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Dynamics of Shrubs Diversity in Chitrakoot Forest Range of Satna District

Mayur Chandranshu Mishra, Ravindra Singh* & Sadhana Chaurasia**
Research Scholar, Department of Biological Sciences
*Head, Department of Biological Sciences
**Head, Department of Energy & Environment
Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna (M.P.)
Adarsh Nagar, Chitrakoot, Satna (Madhya Pradesh) 485334

ABSTRACT

Recent centuries have seen significant changes in plant communities, although not all of these changes are consistent with the prevalent narrative of a biodiversity crisis. Although few extinctions have been recorded during the Anthropocene to date (0.1%), future decreases in plant species diversity are highly anticipated given habitat conversion in the tropics. In many parts of the world, the introduction of non-native species has considerably enhanced the diversity of plant species. At the same time, by bringing previously separated congeners into close proximity, these imports have also sparked the emergence of novel hybrid polyploidy species. At the local level, the conversion of primary vegetation to agriculture has reduced plant diversity, whereas other drivers of change, such as climate change, habitat loss, and nitrogen deposition, have effects that are highly context dependent and produce a distribution of temporal trends with a mean close to zero. These findings necessitate a review of the criteria used to establish and support conservation objectives. The preservation of biodiversity is a major concern in current forest management and can help human societies ensure the long-term sustainability of forest ecosystems, services, and resources. As the earliest woody plants in the succession process and capable of driving the development and succession of the canopy, understory shrubs serve as backup plants for the regeneration, development, and succession of forest ecosystems. In plantations, where it is essential for the growth of communities and the preservation of diversity, the diversity of shrubs is a significant part of the biodiversity of the forest. Additionally, shrubs maintain the soil quality of the stand and are crucial for the growth of forests, the transformation of agriculture into woods, etc. In this study dynamics of shrub diversity of Chitrakoot has been provided. The study area has 18919.80 ha area which is divided in 15 beats, 8 blocks and 86 compartments. Where the data shows primarily 29 types of shrub species with the total number of 16209 individuals. Dominance of *Lantana camara*, *Carissa opaca*, & *Solanum nigrum* has been noted. The different indices of plant diversity show highly diversified flora of shrub in study area.

Key Words: Anthropocene, Biodiversity, Chitrakoot Forest Range, Sustainability, Shrubs.

Introduction

One of the key objectives that ecologists should still strive to achieve is mapping the spread of biodiversity. One of the first "spatial thinkers" and biodiversity mappers in the ecological tradition was Alexander von Humboldt (1769–1859). One of the first scientists to use maps to establish and verify scientific hypotheses, he defined the latitudinal and altitudinal distributions of vegetation zones. The study of mapping the distribution of biodiversity among naturalists gained traction at the turn of the 20th century as a result of Charles Darwin's theories about the necessity of taking into account the intricate interactions between organisms and their environment. Ernst Haeckel (1834–1919) even coined the terms "ecology" and "chorology," the latter of which is defined as "The science of the geographic and topographic spread of organisms.

Biodiversity objectives are the minimal percentages of each ecosystem type that must be preserved in a natural or nearly natural form over the long term in order to preserve a representative sample of all ecosystem types and the vast majority of species associated with those ecosystem types. These goals are typically expressed as a percentage of the historical context of each ecosystem type, which helps to address the question of "How much is enough to ensure the long-term persistence of biodiversity?" The assessment should begin with the establishment of biodiversity targets, which are quantitative interpretations of conservation objectives.[1]

In addition to having a significant impact on the preservation of biodiversity, these trends in forest cover and conditions are also significant because of the vast array of vital ecosystem services that forests provide, including the regulation of the climate, the provision of clean water, pollination, and habitat for forest species. Furthermore, there is mounting evidence that many characteristics of biodiversity are related to the supply of ecosystem services; biodiversity and the majority of ecosystem services have a positive relationship. Biodiversity and ecosystem services have been linked in a variety of ways that can be explained. There may be a complementarity of functional response features as well as niche complementarity in time and location at play.[2]

We concentrate on India since it contains about 8% of the world's biodiversity on just 2.5% of its total land area. India is one of Vavilov's eight global crop diversity hotspots and is home to portions of four of the 36 biodiversity hotspots on the planet. The distinct and varied ecosystems of India, which are spread throughout a variety of cultivated areas, rivers, and seas, are also economically valuable.[3]

India faces a variety of obstacles when it comes to the sustainable use of biodiversity, yet the country's investments in cross-disciplinary biodiversity studies are insufficient given how serious these obstacles are. Habitats on land and in the ocean are disappearing quickly. India is one of the nations with the highest rates of habitat conservation.[4]

STUDY AREA: Satna district is located in between $23^0 58'$ to 25^0 12'N and 80^0 21'to $81^0$23' E in Madhya Pradesh. Satna district has 750200 ha geographical area with 203700 ha forest area. The total forested area is (27.15%) divided in to 10 forest ranges and 150 forest beats.

