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Impact of Shifting Cultivation on Phyto-diversity (Vegetation) under Different Land use Systems in Serchhip District, Mizoram, India

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ABSTRACT

The paper is an attempt to determine the Phyto-diversity (vegetative) conditions under the undisturbed forest and different fallow lands following shifting cultivation by evaluating the species composition, diversity and abundance of trees, shrubs and herbs in Serchhip district, Mizoram, India. The *Jhum* cycle was of 7 years in the selected field sites. Each site was divided into classes of 0-2 years (where shifting cultivation is being practised) which are represented as SC (shifting cultivation), 2-4 years (fallow land) as JF_1 which denotes *Jhum* fallow number 1, 4-6 years (fallow land) as JF_2which denotes *Jhum* fallow number 2 and NF (normal forest) i.e. forest which was untouched for at least 30 years. A total of 88 tree species and 66 genera belonging to 37 families, 53 shrubs species and 44 genera belonging to 28 families and86 herb species and 73 genera belonging to 33 families were recorded from the study area. Our result showed that *Schima wallichii* was found on all the sites of the tree community. The herb community were dominated by early successional species such as *Ageratum conyzoides*, the herbaceous community were dominant in JF_1, the shrub species were dominated by *Clerodendrum infortunatum* and *Chromolaena odorata*. The shrubs mainly dominated the JF_2 and bamboo was also found abundantly in this fallow land.

Key words: *Phyto-diversity, Shifting cultivation, Fallow lands, Mizoram*

Introduction

Shifting cultivation is a practice which consists of a cyclic nature, under which the selection of fields usually on hills slopes is done and clearing the land is done by cutting down the jungle, drying and burning the dry debris on which seeds of different crops are sown by dibbing or broadcasting before the onset of rain is carried out. The ashes are left to enrich soil fertility and the burnt patch of the land is used for the cultivation of paddy and other subsidiary crops (Hauchhum and Singson, 2019). It is a traditional farming method that typically involves cycles of burning and clearing forests (primary or secondary), cropping for a short time and subsequent abandonment of the site for vegetation regeneration (Ramakrishnan, 2007). Shifting cultivation is a highly dynamic and complex socio-ecological system that has evolved over centuries of experiential learning by traditional societies (Cairns, 2015). It is the most well-known and dominant agricultural practice in the North Eastern hilly states.

Recent estimates of its extent show that roughly 280 million hectares of land, with the largest share in Africa, followed by the Americas and Asia, 62% of the investigated one-degree cells in the humid and sub-humid tropics currently show signs of shifting cultivation, the majority being in the Americas (41%) and Africa (37%) (Nath *et al*., 2022). Approximately one billion people (22% of the total population of developing countries situated in tropical and subtropical regions) are dependent upon various types of shifting cultivation, either directly or indirectly (Marak *et al*. 2023). In the past, this agricultural system was sufficiently productive, economically practical and ecologically efficient due to the long fallow period of 20 to 30 years. However, in recent years as a result of a considerable increase in population, the length of fallow periods has been significantly reduced to less than five years (Grogan *et al*., 2012). The increasing population pressure on the limited land resources followed by socio-economic and land tenure systems has led to the decline in soil health and is responsible for the above fallow periods in the northeast region of India (Wapongnungsang *et al*., 2018). The short *Jhum* cycle in Northeast India has resulted in arrested succession where weedy species were not succeeded by pioneer woody species, and over time the soil seed bank is replaced with seeds of weedy shrubs (Saxena and Ramakrishnan, 1984)

Mizoram is one of the states in North East India which is composed of steep slopes and hilly terrain and receives a high amount of rainfall every year. Shifting cultivation is a common practice and people mostly depend on the production of shifting cultivation sites for their livelihood. However, it leads to rapid degradation of land because of leaching and runoff losses of topsoil (Wapongnungsang *et al*., 2019). Secondary forests in the state of Mizoram cover 63% of the total 21,087 km^2 forest covers. These forests are predominantly occupied by bamboo forests interspersed with other tree species (Gogoi *et al*., 2020). Shifting cultivation is not just a means of subsistence but also a way of life that gives "symbolic meanings" to the socio-cultural life and ecological environments. It continues to be a vital component of the Mizos' economic and social existence today. This can be seen from the very fact that the three main festivals of the Mizos such as Chapchar Kut, Mimkut and Pawl kut are connected with *Jhum* operations (Pachuau and Devi, 2020). Mizoram contributed to 62% of the total shifting cultivation fallow hotspot areas (Pasha *et al.,* 2020).

