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Vegetational analysis of open and dense forest under REDD$^+$ project of Mawphlang, Meghalaya

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Abstract
The Khasi hills community REDD$^+$ project is situated in the East Khasi hills District of Meghalaya, India. It deploys strategies for both forest protection and forest degradation or restoration. The project also provides detailed and long-term plans for improving livelihood of surrounding areas. It also aims to show, halt and reserve the loss of the community forests by providing support, new technologies and financial incentives to conserve existing forests and regenerate degraded forests. The area was chosen on the grounds of established Khasi traditions of forest conservation and legal right for natural resource management.
The sacred groves of Khasi hills under REDD$^+$ project with total area 15,217 hectares into dense forest (9,270 ha) and open forest (5,947 ha). Such a diverse forest area needs to be monitored in order to keep a record of the different diversity parameters under check to observe species richness and evenness of the areas. The study conferred that species richness, dense forest showed more evenness, diversity as well as abundance as compared to open forests which is less diverse being a mono-species in the area.

Keywords: REDD$^+$ project, diversity, species richness, evenness, khasi hills.

Introduction
REDD-plus is based on a core principle of financially incentivizing the individuals, communities, and countries to reduce greenhouse gas emissions from forest sector. It is more than a decade when REDD came into existence, yet several elements of it are still to be finalized. The issues of reference levels, MRV of carbon emissions from forest activities, finance and safeguards are some key challenges, which have been centring among most of the climate change negotiations pertaining to REDD-plus. One also needs to find ways to measure reductions in emissions when data are poor or non-existent to put a REDD-plus mechanism into action. It is further required to ensure that reductions in deforestation and degradation are real and it should create mechanism that stops destruction of forest in non-project areas or other countries. (www.un-redd.org).
Meghalaya, one of the north-eastern states, is often cited as a special case of community forest management undisrupted by colonialism where communities have managed their resources traditionally for many generations. On the other hand, the state is frequently used as an example for insufficient community forest management, referring to the extensive environmental degradation through ruthless exploitation of resources such as timber, coal, and limestone. Community Forestry International was approached by the Khasi community leaders in 2005 where a request was made for institutional, technical and financial assistance in order to gain capacity to conserve and restore their community forests. This request was done in response to growing concerns over forest degradation and the increasing pressure on sacred groves and other natural resources in their Umian Watershed. The Umian watershed has the highest recorded rainfall in the world but. Despite this fact the region is experiencing increasing dry season droughts due to accelerated deforestation. This combined with an increased temperature undermines the hydrological function of this critical watershed, disrupting agricultural practices and creating intensified cyclonic storms contributing to erosion and downstream flooding in the Bangladesh (Gangetic) and Assam (Brahmaputra) river basins. (Poffenberger 2012).
The project represents an innovative approach to community-based forest conservation and restoration that has broad application in the neighbouring watersheds in the Khasi hills, as well as more broadly across Meghalaya. The project also seeks to build community institutional capacity to monitor changes in forest cover, hydrological conditions, and biodiversity. The project is located on the traditional forest lands of the Khasi people, which are recognized by the Government of India as community forests under the Sixth Schedule of the Constitution.

Material and Methods

1. Vegetation Analysis

The study area was divided into two sites open and dense at different location. The forest stand was analysed using ten randomly placed quadrates CBH of each in dividable tree in each quadrate was measured and recorded. The primary analysis of the vegetation was carried out to obtain the value of various parameter like density, frequency and abundance (Curtish and McIntosh 1950).