The study area is Chitrakoot forest range. It has 18919.80 ha area which is divided in 15 beats, 8 blocks and 86 compartments. The vegetation of Satna forest is tropical dry deciduous type (Champion and Seth 1968). It is Vindhyan range of forest. They are functioning like lungs and help to maintain its environment[5].

PHYSIOGRAPHY: Chitrakoot comprises vast diversity in its topography, climate, soils and vegetation. The region presents huge varieties of landforms from deep valleys to lofty mountains. [6]

GEOGRAPHY: Chitrakoot is a prehistorically and mythological place, lies between 80^0 44' – 80^0 54' E latitude and 25^0 12'- 25^0 19' N longitude on the border of Madhya Pradesh and Uttar Pradesh in Satna and Karwi District respectively. The forest area of Chitrakoot is 18919.80 hectare, in which our study area will be fallen.[6]

GEOLOGY/MINERALS: A number of rock types of Chitrakoot region belonging to various formations from the oldest unclassified crystalline to the youngest (recent) alluvium constitute the geology of the area.

SOIL TYPES: Soils occurring within the Chitrakoot are in general relation to the underlying rocks, except the alluvial deposits. These deposits are mostly red and black colors with intermediate shades. Soils on the plateau are sand-to-sandy loam.

CLIMATE: The area of Chitrakoot has a typical climate condition because it is situated in the close vicinity of the Tropic of Cancer is land-locked. The temperature and rainfall data is obtained from Satna District metrological department. There are three seasons: (1) Summer, (2) Rainy, (3) Winter. The period of March to June is dry and hot and constitutes the summer season. The period of July to October is moist and hot and constitutes the rainy season. The period of November to February is moist and cold and constitutes the winter season.[6]

VEGETATION TYPE: Vegetation of Chitrakoot are tropical deciduous mixed type. In Chitrakoot forest range 41% area is covered by the forests out of total area of 18919.80 ha. As far as the vegetation of the Chitrakoot is concerned, topography, climate and soil from base to summit and hilly terrain show great variation resulting in enormous diversity at species and habitat levels.[5]

Madhya Pradesh, which covers roughly 3 lakh acres of land, where the forest regions are primarily located. In the Manjhgawan block of the Satna range, the topography is hilly and undulating, ranging from 500 feet to 2354 feet. Vindhyan sediment, Bundelkhand granite, and gneisses are the main geological features in the region.[5]

Materials & Methods

Characterization of Study Area:

This study was conducted on Chitrakoot Forest range, administrated by Department of Biological Sciences, Mahatma Gandhi Chitrakoot Gramodaya University, Chitrakoot.

The flora is located in northeast of the State of Madhya Pradesh, in Central India, in the city of Satna, in the Chitrakoot Forest range. The study area Chitrakoot forest range has 18919.80 ha area which is divided in 15 beats, 8 blocks and 86 compartments. In which 8746.62 ha is dense forest which are occupied by native forests and 4582.37 ha is open type of forest where planted forests, disturbed regimes were presented. [6]

The region is one of drier region of the state, with lesser rain than 800 mm per year and with annual average temperature 26^0C, although it goes 35^0C – 45^0C in summer. The average annual humidity of the area is 56.29%. The area's climate conditions are classified as Semi-arid climatic condition. Water scarcity is a key factor of this area.[6]

The Chitrakoot Forest range is predominantly consisting of tropical deciduous & mixed forest types. Mixed forests occur on underlying rock which is generally sand stones and shales. The soil is sandy to sandy loam, fine to coarse grained and red lateritic. The areas having shallow, coarse-grained sandy and red lateritic soil bear very poor quality forests.[8]

A large number of shrub species constitute mixed forests, out of which *Lantana camara, Carissa opaca,* & *Solanum nigrum* are predominant. Where we primarily seen 29 types of shrub species with the total number of 16209 individuals.

