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Impact of anthropogenic disturbance on diversity and distribution of tree species in a tropical semi-evergreen forest of Aizawl, Mizoram, India

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ABSTRACT

The study aimed to evaluate the diversity and distribution of tree species along a disturbance gradient in Hmuifang forest of Aizawl district, Mizoram. For detailed investigation 0.5 ha area of 3 forest stands each representing undisturbed stand (>50% canopy cover and <10% Disturbance Index), moderately disturbed stand (20-50% canopy cover and 10-50% Disturbance Index), and highly disturbed forest stand (<20% canopy cover and >50% Disturbance Index) was sampled. Altogether, a total of 115 tree species belonging to 81 genera and 47 families were recorded. Of this, undisturbed stand was represented by 89 species belonging to 66 genera and 41 families, moderately disturbed stand with 63 species belonging to 51 genera and 36 families, and highly disturbed stand with 31 species belonging to 24 genera and 20 families. According to the Importance Value Index, *Lindera pulcherrima* was the dominant tree species in the undisturbed forest stand, while in the moderately disturbed stand *Drypetes indica* was dominant, and in the highly disturbed stand, *Schima wallichii* was abundant. The Shannon Wiener diversity index (H') was computed highest (4.06) in the undisturbed stand, followed by moderately disturbed stand (3.79) and highly disturbed stand (3.05). On the contrary, the Simpson's index of dominance (D) was found to be 0.0219, 0.0284 and 0.054 in the undisturbed, moderately disturbed and highly disturbed forest stands respectively. The Pielou's evenness index (J') was computed as 0.91, 0.898 and 0.888 for the undisturbed, moderately disturbed and highly disturbed forest stands respectively. The highest similarity was recorded between undisturbed and moderately disturbed stands (0.64) followed by moderately disturbed and highly disturbed stand (0.42). The least similarity was recorded between undisturbed and highly disturbed stand (0.37). The study conducted in the three different forest stands reveals that the community composition changes with disturbance showing a strong negative correlation with disturbance.

Key words: *Disturbance gradient, Canopy cover, Tree diversity, Tree distribution, Richness*

Introduction

Forests are fundamental parts of terrestrial ecosystems which offer a variety of essential services and tasks that humanity and biodiversity demand. Tropical forest ecosystems feature out in terms of the delivery and accessibility of the majority of these vital services, as well as serving as a key platform for worldwide carbon storage and sequestration, which offers solutions for climate change remediation (Bentsi-Enchill *et al.*, 2022). Forests and woodland encompass over 3.95 billion hectares of the terrestrial masses, with tropical forests accounting for over half of the total forest and containing the world's most diversified communities of plants. The majority of tropical forests are located in resources-hungry developing countries that require massive amounts of energy for growth. This reduces the amount of forest coverage in tropical places and alters the climate (Sharma *et al*., 2018).

In recent decades, a significant portion of tropical forests has experienced increasing levels of stress due to mounting human-induced pressures, underscoring the need for management interventions to uphold global biodiversity, functionality, and long-term sustainability. The extensive depletion of tropical forests has resulted in a gap in our understanding of taxonomy and the underlying structural and dynamic functioning of many tropical forests (Parthasarathy and Sethi, 1997). Destruction of forests is commonly associated with species extinction, biodiversity loss, and a drop in the primary output. As a result, there is a rising curiosity in assessing features of habitat in Indian forests such as forest structure, floristic layout, and diversity of species (Kumar *et al*., 2001). Furthermore, disturbance has a direct impact on community composition and population fluctuations by affecting availability of resources by changing the relative competitive status of people resulting in the loss of old tree species with the impediment of development of fresh recruits (Singh *et al*., 2015).