2. Frequency

Frequency is the important parameter of vegetation analysis, which reflects the spread, distribution or dispersion of a species in a given area and given in percent. The % frequency of a species in a given area is studied by either quadrant method or transects and is calculated by the following formula:

$$\text{Frequency} = \frac{\text{No. of quadrant in which species occured}}{\text{total no. of quadrant studied}} \times 100$$

Relative frequency was calculated by the formula,

$$\text{Relative frequency} = \frac{\text{Number of quadrats in which species occured}}{\text{Total number of quadrats by all species}} \times 100$$

3. Density

It is defined as the number of individuals of a particular species per unit area and is given as:

$$\text{Density} = \frac{\text{Total number of individuals of the species}}{\text{Total number of quadrats used in sampling}}$$

The relative density is the study of numerical strength of a species in relation to total number of individuals of all species and calculated as:

$$\text{Relative density} = \frac{\text{Total number of individuals of the species}}{\text{Sum of all individuals of all species}} \times 100$$

4. Abundance

It is also calculated like density but in this case, only those quadrants are considered for calculation where a species occurs. The formula for calculation of species abundance is:

$$\text{Abundance} = \frac{\text{Total number of individuals of the species}}{\text{Number of quadrats in which they Occured}}$$

5. Dominance

Dominance is measure of the size, bulk, or weight of the vegetation.

Dominant species are those which are highly successful ecologically and determine (to a considerable extent) the condition under which the associated species must grow. It can be calculated as follow-

$$\text{Dominance} = \frac{\text{Total basal area or crown}}{\text{Total area sampled}}$$

Relative dominance is the relative proportion of different species in the community.

$$\text{Dominance Relative} = \frac{\text{Dominance of given species}}{\text{Total dominance ofall species}} \times 100$$

6. Diversity

Diversity measures takes in to account two factors, species richness, that is, number of species, and evenness (sometimes known as equitability), that is, how equally abundant the species are. Although, diversity is one of the central themes of ecology, there has been considerable disagreement about how it should be measured (Magurran, 1988).

The simplest diversity measure is the total number of species recorded i.e. S, often described as alpha diversity or species richness. In the present study diversity values are compared in between eight regions.

$$\text{Species richness (SR)} = \frac{\text{S-1}}{\text{In(N)}}$$

- Where, SR is the Margalef Index of species richness. S is the number of species and N is the total no. of individuals (Margalef 1972).

$$\text{Equitability or Evenness (J')} = \frac{\text{H'}}{\text{In S}}$$

- Where, H is the Shannon- Weiner Index and S is the number of individual of all the species.

For the analysis of vegetation following most widely used indices has been calculated.

a. Shannon Diversity index: It is one of the most important indexes of diversity. Shannon and Wiener independently derived this index.

It is sometimes incorrectly referred to as Shannon-Weaver index (Krebs, 1985). The Shannon index assumes that individuals are randomly sampled from an indefinitely large population. The index also assumes that all species are represented in the sample. It is calculated from the formula -

$$H' = \sum Pi\ ln \sum Pi$$

Where Pi is the proportional abundance of i^{th} species = (ni/N).

- The value ranges from 0-4 where 0 or near 0 is considered to show less evenness and 1.5 to 3.5 shows complete evenness.

b. Simpson's Index: Simpson (1949) gave the probability of any two individuals drawn at random from an indefinitely large community belonging to different species as

$$D = \sum \left[\frac{ni(ni-1)}{N(N-1)}\right]$$

Where, ni = the number of individuals in the i^{th} species, and N = the total number of individuals.

- The value ranges from 0-1 where, 0 or close to 0 shows high diversity whereas 1 or close to 1 shows low diversity.

7. Importance Value Index:

The importance value index is statistical measure, which gives an overall picture of the importance of the species in the vegetation community and is given by,

IVI = Relative density + Relative frequency + Relative dominance

Results and Discussions

Vegetational analysis of dense and open plot

Dense Forest Summit

Table 1 revealed that a total of 348 individuals of 10 different species were found in the dense forest summit. The maximum number of individual tree species were of *Quercus fenestrata* (178) followed by Symplococus (63). The density of Quercus fenestrata (22) is highest followed by Symplococus (64). Quercus fenestrata and Rhododendron arboreum (22) is the most abundant tree species followed by Symplococus (12.8). The basal area of Quercus fenestrata (1415.2) is the highest followed by Rhododendron arboreum (444.24). The most dominant tree species is Quercus fenestrata (1555.2) followed by Rhododendron arboreum (500.24). The total basal area recorded for dense forest summit is 3394.57 cm^2.

