ISBN: 978-81-931247-3-4

BIODIVERSITY ASSESSMENT: TOOL FOR CONSERVATION

Associate Editors

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Dr. (Smt.) Ammani Kandru

Dr. Biplab Kumar Das

Mr. Brij Mohan Upreti

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Bhumi Publishing

First Edition

2017

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Bhumi Publishing

Bhumi Publishing
Nigave Khalasa, Kolhapur 416207, Maharashtra, INDIA

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First Edition: 2017

ISBN: 978-81-931247-3-4

Published by:

Bhumi Publishing,

Nigave Khalasa, Kolhapur 416207, Maharashtra, India

Website: www.bhumipublishing.com

E-mail: bhumipublishing@gmail.com

Available online at:

www.bhumipublishing.com/books/Biodiversity Assessment: Tool for Conservation

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Dr. P. Padmavathi is currently associated with the Department of Zoology, Acharya Nagarjuna University (ANU), Nagarjuna Nagar, A. P., India as an Assistant Professor. She has 25 years of teaching experience. She completed her Doctorate degree on the subject "A study on the water quality, plankton and fish yields of three carp culture ponds in the environs of lake Kolleru, Andhra Pradesh, India" in 1993 from ANU, AP. She is also visiting professor at Huron College of Management, Technology and Health care, Toronto, Canada. Under the guidance of Dr. P. Padmavathi 04 students completed their M. Phil. Research work. Presently she is guiding 06 students for Ph. D. and 04 students for M. Phil.

Dr. Padmavathi has published 53 research papers in the field of Biodiversity, Aquatic Biology, Aquacultur*e*, Limnology and Toxicology. Along with this research publication she edited 06 books and contributed as author for 13 books. She also attended and presented research papers in 125 conferences. She is a Life Member of various national and international level research societies. She is working as an Assistant Director (Sciences), CDE, ANU since May 2016 to till date. For research and academic purposes she visited various research and academic institutes from Canada, USA, Nepal and Dubai.

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Dr. (Smt.) Ammani Kandru is presently working as the Coordinator, Department of Botany and Microbiology, Acharya Nagarjuna University, A. P. She completed her M. Sc. in 1982 and Ph. D. in 1991 from Acharya Nagarjuna University, A. P. Her topic of Ph. D. was, "A study of Vesicular-arbuscular mycrorrhizal fungi in soils of Prakasam and Guntur districts and their association with cereals and grasses". She qualified UGC NET in 1986 and also the recipient of Post Doctoral Research Fellowship by CSIR during 1992–1997. Along with Post–doc she successfully completed Diploma in Herbal Medicine. Dr. K. Ammani has over 33 years of research and 27 years of teaching experience in various fields of Botany and Microbiology, Bacteriology, Virology, Phycology, Pathogenic interactions Immunology, Biology of eukaryotic microbes, Microbial genetics and r DNA technology. She isolated and identified more than 20 AM fungi. She successfully guided 12 Ph. D's & 9 M. Phil's in different fields of Botany, Biotechnology, Microbiology and Biochemistry and Food and Nutrition and supervising 12 students for their research degrees.

Dr. Ammani has published 79 technical papers in renowned International and National journals and communicated 5 papers. She presented more than 140 research papers in National and International conferences in India and abroad (USA, UAE, Sri Lanka, & Nepal). Recently she delivered a Key note address at an International conference of Advances in Biotechnology, held at Dubai, UAE (July, 2017) an Invited lecture at International conference in Nepal (2014) Sri Lanka (2013) and at John Hopkin's University, Maryland, USA (2012) and chaired the sessions. She organized workshops on Patenting and Nanotechnology. Along with the publications she contributed several chapters in reputed books and one book entitled as ―Flora of Gunadala hill Krishna district, A.P., India. A taxonomic study of indigenous plants on highlands is credited on her name published by international publisher Lambert Acadamic publishers, Germany. Dr. K. Ammani is Member / Life Member of more than 17 reputed prestigious institutes and technical associations like ASM, AMI, BRSI, EAES, ISCA, IANCAS, , ISRS, IBS, SBA, SBTI etc. She is the editorial board member for about 6 reputed journals and reviewer for several National & International journals.

Dr. Biplab Kumar Das

Dr. Biplab Kumar Das did his Ph. D. in the year 2015 from Department of Life Science and Bioinformatics of Assam University, Silchar and currently engaged as an Assistant Professor of Department of Zoology in Silapathar Science College, Dhemaji, Assam. Dr. Biplab Kumar Das has significantly contributed in the field of Fish Biodiversity, Entomology, Remote Sensing and Geographic Information System (GIS), His topic of Research is Biodiversity, Entomology, Remote Sensing and GIS. He had presented many research papers in National and International Conference/Seminar/Symposia and also he had attended numbers of National and International Workshop, Training Programmes etc.

Dr. Das had been awarded with Young Scientist of the Year -2014 and Eminent Young Scientist of the Year Award 2015 by Foundation for Science and Environment and International Conference on Environment and Ecology and also with Young Scientist Award-2014 by the Academic Council of the International Consortium of Contemporary Biologists and the Board of Trustees of Madhawi – Shyam Educational Trust (ICCB-MSET), Jharkhand for his outstanding contribution in the field of Biodiversity, Remote Sensing and GIS. He had also selected for Best Poster and also Best Oral Presentation in different International and National Conferences. He had published 45 numbers of Research Papers in National and International Journals having NASS Rating and Impact Factor. He has also contributed number of Book Chapters in Edited books by the others. He is also members of many scientific professional bodies and besides that he is also reviewer of many internationals journals.

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Mr. Brij Mohan Upreti is a research student at Department of Botany, Kumaun University, Nainital, Uttarakhand. He is doing his research for Ph. D. on the topic, "Eco-Taxonomical Exploration of Major Sacred Forest in Pithoragarh District of Kumaun Himalaya and Their Role in Phytodiversity Conservation". He is well known resource person in the sector of knowledge of traditional practices regarding medicinal plants, forests and culture of Kumaun Himalayan region. Mr. Upreti has three years research experience in the said subject. He completed his master degree in Botany from Kumaun University, Nainital in 2012.

Mr. Brij Upreti presented 06 research papers in National and International conferences. Along with same, he attended more than 10 research conferences. He published 16 research papers in renowned International and National journals. He also published three book chapters. He works in the area of Plant Taxonomy, Ethnobiology, Ecology and Soil Science. He works as a research fellow for the research project entitled, "Studies on Conservatoin of Ginkgo biloba linn. (Ginkgoaceace): A rare exotic medicinal plant" funded by University Grants Commission (UGC), New Delhi.

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Presently, she is Fellow/Life Member of more than 08 national and international research societies such as Society of Life Sciences, Satna, (M.P.), Indian Hydrobiology, Chennai, Indian Association for Angiosperm Taxonomy, etc. She received some prestigious awards like Fellow of the Society of Ethenobotanists in 2013, FICCE award in 2004, Fellow of Society of Life Sciences award in 2004. She successfully completed one research project funded by University Grants Commission, India. The area of research of Dr. Shakun Mishra is Ethnobotany and Limnology. Presently she focused in the research area of Floristic diversity assessment of Angiosperms. For her academic contribution she received gold medal from former Lok Sabha Speaker Mr. Balram Jhakhad. Presently, Dr. Mishra works as chairman of Board of Studies (BOS) in the subject of Botany, Soil Science, Sed Technology and Horticulture in D. A. V. V. University, M.P., India. She is also BOS chairman for Horticulture, Central University, M. P.

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There are 35 research papers, 06 book chapters and two books on the name of Dr. Vhanalakar. He attended and presented research papers in more than 50 national and international research conferences. Presently he is working as a principal investigator of one research project funded by University Grants Commission, New Delhi.

He worked as an organizing secretary for one international, one national and 06 university level conferences and seminars. He is presently working as a managing editor for Bhumi Publication, Kolhapur, M.S., India.

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The main area of his research is thin film solar cell. He is actively engaged in research. Dr. Sharadrao Vhanalakar has published more than 100 research papers in various international journals having more than 400 citations and 'h' index is near to 16. He is awarded by prestigious 'Raman Post-Doc Research Fellowship in USA' by University Grants Commission, New Delhi in year 2016. He is recipient of 'Young Scientist Award' by Department of Science and Technology, Government of India in 2014. He is working as a principal investigator of one research project funded by Department of Science and Technology, Government of India.

PREFACE

*We are delighted to publish about our book entitled "**Biodiversity Assessment: Tool for Conservation".** This book is the compilation of esteemed articles of acknowledged experts in the various fields of basic and applied science providing a sufficient depth of the subject to satisfy the need of a level which will be comprehensive and interesting. It is an assemblage of up to date information of rapid advances and developments taking place in the field of biodiversity, environmental science and allied subjects. With its application oriented and interdisciplinary approach, we hope that the students, teachers, researchers, scientists and policy makers in India and abroad will find this book much more useful.*

The articles in the book have been contributed by eminent scientists, academicians. Our special thanks and appreciation goes to experts and research workers whose contributions have enriched this book. We thank our publisher Bhumi Publishing, Nigave Khalasa for taking pains in bringing out the book.

Finally, we will always remain a debtor to all our well-wishers for their blessings, without which this book would not have come into existence.

- Editorial Team

Biodiversity Assessment: Tool for Conservation

CONTENT

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ISBN: 978-81-931247-3-4

CHAPTER 1

COMPARATIVE STUDY OF AVIFAUNAL ASSEMBLAGE WITH REFERENCE TO NESTING ECOLOGY, FEEDING GUILDS AND TREE-VEGETATION COMPOSITION OF JADAVPUR UNIVERSITY CAMPUS WITH ADJACENT URBAN GREENSPACES IN KOLKATA

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ABSTRACT:

Impacts of urbanization on ecosystems and its integral biotic communities are of profound interest. Urban green spaces serve important refuges for urban wildlife and overall urban biodiversity. The avifaunal occurrence is considered as ecosystem health indicator and an evaluative tool for urban green spaces. We have assessed the avifaunal diversity with special reference to nesting ecology and feeding guild structures of the campus of Jadavpur University (JU) and two neighboring urban green spaces - Rabindra Sarovor (RS) and Royal Calcutta Golf Club (RCGC), Nesting density is highest in RCGC and is proportionate to green cover present at each site. The occurrence of tree-bound active bird nests at JU campus is high at lower heights and lesser diameter at breast (DBH) trees though being highly disturbed compared to RS and RCGC. Mosaic of built structure and green cover suited the nesting habitat diversification and the use of urban structures at JU campus. We conclude that though disturbed still JU campus serve as good urban green space due to high resemblance in biotic communities with RS and RCGC as well as forming partially continuous nesting and feeding habitat for urban birds.

KEYWORDS: Kolkata, Jadavpur University, nesting ecology, urbanization, urban greenspaces

INTRODUCTION:

Our planet is urbanizing rapidly as Earth's urban population is growing by one million per week nowadays. The pace of urbanization is well illustrated by the facts that while in 1950 ca. 30 % of our planet's human population lived in cities, this ratio has reached the 50% in 2008 and continuously growing ever since [1]. This trend has been especially dramatic in the developing countries of Africa, Asia and Latin America in the last decades [2]. It is an inevitable consequence that with increasing number and extension of human settlements, the environmental pressures called forth by this process are also become more and more severe. Urbanized landscapes have seriously altered energy flux, nutrient cycles, hydrology and heat balance, highly elevated pollution levels [3].

Of the three leading causes of species endangerment (urbanization, agriculture, and interactions with nonnative species), urbanization ranks highest [4]. The process of urbanization endangers species by directly replacing native habitats with development on the urban-rural fringe, and because resources in the surrounding areas are depleted to support urban economies [4]. The crucial factors based on which species can coexist within human settlement include: a. remnant native vegetation patch and its size [5]; b. competition with exotic species that have a longer history of human cohabitation [6]; c. non-native predators [7]; d. vegetation structure and floristic attributes [8]; e. feed supplementation practice by humans [6, 9]. Conservation of biological diversity is at present of immense interest to the scientific community in light of increasing human impacts on ecosystems. It is definitely very vital to make our future citizens aware of their neighboring biodiversity so that they will learn to live with it in a sustainable manner. Today, urban greenspaces, such as parks, golf courses, university campuses and cemeteries, represent the last remnants of greenery in large cities, providing potential habitat for bird life in urban environments [10, 11]. The number of studies centered on avian responses to urbanization is growing and getting popular [12]. While urban greenspaces differ in many ways from those in the surrounding country side [13], relatively little is known as to whether management recommendations obtained from natural areas can be applied to urban greenspaces [14].

Metropolitan Kolkata is flanked in the east and the west between the East Kolkata Wetlands and the river Ganges, and extends beyond its municipal limits in the northern, southern and eastern suburbs. The wastelands of dhapa, the open Kolkata maidan, the canals with their scrubby banks and some protected stretches of greens, Eden Gardens, the Bidhannagar Central Park, Royal Calcutta Golf Club, the Tollygunge Club, the Rabindra Sarovar, the Subhas Sarovar to name a few are the surviving islets of wildernesses that keeps

urban wildlife communities in the city. The city of Kolkata previously known for its long stretches of greenery. Nearly 276 species of flowering trees were reported till 1944 [15]. Records suggests an estimate of 5.5 % land cover of the total space of the city under parks, gardens and open spaces; ideally, it should be 15 % for city of the size of Kolkata [16, 17]. According to experts, Kolkata's tree cover drop down from 23.4 % to 7.3 % over 20 yrs and this trend will lead to 3.3 % by 2030 [18].

A compiled list of birds in and around Kolkata is prepared during the last 25 yrs covering 260 species [19]. Regular updates were maintained by independent ornithologists as well as under the website www.kolkatabirds.com. Studies shows that the avifaunal diversity of urban parts of Kolkata is subject of continuous attention as the communities are rapidly reshaping under the influence of unplanned growth and urbanization pressure [20, 21, 22]. In this following study, we have evaluated the biotic composition of a university campus taking avifaunal diversity, and tree diversity as indicative tool along with the nesting ecology of resident birds and compared these parameters with two adjacent urban greenspaces.

MATERIALS AND METHODS:

Study Sites:

Jadavpur University (JU) Campus, West Bengal:

Jadavpur University is a state university located in urban landscape of southern Kolkata, West Bengal. The main campus of Jadavpur University is a sprawling 67.7 hectare, outlined by the busy Raja S.C. Mullick road in west, the Jadavpur station road to the east, the Kolkata Suburban Rail line, the CSIR-Central Glass and Ceramic Research Institute to the north and KPC medical hospital to the south (**Figure 1a-g),** The architecture of the campus is typical sub-continental in nature with flat-roof rectangular plans. Though surrounded by noisy streets and railway stations the campus hosts some old, tall indigenous trees and quiet water bodies.

Adjacent Urban Green spaces:

The diversity of avifauna and floral representatives found in university campus is compared with the adjacent urban greenspaces located within a radius of 2 km (**Figure 1d**), These green spaces supports reasonable biodiversity along with viable ecosystems to sustain complex biotic communities although isolated inside rapid transforming human dominated landscape.

Urban green spaces are prone to get ecologically isolated and depleted species diversity while situated in isolation. Natural landscapes within this 2 or 3 km radius have highest probability of preserving the metapopulation attributes of a species, particularly in case of birds. To assign a status of urban green space we need to compare the biodiversity and habitat quality of JU campus with adjacent urban greenspaces. For this comparative study we choose two sites - Rabindra Sarovar and Royal Calcutta Golf Club 2 km and 1.7 km away respectively from JU campus.

Figure 1 a, b & c. Maps of Jadavpur University campus, Rabindra Sarovor & Royal Calcutta Golf Club (RCGC), Thick lines denoting the various survey routes in and around the study sites. **d.** Distances of JU campus from two urban green spaces. **e, f & g.** are images of the three study sites. JU campus, RS & RCGC.

Rabindra Sarovor (RS):

The Rabindra Sarovar is situated in south Kolkata popular for its fresh air supplying attribute and quiet environment. This artificial wetland is surrounded by groves of old trees **(Figure 1b & f),** The area also includes some tree covered islands. The water surface is free of any emergent vegetation due to regular use of recreational purpose and sports. The survey routes at RS were divided into two groups - peripheral zone routes.

Royal Calcutta Golf Club (RCGC):

The Royal Calcutta Golf Club is the oldest golf club outside the United Kingdom and is the second-oldest outside Scotland. It is situated in Tollygunge, Kolkata **(Figure 1c &**

g), It was originally paddy fields consequently very flat in nature. Over time thousands of trees were planted to give a present day look. The club offers plenty of natural habitats for tree dwelling groups, good population of Indian Jackals, common mongoose, palm civets, squirrels which otherwise rare in urban Kolkata. The area is encapsulated by old, trees from all sides from the busy roads preventing noise and other sources of pollution. 5 study routes (A to F) along the green turfs were used for bird study.

The survey:

Bird survey design:

Living groups serve as reliable ecosystem indicators [23]. In the present study, the diversity assessment of two interrelated indicator groups - namely, avifauna and trees was done. They were treated as benchmark of land use pattern and environmental health of urban greenspaces. Line or Belt Transect Method (LCM) was applied in case of denser habitats with limited visibility, high obstructions due to urban structures and to avoid double counting [24]. We use a 'crossed design' at the JU campus comprising two systematic grids of parallel lines (internal lanes of) perpendicular to each other (Figure 1a), These grids are oriented north to south (N/S) and east to west (E/W) respectively. We have named the internal roadways of the campus into two groups – 'A' for E/W and 'B' N/S directions. We have used these lanes as transect lines for bird and tree species survey. The map of the JU campus (**Figure 1a**) demonstrate spatial location of the transect lines.

Nest Survey:

Bird nests are indirect evidence of avifaunal occurrence [25]. Specifically the nest heights were eye estimated and recorded at these study sites along the study routes. Nests were recorded simultaneously with bird counting along transect. The present study span covers the nesting period of majority of the resident urban bird species commonly found which is in full swing (mid-February to mid-March), The counting is not absolute in terms of perfection but only an indicative of bird activity at any habitat. Nesting height is an indicator of human disturbance level as the most birds prefers to avoid humans and other disturbances during the nesting and breeding period. In order to know precise nesting preference, the diameter at breast height (DBH) of trees used for nesting was studied. DBH is one of the most common dendrometric measurements used to define vegetation profile. The nest density and mean nest height were also calculated for JU campus and other green spaces for

correlation. Nesting densities were estimated by dividing the total nest count by total land cover of the study site.

Tools Used:

The birds were observed and identified using Olympus 10 x 50 DPSI binoculars and field guides [26, 27, 28]. Photographs were taken by Canon 450D DSLR equipped with Sigma 300 Telescopic lens setup.

Survey timings and study period:

To assess the temporal changes in bird occurrence due to the influence of human activity birds were counted in three different time points at JU – disturbed (D), undisturbed (U) and control (C),

Table 1. Survey timings:

Slot	Time	Features
U	8:30 to 11:00 a.m.	Less vehicular and human activity, time before university get alive with daily activities.
D	3:00 to 5:00 p.m.	Period of active campus with increased vehicular movement.
C	9:30 to 11:30 p.m.	Sundays and university holidays with no vehicular movement.

Several point counts at fixed radius were chosen along the study routes opted at JU campus. 34 point counts stations with fixed radius of 30 to 50 m depending on the vegetation cover along the 9 study routes (P-1 to 6 and I-1 to 3) in RS and 28 point counts stations (fixed radius of 50 m) at RCGC along the 9 study routes (A to F) during the two hours at morning (0900–1100 AM), and at afternoon (15.30–17.30 PM), All field surveys were conducted during the months February to April, 2016.

Habitats cover analysis:

With reference to maps available through Google Earth Pro the habitat cover and land use pattern of each study sites were measured. Total areas (in ha.) Built spaces or building, open spaces such as open field, vegetation cover and water bodies were measured separately.

Vegetation cover is characterized by effective green spaces (tree covered space and canopy less vegetation), whereas open field is used to demarcate playground, gardens etc. and water bodies (lake, ponds, pools and jheels) located within the study sites.