The principal drivers of global biological diversity reduction are the deterioration of tropical forests and habitat loss caused by human activities. Anthropogenic disruptions have a significant impact on the biodiversity and structural aspects of a community (Mishra *et al*., 2004). Forest degradation and transformation to agricultural land continues at a rapid pace in many tropical nations, threatening the structure and functionality of forest ecosystems. According to Tynsong *et al*. (2022), WWF in 2017 reported that 177,000 km2 of forests and woodlands are cleared annually to make space for farming or to harvest timber trees for fuel and wood products. It is also believed that the Earth underwent a reduction of about fifty percent in its forest cover over the past 8000 years, with over three percent of forests being cleared since the 1990s alone. Furthermore, it has been claimed that the tropics' forests have lost a significant amount of yearly forest area (i.e., 21012 km). Net destruction of forests in South and Southeast Asia was estimated to be roughly 25% greater during 2010 and 2015 as compared to 1990 (Devi *et al*., 2018). As a result, it is vital to comprehend the human influence in order to prioritise tropical forest conservation.

Tree diversity influences a forest's biodiversity since trees offer all supplies and habitats for nearly all other forest species. An understanding of forest structure, composition, and diversity at various degrees of human disturbance might help to plan and implement more effective conservation strategies (Htun *et al*., 2011). Understanding the response of forest vegetation to different intensities of human disturbance would identify where conservation efforts should be given priority and therefore enable the efficient use of limited conservation funds (Bhuyan *et al*., 2003).

Situated within the Indo-Burma hotspot, Mizoram boasts the highest percentage of forest cover among all Indian states. According to the Forest Survey of India (FSI, 2021), the state's forest cover is 17,820 km^2, accounting for 84.53% of the state's total area. It is a hilly region where most indigenous people rely on woods for a living through activities like as timber exploitation, fuelwood, and common agricultural practises such as shifting cropping, all of which contribute to the deterioration of virgin forests (Wapongnungsang *et al*., 2021). According to research, changes in diversity of species, fine biomass of roots, production, and degradation are all substantially influenced during ecosystem recovery after disturbance (Singh *et al*., 2015). As a result, it is vital to understand the human influence in order to prioritise tropical forest conservation, and studying the causes of tropical forest destruction and deterioration is a requirement for improved management of these forests. Although a few studies have been conducted on the biodiversity and ecology of tropical forests of Mizoram, detailed study on the tree diversity in relation to different categories of forest disturbance is lacking. Keeping this in mind, the present study has been conducted in Hmuifang forest, Aizawl district, Mizoram, with the goal of studying the tree diversity and distribution of the forests along different degrees of human disturbance.

Materials and Methods

Study area

Hmuifang, a renowned tourist spot situated approximately 50 km south of Aizawl, the state capital, served as the location for this study, spanning between coordinates 23°2700 N to 23°2724 N latitude and 92°4503 E to 92°4533 E longitude. The woodland area maintains an average elevation of 1619 meters above sea level. According to the classification by Champion and Seth (1968), the flora of the research region falls under tropical semi-evergreen woods, while the Koppen Climate Classification designates the study area as having a humid subtropical climate. With an average annual rainfall of approximately 267.13 mm, the temperatures range from 20 °C to 29 °C in the summer and 7 °C to 21 °C in the winter.

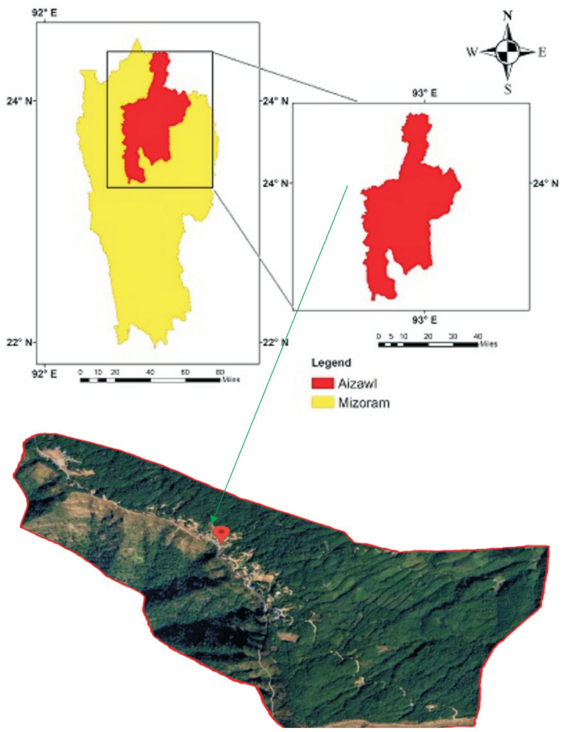

Fig. 1. Map of Hmuifang, Aizawl district, Mizoram

Selection of Study Sites

A total of three (3) study sites representing undisturbed (UD), moderately disturbed (MD) and highly disturbed (HD) forests were selected and the study was conducted by sampling 0.5 ha area of each forest stands.

