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Ecological and conservation study of herbs in Mukundpur forest area, Satna District, Madhya Pradesh

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Abstract
Mukundpur forest range is situated in Amarpatan Tahsil of Satna district of Madhya Pradesh India. Thisstudy area is under high ecological stress for mining purposes. For assessment of biodiversity vegetation sampling was done. The calculation of frequency, density and IVI (Important value Index) for the species of herbs have been done. The threat and conservation status is assessed by Normal Distribution Principle. In the present study the 20 herbs species have been found. There are no species of herbsin Category-4. The 5 species which are Category-3 are *Mimosa pudica*, *Sida veronicaefolia*, *Sida cordifolia*, *Solanum xanthocarpum* and *Rauwolfia serpentine*. These species needed more attention locally in the study area. The MP Biodiversity board has suggested that species of *Rauwolfia serpentina* is in critically endangered state in Vindhyan region and the results of IVI also confirm the same as that it is in conservation and threat status of category 3.

Keywords: IVI, Normal Distribution Principle, Frequency class, Raunkier's frequency law, Threat and Conservation Categories

1. Introduction
India, a land of physical, cultural, social and linguistic diversity is endowed by nature with enormous biological diversity. As a result India ranks amongst one of the 12 mega biodiversity countries of the world and harbors 17,000 flowering plant species. It accounts for 8% of the global biodiversity with only 2.4% of the total land area & the world (Hajara and Mudgal 1997 and Reddy 2008) [7, 23]. A complete picture of threatened status, vulnerability and microclimate are yet has been determined. Conservation status is not properly documented till now. The present work has been taken to assess all relevant information on this aspect. An Assessment of threatened plants of India has been made by Jain and Rao (1983) [8]. Biodiversity Threat assessment of Vindhyan region of Madhya Pradesh has been made by Myres (1988) [13]; Nayar and Sastry (1987, 1988 & 1990) [15]; Nautiyal, *et.al.* (2003) [14]. Conservation of Threatened species is important for maintaining the ecological balance of the habitat. Conservation of rare and endangered species of India as well as in different parts of world have been popularized through the propagation and preservation of these plant species in the botanical gardens or in the natural habitat. Conservation and economic evaluation of Biodiversity has been done by Nayar, *et.al.* (1997) [18]. Status and conservation of rare and endangered medicinal plant in the Indian Trans-Himalaya has been made by Bush (1996) [3]; Kala (2000) [10]; Ayyad, *et.al.* (2000) [2]; Okigbo & Ogbogu (2008) [19]; Soetan & Aiyelaagbe, *et.al.* (2009) [24]; Dubey, *et.al.* (2010) [4]; Oladele, *et.al.* (2011) [20].

The studies on threatened medicinal plants of Andhra Pradesh and forest type have been made by Reddy, *et.al.* (2001) [21] and Reddy (2007) [22]. National special biodiversity assessment and the use of forest inventory data for a national protected area strategy in Guyana have been made by Tersteege (1998) [25] and Turpie (2004) [26]. In Madhya Pradesh the forest are of various types and they provide diversity of vegetation. The varied nature of forests needs a thorough investigation of the soil, climate, bio-geochemical nature and Characteristics of vegetation. In Satna district of the Madhya Pradesh, observation of Medicinal Importance of Sacred Plants of Chitrakoot Region Satna (M.P.) (Bala and Singh, 2015) [11]. This study discussed the 13 sacred plants species which are medicinally used by the tribes of Chirtakoot region district Satna, Madhya Pradesh. The local people believe in the efficacy of these herbs along with some divine power, but the knowledge is restricted to very few elderly folks only.