Tree species diversity:

In this scope of study we have only concentrated on the tree species because trees attracts urban birds for natural nesting purpose, as sources of wild fruits insect preys, and avoid themselves from city noise and other anthropogenic disturbances. Loss of urban birds is associated with tree species disappearance over time for development and natural disaster is a commonplace for any growing city. Tree diversity is thus critically linked with the sustenance of urban fauna especially avifauna. Tree species inventory of the study sites were prepared through series of visits to each sites throughout the study period. Belt transect method is again used as sampling method to reduce chances of repetition. Several walks were implemented across the study sites and the trees on either side are recorded. Counts of each tree were made to find out the species dominance and rarity. The status (ornamental/fruit/timber producing) and origin (indigenous/exotic) of trees were determined using field guide books [15].

Species diversity similarity indices calculation:

Statistical software preprogrammed with formulas and equations known as PAST was used to calculate the various diversity indices (Simpson's index, Shannon-Weiner) of the sites. A diversity index is a mathematical measure of species diversity in a community. Diversity indices provide more information about community composition than simply species richness (i.e., the number of species present); they also take the relative abundances of different species into account, such as about rarity and commonness of species in a community. The ability to quantify diversity in this way is an important tool for biologists trying to understand community structure. The Shannon-Wiener Index measures how evenly species within a community are distributed on a logarithmic scale. Simpson's diversity index (*D*) is a simple mathematical measure that characterizes species diversity in a community. We have also used the Sörensen similarity index [29] to measure the similarity of two study zones. It is based on species numbers and does not take species abundance into account: similarity index = 2c/(a+b), Where 'c' is the number of species shared by the two sites, and 'a' and 'b' the total number of species at each site. Values of this index vary from 0 to 1; 0 indicates that assemblages differ totally, and 1 that they are identical.

RESULTS AND DISCUSSION:

Bird Species composition at JU campus and adjacent urban green spaces:

There are overall of 25 bird species from 15 families are recorded at JU campus. The survey was performed in three time slots – control, undisturbed and disturbed, though occurrence does not vary significantly as we record 22, 21 and 19 species in each slot respectively (Table 2).

Table 2. Checklist of Avifauna spotted at Jadavpur University Campus:

Sr. No.	Common Name	Scientific Name	Family	Feeding Guild	JU			
					C	D	U	Per ha^{-1}
1	Asian Koel	*Eudynamys scolopacea*	Cuculidae	I	8	6	11	0.280
2	Asian Palm Swift	*Apus balasiensis*	Apodidae	I	0	42	22	0.719
3	Black Drongo	*Dicrurus macrocercus*	Dicruridae	I	1	6	1	0.089
4	Black-Napped Oriole	*Oriolus xanthornus*	Oriolidae	F	3	2	5	0.112
5	Blue-Throated Barbet	*Megalaima asiatica*	Megalaimidae	F	1	1	4	0.067
6	House Crow	*Corvus splendens*	Corvidae	O	92	79	136	3.112
7	Common Hoopoe	*Upapa epops*	Upupidae	I	0	1	0	0.011
8	Oriental Magpie Robin	*Copsychus saularis*	Muscicapidae	I	14	0	4	0.202
9	Common Pigeon	*Columba livia*	Columbidae	F	0	0	4	0.044
10	Common Starling	*Acridotheres tristis*	Sturnidae	I	65	33	53	1.471
11	Common Tailorbird	*Orthotomus sutorius*	Cisticolidae	I	16	11	11	0.426
12	Coppersmith Barbet	*Megalaima haemacephala*	Megalaimidae	F	1	0	0	0.011
13	House Sparrow	*Passer domesticus*	Passaridae	G	43	34	32	1.112

14	Jungle Babbler	*Turdoides striatus*	Leiothrichidae	I	2	3	2	0.078
15	Lesser Cormorant	*Phalacrocorax fuscicollis*	Phalacrocoracidae	P	2	1	2	0.056
16	Lesser Goldenback	*Dinopium javanense*	Picidae	I	1	0	0	0.011
17	Pariah Kite	*Milvus migrans*	Accipitridae	C	4	16	35	0.617
18	Pied Starling	*Sturnus contra*	Sturnidae	I	7	10	7	0.269
19	Pond Heron	*Ardeola grayii*	Ardiedae	P	2	2	0	0.044
20	Purpled Rumped Sunbird	*Leptocoma zeylonica*	Nectariniidae	N	4	0	2	0.067
21	Red Vented Bulbul	*Pycnonotus cafer*	Pycnonotidae	I	12	17	9	0.426
22	Rose Ringed Parakeet	*Psittacula krameri*	Psittacidae	F	9	1	3	0.146
23	Rufous Treepie	*Dendrocitta vagabunda*	Corvidae	O	0	0	4	0.044
24	Small Egret	*Egretta garzetta*	Ardiedae	I	4	2	5	0.123
25	Spotted Dove	*Stigmatopelia chinensis*	Columbidae	F	15	14	15	0.494
26	White Throated Kingfisher	*Halcyon smyrnensis*	Halcyonidae	P	1	0	1	0.022
	TOTAL INDIVIDUALS				307	287	368	
	TOTAL SPECIES				21	19	22	

Abbreviations used: CON. = control; DIS. = disturbed; UND. = undisturbed; F = frugivores; O = omnivores; I = insectivores; C = carnivores; G = grainivores; P = piscivores; N = nectarivores

The avifaunal abundance of JU campus is average of visits in three study time slots. The averaged value per species converted to per hectare (ha^{-1}; bird count/area in hectare) in order to compare with other study sites. The noisy surroundings though have little impact on the present species composition except species like Coppersmith Barbets, Blue-throated Barbets Lesser Golden back tends to avoid the period. Overall seven feeding guilds were recorded from which insectivores and are frugivores dominant groups display close association with woody vegetation structure (Figure 3). Parallel short span bird survey in RS

and RCGC, two urban greenspaces reflects considerable diversity of 26 and 28 species respectively (Table 3), The abundance (ha^{-1}) of all three habitats was compared (Figure 2).

All recorded birds are from least concern IUCN category and belongs to resident status which is quite expected as these habitats are located within the growingly urbanized city of Kolkata. There is almost no connection left between outskirt bird habitats due to rapid growth of city along its periphery. Species diversity indices from three habitats were also calculated and compared (Figure 3a).

Table 3. Checklist of Avifauna at the Urban Greenspaces:

Sr. No.	Common Name	Scientific Name	Family	Feeding Guild	Abundance			
					RS	PER ha^{-1}	RCGC	PER ha^{-1}
1	Jungle Myna	*Acridotheres fuscus*	Sturnidae	I	18	0.307	49	0.836
2	Asian Palm Swift	*Apus balasiensis*	Apodidae	I	24	0.409	11	0.187
3	Black Drongo	*Dicrurus macrocercus*	Dicruridae	I	6	0.102	14	0.238
4	Common Crow	*Corvus splendens*	Corvidae	O	409	6.978	54	0.921
5	Jungle Crow	*Corvus macrorhynchos*	Corvidae	O	0	0	14	0.238
6	Common Pigeon	*Columba livia*	Columbidae	F	2	0.034	0	0
7	Common Starling	*Acridotheres tristis*	Sturnidae	I	168	2.866	84	1.433
8	Pied Starling	*Sturnus contra*	Sturnidae	I	128	2.183	65	1.109
9	Common Tailorbird	*Orthotomus sutorius*	Cisticolidae	I	8	0.136	17	0.290
10	Purple-Rumped Sunbird	*Leptocoma zeylonica*	Nectariniidae	N	0	0	1	0.017
11	Coppersmith Barbet	*Megalaima haemacephala*	Megalaimidae	F	2	0.034	16	0.272
12	Blue Throated Barbet	*Megalaima asiatica*	Megalaimidae	F	6	0.102	9	0.153
13	House Sparrow	*Passer domesticus*	Passaridae	G	54	0.921	56	0.955
14	Jungle Babbler	*Turdoides striatus*	Leiothrichidae	I	14	0.238	50	0.853

15	Lesser Cormorant	*Phalacrocorax fuscicollis*	Phalacrocoracidae	P	72	1.228	7	0.119
16	Oriental Magpie Robin	*Copsychus saularis*	Muscicapidae	I	2	0.034	10	0.170
17	Pariah Kite	*Milvus migrans*	Accipitridae	C	23	0.392	48	0.818
18	Sparrow Hawk	*Accipiter nisus*	Accipitridae	C	0	0	1	0.017
19	Pond Heron	*Ardeola grayii*	Ardiedae	P	14	0.238	7	0.119
20	Red Vented Bulbul	*Pycnonotus cafer*	Pycnonotidae	I	4	0.068	14	0.238
21	Rose Ringed Parakeet	*Psittacula krameri*	Psittacidae	F	18	0.307	21	0.358
22	Rufous Treepie	*Dendrocitta vagabunda*	Corvidae	O	6	0.102	5	0.085
23	Spotted Dove	*Stigmatopelia chinensis*	Columbidae	F	4	0.068	11	0.187
24	Yellow Footed Green Pegion	*Treron phoenicoptera*	Columbidae	F	25	0.426	16	0.272
25	White Throated Kingfisher	*Halcyon smyrnensis*	Halcyonidae	P	10	0.170	22	0.375
26	Stork-Billed Kingfisher	*Pelargopsis capensis*	Halcyonidae	P	2	0.034	0	0
27	Small Egret	*Egretta garzetta*	Ardiedae	I	5	0.085	43	0.733
28	White-Rumped Vulture	*Gyps bengalensis*	Accipitridae	C	0	0	6	0.102
29	Black Hooded Oriole	*Oriolus xanthornus*	Oriolidae	I	1	0.017	4	0.068
30	Slaty-Backed Flycatcher	*Ficedula hodgsonii*	Tyrannidae	I	2	0.034	1	0.01
	TOTAL INDIVIDUALS				1027			656
	TOTAL SPECIES				26			28

Abbreviations used: F = frugivores; O = omnivores; I = insectivores; C = carnivores; G = grainivores; P = piscivores; N = nectarivores

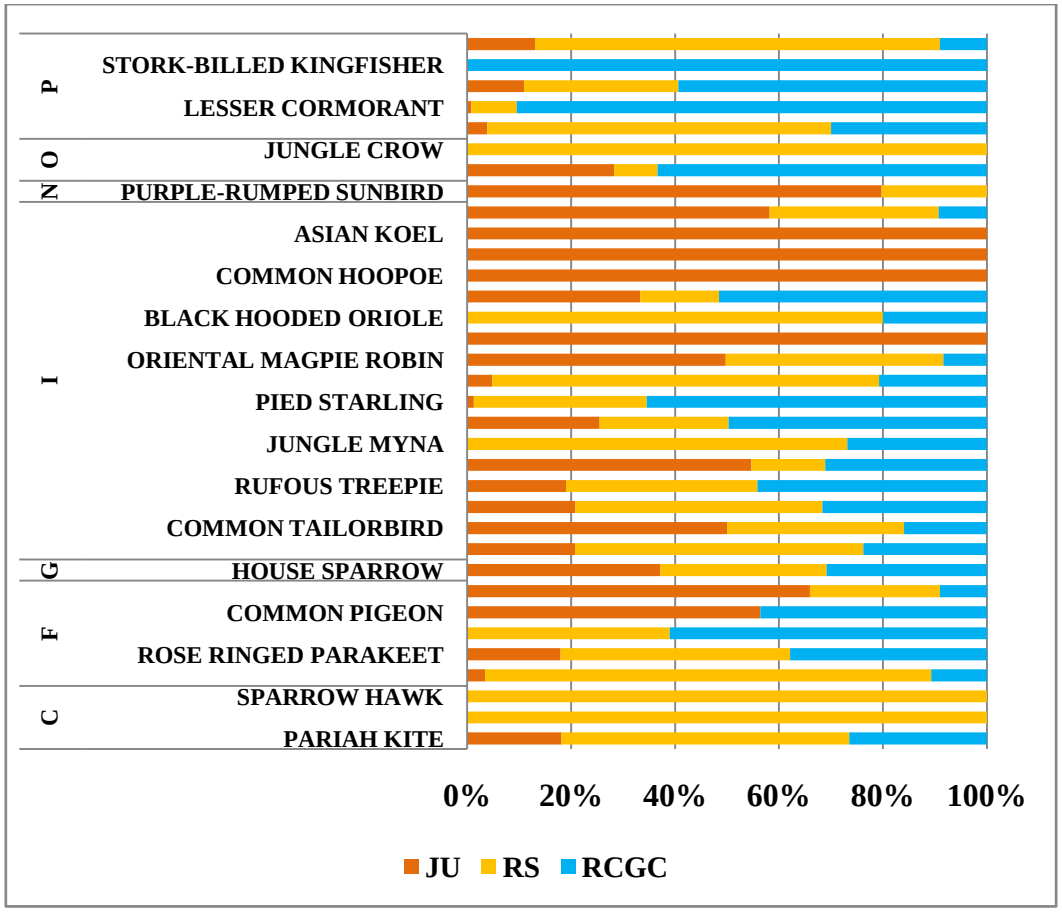
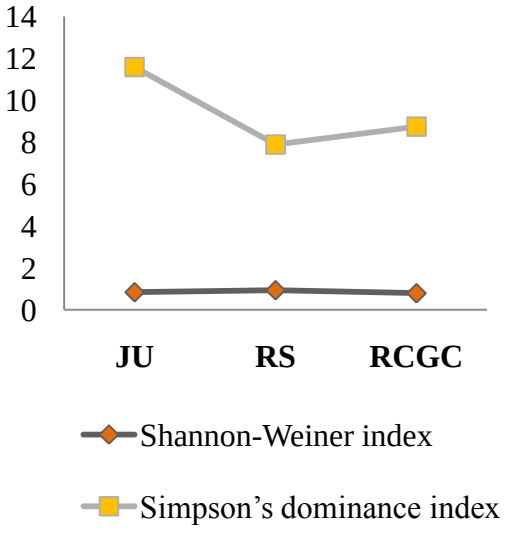


Figure 2. Bar diagrams showing comparative total abundance (per ha^{-1}) of various bird species recorded in three habitats



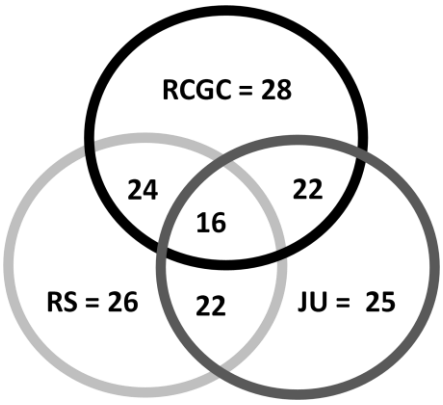


Figure 3 a. Shannon-Wiener and Simpson's Dominance Indices of the three study sites (JU, RS and RCGC)

b. Schematic representation of all the bird species from the three study sites (JU, RS and RCGC) based on commonality of occurrence

Results show Shannon-Weiner index value is highest in RS (2.908) followed by JU (2.304) and RCGC (2.094), Whereas, Simpson's species dominance index shows values 0.931, 0.837 and 0.788 respectively for RS, JU and RCGC. The richness index for the present study was highest in JU (11.58) and lowest in RCGC (8.73), The similarity indices at species level between three habitats were shown in (Figure 3b).

Nesting ecology of birds:

More it is noisy lower the Nest height:

Among the tree nesting community, the most preferred heights and DBH for each habitat were confirmed. Observations suggests that in human interfered JU campus, more number of nests was constructed at lower height, compared to RS and RCGC **(**Figure 4a**),** Moreover, smaller or younger trees with DBH ranging were preferred by birds in JU campus**,** whereas DBH range indicates taller and older trees in RS and RCGC were found to support greater number of nests (Figure 4b).

a. Branch Height **b. DBH**

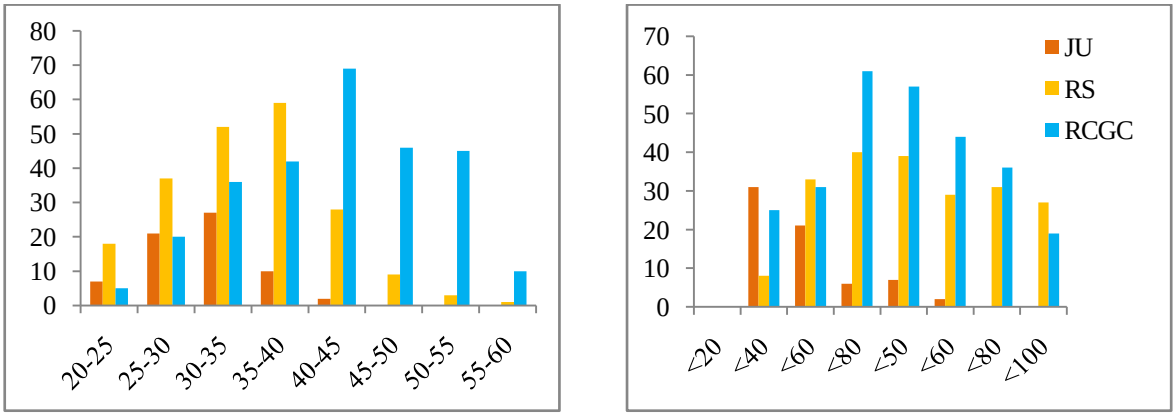


Figure 4 a. Bird Nests at different branch heights (ft) and b. at different DBH (cm)

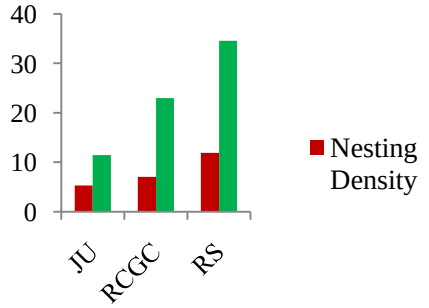


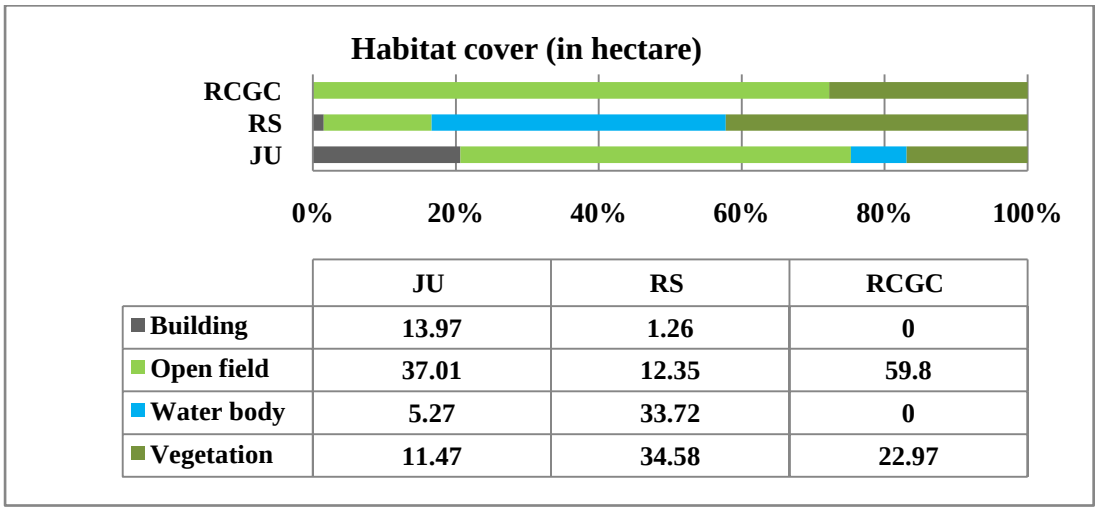
Figure 4 c. relationship between nesting density and green cover at the three study sites

Nesting density is proportionate with amount of green cover per habitat:

Total active bird nests counted in JU, RS and RCGC are 67, 209 and 273 respectively among them majority were on tree branches at different heights. Nesting density calculated in JU, RS and RCGC are 5.29 ha -1, and 7.04 ha -1 and 11.9 ha -1 respectively are proportionate with the available green cover at these sites (Figure 4c).

Nesting habitat diversification attracts greater bird density to JU campus:

Interestingly in JU, 29 out of 67 nests were built on urban structure such as ventilators, light posts window air-conditioner cabinets, building window sheds, false ceilings even in trash piles. Figure 5 depicts the land use pattern in three sites where JU consists of maximum built space and RCGC minimum. Though, JU campus consists of minimum green cover, it still supports high bird density than other two urban greenspaces. This observation proofs built spaces of human use landscape play instrumental role in allowing urban birds to coexist with humans.