Methods

For the present study, quadrat (10m x10m size) method was adopted and quadrats were laid randomly. Individuals of tree species with ≥ 30 cm girth at breast height i.e., 1.37 m above ground were taken into consideration and diameter at breast height (DBH in cm) and tree height (m) were measured and recorded. Identification of tree species were done using the books of "Flora of Mizoram Vol. 1" (Singh *et al*., 2002) and "The book of Mizoram Plants" (Sawmliana, 2013). The species were cross-referenced with the herbarium records of the Department of Environmental Science at Mizoram University.

To quantify the degree of disturbance, canopy cover and disturbance index (DI) were determined on the basis of the number of cut or severed woody individuals, expressed as the percentage of the total number of woody individuals per 100 m^2 area (Pandey and Shukla, 1999). Based on the level of disturbance, the study site was divided into three stands: the UD stand (>50% canopy cover and <10% DI), the MD stand (20-50% canopy cover and 10-50% DI), and the HD stand (<20% canopy cover and >50% DI). A total of 0.5 hectares of each stand was surveyed during the study (Table 1).

Biodiversity indices, such as the Importance Value Index (IVI) (Phillips, 1959), species diversity index (Shannon and Weaver, 1949), species dominance index (Simpson, 1949), species evenness index (Pielou, 1966), species richness (Margalef, 1958), and Sorensen similarity index (Sorensen, 1948), were computed alongside quantitative analyses like density, frequency, and abundance, following the methodologies detailed by Misra (1968) and Mueller-Dombois and Ellenberg (1974).

Results and Discussion

A total of 115 tree species, distributed among 81 genera and 47 families, were recorded. Among these, 89 species from 66 genera and 41 families were observed in the UD stand, 63 species from 51 genera and 36 families in the MD stand, and 31 species from 24 genera and 20 families in the HD stand (Table 2). This study demonstrates the variation in tree species diversity across disturbance gradients within forest stands. Comparative analysis with studies conducted by Malik *et al*. (2014) and Bitew and Tesfaye (2017) reveals a consistent downward trend in tree species diversity from UD to MD to HD forests. These findings are consistent with Clements' (1936) viewpoint regarding the disruptive impact of disturbances on climax assemblages and ecosystem stability. Furthermore, they align with Rao *et al*.'s (1990) observation of reduced species diversity from undisturbed to disturbed stands, influencing the

Table 1. Canopy cover and Disturbance Index in the undisturbed, moderately disturbed and highly disturbed forest stands in Hmuifang forest.

Parameter	Forest stand		
	Undisturbed	Moderately-disturbed	Highly-disturbed
Canopy cover (%)	74	41	9
Disturbance Index, DI (%)	0	20.8	66.89

community composition and structure of tree populations in subtropical broad-leaved forests of Meghalaya, India.

In the study, Lauraceae was found to be the most dominant family in UD and MD forest stands while Fagaceae was the most dominant family in HD stand. Similar results were observed by other researchers (Mishra *et al*., 2004; Parthasarathy and Sethi, 1997) where the family dominance changed from undisturbed to disturbed forests. The alteration in dominance among families could potentially be linked to the level of anthropogenic disturbance.