Open Forest Summit

Table 2 revealed that a total of 247 individuals of 9 different species were found in the open forest summit. The maximum number of individual tree species were of Pinus kesiya (212) followed by Myrica esculenta (19). The density of Pinus kesiya (48.6) is the highest followed by Myrica esculenta (2.4). Pinus kesiya (60.75) is the most abundant tree species followed by Myrica esculenta (12). The basal area of Pinus kesiya (2347.47) is highest followed by Myrica esculenta (204.81). The most dominant tree species is Pinus kesiya (2517.4) followed by Myrica esculenta (229.863). The total basal area recorded for dense forest summit was 31112.12 cm^2.

Table 1- Different parameters recorded for vegetational analysis in dense forest summit

S. No	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Trees	***Castonopsis indica***	***Eurya acuminata***	***Myrica esculenta***	***Pinus kesiya***	***Quercus fenestrata***	***Quercus griffithii***	***Rhododendron arboreum***	***Symplocos***	***Viburnum foetidum***	***Vaccinum graffithianum***	
Equitability	0.03	0.05	0.05	0.06	0.15	0.03	0.01	0.01	0.02	0.04	0.71
Species Richness	9.82	9.82	9.82	9.82	9.82	9.82	9.82	9.82	9.82	9.82	
Simpson's Index	0.0003	0.001	0.001	0.002	0.16	0.0003	0.02	0.05	0.0001	0.001	0.24
Shannon- Diversity Index	0.07	0.12	0.12	0.15	0.36	0.07	0.29	0.33	0.04	0.11	1.70
IVI	22.31	145.02	25.40	261.33	1555.2	217.10	500.24	440.60	75.47	151.80	3394.56
Relative Dominance	0.004	0.5	0.01	1.89	12.45	1.54	3.90	2.79	0.30	0.60	
Relative Frequency	20	80	20	40	100	40	40	100	40	80	
Relative Density	1.81	3.63	3.63	5.45	40	1.81	16	23.27	1.09	3.27	
Basal Area (cm^2)	0.49	61.38	1.77	215.88	1415.22	175.29	444.24	317.38	34.38	68.53	2734.56
Abundance	5	2.5	10	7.5	22	2.5	22	12.8	1.5	2.25	
Frequency	0.2	0.8	0.2	0.4	1	0.4	0.4	1	0.4	0.8	
Density	1	2	2	3	22	1	8.8	12.8	0.6	1.8	
No. Of Indi. Tree	5	10	10	15	178	9	46	63	3	9	348

Table 2- Different parameters recorded for vegetational analysis in open forest summit

Sl. No	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
Trees	**Engelhardita spicata**	**Exbuclanda populnea**	**Helicia erratica**	**Rhus javanica**	**Schima wallichi**	**Eurya acuminate**	**Myrica esculenta**	**Pinus kesiya**	**Quercus fenestrata**	
Equitability	0.02	0.01	0.04	0.01	0.01	0.01	0.08	0.05	0.01	0.27
Species Richness	8.82	8.82	8.82	8.82	8.82	8.82	8.82	8.82	8.82	
Simpson's Index	0.0001	0.00001	0.0005	0.00006	0.00001	0.00001	0.0057	0.73	0.00006	0.74
Shannon- Diversity Index	0.05	0.02	0.08	0.03	0.02	0.02	0.19	0.12	0.03	0.61
IVI	43.47	28.21	106.20	37.14	58.83	46.15	229.23	2517.13	45.70	3112.12
Relative Dominance	0.21	0.07	0.79	0.15	0.36	0.24	1.93	22.19	0.23	
Relative Frequency	20	20	20	20	20	20	20	80	20	
Relative Density	1.10	0.36	2.21	0.73	0.36	0.36	4.42	89.66	0.73	
BASAL AREA (Cm^2)	22.37	7.85	83.99	16.40	38.46	25.79	204.81	2347.47	24.96	2772.12
Abundance	3	1	6	2	1	1	12	60.75	2	
Frequency	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.8	0.2	
Density	0.6	0.2	1.2	0.4	0.2	0.2	2.4	48.6	0.4	
No. of Indi. Tree	3	1	6	2	1	1	19	212	2	247

A total of 15 different tree species in 5 different plots open and dense forest sites were found at sacred groves in Mawphlang forest of Meghalaya.