	JU	RS	RCGC
Building	13.97	1.26	0
Open field	37.01	12.35	59.8
Water body	5.27	33.72	0
Vegetation	11.47	34.58	22.97

Figure 5: Habitat cover analysis for three study sites

Tree species diversity:

The 29.67 ha premises of JU supports 25 tree species among them *Polyalthia longifolia* or Debdaru is the most abundant (N=307) tree followed by *Delonix regia* or Gulmohar (N=147) (Table 4), Most species rich family is Leguminosae in all the habitats (Figure 6a), The area has almost equal share of exotic and indigenous trees. In RS and RCGC, 27 and 30 tree species were recorded in respective habitats.

Table 4. Checklist of trees recorded in three study sites:

Sr. No.	Common name	Scientific name	Family	Type	Origin	Occurrence
1	Debdaru	*Polyalthia longifolia*	Anonaceae	Avenue	Indigenous	RS, JU, RCGC
2	Gulmohor	*Delonix regia*	Leguminosae	Ornamental	Exotic	RS, JU, RCGC
3	Sal	*Shorea robusta*	Dipterocarpaceae	Timber	Indigenous	RS
4	Guava	*Psidium guajava*	Myrtaceae	Fruit	Exotic	RS, JU
5	Kanakchampa	*Pterospermum acerifolium*	Sterculiaceae	Ornamental	Indigenous	RS, JU
6	Khejur	*Phoenix sylvestris*	Palmae	Fruit	Indigenous	RS, JU, RCGC
7	Coconut	*Cocos nucifera*	Palmae	Fruit	Exotic	RS, JU
8	Mahogany	*Swietenia mahagoni*	Dipterocarpaceae	Timber	Exotic	RS, JU, RCGC
9	Segun	*Tectona grandis*	Verbenaceae	Timber	Indigenous	RS, JU, RCGC
10	Mango	*Mangifera indica*	Anacardiaceae	Fruit	Indigenous	RS, JU, RCGC
11	Kadam	*Anthocephallus cadamba*	Rubiaceae	Ornamental	Exotic	RS, JU, RCGC
12	Banyan	*Ficus bengalensis*	Moraceae	Religious	Indigenous	RS, JU, RCGC
13	Basanti	*Tabebuia chrysantha*	Bignoniaceae	Ornamental	Exotic	RS
14	Chhatim	*Alstonia scholaris*	Apocynaceae	Ornamental	Exotic	RS, JU, RCGC
15	Karabi	*Nerium indicum*	Apocynaceae	Multi-use	Indigenous	RS
16	Akashmoni	*Acacia auriculeaformis*	Leguminosae	Avenue	Exotic	RS, JU
17	Krishnachura	*Caesalpinia pulcherima*	Leguminosae	Ornamental	Exotic	RS, JU, RCGC
18	Radhacura	*Peitophorum pterocarcum*	Leguminosae	Ornamental	Indigenous	JU, RCGC

19	Ashathwa or Pepul	*Ficus religiosa*	Moraceae	Religious	Indigenous	RS, JU, RCGC
20	Bangla badam	*Terminalia catappa*	Combretaceae	Fruit	Exotic	RS, JU, RCGC
21	Bakul tree	*Mimusops elengi*	Sapotaceae	Avenue	Indigenous	JU, RS, RCGC
22	Kolke or oleander	*Thevetia peruviana*	Apocynaceae	Ornamental	Exotic	RS, JU
23	Nagalingam/cannon ball tree	*Couroupita guianensis*	Lecythidacae	Ornamental	Exotic	RS, JU, RCGC
24	Palash	*Butea monosperma*	Leguminosae	Ornamental	Indigenous	RS, JU, RCGC
25	Bamboo tree	*Bambusa vulgaris*	Bambuseae	Multi-use	Exotic	JU
26	Palm tree	*Borassus flabellifer*	Arecaceae	Fruit	Indigenous	RS, JU, RCGC
27	Supari	*Areca catechu*	Palmae	Fruit	Exotic	JU
28	Casuarina	*Casuarina Equisetifolia*	Casuaranaceae	Avenue	Indigenous	JU
29	Bottle brush	*Callistemon lanceolatus*	Myrtaceae	Ornamental	Exotic	JU
30	Eucalyptus	*Eucalyptus citriodora*	Myrtaceae	Ornamental	Exotic	JU
31	Simul	*Bombax ceiba*	Malvaceae	Ornamental	Exotic	RS, JU, RCGC
32	Kanthal or Jack fruit	*Artocarpus heterophylla*	Moraceae	Fruit	Indigenous	JU, RCGC
33	Tentul	*Tamarindus indica*	Leguminosae	Fruit	Indigenous	RS, JU, RCGC
34	Arjun	*Terminalia Arjuna*	Combretaceae	Medicinal	Indigenous	RS, JU
35	Babul	*Vachellia nilotica*	Leguminosae	Medicinal	Exotic	RCGC
36	Neem	*Azaradirachta indica*	Meliaceae	Medicinal	Indigenous	RS, JU, RCGC

An open green space provides vital services to the urban ecosystems. Worldwide, urban university campuses offer mosaic of greenery and concretes with low disturbances and substantial biodiversity - a promising landscape pattern. It has been hypothesized that urban green spaces such as in university campuses may provide promising landscape pattern where urban biodiversity can take refuge and maintain or increase their species diversity over time [30]. This comparative study looks into the potential of Jadavpur university campus to be designated as an urban green space for urban wildlife, birds in particular. RCGC and RS are frequented by Kolkata-based ornithologists as they serve as high quality green refuge for urban birds [31]. Results shows JU campus strongly resembles with that of RCGC and RS both in species abundance as well as in community composition (Figure 3a), Moreover, all three habitats display not much contrast in tree species diversity; only exotic species assemblage is greater in JU campus (Table 4; Figure 3b), Despite the fact that these habitats are quite different in habitat area cover and land use, their biotic communities are comparable. Being situated within a radius of 2 km, these habitats shares between and complement each other in terms of biodiversity as urban green spaces often do.

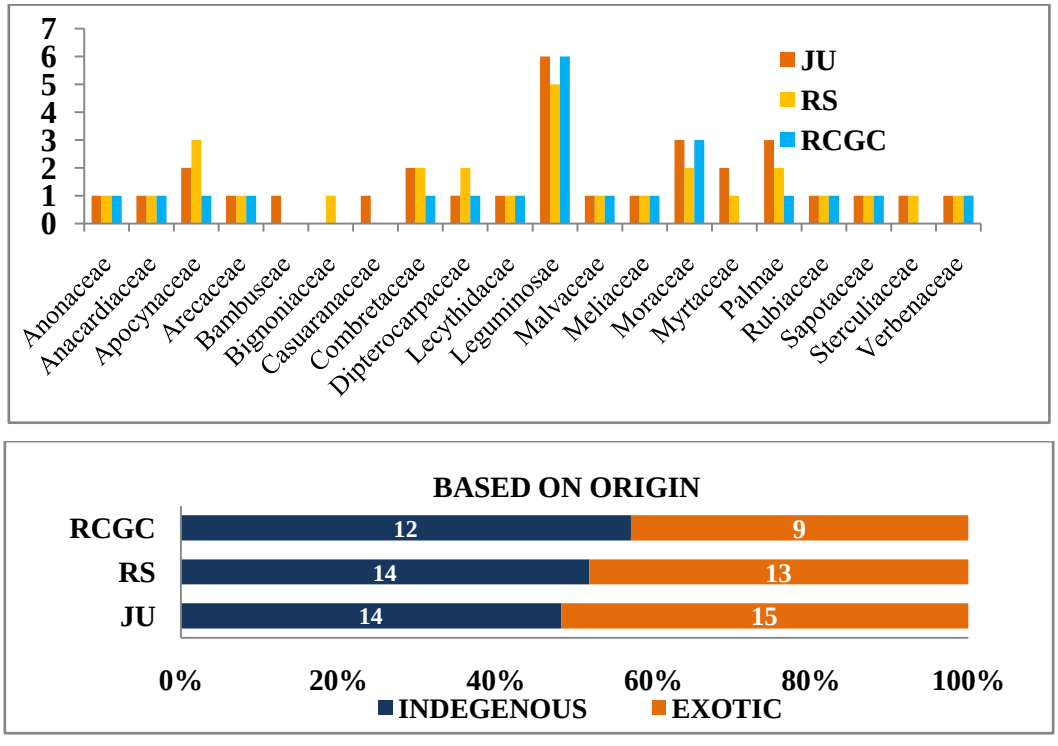


Figure 6 **a: Comparison of Tree composition of three study sites**

b. Family-wise comparison and based on origin

Noise apparently a deterrent to the avifauna in most habitats as they interfere acoustic communication processes essential for reproduction, affects nestling growth [32, 33], overall distribution [34]. For obvious reasons, JU campus is the most noisy habitat among the other, yet birds were reported to construct nests at lowest height as well as choose younger trees (lesser DBH) where impact of noise is maximum (Figure 4 a & b), While lower height nests signify birds are habituated with anthropogenic disturbances and do not feel threatened by the same. However the low number of tree nests is complemented by heterogeneous nesting habitat choice inside the campus as the successful survival in urban birds is largely dependent on its degree coexistence with humans and human used landscapes. Moreover, habitat diversification by birds is also could be a strong a behind considerable density of birds at JU campus. Such finding supports the concept that urban green spaces makes animals to improvise habitat features by utilizing built structures as alternatives in urban ecosystems [12]. The health of bird habitat within the campus can be further bettered by investigating the biasness in tree preference, planting more native trees in days, identifying the functioning food chain and if possible supplying with artificial bird nests in bird rich areas of campus [35].

We can conclude that JU campus is an ecologically alive, good quality urban green space and closely comparable with RS and RCGC in terms of avifaunal diversity and feeding guild composition. Moreover JU campus consists of good vegetation cover to allow conventional tree nesting as well as scopes for nesting habitat diversification with urban structures. Unlike RS and RCGC, JU campus is primarily a man made landscape and for those reason considerable differences in land use, nesting density and height preference can be observed. Our assessment from these observations is that JU campus can be designated as an urban greenspace as it refuges notable bird density with of tree-dependent and urban structure dependent nesting adaptations. Moreover, the homogeneity in overall bird composition between the JU campus and RCGC and RS indicate daily movement of avifauna within these greenspaces for foraging and other purposes.

CONCLUSION:

The outcome of the study is going to be a handy resource for the university administration to promote its ecological sustainability and appreciate the wilderness of the campus. Within this short time-frame we could not collect information on other components of biodiversity viz., mammalian groups and insect which could have made this work more convincing. However, the present observations strongly suggest this campus has tremendous

role in preserving urban greenery and its avifauna. Such studies of urban ecosystems particularly on university campuses serves as a useful tool to any educational institute for maintaining balance within nature and structure and showing environmental commitment.

ACKNOWLEDGEMENTS:

I acknowledgement the valued suggestions of Dr. Biswajit Thakur, Assistant Professor, Department of Civil Engineering, Meghnad Saha Institute of Technology during preparation of this manuscript. Also express sincere thanks to Miss Lisa Karar for her generous help in data collection.

REFERENCES:

1. UN-Habitat (2012), Sterling, V.A. 224 pp.
2. Lee, K.N. (2007), Pp.3-21. In Starke, L. (Ed.): W.W. Norton & company, New York.
3. Collins, J.P., Kinzig, A., Grimm, N.B., Fagan, W.F., Hope, D., Wu, J. and Borer, E.T. (2000), Am. Sci. 88: 416–425. doi: 10.1511/2000.5.416.
4. Czech, B., Krausman, P.R. and Devers, P.K. (2000), Bioscience 50, 593–601.
5. Catterall, C.P., Green, R.J. and Jones, D.N. (1991), In: Saunders, D.A., Hobbs, R.J. (Eds.), Nature Conservation. Surrey and Beatty and Sons Pty Ltd, Chipping Norton, NSW, pp. 247–258.
6. Paton, D.C. (1990), Bird Obs. 696, 34–35.
7. Green, R.J., Catterall, C.P. and Jones, D.N. (1989), Emu 89, 216–222
8. Brittingham, M.C. (1990), In: Adams, L.W., Leedy Jr., D.L. (Eds.), National Institute for Urban Wildlife, Columbia, MD, pp. 185–190.
9. Major, R.E., Gowing, G. and Kendal, C.E. (1996), Aust. J. Ecol. 21, 399–409.
10. Marzluff, J.M. (2001a), In J.M. Marzluff, R. Bowman, and R. Donnelly (Eds.), Kluwer Academic, Norwell, MA. p. 19-47
11. Miller J.R. and Hobbs R.J. (2002), Conserv. Biol. 16:330–337. doi: 10.1046/j.1523-1739.2002.00420.x.
12. Marzluff, J.M., Bowman, R. and Donnelly, R. (Eds.), (2001b), Kluwer Academic Publishers, Boston, MA.
13. McDonnell, M.J. and Pickett, S.T.A. (1990), Ecology 71: 1232- 1237.
14. Fernández-Juricic, E. (2004), Landscape Urban Plan 69:17–32.
15. Benthall A.P. (1946), Thacker Spink & Co. London.
16. Ghosh, A.K. (1991), Government of West Bengal.

17. Ramachandra, T.V., Bharath, H.A. and Sowmyashree M.V., (2014), Appl. Geomat.6(4), 229-244.doi: 10.1007/s12518-014-0135-y
18. Ramachandra T.V., Aithal, H.B., Shivamurthy V., Kumar, U., Venugopal Rao, K. and Joshi, N.V. (2016), In proceedings of ISRO-IISc STC, 7-8 January 2016, Volume: 32.
19. Mookherjee, K. (2004), Naturalist Vol. III: 4-14. Published by Prakriti Samsad, Kolkata.
20. Ghosh, S. and Ghose, S.P. (2007), Rec. Zool. Surv. India: l07 (Part-4): 17-25.
21. Sengupta, S. Mondal, M. and Basu, P. (2014), Urban Ecosyst. Volume 17 (2), pp 585–596.
22. Chowdhury, R., Sarkar, S., Nandy, A. and Talapatra, S.N. (2014), Int. Lett. Nat. Sci. Vol. 16, pp 131-139.
23. Hawksworth, D.L. (Ed.) (1995), The Royal Society and Chapman and Hall, London.
24. Bibby C.J., Burgess N.D. and Hill D.A. (1992), Academic Press, London.
25. Mainwaring, M.C., Hartley, I.R., Lambrechts M.M. and Deeming, D.C. (2014), Ecol. Evol. Oct. 4(20): 3909–3928.
26. Ali, S. (2012), (Ed. by J.C. Daniel.), BNHS and Oxford University Press: New Delhi, India.
27. Grimmett R., Inskipp, C., Inskipp, T. and Allen, R. (2011), Oxford University Press, Christopher Helm, London.
28. Kazmierczak, K. and Perlo, B.V. (2012), Yale University Press 352 pp.
29. Jongman, R.H.G., Ter Braak, C.J.F. and Van Tongeren, O.F.R. (1995), Cambridge University Press, Cambridge, UK.
30. Shultz, A.J., Tingley, M.W. and R.C.K. Bowie (2012), The Condor: May 2012, Vol. 114, No. 2, pp. 258-267.
31. Chattopadhyay, R. and Ghoshal, S. (2015), Int. Lett. Nat. Sci. Vol. 48 pp 61-66.
32. Seress, G., Bókony, V., Pipoly, I., Szép, T., Nagy, K. and Liker, A. (2012), J. Avian Biol. 43: 403–414, 201243 (5), Pages 403–414 DOI: 10.1111/j.1600-048X.2012.05527.x.
33. Ortega C.P. (2012), Ornithological Monographs No. 74 pg(s) 6-22 doi: 10.1525/om.2012.74.1.6
34. McClure C.J.W., Ware, H.E., Carlisle J., Kaltenecker G. and Barber J.R. (2013), Proc. R. Soc. B. 280:20132290.
35. Garcia-Navas, V., Arroyo, L., Sanz, J. and Diaz, M. (1996), Ibis, 150, 356-364.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 2

HABITAT AND ECOLOGY OF LAPWINGS IN INDIA

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INTRODUCTION:

Birds, 'the glorified reptiles with feathers' have always fascinated humankind. The human-bird association has been long and intimate. They are an essential component of human inhabitations, mountains, oceans, ice lands and virtually in each and every corner. Birds are unfailing indicators of a healthy atmosphere and provide lifesaving service, chiefly concerning the jeopardy arising from chemicals and other toxic substances in the environment. The description about Indian birds has been well documented [1], [2]. Birds are astounding with their magnetizing plumage and appealing songs. Few birds are characterized by their unusually veiled presence. Lapwing is one such bird. Lapwings are birds of short grasslands, cultivation and bare ground, often dry but marshland, pools, rivers and lake sides are important habitat features [3]. They are pre-eminently birds of open-country and prefer wide open space, depending on acute vision to detect danger from predators.

The earlier periods have seen severe changes in cattle keeping, agricultural activities and land use. These changes affect the bird species that use either grassland or cultivation land or both for breeding and over the past few decades many bird species breeding in agricultural areas have faced significant population declines as a result of agricultural intensification [4], [5], [6]. Avian communities are susceptible and responsive to changes in the land use pattern [7]. Habitat fragmentation as a consequence of clearance of large tracts of forests leads to changes in the avifaunal structure and composition. Species with narrow habitat ranges respond to such changes either by becoming locally extinct or show a decline, whereas some species adapt to habitat fragmentation [8].

Habitat quality plays a major role in the Lapwings' breeding success and there can be immense variations in nest survival probabilities between diverse habitats [9]. Extensive agricultural land use led to increased habitat fragmentation. When there is expansion of cultivation lands, the other important habitat features like water bodies and barren habitats are lost [10]. The habitat with similar vegetation is liable to attract more predators of the exposed nests of Lapwings [11]. The current turn down in avifauna associated with agriculture is principally an attribute to habitat changes due to anthropogenic activities such as intensification in farming, drainage of water bodies, forest degradations, invasion of shrub, and use of pesticides and insecticides [12].

In parts of India, there is a local belief is that the Lapwing sleeps on its back with the legs upwards and a linked Hindi metaphor *Tithiri se asman thama jayega* ("can the Lapwing support the Sky?"), this is used for a person who undertakes some work that is beyond his capacity [13]. In parts of Rajasthan it is believed that when the lapwing lays its eggs on raised place i.e. higher than the ground, there will be good monsoon [14]. The Hindus speak of Lord Krishna's mercy towards a nesting Lapwing. Just before the Battle of Kurukshetra, He heard the cries of a mother Lapwing, who had her nest on the battlefield. Lord Krishna, then, placed a huge elephant bell over her nest to protect Her and her eggs from the battle's fury [15].

In Eurasia, Northern Lapwing is well-known for his haunting ethereal cry. According to folklore, those who hear his evocative sound will have someone close to them die soon. According to the "Quran", Northern Lapwing became a trusted confidant of King Solomon and brought news to the King about the Queen of Sheba [15].

Early in Egypt's history, the lapwing was a symbol of the people of Egypt under the king's rule (Fig.1), On the Scorpion Macehead (c. 3000 BC), the lapwing is a representation of the law of the Upper Egyptian king over the Lower Egyptian people. The bird was an apparent selection to symbolize the Lower Egyptian people owing to its routine of wintering in the Delta, [16].

Figure 1. Lapwing in Egyptian mythology

(Source: http://www.egyptianmyths.net/lapwing.htm)

Red-wattled Lapwing (*Vanellus indicus)* being insectivorous in its feeding act as an important bio-control agent in the environment and have an effect on the population dynamics of the insects and other invertebrates upon which they feed [17]. A study was conducted on community structure of insectivorous birds on insects infecting cabbage (*Brassica oleracea*) at Anand, Gujarat in 2012. During the study a total of 14 bird species were recorded that foraged chiefly on the cabbage aphids (*Lipaphis erysimi*) in the crop. Red-wattled Lapwing was the most significant and prevailing bird species in the observations. Lapwings can operate as bio-control driving force for managing of insect pests of cabbage as well as other crop and can be encouraged for their abilities to regulate the insect pests of crop pests [18]. The Golden apple snail (*Pomacea canaliculata)* is an invasive species in Hong Kong since early 1980s. Its feeding has caused in a massive loss in semi-aquatic agriculture, especially rice (*Oryza sativa* L.) and other aquatic crops such as taro (*Colocasia esculenta* L.) and water spinach (*Ipomoea aquatica* Forssk), A summary of all potential predators of golden apple snails in Hong Kong wetlands based upon local and international literatures have been compiled [19]. Grey-headed Lapwings *Vanellus cinereus* is one of them that feed on the juveniles of Golden apple snail [20] and act as an important bio-control species.