All individual trees were grouped into different girth classes i.e., 31-60 cm, 61-90 cm, 91-120 cm, 121-150 cm and >151cm (Fig. 2). In UD stand, 84.33% of the trees had girth class ranging between 31-60 cm and 15.67% of the trees were found to have girth >90 cm. In MD stand, 86.09% of trees had girth between 31-90 cm and 13.91% of trees were found having girth >90 cm. In HD stand, 92.05% of trees had girth class ranging between 31-90 cm and lesser than 1% trees had girth class of >121 cm. It has been noted that there were hardly any trees with significant girths in the HD stand, possibly due to more frequent and heavy extraction of forest resources by the local community in and around the disturbed area. The absence of larger girth class trees in the disturbed forest suggests high extraction rates from these classes. The highest tree density of 1,276 individuals per hectare was observed in the UD stand, followed by the MD stand with 906 individuals per hectare and the HD stand with 302 individuals per hectare (Table 2). This trend aligns with observations made by Bhuyan *et al*. (2003), Mishra *et al*. (2004), and Uniyal *et al*. (2010), where tree density decreases with increasing disturbance.

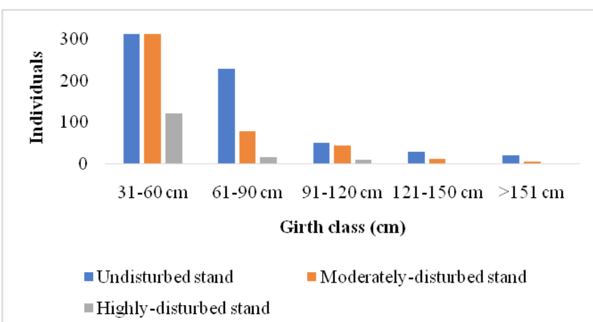

Fig. 2. Graph indicating Girth class with number of individuals in different forest stands.

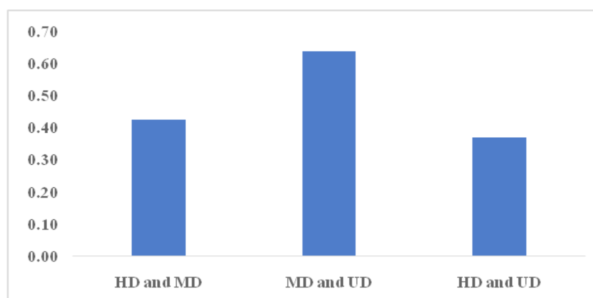

Fig. 3. Sorensen similarity index of tree diversity in different forest stands in Hmuifang

Table 2. Tree diversity and community characteristics along disturbance gradient of different forest stands

Parameter	Forest stand		
	Undisturbed	Moderately-disturbed	Highly-disturbed
Number of Species	89	68	31
Number of Family	41	36	20
Density (ha^¹)	1276	906	302
Simpson's index (D)	0.021	0.028	0.054
Shannon Wiener index (H')	4.06	3.79	3.05
Pielou index (J)	0.91	0.898	0.888
Margalev index (Dmg)	13.63	10.96	5.98

