families were: Leeaceae, Rubiaceae and Urticaceae. In Dhansiripar PF, dominant species were: *Mussaenda frondosa* (23.71), *Maesa indica* (20.20) and *Zanthoxylum armatum* (19.10) (Table 4.2.43) and the dominant families were: Myrsinaceae, Papilionaceae and Rubiaceae. The highest shrub density (individuals $ha^{-1}$) was recorded from New

Chumukedima (4700) and the lowest density was recorded from Dhansiripar (2850) respectively (Table 4.2.41).

**Table 4.2.41** Phytosociological attributes of trees, shrubs and herbs in five study sites of Dimapur District, Nagaland

| Parameters | N. Chumukedima | Medziphema | Hovukhu | Dhansiripar | Kashiram |
|---|---|---|---|---|---|
| **Trees** | | | | | |
| No. of species | 39 | 37 | 35 | 27 | 25 |
| No. of genera | 35 | 36 | 30 | 25 | 24 |
| Families | 24 | 25 | 24 | 17 | 20 |
| Density (individuals $ha^{-1}$) | 360 | 367 | 358 | 248 | 218 |
| Basal area ($m^2 ha^{-1}$) | 30.09 | 34.87 | 33.73 | 22.78 | 21.07 |
| Shannon diversity index (H') | 3.41 | 3.36 | 3.28 | 2.89 | 2.74 |
| Simpson index (CD) | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 |
| Margalef index (Dmg) | 7.65 | 7.22 | 6.85 | 5.66 | 5.37 |
| Evenness (e) | 0.93 | 0.93 | 0.92 | 0.87 | 0.85 |
| Disturbance index (%) | 17 | 14 | 19 | 21 | 24 |
| **Shrubs** | | | | | |
| No. of species | 21 | 16 | 18 | 15 | 20 |
| No. of genera | 18 | 13 | 14 | 11 | 17 |
| Families | 15 | 11 | 16 | 11 | 14 |
| Density (individuals $ha^{-1}$) | 4700 | 4200 | 4300 | 2850 | 4100 |
| Shannon diversity index (H') | 2.60 | 2.45 | 2.54 | 2.32 | 2.79 |
| Simpson index (CD) | 0.07 | 0.08 | 0.07 | 0.09 | 0.06 |
| Margalef index (Dmg) | 4.40 | 3.39 | 3.82 | 3.46 | 4.31 |
| Evenness (e) | 0.85 | 0.88 | 0.87 | 0.85 | 0.93 |
| **Herbs** | | | | | |
| No. of species | 15 | 16 | 19 | 13 | 22 |
| No. of genera | 14 | 12 | 16 | 11 | 20 |
| Families | 11 | 11 | 14 | 10 | 15 |
| Density (individuals $ha^{-1}$) | 41875 | 44375 | 45625 | 38750 | 51875 |
| Shannon diversity index (H') | 2.46 | 2.43 | 2.77 | 2.34 | 2.96 |
| Simpson index (CD) | 0.10 | 0.11 | 0.07 | 0.12 | 0.05 |
| Margalef index (Dmg) | 11.18 | 3.52 | 4.20 | 2.91 | 4.75 |
| Evenness (e) | 0.90 | 0.87 | 0.94 | 0.91 | 0.94 |

**Table 4.2.42** Density (individuals ha$^{-1}$), Basal area (m$^2$ha$^{-1}$), Important value index (IVI) and Distribution pattern (DP) of tree species in five study sites of Dimapur District, Nagaland

| Species | Family | N. Chumkedima | | | | Medziphema | | | | Hovukhu | | | | Dhansiripar | | | | Kashiram | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** | **D** | **BA** | **IVI** | **DP** |
| *Acrocarpus fraxinifolius* Arn. | Leguminosae | | | | | 7.5 | 1.26 | 7.87 | R | | | | | 10 | 1.27 | 14.31 | RE | 7.5 | 0.79 | 12.37 | RE |
| *Aegle marmelos* (L.) Correa | Rutaceae | 7.5 | 0.15 | 4.69 | R | | | | | | | | | | | | | | | | |
| *Ailanthus integrifolia* Lam. | Simaroubaceae | 22.5 | 1.11 | 13.10 | C | 15 | 1.07 | 11.58 | C | | | | | 7.5 | 0.74 | 10.96 | RE | 17.5 | 1.60 | 22.52 | RE |
| *Albizia chinensis* (Osbeck) Merr. | Mimosaceae | 7.5 | 1.33 | 8.61 | R | | | | | 12.5 | 1.12 | 11.37 | C | | | | | | | | |
| *Albizia lebbeck* (L.) Benth. | Mimosaceae | 10 | 1.31 | 11.36 | R | 17.5 | 1.01 | 12.09 | RE | 5 | 0.34 | 4.68 | C | | | | | 15 | 1.68 | 21.78 | RE |
| *Albizia procera* (Roxb.)Benth. | Mimosaceae | 12.5 | 1.63 | 13.09 | C | | | | | | | | | 12.5 | 0.92 | 12.23 | C | | | | |
| *Alstonia scholaris* (L.) R. Br. | Apocynaceae | | | | | 5 | 0.85 | 6.01 | C | | | | | | | | | 10 | 1.10 | 13.26 | R |
| *Altingia excelsa* Noronha | Altingiaceae | 5 | 0.78 | 6.08 | C | | | | | | | | | | | | | | | | |
| *Annona squamosa* L. | Annonaceae | | | | | 12.5 | 0.90 | 9.29 | RE | | | | | | | | | | | | |
| *Antidesma bunius* (L.) Spreng. | Euphorbiaceae | | | | | | | | | | | | | 2.5 | 0.18 | 3.35 | RE | | | | |
| *Aquilaria agallocha* (Lour.) Roxb. | Thymelaeaceae | | | | | 7.5 | 0.39 | 5.38 | C | | | | | | | | | 5 | 0.82 | 7.91 | C |
| *Areca catechu* L. | Piperaceae | 2.5 | 0.13 | 2.19 | R | | | | | | | | | | | | | | | | |
| *Artocarpus heterophyllus* Lam. | Moraceae | 7.5 | 0.41 | 5.55 | R | | | | | 2.5 | 0.25 | 2.58 | R | | | | | | | | |
| *Artocarpus lacucha* Buch.-Ham. | Moraceae | | | | | 5 | 0.66 | 5.47 | C | | | | | 5 | 0.46 | 5.60 | C | | | | |
| *Averrhoa carambola* L. | Oxalidaceae | | | | | 10 | 0.35 | 7.05 | RE | | | | | | | | | | | | |
| *Bauhinia variegata* L. | Caesalpiniaceae | 17.5 | 0.56 | 10.94 | RE | | | | | | | | | | | | | 7.5 | 0.92 | 11.25 | R |
| *Bischofia javanica* Blume | Euphorbiaceae | | | | | 30 | 3.14 | 21.61 | C | | | | | 17.5 | 1.47 | 18.20 | R | 5 | 0.70 | 7.33 | C |
| *Bombax ceiba* L. | Malvaceae | 5 | 1.01 | 6.85 | C | 5 | 1.61 | 8.20 | C | 7.5 | 1.07 | 8.68 | RE | 7.5 | 1.47 | 14.18 | RE | 2.5 | 1.17 | 13.58 | RE |
| *Brassaiopsis glomerulata* (Blume) Regel | Araliaceae | 12.5 | 0.20 | 8.35 | C | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Byttneria aspera* Colebr. ex Wall. | Sterculiaceae | 20 | 0.13 | 10.20 | RE | | | | | | | | | | | | | | | | |
| *Callicarpa arborea* Roxb. | Verbenaceae | | | | | | | | | 15 | 0.83 | 10.08 | R | | | | | | | | |
| *Callistemon species* | Myrtaceae | 2.5 | 0.13 | 2.18 | R | | | | | | | | | | | | | | | | |
| *Canarium bengalense* Roxb. | Burseraceae | 5 | 2.14 | 10.62 | RE | | | | | 5 | 0.52 | 4.06 | C | 10 | 0.87 | 10.98 | R | | | | |
| *Canarium strictum* Roxb. | Burseraceae | | | | | 7.5 | 0.75 | 7.51 | C | 7.5 | 1.01 | 8.50 | C | | | | | | | | |
| *Careya arborea* Roxb. | Lecythidaceae | 15 | 0.92 | 11.43 | RE | | | | | | | | | 2.5 | 0.32 | 3.97 | R | | | | |
| *Cassia fistula* L. | Leguminosae | | | | | 12.5 | 0.66 | 9.71 | C | 5 | 0.47 | 5.07 | RE | | | | | | | | |
| *Cassia siamea* Lam. | Leguminosae | | | | | | | | | | | | | 15 | 1.15 | 17.35 | RE | | | | |
| *Citrus maxima* (Burm.) Merr. | Rutaceae | | | | | 2.5 | 0.11 | 2.10 | R | | | | | | | | | | | | |
| *Croton joufra* Roxb. | Euphorbiaceae | 2.5 | 0.07 | 1.99 | R | | | | | | | | | | | | | | | | |
| *Delonix regia* (Hook.) Raf. | Caesalpiniaceae | 2.5 | 0.23 | 2.50 | R | 5 | 0.93 | 5.13 | C | 2.5 | 1.39 | 5.95 | R | | | | | | | | |
| *Dillenia indica* L. | Dilleniaceae | | | | | | | | | 5 | 0.72 | 4.66 | C | 20 | 1.47 | 20.77 | RE | 2.5 | 0.69 | 7.88 | RE |
| *Dillenia pentagyna* Roxb. | Dilleniaceae | 12.5 | 1.89 | 13.95 | C | | | | | | | | | | | | | | | | |
| *Elaeocarpus aristatus* Roxb. | Elaeocarpaceae | | | | | 25 | 2.99 | 19.82 | R | | | | | | | | | 5 | 0.87 | 8.14 | C |
| *Elaeocarpus floribundus* Blume | Elaeocarpaceae | | | | | | | | | | | | | 7.5 | 1.01 | 10.57 | R | | | | |
| *Elaeocarpus lanceifolius* Roxb. | Elaeocarpaceae | 7.5 | 0.73 | 6.62 | R | | | | | 17.5 | 1.60 | 14.18 | C | | | | | | | | |
| *Elaeocarpus tectorius* (Lour.) Poir. | Elaeocarpaceae | 2.5 | 0.13 | 2.19 | C | | | | | | | | | | | | | | | | |
| *Erythrina variegata* Lam. | Leguminosae | | | | | 2.5 | 0.26 | 2.54 | C | 2.5 | 0.17 | 2.33 | R | 2.5 | 0.20 | 3.46 | R | | | | |
| *Eucalyptus species* L. Hér. | Myrtaceae | | | | | | | | | | | | | 2.5 | 0.14 | 3.20 | R | | | | |
| *Ficus benjamina* L. | Moraceae | | | | | | | | | 5 | 0.39 | 4.83 | C | | | | | | | | |
| *Ficus hispida* L.f. | Moraceae | | | | | | | | | | | | | 7.5 | 0.86 | 9.93 | R | 7.5 | 0.40 | 8.80 | R |
| *Ficus racemosa* L. | Moraceae | 17.5 | 0.95 | 12.24 | RE | | | | | | | | | | | | | | | | |
| *Ficus religiosa* L. | Moraceae | | | | | 2.5 | 0.09 | 2.06 | C | 7.5 | 0.18 | 4.90 | R | | | | | | | | |
| *Ficus rumphii* Blume | Moraceae | | | | | | | | | | | | | 17.5 | 3.34 | 27.97 | RE | | | | |
| *Ficus semicordata* Buch.-Ham. ex Sm. | Moraceae | 5 | 0.08 | 3.74 | C | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Firmiana colorata* (Roxb.) R.Br. | Sterculiaceae | | | | | 27.5 | 2.92 | 19.21 | C | | | | | 12.5 | 1.21 | 16.60 | RE | 12.5 | 1.07 | 16.00 | RE |
| *Garcinia cowa* Roxb. ex Choisy | Clusiaceae | | | | | 10 | 0.50 | 6.36 | R | | | | | | | | | 10 | 0.64 | 11.09 | R |
| *Gmelina arborea* Roxb. | Verbenaceae | | | | | 5 | 0.81 | 5.88 | C | | | | | | | | | 20 | 1.82 | 24.75 | RE |
| *Grevillea robusta* A.Cunn. ex R.Br. | Proteaceae | | | | | 17.5 | 1.61 | 13.80 | C | | | | | | | | | | | | |
| *Holarrhena pubescens* Wall. ex G. Don | Apocynaceae | 7.5 | 0.26 | 5.06 | R | | | | | 5 | 0.19 | 4.22 | RE | | | | | | | | |
| *Jacaranda species* | Bignoniaceae | 2.5 | 0.14 | 2.22 | R | | | | | | | | | | | | | | | | |
| *Lagerstroemia speciosa* (L.) Pers. | Lythraceae | 5 | 0.71 | 5.85 | RE | 2.5 | 0.23 | 2.45 | R | 32.5 | 3.02 | 22.59 | R | 17.5 | 1.24 | 17.18 | R | 5 | 0.44 | 6.12 | C |
| *Litsea monopetala* (Roxb.) Pers. | Lauraceae | | | | | | | | | 7.5 | 0.34 | 5.37 | R | | | | | 2.5 | 0.07 | 3.21 | R |
| *Macaranga denticulata* (Blume) Müll.Arg. | Euphorbiaceae | | | | | | | | | 10 | 0.60 | 7.98 | C | | | | | | | | |
| *Magnolia champaca* (L.) Baill. ex Pierre | Magnoliaceae | | | | | 5 | 0.43 | 3.70 | C | 17.5 | 2.06 | 13.26 | C | | | | | | | | |
| *Magnolia hodgsonii* (Hook.f. & Thomson) H.Keng | Magnoliaceae | | | | | | | | | | | | | | | | | 7.5 | 0.44 | 10.70 | RE |
| *Magnolia insignis* Wall. | Magnoliaceae | | | | | | | | | | | | | | | | | 5 | 0.40 | 5.91 | C |
| *Mallotus paniculatus* (Lam.) Müll.Arg. | Euphorbiaceae | | | | | | | | | 12.5 | 0.59 | 9.80 | RE | | | | | | | | |
| *Mangifera indica* L. | Anacardiaceae | 2.5 | 0.20 | 2.42 | R | | | | | | | | | | | | | | | | |
| *Melia azedarach* L. | Meliaceae | 20 | 1.89 | 16.04 | C | 7.5 | 0.80 | 7.64 | C | 30 | 2.33 | 19.84 | R | 2.5 | 0.32 | 3.97 | C | | | | |
| *Mesua ferrea* L. | Clusiaceae | | | | | | | | | 2.5 | 0.13 | 2.22 | R | 5 | 0.25 | 6.26 | RE | 2.5 | 0.22 | 3.91 | R |
| *Micromelum integerrimum* (Buch.-Ham. ex Colebr.) M. Roem. | Rutaceae | 12.5 | 0.40 | 7.96 | RE | | | | | 27.5 | 0.85 | 14.77 | C | | | | | | | | |
| *Morus laevigata* Wall. ex Brandis | Moraceae | | | | | | | | | | | | | | | | | 10 | 0.60 | 12.63 | RE |
| *Neolamarckia cadamba* (Roxb.) Bosser | Rubiaceae | | | | | | | | | 20 | 1.68 | 15.11 | C | | | | | | | | |
| *Parkia timoriana* (DC.) Merr. | Mimosaceae | | | | | 10 | 0.73 | 8.14 | RE | | | | | | | | | | | | |
| *Polyalthia longifolia* (Sonn.) | Annonaceae | | | | | 2.5 | 0.29 | 2.61 | R | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thwaites | | | | | | | | | | | | | | | | | | | | | |
| *Pongamia pinnata* (L.) Pierre | Leguminosae | | | | | 15 | 1.07 | 11.57 | RE | | | | | 2.5 | 0.26 | 3.72 | R | | | | |
| *Psidium guajava* L. | Myrtaceae | 2.5 | 0.13 | 2.19 | R | | | | | 2.5 | 0.17 | 2.34 | R | | | | | | | | |
| *Pterospermum acerifolium* (L.) Willd. | Sterculiaceae | 15 | 1.56 | 13.55 | RE | 7.5 | 0.42 | 5.45 | R | 15 | 1.84 | 14.21 | RE | 15 | 0.89 | 16.24 | RE | | | | |
| *Pterospermum lanceifolium* Roxb. | Sterculiaceae | | | | | | | | | | | | | | | | | 12.5 | 1.44 | 19.46 | RE |
| *Samanea saman* (Jacq.) Merr. | Mimosaceae | 2.5 | 0.23 | 2.50 | R | 2.5 | 1.90 | 7.22 | R | | | | | | | | | | | | |
| *Schima wallichii* Choisy | Theaceae | | | | | | | | | 7.5 | 0.54 | 7.10 | C | | | | | | | | |
| *Spondias pinnata* (L.f.) Kurz. | Anacardiaceae | | | | | 17.5 | 1.16 | 12.53 | C | | | | | 22.5 | 1.11 | 18.64 | C | 15 | 0.72 | 15.50 | R |
| *Sterculia guttata* Roxb. | Sterculiaceae | 7.5 | 0.49 | 5.81 | R | | | | | 5 | 0.58 | 5.39 | C | | | | | | | | |
| *Sterculia urens* Roxb. | Sterculiaceae | | | | | | | | | | | | | 2.5 | 0.12 | 3.11 | R | | | | |
| *Sterculia versicolor* Wall. | Sterculiaceae | 12.5 | 0.15 | 8.17 | C | | | | | 12.5 | 1.51 | 11.39 | RE | | | | | | | | |
| *Sterculia villosa* Roxb. | Sterculiaceae | | | | | 22.5 | 0.64 | 12.41 | C | 10 | 1.91 | 13.00 | C | 7.5 | 0.90 | 11.68 | RE | 17.5 | 0.56 | 15.86 | R |
| *Stereospermum chelonoides* (L.f.) DC. | Bignoniaceae | 2.5 | 0.54 | 3.53 | R | 2.5 | 0.31 | 2.67 | R | 7.5 | 1.01 | 8.51 | RE | | | | | 5 | 0.91 | 8.36 | C |
| *Tamarindus indica* L. | Caesalpiniaceae | | | | | 5 | 0.65 | 5.43 | RE | 2.5 | 0.43 | 3.11 | R | | | | | | | | |
| *Tectona grandis* L.f. | Lamiaceae | 27.5 | 4.05 | 25.32 | R | 7.5 | 1.34 | 9.19 | C | 22.5 | 2.33 | 17.75 | C | 2.5 | 0.36 | 4.15 | C | | | | |
| *Terminalia myriocarpa* Van Heurck & Müll. Arg. | Combretaceae | | | | | | | | | 5 | 1.24 | 7.35 | C | | | | | | | | |
| *Tetrameles nudiflora* R. Br. | Tetramelaceae | 17.5 | 1.87 | 14.24 | R | 2.5 | 0.68 | 3.73 | R | | | | | | | | | 7.5 | 1.02 | 11.72 | R |
| *Thespesia populnea* ( L.) Sol. Ex correa | Malvaceae | | | | | | | | | | | | | 10 | 0.26 | 11.43 | RE | | | | |
| *Wrightia arborea* (Dennst.) Mabb. | Apocynaceae | 2.5 | 0.13 | 2.18 | C | 12.5 | 0.44 | 7.98 | C | | | | | | | | | | | | |
| *Zanthoxylum rhetsa* DC. | Rutaceae | 15 | 1.11 | 12.08 | R | 10 | 0.90 | 8.62 | RE | 2.5 | 0.33 | 2.81 | C | | | | | | | | |
| *Zizyphus mauritiana* Lam. | Rhamnaceae | 2.5 | 0.21 | 2.45 | R | | | | | | | | | | | | | | | | |