CLASSIFICATION:

Kingdom	:	Animalia
Phylum	:	Chordata
Class	:	Aves
Order	:	Charadriiformes
Family	:	Charadriidae
Subfamily	:	Vanellinae

Charadriiformes is a varied order of small to medium-large birds (12-75cm), It incorporates about 350 species that have a worldwide distribution [21]. Nearly all Charadriiformes reside in close proximity to water bodies and feed on invertebrates or other small animals; however, some are pelagic (seabirds), some occupy deserts and a few are found in thick forests. The bird family Charadriidae includes the plovers, dotterels, and lapwings, about 67 species in the World while Asia has 22 species and India has 19 species [22]. The current trend has been to downsize the common names of the Charadriidae. For example, the earlier 'sociable plover' is now the sociable lapwing.

Although authorities by and large agree that there about 25 species of Vanellinae, classifications within the subfamily continue to be perplexed. The fossil evidence of the Vanellinae is scarce and mostly current in origin; there are no Neogene lapwings to be known [23]. Generally classification of a bird is based on an amalgamation of various characters such as plumage, colour, habitat, season and behaviour when feeding, flying, displaying or flocking. In case of lapwings, bill is short, Pigeon-like to long, slender and straight or down curved. Wings are long and pointed. Legs short to long with tibiae partly bare in many species. Flight strong, swift and well sustained. Sexes may be nearly alike, or female may be much smaller and/or duller.

POPULATION:

India has seven species of Lapwings. Four are winter migrants (Sociable lapwing, Northern Lapwing, Grey-headed Lapwing and White-tailed Lapwing) and three species are resident to India (Red-wattled Lapwing, Yellow-wattled Lapwing and River Lapwing), The population trends of all the seven species indicate the level of conservation efforts required to prevent their extinct in the future (Table 1),

Sociable Lapwing (*Vanellus gregarious)* Pallas, 1771

Vanellus : Mediaeval. L. diminutive from L. *vannus* a winnowing fan; the lapwing.

***gregarious*:** L. gregalis, sociable; (grex, gregis, a flock or herd or drove, a troop in close order) [24]

Population started decreasing since 1988 when it was considered as a threatened species. It was vulnerable from 1994 to 2000. Since 2004 the Sociable lapwing is Critically Endangered [25].

Population justification:

Surveys in 2006 in Kazakhstan estimated 376 breeding pairs in an area of 145,000 km^2. Extrapolating this population density across the breeding range yields a possible total population size of 5,600 breeding pairs, i.e. 11,200 mature individuals, roughly equivalent to 16,000-17,000 individuals in total. This total is consistent with record counts of 3,200 individuals in Turkey in October 2007 and more recent counts on the border of Uzbekistan/Turkmenistan where 6,000-8,000 individuals were recorded [26]. The European population is estimated at 0-10 pairs i.e. 0-20 mature individuals [27].

Trend justification:

It has suffered a very rapid decline and range contraction. In northern Kazakhstan, a decline of 40% during 1930-1960, was followed by a further halving of numbers during

1960-1987. However, recent fieldwork in central Kazakhstan, suggests stable population trend and possibly starting to increase (e.g. the number of nests near Korgalzhyn increased from 85 in 2005 to 107 in 2006 and 113 in 2007 [28], [29]. In Europe the population size is estimated to have decreased by 80% or more in 27 years (three generations) and by 25% or more in 9 years (one generation) [27].

Table 1: Seven Species of Lapwings in India (Birdlife International, 2016)

S. N.	Photograph	Morphology	Distribution & occurrence	Red List Criteria	Population Trend	R/ M
1	 **Sociable Lapwing (*Vanellus gregarious)***	Crown brown; forehead buffy-white running back as a broad white supercilium to meet on hind-neck. A brown eye-stripe till ear-coverts. Breeding birds have a black and maroon patch on belly; crown black.	Pakistan, east to Bihar, south through Rajasthan, Gujarat and Maharastra (irregular), Straggler to Kerela, Sri Lanka and Maldives. Dry wasteland, ploughed fields and stubbles.	Critically Endangered A3bcd+ 4bcd ver 3.1	Decreasing	M
2	 **Northern Lapwing (*Vanellus vanellus*)**	An unmistakable, green, white and black lapwing with long, slender, upstanding pointed black crest. Rump white; tail largely black and white-tipped; vent rufous.	Pakistan and NW India, east through the northern plains to Assam valley, Manipur and NE Bangladesh; also S Gujarat, straggler further south (Maharashtra), Fallow land, stubble and marshland bordering cultivation.	Near Threatened A2abce+ 3bce+ 4abce	Decreasing	M
3	 ***River Lapwing* (*Vanellus duvaucelii*)**	An attractive, sandy above and white below lapwing. Crown, face, throat, flight feathers, belly-patch and tail end black.	Foothills of Himalayas from Himachal to Arunachal; Assam valley; NE hill states; C India and NE Peninsula. Sandbanks and shingle beds of rivers.	Near Threatened ver 3.1	Decreasing	R

S. N.	Photograph	Morphology	Distribution & occurrence	Red List Criteria	Population Trend	R/ M
4	 **Red-wattled Lapwing (*Vanellus indicus)***	Bronze-brown above, white below with black breast, head and fore-neck. A crimson fleshy wattle in front of eyes. Prominent white band from behind eye down sides of neck to the white underparts. Bill red, tipped black.	Sub-Himalayan subcontinent; Sri Lanka. Near water in open country and cultivation.	Least concern	unknown	R
5	 **Yellow-wattled Lapwing (*Vanellus malabaricus)***	Sandy-brown with white belly, black cap, and yellow lappets of skin above and in front of the eyes.	Endemic. Sind in Pakistan; and in India from Gujarat north to Himachal, east to Bihar and south throughout the Peninsula, Sri Lanka. Wasteland, stubbles and fallow fields in dry biotope.	Least concern/ Rare*	Stable	R
6	 **Grey-headed Lapwing *(Vanellus cinereus)***	Head and upper neck grey; light brown above and white below. Tail white with a black terminal band. Lower neck and breast ashy-grey bordered by a chocolate pectoral-band. Bill yellow, tipped black.	Plains from Nepal to Bihar, NE India and Bangladesh. Straggler to Kashmir, Delhi, Rajasthan, Gujarat, Goa, S India, Andamans and Sri Lanka.Wet ground, marshes, ploughed fields and stubble.	Least concern/ Rare*	Decreasing	M

7	 **White-tailed Lapwing (*Vanellus leucurus)***	Somewhat like Yellow-wattled Lapwing, but without black cap, yellow lappets, and always seen near water. In flight, readily separated from the other lapwings by the pure white tail and black inner edge to the white wing-bar.	Pakistan and North India, east Bangladesh and south to Gujarat, Maharashtra, Goa, N Madhya and Orissa. Along jheel edges.	Least concern	Unknown	M

*Uncommon. Encountered with less than 50 percent certainty in preferred habitat; R-residential; M-migratory

[Photo credit: Sociable Lapwing- Aditya Roy, Managing director, Soar Excursions]

[Photo credit: Northern Lapwing- Rajesh Panwar, Managing Director Milieu Hospitality Corbett's Village-Chhoti Haldwani Kaladhungi, Nainital-UK]

[Photo credit: Grey-headed Lapwing -Dr.Nishith Kumar MBBS, MD Consultant Respiratory Medicine & Interventional Pulmonology Orchid Medical Centre Ranchi]

Northern Lapwing (*Vanellus vanellus*) Linnaeus, 1758 *Vanellus* : Med. L. diminutive from L. ***vannus*** a winnowing fan; the lapwing [24]

Population justification:

One of the species following the declining trend is the Northern Lapwing (*Vanellus vanellus*), a Palearctic farmland wader which has declined in abundance over much of its European breeding range [30] as a result of agricultural intensification over the past few decades [31]. The global population is estimated to number c. 5,600,000-10,500,000 individuals [32]. The European population is estimated at 1,590,000-2,580,000 pairs, which equates to 3,190,000-5,170,000 mature individuals [33].

Trend justification:

The overall population trend is decreasing, although some populations have unknown trends [34]. In Europe, since 1980 populations have undergone a moderate decline ($p<0.01$), based on provisional data for 21 countries from the Pan-European Common Bird Monitoring Scheme; this is supported by recent data from Europe, suggesting the European population is decreasing by 30-49% in 27 years (three generations) [33]. A strong decline is also reported for the European and western Asian population between 1988 and 2012, based on annual mid-winter counts [35]. No recent trend data is available for the two other flyway populations (breeding in southern Russia, Kazakhstan, Mongolia and northern China and wintering in southern and eastern Asia [34].

***River Lapwing* (*Vanellus duvaucelii*) Lesson, 1826**

Vanellus: Med. L. diminutive from L. *vannus* a winnowing fan; the lapwing. ***duvaucelii***: After Alfred Duvaucel (1796-1824) French naturalist and collector in Sumatra [24]

Population justification:

River Lapwing was Least Concern in 2009. In 2012 it was included in Near Threatened category [36]. Waterbird Population Estimates provides an estimated population size of 1-25,000 individuals for the period 1987-1991 [37]. The population may possibly number no more than 15,000 individuals [38]. The population is therefore placed in the band 10,000-19,999 mature individuals roughly equivalent to 15,000-29,999 individuals.

Trend justification:

The current population trend is expected to undergo a moderately rapid population decline overall during the next three generations, owing to the impacts of human pressures on riverine ecosystems and multiple dam construction projects. In Cambodia the population has undergone declines; in Sesan the population decreased from 223 birds in 1998 to 102 in 2003 and 60 birds in 2010. Breeding success in all populations in Cambodia is reportedly low owing to multiple human-related threats. Construction of the Don Sahong Mekong-mainstream dam in southern Laos could compound could contribute to further population declines [39].

Red-wattled Lapwing (*Vanellus indicus)* Boddaert, 1783

Vanellus* :** Med. L. diminutive from L. *vannus* a winnowing fan; the lapwing. ***indicus*:* refer to India [24]

Population justification:

The global population is estimated at 50,000-60,000 individuals (Wetlands International 2016), The European population is estimated at 50-100 pairs, which equates to 100-200 mature individuals [27].

Trend justification:

The population trend is difficult to determine because of uncertainty over the extent of threats to the species. The tiny European population is estimated to be stable [40].

Yellow-wattled Lapwing (*Vanellus malabaricus)* Boddaert, 1783

Vanellus* :** Med. L. diminutive from L. *vannus* a winnowing fan; the lapwing. ***malabaricus: after the Malabar coast in kerala, the first Indian province known to Europeans [24].

Population justification:

The population is estimated to number 5,000-10,000 individuals, roughly equating to 3,300-6,700 mature individuals [41].

Trend justification:

The population is suspected to be stable in the absence of evidence for any declines or substantial threats [42].

Grey-headed Lapwing *(Vanellus cinereus)* Linnaeus, 1758

Vanellus : Med. L. diminutive from L. *vannus* a winnowing fan; the lapwing. ***cinereus*:** L. cinereus, ash-colored, ash grey (cinis, ashes) [24]

Population justification:

The global population is estimated to number c.25,000-100,000 individuals (Wetlands International 2006), while national population estimates include: c.100-10,000 breeding pairs and c.1,000-10,000 individuals on migration in China; < c.50 individuals on migration and < c.50 wintering individuals in Taiwan; < c.1,000 individuals on migration in Korea and c.100-10,000 breeding pairs, c.50-1,000 individuals on migration and c.50-1,000 wintering individuals in Japan [43].

Trend justification:

The population is suspected to be in decline owing to ongoing habitat destruction and degradation [45]. Despite the fact that the population trend appears to be decreasing, the decline is not believed to be sufficiently rapid to approach the thresholds for Vulnerable under the population trend criterion i.e. >30% decline over ten years or three generations [46].

White-tailed Lapwing (*Vanellus leucurus)* Lichtenstein, 1923

Vanellus : Mediaeval. L. diminutive from L. *vannus* a winnowing fan; the lapwing. ***leucurus*:** Greak Leukouros, white tailed (leukos, white; ouros, tailed) [24].

Population justification:

The global population is estimated to be 20,000-130,000 individuals [34]. The European population is estimated at 560-5,100 pairs, which equates to 1,100-10,200 mature individuals [33].

Trend justification:

The overall population trend is uncertain, as some populations are decreasing, while others are increasing [34]. The European population is estimated to be increasing [33]. The

population size may be moderately small to large, but it is not believed to approach the thresholds for Vulnerable under the population size criterion (<10,000 mature individuals with a continuing decline estimated to be >10% in ten years or three generations, or with a specified population structure), For these reasons the species is evaluated as Least Concern [46].

ECOLOGY AND BEHAVIOUR:

As a group lapwings typically exhibit several common structural and plumage characteristics. Structurally they have broader and more rounded wings than other plovers, a feature which is most marked in the Northern Lapwing. Their flight often therefore lacks the winnowing dash of species such as the golden plovers, although many species have acrobatic display flights and can move very rapidly. It is the character of this looser and more "floppy" flight that has given rise to the traditional name of lapwing.

Although those of the Northern Lapwing are short, most lapwings are noticeably long-legged, with the feet extending partly or wholly beyond the tail in flight in 20 species (Fig.2), Three species have crests, the only waders to do so, 15 have prominent carpel spurs and 11 have facial wattles (eight have both),Sociable and white-tailed lapwing lack any such adornments. However all lapwings prominent carpel spurs have vestigial ones in the form of bony excrescences under the skin of the carpal joint [47].

Lapwings are birds of striking contrast in plumage, with white underwings and most often white underbodies, black primaries and, in many species, bold white bands on underwings. Consequently the species are vividly patterned in flight that may otherwise be cryptically colored at rest. In plummeting exhibit flights the black or white effect is noticeable. This perceivable pattern may also be an effectual disincentive against the stamping on of nests by livestock.

Figure 2. Feet extending partly or wholly beyond the tail in flight

All the lapwings also have the upper tail boldly patterned: white with a prominent black terminal band, however White-tailed Lapwing is an exception to this, with a completely white tail [48].Inspite of the well-marked plumage with contrast colours, lapwings lack bright

colours. The dazzling colors such as red and yellow are these being mainly restrained to the bare parts such as bills, legs, facial wattles, irides and/or eye rings (Fig.3), The omission to the is the Critically Endangered Sociable Lapwing that is devoid of any such prettification and this species is unique among lapwings in showing a distinct and colourful summer plumage. However, there are slight seasonal variations in plumage amongst lapwings and are most striking in Northern, Grey-headed and Yellow-wattled Lapwings [48].

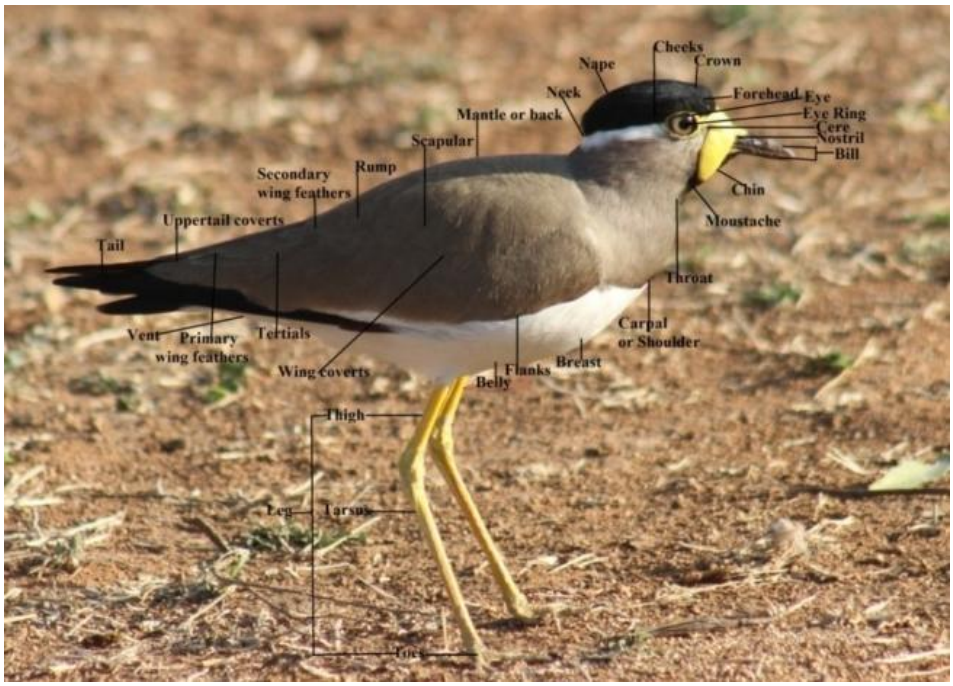

Figure 3. External features of Lapwing

White tailed lapwing are gregarious, occurs in large flocks when migrating, otherwise in smaller groups of up to 25 birds. They feed in shallow water also on land. The White-tailed lapwing visits North India from September to March. These lapwings are mostly found along the jheels or other water bodies (Fig.4). The food comprises of invertebrates such as aquatic insects, crustaceans, mollusks.

Sociable Lapwing generally keeps in small flocks of 5 or 6. Before spring migration the size of flocks increases to 20-100. They feed generally during night, early morning or evening. Sociable Lapwings are winter migrants and arrive by September-October and departs by March-April in North India. The diet mainly comprises of insect (Orthoptera, Coleoptera, and moth larvae). They share the habitat with other waders (Fig.5),

Figure 4. White-tailed lapwing foraging along a jheel

Figure 5. Sociable Lapwings foraging with other waders (Photo credit: Aditya Roy)

Northern Lapwing: It migrates from Western Europe, the east Atlantic islands and North Africa throughout the Mediterranean, Middle East and Iran across northern **India** to south-east China, the Korean peninsula and southern **Japan** [49]. The breeding period is from April to July [50] usually in single pairs [45] even though pairs may also nest close together in favorable habitat [51], [52]. The nest is a superficial scrape in short grass vegetation [45]. Northern Lapwing inhabits rather close environs to water and was often partially or fully surrounded by water. They forage by sight, rather than by feel as longer-billed waders like snipe do. Foods eaten incorporates aquatic and terrestrial invertebrates such as insects, worms, mollusks and crustaceans depending on habitat, and are usually obtained by a run-and-pause technique, rather than the sturdy snooping of some other wader groups [23].

Grey-headed Lapwings are gregarious, in flocks up to 50 birds, commonly associated with Red-wattled Lapwing. They arrive in Northern India by September-October and depart by March end or April. They are carnivorous (Insects, worms, mollusks), After the breeding is over i.e. late July, the pairs and families form a small flock of about ten individuals and undergoes molting. After October the majority of the population breeding in snowy regions migrates south, but some stay back and spend the winter in the breeding grounds. The flocks that migrate south return to the breeding sites around late February [53].

Red-wattled Lapwings are generally crepuscular and nocturnal, feeds-actively in morning, evening or moonlit nights. They keep in pair or threes or small flocks up to a dozen birds (Fig.6), They breed from March to August-September in North India. Nests are constructed on ground in natural depressions, sometimes also at unusual places like rooftops. Red-wattled lapwings are carnivorous (mollusks, insects) and rarely feed on vegetable matter.

Figure 6. Small flock of Red-wattled Lapwing in rain filled depression

Figure 7. Infrequently observed flock of River lapwings

River Lapwings are nor gregarious, they are generally solitary or in pairs and seldom in flocks larger than 3 to 6 birds (Fig.7), in broad-spectrum analogous in behaviour to Red wattled Lapwing. They breed from March to June in North India. They are carnivorous, diet comprising of molluscs, crustaceans and insects. As the name suggests, they inhabit the wide, slow rivers with sand or gravel bars and small islands [54]. They are seen foraging with other waders such as sandpipers, Red-wattled lapwings.

Yellow–wattled lapwing: The yellow-wattled lapwings are gregarious (fig.8), seen in flocks' varying between 10-50 individuals. Very similar to Red wattled Lapwing except that it is less dependent on water. They are also less boisterous and expressive. Breeds from March April to July. They nest on fallow lands circled by pebbles. The food of the yellow-wattled lapwing is beetles, termites and other invertebrates, which are picked from the ground [13].