The stock in mixed forests is insufficient. Due to the generally dry weather, the woodlands are open and have minimal growth. Due to biotic interference such as frequent fires, unrestricted heavy grazing, overexploitation, and indiscriminate nectar cutting, tree development is slowing down at an alarming rate as a result of the oversupply.[9]

Sampling: The work was performed in quadrats of 5 x 5 m (25 m^2). Where vegetation surveys and environmental parameters were made.[7]

Data Collection:

Initially bird eye surveyed was performed for the classification of vegetation and vegetation type. The literature revealed that the method is non-destructive and is most suitable method (FAO 1997).[10]

❖ **Biodiversity Indices:**

Biodiversity indices that provided the evaluation for this work were presented by tables. These were calculated for each sampling unit leased in the study area, both for natural regeneration and for arboreal component. Which are follows: -

A. **Alpha diversity:** The majority of the proposed methods to quantify the biodiversity of species refer to the diversity within communities, namely as alpha diversity. Within this, there are methods based on quantification of the number of the species (richness) & those based on community structure, these can still be based on the information, on dominance or equity of the community.

(1) **Species richness:** The metrics for species richness give diversity an immediate and comprehensible expression. We might mention the Margalef and Menhinic indices while discussing species richness indicators. These indices do a relationship between the numbers of individuals, and the larger the area of the sampling unit. The value of index increases with the number of species entered. The straight forward calculation of the Margalef and Menhinick index, which has been used effectively in academic papers, is one of its major merits.

Margalef Richness Index (R_1) = $\frac{S-1}{\ln N}$

Menhinick Index (R_2) = $\frac{S}{\sqrt{\sum_i n_i}}$

(2) **Information:** The indices based on information theory that are used the most frequently. These metrics are followed are founded on idea that information contained in a code may be quantify similarly to variety or information found in a natural system. The Shannon-Wiener index function was developed by Shannon and Wiener. Researchers have incorrectly referred to it as “Shannon-weaver” in various studies. This index assumes that individuals are chosen at random from an “infinitely huge” population.

Shannon Index (H’) = $-\sum_i \left(\frac{n_i}{N} \cdot \log_2\left(\frac{n_i}{N}\right)\right)$

When there is just one species present and when all species are represented by the same number of in individuals, the Shannon index assumes a vale of zero. Shannon values typically range between 1.3 and 3.5, but they can exceed 4.0 and become as high 4.5 in areas with tropical forest. If there is no objective way to differentiate between abundance and rarity, the authors even assert that this index gives rare species a higher value and is one of the finest indices to employ in comparisons

(3) **Dominance:** The concepts of uniformity are inverse parameter to the dominance based indexes. Without assessing the contribution of other species, these indexes consider the representativeness of the species with the highest value of importance. We can mention the Simpson and MacIntosh indices as examples of this. The Simpson index displays the likelihood that two randomly selected individuals from a particular community belong to a different species. The most prevalent species in the sampling unit has a significant impact on this score, whereas species richness has the least impact. From 0 to 1, the Simpson index scales; the closer it is to 1, the greater dominance. On the other hand, as their values get nearer to 0, the MacIntosh will exert more control. The index of MacIntosh can be calculated as a measure of diversity or dominance that is independent of the overall population size even if it is not a dominance index.

Simpson Index (D) $= \frac{\sum_i n_i(n_i-1)}{N(N-1)}$

MacIntosh Index (D) $= \frac{n-U}{n-\sqrt{n}}$

Dominance Index $= 1-\left(\frac{\sum_i n_i(n_i-1)}{N(N-1)}\right)$

(4) **Equity:** The equity indices reflect how the population of each species is spread, indicating whether the composition of the parcels is more or less uniform. We can name the Pielou, Hill and Alatalo. Pielou index is the most commonly used within the category equity, and measures the proportion of diversity observed with respect to the maximum expected diversity. The value of this index varies from 0 to 1, and when it reaches the value 1, it means that all species are equally abundant.

Hill Index $= E' = \frac{N2}{N1}$

Pielou Index $= J' = \frac{H'}{Hmax}$

Alatalo Index $= F = \frac{N2-1}{N1-1}$

The Hill index is more frequently employed in studies of wildlife than in vegetation. This index describes how the abundance of the species is spread within a community. The equity index must take the greatest value when every species in the sample is plentiful, and it falls until it reaches zero as the relative abundances of species depart from equality. The Simpson and Shannon indices are its input parameters. The Hill index, which reaches high value when equity is strong or when a species dominates the community, might lead to misunderstanding in some specific situations.