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The headquarters of Mukundpur range is in Mukundpur village, situated in Amarpatan Tahsil of Satna district in the state of Madhya Pradesh, India.The first white tiger safari is established at this village. The one of the mandate of this zoo and safari is to establish a small research centre for identification and propagation of various species of medicinal plants naturally occurring in adjoining forest areas. The Mukundpur range is surrounded by mining areas of bauxite, limestone. The nearby located cement factories are always in search of new areas, besides exploiting existing known areas. These houses may obtain non forest land as compensatory forest land in other district of Madhya Pradesh for diversion. The emission of CO_2 in cement manufacturing across the world accounts for 5% of global Co_2 emission due to intensive and extensive mining activities. Thus area is encountering impact of temperature rise, industrialization, desertification, shifting in the growing seasons of plants, loss of pollinators and seed dispersers, causing extinction of precious plants. Thus area of Mukundpur range will confines to be remained under high ecological stress zone in near

future. Ramification and Widening of old roads will cause vehicular pollution, fragmenting the habitat, opening the area for plunder at certain species like *Gymnema sylvestre* (Gudmar) and *Tinospora cardifolia* (Giloy) with excessive commercial exploitation posing a threat to eco-system. Looking at the above reasons, objectives is the identification, characterization, documentation and compilation of data base of threatened and endangered plant and their study of taxonomy, ecology and physiology. Exploration of basic and commercial utility of endangered plants.

2. Study Area
Mukundpur region mainly comprises the present area of Mukundpur range of Satna forest division. The range has geographical area of 589.71 km2 with forest area 111.55 km2. The area lies between north latitude of $24^011'35"$ to $24^026'25"$ and east longitude of $81^06'35"$ to $81^022'20"$. The famous world white tiger safari is also situated in northern side of this range.
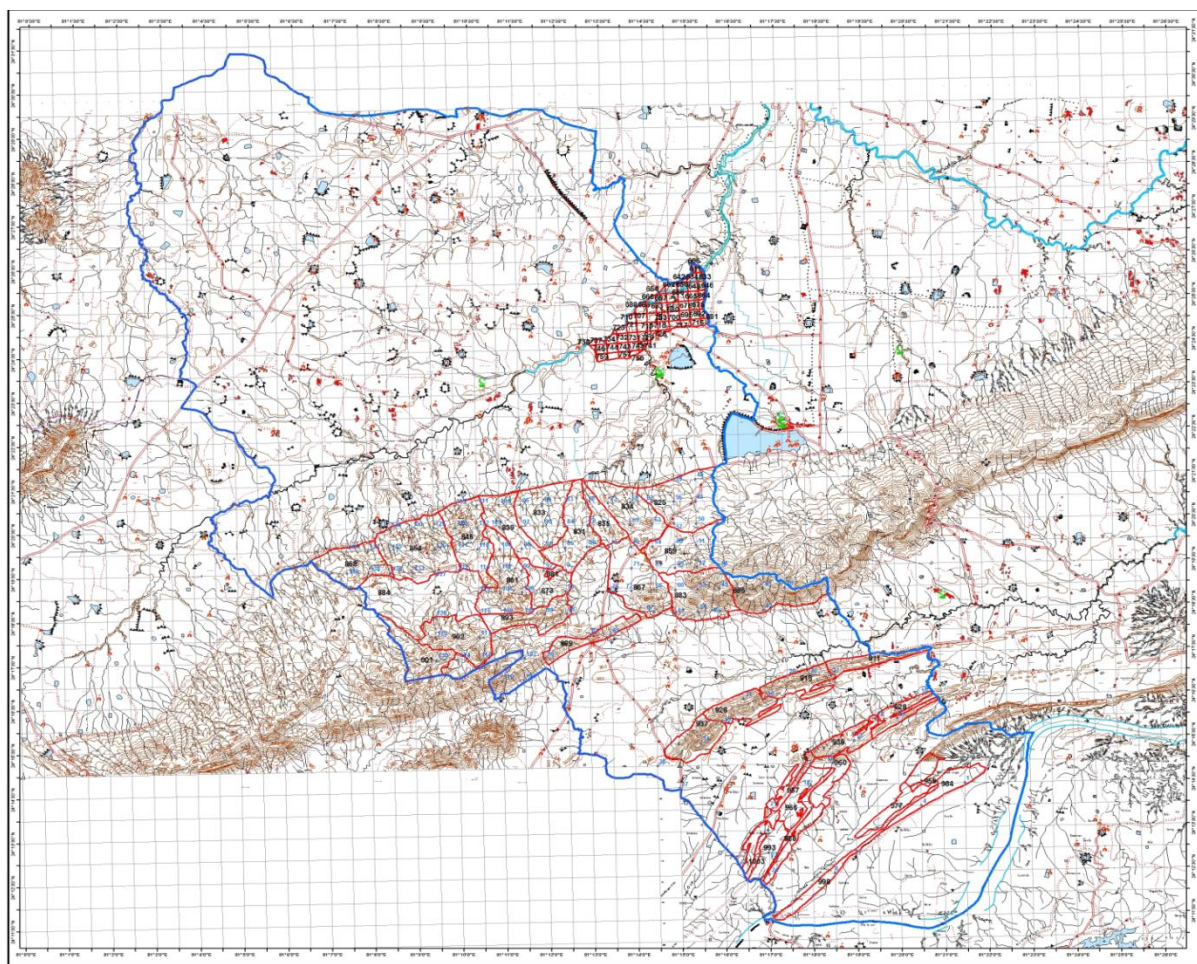