In times gone by, the lapwing has demonstrated an immense ecological flexibility in adapting to ecological changes, if compared with other waders. Foraging is elementary to bird's continued existence and reproduction. It is not just a simple issue of finding food; rather it is a biological necessity. Foraging habitat range by birds can be influenced by large-scale landscape [55], [56], [57] as well as by small-scale microhabitat variables [58], [59], [60]. These, in turn, will circumstance food availability, i.e. plenty of food and its ease of access [61], [62]. Thus the knowledge of food resources is obligatory for studying the ecology and evolution of bird species.

The Lapwings search for food by sight, rather than by feel as longer-billed waders like snipe do. Foods eaten consist of aquatic and terrestrial invertebrates for example insects, worms, mollusks and crustaceans according to the habitat. The foraging behavior involves a run-and-pause procedure, unlike the sturdy snooping of several wader groups [23]. The two activities vigilance and foraging are practically incapable to go hand in hand [63], in

particular for birds that forage on the ground [64]. Lapwing generally lean its body forward to capture its prey and are visual forager, [65], [66]. The basic procedure used by lapwing is "Run and Pause". They energetically follow its prey and then all of a sudden peck at it. The apparent cause for the espousal of such a tactic might because they hunt by sight, so when they discover a prey, they run in order to grasp and restrain it and again repeat the same strategy. Yellow-wattled Lapwing demonstrates an inherent preference for shorter vegetation with bare patches which facilitates an easier detection of food (Fig.9),

Figure 8. Flock of Yellow-wattled lapwings foraging in fallow land

Figure 9. Yellow-wattled Lapwing foraging on termites in bare field.

The behavior of mobbing predators in defense of the nest and young is known in many birds. The genus *Vanellus* is especially noted for their vigorous defense behavior among others [67]. Lapwings use many forms of parental protection, such as simulation of injury, open wing aggression, displays and alarm calling. Lapwings make multifarious assessments regarding threat to their nests and adjust their defensive behaviour accordingly [68]. Sometimes besides the breeding pair, the neighboring two or more pairs also form a defensive flock [69]. If the lapwings fail to chase the predator away, however, they start to circle over the predator to threaten it and further initiate an attack risking a direct contact against it [53].

BREEDING BEHAVIOR:

The Charadridae lay two to four eggs into the nest, which is usually a shallow scrape in the open ground. This may be lined with gravels and sticks. The late breeding pairs keep dried dung bits in the nests besides the usual materials such as gravel pieces and twigs [70]. This sort of foundation is useful during the rains and prevents sinking of eggs into wet earth [71]. The eggs of the residential species, i.e. the Red-wattled, Yellow-wattled and River Lapwing are olive stone coloured, blotched and spotted with shades of brown and black

(Fig.10a & b), As such, they are completely camouflaged with their surroundings. They are pyriform in shape i.e. narrow tip and broad base. The broader end always faces the outer side while the narrow end touches the ground. These pyriform eggs do not roll down, so they are well shaped for a shallow scrape on ground. The incubation period is of 21-30 days [23]. In Lapwings, both parents share the incubation duties, and contribute to their parental duties (Fig.11 a & b), In some pairs, parents replace their incubation duties on the nest in the morning and in the evening such that the incubation regularity pursue 24-hour day, in others males and females this swap over is up to 20 times a day [72].

a. Red-wattled Lapwing **b. Yellow-wattled Lapwing**

Figure 10. Eggs of Lapwings in a shallow scrape nest on ground

a. Red-wattled Lapwing **b. Yellow-wattled Lapwing**

Figure 11. Lapwings incubating the eggs

Protection is secured by the eggs and young of such birds through their remarkably obliterate coloration. The eggshells after hatching were removed from the nest providing both sanitation and concealment. When predators such as jackals, feral dogs, mongoose, snakes, and crows are observed, intense alarm calls are given by the lapwings. The lapwings fly, stand and run in front of the predator, raising their wings, probably to distract and deceive it. The lapwings cover the newly hatched chicks underneath during the day, when the temperatures are extremely high (Fig.12), The chicks are nidifugous i.e. hatch with eyes open and are precocial i.e. their parents do not feed them. They were open and 3-4 hours after

hatching were seen walking at a distance from the nest with one of the parents. They forage in the custody of the parents (Fig.13),

Figure 12. The chick hiding under the parent

Figure 13. Chicks foraging in guardianship

The chicks also demonstrate remarkable camouflaging just like the eggs (Fig.14), The brownish-black downs of the nidifugous chick make them blended in with the surroundings and as such they were highly obliterated in the natural environment. They actively respond to the alarming calls of the parents and crouch in the ground immediately (Fig.15),

The Lapwings breed during the hot summers in India, so to protect the eggs from overbearing heat, the brainy birds soak their belly feathers from the nearest water source to cool the eggs and provide water to the chicks. The parent lapwings also guide the newly hatched chicks to the nearby water body. The chicks crouch in the water and keep them cool during the high temperatures (Fig.16), Yellow-wattled Lapwings by no means leave this nesting and foraging sites and usually remain noiseless. Contrasting to Red-wattled Lapwing, the Yellow-wattled Lapwing is non-obtrusive and generally keeps a low standpoint. It avoids the presence of Red-wattled Lapwing individuals near it, on approaching near them; they swiftly walk away soundlessly [73]. At times, the yellow and Red-wattled lapwings fight for territories and attack each other (Fig.17), Red-wattled lapwings chase the yellow-wattled lapwings. When sharing the same breeding ground, the Yellow-wattled breed about 15-20 days before the Red wattled, so as to evade the competition for food amongst the chicks.

Figure 14. Chicks demonstrate remarkable camouflaging

Figure 15. Chick actively responds to the alarming calls of the parents and crouch in the ground

Figure 16. The chicks crouch in water during the high temperature

Figure 17. Yellow-wattled being mobbed by Red-wattled lapwing

River lapwings on the other hand are usually fairly silent while nesting, not becoming very frantic or vocal until their eggs have hatched. The guarding male's behavior included alarm calls (though usually only a few), stretching its body upwards while raising its crown, lowering its body into a horizontal position, or repeatedly "kneeling" and standing up again. During the time of threat, while one parent leads the chicks away from danger and the other one run off in the opposite direction so as to bluff the predator.

THREATS:

Out of the seven species of Lapwings, The Sociable Lapwing is Critically Endargered, The Northern and River Lapwings are Near Threatened. The Yellow wattled and Grey-headed Lapwing are Rare as per IUCN Red List Category, while the status of Red-wattled and White tailed Lapwing is unknown. There are several threats that are leading to the decline in the population of lapwings; these include agriculture, urban sprawl, infrastructure development, harvesting, pollution, predators, human disturbance, drainage of water bodies

and climate change [74]. Agricultural intensification and urban sprawls are two main reasons to cause rapid declines in recent years. The disturbances due to Humans may vary locally.

Habitat Change:

The overarching reason for the Lapwing decline is deemed to be a consequence of habitat changes linked to agricultural intensification [5], [6]. When agricultural land fields develop, important habitat features like ditches, puddles, habitat islands and other residual habitats are lost [10]. The homogenous landscape also increases the predation risk on the Lapwings, as the nests are more exposed [11]. Making use of heavy machinery in agriculture fields leads to nest destruction [74]. Within arable fields Lapwings are particularly vulnerable to agricultural operations such as ploughing, rolling and chemical applications

Climatic variation:

Climatic variation is an aspect that has adverse impact on Lapwings in all stages of life. Adult survival has been found to be negatively related to measures of winter weather severity, with mortality increasing significantly in bad winters [75]. It's a challenge to collect food on the frozen grounds, and principally when winters are long-lasting. This causes starvation and freezing of Lapwings, leading to mortality [76]. During the breeding period, the unusual rainfall also leads to egg destruction and failure of egg hatching.

Hunting:

There has been no trade or hunting of lapwings in India. However, Lapwings can be legally hunted in France, Greece, Italy, Malta and Spain [74], [30]. Shrubb mentions that an amazing 800000 eggs were imported annually to London from the Friesland region in the Netherlands during the 1870s. The species is also hunted for commercial and recreational purposes in Iran [30]. While hunting is probably not the primary reason for the global Lapwing decline, it does have a negative impact on the population size and could work against conservation efforts [74].

Low food availability:

With the use of chemicals (pesticides and insecticides) in agriculture, the birds are facing the problem of food unavailability. The beetles, ants, mayflies, slugs worms, etc., are destroyed by the chemicals. Earthworms have also been shown to be an important component of chick diet; indeed as chicks develop they depend on a diet rich in earthworms to maintain growth rates and body condition [77], [78]. The practice of Stubble burning i.e. intentional setting fire of the crop remnants after yield of wheat and other grains, not only destroys the nutrients, but also kill the invertebrates that are important source of food for the Lapwings.

Changing River ecosystems:

The growing threats to river ecosystems, the prime habitats of River Lapwings, are another warning to their future population. The White-tailed and Northern Lapwing are also closely associated with water bodies. The anthropogenic activities are destroying the water sources at a rapid pace. The encroachment of wetlands for agriculture and construction are destroying the natural habitats.

Overgrazing by cattle:

A significant portion of world grasslands are over utilized by livestock. Nest failures due to trampling can occur when the density of grazing animals is too high during the breeding season. The trampling by hooves of livestock result in egg damaging that leads to breeding failure. The livestock often prefer the sites with source of water nearby, as such more threat to the breeding Lapwings.

Natural Predators:

The Lapwings being ground nest dwellers have many natural predators. Some of these are feral dogs (*Canis familiaris*), Bengal fox (*Vulpes bengalensis*), crows (*Corvus* species), common buzzard (*Buteo buteo*), Indian jackals (*Canis aureus indicus*), snakes, rats and mongoose (*Herpestes*), Although lapwings are known for their defensive behavior, sometimes the predators succeed in consuming the eggs and the chicks.

Myths:

There are certain myths associated with the Lapwing species throughout the World. In the Netherlands, there is a cultural-historical competition to find the first peewit (Northern Lapwing) egg of the year. It is especially popular in the province Friesland, but there are also regional competitions. Gathering peewit eggs is completely prohibited by the European Union in 2005 [79]. In Bundelkhand region of India, the people believe that the lapwing keeps a special pebble in its nest. This pebble is capable of making an individual invisible, when kept in palm. This results in the disturbance of nests and affects the breeding success. In some places in East Uttar Pradesh, the people collect the egg and break it at one point. They then add a few dew drops from the broken point and use the eggs of Lapwings to become invisible.

MANAGEMENT OF RISK PRONE LAPWINGS IN INDIA:

Avian taxa have providentially been receiving due attention, since the adoption of modem approach. Unfortunately for lapwings not many conservation efforts have been undertaken in India. With Darwin initiatives a project "Tracking the Sociable Lapwing:

conservation beyond the breeding grounds" was undertaken Royal Society for the protection of birds and Birdlife International from 2009 to 2011. The project purpose was to extend and develop local capacity to better understand and improve the conservation status of the Sociable Lapwing in all project sites along its migration routes and its wintering areas. With the support of RSPB, the Gujarat Ecological Society, undertook survey work in north-west India [80]. In recent years, research work have been undertaken on Yellow-wattled and River Lapwings in India; however there is insufficient data and research work on the migratory species.

RECOMMENDATIONS FOR IMPROVED CONSERVATIONAL ACTIONS

- **Strategy and Legislation**: When Policies and Strategies are being undertaken, they should not affect the present breeding populations. The reviewing schemes of Agriculture and environment should consider the requirements of the lapwing when. Any development proposal should give significance to the breeding habitats of lapwings.
- **Protection and Management of Sites:** The feeding, nesting and roosting sites should be designated as Lapwing Management Sites (LMS), Seek to secure appropriate management for this species on grasslands, common land and post-industrial land [81]. Wildlife legislation should be implemented.
- **Undertake Research**: Researchers and conservationists should take up joint projects and apt management strategies, to maintain and restore the required habitats for lapwings. The focus should be on reducing disturbance due to daily anthropogenic activities.
- **Ensure food availability:** The sites visited by winter migrant species of lapwings and the breeding sites of residential species should be ensured for food availability. The farmers near these places should be encouraged for organic farming and less use of pesticides.
- **Involvement of farmers for protection of nests:** When cultivating, encourage the farmers to observe and spot out the nests. Mark them with a stick or stone so as to prevent nest destruction during agricultural activities such as ploughing and sowing. The distance between the markers and nests should be at least 20 m away to avoid predators. Precautions should be taken for six weeks so that the parent lapwings complete the nesting and chick rearing.
- **Involvement of local herders:** During the breeding season, the local herders should be involved in the conservation of breeding pairs and their nests. In the breeding sites, ask them to remove livestock or reduce numbers during the breeding season (late March to

June), They can also mark the nests and prevent the trampling by averting the cattle from moving in that area.

- **Future exploration and Monitoring:** surveys for all possible sites that support the lapwing populations and monitor these places to improve baseline data for undiscovered lapwing colonies with the help of bird watchers, Forest Department and farmers.
- **Utilize Social Media:** For obtaining the baseline data, social media such as facebook and watsup can also be used to encourage the people to provide information about the status of lapwings in their regions.
- **Awareness:** There are few people who know about the Critically Endangered "Sociable Lapwings" and Near Threatened "Northern and River Lapwing". There is an urgent need to create awareness amongst the people and involve them in their conservation plans. The students can be involved by organizing various competitions based on lapwings for them. Prepare Awareness material in the local language for the students and local people. Involvement of press media can disseminate the message to wider group of people.

Therefore on this background, it is imperative to evaluate the existing conservation status of the Lapwings and the accessible research outcomes so to review the in progress efficacy of conservation plans and actions. With these observations, recommendations should be undertaken for future management and restoration of the Lapwing populations.

ACKNOWLEDGEMENTS:

Gratitude is expressed towards Mr.Devendra Kumar, CCF Bundelkhand Zone, Forest Department, Uttar Pradesh, for providing all the facilities to undertake the Research Work. I am grateful to Dr. Nelson George, SRF, Department of Endosurgery, SGPGI, Lucknow for his kind support in getting several beautiful photographs for the chapter. We have to express our appreciation to Dr.Nishith Kumar (MBBS, MD Consultant Respiratory Medicine & Interventional Pulmonology Orchid Medical Centre Ranchi), Rajesh Panwar (Managing Director Milieu Hospitality Corbett's Village- Chhoti Haldwani Kaladhungi, Nainital (UK) and Mr.Aditya Roy Managing Director (Soar Excursions) for sharing their photographs of Lapwings. We are grateful to the local people who helped by giving the valuable information about lapwings. Our most genuine indebtedness is owed to the volunteers who accompanied us for the field visits to collect the scientific data.

CONFLICT OF INTEREST:

The author declares no conflict of interest

REFERENCES:

1. Whistler, H. (1948), Natraj Publication, Dehradoon. P.459-461.
2. Ali, S. and Ripley, S.D. (1980), Oxford University Press. P. 212–215.
3. Shrubb, M. (1990), Bird Study 37, P.115–127.
4. Siriwardena, G.M., Baillie, S.R. and Wilson, J.D. (1998), Bird Study 45(3), P. 276-292.
5. Donald, P.F., Green, R.E. and Heath, M.F. (2001), Proceedings the Royal Society B-Biol. Sciences 268, P.25-29.
6. Benton, T.G., Vickery, J.A. and Wilson, J.D. (2003), Tre. Eco. Evol.18 (4), P.182-188.
7. Daniels, R. J. R., N. V.Joshi and M. Gadgil (1990), Biol.Consent. 52, P.37-48.
8. Arnold, G. W and J. R. Weeldenburg (1990), Bid. Conserv. 53, P. 295-315.
9. Berg, A., Lindberg, T. and Kallebrink, K.G. (1992), J. Ani. Ecol. 61(2), P.469-476.
10. Johansson, O.C. and Blomqvist, D. (1996), J. Applied Ecology 33(5), P.1030-1040.
11. Whittingham, M.J. and Evans, K.L. (2004), Ibis146 (Suppl. 2), P.210-220.
12. Petersen, B.S. (2009), Natura 2000, Technical Report 2009-033.
13. Jerdon, T.C. (1864), George Wyman and Co. P.648–649
14. *Saxena, V.S. (1974),* Newsletter for Birdwatchers *14 (11),* P. *3–5.*
15. naturemeanings.blogspot.com/2010/05/northern-lapwing-pee-wit-encounters.html
16. http://www.egyptianmyths.net/lapwing.htm
17. Koul, S., Kour, P. and Sahi, D.N. (2014), J. Int. Aca. Res.Multidisc.2 (7),
18. Jadav, P. C. , Pathak, R. D. , Borad C. K., Parasharya, B. M. (2013), J. Biol. Control. 27(2), P.135-138
19. Kelvin Ka Lok Ip (2013), Open Access Theses and Dissertations. http://repository.hkbu.edu.hk/etd_oa/85. Hong Kong Baptist University
20. Kirwan, G.M. (1996), Family Rostratulidae (Painted Snipes), In: Del Hoyo, J., Elliott, A., Sargatal, J., Eds.), Lynx Edicions, Spain, P.821.
21. Sibley, C.G. and Ahlquist, J.E. (1990), Phylogeny and Classification Birds. Yale Univ. Press, New Haven, CT
22. Alfred, J.R.B., Kumar, A. Tak, P.C. and Sati, J.P. (2002), Rec. zool. Surv. India, Oce. Paper No. 190 : i-xxiv, P. 1-227
23. Piershma, T. and Wiersma P. (1996), Family Charadriidae (Plovers), Lynx Edicions, Barcelona.
24. Pande, S. (2009), Bombay Natural History Society and Oxford University press.
25. BirdLife Int. (2017), Species factsheet: *Vanellus gregarius*. BirdLife Int. (2017
26. Donald, P.F., Azimov, N., Ball, E., Green, R.E., Kamp, J., Karryeva, S., Kashkarov, R., Kurbanov, A., Rustamov, E., Saparmuradov, J., Sheldon, R., Soldatov, V., Ten, A., Thorpe, R., Underhill, M., Urazaliyev, R. and Veyisov, A. (2016), Sandgrouse 38, P.82-95.
27. BirdLife Int. (2015), European Red List Birds.

28. Kamp, J., Sheldon, R. D., Koshkin, M. A., Donald, P. F., Biedermann, R. (2009), Ibis 151. P.452-463.
29. Sheldon, R. D., Grishina, K. V., Kamp, J., Khrokov, V. V., Knight, A., Kushkin, M. A. (2006), Revising the breeding population estimate and distribution the Critically Endangered Sociable Lapwing *Vanellus gregarius*.
30. BirdLife Int. (2012), *Vanellus vanellus*. In: IUCN 2012. IUCN Red List Threatened Species. Version (2012), <www.iucnredlist.org>.
31. BirdLife Int. (2017), Species factsheet: *Vanellus vanellus*. BirdLife Int.
32. Wetlands Int. (2012), *Waterbird Population Estimates: Fifth Edition. Summary Report*. The Netherlands.
33. BirdLife Int. (2015), European Red List Birds. Fice for ficial Publications the European Communities, Luxembourg.
34. Wetlands Int. (2015), Waterbird Population Estimates. Available at: wpe.wetlands.org.
35. Nagy, S., Flink, S. and Langendoen, T. (2014), Waterbird trends 1988-2012:
36. BirdLife Int. (2017), Species factsheet: *Vanellus duvaucelii*. BirdLife Int. (2017) IUCN Red List for birds.
37. Wetlands Int. (2016), Waterbird Population Estimates. Available at: wpe.wetlands.org.
38. Wiersma, P. and Kirwan, G.M. (2016), River Lapwing (*Vanellus duvaucelii*), *Handbook the Birds the World Alive*, Lynx Edicions, Barcelona.
39. Goes, F. (2014), Fauna and Flora Int.
40. BirdLife Int. (2017), Species factsheet: *Vanellus indicus*. BirdLife Int. (2017) IUCN Red List for birds.
41. BirdLife Int. (2017), Species factsheet: *Vanellus malabaricus*. BirdLife Int. (2017) IUCN Red List for birds.
42. del Hoyo, J., Collar, N.J., Christie, D.A., Elliott, A. and Fishpool, L.D.C. (2014), Lynx Editions BirdLife Int., Barcelona, Spain and Cambridge, UK.
43. Brazil, M. (2009), Birds East Asia (Helm),
44. BirdLife Int. (2017), Species factsheet: *Vanellus cinereus*. BirdLife Int. (2017)
45. del Hoyo, J., Elliot, A., Sargatal, J. (Eds.), (1996) Lynx, Barcelona.
46. BirdLife Int. (2017), Species factsheet: *Vanellus leucurus*. BirdLife Int.
47. Cramp, S. and Simmons, K.E.L. (eds) (1982), The Birds the Western Palearctic 3, P. 251–266. Oxford University Press, Oxford.
48. Shrubb, M. (2010), The Lapwing. Bloomsbury Publication
49. Wiersma, P. and Sharpe, C.J. (2015), Handbook the Birds the World Alive, Lynx Edicions, Barcelona.
50. Hayman, P., Marchant, J., Prater, A. J. (1986), Shorebirds. Croom Helm, London.
51. Johnsgard, P. A. (1981), University Nebraska Press, Lincoln, U.S.A. and London.
52. Trolliet, B. (2003), *Game and Wildlife Science* 20(1-2), P.93-144.
53. Takahashi, M. (2008), Bird Research News Vol.5 (11),
54. Duckworth, J. W., Timmins, R. J. and Evans, T. D. (1998), Biol. Conservation 84 (3), P. 215 222.
55. Korpimaki, E. (1986), Ornis Fennica 63, P.84-90.
56. Redpath, S.M. (1995), Behavioural Ecology 6, P.410-415.
57. Valkama, J., Korpimaki, E. and Tolonen, P. (1995), Ornis Fennica 72 P.49-61.