Materials and Methods

Study area (Site description)

Mizoram is one of the states of Northeast India and is situated in the southernmost landlocked state, with Aizawl as its capital city. The name is derived from *Mi* (People), *Zo* (lofty place, such as hill) and *Ram* (land), and thus Mizoram implies "Land of the hill people. It is the fifth smallest state of India with a total geographical area of 21,087 km^2 and extends from 21°56' to 24°31' North latitude and 92°16' to 93°26' East longitude. Situated in a mountainous area with heavy rainfall of approximately 2500mm annually, Mizoram is richly endowed by nature with varieties of flora and fauna and is anointing with a pleasant climate. The total forest cover of Mizoram is at 17,820 km^{2}which is 84.53% of the total geographical area (ISFR, 2021) but also sits at the 4th highest forest cover loss behind Arunachal Pradesh, Manipur and Nagaland at a loss of 186 km^2 (ISFR, 2021). It also has the highest forest cover loss in ISFR 2017 amongst all the states in India.The study areas so selected are Buangpui, Chhingchhip and East Lungdar all under the Serchhip district which is located at the centre of the state and the tropic of cancer passes through it, the main headquarters Serchhip lies 112 km away from the capital city Aizawl. The district occupies an area of 1421 km^{2}out of which 1143.44 km^2 is covered by forest which is 80.47% of the total geographical area and has the second least forest cover per percentage of Geographical Area in Mizoram districts (ISFR, 2021). It extends from 23°0'50.3'' to 23°37'30.9'' North latitude, and 92°47'49.9 '' to 93°7'11.2'' East longitude. It has an average elevation of 888 meters (2913 ft). It is the 3rd smallest district but stands 4thin terms of the area of Very Dense Forest but shows the 3rd most decrease in forest cover (-18.21 km^2).

Site Selection

A preliminary survey was carried out under three administrative sub-divisions (as Serchhip is comprised of three administrative sub-divisions) *viz.* Serchhip Sadar sub-division, Thenzawl sub-division and North Vanlaiphai sub-division for understanding the social structure, administrative setups, major