Simpson Index $= \frac{\sum_i n_i(n_i-1)}{N(N-1)}$

(A) **Beta diversity:**

The degree of species changes and biotic change brought about by environmental gradients is represented by beta diversity, or the diversity of habitats. It is based on properties of differences, which can be measured using beta diversity indices as well as similarity coefficients of dissimilarity between the plots, depending on qualitative or quantitative data. It is also based on proportions, which can be measured using beta diversity indices as well as similarity coefficient of distance between the plots, depending on qualitative or quantitative data.
The use of similarity coefficients is the simplest methods for measuring beta diversity between pairs of localities. The Jaccard and Sorensen indexes are the most popular. These indices are intended to equal 1 in complete similarity circumstances a zero in dissimilarity cases. The Simplicity of these methods is one of the major benefits. Since the coefficients do not account for species abundance, this could also be a drawback. Whether they are common or rare, all species are given the same importance in calculation.

Absolute beta Value $= ((S_0\text{-}c)\text{-}(S_1\text{-}c))$

Jaccard Index $(Ij) = \frac{c}{a+b+C} = \frac{c}{A+B-C}$

Sorensen Index $(Is) = \frac{2c}{a+b} = \frac{2c}{A+B-c}$

Result & Discussion

The study has been taken place in different set of indices for all the data of shrub species. In findings, get 29 types of shrub species which is consisting of 16209 number of shrubs in various sampling stations. Those sampling sets have been setup between 86 compartments of all the 15 beats and 8 blocks of Chitrakoot forest range where the random sampling of quadrate method has been applied. During the sampling the higher numbers of seedling and sapling has been noted which shows the higher regeneration capacity of forest area.

The various indices were shown formulas on the given data of Herb, Shrub & Tree. Which gives the various results where Margalef and Mehinick indexes represents the higher & lower diversity of these herb, shrub & tree species. And Simpson and MacIntosh indexes represent the higher & lower dominance of these species. And Shanon values represents the lower diversity. And Pielou, Alatalo and Hill index represents the uniformity levels of these species. Jaccard and Sorensen indexes are representing the values for the higher and lower similarity rates between these herbs, shrubs and trees species with graphs as well which are follows-

Table 1: Various Indices Results

Dataset Totals			
Total Number of Shrubs:	16209	Total Number of Species:	29
Average population size:	558.9	Decimal Accuracy:	4
Total Number of Regions:	1	Total Number of Region Sets:	420

Table 2: Result of Alpha Biodiversity [α] Indices

Alpha Biodiversity [α]			
Simpson Index $\frac{\sum_i n_i(n_i-1)}{N(N-1)}$	0.4227	Simpson Index Approximation $\frac{\sum_i n_i^2}{N^2}$	0.4228
Dominance Index $1-\left(\frac{\sum_i n_i(n_i-1)}{N(N-1)}\right)$	0.5773	Dominance Index Approximation $1-\left(\frac{\sum_i n_i^2}{N^2}\right)$	0.5772
Reciprocal Simpson Index $\frac{1}{\left(\frac{\sum_i n_i^2}{N^2}\right)}$	2.366	Alternate Reciprocal Simpson Index $\frac{1}{\left(\frac{\sum_i n_i(n_i-1)}{N(N-1)}\right)}$	2.365
Shannon Index $-\sum_i\left(\frac{n_i}{N}\cdot\log_2\left(\frac{n_i}{N}\right)\right)$	2.322	Berger-Parker Dominance Index $\frac{n_{max}}{N}$	0.6387
Shannon Index $-\sum_i\left(\frac{n_i}{N}\cdot\ln\left(\frac{n_i}{N}\right)\right)$	1.609	Inverted Berger-Parker Dominance Index $\frac{N}{n_{max}}$	1.566
Shannon Index $\sum_i\left(\frac{n_i}{N}\cdot\log_{10}\left(\frac{n_i}{N}\right)\right)$	-0.6989	Margalef Richness Index $\frac{S-1}{\ln N}$	2.889
Menhinick Index $\frac{S}{\sqrt{\sum_i n_i}}$	0.2278	Rényi Entropy/Hill Numbers (r=0,1,2,∞) $\frac{1}{1-r}\cdot\ln\left(\sum_i p_i^r\right)$	29, 5.096, 2.365, ≈∞
Buzas and Gibson's Index $\frac{e^{-\sum_i\left(\frac{n_i}{N}\cdot\ln\left(\frac{n_i}{N}\right)\right)}}{S}$	0.1724	Gini Coeffificient $\frac{2\Sigma_i\, in_i}{n\Sigma_i\, n_i}-\frac{N+1}{N}$	0.8084
Equitability Index $-\frac{\sum_i\left(\frac{n_i}{N}\cdot\ln\left(\frac{n_i}{N}\right)\right)}{\ln N}$	0.4779	ln() of Hill Numbers (0,1,2,∞):	3.367, 1.628, 0.8609, ≈0.4488