**Key to abbreviation:** RE= Regular; R= Random; C= Clumped

*Herb species composition*

In herbs, a total of 59 species, 52 genera representing 33 families were recorded from five study sites of Dimapur district, Nagaland, Northeast India. Of these, 22 species belonging to 20 genera and 15 families were recorded from Kashiram PF followed by 19 species belonging to 16 genera and 14 families from Hovukhu CF; 16 species, 12 genera and 11 families from Medziphema CF; 15 species, 14 genera and 11 families from New Chumukedima PF and 13 species, 11 genera and 10 families were recorded from Dhansiripar PF (Table 4.2.41). Based on IVI value, the most dominant herb species in Kashiram PF were: *Spilanthes acmella* (18.84), *Sigesbeckia orientalis* (15.23) and *Mikania cordata* (13.23) (Table 4.2.43) and the dominant families were: Asteraceae and Zingiberaceae. In Hovukhu CF, the most dominant species were: *Mikania micrantha* (19.00), *Blumea densiflora* (18.48) and *Bauhinia vahlii* (16.26) (Table 4.2.43) and the dominant families were: Asteraceae, Menispermaceae and Poaceae. In Medziphema CF, the dominant species were: *Ampelopsis rubifolia* (31.65), *Mikania micrantha* (28.82) and *Elatostema lineolatum* (19.16) (Table 4.2.43) and the dominant families were: Asteraceae, Menispermaceae and Urticaceae. In New Chumukedima PF, the dominant herb species were: *Ageratum conyzoides* (28.17), *Cyanotis axillaris* (23.69) and *Mikania micrantha* (21.13) (Table 4.2.43) and the most dominant families were: Asteraceae, Convolvulaceae and Menispermaceae. In Dhansiripar PF, dominant species were: *Achyranthes aspera* (26.66), *Sida acuta* (21.82) and *Justicia japonica* (20.20) (Table 4.2.43) and the dominant families were: Acanthaceae and Malvaceae. The highest herb density (individuals $ha^{-1}$) was recorded from Kashiram PF (51875) and lowest in Dhansiripar PF (38750) respectively (Table 4.2.41).

**Table 4.2.43** Density (individuals ha$^{-1}$) and Important value index (IVI) of shrubs and herbs species in five study sites of Dimapur District, Nagaland

| Species | Family | N. Chumukedima | | Medziphema | | Hovukhu | | Dhansiripar | | Kashiram | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D | IVI | D | IVI | D | IVI | D | IVI | D | IVI |
| **Shrubs** | | | | | | | | | | | |
| *Acacia pruinescens* Kurz | Mimosaceae | | | | | 200 | 11.17 | | | | |
| *Amomum pterocarpum* Thwaites | Zingiberaceae | | | 100 | 9.05 | 150 | 5.66 | 200 | 12.73 | | |
| *Boehmeria glomerulifera* Miq. | Urticaceae | 700 | 22.59 | 150 | 6.90 | | | | | | |
| *Boehmeria hamiltoniana* Wedd. | Urticaceae | | | | | | | | | 200 | 10.88 |
| *Boehmeria japonica* (L.f.) Miq. | Urticaceae | | | | | 350 | 16.84 | | | | |
| *Breynia retusa* (Dennst.) Alston | Euphorbiaceae | | | 600 | 17.62 | | | | | | |
| *Buddleja macrostachya* Benth. | Buddlejaceae | | | | | 250 | 12.34 | | | | |
| *Calamus erectus* Roxb. | Arecaceae | 50 | 2.99 | | | | | | | 150 | 7.66 |
| *Casearia vareca* Roxb. | Flacourtiaceae | 100 | 4.05 | | | | | | | 450 | 18.98 |
| *Chassalia curviflora* (Wall.) Thwaites | Rubiaceae | | | 200 | 8.10 | | | | | | |
| *Clerodendrum chinense* (Osbeck) Mabb. | Verbenaceae | 250 | 11.09 | | | | | | | | |
| *Clerodendrum glandulosum* Lindl. | Verbenaceae | | | 650 | 25.48 | | | | | 300 | 15.32 |
| *Clerodendrum infortunatum* L. | Verbenaceae | | | | | | | | | 500 | 20.20 |
| *Crotalaria juncea* L. | Papilionaceae | 150 | 7.04 | | | | | 150 | 10.98 | | |
| *Croton caudatus* Geiseler | Euphorbiaceae | 100 | 5.97 | | | 50 | 3.34 | | | 300 | 13.32 |
| *Daphne involucrata* Wall. | Thymelaeaceae | 50 | 2.99 | | | 400 | 15.82 | 250 | 17.34 | 150 | 7.66 |
| *Debregeasia longifolia* (Burm.f.) Wedd. | Urticaceae | | | 600 | 24.29 | | | | | | |
| *Dendrocnide sinuata* (Blume) Chew | Urticaceae | 550 | 19.39 | 250 | 12.62 | | | | | 200 | 8.88 |
| *Desmodium hispidum* Franch. | Papilionaceae | 200 | 10.02 | 150 | 10.24 | | | | | | |
| *Desmodium sequax* Wall. | Papilionaceae | | | | | | | | | 50 | 3.22 |
| *Dracaena angustifolia* (Medik.) Roxb. | Dracaenaceae | 300 | 14.08 | | | | | 150 | 8.12 | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Duranta species* | Verbenaceae | 100 | 5.97 | | | | | | | | |
| *Embelia ribes* Burm.f. | Myrsinaceae | | | 200 | 8.10 | | | 200 | 15.59 | | |
| *Eurya japonica* Thunb. | Theaceae | | | | | | | 50 | 4.61 | | |
| *Ficus heterophylla* L. f. | Moraceae | 50 | 2.99 | | | 150 | 5.66 | | | | |
| *Hibiscus sabdariffa* L. | Malvaceae | | | | | 100 | 6.67 | | | | |
| *Ixora acuminata* Roxb. | Rubiaceae | 350 | 15.14 | 100 | 5.71 | | | 100 | 9.22 | 50 | 3.22 |
| *Lantana camara* L. | Verbenaceae | 200 | 10.02 | | | 300 | 15.67 | | | 400 | 17.76 |
| *Leea alata* Edgew. | Leeaceae | | | 300 | 17.14 | | | | | | |
| *Leea asiatica* (L.) Ridsdale | Leeaceae | | | 350 | 18.33 | | | | | | |
| *Leea compactiflora* Kurz | Leeaceae | 150 | 8.96 | | | | | | | | |
| *Leea macrophylla* Roxb. ex Hornem. | Leeaceae | | | | | 500 | 20.32 | | | | |
| *Maesa indica* (Roxb.) A. DC. | Myrsinaceae | 400 | 16.20 | | | 450 | 19.16 | 250 | 20.20 | | |
| *Maesa montana* A. DC. | Myrsinaceae | | | | | | | | | 300 | 15.32 |
| *Maesa ramentacea* (Roxb.) A. DC. | Myrsinaceae | | | | | | | | | 200 | 8.88 |
| *Manihot esculenta* Crantz | Euphorbiaceae | | | 50 | 4.52 | | | | | | |
| *Millettia pachycarpa* Benth. | Papilionaceae | | | | | | | 200 | 15.59 | | |
| *Morinda angustifolia* Roxb. | Rubiaceae | 450 | 13.42 | | | | | | | | |
| *Mussaenda frondosa* L. | Rubiaceae | 250 | 9.17 | | | 350 | 14.66 | 350 | 23.71 | 100 | 6.44 |
| *Osbeckia nepalensis* Hook.f. | Melastomataceae | | | 250 | 12.62 | | | 250 | 17.34 | 250 | 12.10 |
| *Osbeckia stellata* Buch.-Ham. ex Ker Gawl. | Melastomataceae | 150 | 8.96 | | | | | | | 150 | 5.66 |
| *Phlogacanthus curviflorus* Ness | Acanthaceae | | | | | | | 150 | 10.98 | | |
| *Phrynium species* | Marantaceae | | | | | | | | | 50 | 9.22 |
| *Phyllanthus leschenaultii* Müll.Arg. | Euphorbiaceae | | | | | 150 | 7.84 | | | | |
| *Polygonum microcephalum* D. Don | Polygonaceae | | | | | | | | | 100 | 6.44 |
| *Sambucus javanica* Blume | Sambucaceae | | | | | | | 100 | 6.37 | 50 | 3.22 |
| *Senna hirsuta* (L.) H.S.Irwin & Barneby | Leguminosae | 100 | 5.97 | | | 100 | 4.50 | | | 150 | 5.66 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Solanum indicum* L. | Solanaceae | | | | | 50 | 3.34 | | | | |
| *Strobilanthes adnata* C.B.Clarke | Acanthaceae | | | | | 300 | 13.50 | 150 | 8.12 | | |
| *Symplocos lucida* (Thunb.) Siebold & Zucc. | Symplocaceae | | | | | 250 | 12.34 | | | | |
| *Urena labota* L. | Malvaceae | | | | | 200 | 11.17 | | | | |
| *Vernonia saligna* DC. | Asteraceae | | | 150 | 13.57 | | | | | | |
| *Viburnum foetidum* Wall. | Caprifoliaceae | | | 100 | 5.71 | | | | | | |
| *Zanthoxylum armatum* DC. | Rutaceae | 50 | 2.99 | | | | | 300 | 19.10 | | |
| **Herbs** | | | | | | | | | | | |
| *Achyranthes aspera* L. | Amaranthaceae | | | | | 1875 | 8.55 | 6250 | 26.66 | 2500 | 8.82 |
| *Aeschynanthus acuminatus* Wall. Ex A. DC. | Gesneriaceae | | | | | | | 3750 | 17.57 | 1250 | 6.41 |
| *Ageratum conyzoides* (L.) L. | Asteraceae | 7500 | 28.17 | | | 3750 | 12.66 | | | | |
| *Alpinia species* | Zingiberaceae | | | | | | | | | 625 | 3.20 |
| *Ampelopsis rubifolia* (Wall.) Planch. | Vitaceae | | | 9375 | 31.65 | | | | | | |
| *Arundinella nepalensis* Trin. | Poaceae | | | | | | | | | 3125 | 12.02 |
| *Bauhinia vahlii* Wight & Arn. | Caesalpiniaceae | | | | | 4375 | 16.26 | | | | |
| *Begonia roxburghii* A. DC. | Begoniaceae | | | | | | | 1250 | 8.49 | | |
| *Bidens bipinnata* L. | Asteraceae | | | 625 | 4.04 | | | | | | |
| *Blumea aromatica* DC. | Asteraceae | 2500 | 13.66 | | | | | | | | |
| *Blumea densiflora* (Wall.) DC. | Asteraceae | | | | | 4375 | 18.48 | | | 3750 | 13.23 |
| *Boehmeria clidemioides* Miq. | Urticaceae | | | | | 3750 | 14.89 | | | | |
| *Brachystemma calycinum* D. Don | Caryophyllaceae | 3125 | 15.15 | | | 1250 | 7.18 | | | 1875 | 7.61 |
| *Carex stramentitia* Boott ex Boeckeler | Cyperaceae | | | | | 2500 | 12.15 | | | | |
| *Combretum pilosum* Roxb. | Combretaceae | | | | | | | | | 1250 | 6.41 |
| *Cyanotis axillaris* (L.) D. Don ex Sweet | Commelinaceae | 5625 | 23.69 | | | | | | | 2500 | 10.82 |
| *Cymbopogon clandestinus* (Nees ex Steud.) Stapf | Poaceae | 3750 | 19.21 | | | | | | | | |
| *Cynoglossum lanceolatum* Forssk. | Boraginaceae | | | 1250 | 5.45 | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| *Dysphania ambrosioides* (L.) Mosyakin & Clemants | Chenopodiaceae | | | | | | | 3125 | 13.33 | | |
| *Elatostema lineolatum* Wight | Urticaceae | | | 5000 | 19.16 | | | | | | |
| *Elatostema monandrum* (Buch.-Ham. ex D. Don) H. Hara | Urticaceae | | | 3125 | 14.94 | | | | | | |
| *Entada rheedei* Spreng. | Papilionaceae | 625 | 4.06 | | | 625 | 3.59 | | | | |
| *Gouania tiliifolia* Lam. | Rhamnaceae | | | | | | | | | 1875 | 9.61 |
| *Hedychium villosum* Wall. | Zingiberaceae | 1875 | 9.61 | | | | | | | | |
| *Holboellia latifolia* Wall. | Lardizabalaceae | | | | | | | 1875 | 10.10 | | |
| *Hypericum japonicum* Thunb. | Hypericaceae | | | | | | | | | 3125 | 10.02 |
| *Imperata cylindrica* (L.) Raeusch. | Poaceae | | | | | 3125 | 15.74 | | | | |
| *Ipomoea asarifolia* (Desr.) Roem. & Schult. | Convolvulaceae | 1250 | 8.11 | 625 | 4.04 | 1875 | 8.55 | | | | |
| *Ipomoea pileata* Roxb. | Convolvulaceae | 2500 | 13.66 | | | | | | | | |
| *Juncus effusus* L. | Juncaceae | | | | | | | 625 | 4.24 | 1875 | 5.61 |
| *Justicia japonica* Thunb. | Acanthaceae | | | | | | | 3750 | 20.20 | | |
| *Larsenianthus careyanus* (Benth.) W.J.Kress & Mood | Zingiberaceae | | | | | | | | | 1250 | 6.41 |
| *Lygodium flexuosum* (L.) Sw. | Lygodiaceae | 625 | 4.06 | | | | | 1875 | 10.10 | | |
| *Mikania cordata* (Burm.f.) B.L. Rob | Asteraceae | | | | | | | | | 3750 | 13.23 |
| *Mikania micrantha* Kunth | Asteraceae | 5625 | 21.13 | 8125 | 28.84 | 5625 | 19.00 | | | | |
| *Mimosa pudica* L. | Mimosaceae | | | | | 1250 | 4.96 | | | | |
| *Panicum brevifolium* L. | Poaceae | | | | | 1875 | 10.78 | 2500 | 16.98 | | |
| *Panicum repens* L. | Poaceae | | | 1250 | 8.08 | | | | | | |
| *Phragmites karka* (Retz.) Trin. ex Steud. | Poaceae | | | 1875 | 9.49 | | | | | | |
| *Piper longum* L. | Piperaceae | 1875 | 12.17 | 2500 | 13.53 | 625 | 3.59 | | | | |
| *Pogostemon auricularius* (L.) Hassk. | Lamiaceae | | | | | | | | | 3750 | 11.23 |
| *Rhynchostylis retusa* (L.) Blume | Orchidaceae | | | 1250 | 8.08 | | | | | | |
| *Rumex patienta* L. | Polygonaceae | | | | | | | | | 1250 | 4.41 |

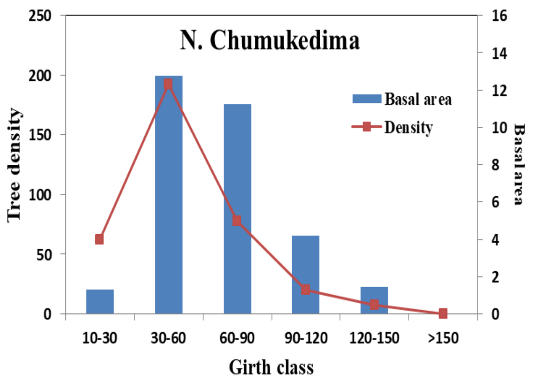
| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Senecio nagensium* C.B.Clarke | Asteraceae | | | | | 2500 | 12.15 | | | | |
| *Sida acuta* Burm.f. | Malvaceae | | | 3125 | 17.57 | | | 4375 | 21.82 | | |
| *Sigesbeckia orientalis* L. | Asteraceae | | | | | | | | | 3750 | 15.23 |
| *Smilax glabra* Roxb. | Smilacaceae | | | | | | | | | 2500 | 10.82 |
| *Smilax perfoliata* Lour. | Smilacaceae | | | | | 1250 | 4.96 | | | | |
| *Solena amplexicaulis* (Lam.) Gandhi | Cucurbitaceae | 3125 | 15.15 | | | | | | | | |
| *Sonchus wightianus* DC. | Asteraceae | | | 1250 | 8.08 | | | | | 1875 | 7.61 |
| *Spermacoce hispida* L. | Rubiaceae | | | 1875 | 9.49 | | | | | | |
| *Spilanthes acmella* (L.) L. | Asteraceae | | | | | | | 3750 | 17.57 | 5625 | 18.84 |
| *Stephania glandulifera* Miers | Menispermaceae | | | | | 3125 | 15.74 | 2500 | 14.35 | | |
| *Stephania japonica* (Miq.) Forman | Menispermaceae | 1250 | 8.11 | 625 | 4.04 | | | | | | |
| *Thysanolaena latifolia* (Roxb. ex Hornem.) Honda | Poaceae | | | | | | | | | 2500 | 8.82 |
| *Tinospora sinensis* (Lour.) Merr. | Menispermaceae | 625 | 4.06 | 2500 | 13.53 | 625 | 3.59 | | | | |
| *Trichosanthes cucumerina* L. | Cucurbitaceae | | | | | | | 3125 | 18.59 | 625 | 3.20 |
| *Vanda tessellata* (Roxb.) Hook. ex G.Don | Orchidaceae | | | | | 1250 | 7.18 | | | | |
| *Zingiber chrysanthum* Roscoe | Zingiberaceae | | | | | | | | | 1250 | 6.41 |

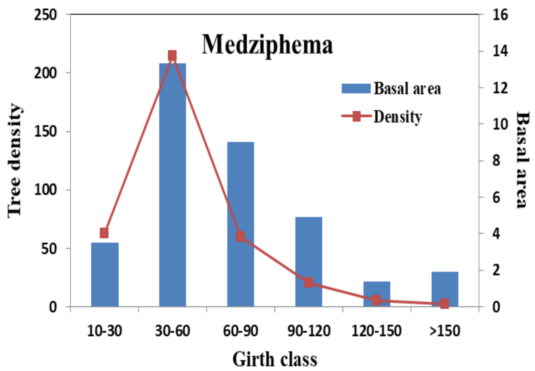
### 4.2.11.2 Species diversity indices

Shannon-Wiener index in all the community (trees, shrubs and herbs) showed high diversity. The Simpson dominance index value was inversely proportional to the Shannon's diversity index whereas Margalef species richness index correspond well with the diversity index value. In trees, New Chumukedima CF (3.41) recorded the highest Shannon diversity whereas Kashiram PF (2.74) recorded the lowest diversity index. In shrubs and herbs species, Kashiram PF recorded the highest diversity index (2.79 and 2.96) whereas Dhansiripar PF recorded the lowest diversity index (2.32 and 2.34) respectively. Pielou's evenness index in all the community showed high evenness of species (Table 4.2.41).