Fig 1

The forest area of this range exists in 7 forest blocks namely Mand, Govindgarh extension, Papra, Jhinna, Sarhai, Kokahansar and Mankesar. The forest blocks of Govindgarh extension and papra extend in Satna and Rewa forest districts. The part of Mankesar forest block lies in submerged area of Bansagar dam.
Northern boundary lies with Beehar River demarcating Satna and Rewa district. The forest of Mand reserve is situated in this area where first white tiger safari is established. Eastern boundary lies mainly with the district boundaries bifurcating Rewa and Satna districts. The famous Charaki

ghati forms one of its boundaries. Southern boundary lies mainly with submerged area of Son River and it extends to district boundaries of Shahadol and Satna districts.

3. Materialand Method
For the assessment of biodiversity of Mukundpur region, the vegetation sampling was done for the trees, shrubs, herbs, climbers, grasses and tubers. Stratified systematic random sampling method was used for sampling the vegetation (Anon, 1996) [1]. For determining minimum number of sample

points, the formula used is $n = z^2 \frac{pq}{E^2}$ where E= difference between population proportion mean and sample proportion average, p = population proportion, q= 1- p, z=1.96 for a level of significance of 95% (Elhance, 1994) [5].

Based on the secondary data from Mukundpur range and Satna forest division, the sample size for various tree parameters i.e. number of trees per hectare, volume per hectare and established regeneration per hectare was calculated at 10% error (E) between population and sample proportion at 95% level of significance keeping in view time and other resources (Jain, 2008) [9].

Minimum 95 numbers of sample points were calculated from the above formula to assess the vegetation. The forest maps of Mukundpur range on survey of India topo sheet is of the scale of 1:15000. The grids at 35"x 35" and 30"x30" intervals are drawn by trial and error, for systematic random sampling. The 111 and 151 random points were recorded on above grid. The 151 sample points at 30"x 30" were selected on safer side, so that points may fall in river bed, submergence and encroachments. The longitudes and latitudes of 151 points were noted and listed from topo sheets.
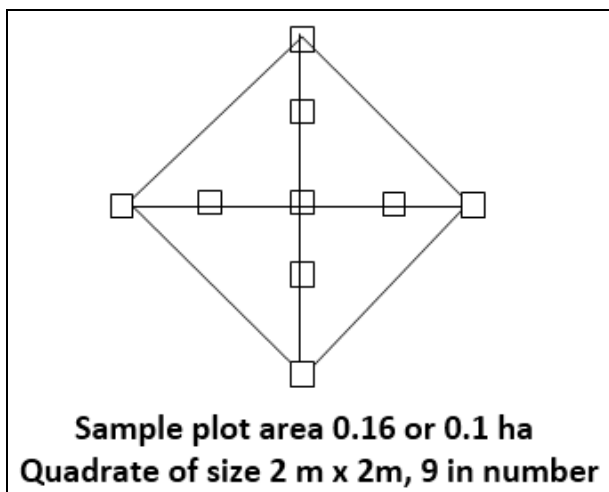

