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Tree Species Diversity and Carbon Stock of Tropical and Sub-Tropical Forests of Mizoram, Northeast India

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ABSTRACT

The present study was conducted in tropical and sub-tropical forests of Mizoram, Northeast India. A total of 49 species belonging to 40 genera and 26 families were recorded in the tropical forest (TF). Whereas, in the subtropical forest (STF), 47 species belonging to 42 genera and 28 families were recorded. As per Importance Value Index (IVI), the most dominant species in TF were : *Castanopsis tribuloides* (47.67), *Schima wallichii* (40.71), *Aporosa octandra* (20.96) and *Wendlandia budleioides* (17.79). Whereas, the species such as *Ilex godajam* (41.42), *Saprosma ternatum* (32.74) and *Diospyros racemosa* (31.34) were the most dominant species in STF. The total tree density and basal area were 1610 individuals ha^{-1} and 25.016 m^2 ha^{-1} in TF and 1380 individuals ha^{-1} and 24.20 m^2 ha^{-1} respectively in STF. The diversity indices such as Shannon's diversity index (H′), Simpson's dominance index (CD), Margalef richness index (d), and Pielou's evenness index (J) ranged from 2.93-3.16, 0.91-0.94, 7.82-8.15, 0.76-0.81 in both the forests. The total tree biomass was 178 Mg ha^{-1} in TF and 144 Mg ha^{-1} in STF. Similarly, the total carbon stock in TF was 85 Mg C ha^{-1} and 68 Mg C ha^{-1} in STF. Such information on these forests can serve as a valuable tool for improving our capacity to enhance biodiversity conservation efforts and management of tropical forests for their sustainable use in the future.

Keywords Tropical forest, Subtropical forest, Important value index (IVI), Diversity indices, Tree biomass, Carbon stock, Sustainable forest management.

INTRODUCTION

Forests are essential to mitigate climate change effects by reducing the amount of carbon dioxide (CO_2) in the atmosphere and sequestering them into tree biomass for a longer time (Ao *et al*. 2023a). About half of the world's biodiversity is found in forests significantly contributes to the total global terrestrial carbon stocks and supports human populations by offering a variety of products and services (Ozukum *et al.* 2019). The relationship between forest diversity and carbon stock has gained significant importance in the context

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of the carbon cycle and climate change adaptation. However, human-induced forest fragmentation and deforestation are significantly affecting the health of the forests, particularly in tropical and subtropical forests (Ao *et al.* 2024). The carbon emissions from deforestation provide 20% of the carbon emissions worldwide (IPCC 2006). For instance, the concentration of CO_2 in the atmosphere has increased to over 50% from the pre-industrial area (i.e. 280 ppm to 420 ppm) currently (Alli *et al.* 2023). The rise in atmospheric CO_2 concentration will raise the surface temperature of the earth along with several other detrimental effects (such as rising sea levels, flooding, and erratic rainfall patterns) that will adversely affect human and ecosystem health (IPCC 2007, IPCC 2014, Kumar *et al.* 2021). To address these challenges, it is crucial to reduce carbon emissions and raise the biosphere's carbon sink through its sequestration in the soil and plant biomass to mitigate the rapid rise of CO_2 in the atmosphere (Mahajan *et al.* 2023).

In general, the diversity measurement is important for understanding the health and productivity of the ecosystems (Daly *et al.* 2018). High species diversity in forest ecosystems is maintained by high species richness and high evenness, which can improve ecosystem resilience and stability, and in turn, promote ecosystem health, primary production, and ultimately, the capacity of the forest ecosystems to sequester carbon in both aboveground and belowground biomass (Di Sacco *et al.* 2021). Prior studies have indicated that species diversity is influenced by species richness and evenness, with richness generally increasing from the poles towards the equator (Roy *et al.* 2004). Species diversity is also severely impacted by the conversion of forests to multiple land use types due to increasing population and developmental activities (Watson *et al.* 2014). Worldwide about 0.8 to 2% of forests are lost annually (Sagar *et al.* 2003) and a large number of flora and fauna are facing a high degree of threat posing significant environmental and economic challenges. Thus, it is essential to integrate data regarding the spatial distribution of carbon stocks and the variety of plant species found in forests across wide areas to conserve biodiversity and mitigate climate change (Ao *et al.* 2024).