### 4.2.11.3 Population structure of tree species in various girth-classes

The tree density and basal area varied with girth classes in different communities. The density of younger trees (10 – 60 cm girth class) contributed 70% (N. Chumukedima PF) to 76% (Hovukhu CF) of the total tree density in all the community. Similarly the contribution of basal area varied from 45 – 50% in these communities (Figure 4.2.41). The contribution of older trees density was highest (8% of the total) in Medziphema CF, whereas, no individuals were recorded in girth class >150 cm in other study sites. The contribution of basal cover by older tree followed the pattern similar to that of tree density. Overall population structure of all communities showed a reverse *J*-shaped population curve (Figure 4.2.21). Higher density in lower girth classes also indicates a good regeneration potential of the forest and can be sustained unless there is any major biotic or abiotic changes in the community.



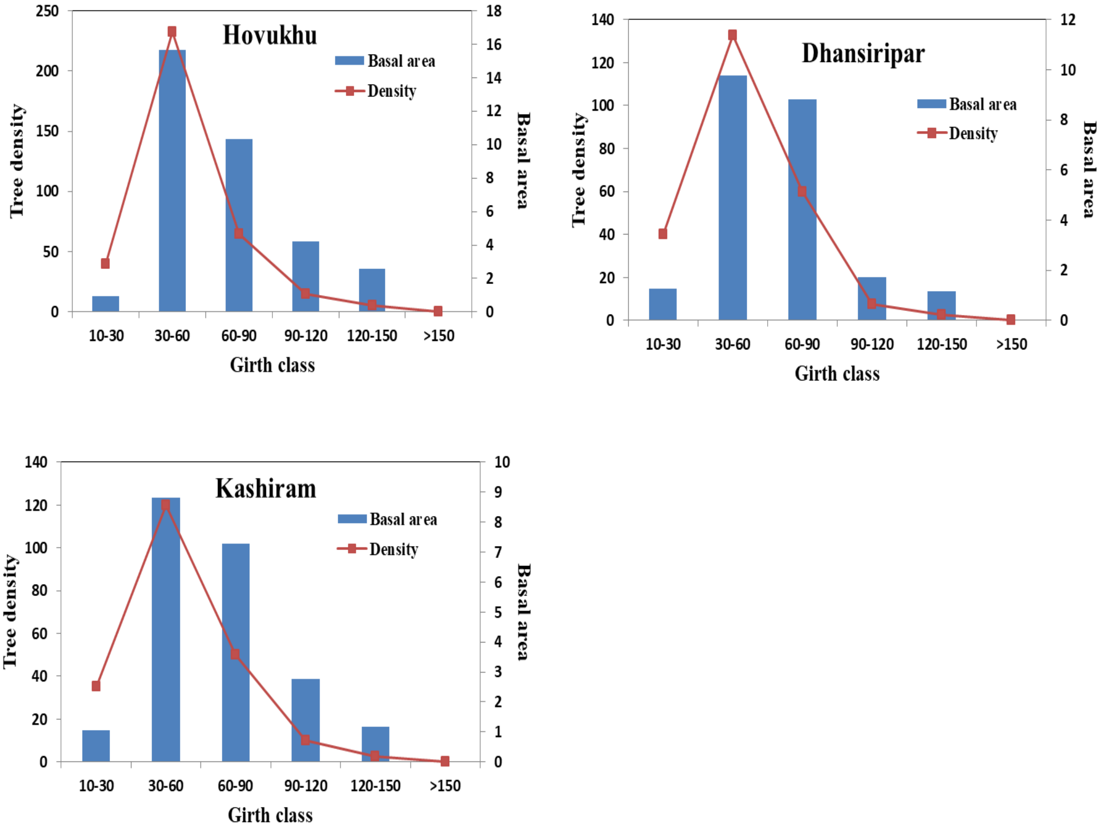



**Figure 4.2.21** Contributions of tree stand density and basal area based on girth class contribution in five study sites of Dimapur District, Nagaland

### 4.2.11.4 Dominance-diversity curve

The Dominance-diversity curve in the present study showed different species distribution with site wise variations in different communities. The dominance-diversity curve of tree, shrub and herb layer showed a log normal distribution pattern indicating mixed nature of vegetation and high species richness in the community (Figure 4.2.22). In trees, the most dominant species were: *Tectona grandis* (N. Chumukedima), *Bischofia javanica* (Medziphema), *Lagerstroemia speciosa* (Hovukhu), *Ficus rumphii* (Dhansiripar) and *Gmelina arborea* (Kashiram). In shrubs, *Boehmeria glomerulifera* (N. Chumukedima), *Clerodendrum infortunatum* (Kashiram), *Leea macrophylla* (Hovukhu), *Clerodendrum glandulosum* (Medziphema) and *Mussaenda frondosa* (Dhansiripar). In herbs, *Spilanthes acmella* (Kashiram), *Mikania micrantha* (Hovukhu), *Ampelopsis rubifolia* (Medziphema), *Ageratum conyzoides* (N. Chumukedima) and *Achyranthes aspera* (Dhansiripar).

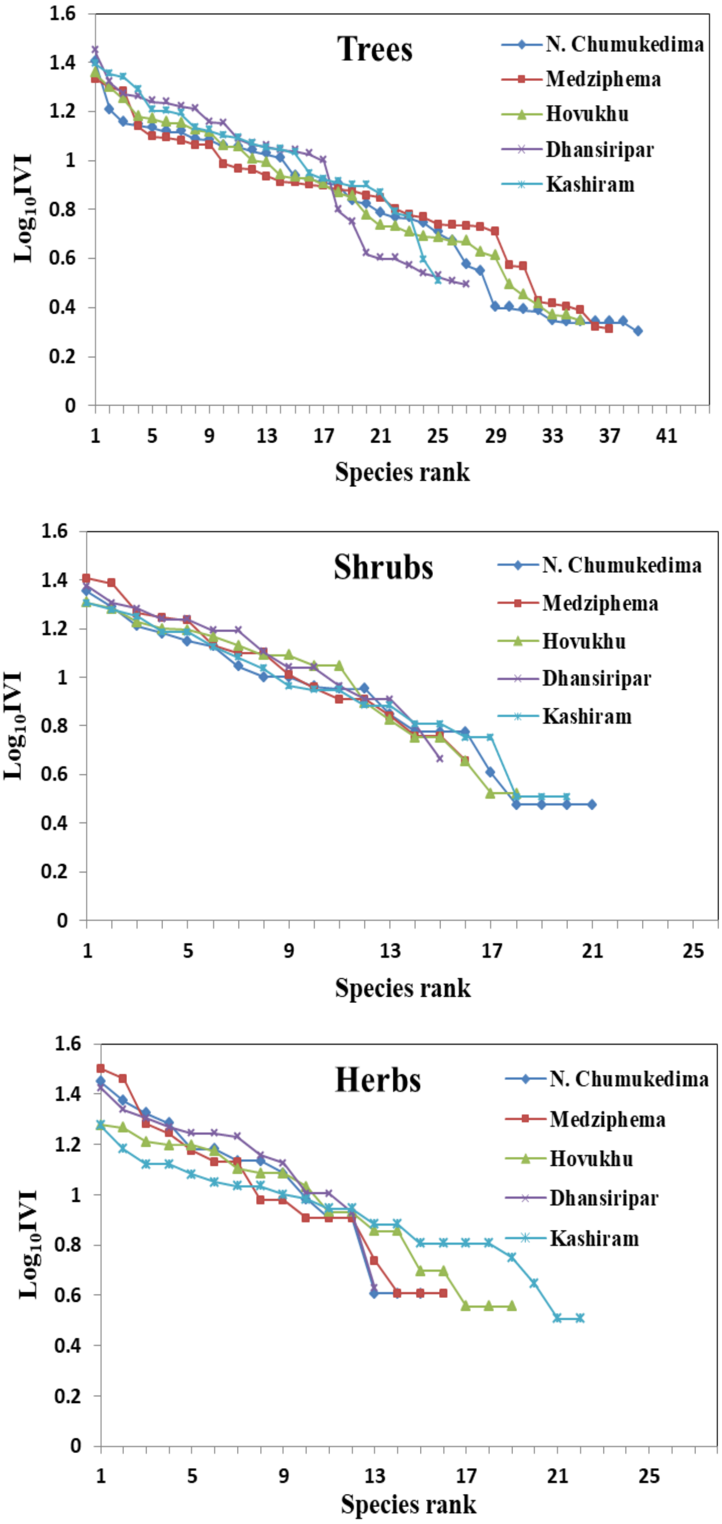



**Figure 4.2.22** Dominance-Diversity curve for trees, shrubs and herbs in five study sites of Dimapur District, Nagaland

#### 4.2.11.5 Distribution pattern of tree species

The Whitford similarity index showed that the woody species exhibited maximum clumped distribution in all the five study sites. The study showed that 37% of the species exhibited random distribution followed by clumped/contagious distribution (36%) and regular distribution pattern (27%) of the total species. Community forest (e.g Medziphema and Hovukhu) exhibited maximum clumped/contagious distribution contributing 49% – 50% whereas plantation forest (e.g Kashiram and Dhansiripar) exhibited maximum regular distribution contributing 40% - 44% and N. Chumukedima (51%) exhibited maximum random distribution pattern (Table 4.2.42).

#### 4.2.11.6 Sorenson's similarity indices for tree species

Sorenson's similarity showed an average of 36% similarity of species in all the study sites. The highest similarity of 52% was recorded between Medziphema CF and Kashiram PF followed by Medziphema CF and Hovukhu CF with 48% similarity in tree species composition. Among the plantaion forest, 42% similarity between Dhansiripar and Kashiram was recorded followed by 24% in N. Chumukedima and Dhansiripar and 22% in Kashiram and N. Chumukedima (Table 4.2.44).

**Table 4.2.44** Sorenson Similarity indices for tree species between five study sites of Dimapur District, Nagaland

| Study area | N. Chumukedima | Medziphema | Hovukhu | Dhansiripar | Kashiram |
|---|---|---|---|---|---|
| **N. Chumukedima** | x | | | | |
| **Medziphema** | 0.32 | x | | | |
| **Hovukhu** | 0.43 | 0.48 | x | | |
| **Dhansiripar** | 0.24 | 0.44 | 0.32 | x | |
| **Kashiram** | 0.22 | 0.52 | 0.23 | 0.42 | x |

#### 4.2.11.7 Disturbance pattern

The intensity of disturbance in various community forests is shown in table 4.2.41. The average disturbance index for all the study sites was 19%. The highest disturbance index was recorded in Kashiram (24%), followed by Dhansiripar (21%), Hovukhu (19%), N. Chumukedima (17%) and the lowest was in Medziphema (14%). The tree density value corresponds well to the disturbance index of different communities. The study also revealed that high disturbances in all these regions are mainly due to logging and fuelwood requirements by the local people.

### 4.3 Species regeneration pattern

### 4.3.1 Mokokchung district

On the basis of density of seedlings, saplings and trees, different types of regeneration status (i.e. good, fair, poor, none and new regeneration) were observed in different community forest of Nagaland. The study showed that density (individuals ha$^{-1}$) of seedling was highest (2500 – 4550) followed by sapling (2000 – 3500) and trees (313 – 330) in all the community forests of Mokokchung district (Figure 4.3.1a). Maximum species showed good regeneration contributing 29% (Longkhum) to 52% (Changtongya) of the total species in the forest (Figure 4.3.1b). Changki CF showed the highest new regeneration (24%) followed by Longkhum (21%) and Changtongya (19%) whereas Tuli CF showed the highest no regeneration (21%). Species such as *Cinnamomum zeylanicum*, *Garcinia sopsopia*, *Grewia serrulata*, *Itea macrophylla*, *Mallotus tetracoccus*, *Meliosma simplicifolia*, *Phyllanthus reticulatus*, *Premna longifolia*, *Wendlandia bicuspidata* etc., were represented by their seedling/sapling stage only and hence new to these forests.

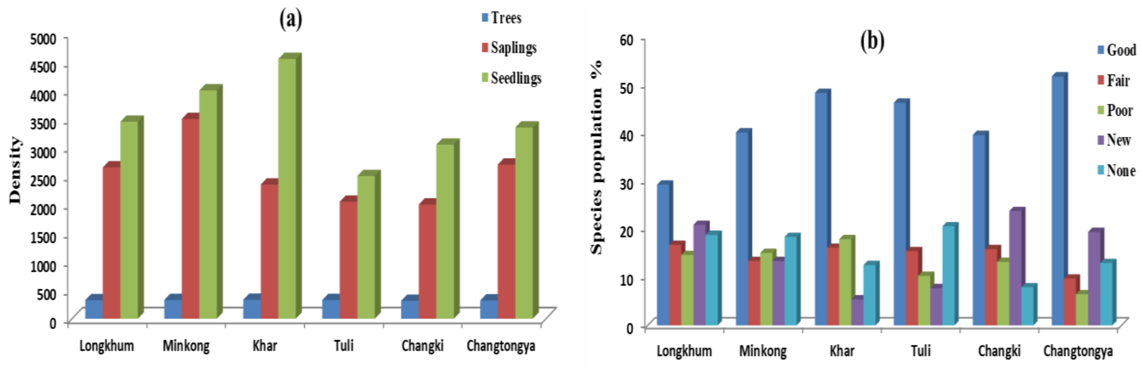



**Figure 4.3.1** Density of seedlings, saplings and trees **(a)** and their regeneration status (%) **(b)** in six study sites of Mokokchung District, Nagaland

### 4.3.2 Mon district

In the present study, community forest (i.e. Langpongshianga, Aboi and Longwa) recorded the highest density of sapling (1800 – 2150) whereas community forest (i.e. Longching and Singphan) recorded the highest density of seedling (1650 – 2250). Density of trees, saplings and seedling of all the community forests is shown in Figure 4.3.2a. The study showed that maximum species exhibited good regeneration (38% – 57%) followed by fair regeneration (23% – 35%). About 14% of the total species showed no regeneration and only 3% of the species showed new regeneration (Figure 4.3.2b). Species such as *Amoora wallichii*, *Kydia calycina*, *Macropanax dispermus*, *Magnolia rabaniana* and *Mangiferae sylvatica* were represented only in seedling stage in Aboi and Longching CF and hence new regenerating species in these forests.

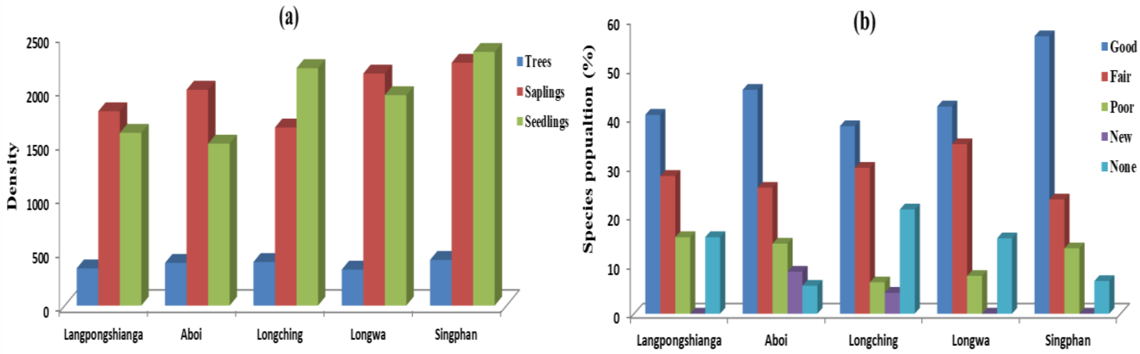



**Figure 4.3.2** Density of seedlings, saplings and trees **(a)** and their regeneration status (%) **(b)** in five study sites of Mon District, Nagaland

### 4.3.3 Kiphire district

The present study showed that the highest seedling density (individuals ha$^{-1}$) was highest in Fakim WLS and Sitimi CF (3100 and 3900) and lowest in Samphure CF (1900). In shrubs, Sitimi and Chinkhu CF recorded the highest density (3350 and 3050) whereas in trees, Pungro CF and Fakim WLS recorded highest density (433 and 403) and Samphure CF (290) recorded the lowest stand density (Figure 4.3.3a). Overall in all the community forest, 33% of the tree species showed good regeneration followed by fair (27%), none (20%), poor (13%) and only 6% of the total species showed new regeneration (Figure 4.3.3b). Species such as *Croton joufra*, *Diospyros kaki*, *Eurya acuminata*, *Erythrina stricta*, *Ficus tinctoria*, *Ilex dipyrena*, *Magnolia rabaniana*, *Myrica esculenta* etc., are some of the tree species represented only in seedling/sapling stage in different community forest.