According to the Importance Value Index (IVI) presented in Table 3, *Lindera pulcherrima* emerged as the most dominant tree species in the UD forest, with an IVI of 23.806, followed by *Engelhardia spicata* (22.26), *Helicia excelsa* (17.48), *Quercus floribunda* (14.077), and others. In the MD forest, *Drypetes indica* was identified as the predominant species with an IVI of 35.66, followed by *Drimycarpus racemosus* (19.7), *Croton hookeri* (15.75), *Symplocos theifolia* (14.37), and others. The HD Forest was predominated by *Schima wallichii* with an IVI of 57.362, followed by *Wendlandia grandis* (25.886), *Macaranga denticulata* (13.137), *Eurya cerasifolia* (12.494), and others. It can be clearly seen that the dominant species differ along different level of disturbance. The Sorensen similarity index (Fig. 3) showed great variations in different forest stands along disturbance gradient. The highest similarity was recorded between UD and MD stands (0.64) which was followed by MD and HD stand (0.42). The least similarity was recorded between UD and HD stand (0.37). Species such as *Beilschmiedia roxburghiana*, *Castanopsis echinocarpa*, *Eurya cerasifolia*, *Eurya laquaiana*, *Helicia excelsa*, *Lithocarpus elegans*, *Macaranga denticulata*, *Macaranga indica*, *Quercus floribunda, Quercus xylocarpus, Rapanea capitellata, Schima wallichii, Symplocos theifolia, Syzygium claviflorum, Syzygium cuminii*, *Wendlandia grandis*, and *Zizyphus incurva* were observed in all forest stands, indicating their tolerance to disturbance or their broad ecological adaptability across varying levels of disturbance. Tree species present in the UD stand, such as *Ailanthus integrifolia*, *Albizia chinensis*, *Alnus nepalensis*, *Balakata baccata*, *Camellia kissi*, *Chukrasia tabularis*, *Cinnamomum bejolghota*, *Cinnamomum cassia*, *Debregeasia longifolia*, *Embelia tsjeriam-cottam*, *Euphorbea cotinifolia*, *Ficus benjamina*, *Ficus simplicissima*, *Glochidion lanceolarium*, *Heteropanax fragrans*, *Holigarna longifolia*, *Ligustrum robustum, Litsea salicifolia, Myrica esculenta, Myricaesculenta*, *Ostodes paniculata*, *Palaquium polyanthum*, *Persea odoratissima*, *Pinus kesiya, Pyrularia edulis, Saurauia napaulensis*, *Saurauia punduana*, *Tetradium fraxinifolium*, *Toddalia asiatica*, *Trema cannabina*, and *Vitex quinata*, were absent in the HD stand, indicating their susceptibility to anthropogenic disturbance. Tree species such as *Carallia brachiate*, *Castanopsis tribuloides*, *Drysoxylum excelsum*, *Ficus religiosa*, *Ficus semicordata*, *Litsea cubeba*, *Mangifera indica*, and *Rhus chinensis* was restricted only to HD forest stand, indicating that they are either shade-intolerant species or cannot compete with the primary tree species growing in UD or MD stands. Mild disturbance favoured the growth of *Bauhinia variegata*, *Bischofia javanica*, *Bruinsmia polysperma*, *Cinnamomum tamala*, *Dimocarpus longan*, *Diospyros stricta*, *Elaeocarpus rugosus*, *Ficus gibbosa*, *Garcinia cowa*, *Machilus glaucescens*, *Memecylon grande*, *Morus macroura*, *Olea salicifolia*, and *Xantolis hookeri*, which were restricted to the MD forest stand. There is evidence of a shift in both the position and distribution patterns along the disturbance gradient.

The Shannon Wiener index (H’) of diversity shows that the UD forest stand has the highest diversity (4.06), followed by MD forest stand (3.79) and HD forest stand (3.05) had the lowest diversity and similar results were reported by Bhuyan et.al. (2003), Bitew and Tesfaye (2017) and Malik *et al*. (2014). The Shannon Weiner index values of the study fell within the range observed in Indian forests, between 0.83 and 4.1 (Visalakshi, 1995; Devi and Yadava, 2006). As observed by Noble and Dirzo (1997), anthropogenic disturbances like logging typically lead to an immediate decline in species diversity, resulting in a positive and significant correlation between the diversity index and disturbance. The higher richness of tree species in the UD site may be attributed to the forest’s inaccessibility, resulting in less human interference. The Simpson’s index of dominance (D) was found to be 0.0219, 0.0284, and 0.054 for the UD, MD, and HD forest stands respectively, indicating a reverse trend compared to the Shannon Wiener diversity index (H’). This suggests that the UD stand is more diverse than the MD and HD stands, as dominance is inversely proportional to diversity. Similar results have been reported by other researchers such as Mishra *et al*. (2004), Borah and Garkoti (2011), and Ovung and Tripathi (2021). The Pielou’s evenness index (J’) was determined to be 0.91, 0.898, and 0.888 in the UD, MD, and HD forest stands respectively, consistent with findings from Borah and Garkoti (2011) and Bitew and Tesfaye (2017). The UD stand exhibits greater consistency in species distribution as indicated by the higher evenness index. Margalef’s richness index (Dmg) was calculated as 13.629, 10.96, and 5.98 in the UD, MD, and HD forest stands respectively, falling within the range of 4.54 to 23.41 for Indian forests as reported by Kumar *et al*. (2010) and Sathish *et al*. (2013). The UD Forest stand demonstrates relatively higher richness compared to the