The north-eastern region of India, consisting of eight states, is home to 75% of the country's diversity of flora and fauna which covers an area of 262,179 km^2 (Upadhaya *et al.* 2012). Further, the region harbors significantly large number of endemic species along with high degree of threat to the region's biodiversity, and thus the region is one of the world's biodiversity hotspots (Ao *et al.* 2023a). Mizoram is regarded as one of the north-eastern states of India, which is situated within the Indo-Burma biodiversity hotspot. As per the State of Forest Report of India, Mizoram Forest covers 18,748 km^2 area and encompasses a total of 2358 plant species out of which 2141 belong to angiosperms distributed over 176 families and 905 genera where two-thirds constitute dicots and one-third monocots (Singh 1997, Ao *et al.* 2023b). In hilly state of Mizoram, a large number human population relies on forest resources for their social livelihood through activities like shifting agriculture, harvesting of timber, and collection of fuel wood (Tripathi *et al.* 2017) all contribute to the degradation of the ecosystems and the thinning of the forests in the region (Tripathi *et al.* 2016). Therefore, conservation of biodiversity and promotion of forest's carbon density are important areas needing attention. The present study aims to assess tree species diversity and carbon stock in the tropical and sub-tropical forests of Mizoram.

MATERIALS AND METHODS

Study area

The present study was conducted in two forest types i.e. tropical forest (TF) located in Mizoram University campus and the subtropical forest (STF) in Hmuifang, Aizawl district of Mizoram (Fig.1). Mizoram University lies between 21°56'N and 24°31'N latitude and 92°16'E and 93°26'E longitude with an average elevation of 706 meters amsl with a gradual rise toward the east whereas Hmuifang lies between 23°27′N and 23°27′ N latitudes and 92°45′E and 92°45′E longitudes with an average elevation of 1619 meters amsl. The state received an average annual rainfall of 2000-3200 mm. The vegetation is semi-evergreen, and the region has cool, low-to-moderate temperatures throughout the year. The temperature ranges from 20°C to 29°C in the summer and 7°C to 21°C in the winter.

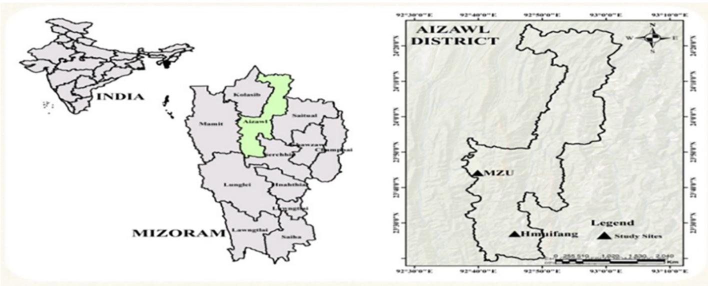

Fig.1. Site map (MZU- Mizoram University and Hmuifang).

Data collection and analysis

We opted to use a quadrat method to conduct a floristic study of trees in the area, during which we demarcated 18 plots of size 12 m × 12 m across the forest (0.2 ha each). All trees within each plot were recorded and analyzed for species composition and carbon stocks of the forests. The data recorded from the study was employed to compute several quantitative indices, including frequency, density, and basal area. The important value index (IVI) was subsequently determined by summing the relative frequency, relative density, and relative dominance (Curtis and McIntosh 1950). Diversity indices were computed by using both Shannon's diversity index (H') and Simpson's dominance index (CD) (Magurran 2004) as shown below:

Shannon's diversity index (H') = $-\sum$ pi ln pi

Where, pi = Proportion (n/ N) of individuals of one species found (n) divided by the total number of individuals found (N).

Simpson's dominance index (CD)

$$CD = 1 - \frac{\sum n\,(n-1)}{N\,(N-1)}$$

Where, CD = Simpson's index, n is the total number of individual species and N is the total number of all species.