Table 3: Result of Beta Biodiversity [β] Indices

Beta Biodiversity [β] *Comparing two sample areas*			
Absolute beta Value ($(S_0-c)-(S_1-c)...$):	28	Whittaker's Index (S/alpha):	1
Sørensen's similarity index:	1	Alternate Whittaker's Index (S/alpha-1):	0
Sørensen's similarity index (%):	100%	Jaccard Index:	-1
Routledge beta-R Index:	9.667	Jaccard Index (%):	-100%
Mountford Index:	-0.07407	Number of Common Species:	29
Mountford Index (%):	-7.407%	Bray Curtis dissimilarity	0

Table 4: Result of Beta Gamma Biodiversity [γ] Indices

Gamma Biodiversity [γ] *Comparing many sample areas*			
Absolute gamma ($S_0+S_1...-c$):	0		

By the definitions used in this calculator, Alpha indices are for a single sample of a single region. This is the most typical way to study and measure biodiversity. These indices are calculated with *all* data provided to the calculator as a single sample, if you are unsure which indices to use, start with Alpha values. Beta diversity indices compare two sample regions for "similarity" and other correlations of biodiversity between *two different* areas/regions. This is less common and requires careful, consistent data collection to be useful. Gamma diversity indices calculator for large or global areas, where many samples are being compared, and are the rarest to use in published studies and articles.

Table 5: Dynamic Charts

Species Name159131721252902,5005,0007,50010,00012,500Species

S. No.	Species Name Local Name	Species Name Botanical Name	Population
1	*CHITRAK*	*(Plumbago zeylanica)*	204
2	BHUIKHAJUR	(*Phoenix acaulis*)	83
3	VANKAPAS	(*Thespesia lampas*)	87
4	JUNGLI BHANTA	(*Solanum incanum)*	96
5	ATHIL	(*Helicteres isora)*	76
6	ARAND	(*Ricinus communis)*	97
7	BADI KATAIYA	(*Solanum violaceum*)	203
8	KANGHI	(*Abutilon indicum)*	66
9	KASAUNDHI	(*Cassia occidentalis*)	101
10	KATSARAIYA	(*Barleria prionitis)*	116
11	MARODFALI	(*Helicteres isora)*	192
12	MAANKAND	(*Flemingia nana)*	74
13	SAFED MADAR	*(Calotropis gigantea)*	94
14	SITAFAL	(*Annona sequamosa L.*)	63
15	SEHUR	(*Euphorbia nenifolia L.*)	442
16	ADUSAA	(*Adhatoda zeylanica*)	30
17	GANGERUAA	(*Grewia rothii DC.)*	53
18	GUDSANKRI	(*Grewia hirsuta vahi)*	122
19	DHAWAII	*(Woodfordia fruticosa)*	134
20	GHOTHAR	(*Ziziphus xylopytus)*	98
21	BARIYARI	(*Ziziphus oenoplia*)	64
22	KARAUNDA	(*Carissa opaca)*	1,044
23	DHATURA	(*Datura metel)*	39

24	NIRGUNDI	*(Vitex negundo*)	74
25	HAR SINGAR	*(Nyctanthes arbortristis)*	41
26	BER	(*Ziziphus nummularia)*	898
27	GULABI MADAAR	(*Calotropis procera*)	18
28	MAKOYE	(*Solanum nigrum*)	1,248
29	GANDHATA	(*Lantana camara*)	10,352

Lorenz graph05010002040608010 0Total Population (%)