58. Rice, J., Anderson, B.W. and Ohmart, R.D. (1984), J. Wildlife Management 48, P.895-911.
59. Wiens, J.A. (1985), Habitat selection in birds: 227-251. Academic Press, USA
60. Widen, P. (1994), J. Avian Biology 25, P.219-23.
61. Perrins, C.M. and Birkhead, T.R. (1983), Avian Ecology. Blackie. New York. USA. Cody, M. L. (1985), Academic Press, Inc. San Diego.USA.
62. Cresswell, W., Lind, J. and Quinn, J.L. (2010), J. Animal Ecology 79, P.556-562.
63. Roberts, G. (1995), Anim. Behav. 50, P.1371–1374
64. Proctor, C.J., Broom, M., Ruxton, G.D. (2006), Math Biosci 199, P.79–96
65. Kumar, S. (2006), Ph.D. Thesis. University Jammu, Jammu.
66. Kotwal, D. (2007), M.Phil. Dissertation, University Jammu, Jammu.
67. Elliot, R. D. (1985), Behaviour 92, P.168-l 87.
68. Marchant S., Higgins P.J. (1993), Oxford University Press Australia; Melbourne Walters, J.R. (1982), Evolution 36, P.1030-1040.
69. Jayakar, S.D. and Spurway H. (1965), Zool. Jahrb. Abt. Zool. and Phys; 92, P.53-72.
70. Singhji, D., Kumar R.S. and Lavkumar, K.S. (1972), Ministry of Information and Broadcasting, Government India, 100.
71. Bulla, M., Valcu, M., Dokter, A. M., Dondua, A.G., Kosztolányi, A., Rutten, A. L., Helm, B., Sandercock, B.K. and Casler, B. (2016), Nature. 540 (7631), P.109–113. doi:10.1038/nature20563
72. Kumar, C. (2015), JEZS (2015), 3 (1) P.129-134.
73. European Union Management Plan (2009-2011): Lapwing *Vanellus vanellus.*
74. Catchpole, E.A., Morgan, B.J.T., Freeman, S.N. and Peach, W.J. (1999), Bird Study. 46 (Suppl.), P.5-13.
75. Olsen, K.S. (2013), Vipe – status for Pipelerka.
76. Beintema, A.J., Thissen, J.B., Tensen, D. and Visser, G.H. (1991), Ardea 79, P.31–43.
77. Sheldon, R.D. (2002), PhD thesis, Harper Adams University College.
78. Walinga, R. (2005), Friesch Dagblad. Retrieved 19 February 2009.
79. Sheldon, R., Johannes, K. and Donald, P, (2011), Darwin Initiatives: Final Report EIDP0035.
80. CCB Biodiversity Action Plan – Lapwing Issue 1

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 3

ICTHYOFAUNA OF GENUS: *Labeo Cuvier* 1816, RECORDED IN RIVER SIANG OF ARUNACHAL PRADESH, INDIA

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ABSTRACT:

Labeo is a genus of carps in the family Cyprinidae. Labeos are larger, and have a more spindle-shaped body, as they are mostly free-swimming. Their mouths look very different, too; they have a pronounced rostral cap, which covers the upper lip except when feeding. The lips are expanded into thick, sausage-shaped pads which have keratinized edges. Thus, their mouth parts are moderately apomorphic; not as little-developed as in barbs. Labeos have the two barbels on the rostrum which are common among the Cyprinidae, and also another pair of barbels at the rear edges of the lower maxilla, which has been lost in some of their relatives. They have a well-developed vomeropalatine organ. In the weberian apparatus, the posterior supraneural bone is elongated and contacts the skull at the forward end. There are five species of *Labeo* are recorded in River Siang of Arunachal Pradesh, these are *Labeo bata, Labeo calbasu*, *Labeo gonius, Labeo pangusia* and *Labeo rohita.*

KEYWORDS: *Labeo,* Cyprinidae, River Siang, Arunachal Pradesh.

INTRODUCTION:

River Siang, a hill-stream of 1st order river; had colluvial valley segment and pool-riffle type of reach. Pools, riffles and runs were by and large found to command the small scale environment sort with visit event of trench pools. Waterway Siang was said to be more settled in light of V-molded valley section. The substrate sort had been observed to be ruled by rock and cobbles with much of the time happening very vast number of stones and some bed rocks. Stream Siang was the remarkable in the ichthyofaunal assorted variety. Fish

examining was done with the assistance of various types of nets, for example, cast net, gill net and traps, lines and snares, and so forth. Over half of fish types of River Siang has a place with the order Cypriniformes though different fishes were spoken to by the orders viz., Siluriformes, Perciformes, Clupeiformes, Synbranchiformes, Osteoglossiformes, Tetradontiformes and Beloniformes. In the present investigation on angle assorted variety, it was uncovered that the quantity of fishes was recorded higher in pre-rainstorm and storm seasons in all the examination years. In such manner, the present target is the quantities of various types of Labeo are accessible in River Siang of Arunachal Pradesh.

MATERIALS AND METHODS:

Study Site:

The River Siang, is largest river of Brahmaputra river system, originates from Chema Yungdung Glacier near Kubi at 5150 m in Tibet. In Tibet it is prevalently known as Tsang-Po, streams in West–East course. Subsequent to navigating a separation of around 1625 km waterway in Tibet and afterward it takes a hand over south bearing, enters the domain of India close Tuting in the Upper Siang region of Arunachal Pradesh and courses through North–South heading in East Siang locale towards Assam lastly it converges with Lohit and Dibang in Assam and it turns into the compelling River Brahmaputra [1], [2] (Figure 1),

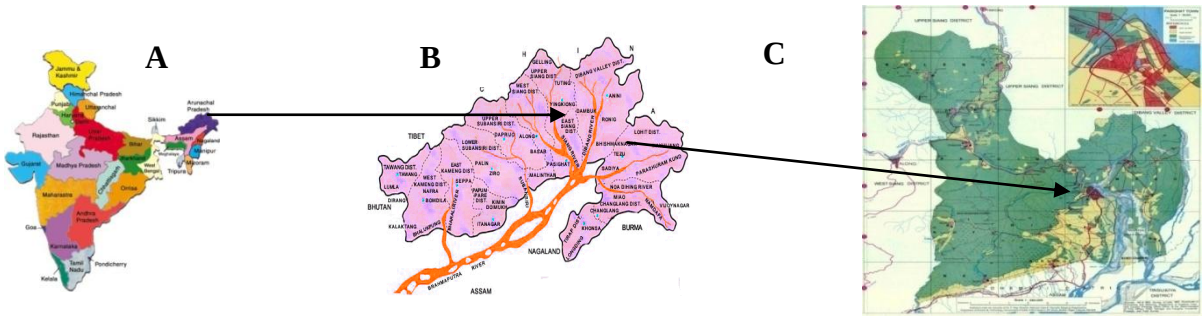

Figure 1. Map of (A) India indicating Arunachal Pradesh, (B) Arunachal Pradesh indicating to East Siang District, (C) In East Siang district highlighting River Siang (Study Area) of Arunachal Pradesh

Freshwater Survey:

Fish samples were collected from River Siang during January 2012 to December 2014 through experimental fishing; using cast nets (dia.3.7 m and 1.0 m), gill nets (vertical height 1.0 m- 1.5 m; length 100 m -150 m), drag nets (vertical height 2.0 m), triangular scoop nets (vertical height 1.0 m) and a variety of traps and with hook and lines in certain places (where

netting is not possible), River was surveyed and classified into different habitat units based on morphology [3] and finally divided in to six (6) different study sites covering upstream, mid-stream and downstream stretches of the river. General survey of the fish biodiversity was done using standard procedures [4].

Fish Measurement:

The morphometric study included measurement of Total length (TL), Standard length (SL), Body depth (BD) Snout length, Post orbital length, Head length (HL), Pre dorsal length, Prepelvic distance, Eye diameter (ED), length of Caudal Peduncle, and Length of caudal fin. SL was the distance from the tip of the snout to the mid base of the caudal fin and TL was the distance from the tip snout to the furthest tip of the caudal fin. BD was the greatest vertical distance across the body. The measurements were done using Vernier Calliper Scale and Digital Sartorious Electronic Balance.

Fish Preservation and Identification:

Fish species had been preserved, at first, in concentrated formaldehyde in the field. After that, the fishes were transferred to laboratory and preserved in 10 % formalin. The small size fishes were preserved in 5% aqueous formalin solution and big size fishes in 10% aqueous formalin solution and kept in the air-tight plastic bottles.

In the laboratory, the fishes were identified by following standard literature, notably, [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16] and [17]. All the fishes were kept in the Assam University Fish Museum (AUFM) for preservation and record. After labeling the fishes were drawn and photographed with the help of digital camera (Nikon Coolpix L-810),

RESULTS AND DISCUSSION:

In River Siang we had recorded *Labeo bata, Labeo calbasu, Labeo gonius, Labeo pangusia* and *Labeo rohita.* They are described as follows:

Genus: *Labeo* Cuvier 1816:

Labeo Cuvier, [18], *Regne Animale,* 2 (ed.1), p. 194 (type-species, *Cyprinus niloticus* Forsskal, by subsequent designation)- [19], *Occ. Papers Zool. Survey India*, (revision), *Bangana* [20], Fish Ganges, p-277, 385 (type-species, *Cyprinus dero* Hamilton-Buchanan, by subsequent designation),

Diagnosis:

Body moderate size, elongated, much deep with abdomen rounded. Head fairly large. Snout more or less swollen, rounded, often projecting beyond mouth, covered by a groove across and with tubercles, mostly overhanging the mouth. Eyes moderately large generally placed at the commencement of the posterior half of the head, not visible from below the ventral surface; lips thick, fleshy. Barbel two pairs, one pair maxillary and second pair was rostral. Dorsal fin inserted above anterior to origin of pelvic fins with 15 rays and without any osseous ray. Anal fin short with 7 rays. Caudal fin deeply forked. Scales moderate with numerous striae. Lateral line complete, straight or little curved, running in the center of the caudal peduncle up to the tail.

***Labeo bata* (Hamilton-Buchanan, 1822):**

Lateral line scales 40. Dorsal fins with 15 rays. 2 pairs of barbels. Pectoral fin was nearly long as head. Snout overhanging mouth. Eye diameter 4 times in head length. Lips thin, scales between lateral line to pelvic fin 6 ½ (Figure 2 and Plate 1),

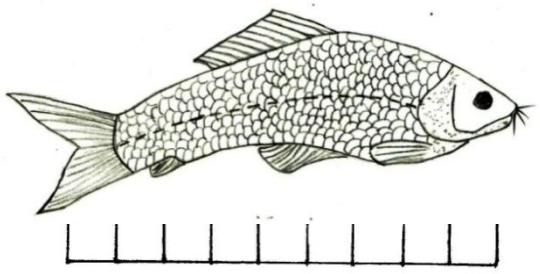

Figure 2: ***Labeo bata***

Plate 1: ***Labeo bata***

Key to Species:

Snout length = 1.9 cm, Post orbital length = 2.8 cm, Head length = 4.9 cm, Pre-dorsal length = 8.7 cm, Pre-pelvic distance= 10.5 cm, Standard length= 19.5 cm, Total length = 23.2 cm, Eye diameter = 1.0 cm, Length of caudal peduncle = 3.5 cm, Length of caudal fin = 4.9 cm, Body depth = 5.7 cm and Weight = 143.73 g.

Distribution:

River Siang, Subansiri, Simen, Brahmaputra of India. Bangladesh, Nepal and Pakistan.

***Labeo calbasu* (Hamilton-Buchanan, 1822):**

***Key to Species*:**

Lateral line with 41 scales. Dorsal fin with 15 rays. 2 pairs of barbels. Upper edge of dorsal fin concave. Pectoral fin as long as head length. Mouth distinctly inferior (Figure 3 and Plate 2),

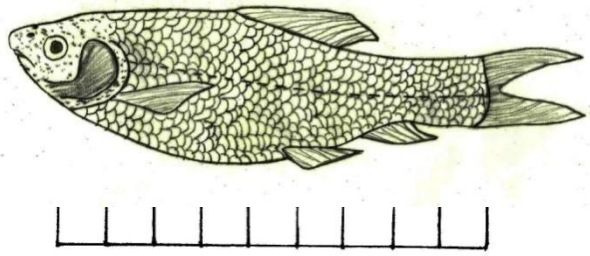

Figure 3: *Labeo calbasu*

Plate 2: *Labeo calbasu*

Snout length = 1.6 cm, Post orbital length = 2.4 cm, Head length = 4.1 cm, Pre-dorsal length = 6.4 cm, Pre-pelvic distance= 7.5 cm, Standard length = 13.7 cm, Total length = 17.1 cm, Eye diameter = 0.9 cm, Length of caudal peduncle = 2.7 cm, Length of caudal fin = 4.1 cm, Body depth = 4.2 cm and Weight = 56.21 g.

Distribution:

River Siang, Jia Bharali, Brahmaputra of India. Bangladesh. Myanmar. Nepal. Pakistan. Thailand.

***Labeo gonius* (Hamilton-Buchanan, 1822):**

Key to Species:

Lateral line with 65 scales. Dorsal fin with 15 rays. Barbels 2 pairs (Figure 4 and Plate 3),

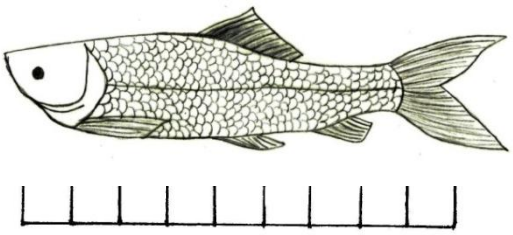

Figure 4: *Labeo gonius*

Plate 3: *Labeo gonius*

Snout length = 1.1 cm, Post orbital length = 1.8 cm, Head length = 3.3 cm, Pre-dorsal length = 5.2 cm, Pre-pelvic distance = 6.2 cm, Standard length = 11 cm, Total length = 15.3 cm, Eye diameter = 0.8 cm, Length of caudal peduncle = 1.9 cm, Length of caudal fin = 3.3 cm, Body depth = 3.2 cm and Weight = 31.77 g.

Distribution:

River Siang, Subansiri, Brahmaputra of India. Bangladesh, Nepal and Pakistan.

***Labeo pangusia* (Hamilton-Buchanan, 1822):**

***Key to Species*:** Lateral line with 42 scales. Dorsal fin with 12 rays. Scales between lateral line and pelvic fin was 6 (Figure 5 and Plate 4),

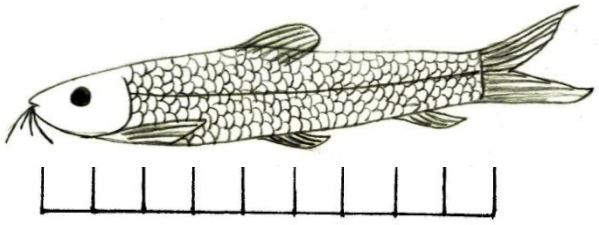

Figure 5: ***Labeo pangusia***

Plate 4: ***Labeo pangusia***

Snout length = 0.8 cm, Post orbital length = 2.4 cm, Head length = 4.2 cm, Pre-dorsal length = 8.6 cm, Pre-pelvic distance = 8.8 cm, Standard length = 18.0 cm, Total length = 22.7 cm, Eye diameter = 0.9 cm, Length of caudal peduncle = 3.8 cm, Length of caudal fin = 4.7 cm, Body depth = 5.3 cm and Weight = 108.85 g.

Distribution:

River Siang, Subansiri, Brahmaputra of India. Bangladesh. Nepal. Pakistan. Thailand.

***Labeo rohita* (Hamilton-Buchanan, 1822):**

Key to Species:

Presence of 14 dorsal fin rays. Upper edge of dorsal fin concave. Presence of two pairs of barbels. Dorsal fin inserted midway between tip of snout and caudal fin base. Pectoral fins as long as head excluding snout; body oblong; mouth terminal; narrow (Figure 6 and Plate 5),

Snout length = 1.2 cm, Post orbital length = 1.9 cm, Head length = 3.5 cm, Pre-dorsal length = 5.6 cm, Pre-pelvic distance = 6.7 cm, Standard length = 11.6 cm, Total length = 12.5 cm, Eye diameter = 6.7 cm, Length of caudal peduncle = 2.1 cm, Length of caudal fin = 2.9 cm, Body depth = 3.3 cm and Weight = 54.33 g.

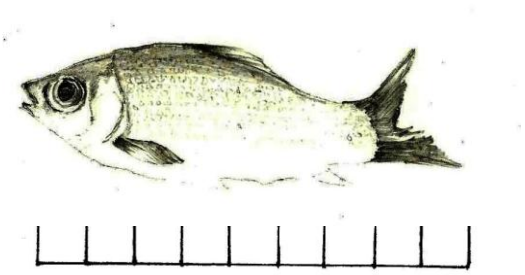

Figure 6: ***Labeo rohita***

Plate 5: ***Labeo rohita***

Distribution:

River Siang, Subansiri, Brahmaputra of India. Bangladesh. Nepal. Pakistan. Myanmar. Sri Lanka.

A**CKNOWLEDGEMENT:**

The authors are thankful to Assam University, Silchar and to the UGC, New Delhi for granting UGC-Fellowship to the First author. Most importantly, we thank the Fishermen of East Siang district of Arunachal Pradesh for their kind necessary help and co-operation for this study.

REFERENCES:

1. Das, B. K.; Boruah, P. and Kar, D. (2014 a), IOSR J. Enviro. Sci., 8 (2IV): 11-20.
2. Das, B. K. and Kar, D. (2015), Krishi Sanskriti Publications, New Delhi, pp. 53-56.
3. Bisson, P. A.; Nielson, J. A.; Palmason, R. A. and Grove, L. E. (1982), American Fisheries Society, Bethesda, Maryland: pp. 62-73.
4. Armontrout, N. B. (1990), Aquatic Inventory. USA, pp. 32.
5. Day, F. (1875-1878), W_M Dawson and Sons Ltd. (London): pp. xx + 778.
6. Rainboth, W. J. (1996), FAO, Fishes of the Cambodian Mekong, Rome: pp. 265.
7. Sen, N. (2000), National Bureau of Fish Genetic Resources, ICAR, India: pp. 31-48.
8. Talwar, P. K. and Jhingran, A. G. (1991), Oxford and IBH Co., Pvt. Ltd. (New Delhi), India, Vol. I and II: pp. xix + 1158.
9. Jayaram, K. C. (1999), Narendra Publishing House, India : pp. xvii +551.
10. Jayaram, K. C. (2010), Narendra Publishing House, India, IInd Edn. xxxi + 616.
11. Nath, P. and Dey, S. C. (1997), Fish and Fisheries of North-East India. Arunachal Pradesh. Vol. I: pp. 140.