Margalef richness index (d) was employed to estimate species richness (Ulanowicz 2001).

$$d = \frac{S - 1}{\text{In}\,(N)}$$

Where, d = Margalef index of species richness, S = Number of species, N = Total number of individuals.

Pielou's index (J) was used to determine the species evenness (Bray and Curtis 1957).

$$\text{Pielou's index (J)} = \frac{H'}{\text{In}\,(S)}$$

Where, J = Pielou's measure of species evenness, H' = Shannon diversity index, S = Total number of species.

Estimation of tree biomass and carbon stock

The aboveground biomass of trees was calculated using the allometric equation developed by Nath *et al.* (2019) for the trees of Northeast India.

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

Where D is the DBH, H denotes the height of the tree, and δ is specific wood gravity. Tree-specific gravities were derived from the Global Wood Density Database by Zanne *et al.* (2009).

Belowground biomass was calculated using the Cairns *et al.* (1997) equation.

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

The total carbon stock of trees was computed as the sum of AGB and BGB multiplied by their carbon content assuming 47% in tree biomass (Martin and Thomas 2011).

RESULTS AND DISCUSSION

The findings of this study elaborated diversity and carbon stock of two distinct forest types characterized by different ecological zones. A total of 49 species belonging to 26 families were recorded in TF and 47 species belonging to 28 families were recorded in STF (Table 1). Majority of the species found in TF belonged mainly to Fabaceae (6 species), Fagaceae (5 species), and Lauraceae (4 species) families, whereas in STF most of the species mainly belonged to families, e.g. Lauraceae (7 species) and Euphorbiaceae (6 species). The number of tree species recorded in the current study can be compared to the tree species of the subtropical forest of Lalsavunga Park, Mizoram (Ao *et al.* 2023b, 41 species), Manipur (Meetei *et al.* 2017, 43 species), Rowa Wildlife Sanctuary, Tripura (Debnath *et al.* 2021, 44 species) and Tierra del Fuego Island, South America (Mestre *et al.* 2017, 46 species). In contrast, the number of species in these forests were lower as compared to trees species in Fakim Wildlife Sanctuary (Ao *et al.* 2020, 60 species), Reiek community reserve forest in the Mamit district of Mizoram (Devi *et al.* 2018, 125 species) and plant species diversity in West Himalaya, Uttarakhand, India (Rawal *et al.* 2018, 106 species). In both sites, few tree species were consistently and frequently reported in the sample plots indicating high prevalence of these species. However, other species were less commonly observed showing rarity of the species within the sample plots. The most frequently found species in TF were *Castanopsis tribuloides*, *Schima wallichii, Aporosa octandra* and *Wendlandia budleioides*, whereas in STF, *Ilex godajam*, *Saprosma ternatum*, *Diospyros racemosa* and *Dipterocarpus retusus* were the most common species. Based on the IVI ranking of the species, in TF the species such as *Castanopsis tribuloides* (47.67) had highest IVI followed by *Schima wallichii* (40.71), *Aporosa octandra* (20.96), and *Wendlandia budleioides* (17.79) (Table 2, Fig. 2). However, in STF, the most dominant species was Ilex *godajam* showing the highest IVI (41.42) followed by *Saprosma ternatum* (32.74) and *Diospyros racemosa* (31.34) (Table 3, Fig. 3).

Table 1. Tree community's phytosociological characteristics in TF and STF.