Table 3. IVI of three different forest stands (HD – Highly disturbed, MD – Moderately disturbed, LD – Least disturbed)

Species Name	Family	UD	MD	HD
Acer oblongum Wall. ex DC.	Sapindaceae	1.038	3.35	-
Acrocarpus fraxinifolious Wight & Arn	Fabaceae	0.453	-	-
Ailanthus integrifolia Lam.	Simaroubaceae	3.581	-	-
Albizia chinensis (Osb.) Merr	Fabaceae	0.814	-	-
Alnus nepalensis D. Don	Belulaceae	0.399	-	-
Alseodaphnopsis petiolaris (Meisn.) H.W.Li & J.Li	Lauraceae	0.81	7.56	-
Balakata baccata (Roxb) Esser	Euphorbiaceae	0.824	-	-
Bauhinia variegata L.	Fabaceae	-	0.58	-
Beilschmiedia gammieana King ex Hook.f.	Lauraceae	2.497	1.17	-
Beilschmiedia roxburghiana Nees.	Lauraceae	1.713	1.66	0.957
Betula alnoides Buch.-Ham. ex D. Don	Belulaceae	2.228	-	-
Bischofia javanica Blume	Phyllanthaceae	-	1.08	-
Bruinsmia polysperma (C.B.Clarke) Steenis	Styracaceae	-	3.03	-
Calophyllum polyanthum Wall. ex Choisy	Calophyllaceae	1.5	1.84	-
Camellia kissi Wallich	Theaceae	0.97	-	-
Carallia brachiata Merr.	Rhizophoraceae	-	-	5.379
Castanopsis echinocarpa Miq.	Fagaceae	0.858	4.08	5.012
Castanopsis indica A.DC.	Fagaceae	0.422	2.58	-
Castanopsis tribuloides A.DC.	Fagaceae	4.501	-	5.189
Celtis timorensis Span.	Cannabaceae	-	11.25	7.951
Chukrasia tabularis A.Juss.	Meliaceae	0.446	-	-
Cinnamomum bejolghota (Buch.-Ham.) Sweet	Lauraceae	4.7	-	-
Cinnamomum cassia (L.) J.Presl	Lauraceae	0.943	-	-
Cinnamomum tamala T.Nees & Eberm.	Lauraceae	-	1.75	-
Cinnamomum glanduliferum (Wall.) Meisn	Lauraceae	0.402	-	-
Coffea khasiana (Korth.) Hook. F.	Rubiaceae	0.942	-	-
Croton Hookeri Veitch	Euphorbiaceae	2.694	15.75	-
Debregeasia longifolia (Burm. F.) Wedd.	Urticaceae	0.588	-	-
Dimocarpus longan Lour.	Sapindaceae	-	1.19	-
Diospyros lanceifolia Roxb.	Ebenaceae	3.866	-	0.988
Diospyros stricta Roxb.	Ebenaceae	13.912	2.02	-
Dipterocarpus retusus Blume	Dipterocarpaceae	-	4.14	1.166
Drimycarpus racemosus (Roxb.) Hook.f. ex Mchand	Anacardiaceae	1.65	19.7	-
Dysoxylum excelsum	Meliaceae	-	-	7.995
Dysoxylum mollissimum Blume	Meliaceae	0.403	13.51	-
Drypetes indica Müll.Arg.	Phyllanthaceae	-	35.66	-
Elaecoarpus tectorius (Lour.) Poir.	Elaeocarpaceae	4.811	1.38	-
Elaeocarpus rugosus Roxb. ex G.Don	Elaeocarpaceae	-	3	-
Embelia tsjeriam-cottam (Roem. & Schult.) A.DC.	Primulaceae	8.35	-	-
Engelhardia spicata Lechen ex Blume	Juglandaceae	22.26	13.29	-
Eriobotrya bengalensis Kurz	Rosaceae	1.709	0.54	-
Euphorbea cotinifolia Linn	Euphorbiaceae	1.726	-	-
Eurya cerasifolia (D.Don) Kobuski	Pentaphylacaceae	3.06	4.62	12.494
Eurya loquaiana Dun	Pentaphylacaceae	1.388	2.62	4.125
Benkara fasciculata (Roxb.) Ridsdale	Rubiaceae	-	1.62	-
Ficus benjamina L.	Moraceae	0.824	-	-
Ficus curtipes Corner	Moraceae	-	6.62	-
Ficus gibbosa Blume	Moraceae	-	1.12	-
Ficus religiosa L.	Moraceae	-	-	0.961
Ficus semicordata Buch. Ham ex Sm.	Moraceae	-	-	0.99
Ficus simplicissima Lour.	Moraceae	0.396	-	-
Ficus sp.	Moraceae	1.25	0.55	2.419
Garcinia cowa Roxb. Ex Choisy	Clusiaceae	-	0.6	-