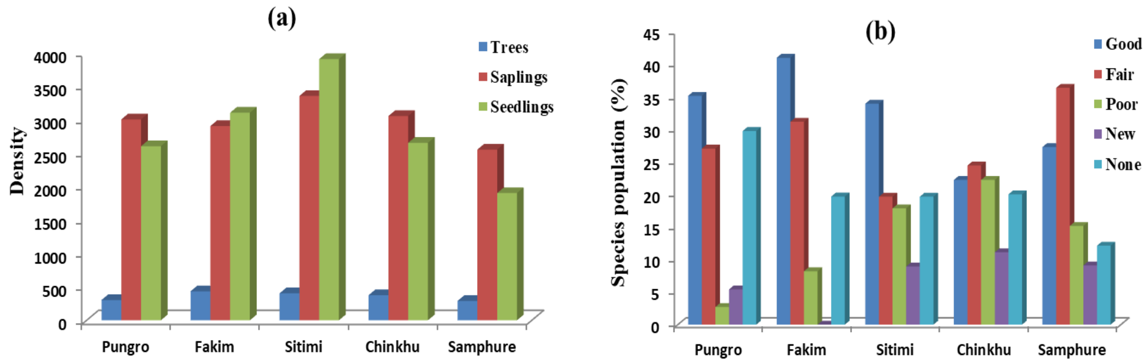



**Figure 4.3.3** (Density of seedlings, saplings and trees **(a)** and their regeneration status (%) **(b)** in five study sites of Kiphire District, Nagaland

### 4.3.4 Tuensang district

The highest seedling density (individuals ha$^{-1}$) was recorded from Chendang CF (2550) whereas Helipong and Pangsha CF (440 and 2300) recorded the highest trees and saplings density. Density of trees, saplings and seedling of all the community forests is shown in Figure 4.3.4a. The study on regeneration potential showed that maximum species in the community exhibited good regeneration contributing 31% (Yangli) to 43% (Chendang) of the total species in the forest (Figure 4.3.4b). Overall about 17% of the species showed no regeneration and only 6% of the total species showed new regeneration. No new individual was recorded from Chendang and Panso CF. Species such as *Bridelia glauca*, *Colona floribunda*, *Juniperus species*, *Lindera nacusua*, *Nephelium lappaceum*, *Prunus ceylanica*, *Thespesia populnea*, *Zanthoxylum armatum* etc., were represented only in seedling/sapling stage in different community forest.

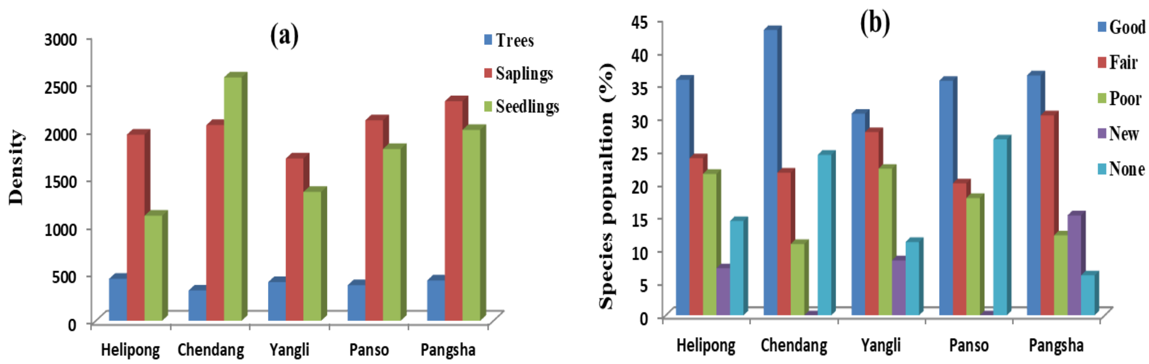



**Figure 4.3.4** Density of seedlings, saplings and trees **(a)** and their regeneration status (%) **(b)** in five study sites of Tuensang District, Nagaland

### 4.3.5 Phek district

In the present study, Chizami CF recorded the higher seedling and sapling density (2400 and 1850 individuals ha$^{-1}$) as compared to other community forest and Akhegwo (385 individuals ha$^{-1}$) recorded the highest tree density (Figure 4.3.5a). In all the community, maximum tree species exhibited good regeneration (37%) followed by fair (27%), poor (19%), none (13%) and only 4% as new regeneration of the total species in the community. Chizami CF inhabited the maximum good regeneration (38%) whereas no new regenerating species was observed in Chizami and Zipu CF (Figure 4.3.5b). Species such as *Aquilaria agallocha*, *Beilschmiedia fagifolia*, *Magnolia cathcartii*, *Macropanax dispermus* and *Sorbus foliolosa* were represented by their seedling/sapling stage only.

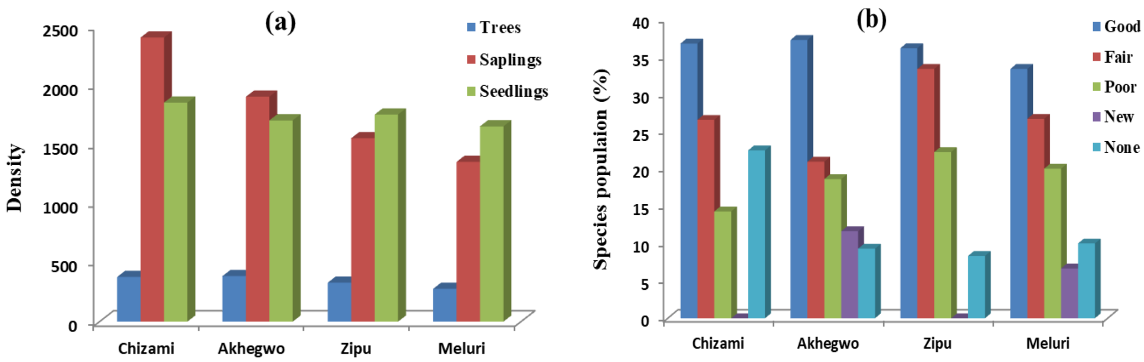



**Figure 4.3.5** Density of seedlings, saplings and trees **(a)** and their regeneration status (%) **(b)** in four study sites of Phek District, Nagaland

### 4.3.6 Wokha district

The density (individuals ha$^{-1}$) of seedling ranged from 1850 – 2400, sapling from 1600 – 2350 and trees from 285 – 493 (Figure 4.3.6a). Maximum species in the community exhibited good regeneration contributing 44% (Wokha village) to 32% (Ralan) of the total species in the forest. Overall the study showed that 20% of species exhibited fair, 16% poor, 27% none and only 3% showed new regenerating species (Figure 4.3.6b). Species such as *Benkara griffithii*, *Chukrasia tabularis*, *Holarrhena pubescens*, *Litsea doshia*, and *Wendlandia budleioides* were represented by their seedling/sapling in different community forest.

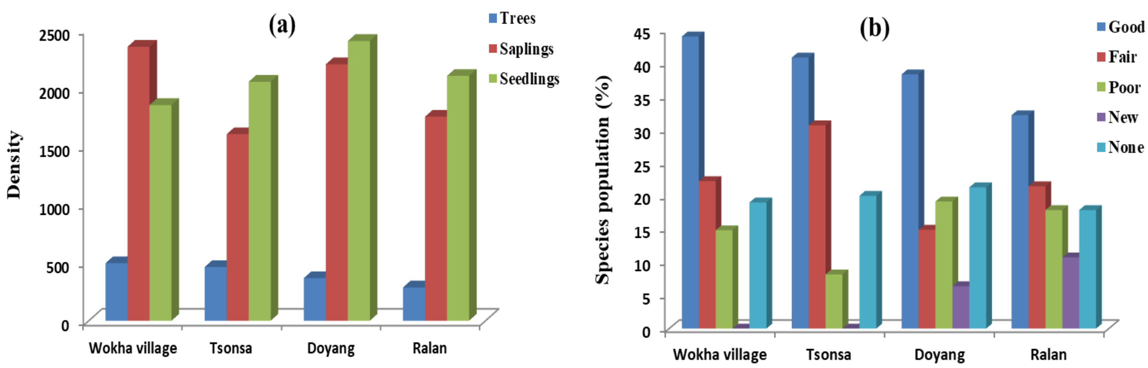



**Figure 4.3.6** Density of seedlings, saplings and trees **(a)** and their regeneration status (%) **(b)** in four study sites of Wokha District, Nagaland

### 4.3.7 Zunhebhoto district

The study showed high density in all the community (trees, saplings and seedlings) of different study sites. The highest seedling density (individuals ha$^{-1}$) was recorded from Aichisanghemi (4350) whereas in saplings and trees, Luvishe and Lumami (4300 and 378) recorded the highest density (Figure 4.3.7a). The study on regeneration potential showed that maximum species in the community exhibited good regeneration contributing 38% (Lumami) to 51% (Satakha) of the total species in the all the study sites (Figure 4.3.7b). Overall ~19% of the species showed fair regeneration, 10% each in poor and new and 16% showed no regeneration. Species such as *Brassaiopsis hainla*, *Castanopsis hystrix*, *Ficus auriculata*, *Magnolia oblonga*, *Rhus succedanea*, *Meliosma simplicifolia*, *Murraya koenigii* etc., were represented only in seedling/sapling stage in different community forest.

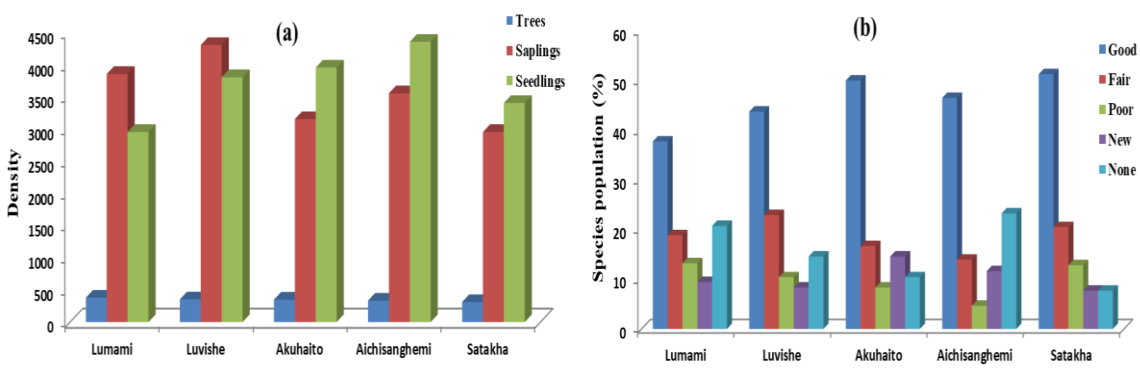



**Figure 4.3.7** Density of seedlings, saplings and trees **(a)** and their regeneration status (%) **(b)** in five study sites of Zunhebhoto District, Nagaland

### 4.3.8 Longleng district

The average density (individuals ha$^{-1}$) of seedling, sapling and tree was 3113, 3125 and 403 respectively. Yongam, Mongtikong and Yongphang CF recorded the highest seedling, sapling and tree density (4050, 3650 and 410 respectively) (Figure 4.3.8a). In all the community forest, maximum species exhibited good regeneration contributing 50% (Dikhu) to 56% (Yongam) of the total species in the forest followed by fair regeneration which contributed 21% (Yongam) to 45% (Mongtikong). Around 13% of the total species showed no regeneration and only 4% were recorded as new regeneration (Figure 4.3.8b). Species such as *Bauhinia purpurea Croton joufra*, *Ficus tinctoria* and *Myrica esculenta* were recorded as new regenerating species in different community forest.

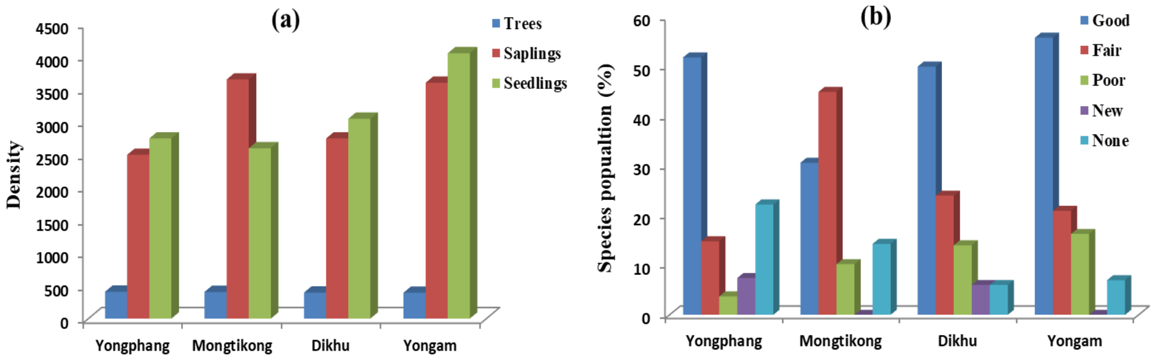



**Figure 4.3.8** Density of seedlings, saplings and trees **(a)** and their regeneration status (%) **(b)** in four study sites of Longleng District, Nagaland

### 4.3.9 Kohima district

The study showed that density (individuals ha$^{-1}$) of seedling was highest (3250 – 5650) followed by sapling (2700 – 3200) and trees (228 – 398) in all the community forests (Figure 4.3.9a). Maximum species in the community exhibited good regeneration (53%) followed by fair (16%), new (13%), none (11%) and poor regeneration (7%). Touphema contributed maximum good regeneration (60%) followed by Peducha (59%) and Khonoma (51%). High new regenerations were observed in all the community forest contributing 14% (Khonoma) to 19% (Longwesunyu) of the total tree species in the forest. Species such as *Alangium chinense*, *Garcinia sopsopia*, *Schefflera wallichiana*, *Mallotus tetracoccus*, *Oreocnide integrifolia*, *Prunus ceylanica*, *Saurauia roxburghii*, *Wendlandia tinctoria*, etc., were represented by their seedling/sapling in different community forest.

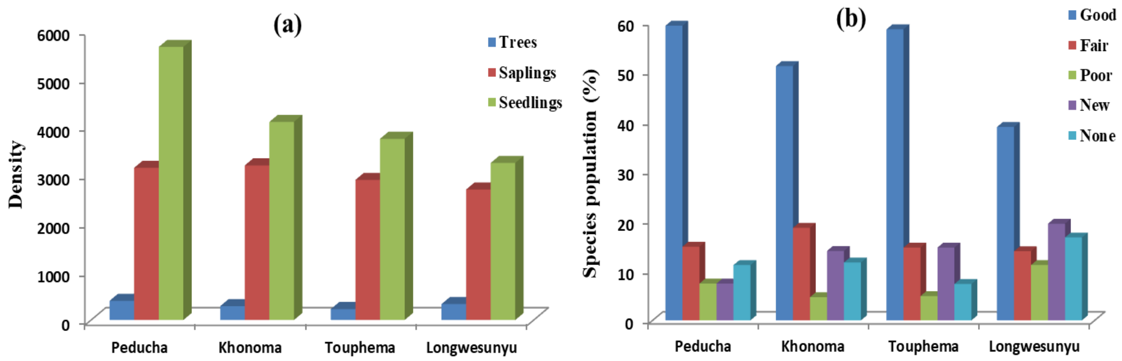



**Figure 4.3.9** Density of seedlings, saplings and trees **(a)** and their regeneration status (%) **(b)** in four study sites of Kohima District, Nagaland

### 4.3.10 Peren district

Density of trees, saplings and seedling of all the community forests is shown in Figure 4.3.10a. Dunki CF recorded the highest tree and seedling density (420 and 4450 individuals ha$^{-1}$) whereas Tesen CF recorded the highest sapling density (3800 individuals ha$^{-1}$). The study on regeneration potential also showed that species distribution in New Jaluki CF exhibited the maximum good regeneration (53%) followed by Dunki (45%) and Benreu (43%) (Figure 4.3.10b). Overall 12% of the species showed new regeneration and 19% showed no regeneration. Species such as *Alangium chinense*, *Colona floribunda*, *Chukrasia tabularis*, *Holarrhena pubescens*, *Lindera latifolia*, *Mangifera sylvatica* etc., were represented only in seedling/sapling stage.

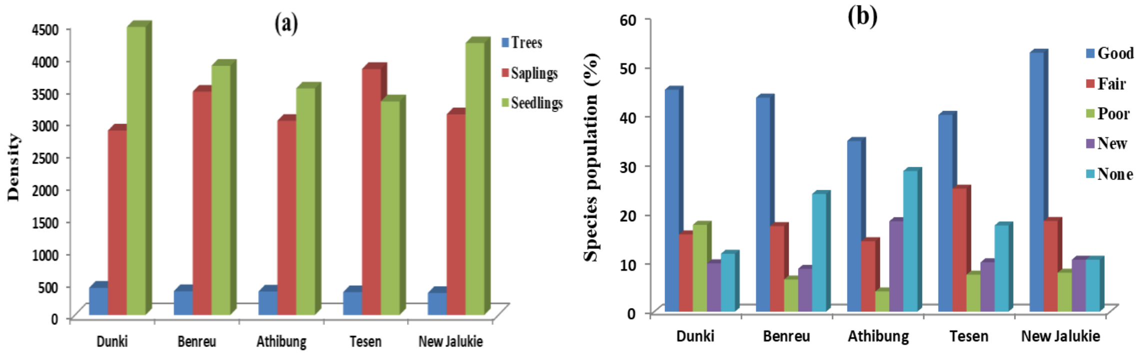



**Figure 4.3.10** Density of seedlings, saplings and trees **(a)** and their regeneration status (%) **(b)** in five study sites of Peren District, Nagaland

### 4.3.11 Dimapur district

The study showed that density (individuals ha$^{-1}$) of seedling was highest (2250 – 3000) followed by sapling (1150 – 2450) and trees (218 – 367) in all the six study sites (Figure 4.3.11a). The study also showed that maximum species in all the study sites exhibited maximum good regeneration contributing 38% (New Chumukedima) to 47% (Dhansiripar) of the total species whereas 24% (New Chumukedima) to 29% (Medziphema) of species exhibited no regeneration (Figure 4.3.11b). Only 4% of the total species showed new regeneration whereas no regenerating individual was recorded from Hovukhu CF. Species such as *Eurya acuminata*, *Garcinia sopsopia*, *Careya arborea* and *Samanea saman* were only represented in seedling/sapling stage.