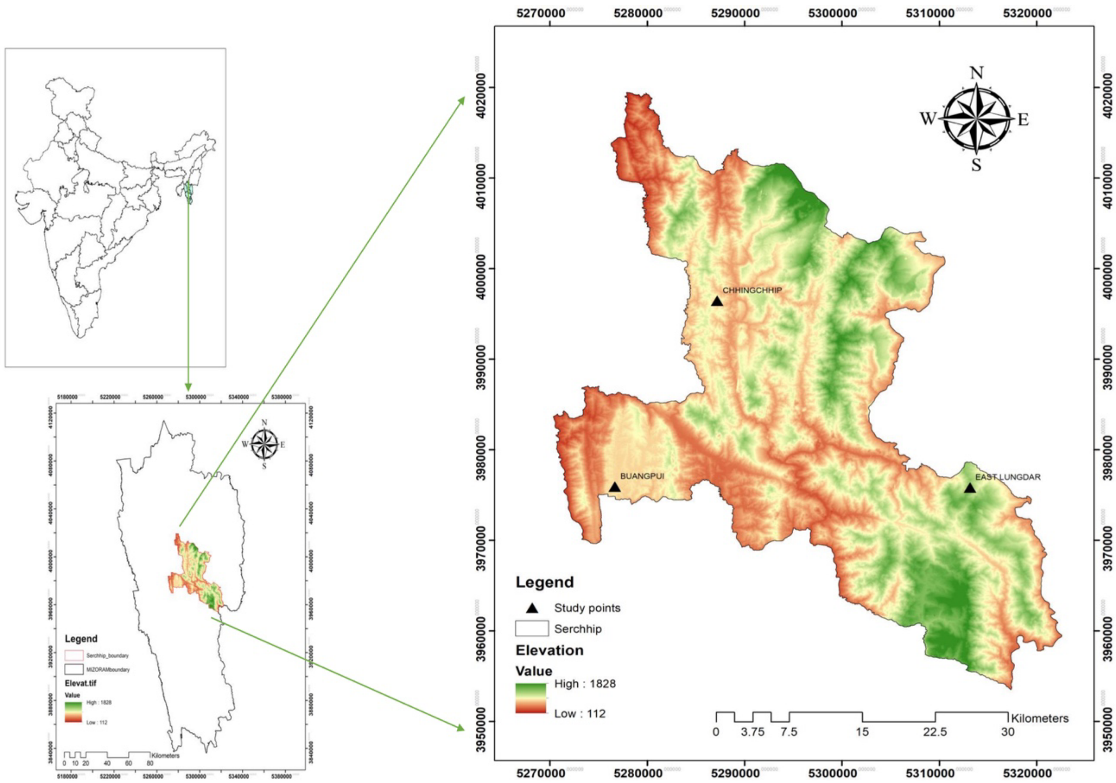

Fig. 1. Map of the study area

forest category, topography, policies, etc. The feasibility and accessibility of carrying out the phyto-sociological survey were understood. During the survey, expert local cultivators and village council members, who are in charge of annually allocating *Jhum* lands to the farmers, assisted in the identification of the differentially aged *Jhum* fallows. As the selected sites will reflect the entire district, they must include Normal Forest (forest that hasn't been altered in at least 30 years) as a control and Shifting Cultivation Sites (shifting cultivating land and fallow land) as treatments. To determine the duration of the fallow period, which is 7 years in all three of the chosen sites *viz*. Buangpui, Chhingchhip, and East Lungdar, secondary data were also gathered. The sites include Buangpui in the Thenzawl sub-division, Chhingchhip in the Serchhip Sadar sub-division and East Lungdar in the North Vanlaiphai sub-division. Each site was divided into classes of 0-2 years (where shifting cultivation is being practised) which are represented as SC (shifting cultivation), 2-4 years (fallow land) as JF_1 which denotes *Jhum* fallow number 1, 4-6 years (fallow land) as JF_2 which denotes *Jhum* fallow number 2 and NF (normal forest), i.e. forest which was untouched for at least 30 years.

Vegetation Sampling and data collection

Stratified Two Stage Random Sampling with Proportional Allocations was used to select the villages and forests from the selected villages in each sub-division of the Serchhip district of Mizoram. Each sub-division was treated as a stratum, villages as first stage units and selected forests as second stage units. The classes of SC, JF_1, JF_2 and NF were made from the selected forests. The representation of the vegetation (trees, bamboo, herbs and shrubs) in the study area consists of different plot sizes which were laid using the method of simple random sampling (Latpate *et al*., 2021). Ten quadrats (plots) of size 10m x10m were randomly established for trees and bamboo in each site of Buangpui, Chhingchhip and East Lungdar which consist of each class of SC, JF_1, JF_2 and NF in all three sites. Likewise, in all the sites and classes twenty quadrats each of 5m x 5m for shrubs and forty quadrats each of size 1m x 1m for herbs. An equal number of nested plots were established in each fallow land. A minimum number of quadrats were worked out by plotting an increasing number of quadrats against the number of species (Misra, 1968). During the initial SC there were no trees as the land is actively utilized for shifting cultivation. So, the vegetative index for trees is calculated from NF and $JF_2$where tree species are present. For shrubs and herbs, it was calculated from JF_1, JF_2 and NF. For trees, the diameter at breast height (DBH) was calculated at 1.37m and for shrubs it was measured at collar diameter (CD), for herbs the cover percentage was calculated according to Daubenmire (1968). Quantitative analysis of vegetation for frequency, density and dominance was calculated following the method of Misra (1968).

Statistical analysis

Quantitative analysis of Vegetation for Species Richness, Frequency, Density, Basal Area/Cover, Abundance and Importance Value Index (IVI) were calculated by following standard methods of Misra (1968), Plant diversity measures such as Shannon-Wiener's Index (1963), Concentration of dominance (*Cd*) by Simpsons' Diversity Index (1949), Pielou's Evenness Index (*J*) (1966) and Sorensen's Index of Similarity (*S*) (1948) were also determined.

$H' = -\Sigma$ pi ln pi where pi is the proportional abundance of species

(i.e., number of species divided by total number in the community).