Parameters	TF	STF
No. of species	49	47
No. of genera	40	42
No. of families	26	28
Stand density (individuals ha^{-1})	1610	1380
Total basal area (m^2 ha^{-1})	25.01	24.20
Shannon diversity index (H')	3.16	2.93
Simpson's dominance index (CD)	0.94	0.91
Margalef richness index (d)	8.15	7.81
Pielou evenness (J)	0.81	0.76

The total tree density and basal area were 1610 individuals ha^{-1} and 25.01 m^2 ha^{-1} and 1380 individuals ha^{-1} and 24.20 m^2 ha^{-1} in TF and STF, respectively. The tree density values of the present study were similar to that of tree density (245-1620 individuals ha^{-1}) reported from the tropical and sub-tropical forests of Northeast, India (Devi *et al.* 2018, Joshi 2020, Suchiang *et al.* 2020, Ao *et al.* 2021). The species composition and the size class analysis of trees suggested that the site characteristics particularly edaphic conditions including other biotic factors were linked to the changes in tree density in these forest (Saikia *et al.* 2017). It has been observed that changes in altitude, age structure, species composition, level of disturbance, and forest successional stage all are linked to variations in basal area among different forest communities (Gogoi *et al.* 2020, Ao *et al.* 2024).

Plant species diversity indices provide a measure of forest functioning of different population sizes among the species in varied environmental conditions (Ao *et al.* 2021). The higher value of diversity index in the present forests indicates greater species richness and stability of these ecosystems (Devi *et al.* 2014, Devi *et al.* 2018). The diversity index value depends on the number of species and their evenness, and thus increasing species richness and evenness indicates higher diversity. The present study indicates that the Shannon's diversity index (H') was 3.16 and 2.93, respectively for TF and STF (Table 1). The diversity values in the present forests were towards the higher side of the range (i.e. 0.80 to 4.15) reported for other Indian forests from similar climate settings (Suchiang *et al.* 2020, Shaheen *et al.* 2015, Ao *et al.* 2021). More

Table 2. Tree species and their importance value index (IVI) in Tropical Forest.