Fig 2: Each sample points were located on ground with the help of GPS.

At each sample points, the layout of sample plot of 0.16 hectare with 9 quadrat of 2mX2m on ground was done with the help of prismatic compass (Anon, 1996) [1]. At these points recording of data of the girth and species of the trees, along with species of shrubs, climbers and tubers (numbers) were taken on whole sample plot of 0.16 hectare and data for species of herbs, grasses and established regeneration was recorded at each 9quadrate of 2mX2m. The Microsoft access program was developed to calculate the number, regeneration of trees per hectare and volume in m3 per hectare by using local volume table, prepared for Satna forest division, the results were analyzed with this program. The name and number of herb plants and established regeneration of plant species was also noted during the survey at each quadrate. The calculation for the density, frequency and IVI of the all species of herbs was done with same program (Mishra, 1968) [12]. All the IVI for all the species was summarized in decreasing order and analyzed further to assess the conservation and protection status of species by using the

normal distribution principle (Elhance, 1994) [6].
Principle is as under:

μ = mean of IVI of all species, σ= standard deviation of IVI,
Then normal distribution principal states that there should be:-

a 68% of total number of species whose IVI is between μ +σand μ -σ.

b 95% of the total number of species whose IVI is between μ + 1.96σ andμ - 1.96σ.

c 99% of the total number of species whose IVI is between μ + 2.58σ and μ - 2.58σ.

For safer evaluation for IVI, for conditions (b) and (c) μ - 2σto μ + 2σand μ - 3σto μ + 3σhave been calculated and used in further study. Now again here, μ is the population mean and is equivalent to sample average and σis population standard deviation and here for sample it is replaced by σ/√n i.e. standard error(SE).
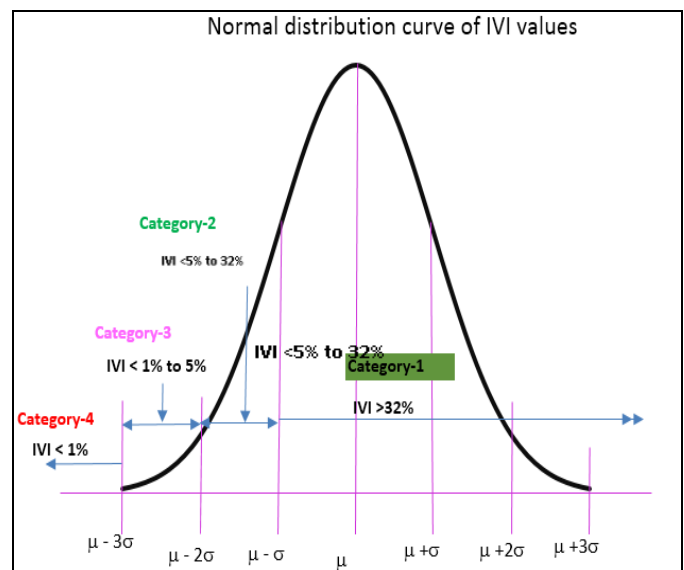

Fig 3: Now, with the help of this principle, categorization is done as follows:

IVI <μ - 3σ (species having IVI less than 1%) - category 4.

μ - 3σ ≤ IVI <μ - 2σ (species having IVI between 1 to 5%) - category 3.

μ - 2σ ≤ IVI <μ - σ (species having IVI between 5 to 32%) - category 2.