12. Nath, P. and Dey, S. C. (2000), National Bureau of Fish Genetic Resources, ICAR (Lucknow), India: pp. 49-67.
13. Viswanath, W. (2000), Manipur Association for Science and Society, Imphal (Manipur), India: pp.143
14. Viswanath, W. (2002), Manipur: National Agricultural Technology Project. Manipur University, India: pp. 198.
15. Kar, D. (2007), Daya Publishing House. New Delhi. India: pp. xvi + 609.
16. Kar, D. (2013), Springer Publications (London): pp. xxx + 687.
17. http://www.fishbase.org.
18. Cuvier, G. L. C. F. D. (1817), Le Regne animal distribu d' Apres son organization. Paris; pp. xviii + 532.
19. Jayaram, K. C. and Dhas, J. C. (1999), Rec. Zool. Surv. India. Occ. Paper 25: 35-45.
20. Hamilton-Buchanan, F. (1822), Edinburg and London: pp. viii + 405.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 4

PROTECTIVE ROLE OF *CURCUMA LONGA* EXTRACT SUPPLEMENTATION IN STZ INDUCED DIABETIC RATS

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ABSTRACT:

Diabetes mellitus is a chronic metabolic disorder that prevents the body to utilize glucose completely or partially. It is characterized by raised glucose concentration in the blood and alterations in carbohydrate, protein and fat metabolism. *Curcuma longa* has several biological properties, including antidiabetic and antioxidant activity. The present study was designed to investigate the antidiabetic effect of *Curcuma longa* extract against streptozotocin (STZ) induced perturbations in blood glucose, body weights and hematological alterations in albino rats. Adult male albino Wister rats, weighing 180 ± 20 g was made diabetic by injecting STZ (40mg/kg body weight) intraperitoneally. Diabetic rats were supplemented with ethanolic extract of *Curcuma longa* rhizomes (250 mg/kg body weight) for a period of three weeks. After this period, rats were decapitated and blood was collected from control and experimental rats. Blood glucose levels, WBC, RBC, serum total proteins, albumin, globulin, creatinine, urea and cholesterol were significantly elevated in diabetic rats with decreased hemoglobin and body weight levels when compared with control. The above mentioned parameters were significantly restored to near normal by oral administration of *Curcuma longa extract* once daily for three weeks as compared to untreated rats. The results obtained indicated that *Curcuma longa extract* to be beneficial in preventing diabetes induced alterations in blood glucose, body weights and hematology in rats.

KEYWORDS: Diabetes; Streptozotocin; *Curcuma longa*; Blood glucose; Body weight; hematology; Rats.

INTRODUCTION:

Diabetes mellitus, is a chronic metabolic disorder commonly known as diabetes, is a disorder of carbohydrate metabolism characterized by high blood sugar level (hyperglycemia) and high level of sugar in urine (glycosuria), Insulin lowers the blood glucose level. Insulin is released from the pancreas to normalize the glucose level. In patients with diabetes, the absence or insufficient production of insulin causes hyperglycemia.

This can be due to failure in the formation of insulin or liberation or action [1]. Since insulin is produced by the β-cells of the islets of langerhans, any alterations in the number of functioning cells will decrease the amount of insulin synthesis. Many diabetics can produce sufficient insulin but some stimulus to the islets tissue is needed for its secretion.

This study is a part of the national non-communicable diseases (NCD) risk factor surveillance conducted in different geographical locations in India, This nation-wide NCD risk factor surveillance study showed that the prevalence of self reported Diabetes is higher in urban, intermediate in Peri-urban and lowest in rural areas.

Table 1. Top countries for estimated number of people with Diabetes, 2000-2030

Ranking	2000		2030	
	Country	People with Diabetes (Millions)	Country	People with Diabetes (Millions)
1	India	31.7	India	79.4
2	China	20.8	China	42.3
3	U.S.	17.7	U.S.	30.3
4	Indonesia	8.4	Indonesia	21.3
5	Japan	6.8	Japan	8.9
6	Pakistan	5.2	Pakistan	11.9
7	Brazil	4.6	Brazil	11.3
8	Bangladesh	3.2	Bangladesh	11.1

Ayurvedic Approach in Diabetes treatment:

Ayurvedic physicians have treated diabetes for thousands of years using a combination of regulated lifestyle and herbal formulations. The physicians also prescribed specific herbal formulations for the treatment of diabetes. In recent times, the safety and efficacy of these herbs have been validated by laboratory experiments and clinical trials. A large variety of compounds obtained from several plant families were found to hypoglycemic effect. The glycosides, glycans, certain triterpenes, various types of sulfide molecules, polysaccharides, oils, vitamins, alkaloids, saponins, glycoproteins, peptides, amino acids and

proteins isolated from various plant families showed beneficial effects in reducing the blood sugar. Many Indian medicinal plants are reported to be useful in diabetes [2, 3, 4, 5] and [6]. Medicinal plants used to treat hypoglycemic or hyperglycemic conditions are of considerable interest for ethno-botanical community as they are recognized to contain valuable medicinal properties in different parts of the plant and a number of plants have shown varying degree of hypoglycemic and anti-hyperglycemic activity. The active principles of many plant species are isolated for direct use as drugs, lead compounds or pharmacological agents. Several species of medicinal plants are used in the treatment of *Diabetes mellitus*. Traditional plant medicines or herbal formulations might offer a natural key to unlock diabetic complications.

Antioxidants play an important role to protect against damage by reactive oxygen species and their role in diabetes has been evaluated. Many plant extracts and products were shown to possess significant antioxidant activity. In the present study two of such plants were selected for evaluation of their antioxidant potential mediated antidiabetic activity.

***Curcuma longa*:**

In Ayurvedic medicine, turmeric is thought to have many medicinal properties and in India many people use it as a readily available antiseptic for cuts, burns and bruises. Practitioners of Ayurvedic medicine say that it has fluoride which is thought to be essential for teeth. It is also used as an antibacterial agent. It is taken in some Asian countries as a dietary supplement, which allegedly helps with stomach problems and other ailments. It is popular as a tea in Okinawa, Japan. The active ingredient in turmeric is exploding. U.S. National Institutes of Health had four clinical trials to study curcumin treatment for pancreatic cancer, multiple myeloma, Alzheimer's, and colorectal cancer. Curcumin has been used for thousands of years as a safe anti-inflammatory agent in a variety of ailments as part of Indian traditional medicine". A recent study involving mice has shown that turmeric slows the spread of breast cancer into lungs and other body parts. Turmeric also enhances the effect of taxol in reducing metastasis of breast cancer.

Researchers had discovered that turmeric-treated mice were less susceptible to developing type-II diabetes, based on their blood glucose levels, and glucose and insulin tolerance tests. They also discovered that turmeric-fed obese mice showed significantly reduced inflammation in fat tissue and liver compared to controls. They speculated that curcumin in the turmeric lessens insulin resistance and prevents type-II diabetes in these mouse models by dampening the inflammatory response provoked by obesity. Curcumin and

its analogues have a variety of physiological and pharmacological activities such as antiinflammatory, anticarcinogenic and antioxidant properties [4, 5, 6, 7 and 8].

The present research work was carried out to evaluate the beneficial effects and Protective role of Plant Extract of *Curcuma longa* against Streptozotocin induced Diabetes. Other objective of the study was to determine the role of plant extract on hematological and serum biochemical parameters.

MATERIAL AND METHODS:

Procurement and Maintenance of Animals:

Healthy female albino wistar rats (180±20g) were procured from Sri Venkateswara Enterprises, Bangalore, Karnataka, India (Reg. No: 237/99/CPCSEA), Animals were maintained in the animal house of Sri Venkateswara University, Dept of Zoology, Tirupati. Rats were kept in sterilized polypropylene cages lined with paddy husk (18"x10"x8"), The animals were maintained under a regulated 12 h light: 12 h dark scheduled at 24±1^{o}C and relative humidity of 55±15%. Rats were provided standard rat chow (Sai Durga Feeds and Foods, Bangalore, India) and water *ad libitum*.

Procurement of chemicals:

All the chemicals used in the present study were Analar Grade (AR) and were obtained from Sigma (St. Louis, MO, USA), Fisher (Pitrsburg, PA, USA), Merck (Mumbai, India), Ranbaxy (NEW Delhi, India), Qualigens (Mumbai, India) scientific companies.

For the present work Barnstead Thermoline water purification plant was used for Nano pure water, Kubota KR 200000T centrifuge for centrifugation of the homogenates and Hitachi UV -2000 Spectrophotometer for measuring the optical density values were used for high –quality results.

Streptozotocin:

Systematic (IUPAC) name: - 2-deoxy-2-({[methyl (nitroso) amino] carbonyl} amino)-β-Dglucopyranose

Streptozotocin is a mixture of α- and β-stereoisomers. It occurs as pale yellow or off-white crystals, powder, or platelets, while the research grade may be off-white to tan solid. It is very soluble in water, ketones, and lower alcohols, slightly soluble in polar organic solvents, and insoluble in monopolar organic solvents. The pure compound is sensitive to humidity and light. Streptozotocin decomposes to diazomethane in alkaline solutions at 0°C. When heated to decomposition, it emits toxic fumes of nitrogen oxides (IARC 1978, HSDB 2001),

Preparation of *Curcuma longa* extract:

The fine powder of *Curcuma longa* rhizome powder were purchased (AGMARK symbol) in Tirupati. The power is extracted by cold percolation with 95% ethanol for 24h. The extract was recovered and 95% ethanol was further added to the plant material and the extraction was continued. The process was repeated three times. The three extractions were pooled together, combined, filtered and the filtrate was concentrated to dryness under reduced pressure in rotary evaporator. The resulting ethanol extract was air-dried. Finally light yellow powdery, crude ethanol extract of *Curcuma longa* was obtained. Without any further purification the plant crude ethanol extract was used in the study. Dose equivalent to 250mg kg/body was calculated and suspended in 2% v/v Tween 80 solution for the experiment [4].

Induction of Diabetes:

Streptozotocin (STZ, 2-deoxy-2-({[methyl (nitroso) amino] carbonyl} amino)-β-Dglucopyranose) frequently used dosage is 40mg/kg BW [9] Single injection of STZ given intravenously or intraperitonially to the adult rats to induce diabetes. After fasting for 18hrs, rats were injected intraperitonially with a single dose of 40mg STZ (Sigma, St. Louis, Mo., USA) freshly dissolved in 0.1 M cold sodium citrate buffer, (pH 4.5), After injection, they had a free access to food and water was given 5% glucose solution to drink overnight to counter hypoglycemic shock. Diabetes in rats was identified by moderate polydipsia and marked polyuria. From the second day onwards fasting blood samples were collected from the rats by tail vein and blood glucose was measured by Accu chek Sensor comfort glucometer (Manufacture-Johnson and Johnson) to know the induction of diabetes. If the blood glucose levels were more than 300mg/dL, insulin (IIU Protamine Zinc Insulin) is given to the diabetic rats for diabetic condition for one week. After one week the rats with hyperglycemia (blood glucose level 250mg/dL) were selected and used for the experiment [10].

Grouping of animals:

Group -1 : Normal Control rats.

Group- 2 : Diabetic rats (Streptozotocin)

Group -3 : Diabetic rats treated with 250 mg/Kg b.w. of *Curcuma longa*.

The blood samples were collected after completion of treatment i.e. on 22nd day of the treatment. The blood was used for the hematological parameters and separated serum was used for the serum biochemical parameters.

Estimation of Blood glucose:

Estimation of Blood glucose levels was carried out by using Accu Chek glucometer (Sensor Comfort),

Body Weight Changes:

Body weights of all groups of (eight) rats were recorded before and after treatments. The body weights of all groups were recorded at an interval of one week till the completion of the experiential period (21 days),

Hematology:

Blood samples were collected at the end of experimentation period immediately after sacrifice the blood was collected from the jugular vein and the blood was allowed into a graduated centrifuge tubes containing 10% EDTA, a common anticoagulant used for routine hematological work. The blood parameters like total erythrocytic count, total leucocyte count, hemoglobin and hematocrit (PCV) were estimated by using standard procedures.

Biochemical Parameters:

With out adding anticoagulant, the blood was collected into separate tubes and subject for centrifugation and serum collected was used for biochemical analysis. The parameters such as of glucose, total proteins, albumin, globulin, total cholesterol, creatinine, blood urea nitrogen, and bilirubin were estimated by using diagnostic kits supplied by SD fine, Ranbaxy, span diagnostics Ltd., India, and the procedures mentioned in the kit.

RESULTS AND DISCUSSION:

Blood Glucose:

Blood glucose levels were measured using glucometer (Accu Chek) in control, diabetic, diabetic treated with *Curcuma longa* extract groups before and after treatment. In group II, the blood glucose levels were significantly increased after induction with STZ when compared with control.

Table1. Showing Blood glucose levels in the control and experimental animals:

Days	Group-I	Group-II	Group-III
1st Day	89.33 ±8.38	282.16 ±37.92	280.16 ±34.62
10th Day	106.50 ±9.35	306.66 ±30.32	208.67 ±24.41
21st Day	119.52 ±12.56	271.33 ±42.78	137.16 ±23.92

Values are mean ± S.D. of 6 individual rats

Blood glucose levels were significantly decreased in the group III, where the rats were subjected to *Curcuma longa* extract. The various blood glucose values of alterations are as shown in Table-1 and Figure-1.

Most of the body cells use the sugar called glucose as their major source of energy. Glucose molecules are broken down within cells in order to produce adenosine triphosphate (ATP) molecules, energy-rich molecules that power numerous cellular processes. Glucose molecules are delivered to cells by the circulating blood and therefore, to ensure a constant supply of glucose to cells, it is essential that blood glucose levels be maintained at relatively constant levels. Level constancy is accomplished primarily through negative feedback systems, which ensure that blood glucose concentration is maintained within the normal range of 70-110 mg/dl.

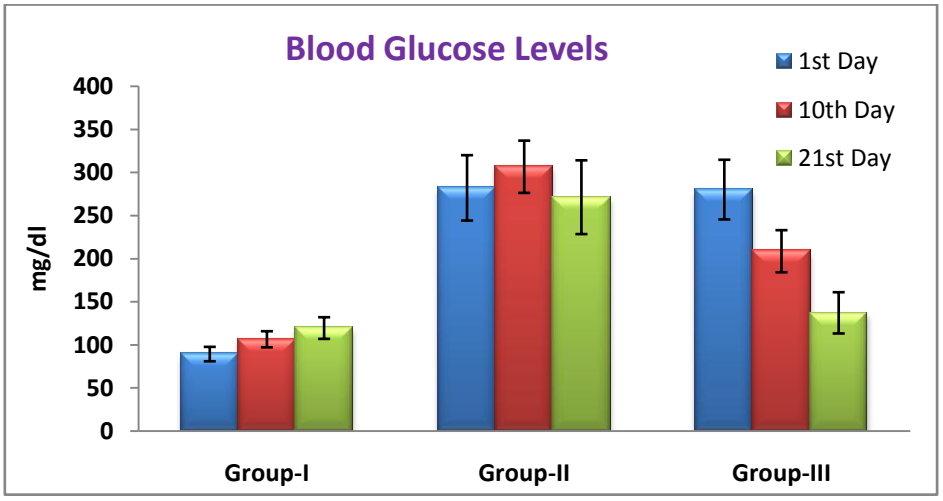

Figure 1. Blood glucose levels in control and experimental animals

The levels of glucose in the blood are monitored by the cells in the pancreas. If the blood glucose level falls to dangerous levels (as in very heavy exercise or lack of food for extended periods), the Alpha cells of the pancreas release glucagon, a hormone which alerts the liver to increase blood glucose levels and converts stored glycogen into glucose (Glycogenesis), Thus glucose is released into the blood stream, increasing blood sugar levels. There are several other causes for an increase in blood sugar levels. Among them diabetic stress due to the accumulation of reactive oxygen spices is a major cause.

In the present study blood glucose levels were maintained at normal levels in control rats. A significant increase in glucose levels found in STZ treated rats could be due to the distruction of pancreatic beta-cells by STZ induced oxidative stress. The elevation of glucose in STZ treated rats was due to an oxidative stress produced in the pancreas, due to a single

strand break in pancreatic islets DNA [11]. In experimental diabetes, enzymes of glucose and fatty acid metabolism are markedly altered; hence blood glucose levels were increased [12]. An increased hyperglycemia has been reported to induce oxidative stress due to glycation of proteins and accumulation of polyols [13]. One of the consequences of hyperglycemia is increased metabolism of glucose by sorbitol pathway. Besides this, other path ways, such as fatty acid and cholesterol biosynthesis favor hyperglycemia [14]. Hyperglycemia is currently considered to be primarily responsible for the auto-oxidative glycosylation, formation of hydro peroxides and free radicals, in particular the hydroxyl radical and low density lipoprotein oxidation [15].

The action of STZ in the pancreas is preceded by its rapid uptake by the B cells [16]. Rapid uptake by insulin-secreting cells has been proposed to be one of the important features determining STZ diabetogenicity. Another aspect concerns the formation of reactive oxygen species [17]. A similar uptake of STZ also takes place in the liver. However, the liver and other tissues are more resistant to reactive oxygen species in comparison to pancreatic β cells and this resistance protects them against STZ toxicity [18, 19]. The formation of reactive oxygen species is preceded by STZ reduction. In beta cells of the pancreas its reduction occurs in the presence of different reducing agents. Since STZ exhibits a high affinity to the SH-containing cellular compounds, reduced glutathione (GSH), cysteine and protein-bound sulfhydryl groups (including SH containing enzymes) are very susceptible to its action [20]. However, other reducing agents such as ascorbate may also participate in this reduction [21, 22] proposed that one of the SH-containing compounds essential for proper glucose-induced insulin secretion is glucokinase (EC 2.7.1.2), being very vulnerable to STZ. STZ reacts with two -SH groups in the sugarbinding side of glucokinase resulting in the formation of the disulfide bond and inactivation of the enzyme. Glucose can protect glucokinase against the inactivation hindering the access of alloxan to the -SH groups of the enzyme [22].

In case of rats which were subjected to both STZ and plant extracts, the decrease in blood glucose was due to the hypoglycemic activity of the extracts. Changes of blood glucose levels in the group III where diabetic rats were treated with plant extract is due to the flavonoid and triterpenoid compounds in them. A number of investigations had reported that 6-gingerol, tannins, polyphenolic compound, flavonoids, triterpenoids posses analgesic, hypoglycemic and other pharmacological actions in various experimental animal models [23, 24].The plant favorably affected glycolytic, gluoneogenic, and liogenic enzymes to restore glucose homeostasis in STZ-induced diabetic rats [25]. The administration of *Curcuma longa*

powder to diabetic animals has been shown to lower blood glucose levels and partially restore the activities of key enzymes of carbohydrate and lipid metabolism close to normal values in animal model systems [25, 26]. Oxidant induced alterations in the glucose utilizing system during diabetic manifestation is partially reversed by the administration of herbal extracts (Methanol extracts (75%) of *Aegle marmelos, Momordica charantia, Trigonella foenum-graecum, curcuma longa, Eclipta prostrata, Salacia oblonga, Coriandrum sativum, Vernonia anthelmintica* and *Murraya koenigii*) having antioxidant activity. Various reports demonstrated that the *Curcuma longa* have hypoglycemic, hypocholserolemic and hyperinsulinomic effects on type 1 and type 2 *Diabetes mellitus* patients and experimental diabetic animals [27, 28]. Oral administration of extract from *Curcuma longa* lowers blood glucose and attenuates STZ-induced hyperlipidemia in diabetic rabbits. [29]. *Curcuma longa* rhizomes he been reported to possesses active constituents showing blood glucose lowering activity in STZ induced diabetic rats [30]. Curumin has been shown to lower blood glucose levels in typ-2 diabetic KK-ay mice [31] and STZ treated rats [32]. The administration of an aqueous extract of turmeric and abromine powder resulted in a significant reduction in blood glucose.

Body Weights:

Body weights of rats were measured using a digital balance at an interval of 10 days during the experimental period. The initial average weight of animals was in the range of 180 ± 200g. In group II, the body weights were significantly decreased after induction with STZ when compared with the control rats. In the group III, the body weights were significant increased when compared with the diabetic (group II) rats. The changes of body weights are as shown in Table-2 and figure-2.