Name of the species	Local name	Family	Total	Density	Basal area	Frequency	IVI
Acronychia pedun-culata (L.) Miq.	Par-ar-si/ Rah-var	Rutaceae	9	2.14	0.66	2.46	5.27
Aganope thyrsiflora (Benth.)	Hulhu	Fabaceae	1	0.24	0.01	0.49	0.74
Aglaia chittagonga Miq.	The-hlei-khak	Meliaceae	1	0.24	0.02	0.49	0.75
Albizia lucidior (Steud.)	Ardah	Fabaceae	4	0.95	0.49	1.97	3.42
Albizia odoratissima (L.f.) Benth.	Thing-ri	Fabaceae	7	1.67	2.31	2.96	6.93
Albizia procera (Roxb.) Benth.	Kang-tek	Fabaceae	1	0.24	0.19	0.49	0.92
Alstonia scholaris (L.) R. Br	Thuam-riat	Apocynaceae	1	0.24	0.14	0.49	0.87
Aporosa octandra (Buch.-Ham. Ex D.Don)	Chhawn-tual	Phyllanthaceae	42	10.00	3.58	7.39	20.96
Baccaurea ramiflora Lour.	Pang-kai	Phyllanthaceae	3	0.71	0.66	1.48	2.85
Callicarpa arborea Roxb.	Hnah-kiah	Verbenaceae	1	0.24	0.04	0.49	0.77
Carya tonkinenis Lecomte	Hnum-reuh	Juglandaceae	1	0.24	0.57	0.49	1.30
Castanopsis indica (Sm.) A.DC.	Se-hwar	Fagaceae	7	1.67	3.35	3.45	8.46
Castanopsis lancei-folia (Sm.) A.DC	Vawm-buh	Fagaceae	14	3.33	4.71	4.43	12.48
Castanopsis tribuloides (Sm.) Lindl.	Thing-sia	Fagaceae	60	14.29	26.00	7.39	47.67
Chasalia curviflora (Wall.)	Seh-sen	Rubiaceae	1	0.24	0.52	0.49	1.25
Dalbergia obtusifolia L.f.	Biang-hrei	Fabaceae	1	0.24	0.12	0.49	0.85
Derris robusta (Roxb. ex DC.)	Thing-kha	Fabaceae	3	0.71	0.33	1.48	2.52
Elaeocarpus lanceifolius Roxb.	Kha-ruan	Lauraceae	12	2.86	2.34	2.96	8.15
Elaeocarpus prunifoilius (Mull.Berol.) Wall. ex Mast.	Thei-kel-ek	Elaeocarpaceae	3	0.71	0.19	1.48	2.38
Elaeocarpus tecto Rius (Lour.) Poir.	Kum-khal	Elaeocarpaceae	2	0.48	0.27	0.49	1.24
Engelhardtia spicata Lesch. ex Blume	Hnum	Juglandaceae	5	1.19	1.44	1.97	4.61
Eurya acumnita DC.	Si-hneh	Pentaphylacaceae	7	1.67	0.52	2.46	4.65
Ficus prostrata (Wall. Ex Miq.) Buch	Thei-tit	Moraceae	2	0.48	0.38	0.49	1.35
Glochidon sphaerogynum (Mull.Arg) Kurz	Dawdung	Phyllanthaceae	4	0.95	0.29	1.48	2.72
Gmelina arborea Roxb.	Thlang-vawng	Lamiaceae	16	3.81	7.86	2.46	14.13
Ilex godajam Colebr. Ex Hook.f.	Thing-ui-ha-hni	Elaeocarpaceae	7	1.67	0.99	3.45	6.11
Leea indica (Burm.f.) Merr	Kawl-kar	Leeaceae	3	0.71	0.10	0.49	1.30
Lithocarpus elegans (Blume) Hatus. Ex Soepadmo.	Thing-pui-thing	Fagaceae	4	0.95	0.62	1.97	3.54
Litsea lancifolia (Roxb. Ex Nees) Fern.-Vill.	Hnah-paw-te	Lauraceae	4	0.95	0.41	0.99	2.34
Litsea monopetala (Roxb.) Pers.	Nau-thak	Euphorbiaceae	7	1.67	0.76	2.96	5.38
Macaranga indica Wight	Hnah-khar	Aquifoliaceae	10	2.38	1.75	2.96	7.08
Macaranga peltata Roxb. Mueller	Khar-duap	Euphorbiaceae	3	0.71	1.78	0.49	2.99
Macropanax dispermus (Blume) Kuntze	Phuan-berh	Araliaceae	3	0.71	0.21	0.49	1.41
Mallotus nudiflorus (L.)	Thing-a-lu	Euphorbiaceae	2	0.48	0.10	0.49	1.07
Morus macroura Miq.	Lungli	Primulaceae	1	0.24	0.10	0.49	0.83
Nostolachma khasiana (Korth.)	Ngul-ri-thet	Rubiaceae	1	0.24	0.03	0.49	0.76
Persea minutiflora Kosterm.	Ngha-leng-lu-tar	Lauraceae	1	0.24	0.11	0.49	0.84
Phoebe attenuate Roxb.	Bul	Lauraceae	26	6.19	2.62	5.42	14.23
Polyalthia simiarum (Buch.-Ham. Ex Hook.f. & Thomson)	Zathu	Annonaceae	1	0.24	0.08	0.49	0.81
Premna milleflora C.B. Clarke	Vawng-thla	Lamiaceae	2	0.48	0.55	0.49	1.52
Quercus oblongata D.Don.	Then	Fagaceae	8	1.90	1.92	1.97	5.80
Saurauia punduna Wall.	Tiar	Actinidiaceae	4	0.95	0.36	0.99	2.29
Schima wallichiii (DC.) Korth.	Khiang	Theaceae	54	12.86	20.96	6.90	40.71
Streblus indicus (Bur.)	Khaw-reng	Moraceae	3	0.71	0.08	0.49	1.29
Styrax serrulatus Roxb.	Hmar-hleng	Styracaceae	10	2.38	0.87	3.45	6.70
Sycopsis griffithiana Oliv.	Pi-chil-i-mim	Hamamelidaceae	2	0.48	0.05	0.99	1.51
Syzygium grande (Wight) Walp.	Thei-chhawl	Myrtaceae	3	0.71	0.22	1.48	2.41
Syzyguim cumini (L.)	Len-hmui	Myrtaceae	23	5.48	4.12	4.43	14.03
Wendlandia budleioides Wall. Ex Wight & Arn.	Ba-tling	Anacardiaceae	30	7.14	4.25	6.40	17.79