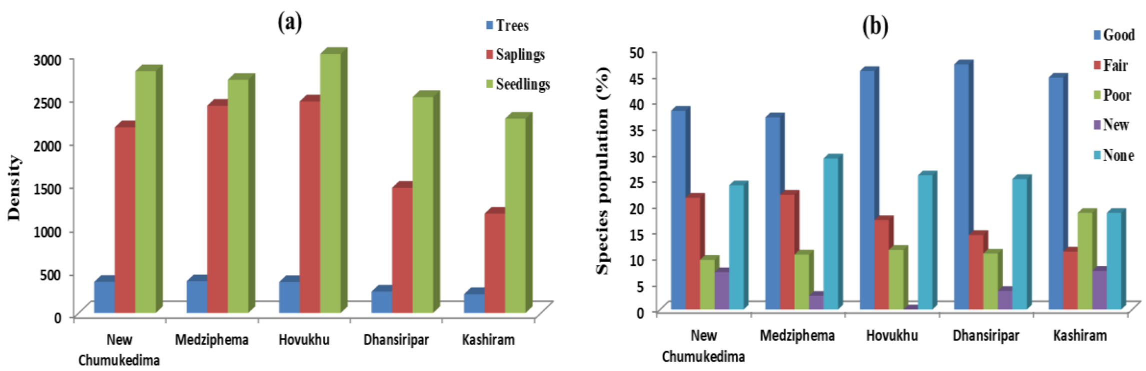



**Figure 4.3.11** (Density of seedlings, saplings and trees **(a)** and their regeneration status (%) **(b)** in five study sites of Dimapur District, Nagaland

## 4.4 Tree biomass and carbon stocks

### 4.4.1 Tree stand biomass of different districts of Nagaland

The overall study showed that both tree above- and below ground biomass varied significantly between various study sites and tree species, among individuals of the same species and between tree components (e.g. density, basal area, height, wood density etc.). The study also showed that the total plant biomass was largely influenced by tree density, basal area and species composition resulting into variations in the total living biomass of forest. Maximum biomass was contributed by older trees at higher DBH class indicating a strong relationship between basal area and biomass in the present study. The total tree biomass, AGTB and BGB were significantly different between various communities of Nagaland. The highest total stand biomass was recorded from Tuensang district (1031.41 Mg $ha^{-1}$) followed by Peren (946.72 Mg $ha^{-1}$), Kiphire (930.97 Mg $ha^{-1}$) and Mokokchung district (912.45 Mg $ha^{-1}$) whereas the lowest stand biomass was recorded from Kohima and Phek district (634.10 and 687.53 Mg $ha^{-1}$ respectively). Distribution of plant biomass in different study sites is presented in table 4.4.1.

In the present study, the above ground biomass ranged from 117.46 to 128.92 Mg $ha^{-1}$ and below ground biomass ranged from 27.84 to 30.35 Mg $ha^{-1}$ in Mokokchung district of Nagaland. The study showed that the average tree biomass (AGB + BGB) were stored highest in Khar CF (159.27 Mg $ha^{-1}$) followed by Minkong (155.69 Mg $ha^{-1}$) and Longkhum (153.42 Mg $ha^{-1}$) and lowest in Changki and Changtongya CF (145.30 and 147.25 Mg $ha^{-1}$ respectively) (Table 4.4.1). In Mon district, the total tree biomass was recorded highest in Singphan WLS (238.90 Mg $ha^{-1}$) followed by Longching CF (213.78 Mg $ha^{-1}$) and lowest in Longwa CF (162.59 Mg $ha^{-1}$). The above ground biomass ranged from 131.65 to 194.50 Mg $ha^{-1}$ and below ground biomass ranged from 30.94 to 44.40 Mg $ha^{-1}$ (Table 4.4.1). In Kiphire, Fakim WLS recorded the highest stand biomass (240.12 Mg $ha^{-1}$) followed by Sitimi CF (214.40 Mg $ha^{-1}$) and Chinkhu CF (192.37 Mg $ha^{-1}$) whereas Samphure CF recorded the lowest stand biomass (141.19 Mg $ha^{-1}$). The above ground biomass in the present study ranged from 112.59 to 195.54 Mg $ha^{-1}$ and below ground biomass ranged from 28.59 to 44.58 Mg $ha^{-1}$ (Table 4.4.1). In Tuensang district, the highest tree biomass were stored in Helipong CF (241.45 Mg $ha^{-1}$) followed by

Pangsha CF (235.51 Mg ha$^{-1}$) and Yangli CF (217.29 Mg ha$^{-1}$) and lowest in Chendang CF (146.48 Mg ha$^{-1}$). The above ground biomass ranged from 118.43 to 196.61 Mg ha$^{-1}$ and below ground biomass ranged from 28.05 to 44.84 Mg ha$^{-1}$ (Table 7.1). In Phek district, Akhegwo CF (198.58 Mg ha$^{-1}$) recorded the highest tree biomass followed by Chizami and Zipu CF (194.78 and 160.46 Mg ha$^{-1}$) whereas Meluri CF recorded the lowest tree biomass (133.70 Mg ha$^{-1}$). The above ground biomass in the present study ranged from 133.70 to 198.59 Mg ha$^{-1}$ and below ground biomass ranged from 25.75 to 37.33 Mg ha$^{-1}$ (Table 4.4.1). In Wokha district, Wokha village CF recorded the highest tree biomass (260.86 Mg ha$^{-1}$) followed by Tsonsa and Doyang CF (245.35 and 185.44 Mg ha$^{-1}$) whereas Ralan CF recorded the lowest tree biomass (134.47 Mg ha$^{-1}$). The above ground biomass in the present study ranged from 108.59 to 212.65 Mg ha$^{-1}$ and below ground biomass ranged from 25.89 to 48.22 Mg ha$^{-1}$ (Table 7.1). In Zunhebhoto district, Lumami CF recorded the highest tree biomass (193.72 Mg ha$^{-1}$) followed by Luvishe and Akuhaito CF (172.65 and 170.12 Mg ha$^{-1}$) whereas Satakha CF recorded the lowest tree biomass (143.66 Mg ha$^{-1}$). The above ground biomass in the present study ranged from 116.12 to 157.26 Mg ha$^{-1}$ and below ground biomass ranged from 27.55 to 36.46 Mg ha$^{-1}$ (Table 4.4.1). In Longleng district, the average highest tree biomass were stored in Yongphang (230.50 Mg ha$^{-1}$) followed by Mongtikong CF (224.87 Mg ha$^{-1}$) and Dikhu CF (211.53 Mg ha$^{-1}$) and lowest in Yongam CF (202.01 Mg ha$^{-1}$). The average above ground biomass ranged from 164.08 to 187.57 Mg ha$^{-1}$ and below ground biomass ranged from 37.93 to 42.93 Mg ha$^{-1}$ respectively (Table 7.1). In Kohima district, the average highest stand biomass were stored in Peducha CF (205.82 Mg ha$^{-1}$) followed by Longwesunyu CF (159.91 Mg ha$^{-1}$) and lowest in Touphema CF (130.96 Mg ha$^{-1}$). Similarly, the average above ground biomass ranged from 105.71 to 167.22 Mg ha$^{-1}$ and below ground biomass ranged from 25.25 to 38.60 Mg ha$^{-1}$ respectively (Table 7.1). In Peren district, the highest tree biomass were stored in Dunki CF (236.55 Mg ha$^{-1}$) followed by Benreu CF (188.25 Mg ha$^{-1}$) and Athibung CF (217.29 Mg ha$^{-1}$) and lowest in New Jalukie CF (164.91 Mg ha$^{-1}$). The above ground biomass ranged from 133.56 to 192.60 Mg ha$^{-1}$ and below ground biomass ranged from 31.35 to 43.96 Mg ha$^{-1}$ (Table 4.4.1). In Dimapur district, Medziphema CF recorded the highest tree biomass (184.04 Mg ha$^{-1}$) followed by

New Chumukedima and Hovukhu (177.56 and 176.12 Mg $ha^{-1}$) whereas Dhansiripar PF recorded the lowest tree biomass (131.60 Mg $ha^{-1}$). The above ground biomass in the present study ranged from 106.23 to 149.32 Mg $ha^{-1}$ and below ground biomass ranged from 25.37 to 34.76 Mg $ha^{-1}$ (Table 4.4.1).

**Table 4.4.1** Total tree biomass (Mg $ha^{-1}$) and carbon stocks (Mg C $ha^{-1}$) in various districts of Nagaland. Values in parentheses are for carbon stocks.

| Districts | Above ground biomass | Below ground biomass | Total stand biomass |
|---|---|---|---|
| **1. Mokokchung** | | | |
| Longkhum | 124.12 ± 1.50 (55.85) | 29.30 ± 0.33 (13.18) | 153.42 (69.04) |
| Changtongya | 119.06 ± 2.72 (53.58) | 28.19 ± 0.60 (12.69) | 147.25 (66.26) |
| Khar Lumdang | 128.92 ± 2.24 (58.02) | 30.35 ± 0.49 (13.66) | 159.27 (71.67) |
| Minkong | 126.05 ± 3.75 (56.72) | 29.64 ± 0.83 (13.34) | 155.69 (70.06) |
| Tuli | 121.63 ± 4.18 (54.73) | 28.79 ± 0.92 (12.95) | 150.41 (67.69) |
| Changki | 117.46 ± 1.57 (52.86) | 27.84 ± 0.34 (12.53) | 145.30 (65.39) |
| Total | | | **912.45 (410.60)** |
| **2. Mon** | | | |
| Singphan | 194.50 ± 5.17 (87.52) | 44.40 ± 1.09 (19.98) | 238.90 (107.50) |
| Longching | 173.78 ± 5.30 (78.20) | 40.00 ± 1.13 (18.00) | 213. 78 (96.20) |
| Aboi | 159.79 ± 2.69 (71.90) | 37.01 ± 0.58 (16.66) | 196.80 (88.56) |
| Longwa | 131.65 ± 1.06 (59.24) | 30.94 ± 0.23 (13.92) | 162.59 (73.17) |
| Langpongshianga | 135.96 ± 1.73 (61.18) | 31.88 ± 0.37 (14.34) | 167.83 (75.53) |
| Total | | | **766.12 (344.75)** |
| **3. Kiphire** | | | |
| Fakim | 195.54 ± 19.11 (87.99) | 44.58 ± 4.04 (20.06) | 240.12 (108.05) |
| Sitimi | 174.70 ± 11.77 (78.62) | 39.70 ± 2.96 (17.87) | 214.40 (96.48) |
| Chinkhu | 156.14 ± 3.96 (70.26) | 36.23 ± 0.85 (16.30) | 192.37 (86.57) |
| Samphure | 112.59 ± 2.41 (50.67) | 28.59 ± 2.13 (12.87) | 141.19 (63.53) |
| Pungro | 115.48 ± 2.00 (51.97) | 27.41 ± 0.44 (12.33) | 142.89 (64.30) |
| Total | | | **930.97 (418.94)** |
| **4. Tuensang** | | | |
| Helipong | 196.61 ± 10.10 (88.48) | 44.84 ± 2.13 (20.18) | 241.45 (108.65) |
| Pangsha | 191.70 ± 3.85 (86.26) | 43.81 ± 0.81 (19.71) | 235.51 (105.98) |
| Yangli | 176.67 ± 3.89 (79.50) | 40.62 ± 0.83 (18.28) | 217.29 (97.78) |
| Chendang | 118.43 ± 6.09 (53.29) | 28.05 ± 1.34 (12.62) | 146.48 (65.92) |
| Panso | 154.75 ± 1.67 (69.64) | 35.93 ± 0.36 (16.17) | 190.68 (85.85) |
| Total | | | **1031.41 (464.13)** |
| **5. Phek** | | | |
| Chizami | 158.12 ± 4.89 (71.16) | 36.66 ± 1.05 (16.49) | 194.78 (87.65) |
| Meluri | 107.95 ± 0.93 (48.58) | 25.75 ± 0.20 (11.59) | 133.70 (60.16) |
| Akhegwo | 161.27 ± 5.85 (72.57) | 37.33 ± 1.26 (16.80) | 198.59 (89.37) |

| | | | |
|---|---|---|---|
| Zipu | 130.00 ± 2.41 (58.45) | 30.56 ± 0.53 (13.75) | 160.46 (72.20) |
| Total | | | **687.53 (309.39)** |
| **6. Wokha** | | | |
| Wokha village | 212.65 ± 8.12 (95.69) | 48.22 ± 1.70 (21.70) | 260.86 (117.39) |
| Tsonsa | 199.83 ± 4.64 (89.92) | 45.52 ± 0.98 (20.49) | 245.35 (110.41) |
| Doyang | 150.44 ± 2.98 (67.70) | 35.01 ± 0.64 (15.75) | 185.44 (83.45) |
| Ralan | 108.59 ± 1.29 (48.86) | 25.89 ± 0.28 (11.65) | 134.47 (60.51) |
| Total | | | **826.12 (371.75)** |
| **7. Zunhebhoto** | | | |
| Akuhaito | 136.84 ± 2.37 (62.03) | 32.28 ± 0.51 (14.53) | 170.12 (76.55) |
| Luvishe | 139.92 ± 0.95 (62.96) | 32.73 ± 0.21 (14.73) | 172.65 (77.69) |
| Lumami | 157.26 ± 8.44 (70.77) | 36.46 ± 1.82 (16.41) | 193.72 (87.17) |
| Aichisanghemi | 132.58 ± 3.24 (59.66) | 31.14 ± 0.70 (14.01) | 163.72 (73.68) |
| Satakha | 116.12 ± 0.53 (52.25) | 27.55 ± 0.12 (12.40) | 143.66 (64.65) |
| Total | | | **843.87 (379.74)** |
| **8. Longleng** | | | |
| Dikhu | 171.92 ± 2.96 (77.36) | 39.61 ± 0.63 (17.82) | 211.53 (95.19) |
| Mongtikong | 182.93 ± 10.01 (82.32) | 41.94 ± 2.13 (18.87) | 224.87 (101.19) |
| Yongphang | 187.57 ± 4.57 (84.41) | 42.93 ± 0.97 (19.32) | 230.50 (103.73) |
| Yongam | 164.08 ± 4.25 (73.84) | 37.93 ± 0.91 (17.07) | 202.01 (90.91) |
| Total | | | **868.91 (391.01)** |
| **9. Kohima** | | | |
| Peducha | 167.22 ± 7.29 (75.25) | 38.60 ± 1.56 (17.37) | 205.82 (92.62) |
| Touphema | 105.71 ± 1.04 (37.57) | 25.25 ± 0.23 (11.36) | 130.96 (58.93) |
| Khonoma | 110.99 ± 1.69 (49.95) | 26.42 ± 0.37 (11.89) | 137.41 (61.83) |
| Longwesunyu | 129.45 ± 2.91 (58.25) | 30.46 ± 0.63 (13.71) | 159.91 (71.96) |
| Total | | | **634.10 (285.35)** |
| **10. Peren** | | | |
| New Jalukie | 133.56 ± 1.31 (60.10) | 31.35 ± 0.28 (14.11) | 164.91 (74.21) |
| Tesen | 141.75 ± 2.62 (63.79) | 33.13 ± 0.57 (14.91) | 174.88 (78.70) |
| Benreu | 152.75 ± 1.14 (68.74) | 35.50 ± 0.25 (15.98) | 188.25 (84.71) |
| Athibung | 147.71 ± 3.51 (66.47) | 34.42 ± 0.76 (15.49) | 182.13 (81.96) |
| Dunki | 192.60 ± 18.18 (86.67) | 43.96 ± 3.87 (19.78) | 236.55 (104.45) |
| Total | | | **946.72 (426.02)** |
| **11. Dimapur** | | | |
| New Chumukedima | 143.96 ± 5.08 (64.78) | 33.60 ± 1.10 (15.12) | 177.56 (79.90) |
| Hovukhu village | 142.77 ± 2.71 (64.25) | 33.35 ± 0.59 (15.01) | 176.12 (79.25) |
| Medziphema | 149.32 ± 1.35 (67.19) | 34.76 ± 0.29 (15.64) | 184.08 (82.84) |
| Dhansiripar | 106.23 ± 1.75 (47.81) | 25.37 ± 0.39 (11.42) | 131.60 (59.22) |
| Kashiram | 103.69 ± 3.36 (46.66) | 24.80 ± 0.75 (11.16) | 128.49 (57.82) |
| Total | | | **797.85 (359.03)** |

Values are ±SE.

### 4.4.2 Carbon stocks

Accurate estimation of forest carbon stocks is one of the most scientific tool that can used for successful policy implementation in the region. Significant differences were observed in the biomass carbon storage between various community forests of Nagaland. Total carbon storage in different study sites showed a similar trend as that of the total biomass; showing highest value in Tuensang district (464.13 Mg C $ha^{-1}$) followed by Peren (426.02 Mg C $ha^{-1}$), Kiphire (418.94 Mg C $ha^{-1}$) and Mokokchung district (410.60 Mg C $ha^{-1}$) whereas the lowest carbon storage was recorded from Kohima (285.35 Mg C $ha^{-1}$) and Phek district (309.39 Mg C $ha^{-1}$) respectively. The study showed that higher basal area and tree species diversity in community forest of various districts (e.g. Kiphire, Mokokchung, Tuensang and Peren) reflected higher forest productivity and increased carbon stock in its plant biomass. The study also revealed that variations in tree density also contributed differences in carbon storage among the different community forests. Distribution of carbon stock (Mg C $ha^{-1}$) in different study sites is presented in table 4.4.1.

**CHAPTER 5**

# DISCUSSION

## 5.1 Species composition, population structure and community characteristics

Forest inventories are estimated to provide information on species composition and distribution of plant community and forest resources, species diversity patterns and the relationship between the species, thus helps in enabling management decisions for biodiversity conservation (Shaheen *et al.,* 2015). Understanding floristic diversity and species distribution patterns is significant to evaluate the ecological complexity as well as the prospects of different forest ecosystems (Kohl and Marchetti, 2014). In the present study, considerably high species richness was observed in community forest of various districts (Mon, 356 species; Zunhebhoto, 341 species; Peren, 318 species; Tuensang, 315 species; Wokha, 311 species; Mokokchung, 306 species; Kiphire, 303 species) which were dominated by subtropical evergreen to temperate broad-leaved forest and presence of late successional-species as compared to community forest of districts (Kohima, 292 species; Phek, 266 species; Longleng, 223 species; Dimapur, 198 species) dominated by tropical semi-evergreen and pine forest and small percentage of temperate forest. The variations in species richness in all community forest of various districts may be attributed to different management practices adopted by the local communities and also anthropogenic pressures in low elevated forest because of easy accessibility for the locals to extract natural resources (Ao *et al.,* 2021). Several workers have also reported that anthropogenic activities such as tree felling for timber, agriculture expansion, forest fires and collection of fuelwood has led to reduction of species richness in various tropical and subtropical forests (Singh *et al.,* 2015; Dagba *et al.,* 2017; Kalkidan *et al.,* 2017). Further, differences in species richness in the present study may also attribute to variations in vegetation growth forms due to changing altitudes (Gairola *et al.,* 2008). The present study also showed higher diversity of overstory species as compared to understory species. The lower species richness of shrub and herb species as compared to tree species may be attributed to dense canopy cover of trees resulting low light availability for undergrowth vegetation (Grau, 2002). According to Singh *et al.,* (2013a) the species richness variations in understory vegetation depends of edaphic factors, soil nutrients and water, canopy cover percentage, light intensity for undergrowth species, species composition and decomposition rate of organic matter in the soil. Regardless of high level of disturbance index due to timber extraction, forest fire and land encroachments, the higher diversity in Mokokchung, Mon and Zunhebhoto district as compared to other districts, may be due to higher rainfall which promotes soil nutrient and pH, facilitating faster rate of organic matter decomposition (Saikia *et al.*, 2017). The most dominant families in trees were: Elaeocarpaceae, Euphorbiaceae, Fagaceae, Lauraceae, Magnoliaceae, Moraceae, Rosaceae, Sterculiaceae and Theaceae whereas in shrubs, the dominant families were: Asteraceae, Ericaceae, Euphorbiaceae, Leeaceae, Malvaceae, Melastomataceae, Rosaceae, Urticaceae, Verbenaceae and Zingiberaceae and in herbs, the dominant families were: Acanthaceae, Araliaceae, Asteraceae, Combretaceae, Lamiaceae, Rubiaceae and Zingiberaceae. The result of the present study is in accordance with the findings of the present study reported from natural undisturbed forest of tropical, subtropical and temperate regions in various South-East Asia (Nath *et al.*, 2005; Sarkar and Devi, 2014; Mittermeier *et al.* 2015; Upadhaya *et al.*, 2015; Lynser and Tiwari, 2015; Malik and Bhatt, 2016; Ao *et al.*, 2021).