Table 3. *Continued ...*

Species Name	Family	UD	MD	HD
Garcinia succifolia Kurz.	Clusiaceae	-	1.14	1.02
Glochidion lanceolarium Mull. Arg.	Phyllanthaceae	3.08	-	-
Helicia excelsa Blume	Proteaceae	17.48	13.21	5.655
Helicia robusta (Roxb.) R. Br.	Proteaceae	0.402	-	-
Heteropanax fragrans Seem.	Araliaceae	2.017	-	-
Laurocerasus jenkinsii (Hook.f. & Thomson) Browicz	Rosaceae	0.813	2.05	-
Ligustrum robustum (Roxb.) Blume	Oleaceae	0.823	-	-
Lindera pulcherrima (Nees) Benth. ex Hook.f.	Lauraceae	23.806	0.8	-
Lithocarpus dealbata (Hook.f. & Thomson ex Miq.) Rehder	Fagaceae	4.408	2.55	-
Lithocarpus elegans	Fagaceae	6.488	2.64	0.971
Litsea cubeba (Lour.) Pers.	Lauraceae	-	-	2.734
Litsea monopetala Pers.	Lauraceae	3.113	6.13	-
Litsea salicifolia Hook.f.	Lauraceae	3.2	-	-
Macaranga denticulata (Blume) Müll.Arg.	Euphorbiaceae	4.803	11.46	13.137
Macaranga indica Wight	Euphorbiaceae	6.106	2.71	1.079
Machilus gamblei King ex Hook.f.	Lauraceae	0.89	3.37	-
Machilus glaucescens (Nees) Wight	Lauraceae	-	0.6	-
Machilus sp.	Lauraceae	1.067	0.5	-
Magnolia doltsopa (Buch.-Ham. ex DC.) Figlar	Magnoliaceae	0.588	2.45	-
Mangifera indica	Anacardiaceae	-	-	3.466
Meliosma punnata (Roxb.) Maxim.	Sabiaceae	4.755	1.47	-
Memecylon grande Retz.	Melastomataceae	-	1.989	-
Morus macroura Miq.	Moraceae	-	7.86	-
Myrica esculenta Buch.-Ham. ex D.Don	Myricaceae	1.415	-	-
Nyssa javanica (Blume) Wanger	Cornaceae	0.568	1.11	-
Olea dioica Roxb.	Oleaceae	2.858	1.95	-
Olea salicifolia Wall. Ex G.Don	Oleaceae	-	3.01	-
Ostodes paniculata Blume	Euphorbiaceae	6.862	-	-
Palaquium polyanthum (Wall. Ex G. Don) Baill.	Sapotaceae	1.243	-	-
Persea odoratissima (Nees) Kosterm.	Lauraceae	0.812	-	-
Phoebe attenuata (Nees) Nees	Lauraceae	1.131	1.02	-
Pinus kesiya Royle ex. Gordon	Pinaceae	9.15	-	-
Premna racemosa Wall. ex Schauer	Lamiaceae	1.874	1.68	-
Prunus undulata Buch.-Ham. ex D.Don	Rosaceae	1.259	13.64	-
Pyrularia edulis (Wall.) A.DC.	Santalaceae	1.011	-	-
Quercus glauca (Thunb)	Rubiaceae	10.05	1.19	-
Quercus floribunda Lindl. ex A.Camus	Fagaceae	14.077	0.78	0.954
Quercus xylocarpus (Kurz.) Markgr	Fagaceae	8.999	3.43	12.375
Rapanea capitellata (Wall), Mez	Primulaceae	3.108	2.82	9.72
Rhus chinensis Mill.	Anacardiaceae	-	-	4.645
Saurauia napaulensis DC	Actinidiaceae	0.813	-	-
Saurauia punduana Wall.	Actinidiaceae	2.226	-	-
Schima khasiana Dyer	Theaceae	1.392	3.84	-
Schima wallichii (DC.) Choisy	Theaceae	12.236	1.98	57.362
Semecarpus anacardium L.f.	Anacardiaceae	1.42	-	-
Stevia rabaudiana (Bertoni) Hemsl.	Asteraceae	0.396	-	0.951
Symplocos racemosa Roxb.	Symplocaceae	1.797	0.55	-
Symplocos theifolia D.Don	Symplocaceae	3.376	14.37	0.947
Syzygium claviflorum Wall.	Myrtaceae	0.417	1.14	4.312
Syzygium cuminii var. axillare (Gamble) Tenjarla & Kashyapa	Myrtaceae	2.687	3.72	0.949
Syzygium fruticosum DC.	Myrtaceae	0.997	-	-