$Cd = \Sigma$ pi² where pi is same for Shannon's index

$J = H'/\ln S$ where is the number derived from the Shannon diversity index and S is the total number of species

S = 2C/(A+B) Where, *A* = No. of species in the community A, B = No. of species in the community B, C = No. of common species in both communities

Results and Discussion

Stand characteristic and abundance

The Species composition varied significantly between *Jhum* fallows and normal forests, and also between the different types of *Jhum* fallows. A total of 88 tree species and 66 genera belonging to 37 families were recorded from the study area (3 field sites). The most prevalent families are Fagaceae and Lauraceae, which contribute 9 species each, followed by Fabaceae, which contributes 8 species. A total of 24 families, 36 genera and 47 different tree species were recorded from Buangpui at Chhingchhip a total of 22 families, 36 genera and 39 tree species were recorded and at East Lungdar a total of 18 families, 27 genera and 33 tree species were recorded. A total of 53 shrubs species and 44 genera belonging to 28 families were recorded from the study area. A total of 16 families, 22 genera and 24 shrub species were recorded from Buangpui in which Fabaceae was the dominant family by contributing 4 species, in Chhingchhip a total of 14 families, 21 genera and 23 shrub species were recorded and were dominated by 2 families viz. Euphorbiaceae and Fabaceae both contributing 3 species each and East Lungdar have a total of 19 families, 24 genera and 26 species of shrubs which were dominated by Rubiaceae family contributing 5 species. A total of 86 herb species and 73 genera belonging to 33 families were recorded from the study area. A total of 21 families, 47 genera and 49 species of hers were recorded from Buangpui out of which Asteraceae and Poaceae are dominant by contributing 8 species each, Chhingchhip is comprised of 21 families, 44 genera and 46 herbs species which was dominated by Asteraceae family by contributes 14 species and East Lungdar has a total of 24 families, 37 genera and 41 herbs species and the dominant family was Asteraceae contributing 10 species. The field sites contain only one species of bamboo which is *Melocanna baccifera* as shown in figure3.

Dominance

The IVI values of the tree, shrub, and herb species revealed a variety of dominance patterns in the *Jhum* fallows and in normal forests. The importance value index (IVI) indicates the ecological importance of a species in the community and provides an overview of the social structure of a species (Gogoi *et al*., 2020). On the base of IVI at Buangpui, *Schima wallichii* (IVI-18.65) and *Lithocarpus xylocarpus* (IVI-21.41) were the two most common tree species for NF and JF_2, respectively. *Clerodendrum infortunatum* (IVI-38.13), *Solanum rudepannum* (IVI-22.78), and *Chromolaena odorata* (IVI-43.85) for NF, JF_2 and JF_1 respectively, are the prominent species among the shrubs in Buangpui. *Amomum dealbatum* (IVI-65.09), *Ageratum conyzoides* (IVI-38.89), and *Saccharum arundinaceum* (IVI-24.93) are the herbs found in Buangpui for NF, JF_2 and JF_1respectively.

In Chhingchhip, *Lithocarpus dealbatus* (IVI-69.57) and *Schima wallichii* (IVI-18.64) are the two dominating tree species for $JF_2$and NF. For Chhingchhip, the dominating shrubs for NF, JF_2 and JF_1 correspond-