IVI ≥ μ - σ (species having IVI greater than 32%) - category 1.

The species in category 4 require highest degree of protection. The species in category 3 require lesser protection than category 4. The species in category 2 require lesser protection than category 3. The species in category 1 require least protection and are available in plenty and they are available for harvesting.

4. Result and Discussion
4.1 Analysis of frequency and Density status of Herbs.
Frequency and Density status of herbs are presented in table 1. It shows that whole area is infested with the herbs of Vantulshi (*Ocimun basilicum*). It is inhabited like invasion.

Table 1

S. No.	eSpecies	Botnical Name	Presence	Total Plots	Total Spcs	Density	Frequency
1	Van Tulsi	*Ocimun basilicum*	847	1287	2038	3958.82	65.81
2	Shankh Pushpi	*Convolvulus pluricaulis*	225	1287	546	1060.61	17.48
3	Van Mung	*Phaseolus trilobus*	23	1287	141	273.89	1.79
4	Nagar Motha	*Cyperus rotundus*	55	1287	81	157.34	4.27
5	Kalmegh/Nadi Damdami	*Andrographis paniiculata*	25	1287	8	15.54	1.94
6	Bhulitingi	*Sida veronicaefolia*	5	1287	9	17.48	0.39
7	Bhata Kateri	*Solanum xanthocarpum*	2	1287	10	19.43	0.16
8	Gokhru	*Tribulus terrestris*	41	1287	95	184.54	3.19
9	Gudmaar	*Gymnema sylvestre*	11	1287	14	27.20	0.85
10	Bhumi Amla	*Phyllanthus nirurii*	192	1287	312	606.06	14.92
11	Bramhi	*Bacopa monnieri*	72	1287	116	225.33	5.59
12	Vish Kafri	*Aconitum ferox*	171	1287	216	419.58	13.29
13	Ghamra	*Eclipta alba*	149	1287	216	419.58	11.58
14	Satgathiya	*Borreria articularis (Linn,f)*	70	1287	210	407.93	5.44
15	Lajvanti	*Mimosa pudica*	11	1287	6	11.66	0.85
16	Miryari	*Sida cordifolia*	7	1287	2	3.89	0.54
17	Bajradanti	*Coix aqatica*	15	1287	15	29.14	1.17
18	Sarpgandha	*Rauwolfia serpentina*	1	1287	3	5.83	0.08
19	Pashanbhed	*Coleus forskohlii*	24	1287	34	66.05	1.86
20	Nay	*Enicostemma littorale*	7	1287	39	75.76	0.54
		Total :-			4111	7986	151.74

Table 1 shows that 20 herbs species are found in the area surveyed. Total density of herbs in Mukundpur range is 7986 no/ha. Vantulshi (*Ocimun basilicum*) occupies highest density. Lowest density is occupied by Miryari (*Sida cordifolia*).

Highest frequency is also occupied by Vantulshi (*Ocimun basilicum*). Second highest density of Shankhpushpi (*Convolvulus pluricaulis*) exists in Mukundpur region. Sharpgandha (*Rauwolfia serpentina*) occupies the lowest presence in the area.

In order to check the Raunkier's frequency law, the various frequency classes of herbs are presented in table 2 below:

Table 2

Frequency Class	Number of species in Class	Percentage of species in a class from total number of species
A frequency $\leq$ 20%	19	95%
B frequency 21 to 40%	0	0
C frequency 41 to 60%	0	0
D frequency 61 to 80%	1	5%
E frequency 81 to 100%	0	0
Total	20	100%

Thus Frequency distribution does not follow Raunkier's frequency law. The nearly all the species are found in Frequency class A. Frequency class D is occupied by Vantulshi (*Ocimun basilicum*). The frequency class B, C and E for herbs are missing in the area. This means the area suffers as heavy invasion of Vantulshi (*Ocimun basilicum*)

due to excessive grazing pressure. So areas require protection from grazing.