Wide variations in average tree density (310 – 403 individuals $ha^{-1}$) and basal area (26.39 – 38.05 $m^2$ $ha^{-1}$) was observed in various community forests of eleven districts of Nagaland. Rapid growth of tree seedling and sapling observed in some of the sites was because of natural (Lightning strock) or anthropogenic disturbances due to tree felling created canopy gaps due to opening that allows sufficient light to reach forest floor and induce the growth of understorey vegetation. Lower tree density and variation in species composition in Dimapur and Kohima district may be attributed to various anthropogenic factors (e.g. tree lopping for fodder, fuelwood collection, timber extraction for house construction and agricultural tools grazing and shifting cultivation) by the local people living near the forest area. Generally, variations in tree density in any natural forest may be attributed to forest community type, species composition and size, forest age class, elevations, site history, soil, level of disturbance and various other factors (Amjad *et al.*, 2014). The average total tree, shrub and herb density recorded in the present study was comparable with the reported value of various community forest in tropical and temperate regions of Northeast India (Tripathi and Tripathi, 2010; Jhariya and Oraon, 2012; Dutta and Devi, 2013; Borah *et al.,* 2014; Saikia *et al.,* 2017; Hrahsel *et al.,* 2019; Suchiang *et al.,* 2020; Ao *et al.,* 2020).

The average total basal area of trees (26.39 – 38.05 $m^2 ha^{-1}$) recorded in the present study showed significantly higher than basal area of tropical forests (Sharma and Kant, 2014; Singh *et al.,* 2015; Singh *et al.,* 2015a; Gandhi and Sundarapandian, 2020). However, the basal area of the present study was well comparable to the reported value of various tropical and subtropical regions of Indian subcontinent (Sayed *et al.,* 2015; Saha *et al.,* 2016; Meetei *et al.,* 2017; Suchiang *et al.,* 2020). The higher basal area ($m^2$ $ha^{-1}$) recorded in Wokha (38.05), Longleng (37.91), Kiphire (36.56) and Peren (35.51) as compared to other parts of the states may be attributed to presence of large trees in higher girth classes because of lesser anthropogenic disturbances and favorable climatic condition. The variations of stand basal areas in different forest may also be attributed to altitudinal gradient, forest age, species composition and size, soil conditions, topography, successional stage of the forest and level of disturbances in the community (Tripathi *et al.* 1987; Swamy *et al.* 2000; Jaworski and Paluch, 2002).

The analysis of plant diversity indices help us to understand the species diversity patterns and species abundance in the community and also various factors responsible for variations in diversity of natural forest (Brockerhoff *et al.,* 2017b). In the recent years, number of researchers investigated floristic composition and species diversity in different forest types and reported that the existence of high species diversity in tropical rain forests and concluded that anthropogenic activities are posing serious threat to biodiversity in the region (Singh, 2015; Mehrvarz *et al.,* 2016; Borah *et al.,* 2021). According to recent studies conducted by number of researchers, the Shannon diversity index was higher (0.80 – 4.30) in tropical and subtropical regions of Indian forest (Sharma *et al.* 2014; Shaheen *et al.,* 2015; Saikia *et al.,* 2017; Das *et al.,* 2017 and Ao *et al.,* 2020). The range of mean Shannon diversity value for trees (3.13 – 3.67), shrubs (2.54 – 3.09) and herbs (2.59 – 3.10) in the present study were well within the range (0.80 – 4.30) reported for these forests reflecting high plant species diversity in all forest communities. High diversity value and low dominance is a distinct characteristic feature of an old growth natural forest (Spies, 2004) which is also supported by the findings of the present study. The lower diversity index of trees in Dimapur, Kohima, Kiphire and Phek district as compared to other district forest may be attributed to unceasing disturbances caused due to excessive forest product extraction, shifting cultivation, uncontrolled grazing, changing of land use pattern, encroachments, forest fires and tree felling for timbers and also for making various agricultural implements. The average Simpson dominance index for trees (0.03 – 0.12), shrubs (0.05 – 0.09) and herbs (0.04 – 0.08) in the present study was within the reported range (0.03 – 0.94) for different tropical and temperate forest in Indian subcontinent (Deb and Sundriyal, 2011; Akash *et al.*, 2018; Verma and Pal, 2019; Subashree *et al.*, 2020; Joshi, 2020). Generally, diversity index and concentration of dominance shows an inverse relationship (Joshi and Behera, 1991) which was also observed in the present study. The average species richness index for trees (6.55 – 9.10), shrubs (3.88 – 5.83) and herbs (5.24 – 6.73) in the present study corresponds well with the Shannon diversity index value. The species richness index recorded in the different forest communities was comparable to species richness index reported from various Indian tropical forests (Kumar *et al.*, 2010; Sathish *et al.*, 2013; Sharma and Raina, 2018; Kumari *et al.*, 2018; Verma and Pal, 2019).

Based on species IVI value, the dominance-diversity curve (d-d curve) or species rank abundance distribution curve (RAD) for tree, shrub and herb layer in the present study showed mixed nature of vegetation and exhibited different species distribution models in all the communities. The study showed that the dominance-diversity curve in all the community (trees, shrubs and herbs) exhibited log normal distribution pattern indicating high species richness, low dominance and high equitability of species reflecting equal sharing of natural resources among the species in the ecosystem (Upadhaya, 2015; Zhu *et al.*, 2015; Swamy *et al.*, 2000). However, few community forests exhibited broken stick distribution model reflecting the disturbances faced by the communities. The dominance-diversity curve for trees in various community forest such as Changki, Changtongya and Tuli (Mokokchung district); Longwa (Mon district); Pungro and Samphure (Kiphire district) and Aichisanghemi and Satakha (Zunhebhoto district) exhibited broken stick distribution pattern indicating lower species richness and low equitability which is attributed to various anthropogenic activities such as cutting of timber species like *Alnus nepalensis, Duabanga grandiflora, Gmelina arborea, Prunus cerasoides, Sapium baccatum, Terminalia myriocarpa* and *Toona ciliata.* Further, it also indicates unequal sharing of natural resources where the most dominant species utilizes most resources in the community (Upadhaya, 2002; Sahu *et al.,* 2012; Mylliemngap *et al.* 2016; Sharma *et al.,* 2018). The decrease of species richness in a community may also be caused due to high dependence on forest products by the tribal communities for fuelwood, fodders, medicines and various agricultural purposes (Singh, 2017).

The study of species distribution pattern provides information on competition and territoriality and helps us to understand the biogeography of plants in a forest ecosystem (Walker, 2011). In the present study, 22 – 64% of tree species showed contagious/clumped distribution while 23 – 55% of the species showed random distribution and 10 – 38% of species showed regular distribution across different community forest of Nagaland. Community forest of various districts such as Dimapur, Kohima, Longleng, Mokokchung, Peren Tuensang and Wokha exhibited maximum clumped/contagious distribution indicating clustering of individuals in a community while Kiphire, Mon and Zunhebhoto district exhibited maximum random distribution indicating individuals distributed at unpredictable distances from each other and Phek district exhibited maximum regular distribution indicating severe competition among individuals in the community. According to Odum (1971), contagious/clumped distribution is a significant characteristic feature of any natural vegetation and considered as the most pervasive pattern in tropical forest while random distribution is usually confined in uniform environments and regular distribution pattern occurs on those environments where high competition between individuals exist. Species distribution pattern in a community is not permanent and can change seasonally depending on the availability of resources (Putten *et al.,* 2010). Distribution of species also depends on various factors such as local habitat, extinction, weather conditions, reproductive process and continental drift (Kandari *et al.,* 2013). Number of researchers have also reported similar type of distribution pattern in various natural forest (Nath *et al.,* 2005; Kumar and Bhatt, 2006; Tripathi and Tripathi, 2010; Sobuj and Rahman, 2011; Gazal, 2015; Das *et al.*, 2017; Arya *et al.*, 2017; Sharma and Raina, 2018).

Similarity or dissimilarity in community composition is considered as the most conspicuous feature of any natural forest (Verma and Pal, 2019). Similarity indices characterizes variation of species diversity based on two major factors (a) species composition on two sites (b) species shared between two sites (Diserud and Odegaard, 2007). The similarity index reflects the interconnection of each forest types and helps us to interpret the process of succession of different forest types in an ecosystem (Sanyam and Vipasha, 2018). The present study showed that the species similarity index under various community forests of Nagaland was influenced by factors such as altitude, climate, forest types and forest successional stage. The highest similarity was observed between Mon and Kiphire (79%) followed by Mokokchung and Tuensang (56%); Mokokchung and Mon (55%) and Mokokchung and Kiphire (54%). However, lowest similarity was observed between Kiphire and Dimapur (11%) followed by Tuensang and Dimapur (22%) and Kiphire and Wokha (24%). The very less similarity was observed between high and low elevation sites due to the changing species patterns at altitudinal gradient. The finding of the present study is also supported by the study of species similarity along altitudinal gradient in Eastern Himalaya, Arunachal Pradesh (Das *et al.,* 2017). Authors found very low similarity of tree species composition between high and low elevation sites. In present study, the community forest of each district located at elevations ≥ 1000 meter above sea level showed higher similarity value as compared to other parts of state located at lower elevations. The low species similarity between two communities may be attributed to progressive succession due to different micro-environmental condition, natural or anthropogenic disturbances and forest fragmentation (Novotny and Weiben, 2005; Davidar *et al.,* 2007). According to Hao *et al.,* (2019), high dissimilarity of species between forest communities may be because of the anthropogenic factors such as selective tree harvesting, alteration on species composition due to climate change and species invasions. Suchiang *et al.,* (2020) conducted a study on tree species composition in scared and community forest in Meghalaya and concluded that similarity in plant species composition is largely depend on micro-habitat condition, altitude, level of disturbances and stages of succession in the forest.

### 5.2 Regeneration trends

Natural regeneration is a major component of any tropical forest ecosystem dynamics and essential for preservation, conservation and maintenance of forest biodiversity (Sarkar and Devi, 2014). The nature of forest ecosystem is largely influenced by various ecological characteristics such as species diversity, composition and regeneration potential of species in the forest (Rahman *et al.,* 2011). Natural forest with high diversity of seedling, sapling and young trees indicates a good successful regeneration while complete absence or low diversity of seedling or saplings indicates poor regeneration in the community (Khalik *et al.*, 2013; Saha *et al.,* 2016). Further, good regeneration in a forest community is characterized by large production of seeds and successful establishment of seedlings and saplings in the soil (Khumbongmayum *et al.,* 2006). According to Devancy *et al.*, (2014) the population structure and its regeneration pattern are interconnected to each other. Seedling, sapling and young trees maintaining the population structure in a forest is largely influenced by micro-environmental factors which vary with seasonal changes (Kharkwal, 2009). Regeneration status of species is also reflected by various levels of natural or anthropogenic disturbances and interactions of biotic factors in the forest ecosystem (Hossain *et al.,* 2011; Iqbal *et al.,* 2012). In the present study, an attempt was made to assess the population structure and regeneration potential of tree species of different forest communities of Nagaland. The study of regeneration status was determined based on densities of seedling, sapling and trees. The study showed that the seedling density (individuals ha$^{-1}$) ranged from 1738 (in Phek) to 4188 (in Kohima), sapling from 1920 (in Dimapur) to 3560 (in Zunhebhoto) and tree density from 310 (Dimapur) to 403 (Longleng). The lowest seedling density recorded in Phek district may be attributed to continuous anthropogenic activities such as timber harvesting, fuelwood collection, and grazing. The lowest sapling and tree density recorded in Dimapur district which is considered as the only commercial hub of the state may be attributed to its urbanization and increasing number of human population leading to extreme human pressure on the urban forest, clear felling for infrastructures, lopping for fodders, tree felling for timber, fuelwood and construction materials.

Studies on regeneration status of tree species have been conducted by various workers in Eastern and Western Himalayan region where the reported values were found to be similar with the present study (Gairola *et al.,* 2012; Bhat, 2012; Pant and Sammant, 2012; Ballabha *et al.,* 2013; Pala *et al.,* 2013; Malik and Bhatt, 2016). The overall regeneration status showed fairly high in all the community forest of different parts of the state. Maximum species exhibited good regeneration and only about 12% of the total species showed no or poor regeneration which may be attributed to existing human disturbances such as timber and firewood extraction, uncontrolled grazing and shifting cultivation. Poor regeneration of species may also attribute to high canopy cover affecting the survival of the seedlings by reducing sunlight to reach forest floor (Pokhriyal *et al.*, 2010). Clark *et al.*, (1999) reported that poor or no regeneration in a natural forest may be attributed to unfavorable microsites for seed germination and growth, presence of various ecological factors affecting the seed survival and poor biotic potential of tree resulting less or uncertain seed production and establishment. According to Rahman *et al.*, (2011) clear felling for agriculture expansion, particularly in hilly regions also accelerates the loss of seedling and saplings in a primary forest. The present study also showed that about 42% and 16% of total tree species exhibited good and new regeneration indicating high species diversity and good forest health. The establishment of new species to the study site may be attributed to various factors such as wind, water, fire (e.g. pine trees), humans and drooping of birds or animals getting favorable microsite habitat for seed to germinate and establish (Good and Good, 1972). The germination potential of a species may also depend on factors such as ability of seedlings and saplings to survive and grow, canopy density, light penetration, soil moisture, nutrients, mode of seed dispersal and anthropogenic pressure (Web and Sah, 2003; Ma *et al.,* 2009).

### 5.3 Tree biomass and carbon stocks

In the present study, the total mean stand biomass of different district forest ranged from 634.10 to 1031.41 Mg ha$^{-1}$ with a mean value of 840.55 Mg ha$^{-1}$ which is much higher than the range (40 – 608 Mg $ha^{-1}$) reported for tropical forest of Indian subcontinent (Salunkhe *et al.,* 2018) reflecting high potential of the Nagaland forest to store carbon in its plant biomass. The recorded value in the present study can be compared with the reported biomass value of forest of Himalaya in western Himalayan range (Sharma *et al.,* 2008), Sem Mukhem sacred forest of Tehri, Garhwal Himalaya (Pala *et al.,* 2013a), Oak and Pine dominated forest of Central Himalaya (Nautiyal and Singh, 2013), tropical wet evergreen forest of Eastern Himalaya (Gogoi *et al.,* 2017) and tropical dry deciduous forest in Central Himalaya (Joshi and Dyani, 2018). The estimated total mean carbon stock in the present study ranged from 285.35 to 464.13 Mg C $ha^{-1}$ with an average value of 378.25 Mg C $ha^{-1}$ with the highest being in Tuensang district (463.13 Mg C $ha^{-1}$) followed by Peren (426.02 Mg C $ha^{-1}$), Kiphire (418.94 Mg C $ha^{-1}$) and Mokokchung district (410.60 Mg C $ha^{-1}$), respectively. The carbon stock value recorded in the present study was well within the range (42.66 – 628.91 Mg C $ha^{-1}$) reported for different physiographic zones of Indian forests (Sheikh *et al.,* 2011). The above ground biomass (AGB) in the present study ranged from 513.37 to 836.16 Mg $ha^{-1}$ with a mean value of 697.39 Mg $ha^{-1}$ which were found to be comparable with average AGB values of various forest types of India such as moist temperate forest of Garhwal Himalaya (Gairola *et al.,* 2011), moist deciduous forest of Gujarat (Patil *et al.,* 2012), deciduous forest of Western Himalaya (Shahid and Joshi, 2015), tropical forest of Katerniaghat Wildlife Sanctuary, Uttar Pradesh (Behera *et al.,* 2017) and tropical moist deciduous forest of Similipal Biosphere Reserve, Odisha (Mohanta *et al.,* 2020). The study also showed that the average mean AGB value in the present study was well within the range (85.01 – 732 Mg $ha^{-1}$) reported for various tropical forests of India (Singh and Singh, 1991; Gandhi and Sundarapandian, 2017). The higher biomass and carbon stock values in the community forest (e.g. Tuensang, Peren, Kiphire and Mokokchung districts) may be due to higher tree density and basal area as compared to other parts of the state (Agnihotri et al., 2006).

The below ground biomass (BGB) also acts as an important carbon pool for many vegetation types and different land use systems. The BGB in the present study contributed 8 – 12% to the total stand biomass. The contribution of BGB values to the total biomass in the present study were towards to lower side of the range (11 –

26%) reported for tropical forest ecosystems (Santantonio *et al.,* 1997; Cairns *et al.,* 1997). The present study showed higher mean total biomass and carbon stock values as compared to the reports of various studies in different Northeastern states of India (Devi and Yadava, 2009; Borah *et al.,* 2013; Majumdar *et al.,* 2016; Kalita *et al.,* 2016; Thokchom and Yadava, 2017; Gogoi *et al.,* 2017; Niirou and Gupta, 2017). This clearly indicates that the forests of Nagaland forests have high potential to mitigate climate change and decrease global warming by sequestering more carbon from the atmosphere if managed properly.

