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COMPARING COMMONLY USED DIVERSITY INDICES TO MEASURE TREE DIVERSITY OF YELLA VILLAGE FOREST OF MULCHERA TALUKA OF GADCHIROLI DISTRICT

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ABSTRACT:

Measuring tree diversity is prerequisite to understand, conserve and manage the forest ecosystem. To measure the tree diversity and to analyse the collected data is always a tedious job. But there are a number of diversity indices proposed by various researchers, which enables us to easily compare and differentiate two or more ecosystems or geographical areas or sites within an ecosystem or geographical area. Still, there may occur confusion while selecting a particular diversity index for any particular study. To overcome such confusions, the present study compares five commonly used diversity indices in forest ecosystems to measure tree diversity.

Yella' village forest of Mulchera taluka of Gadchiroli district is selected for the present study. Sampling was done by using the belt transect method. And with the help of same collected data, five diversity indices i.e., Shannon-Wiener Index, Simpson's Index, Pielou's Index, Margalef's Index and alpha (α)-, beta (β)-, and gamma (γ)- diversity were calculated and compared.

Keywords: - Shannon-Wiener Index, Simpson's Index, Pielou's Index, Margalef's Index, α-, β-, and γ- diversity.

INTRODUCTION :

The total geographical area of Gadchiroli district of Maharashtra state is 14412 sq.km., which is 4.68 % of the total geographical area of the state. But being the most forested district of the Maharashtra, Gadchiroli holds about 20% of total forested area of the state. In 2015, the total forested area of the district was 10,097 sq.km. (ISFR, 2015), which is reduced to 9902.82 sq. km. in 2021 (ISFR, 2021). That means, about 194 sq.km. of forest of Gadchiroli district has been destroyed in last 6 years.

We know that forest provide us number of ecosystem services like food, medicine, fuel, timber, etc. and also help us to clean atmospheric air, to filter water supplies, control soil erosion and flood etc. Forest plays an important role to maintain the CO_2 level by capturing it through photosynthesis. It also provides opportunities for education, research, tourism, aesthetic and cultural enrichment. Beside all this, forest is very important to sustain biodiversity because it is biologically the most diverse ecosystem on land. So many types of microclimate are formed within the forest and within an individual tree in the forest, and hence, supports various life forms. Considering the all above facts, it is very essential to conserve and manage the forests of the Gadchiroli district. And to conserve and manage the forest, measuring its tree diversity is prerequisite. There are number of diversity indices proposed by various researchers to quantify the biodiversity of any area or ecosystem. The commonly used diversity indices in forest ecosystem to measure tree diversity are Shannon-Wiener Index, Simpson's Index, Pielou's Index and Margalef's Index.

In ecology, the biodiversity indices are the numerical indicators of different types of species or genera or families or functional types (depending upon the interest of the researcher)

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present in the study area. Statistically the diversity indices represent biodiversity in various contexts such as richness, evenness and dominance. Richness measures the different types of species present in given area. Evenness measures the relative abundance of different species contributing to richness of an area.

Margalef's diversity index: -

Margalef's index is the measure of species richness. This index was proposed by Ramon Margalef in 1958.

Simpson index:

Simpson index is a popular diversity index. This index is given by Edward Simpson in 1949, and it considers both richness and evenness.

Shannon-Wiener Index:

Shannon–Wiener index is the most widely used and popular diversity index in ecology. This index is derived from information theories developed by Claude E. Shannon and Norbert Wiener and published in 1949 by Shannon and Warren Weaver. This index also accounts both species richness and evenness. It assumes that individuals are randomly sampled from a very large community, and that all species are represented in the sample.

Pielou's Index:

This index was proposed by Pielou in 1966. Pielou's index measures species evenness of the study area or community or ecosystem.

Both Simpson's index and Pielou's index can be used as measures of species dominance (the opposite of diversity) in a study area or community or ecosystem.

In the present study, all the above-mentioned diversity indices are calculated along with the additive model of Whittaker's diversity components i.e., alpha (α)-, beta (β)-, and gamma (γ)- diversity of 'Yella' village forest.