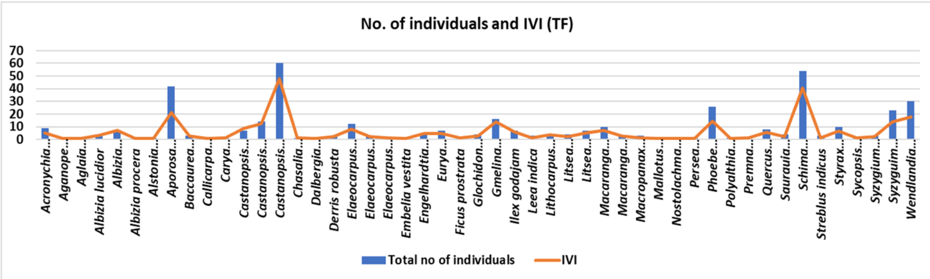

Fig. 2. Species and their important value index in TF.

specifically, the tree species diversity in the present forests was higher compared to diversity value (0.77–2.53) of dry deciduous forests of central India (Dar *et al.* 2019) and almost comparable (3.31) to Batuputih Nature Tourism Park in Indonesia (Arrijani and Rizki 2020). The value of Simpson's dominance index (CD) was 0.94 and 0.91 for TF and STF, respectively (Table 1), which was higher side of the range of CD values

Table 3. Tree species and their importance value index (IVI) in Sub-tropical forest.

Name of the species	Local name	Family	Total	Density	Basal area	Frequency	IVI
Acer laevigatum Wall.	Thing khim	Sapindaceae	1	0.28	0.23	0.65	1.16
Alseodaphne petioleris (Meisn.) Hook. Fil	Khuangthuld	Juglandaceae	1	0.28	0.48	0.65	1.41
Bruinsmia polysperma C.B. Clarke	Thei-pa-ling-kwah	Styraceae	1	0.28	0.65	0.65	1.58
Calophyllum polyanthum Wall. Ex Choisy	Sen-te-zel	Clusiaceae	2	0.56	0.31	1.31	2.17
Castanopsis tribuloides (Sm.) A.DC.	Thing sia	Fagaceae	2	0.56	0.30	1.31	2.16
Celtis timorensis Span	Thing-hmar-cha	Ulmaceae	3	0.83	0.22	1.96	3.01
Cinnamomum glandiliferum (Wall.) Nees	Bulrimna	Lauraceae	1	0.28	0.29	0.65	1.22
Cinnamomum tamala (Buch.Ham)	Hnah-rim-tui	Lauraceae	3	0.83	1.56	0.65	3.04
Cinnamomum verum J. Presl	Thakthing	Lauraceae	5	1.39	0.20	1.96	3.55
Cordia dichotama G. Forst.	Muk-fang	Boraginaceae	1	0.28	0.04	0.65	0.97
Croton joufra Roxb.	Val-thi	Euphorbiaceae	1	0.28	1.02	0.65	1.96
Diospyros racemose L.	Zo-thing-hang	Ebenaceae	43	11.94	12.86	6.54	31.34
Dipterocarpus retusus Blume	Thingsen	Dipterocarpaceae	50	13.89	2.36	11.11	27.36
Drypetes indica (Hook.f.) Pax & K.Hoffm.	Khawi-tur	Putanjivaceae	1	0.28	0.34	0.65	1.27
Elaeocarpus rugosus Roxb.	Theikelek	Elaeocarpaceae	1	0.28	0.43	0.65	1.37
Elaeocarpus tectorius (Lour.)	Kumkhal	Elaeocarpaceae	5	1.39	3.68	2.61	7.68
Engelhardia spicata Lesch. ex Blume	Hnum	Juglandaceae	4	1.11	6.11	1.31	8.53
Euphorbia cotinifolia L.	Hnah-sen	Euphorbiaceae	5	1.39	0.24	1.96	3.59
Eurya cerasifolia (D. Don)	Si-hneh	Pentaphyllaceae	3	0.83	0.52	1.96	3.31
Ficus curtipes L.	Hnahlun	Moraceae	3	0.83	1.66	0.65	3.15
Garcinia cowa Roxb. ex Choisy	Cheng-kek	Clusiaceae	1	0.28	0.03	0.65	0.96
Glochidon sphaerogynum (Mull.Arg.) Kurz	Thing pawn-chhia/Dawn-dung	Phyllanthaceae	5	1.39	1.95	2.61	5.95
Helicia excelsa (Roxb.) Blume	Sialma	Proteaceae	12	3.33	3.28	3.27	9.88
Ilex godajam Colebr.	Rahsen	Primulaceae	37	10.28	23.30	7.84	41.42
Ligustrum robustum (Roxb.) Blume	Chawn-zil	Oleaceae	1	0.28	0.26	0.65	1.19
Litsea lancifolia (Roxb. ex Nees)	Hnapawhte	Lauraceae	4	1.11	1.41	2.61	5.13
Litsea salicifolia Roxb. (LS)	Par-sen	Lauraceae	2	0.56	1.34	0.65	2.55
Macaranga indica Wight	Hnahkhar	Euphorbiaceae	3	0.83	4.73	1.96	7.53
Macaranga peltata Roxb. Mueller	Khar-dwap	Euphorbiaceae	1	0.28	0.10	0.65	1.03
Machilus sp Siebold & Zucc	Thing-buh-chang	Lauraceae	2	0.56	1.21	1.31	3.07