4.2 Evaluation of IVI of each herb species
IVI status of species of herbs is presented in table 3 with their relative frequency and relative density.

Table 3

S. No	Herb Species	Botnical Name	Relative Density	Relative Frequency	IVI	Cat
1	Van Tulsi	*Ocimun basilicum*	49.57	43.37	92.94	CAT-1
2	Shankh Pushpi	*Convolvulus pluricaulis*	13.28	11.52	24.8	CAT-1
3	Bhumi Amla	*Phyllanthus nirurii*	7.59	9.83	17.42	CAT-1
4	Vish Kafri	*Aconitum ferox*	5.25	8.76	14.01	CAT-1
5	Ghamra	*Eclipta alba*	5.25	7.63	12.88	CAT-1
6	Satgathiya	*Borreria articularis (Linn.f)*	5.11	3.59	8.7	CAT-1
7	Bramhi	*Bacopa monnieri*	2.82	3.68	6.5	CAT-1
8	Nagar Motha	*Cyperus rotundus*	1.97	2.81	4.78	CAT-2
9	Van Mung	*Phaseolus trilobus*	3.43	1.18	4.61	CAT-2
10	Gokhru	*Tribulus terrestris*	2.31	2.1	4.41	CAT-2
11	Pashanbhed	*Coleus forskohlii*	0.83	1.23	2.06	CAT-2
12	Kalmegh/Nadi Damdami	*Andrographis paniiculata*	0.19	1.28	1.47	CAT-2
13	Nay	*Enicostemma littorale*	0.95	0.36	1.31	CAT-2
14	Bajradanti	*Coix aqatica*	0.36	0.77	1.13	CAT-2
15	Gudmaar	*Gymnema sylvestre*	0.34	0.56	0.9	CAT-2
16	Lajvanti	*Mimosa pudica*	0.15	0.56	0.71	CAT-3
17	Bhulitingi	*Sida veronicaefolia*	0.22	0.26	0.48	CAT-3
18	Miryari	*Sida cordifolia*	0.05	0.36	0.41	CAT-3

19	Bhata Kateri	*Solanum xanthocarpum*	0.24	0.11	0.35	CAT-3
20	Sarpgandha	*Rauwolfia serpentina*	0.07	0.05	0.12	CAT-3
				Average :	10.00	
				Std :	20.66	
				Sqrt :	4.47	
				StdErr :	4.62	

4.3 Assessment of herb species for conservation and threat status

Highest IVI is attached with Vantulshi (*Ocimun basilicum*). Another 4 species in decreasing order of IVI are Shankhpushpi (*Convolvulus pluricaulis*), Bhumiamla (*Phyllanthus nirurii*), Vishkhapari (*Aconitum ferox*) and Ghamara (*Gymnema sylvestre*). Sharpgandha (*Rauwolfia serpentina*) has lowest IVI. Average IVI value herbs are 10 with standard error 4.62.

Using normal distribution principle, various conservation categories are analyzed and results are summarized below:

1. Species of herbs having IVI > 32% (Category-1). There are 7 species in this category. These species are Vantulshi (*Ocimun basilicum*), Shankhpushpi (*Convolvulus pluricaulis*), Bhumiamla (*Phyllanthus nirurii*), Vishkhapari (*Aconitum ferox*), Ghamara (*Gymnema sylvestre*), Satgathia (*Borreria articularis (Linn.f)*), and Brahmi (*Bacopa monnieri*). These species are having no threat and require no protection. Eradication of Vantulsi should be taken at massive scale.
2. Species of herbs having IVI between 5 to 32% (Category-2). There are 8 species are found in this category. These are Nagarmotha (*Cyperus rotundus*), Vanmung (*Phaseolus trilobus*), Gokhru (*Tribulus terrestris*), Pashanbhed (*Coleus forskohlii*), Kalmegh (*Andrographis paniiculata*), Nay (*Enicostemma littorale*), Bajrdanti (*Coix aqatica*) and Gudmar (*Gymnema sylvestre*). These species require more protection than category 1 species, though they have little threat to extinct.
3. Species of herbs having IVI between 1 to 5% (Category-3). There are 5 species are classified under this category. These are Lajvanti (*Mimosa pudica*), Bhulitingi (*Sida veronicaefolia*), Miriyari (*Sida cordifolia*), Bhatakateri (Solanum xanthocarpum) and Sarpgandha (*Rauwolfia serpentina*). These species have more threat than category 2 species and they are in danger zone of extinction. Their in-situ and ex-situ cultivation can be promoted by removing the Lantana (*Lantana camara*) (shrub) and Vantulshi (*Ocimun basilicum*).
4. Species of herbs having IVI less than 1% (Category-4). There are no species under this category. Hence no species exists in this endangered category.

5. Conclusion

There are no species under this category 4. Hence no species exists in this endangered category. There are 5 species classified under thecategory 3. These are Lajvanti (*Mimosa pudica*), Bhulitingi (*Sida veronicaefolia*), Miriyari (*Sida cordifolia*), Bhatakateri (*Solanum xanthocarpum*) and Sarpgandha (*Rauwolfia serpentina*). These species have more threat than category 2 species and they are in danger zone of extinction. Their in-situ and ex-situ cultivation can be promoted by removing the Lantana (*Lantana camara*) and Vantulshi (*Ocimun basilicum*).

Though MP Biodiversity board has suggested that species of Sarpgandha (*Rauwolfia serpentina*) is in critically endangered state in Vindhyan region. The results of IVI show that it is in conservation and threat status of category 3. Thus in Vindhyan region and Mukundpur forest the presence and dominance of Sarpgandha (*Rauwolfia serpentina*) is in dangerous state.

Similarly the MP Biodiversity board has suggested Gokharu (*Tribulus terristris*) species is in endangered category while results of IVI for Gokharu (*Tribulus terristris*) indicate that it is in threat and conservation status of category 2. It means that in Mukundpur area the presence and dominance of Gokharu (*Tribulus terristris*) is not in endangered state. But it may be endangered category in other area of Vindhyan region.

The IVI results for species of Viskhapri (*Aconitum ferox*), Brahmi (*Bacopa monnieri*) and Ghamara (*Eclipta alba*) are in threat and conservation status of category 1. It means that these species are in abundance in number and frequency in Mukunpur range though they are in vulnerable condition suggested by MP Biodiversity board for Vindhyan region. Thus the area for these species should be well demarcated in Mukundpur range and it can be used as a source of production for other areas of Vindhyan region.

The IVI results of other herbs for threat and conservation status category 3 are Lajvanti (*Mimosa pudica*), Mirayari (*Sida cordifolia*), Bhulitingi (*Sida veronicaefolia*) and Bhatakateri (*Solanum xanthocarpum*). It means that these species of herbs are endangered category for Mukundpur forest range but it is not in endangered state for other areas of forest of Vindhyan region. In other areas of forest of Vindhyan region these species of herbs should be well demarcated.

7. References

1. Anon. Working plan code published by Chief Conservator Forests, working plan Satpuda Bhawan Bhopal, Madhya Pradesh Forest department, 1996.
2. Ayyad MA, Fakhry AM, Moustafa ARA. Plant biodiversity in the saint Catherine area of the sinai Peninsula, Egypt Biodiversity and Conservation. 2000; 9(2):265-281.
3. Bush MB. Amazonian Conservation in a changing world. Biological Conservation. 1996; 76(3):219-228.
4. Dubey KP, Kumud Dubey. Conservation of medicinal plants and poverty Alleviation, national conference on biodiversity, development and poverty Alleviation, 2010, 22.
5. Elhance DL. Book Estimating sample size for population proportion, Page No. 21.14 published by kitabmahal, Sarojaini Naidu marg, Allahabad, 1994, 22-A.
6. Elhance DL. Properties of normal distribution, book of Fundamentals of Statistics, 1994, 18.32.
7. Hajara PK, Mudgal V. An overview, BSI India, 1997.
8. Jain SK, Rao RR. (Ed.) An assessment of threatened plants of India, Botanical survey of India, Culcutta, 1983.
9. Jain Atul Kumar IFS, Forest resource survey, working plan of Satna revised for 2008-09 to 2017-18,