Alpha (α)-, beta (β)-, and gamma (γ)- diversity:

The additive model of Whittaker's diversity components was proposed by Lande in 1996 and Veech et. al. in 2002. According to them these terms are presented as,

Gamma = Alpha + Beta

Alpha diversity is also called as 'species richness' which involves the counting of the number of individuals or even families present within a particular area, habitat or ecosystem. Beta diversity measure is used to compare the alpha diversity of two ecosystems or between two sites of a same ecosystem or between same sites with different period of time. Gamma diversity is the total species richness (alpha diversity) over a large area or landscape.

MATERIALS AND METHODS :

Study area:

The present study is carried out in the village forest of Yella village. Yella village is situated in Mulchera taluka of Gadchiroli district of Maharashtra at 19°50'63" N, 79°88'71" E. The village has more than 100 hectares of village forest on which the forest department has implemented Joint Forest Management (JFM). The village is connected to Chandrapur-Allapalli-Aheri highway and accessible by public and private transport.

Sampling Method:

We applied continuous belt transect method for sampling, because it is fast, systematic and can be applied on large scale. According to Todd A. Grant et al. 2004, belt transect method enables the researcher to detect vegetation problem, to plan management treatments, to evaluate results of restoration efforts and it also helps to develop wildlife-habitat models. We selected two sites viz; Site-A and Site-B within the village forest for sampling.

In case of larger study area, the conscientious study of minimum one hectare area can produce representative sample (M.G. Thakare, 2012); hence at each site, we sampled one hectare area of the village forest by laying 20 quadrats having dimension of 25m X 20m each, with the help of rope, compass and measuring tape. All the trees

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inside the quadrat having GBH (Girth at breast height) ≥ 30 cm identified, counted and noted down.

Formulae applied for calculations:

After collecting data from Site-A and Site-B of the Yella village forest, we calculate four commonly used diversity indices viz; Margalef's Index, Simpson's Index, Shannon-Wiener Index and Pielou's Index and additive model of Whittaker's diversity components i.e., alpha (α)-, beta (β)-, and gamma (γ)- diversity.

1. Margalef's Index:

D_{Mg} = (S-1)/Ln (N)

Where, S = number of species, and N = total number of individuals

Generally, the values of Margalef's index ranges from 0 to 8, the higher values indicate higher diversity.

2. Simpson's Index:

$$D = \frac{\sum_{i=1}^{R} ni(ni-1)}{N\,(N-1)}$$

Where, R is total no. of species pi is the proportion of individuals in i^{th} species, *ni* is the number of individual species and N is total number of species. This formula is used for large sampling area.

The value of D lies between 0 to 1. The value of D = 0 shows infinite diversity and D = 1 shows no diversity. That is, the diversity increases with decreasing value of D.

3. Shannon-Wiener Index:

H' = $-\sum_{i=1}^{S} pi$ ln pi

$pi = ni/N$

Where, S = Total no. of species, p_i = Proportion of individuals of each species belonging to the ith species, n_i = no. of individual of ith species, and N = Total number of individuals.

Generally, Shannon–Wiener index value ranges from 1 to 4, and higher values shows higher diversity.

4. Pielou's evenness Index:

J = H′/ln(S)

Where, H' is Shannon Weiner diversity and S is the total number of species in a study area.

Its value ranges from 0 to 1, where, 0 shows no evenness and 1 shows complete evenness.

5. Formulae to calculate Alpha, beta and gamma diversity:

1. Alpha diversity:

Alpha (α) diversity = Total Number of tree species in sampled site.

2. Beta diversity:

Beta diversity of Site-A and Site-B (β_{ab}) = (α_a-C_{ab}) + (α_b-C_{ab})

Where, α_a and α_b are the alpha diversity of Site-A and Site-B respectively. And C_{ab} is the number of common species in Site-A and Site-B.

3. Gamma diversity:

Gamma diversity of Site-A and Site-B = pooled Alpha diversity of both the Site.

RESULTS AND DISCUSSIONS :

The tree species found in Site-A and Site-B of the village forest of Yella village are given in table no. 1 and table no. 2 respectively.

Sag (Tectona grandis), Palash (Butea monosperma), Ain (Terminalia alata), Mowai (Lannea coromandelica), Dhawda (Anogeissus latifolia) etc. are the predominant tree species at both the Site. From collected data, diversity indices are calculated for each sampled site of Yella village forest. Margalef index, Pielou's index and Whittaker's diversity components are simply calculated on sheet by using their respective formulas, whereas, Simpson's index and Shannon-Wiener index are calculated by applying formula on Microsoft excel worksheet. The values obtained are shown in the table no. 3. The Margalef's index values shows that both the site has poor tree diversity and Site-B has slightly better diversity than Site-A. Simpson's index value of both the sites are nearer to zero, which indicates that the degree of evenness is high or dominance is less. The value of Shannon-Wiener index indicates that both the sites have an average tree diversity. Like

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Simpson's index, the Pielou's evenness index also shows that the degree of evenness is high at both the sites and slightly higher in Site-A.