Table 3. Continued.

Name of the species	Local name	Family	Total	Density	Basal area	Frequency	IVI
Macropanax undulatus (Wall. ex G. Don)	Phuanberh	Araliaceae	3	0.83	1.94	1.96	4.74
Mangifera indica L.	Theihai	Anacardiaceae	1	0.28	0.07	0.65	1.00
Myrica esculenta Buch.-Ham. ex D. Don	Keifang	Myricaceae	6	1.67	0.17	1.31	3.15
Olea dioica Roxb.	Sevuak	Oleaceae	4	1.11	0.97	2.61	4.69
Ostodes paniculata Blume	Beltur	Euphorbiaceae	36	10.00	5.65	5.88	21.53
Phoebe attenuta (Nees)	Bul	Lauraceae	6	1.67	2.26	1.31	5.23
Pinus kesiya Royle ex Gordon	Far	Pinaceae	2	0.56	2.29	1.31	4.15
Premna racemosa Wall.	Thing-sa-um	Verbenaceae	3	0.83	1.94	0.65	3.43
Prunus nepalensis L.	Lum-ler	Myrsinaceae	2	0.56	0.40	0.65	1.61
Quercus leucotrichophora A.Camus	Then	Fagaceae	10	2.78	0.64	3.27	6.68
Rapanea capitellata Wall.	Neihlaia-thing	Myrsinaceae	1	0.28	0.07	0.65	1.00
Sapium eugeniaefolium Buch.-Ham	Tek-em	Euphorbiaceae	3	0.83	0.25	1.31	2.39
Saprosma ternatum (Wall.) Hook.f.	Lawleng	Rubiaceae	60	16.67	5.62	10.46	32.74
Schima walichii (DC.) Korth.	Khiang	Theaceae	13	3.61	3.14	3.92	10.67
Sterculia urens Roxb.	Khaukhim	Sapindaceae	1	0.28	0.21	0.65	1.14
Syzygium claviflorum (Roxb.) Wall. ex Steud.	Hmuifa-rial	Myrtaceae	3	0.83	3.16	1.31	5.30
Wendlandia budleioides Wall. ex Wight & Arn.	Ba-tling	Anacardiaceae	2	0.56	0.12	1.31	1.98