Table 3 revealed the diversity parameters of trees in Mawphlang forest Meghalaya. The Shannon-weiner index (H') of trees in summit of the dense forest was recorded highest followed by summit of open forest. Concentration of dominance (Cd) of tree in summit of open forest was *highest* followed by summit of dense forest. Equitability (J') of trees was higher in summit of dense forest followed by open forest. Species richness (SR) of tree was highest in summit of dense forest followed by open forest.

Table 3: Diversity parameter of trees in Mawphlang forest

Sites	**Shannon-weiner index (H') (Range 0-4)**	**Value interpretation**	**Simpson's index (Range 0-1)**	**Value interpretation**	**Equitability (J')**	**Value interpretation**	**Species-richness(SR)**	**Value interpretation**
Summit of dense forest	1.70	Complete evenness	0.24	High diversity	0.71	High equitability	9.82	High richness
Summit of open forest	0.50	Low evenness	0.80	Low diversity	0.22	Low equitability	8.82	Relatively Less richness

***Value of all the parameters-**

1. **Shannon- weiner index-** the value ranges from 0 to 4 with values 0 or near zero representing low evenness and values with 1 to 4 representing complete evenness.
2. **Simpson's index-** the value ranges from 0 to 1 with values near 0 or 0 representing high diversity and values near 1 or 1 representing low diversity.
3. **Equitability-** the closer the value is to 1 the high equitability it shows.
4. **Species richness**- the higher the value the higher richness it has.

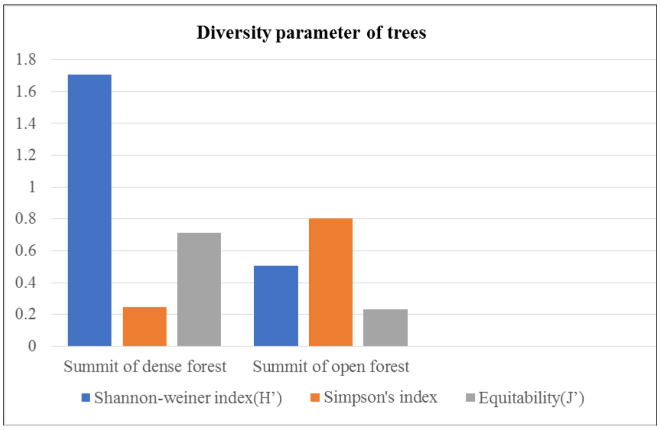

Fig 1: Diversity parameter of trees

Conclusion

From the present research work it was concluded that the selected forest sites of Khasi hills under REDD+ in Mawphlang, Meghalaya composed of 546 individuals of 15 different tree species. The dominant tree species and sub species in the dense forest were *Querecus fenestrate* and *Pinus kesia* respectively, however in open forest *Pinus kesia* showed highest dominance.

The diversity parameters revealed that the dense forest shows more evenness of species, diversity as well as abundance as compared to open forests which is less diverse because of mono species.

Hence, it can be concluded that due to low level of disturbances the sacred forests of the Mawphlang, Meghalaya remains rich in diversity as compared to other sacred groves which are facing different degrees of disturbances. Due to time and logistical limitations, not every sacred grove of the state in the study region of Meghalaya could be visited. Hence comprehensive study of sacred groves throughout India is still needed, for an inventory of the number, size, and distribution of sacred groves as well as systematic botanical survey of sacred groves predicting that this would lead to discovery of new species.

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