The differences in total biomass and carbon storage values observed across different community forests of the study area may be attributed to variations in tree species composition, species diversity and distribution pattern, forest age, site history, natural or anthropogenic disturbances and forest management practices (Joshi and Dhyani, 2018). According to Gogoi *et al.,* (2017), variations in total stand biomass may occur due to differences in basal area of trees. The presence of large trees in higher girth class in community forest of Tuensang, Peren, Kiphire and Mokokchung districts has significantly increased the biomass as compared to other districts indicating the importance of mature trees in carbon storage in a natural forest ecosystem (Meena *et al.,* 2019). Various studies also reported that large trees (>90 cm GBH) contribute more than 50% of above ground biomass in a tropical forest ecosystem (Brown *et al.,* 1996; Baishya *et al.* 2009; Gogoi *et al.,* 2020). Studies on above ground biomass and carbon estimation conducted by various workers in central Indian forest, concluded that large diameter trees contribute 10 – 35% of biomass carbon stock in a tropical forest (Bijalwan *et al.* 2010, Nizalapur *et al.* 2010; Kumar *et al.,* 2011; Pandya *et al.* 2013; Lal *et al.* 2016). The present study showed a strong relationship between biomass and basal area as diameter was used to estimate the biomass of an individual tree species. Similar observation was also reported by various researchers (Baraloto *et al.,* 2011; Lin *et al.,* 2015; Goncalves *et al.,* 2018). Many studies also suggest that wood density of different tree species also plays a major role in variations of forest living biomass (Manhas *et al.,* 2006; Rizvi *et al.,* 2011; Mohanta *et al.,* 2020) and shares a positive relationship in total biomass stored in the forest (Baker *et al.,* 2004). In the recent years, the studied forest are facing extreme anthropogenic pressures such as land encroachments, exploitation of natural resources, construction, large scale deforestation for shifting cultivation, over grazing, plantation of exotic species and urbanization resulting to forest fragmentation and change in stand structure and species composition (Sinha, 2014). Forest disturbances is one of the major factors for forest biomass variations which also influence the amount of carbon stored in the forest by altering stand structure and composition (Dale *et al.,* 2001; Marin-Spiotta *et al.,* 2007; Thong *et al.,* 2016). The present study also showed that the forest disturbance index value in different community forest corresponds well with the tree biomass values. Similar finding was also reported by Bhatti *et al.,* (2002) in Boreal forest of central Canada. Human-caused disturbances such as selective felling and firewood collection was commonly observed in all the community forests particularly in districts such as Dimapur, Kohima, Mon and Phek resulting in huge carbon loss and variations in forest living biomass. According to Pearson *et al.,* (2014), these activities have a very low influence on total stand biomass on per hectare basis but when these anthropogenic activities occur over a large forest area, the total carbon emission could be very significant. Some studies also reported that intense slash and burn fires can convert more than 39% of the total above ground carbon to carbon emission (Fearnside *et al.,* 2000). Carbon losses from trees that are accidentally damaged during felling and trees felled due to natural disasters (e.g. lightning strike) that are abandoned in the forest are reported to make upto 50% of the total carbon emission during harvesting (Andrade *et al.,* 2017). According to Global Footprint Network (GFN), carbon update of forest is the only method to mitigate green house gas emission which can be possible only by planting more trees to increase forest cover and bring our ecological footprint to balance (Blomqvist *et al.,* 2013; Rees and Wackernagel, 2013). Another way to achieve these objectives is through involving local communities by addressing carbon emission reductions resulting from activities such as deforestation and forest degradation (Gogoi *et al.,* 2017).

Overall, tree biomass and carbon estimation in the present study suggest that the community forest of different districts in Nagaland could play a significant role in storage of carbon in its plant biomass and help in maintaining global carbon cycle and mitigate climate change through proper management plans. The maximum biomass was contributed by trees in higher DBH classes indicating the importance of old-growth mature trees which acts as a sink of carbon in the studied forest. Furthermore, the study showed that the carbon storage potential in different community forest is influenced by tree density, basal area, species composition and level of disturbances.

## CHAPTER 6

## Summary and conclusion

The present work was undertaken to study the plant species composition, diversity and community characteristics, population structure, regeneration status, and biomass and carbon stocks of different forest communities of Nagaland, Northeast India. The survey was carried out from March 2016 to August 2018 in different community forest of eleven districts of Nagaland. In each forest site, a plot of 250 m × 250 m size was established and at each corner of the plot, 31.62 m × 31.62 m (0.1 ha) subplot with a total of four subplots were demarcated for tree vegetation and biomass inventory. Individuals with a girth ≥10 cm GBH were considered as woody species and were measured at 1.37 m above the ground. For shrub vegetation, two 5 m × 5 m subplots were nested on the opposite corners and for herbs (including epiphytes, lithophytes and climbers), four 1 m x 1 m subplots in were laid in the corner of each tree subplot. For sapling, plants with 3 to <10 cm girth with >10 cm height were considered, whereas for seedling, plants with <3 cm girth and height upto 10 cm with 3 to 8 leaves were considered. The enumeration of sapling and seedling was done in same plot of 5 m x 5 m as laid for shrubs. The major findings of the present investigation may be summarized as follows:

### Floristic structure and species diversity

A total of 1357 species belonging to 609 genera and 161 families were recorded from different forest communities of Nagaland, Northeast India. Of which 413 species, 198 genera and 74 families of trees; 344 species, 168 genera and 65 families of shrubs; and 601 species, 298 genera and 91 families of herbs were recorded. The most dominant species were: *Alstonia scholaris, Albizia procera, Alnus nepalensis, Betula alnoides, Bischofia javanica, Callicarpa arborea, Canarium strictum, Castanopsis indica, Choerospondias axillaris, Duabanga grandiflora, Erythrina arborescens, Gmelina arborea, Lagerstroemia speciosa, Lithocarpus elegans, Pinus kesiya, Phoebe lanceolata, Prunus cerasoides, Pterospermum acerifolium, Quercus serrata, Stereospermum chelonoides, Terminalia myriocarpa etc.* The most dominant families of trees were:

Elaeocarpaceae, Euphorbiaceae, Fagaceae, Lauraceae, Leguminosae, Magnoliaceae, Meliaceae, Moraceae, Rosaceae, Rutaceae, Sterculiaceae and Theaceae. Among the shrubs, the most dominant species were: *Artemesia nilagirica, Boehmeria hamiltonia, Boehmeria japonca, Casearia vareca, Clerodendrum glandulosum, Clerodendrum infortunatum, Clerodendrum japonicum, Croton caudatus, Dendrocnide sinuata, Eupatorium odoratum, Leea alata, Leea compactiflora, Maesa indica, Mussaenda roxburghii, Mahonia nepalensis, Melastoma malabathricum, Mussaenda macrophylla, Osbeckia crinita, Phrynium capitatum, Polygonum molle, Rubus calycinus, Urena labota etc.* The most dominant families of shrubs were: Asteraceae, Ericaceae, Euphorbiaceae, Leeaceae, Leguminosae, Malvaceae, Melastomataceae, Myrsinaceae, Rosaceae, Rubiaceae, Symplocaceae, Urticaceae, Verbenaceae, and Zingiberaceae. Among the herbs, the most dominant species were: *Ageratina riperia, Ajuga integrifolia, Artemisia indica, Bidens pilosa, Cheilocostus speciosus, Chrysanthemum indicum, Commelina benghalensis, Cyanotis axillaris, Dioscorea glabra, Dioscorea tomentosa, Elatostema hookerianum, Fagopyrum esculentum, Galinsoga parviflora, Girardinia diversifolia, Geranium nepalense, Leucas ciliata, Mikania micrantha, Tinospora sinensis etc.* The most dominant herb families were: Acanthaceae, Araliaceae, Asteraceae, Combretaceae, Commelinaceae, Cyperaceae, Lamiaceae, Leguminosae, Malvaceae, Mimosaceae, Orchidaceae, Poaceae, Rubiaceae, Urticaceae and Zingiberaceae.

**The stand density and basal area**

The overall mean density (individuals $ha^{-1}$) of trees, shrubs and herbs recorded from the present study was 358, 6521 and 66528, respectively, where the highest tree density was recorded in the community forest of Longleng (403), Wokha (401), Tuensang (392) and Mon (380) district. The highest density of shrubs was recorded in community forest of Longleng (8860), Dimapur (7820) and Phek (7500) whereas; the highest herb density was noted in community forest of Longleng (107300), Phek (80313) and Zunhebhoto (73438). In all the study, the density of younger trees (10 – 60 cm girth class) contributed more than 50% of the total tree density in all the community and lower density was observed in older trees (>120 cm girth class) which may be ascribed due to various anthropogenic factors (e.g. tree lopping for fodder, fuelwood collection, timber extraction for house construction and agricultural tools grazing and shifting cultivation) by the local people living near the forest area. Higher density in lower girth classes indicates a good regeneration potential of the forest showing that future plant communities can be sustained unless there is any occurrence of major biotic or abiotic changes. The mean basal area ($m^2ha^{-1}$) of trees was 32.55 where various community forest of Wokha (38.05), Longleng (37.91), Kiphire (36.56) and Peren (35.51) district recorded the highest basal area which may be attributed to the presence of large trees in higher girth classes. The overall population structure of all communities showed a reverse *J*-shaped population curve indicating a good forest health and high species richness.

**Species distribution pattern**

The Whitford index (A/F ratio) revealed that most of the plant species in the present study showed contagious/clumped distribution pattern. The study showed that about 22 – 64% of tree species exhibited contagious/clumped distribution while 23 – 55% exhibited random and only 10 – 38% of species exhibited regular distribution across different community forest of Nagaland. Community forest of Dimapur, Kohima, Longleng, Mokokchung, Peren Tuensang and Wokha exhibited maximum clumped/contagious distribution indicating clustering of individuals in a community while Kiphire, Mon and Zunhebhoto district exhibited maximum random distribution indicating individuals distributed at unpredictable distances from each other and Phek district exhibited maximum regular distribution indicating severe competition among individuals in the community.

**Similarity of tree species in different community forests**

The similarity index was carried out to understand the interconnection of each forest types and to determine how closely the current plant communities resemble to each other. The highest similarity of 79% was observed between Mon and Kiphire followed by Mokokchung and Tuensang (56%); Mokokchung and Mon (55%) and Mokokchung and Kiphire (54%) in terms of presence and absence of species. Whereas, lowest similarity was observed between Kiphire and Dimapur (11%) followed by Tuensang and Dimapur (22%), and Kiphire and Wokha (24%). The present study indicated that the species similarity under different community forests of Nagaland was influenced by various factors such as altitude, climate, forest types and forest successional stage.

**Regeneration potential of different forest communities of Nagaland**

The study of regeneration status was determined based on densities of seedling, sapling and trees. The mean seedling, sapling and tree density (individuals $ha^{-1}$) in different community forests of Nagaland was recorded as 2848, 2555 and 358 respectively. The highest seedling and sapling density was recorded in community forest of Kohima (4188), Peren (3860) and Zunhebhoto (3690). Similarly, the highest saplings density was recorded in Zunhebhoto (3560), Peren (3240) and Longleng (3125). These sites showed good regeneration of species as compared to other community forests reflecting the potential of plant communities' sustenance in future. The study also showed that the poor regeneration of species in the present investigation may be attributed to continuous practice of shifting cultivation, fuelwood collection, timber harvesting, uncontrolled grazing and poor biotic potential of tree species which either affect the fruiting or seed germination or successful conversion of seedling to sapling stage. The overall population structure of tree species in all the forest communities of Nagaland reveals that contribution of seedlings to the total population was highest followed by saplings and adult trees. The study also shows that regeneration of tree species in all the community forest is "good' and the future communities may be sustained unless there is any major environmental stress or interference exerted by anthropogenic activities.

**Biomass and carbon stocks in different forest communities of Nagaland**

In the present study, the total mean stand biomass of different district forest ranged from 634.10 to 1031.41 Mg $ha^{-1}$ with an average value of 840.55 Mg $ha^{-1}$. The estimated total average carbon stock ranged from 285.35 to 464.13 Mg C $ha^{-1}$ with an average value of 378.25 Mg C $ha^{-1}$. The highest total mean stand biomass was recorded from community forests of Tuensang (1031.41 Mg $ha^{-1}$) followed by Peren (946.72 Mg $ha^{-1}$), Kiphire (930.97 Mg $ha^{-1}$) and Mokokchung district (912.45 Mg $ha^{-1}$). Whereas the lowest stand biomass was recorded from Kohima and Phek district (634.10 and 687.53 Mg ha$^{-1}$, respectively). The present study showed that the total plant biomass was largely influenced by tree density, basal area and species composition resulting to variations in the total living biomass of forest. Maximum biomass was contributed by older trees at higher DBH class indicating a strong relationship between basal area and biomass in the forest.

**Conclusion**

On the basis of species composition, stand structure and regeneration potential it is clear that that the community forests of Nagaland are very rich in terms of trees, shrubs and herbs species composition (1357 species) constituting a good forest wealth in the state. Apart from various anthropogenic activities affecting the species composition and diversity, the study also indicates that various abiotic factors (e.g. altitudes, climate, light intensity, edaphic etc.) also influences the tree species composition, diversity, species richness and distribution patterns in the community forest of Nagaland. The overall regeneration of tree species in the different forest communities is good which is evident by the higher seedling density to the total population as compared to sapling and adult trees indicating that the future plant communities can be conserved and sustained unless there is no major environmental stress or disturbance by human activities in the forest ecosystems. The result of this study will also serve as baseline information for the forest department, conservationist and ecologist to develop policy for sustainable management of different forest communities of Nagaland, Northeast India. Estimation of stand biomass and carbon stock in the present study showed that community forest of Kiphire, Mokokchung, Peren and Tuensang districts share the maximum storage of carbon in tree biomass contributing 45% of the total forest carbon stock suggesting that these forests can serve as a great potential pool of carbon storage. Maximum biomass contribution by trees in higher DBH classes also revealed the importance of mature trees as major carbon sinks in these community forests. The overall study showed a positive relationship between species density, basal area and stand biomass which indicate that total carbon storage in the forest depends on the community characteristics of the forest. Overall tree biomass and carbon stock suggest that the community forest of different districts in Nagaland could play a significant role in storage of carbon in its plant biomass that can help in maintaining regional carbon cycle and mitigate future climate change in the region.

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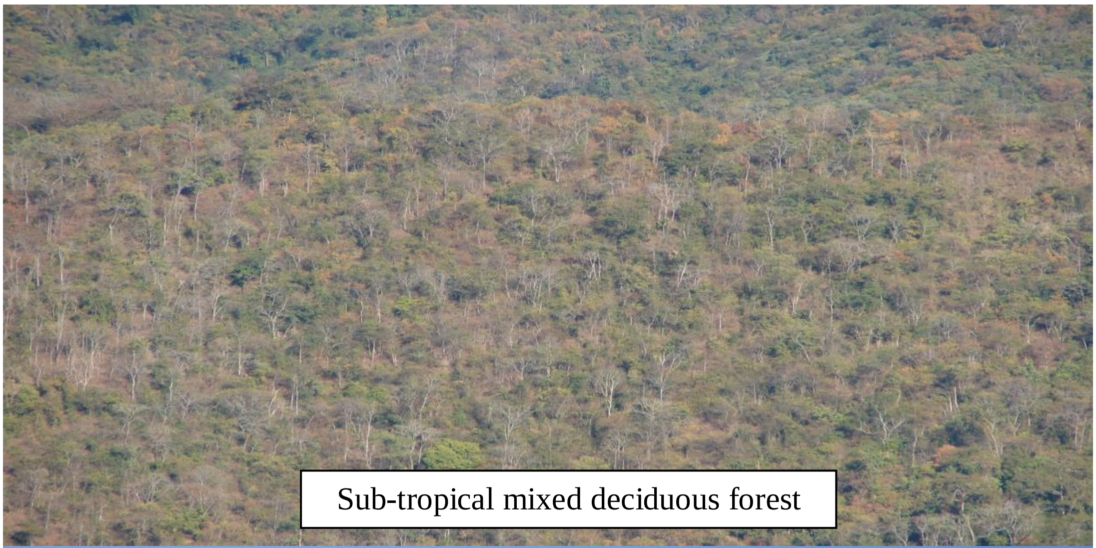
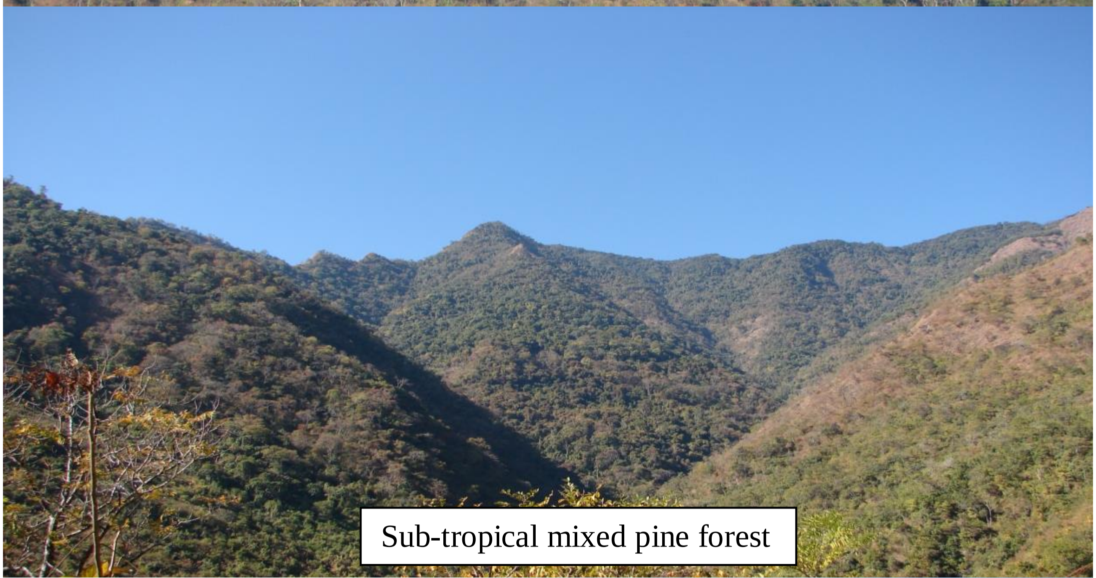
## MAJOR FOREST TYPES OF NAGALAND

Temperate Broad leaved forest

Tropical evergreen forest

Sub-tropical evergreen forest


Sub-tropical mixed deciduous forest


Sub-tropical mixed pine forest


Grassland in Limestone belt

## Some important tree species of Nagaland

*Acer oblongum*

*Actinodaphne obovata*

*Amoora wallichii*

*Artocarpus chaplasha*

*Bauhinia tenuiflora*

*Bischofia javanica*

*Brassiopsis hainla*

*Careya arborea*

*Cinnamomum zeylanicum*

*Croton joufra*

*Duabanga grandiflora*

*Engelhardtia spicata*

*Erythrina arborescens*

*Exbucklandia populnea*

*Juglan regia*

*Macaranga pustulata*

*Michelia champaca*

*Myrica esculenta*

*Prunus nepaulensis*

*Schima wallichii*

*Terminalia myriocarpa*

*Zanthoxylum armatum*

## **Some medicinally important plants of Nagaland**

*Aconitum ferox*

*Acorus calamus*

*Allamanda cathartica*

*Aloe barbedensis*

*Amphineuron opulentum*

*Argemone mexicana*

*Buddleja asiatica*

*Buddleja macrostachya*

*Catharanthus roseus*

*Cana indica*

*Calapropis gigantae*

*Cassia floribunda*

*Centilla asiatica*

*Clerodendron fragrans*

*Clerodendrum viscosum*

*Curculigo orchioides*

*Crotalaria striata*

*Elsholtzia comunis*

*Entada purseatha*

*Eryngium foetidum*


*Euphorbia hirta*


*Gynura cusimbua*


*Hedychium spicatum*


*Houttuynia cordata*


*Hedyotis scandens*


*Hibiscus sabdariffa*


*Ipomea vitifolia*


*Lantana camara*


*Leea compactiflora*


*oxalis corniculata*


*Plantago major*


*Rubus ellipticus*


*Smilax macrophylla*

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8. **Educational Qualification :-**

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| HSSLC | 2008 | KMC, Dimapur | Maths, Phy., Che., Eng., Alt. Eng. |
| B. Sc | 2012 | SHIATS, Allahabad | Forestry |
| M. Sc | 2014 | NERIST, Itanagar | Forestry |
| Doctor of Philosophy (Ph.D.) | Pursuing | Mizoram University | Forestry |

9. **Additional Qualification:**

i. Computer certificate in Multilingual Office Automation of C-DAC, GIST
ii. Diploma in Computer Application

10. **Job Experience**

i. Field Assistant in the project entitled "Impact assessment of Jhumming on native plants and soil micro biota and restoration of sustainable jhum agro-ecosystem in Northeast India" sponsored by the Department of Biotechnology, Govt. of India, New Delhi for the period of **1 year 6 months** in the Department of Genetics and Plant Breeding, School of Agricultural Sciences and Rural Development, Nagaland University.
ii. Research Fellow (JRF – SRF) in the project entitled "Measurement of Vegetation and Biomass Parameters under Vegetation-Carbon Pool

Assessment” under National Carbon Project (NCP) funded by National Remote Sensing Centre (NRSC), Department of Space, Dehra Dun for the period of **4 years** in the Department of Genetics and Plant Breeding, SASRD, Nagaland University.