Table 3. *Continued ...*

Species Name	Family	UD	MD	HD
Terminalia bellirica (Gaertn.) Roxb.	Combretaceae	1.939	1.48	-
Tertradium fraxinifolium (Hook.f.) T. G. Hartley	Rutaceae	0.395	-	-
Toddalia asiatca (L.) Lam.	Rutaceae	1.225	-	-
Trema cannabina Lour.	Cannabaceae	0.56	-	-
Vitex canescens Kurz	Lamiaceae	0.804	0.55	-
Vitex quinata F.N. Williams	Lamiaceae	2.268	-	-
Wendlandia grandis Hook. F Cowan	Rubiaceae	9.154	0.57	25.886
Lindera nacusua var. nacusua	Lauraceae	1.027	-	-
Wightia speciosissima (D. Don) Merr.	Paulowniaceae	1.655	0.56	-
Xantolis hookeri (C.B.Clarke) P.Royen	Sapotaceae	-	11.31	-
Zizyphus incurva Roxb.	Rhamnaceae	6.396	0.55	1.35

other forest stands (Table 2).

Conclusion

Disturbance, whether natural or anthropogenic, has the capacity to shape the tree community. The study encompassed undisturbed (UD), moderately disturbed (MD), and highly disturbed (HD) forest stands within the Hmuifang forest, Aizawl, revealing notable alterations in community composition and structure along the anthropogenic disturbance gradient. The results indicated a decline in tree diversity, richness, and density from UD to HD forest stands. The UD stand exhibited a wider array of trees with larger girths, which progressively diminished in more disturbed areas. Furthermore, several crucial species observed in the UD forest were absent in the HD forest, impacting both community structure and species composition. Moreover, dominant families and species exhibited notable variations among the stands, indicating ecological shifts attributed to anthropogenic activities. The conducted study concludes that the Hmuifang forest in Aizawl district of Mizoram boasts rich tree diversity, encompassing diverse species, genera, and families. The residents residing in and around the study site heavily depend on the forest for essentials such as food, fuelwood, and timber. Continued exploitation of these forest would render the ecosystem services provided by these species to disappear locally. Coordinated outreach efforts aimed at educating villagers on sustainable use, along with policies and incentives for community-based protection is the need of the hour as these would lower the pressure on the forest which in turn will decrease the damage caused by various anthropogenic disturbance.

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Conflict of Interests

The authors stated that they had no conflicts of interest related to the research, authorship, or publication of this paper.

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