(0.13 to 0.97) reported for the other forests (Saha *et al.* 2016, Ndah *et al.* 2013, Ao *et al.* 2020), and were comparable to the value (0.93) reported for Kamjong Sub-division primary forest of Manipur (Vashum and Jayakumar 2016). Marginally less diversity in STF compared to TF could be attributed to anthropogenic disturbances such as forest fires, selective felling of trees for timber, and extraction of forest products for other utility products by the adjoining population may be attributed to reduce the diversity of species in sub-tropical forests (Grant *et al.* 2010, Singh *et al.* 2015). Further, elevational shifts in plant growth forms may be responsible for variation in species richness in two forest communities (Ao *et al.* 2024). The value of Margalef richness index (d) was 8.15 and 7.82 in TF and STF, respectively. The values of 'd' were towards to lower side of the range (4.54 – 23.41) reported for tropical forests (Mishra *et al.* 2005, Kumar *et al.* 2010, Sathish *et al.* 2013). Pielou's evenness index (J) in the present study was 0.81 and 0.76 in TF and STF, respectively. These values closely match (0.81) with the earlier reports of tropical moist deciduous forest of Mizoram, Northeast India (Wapongnungsang *et al.* 2021). The study shows consistency in species distribution within the forest ecosystems. The tree diversity information and their distribution can be documented to create a solid database for management decisions in these forest ecosystems.

The total tree biomass was 180 Mg ha^{-1} and 144 Mg ha^{-1} in TF and STF, respectively. The aboveground biomass (AGB) constitutes 80-81% of bio-

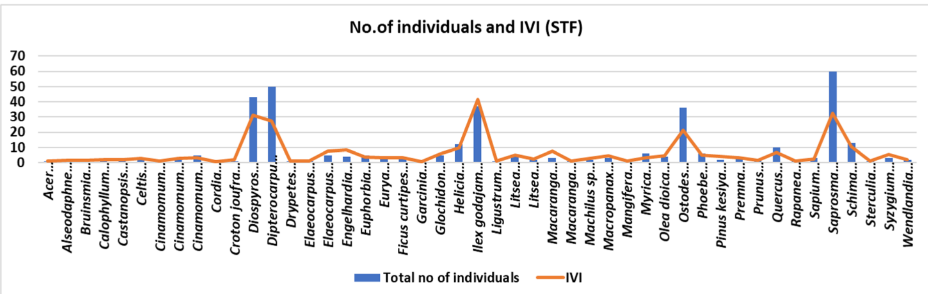

Fig. 3. Species and their important value index in STF.

mass in two forests with remaining in below-ground biomass (BGB). The biomass values are well within the range (32.75 – 280.71 Mg ha^{-1}) Indian tropical forests (Deb *et al.* 2019, Sajad *et al.* 2021). Consequently, the total aboveground carbon stock in the present study was 68.53 Mg C ha^{-1} and 54.56 Mg C ha^{-1}, in TF and STF, respectively. The aboveground carbon stocks were in the mid of the range reported for different forest sites of Manipur (60.09–121.43 Mg C ha^{-1}) Northeast India (Thokchom and Yadava 2017) and Assam (16.24–130.82 Mg C ha^{-1}) (Borah *et al.* 2013). The total carbon stocks (85 Mg C ha^{-1} and 68 Mg C ha^{-1}) in TF and STF of the present study were also comparable to Monbel Forest (83.47 Mg C ha^{-1}) and Rosekandy forest (72 Mg C ha^{-1}) of Cachar district of Assam, North-east India (Borah *et al.* 2013). The lower carbon stock in STF in the present study was mainly attributed to various anthropogenic disturbances in sub-tropical forests. This study on forest diversity and carbon stock has a strong bearing on biodiversity conservation and climate change mitigation efforts in the region.

CONCLUSION

The tree species diversity and carbon stock in tropical and subtropical forests varies significantly across different locations due to variations in biogeography, habitat, and disturbance regimes. The outcome of the present study indicates that forest management measures are required for the conservation of biodiversity and promotion of climate change mitigation measures in the region. This can be achieved by maintaining the natural balance of the forests through conservation of dominant tree species and creation of the canopy in these forests using forest management approach. Further, this study provides a valuable source of reference for assessing the forests and enhancing our knowledge of ecologically useful species which will be useful in identifying and implementing conservation initiatives to ensure long-term conservation efforts for the sustainability of the forest ecosystem.

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