The additive model of Whittaker's diversity components clearly shows that Site-A have total 13 tree species and Site-B has 17 tree species. When both the sites are compared, it is found that Site-B has 4 unique species which are not present in Site-A. Both the sites share 13 common species and total species richness of both the sites are 17.

It is observed that the values of Margalef's index, Pielou's index and Whittaker's diversity components can be highly influenced by the size of the sample. Margalef's index neglects species evenness, whereas, Pielou's index and Whittaker's diversity components needs the correct estimation of all the species present in the area for its calculation, which is not possible for larger area. Simpson's index is based on dominance and always influenced by the most abundant species and is least sensitive to species richness.

CONCLUSION :

For all sample sizes, the Shannon-Wiener index is best to be used because it is based on information theory and considers both species evenness and species richness. From small to medium sample size, the combination of Shannon-Wiener index and the additive model of Whittaker's diversity Components can be used, because, along with biodiversity status, it can provide detailed information of forest for better understanding and management of forest ecosystem.

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Table No. 1: Tree species at Site-A of Yella village forest

Sr. No.	Species	Scientific name	Family	No. of individuals
1	Ain	*Terminalia alata*	Combretaceae	42
2	Amla	*Phyllanthus emblica*	Euphorbiaceae	1
3	Bor	*Zizyphus mauritiana*	Rhamnaceae	19
4	Dhaman	*Grewia tilifolia*	Tiliaceae	9
5	Dhawada	*Anogeissus latifolia*	Combretaceae	17
6	Garari	*Cleistanthus collinus*	Euphorbiaceae	2
7	Khair	*Acacia catechu*	Mimosaceae	3
8	Moha	*Madhuca indica*	Sapotaceae	8
9	Mowai	*Lannea coromandelica*	Anacardiaceae	48
10	Neem	*Azadirachta indica*	Meliaceae	2
11	Palash	*Butea monosperma*	Fabaceae	49
12	Sag	*Tectona grandis*	Verbenaceae	107
13	Tendu	*Diospyros melanoxylon*	Ebenaceae	39
			Total	**346**

Table No. 2: Tree species at Site-B of Yella village forest

Sr. No.	Species	Scientific name	Family	No. of individuals
1	Ain	*Terminalia alata*	Combretaceae	69
2	Amba	*Mangifera indica*	Anacardiaceae	7
3	Amla	*Phyllanthus emblica*	Euphorbiaceae	2
4	Bor	*Zizyphus mauritiana*	Rhamnaceae	3
5	Dhaman	*Grewia tilifolia*	Tiliaceae	4
6	Dhawada	*Anogeissus latifolia*	Combretaceae	30
7	Garari	*Cleistanthus collinus*	Euphorbiaceae	7
8	Ghoti	*Ziziphus xylopyrus*	Rahamnaceae	10
9	Karai	*Millusa velutina*	Anonaceae	1
10	Khair	*Acacia catechu*	Mimosaceae	8
11	Moha	*Madhuca indica*	Sapotaceae	25
12	Mowai	*Lannea coromandelica*	Anacardiaceae	47
13	Neem	*Azadirachta indica*	Meliaceae	10
14	Palash	*Butea monosperma*	Fabaceae	41
15	Sag	*Tectona grandis*	Verbenaceae	138
16	Sona	*Bauhinia racemosa*	Caesalpiniaceae	2
17	Tendu	*Diospyros melanoxylon*	Ebenaceae	9
			Total	**413**

Table no. 3: Diversity index values of Site-A and Site B

Sr. No.	Diversity Index		Site-A	Site-B
1	Margalef's Index (D_{Mg})		2.0525	2.8223
2	Simpson's Index (D)		0.1667	0.1721
3	Shannon-Wiener Index (H')		2.0199	2.1272
4	Pielou's Evenness Index (J)		0.7875	0.7599
5	Additive model of Whittaker's diversity Components	α	13	17
		β	4	
		γ	17	

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