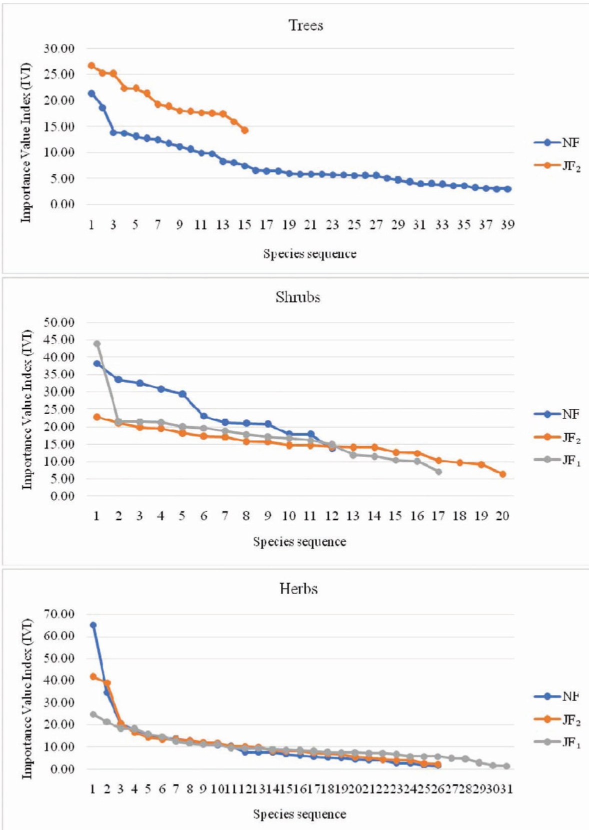

Fig. 2. Dominance-diversity curve for trees, shrubs and herbs at Buangpui

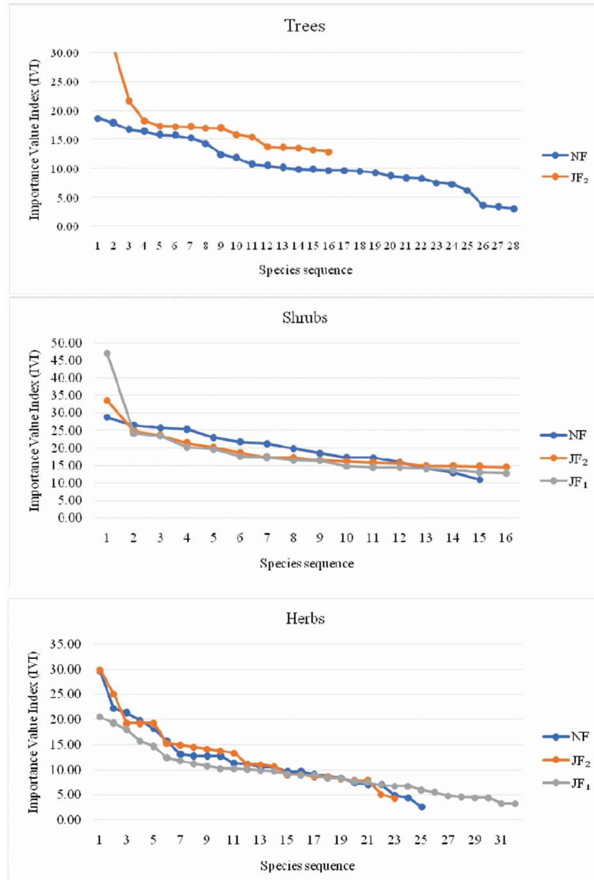

Fig. 3. Dominance-diversity curve for trees, shrubs and herbs at Chhingchhip

ingly are *Gnetum gnemon* (IVI-28.76), *Clerodendrum infortunatum* (IVI-33.48), and *Chromolaena odorata* (IVI-46.93). For NF, JF_2 and JF_1, respectively, the dominant herbs are *Persicaria nepalensis* (IVI-29.61), *Ageratum conyzoides* (IVI-29.85), and *Ageratum conyzoides* (IVI-20.50).

In East Lungdar, *Castanopsis tribuloides* (IVI-33.26) and *Castanopsis echinocarpa* (IVI-30.91) are the two most common tree species for NF and JF_2 fallow. For NF, JF_2 and JF_1correspondingly, the prominent shrubs are *Clerodendrum infortunatum* (IVI-24.97), *Woodfordia fruticosa* (IVI-23.81), and *Chromolaena odorata* (IVI-37.91) for NF, JF_2, and JF_1respectively. For NF, JF_2, and $JF_1$the dominant herbs include *Persicarian epalensis* (IVI-32.77), *Euphorbia hirta* (IVI-34.85), and *Ageratum conyzoides* (IVI-28.38). These results provide insights into the dominant species within each category and their importance in different land use types and locations. The IVI values indicate the relative significance of each species within the community.

Ecological diversity

Tree species showa Higher Shannon-Wiener's Index in NF than in JF_2in all the field sites,this indicates high diversity and species richness but the Pielou's Index is higher in JF_2 than NF for Buangpui and East Lungdar site which indicates that tree species in JF_2 are more evenly distributed in these specific sites compared to NF. In all field sites, JF_2 shows the highest species richness and diversity for shrubs. This suggests that shrub communities are more diverse and rich in JF_2 compared to the other land use types as shown in Table 2. JF_2 also exhibits an equitable distribution of shrub species across the sites. The herbs in each site has the highest diversity and richness in JF_1 but the distribution changes according to the sites as shown in Table 3.