**11. Field Experience:**

i. Welfare of Mithun (*Bos frontalis*) living under domestic and free Range condition in Kohima district of Nagaland.
ii. Plant Diversity & Community characteristics of Singphan Wildlife Sanctuary.

**12. Details of professional trainings:**

i. Undergone DST sponsored one week training program on “Climate Change Adaptation for Natural Resource Management for the State of Mizoram” in 2021.
i. Completed one week One Week Online Short Term Course on LaTeX conducted by Department of Information Technology, Mizoram University in association with Spoken Tutorial Project, IIT Bombay, MHRD, Govt of India in 2020.
ii. Completed on week training on "Statistical and Computing Methods for life-Science Data Analysis” organized by Indian Statistical Institute, Kolkata in 2018.
iii. Undergone BSI (Botanical survey of India) sponsored one week training on “Basics of plant identification and Nomenclature” in 2017.

**13. Paper published**

i. **Ao, A.,** Changkija, S. & Tripathi, S.K. (2021). Stand structure, community composition and tree species diversity of sub-tropical forest of Nagaland, Northeast India. *Tropical ecology*. https://doi.org/10.1007/s42965-021-00170-5 [Springer].
ii. **Ao, A.,** Changkija, S. & Tripathi, S.K. (2020). Species diversity, population structure, and regeneration status of trees in Fakim Wildlife Sanctuary, Nagaland, Northeast India. *Biodiversitas*, 21(6): 2777 – 2785.
iii. **Ao, A.,** Changkija S. & Tripathi S.K. (2019). “Ethnobotanical studies on Khiamniungan tribe in Tuensang district of Nagaland, Northeast India: Ethnomedicinal plants”. East Himalayan Society for Spermatophyte Taxonomy. *Pleione* 13(1): 70 – 81.
iv. Pangging. G., **Ao. A.** & Das. A.K. (2015). “Plant Diversity and CommunityCharacteristics in Different Disturbances Regime in Singphan

Wildlife Sanctuary, Nagaland, India" *International Journal of Current Research.* Vol. 9:11, 22955 – 22958.

v. Pangging. G., **Ao. A.** & Das. A.K. (2017). "Population Structure and Regeneration status of *Dipterocarpus macrocarpus, Sapium baccatum* and *Stereospermum personatum* along three Disturbance Regime in Singphan Wildlife Sanctuary, Nagaland, India" *Environment & Ecology*. 25:2C, 1287 – 1290.

**14. Book Chapters/Proceedings**

i. **Ao. A.,** Tripathi, S.K. and Changkija, S. (2021). Diversity, Regeneration pattern and standing biomass of trees in tropical wet evergreen forest of Singphan Wildlife Sanctuary, Nagaland, Northeast India. ISBN:978-93-92403-01-9. Chawla Reprographics, New Delhi. pp 39

ii. **Ao. A.,** Tripathi, S.K. and Changkija, S. (2019). Tree diversity, Stand Structure and Community Composition of Sub Tropical Evergreen Forest in Mokokchung District of Nagaland. ISBN: 978-93-85822-92-6. Krishni Sanskriti Publications. pp 33.

iii. **Ao. A.,** Changkija, S. and Tripathi, S.K. (2019). Traditional knowledge of medicinal plants of Khiamniungan tribe of Nagaland, North-East India. ISBN: 9788170196525. Today & Tomorrow's Printers and Publishers, New Delhi-110002, India. pp 223 – 244.

**15. Papers presented**

i. Presented paper titled "Diversity, Regeneration pattern and standing biomass of trees in tropical wet evergreen forest of Singphan Wildlife Sanctuary, Nagaland, Northeast India" in International conference (online) on Agriculture, Biological and Life Science (ICABLS-2021) organized by Vidya Kutir Foundation, New Delhi, India on 25$^{th}$ – 26$^{th}$ September, 2021.

ii. Presented paper titled "Tree species diversity, population structure and regeneration status of sub-tropical evergreen forest of Nagaland, Northeast India" on 2$^{nd}$ Annual convention of North East (India) Academy of Science and Technology (NEAST) & International seminar on Recent Advances in Science and Technology (ISRAST) held at Mizoram University, Aizawl on 16$^{th}$ – 18$^{th}$ November, 2020.

iii. Presented paper titled "Tree diversity, Stand Structure and Community Composition of Sub Tropical Evergreen Forest in Mokokchung District of Nagaland" in International conference on "Recent Trend and Practices in Science, Technology, Management and Humanities for Sustainable Rural Development" (STHM-2019) held at University of Science and Technology, Meghalaya on 6$^{th}$ – 7$^{th}$ September, 2019.

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| | | |
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| DEPARTMENT | : | Forestry |
| TITLE OF THESIS | : | Plant species diversity and community characteristics of forest ecosystems of Nagaland, Northeast India. |
| DATE OF ADMISSION | : | 09$^{th}$ August, 2017 |

APPROVAL OF RESEARCH PROPOSAL:

| | | |
|---|---|---|
| 1. BOS | : | 20$^{th}$ April, 2018 |
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**ABSTRACT**

# PLANT SPECIES DIVERSITY AND COMMUNITY CHARACTERISTICS OF FOREST ECOSYSTEMS OF NAGALAND, NORTHEAST INDIA

**A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY**

**AOSANEN AO**

MZU REGISTRATION NO. : 1700105

Ph.D REGISTRATION NO.: MZU/Ph.D/1142 of 27.04.2018

**DEPARTMENT OF FORESTRY**

**SCHOOL OF EARTH SCIENCES & NATURAL RESOURCE MANAGEMENT**

**DECEMBER, 2021**

# PLANT SPECIES DIVERSITY AND COMMUNITY CHARACTERISTICS OF FOREST ECOSYSTEMS OF NAGALAND, NORTHEAST INDIA

**BY**

**AOSANEN AO**

**Department of forestry**

Under the Supervision of

**Prof. S.K. TRIPATHI**

**&**

**Prof. SAPU CHANGKIJA**, Jt Supervisor

SASRD, Nagaland University

Submitted

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

**Vegetation Sampling**

The present work was undertaken to study the plant species composition, diversity and community characteristics, population structure, regeneration status, and biomass and carbon stocks of different forest communities of Nagaland, Northeast India. The survey was carried out from March 2016 to August 2018 in different community forest of eleven districts of Nagaland. In each forest site, a plot of 250 m × 250 m size was established and at each corner of the plot, 31.62 m × 31.62 m (0.1 ha) subplot with a total of four subplots were demarcated for tree vegetation and biomass inventory. Individuals with a girth ≥10 cm GBH were considered as woody species and were measured at 1.37 m above the ground. For shrub vegetation, two 5 m × 5 m subplots were nested on the opposite corners and for herbs (including epiphytes, lithophytes and climbers), four 1 m x 1 m subplots in were laid in the corner of each tree subplot. For sapling, plants with 3 to <10 cm girth with >10 cm height were considered, whereas for seedling, plants with <3 cm girth and height upto 10 cm with 3 to 8 leaves were considered. The enumeration of sapling and seedling was done in same plot of 5 m x 5 m as laid for shrubs. The major findings of the present investigation may be summarized as follows:

**Floristic structure and species diversity**

A total of 1357 species belonging to 609 genera and 161 families were recorded from different forest communities of Nagaland, Northeast India. Of which 413 species, 198 genera and 74 families of trees; 344 species, 168 genera and 65 families of shrubs; and 601 species, 298 genera and 91 families of herbs were recorded. The most dominant species were: *Alstonia scholaris, Albizia procera, Alnus nepalensis, Betula alnoides, Bischofia javanica, Callicarpa arborea, Canarium strictum, Castanopsis indica, Choerospondias axillaris, Duabanga grandiflora, Erythrina arborescens, Gmelina arborea, Lagerstroemia speciosa, Lithocarpus elegans, Pinus kesiya, Phoebe lanceolata, Prunus cerasoides, Pterospermum acerifolium, Quercus serrata, Stereospermum chelonoides, Terminalia myriocarpa etc.* The most dominant families of trees were: Elaeocarpaceae, Euphorbiaceae, Fagaceae, Lauraceae, Leguminosae, Magnoliaceae, Meliaceae, Moraceae, Rosaceae, Rutaceae, Sterculiaceae and Theaceae. Among the shrubs, the most dominant species were: *Artemesia nilagirica, Boehmeria hamiltonia, Boehmeria japonca, Casearia vareca, Clerodendrum glandulosum, Clerodendrum infortunatum, Clerodendrum japonicum, Croton caudatus, Dendrocnide sinuata, Eupatorium odoratum, Leea alata, Leea compactiflora, Maesa indica, Mussaenda roxburghii, Mahonia nepalensis, Melastoma malabathricum, Mussaenda macrophylla, Osbeckia crinita, Phrynium capitatum, Polygonum molle, Rubus calycinus, Urena labota etc.* The most dominant families of shrubs were: Asteraceae, Ericaceae, Euphorbiaceae, Leeaceae, Leguminosae, Malvaceae, Melastomataceae, Myrsinaceae, Rosaceae, Rubiaceae, Symplocaceae, Urticaceae, Verbenaceae, and Zingiberaceae. Among the herbs, the most dominant species were: *Ageratina riperia, Ajuga integrifolia, Artemisia indica, Bidens pilosa, Cheilocostus speciosus, Chrysanthemum indicum, Commelina benghalensis, Cyanotis axillaris, Dioscorea glabra, Dioscorea tomentosa, Elatostema hookerianum, Fagopyrum esculentum, Galinsoga parviflora, Girardinia diversifolia, Geranium nepalense, Leucas ciliata, Mikania micrantha, Tinospora sinensis etc.* The most dominant herb families were: Acanthaceae, Araliaceae, Asteraceae, Combretaceae, Commelinaceae, Cyperaceae, Lamiaceae, Leguminosae, Malvaceae, Mimosaceae, Orchidaceae, Poaceae, Rubiaceae, Urticaceae and Zingiberaceae.

**The stand density and basal area**

The overall mean density (individuals ha$^{-1}$) of trees, shrubs and herbs recorded from the present study was 358, 6521 and 66528, respectively, where the highest tree density was recorded in the community forest of Longleng (403), Wokha (401), Tuensang (392) and Mon (380) district. The highest density of shrubs was recorded in community forest of Longleng (8860), Dimapur (7820) and Phek (7500) whereas; the highest herb density was noted in community forest of Longleng (107300), Phek (80313) and Zunhebhoto (73438). In all the study, the density of younger trees (10 – 60 cm girth class) contributed more than 50% of the total tree density in all the community and lower density was observed in older trees (>120 cm girth class) which may be ascribed due to various anthropogenic factors (e.g. tree lopping for fodder, fuelwood collection, timber extraction for house construction and agricultural tools grazing and shifting cultivation) by the local people living near the forest area. Higher density in lower girth classes indicates a good regeneration potential of the forest showing that future plant communities can be sustained unless there is any occurrence of major biotic or abiotic changes. The mean basal area ($m^2ha^{-1}$) of trees was 32.55 where various community forest of Wokha (38.05), Longleng (37.91), Kiphire (36.56) and Peren (35.51) district recorded the highest basal area which may be attributed to the presence of large trees in higher girth classes. The overall population structure of all communities showed a reverse *J*-shaped population curve indicating a good forest health and high species richness.

**Species distribution pattern**

The Whitford index (A/F ratio) revealed that most of the plant species in the present study showed contagious/clumped distribution pattern. The study showed that about 22 – 64% of tree species exhibited contagious/clumped distribution while 23 – 55% exhibited random and only 10 – 38% of species exhibited regular distribution across different community forest of Nagaland. Community forest of Dimapur, Kohima, Longleng, Mokokchung, Peren Tuensang and Wokha exhibited maximum clumped/contagious distribution indicating clustering of individuals in a community while Kiphire, Mon and Zunhebhoto district exhibited maximum random distribution indicating individuals distributed at unpredictable distances from each other and Phek district exhibited maximum regular distribution indicating severe competition among individuals in the community.

**Similarity of tree species in different community forests**

The similarity index was carried out to understand the interconnection of each forest types and to determine how closely the current plant communities resemble to each other. The highest similarity of 79% was observed between Mon and Kiphire followed by Mokokchung and Tuensang (56%); Mokokchung and Mon (55%) and Mokokchung and Kiphire (54%) in terms of presence and absence of species. Whereas, lowest similarity was observed between Kiphire and Dimapur (11%) followed by Tuensang and Dimapur (22%), and Kiphire and Wokha (24%). The present study indicated that the species similarity under different community forests of Nagaland was influenced by various factors such as altitude, climate, forest types and forest successional stage.

**Regeneration potential of different forest communities of Nagaland**

The study of regeneration status was determined based on densities of seedling, sapling and trees. The mean seedling, sapling and tree density (individuals $ha^{-1}$) in different community forests of Nagaland was recorded as 2848, 2555 and 358 respectively. The highest seedling and sapling density was recorded in community forest of Kohima (4188), Peren (3860) and Zunhebhoto (3690). Similarly, the highest saplings density was recorded in Zunhebhoto (3560), Peren (3240) and Longleng (3125). These sites showed good regeneration of species as compared to other community forests reflecting the potential of plant communities' sustenance in future. The study also showed that the poor regeneration of species in the present investigation may be attributed to continuous practice of shifting cultivation, fuelwood collection, timber harvesting, uncontrolled grazing and poor biotic potential of tree species which either affect the fruiting or seed germination or successful conversion of seedling to sapling stage. The overall population structure of tree species in all the forest communities of Nagaland reveals that contribution of seedlings to the total population was highest followed by saplings and adult trees. The study also shows that regeneration of tree species in all the community forest is "good' and the future communities may be sustained unless there is any major environmental stress or interference exerted by anthropogenic activities.

**Biomass and carbon stocks in different forest communities of Nagaland**

In the present study, the total mean stand biomass of different district forest ranged from 634.10 to 1031.41 Mg $ha^{-1}$ with an average value of 840.55 Mg $ha^{-1}$. The estimated total average carbon stock ranged from 285.35 to 464.13 Mg C $ha^{-1}$ with an average value of 378.25 Mg C $ha^{-1}$. The highest total mean stand biomass was recorded from community forests of Tuensang (1031.41 Mg $ha^{-1}$) followed by Peren (946.72 Mg $ha^{-1}$), Kiphire (930.97 Mg $ha^{-1}$) and Mokokchung district (912.45 Mg $ha^{-1}$). Whereas the lowest stand biomass was recorded from Kohima and Phek district (634.10 and 687.53 Mg $ha^{-1}$, respectively). The present study showed that the total plant biomass was largely influenced by tree density, basal area and species composition resulting to variations in the total living biomass of forest. Maximum biomass was contributed by older trees at higher DBH class indicating a strong relationship between basal area and biomass in the forest.

Thus, on the basis of species composition, stand structure and regeneration potential it is clear that that the community forests of Nagaland are very rich in terms of trees, shrubs and herbs species composition (1357 species) constituting a good forest wealth in the state. Apart from various anthropogenic activities affecting the species composition and diversity, the study also indicates that various abiotic factors (e.g. altitudes, climate, light intensity, edaphic etc.) also influences the tree species composition, diversity, species richness and distribution patterns in the community forest of Nagaland. The overall regeneration of tree species in the different forest communities is good which is evident by the higher seedling density to the total population as compared to sapling and adult trees indicating that the future plant communities can be conserved and sustained unless there is no major environmental stress or disturbance by human activities in the forest ecosystems. The result of this study will also serve as baseline information for the forest department, conservationist and ecologist to develop policy for sustainable management of different forest communities of Nagaland, northeast India. Estimation of stand biomass and carbon stock in the present study showed that community forest of Kiphire, Mokokchung, Peren and Tuensang districts share the maximum storage of carbon in tree biomass contributing 45% of the total forest carbon stock suggesting that these forests can serve as a great potential pool of carbon storage. Maximum biomass contribution by trees in higher DBH classes also revealed the importance of mature trees as major carbon sinks in these community forests. The overall study showed a positive relationship between species density, basal area and stand biomass which indicate that total carbon storage in the forest depends on the community characteristics of the forest. Overall tree biomass and carbon stock suggest that the community forest of different districts in Nagaland could play a significant role in storage of carbon in its plant biomass that can help in maintaining regional carbon cycle and mitigate future climate change in the region.