Government of Madhya Pradesh Forest Department, Chapter of Forest resource survey, 2008; 1:47-53.

10. Kala CP. Status and conservation of rare and endangered medicinal plant in the Indian trans-Himalaya. Biol. Conserv. 2000; 93:371-379.

11. Lipika Devi Bala Ravindra Singh. Faculty of Science & environment, MGCGV, Chitrakoot, Satna (M.P.), India Medicinal Importance of Sacred Plants of Chitrakoot Region Satna (M.P.), International Journal of Science and research. 2015, 4(8). (IJSR) ISSN (Online): 2319-7064.

12. Mishra R. Ecology work book, Page Professor and head of Department of Banaras Hindu University Varansi India, published by Oxford & IBH Co. 17, Park street Calcutta, 1968, 16:36-48.

13. Myres N. Threatened Biotas: Hotspots in tropical forests, the Environment. 1988; 8(3):987-208.

14. Nautiyal, Sunil. Plant Biodiversity and its Conservation in Institute for Social and Economic change (ISEC) campus, Banglore; A case study. J Biodiversity. 2003; 2(1):9-26.

15. Nayar MP, Sastry ARK. Red data book of Indian plants, Botanical survey of India, Culcutta, CAMP, CAMP Workshop, Shimla. 1987, 1.

16. Nayar MP, Sastry ARK. Red data book of Indian plants, Botanical survey of India, Culcutta, CAMP, CAMP Workshop, Shimla, 1988, 2.

17. Nayar MP, Sastry ARK. Red data book of Indian plants, Botanical   survey of India, Culcutta, CAMP, CAMP Workshop, Shimla, 1990, 3.

18. Nayar MP, Puspangadan P, Ravi K, Santosh V. Conservation of rare and endangered species of Indian flora: strategies for botanic gardens. In (eds) conservation and economic evaluation of biodiversity. Oxford &IBH publishing co. New Delhi, 1997; 1:47-57.

19. Okigbo, Eme UE, Ogbogu S. Biodiversity and Conservation of medicinal and aromatic plants in Africa, Biotechnology and molecular Biology Reviews. 2008; 3(6):127-134.

20. Oladele AT, Alade GO, Omobuwajo OR. Medicinal plants conservation and cultivation by traditional medicine practitioners (TMPs) in Aiyedaade Local Government Area of Osun state, Nigeria, Africa, Biol. JN. Am. 2011; 2(3):476-487.

21. Reddy CS, Reddy KN, Jodhav SN. EPTRI. Hyderabad, 2001.

22. Reddy CS. Forest types of Andhra Pradesh. Paryavaranam. Eptrienvis (Soeap) New letter. 2007; 1(land):1-8.

23. Reddy CS. Life Sci J. 2008; 5(2):84-89.

24. Soetan KO, Aiyelaagbe OO. The need for bioactivity safety evaluation and   conservation of medicinal plants- A review, Journal of medicinal plants research. 2009; 3(5):324-328.

25. Tersteege H. The use of forest inventory data for a national protected area strategy in Guyana. Biodiversity and conservation. Hill AF. Economic Botany. A Textbook of useful plants and plant products, 2nd edn, 1998; 7(11):1457-1483.

26. Turpie JK. National spatial Biodiversity Assessment Technical report. Volume 3: Estury component. South African National Biodiversity institute Pretoria, 2004.