Species richness exhibited variability across different sites, even within the same NF, $JF_2$and JF_1. As a result, the beta diversity demonstrated distinct variations among these sites. Sorensen Index of

Table 1. Species richness, density, basal area and diversity indices of tree species in comparison with NF and JF_2

Sites		Species richness	Density (ha^{-1})	Basal Area (m^2ha^{-1})	*H′*	*Cd*	*J′*
Buangpui	NF	39	1,020	12.20	3.522	0.034	0.961
	JF_2	15	840	0.058	2.692	0.069	0.994
Chhingchhip	NF	28	920	15.47	3.250	0.041	0.975
	JF_2	16	1,210	0.051	2.697	0.074	0.973
East Lungdar	NF	25	1,590	10.19	3.069	0.053	0.953
	JF_2	15	1,130	0.045	2.696	0.068	0.996

Note: (*H′*) is Shannon-Wiener's Index, (*Cd*) is Concentration of Dominance, (*J′*) is Pielou's Evenness Index
JF_1 and SC are not included as there are no tree species in the sites

Table 2. Pecies richness, density, basal area and diversity indices of shrubs in comparison with NF, JF_2 and JF_1

Sites		Species richness	Density (ha^{-1})	Basal Area (m^2ha^{-1})	*H′*	*Cd*	*J′*
Buangpui	NF	12	3,900	0.191	2.442	0.090	0.982
	JF_2	20	3,040	0.133	2.957	0.054	0.987
	JF_1	17	2,560	0.138	2.748	0.070	0.970
Chhingchhip	NF	15	3,500	0.094	2.675	0.071	0.988
	JF_2	16	3,460	0.138	2.742	0.067	0.989
	JF_1	16	4,300	0.080	2.701	0.074	0.974
East Lungdar	NF	17	2,500	0.128	2.818	0.060	0.995
	JF_2	18	2,940	0.123	2.877	0.057	0.996
	JF_1	17	3,300	0.074	2.796	0.064	0.987

Note: SC is omitted as there are no shrub species in the sites

Table 3. Species richness, density, basal area and diversity indices of herbs in comparison with NF, JF_2 and JF_1

Sites		Species richness	Density(ha^{-1})	*H′*	*Cd*	*J′*
Buangpui	NF	26	92,000	2.849	0.086	0.874
	JF_2	26	96,250	3.001	0.064	0.921
	JF_1	31	1,57,000	3.284	0.042	0.956
Chhingchhip	NF	25	61,250	3.096	0.050	0.962
	JF_2	23	63,500	3.032	0.053	0.967
	JF_1	32	1,22,500	3.362	0.038	0.970
East Lungdar	NF	24	98,750	3.097	0.049	0.974
	JF_2	25	1,127,50	3.087	0.052	0.959
	JF_1	28	1,62,750	3.156	0.049	0.947

Note: SC is omitted as there are no herb species in the sites

Similarity (*S*) for tree species in NF is highest in Chhingchhip-East Lungdar (30.19) and for JF_2 the tree species have the highest similarities in Buangpui-East Lungdar (26.67) as shown in Table 4. Similarly, for shrub and herb species Sorensen Index of Similarity is highest in all the same sites, which is in Buangpui-Chhingchhip as mentioned in Table 5 and Table 6 respectively.

Conclusion

The ability of tree species to colonise new areas and repair degraded forest ecosystems are key factors in the natural succession and regeneration of intact forests. The findings of this study are in agreement with earlier studies which state that there is an increase in the number of trees with an increase in fallow age (Klanderud *et al*., 2010). Natural restoration of degraded forest ecosystems to intact forests