Table 6: Equtity Population

Species (%)	Total Population (%)	Line of Perfect Equality (%)
0	0	0
3.448	0.111	3.448
6.897	0.296	6.897
10.34	0.537	10.34
13.79	0.79	13.79
17.24	1.117	17.24
20.69	1.505	20.69
24.14	1.9	24.14
27.59	2.307	27.59
31.03	2.764	31.03
34.48	3.22	34.48
37.93	3.689	37.93
41.38	4.201	41.38
44.83	4.738	44.83
48.28	5.318	48.28
51.72	5.91	51.72
55.17	6.509	55.17
58.62	7.113	58.62
62.07	7.736	62.07
65.52	8.452	65.52
68.97	9.205	68.97
72.41	10.03	72.41
75.86	11.22	75.86
79.31	12.47	79.31
82.76	13.73	82.76
86.21	16.45	86.21
89.66	21.99	89.66

93.1	28.43	93.1
96.55	36.13	96.55
100	100	100

Table 7: Integrated Diversity Interpretation

S. No.	Diversity Indices	Index	Standard Values	Inference	Result	Classification
1.	**Species Richness**	Margalef Index	0-8	Inversely Proportional	2.88	High Diversity
		Menhinick Index	0-8	Inversely Proportional	0.22	High Diversity
		Whittaker Index	0-8	Inversely Proportional	1	High Diversity
2.	**Dominance**	Simpson Index	0-1	Direct Proportional	0.42	Medium Dominance
		Reciprocal Simpson Index	0-1	Direct Proportional	2.36	Very High Dominance
		Dominance Index	0-1	Direct Proportional	0.57	Medium Dominance
3.	**Information**	Shanon Index	1.5-3.5	Direct Proportional	1.60	Medium Diversity
4.	**Equity**	Equitability	0-1	Direct Proportional	0.47	Medium Uniformity
		Gini Coefficient Index	0-1	Direct Proportional	0.80	High Uniformity
5.	**Similarity**	Jaccard Index	0-1	Direct Proportional	-1	Very low similarity
		Sorensen Index	0-1	Direct Proportional	1	High Similarity
		Mountford Index	0-1	Direct Proportional	0.07	Low Similarity
		Bray Curtis Index	0-1	Direct Proportional	0	Low Similarity

CONCLUSION

The diversity of shrubs in Chitrakoot forest range Satna is as follows. Species richness of shrubs are highly diversifying in the area but dominance of species is medium according to Simpson and Dominance index but according to Reciprocal Simpson index result is showing very high dominance.

Information regarding the diversity Shanon index shows medium diversities. In the equitability of species are medium uniform but Ginny coefficient index is shows high uniformity.

Similarity index is showing low to very low similarity between the sampled areas therefore in integrated manner the Chitrakoot forest range is higher diversified regarding the shrubs population.

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Reference

1. Williams D.M., Ebach M.C., 2008, Biogeographical Relationships, Evolution, and Classification. *Foundations of Systematics and Biogeography, Springer, Boston, p.p.* 228-258
2. Ghosh S, 2020, Bringing biodiversity and conservation to the forefront in India, *Mongabay Series.*
3. Joshi N. 2019, Global biodiversity an overview and Indian perspective. Biodiversity International Journal, DOI:10.15406/bij.2019.03.00118
4. Patricia M., Pavol E., 2016, The role of phytodiversity in riparian alder forests in supporting the provision of ecosystem services, *Acta Regionalia et Environmentalica*, DOI:10.1515/aree-2016-0010
5. Champion, H. G. and Seth, S. K. 1968, A revised Forest types of India. *Manager of Publications*, Government of India, Delhi.
6. Sikarwar, R. L. S., 2011, Chitrakoot Forests: A treasure of Cultural and Biological Diversity, https://www.researchgate.net/publication/346413292
7. Kanieski M.R., Longhi S. J. and Casemiro P. R. S, 2018, Methods for Biodiversity Assessment: Case Study in an area of atlantic forest in southern Brazil, DOI.org/10.5772/intechopen.71824 Intech Open, pp 45-48
8. Singh A.P., Umrao R, Kumar H and Apurva K, 2022, Tree species distribution and composition of dense forest in different ranges of chitrakoot forest division, The Pharma Innovation, pp 1216-1219
9. Gautam N.C. and Singh R., 2015, Depletion / Erosion status of Agro- biodiversity of Chitrakoot in last two Decades, *MGCGV p.p.* 1-7
10. D. M. Williams, M. C. Ebach, 2008, Biogeographical Relationships, Evolution, and Classification. *Foundations of Systematics and Biogeography, Springer, Boston, p.p.* 228-258.