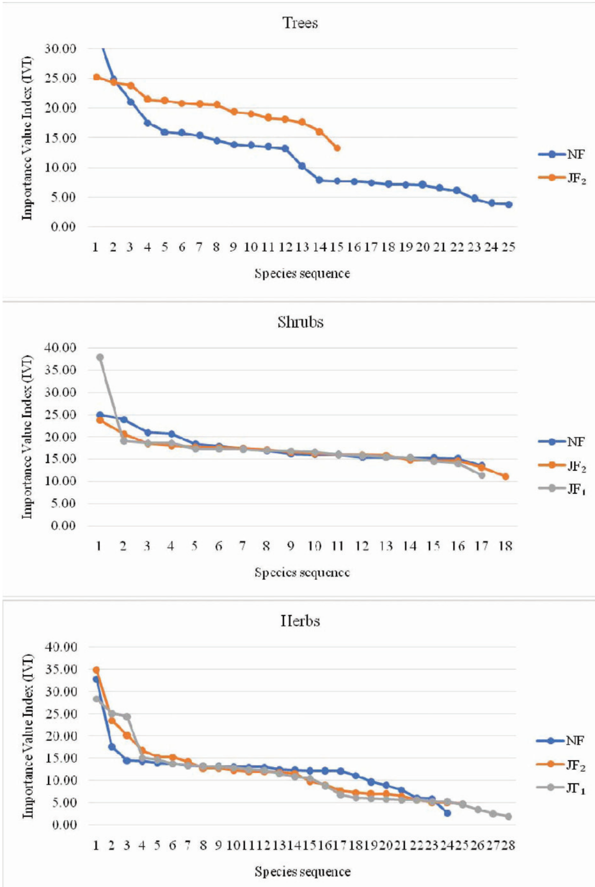

Fig. 4. Dominance-diversity curve for trees, shrubs and herbs at East Lungdar

Table 4. Sorensen's Index of Similarities for trees from all three sites

Sites	NF Buangpui	Chhingchhip	East Lungdar
Buangpui	100	26.87	28.13
Chhingchhip		100	30.19
East Lungdar			100
		JF_2	
Buangpui	100	25.81	26.67
Chhingchhip		100	19.35
East Lungdar			100

greatly depends on the establishment ability of tree species (Ulh, 1987). Massive invasion of shrubs into open fallows may be one of the possible causes of hampering the growth of tree seedlings and saplings through competition (Styger *et al*., 2007). From the Basal area and Density on the study site, the normal

Table 5. Sorensen's Index of Similarities for shrubs from all three sites

Sites	NF Buangpui	Chhingchhip	East Lungdar
Buangpui	100	51.85	6.25
Chhingchhip		100	13.79
East Lungdar			100
JF_2			
Buangpui	100	61.11	21.05
Chhingchhip		100	23.53
East Lungdar			100
JF_1			
Buangpui	100	54.55	23.53
Chhingchhip		100	30.30
East Lungdar			100

Table 6. Sorensen's Index of Similarities for herbs from all three sites

Sites	NF Buangpui	Chhingchhip	East Lungdar
Buangpui	100	50.98	24.00
Chhingchhip		100	48.98
East Lungdar			100
JF_2			
Buangpui	100	57.14	11.76
Chhingchhip		100	25.00
East Lungdar			100
JF_1			
Buangpui	100	60.32	37.29
Chhingchhip		100	46.67
East Lungdar			100

forest is much higher than JF_2 which indicates shifting cultivation decreased plant species richness and affected species abundance. The *Jhum* cycle of 7 years is not enough to recover the fallow lands but from the species composition we can conclude that the secondary forest is as important as the primary forest, soil properties could play a major role in this as the natural succession are not as slow as reported from certain other places. Fardhani *et al.* (2020) mentioned that *Schima wallichii* is a forest tree species that grows in critical land areas and is widely used for forest restoration,as a native of Mizoram *Schima wallichii* was found on all the sites that clearly depict the restoration and recovery of the forest and fallow land.

Our results confirm that JF_1 was dominated by early successional species such as *Ageratum conyzoides* and *Mikania micrantha*. *Mikania micrantha* has been recognised as an aggressive exotic invasive weed during secondary succession (Swamy and Ramakrishnan, 1987).The shrub species is dominated by *Clerodendrumin fortunatum* and *Chromolaena odorata*.The invasion of *Chromolaena odorata* appears to be the primary factor responsible for the poor regeneration of degraded forests (Honu and Dang, 2000). In JF_1there are no tree species only herbs and shrubs with young bamboo shoots are found and in JF_2 few young seedlings and a huge number of bamboo culms are found, the secondary forests are mostly covered with bamboo in the field site. After shifting cultivation, secondary forests are important carbon sinks, and their ability to store carbon gets better with age. It may be possible to lessen the effects of deforestation and forest degradation and to aid in global carbon sequestration by allowing the development of such secondary regrowth. Farmers are still engaged in slash-and-burn farming to support themselves and their families, despite the fact that shifting cropping followed by brief fallow periods degrades ecological systems. Institutional and policy initiatives are needed in these regions to accommodate the longer fallow period needed for fallow lands to regenerate into natural forests.

Conflict of Interest

Authors declare there is no conflict of interest.

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