Table 2. Body Weight levels in the control and experimental animals:

Days	Group-I	Group-II	Group-III
1st Day	242.53±28.41	229.66±31.38	227.64±15.73
10th Day	260.43±24.31	188.42±13.76	220.88±25.57
21st Day	276.17±19.28	140.19±14.71	237.33±19.02

Values are mean ± S.D. of 6 individual rats

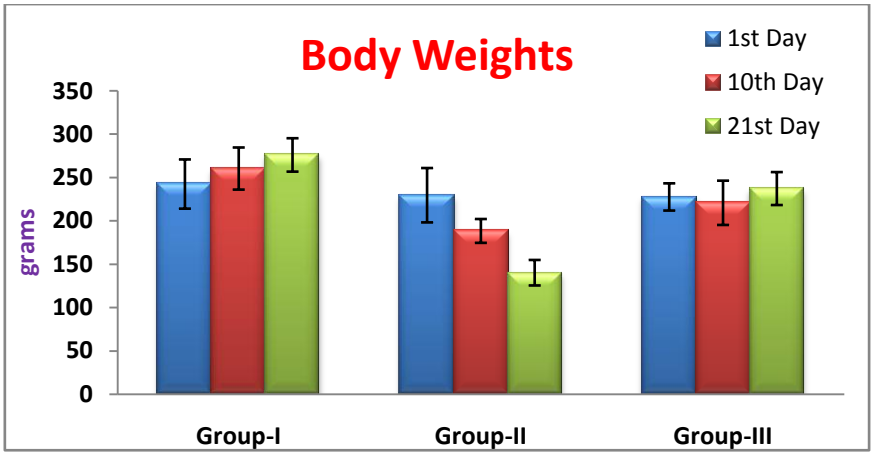

Figure 2. Body weights levels in control and experimental animals

Body weight is determined by energy intake on one hand and energy expenditure on the other. Imbalance between energy intake and expenditure results in a change in body weight. Organisms expend energy to perform daily work required for survival, such as finding food or evading predators. Metabolic efficiency refers to the amount of energy an organism has to exert to perform a given amount of work.

Metabolic efficiency varies among different species of organisms and among different individuals within a species. An individual with high metabolic efficiency will expend less energy to perform a specific task, such as climbing a set of stairs, than an individual with low metabolic efficiency. Compared with an individual with low metabolic efficiency, an individual with high metabolic efficiency is better able to preserve body weight during negative daily energy balance (expenditure exceeding intake), but likely to gain more weight during positive energy balance (intake exceeding expenditure), The ability of an organism to minimize reduction in body weight during long periods of starvation is likely associated with its survival. As a result, millions of years of evolution may have favored organisms with high metabolic efficiency [33, 34, 35, 36].

A constellation of clinical studies has established the close link between obesity and type 2 diabetes[37, 38]. This correlation, however, is not perfect; many diabetic patients are not obese, and many obese individuals are perfectly responsive to insulin. Regardless of whether a causal relationship exists between obesity and the body's response to insulin, beneficial effects of weight loss on the metabolic parameters of many diabetic patients are well documented [39, 40]. Thus, it is not surprising that a combination of weight loss and exercise is an effective treatment for many diabetic patients [41].

In the present study, STZ induced diabetic rats showed decreased level of body weights. The decrease in body weight in diabetic rats clearly shows a loss or degradation of structural proteins. Weight loss which is one of the clinical features of *Diabetes mellitus* may be due to the degeneration of the adipocytes and muscle tissues to make up for the energy lost from the body due to frequent urination and over conversion of glycogen to glucose. Weight loss is a very serious issue in the management of *Diabetes mellitus* [42].

Due to diabetes the structural proteins are known to contribute for the body weight [43]. STZ induced diabetes is characterized by a severe loss in body weight. The control diabetic animals showed a significant decrease in body weight compared with normal rats [44]. Changes in body weight in adult and non adult diabetic rats varied. Since the non adult diabetic rats are in the growing age, diabetic loss of weight is not seen in them and they even show a slight weight gain. In adult rats, however diabetes is an accompanied by loss of weight [45]. Weight loss during diabetes is mainly related to urinary glucose excretion because cells become to use glucose. Another factor could be also the osmotic diuresis resulting in hyper osmotic dehydration.

In the case of diabetic rats treated with *Curcuma long* extract (group III) increased levels in body weights were observed. They showed almost same response as that of control rats. This shows that *Curcuma long* plant extract apposes degeneration of the adipocytes and muscle tissues which occurs during diabetic stress in order to make up for the energy lost from the body due to frequent urination and over conversion of glycogen to glucose.

Hematological Parameters:

Significant decreased levels of hemoglobin, during diabetes when compared with corresponding control group. But WBC and RBC was increased in diabetes rats.

Table 3. Blood Parameters levels in the control and experimental animals:

Parameters	Group I	Group II	Group III
Haemoglobin (gm/dl)	12.8± 0.7	9.2± 0.86	12.4± 0.98
RBC (millions/µl)	4.5± 0.32	3.8± 0.37	4.8± 0.43
WBC (cells/µl)	5600± 348.23	5800± 316.23	6400± 361.24

Values are mean ± S.D. of 6 individual rats

Administration of *Curcuma longa* extract tended to bring the values to near to normal range and the effect was more pronounced in the group of rats treated with plant extract.

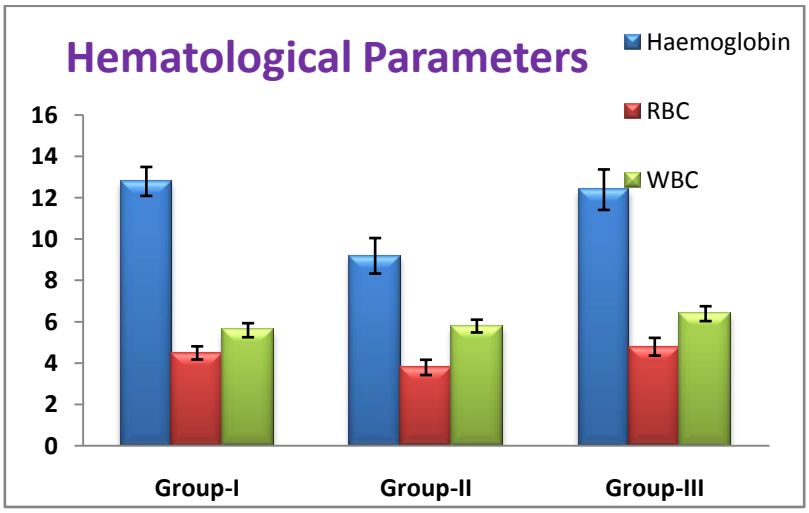

Figure 3. Blood Parameters levels in the control and experimental animals

In diabetic rat haemoglobin (Hb) levels were found to be low when compared to normal rats, as the Hb synthesis might also be depressed. Thus *Curcuma longa* treated rats showed improved levels of Hb because of its glucose lowering effect. The various proteins including hemoglobin undergo an enzymatic glycation in diabetes. Glycosylated hemoglobin was found to be increased in diabetes condition and the amount of increase is directly proportional to that of fasting blood glucose level [46]. Lowered levels of hemoglobin were observed in diabetic rats which might be due to the increased formation of HbA1c. Hyperglycemia is the clinical hallmark of poorly controlled diabetes, which is known to cause glycation, and also known as nonenzymatic glycosylation. HbA1c was found to increase in patients with *Diabetes mellitus* and the increase was directly proportional to the fasting blood glucose levels. Previous studies reported that the active components present in *Curcuma longa* were effective in raising the hemoglobin levels in rats.

The link between chronic diseases and anemia is well characterized [47]. The occurrence of anaemia in *Diabetes mellitus* has been reported due to the increased non-enzymatic glycosylation of RBC membrane proteins, which correlates with hyperglycemia. Oxidation of these proteins and hyperglycaemia in *Diabetes mellitus* causes an increase in the production of lipid peroxides that lead to haemolysis of RBC. The major pathological consequences of free radical induced membrane lipid peroxidation include increased membrane rigidity, decreased cellular deformability, reduced erythrocyte survival, and lipid

fluidity [48]. In this study, the RBC membrane lipid peroxide levels in diabetic rats were not measured. The reversal effect shown by the *Curcuma longa* were effective in reduce the RBC levels in rats.

Peripheral WBC count has been shown to be associated with insulin resistance, type 2 diabetes, coronary artery disease, stroke, and diabetes micro- and macrovascular complications [49, 50]. Peripheral blood leukocytes are composed of polymorphonuclear cells, including monocytes as well as lymphocytes. Polymorpho- and mononuclear leukocytes can be activated by advanced glycation end products, oxidative stress, angiotensin II [51, 52], and cytokines in a state of hyperglycemia. Leukocytes may be activated through the release of cytokines, such as TNF-α, transforming growth factor-1, superoxide, nuclear factor κB (NF-κB), monocyte chemoattractant protein 1, interleukin-1β, and others [53] to participate in the pathogenesis of diabetic micro- and macrovascular complications. The profile of the WBC count reflects the balance between the rate of granulocyte production and that of WBC. [54] reported that diabetes in mice was accompanied by moderate neutrophilic leukocytosis and prolonged circulation times of neutrophils and monocytes, and a shortened circulation time of lymphocytes, which increases the susceptibility to infection. The active components present in *Curcuma longa* decreases the WBC count.

Serum Biochemical Parameters:

A significant increase in serum total proteins (5.42), albumin (2.52) and globulin (3.86) was recorded in diabetic untreated rats when compared to the normal control rtes (Group-I), *Curcuma longa* treated diabetic rats showed significant decrease in serum total proteins (4.72), albumin (2.24) and globulin (2.68) levels compared to the diabetic rats and also nearly levels of the control rats.

Table 4. Serum Biochemical Parameters levels in the control and experimental animals:

Parameters	Group I	Group II	Group III
Total Proteins (g/dl)	4.68± 0.53	5.42± 0.92	4.72± 0.34
Albumin (g/dl)	2.12± 0.32	2.52± 0.48	2.24± 0.36
Globulin (g/dl)	2.44± 0.38	3.86± 0.97	2.68± 0.82

Values are mean ± S.D. of 6 individual rats

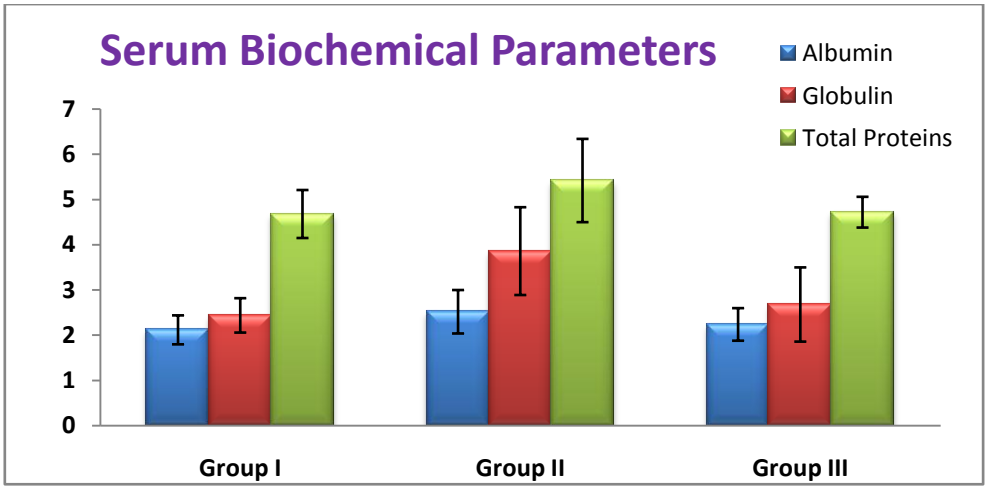

Figure 4. Serum Biochemical Parameters levels in the control and experimental animals

Hyperlipidemia is a known complication of *Diabetes mellitus* and coexists with it and is characterized by increased levels of cholesterol and also changes in lipoprotein patterns. Interest in the study of plasma lipids in diabetes arises from the widely acknowledged higher incidence of atherosclerotic disease which is a major cause of premature death in diabetic patients whether it is type-I or type-II [55].

In the present investigation, results show a significant in plasma albumin, globulin, total protein levels in diabetic rats which are in agreement with many earlier reports. These alterations in diabetes are due to enhanced catabolism of proteins [46, 56]. It is well known that in insulin deficiency (diabetes) decreased protein synthesis and increased protein degradation lead to release of amino acids which are directed for gluconeogenesis. Lowered albumin and globulin in diabetic rats might be due to increased degradation and/or decreased production and/or increased urinary excretion of these substrates. Microalbuminuria in STZ-diabetic rats and humans is well documented with increased albumin excretion range (AER) [57] and formation of advanced glycation and products (AGEs) leading to kidney damage and diabetic glomerulopathy [58]. *Curcuma longa* supplementation appears to have rectified this abnormality in diabetic rats as evidenced by significantly elevated serum albumin levels in rats receiving *Curcuma longa* observed that the risk of progression to over proteinuria can be reduced by improved glycemic control. In the present study also, the glycemic control exerted by *Curcuma longa* might have contributed to the restored plasma albumin levels. Moreover, supplementation of *Curcuma longa* might have induced protein synthesis by effective utilization of the available amino acids and also by reducing protein catabolism and/or by regulating certain signal transduction mechanisms and enzymes. Phytochemicals of

Curcuma longa extract appear to have mitigated the metabolic abnormalities and restored the urea and creatinine levels.

Insulin is the principal regulatory hormone involved in the tight regulation of fuel metabolism. In response to blood glucose levels, it is secreted by the β-cell of the pancreas and exerts its effects by binding to cell surface receptors that are present on virtually all cell types and tissues [59]. In the present study, normal rats treated with *Curcuma longa* extract showed normal levels of insulin while diabetic rats had shown very low levels of insulin as a consequence of pancreatic β-cell damage indicating low pancreatic β-cell activity followed by Streptozotocin.

The serum biochemical parameter of control rats are Creatinine (2.16), Urea (26.945) and (95.74) was tabulated in Table-1. Increased levels of the creatinine (2.83), urea (35.36) and cholesterol (135.38) was recorded in the diabetic untreated rats (group-II), *Curcuma longa* treated rats shows significantly decreased levels of creatinine (2.34), urea (28.28) and cholesterol (102.68) when campared to the diabetic rats and also near to the normal rats (Table-5 and Figure-5),

Table 5. Serum Biochemical Parameters levels in the control and experimental animals

Parameters	Group I	Group II	Group III
Creatinine (mg/dl)	2.16± 0.16	2.83± 0.42	2.34± 0.68
Urea (mg/dl)	26.94± 3.94	35.36± 6.46	28.28± 5.98
Cholesterol (mg/dl)	95.74± 10.92	135.38± 23.6	102.68± 18.74

Values are mean ± S.D. of 6 individual rats

Hyperlipidemia is a known complication of *Diabetes mellitus* and coexists with it and is characterized by increased levels of cholesterol and also changes in lipoprotein patterns [60]. Interest in the study of plasma lipids in diabetes arises from the widely acknowledged higher incidence of atherosclerotic disease which is a major cause of premature death in diabetic patients whether it is type-I or type-II [51, 55].

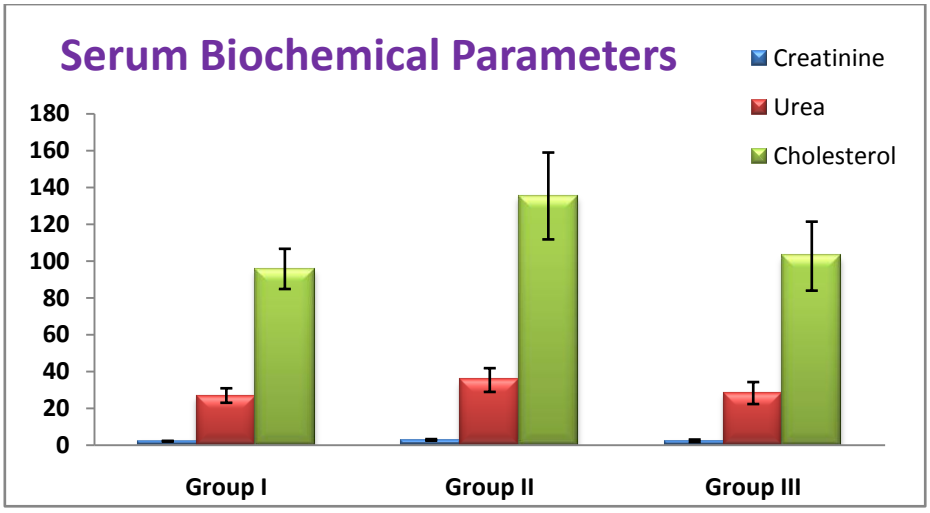

Figure 5. Serum Biochemical Parameters levels in the control and experimental animals

In the present investigation, results show a significant in urea and creatinine levels in diabetic rats which are in agreement with many earlier reports. These alterations in diabetes are due to enhanced catabolism of proteins [56]. It is well known that in insulin deficiency (diabetes) decreased protein synthesis and increased protein degradation lead to release of amino acids which are directed for gluconeogenesis. Due to increased catabolism of proteins and amino acids, hepatic ureagenesis and creatinine production are elevated in diabetic rats [46]. As a consequence, increments in urea and creatinine levels occur in plasma. Microalbuminuria in STZ-diabetic rats and humans is well documented with increased albumin excretion range (AER) [57] and formation of advanced glycation and products (AGEs) leading to kidney damage and diabetic glomerulopathy [58]. *Curcuma longa* supplementation appears to have rectified this abnormality in diabetic rats as evidenced by significantly elevated serum albumin levels in rats receiving *Curcuma longa* observed that the risk of progression to over proteinuria can be reduced by improved glycemic control. In the present study also, the glycemic control exerted by *Curcuma longa* might have contributed to the restored plasma albumin levels. Moreover, supplementation of *Curcuma longa* might have induced protein synthesis by effective utilization of the available amino acids and also by reducing protein catabolism and/or by regulating certain signal transduction mechanisms and enzymes. Phytochemicals of *Curcuma longa* extract appear to have mitigated the metabolic abnormalities and restored the urea and creatinine levels.

Insulin is the principal regulatory hormone involved in the tight regulation of fuel metabolism. In response to blood glucose levels, it is secreted by the β-cell of the pancreas and exerts its effects by binding to cell surface receptors that are present on virtually all cell

types and tissues [59]. In the present study, normal rats treated with *Curcuma longa* extract showed normal levels of insulin while diabetic rats had shown very low levels of insulin as a consequence of pancreatic β-cell damage indicating low pancreatic β-cell activity followed by Streptozotocin.

SUMMARY AND CONCLUSION:

In present investigation, anti-diabetic properties of *Curcuma longa* in STZ induced diabetic rat hematological parameters and serum biochemical parameters were studied with the blood glucose and body weight levels. Wistar stain male albino rats of 3 months age were used in the present study. They were maintained in the animal house at 24±2° C, humidity of 45-64% with photoperiod of 12 hours light and 12 hours darkness. Regarding selection of age and grouping of animals as mentioned in "Material and methods" was taken in to consideration to select 3 months old rats as adult age in this experimental design for expected results. They were maintained in clean poly propylene cages and fed with standard rat pellet diet (Hindustan lever Ltd., Mumbai) and water *ad libitum.* The animals of same age group were divided in to 3 groups, each group consists of six animals and the division of groups is as follows.

Group -1 : Normal Control rats.

Group- 2 : Diabetic rats (Streptozotocin)

Group -3 : Diabetic rats treated with 250 mg/Kg b.w. of *Curcuma longa*.

The blood samples were collected after completion of treatment i.e. on 22nd day of the treatment. The blood was used for the hematological parameters and separated serum was used for the serum biochemical parameters.

The summary of the results from this study is presented as follows:

1. No significant blood glucose level changes were observed in control rats. In diabetic rats blood glucose levels were increased. *Curcuma longa* rats, which were subjected to *Curcuma longa* extract supplementation showed decreased levels of blood glucose. This may be due to the antidiabetic compounds present in *Curcuma longa*.

2. We observed body weight changes in the current investigation in all experimental rats. In diabetic rats, the body weights were significantly decreased after induction of STZ. The decrease in body weight in diabetic rats clearly showed a loss or degradation of structural proteins. Weight loss which is one of the clinical features of *Diabetes mellitus* may be due to the degeneration of the adipocytes and muscle tissues to make up for the energy loss from the

body due to frequent urination and over conversion of glycogen to glucose. In the *Curcuma longa* treated rats, body weights were gained near to control levels after treatment with *Curcuma longa* plant extract.

3. The blood parameters revealed significant alterations in all experimental groups. In group-II (Diabetic rats) the blood parameters such as Hemoglobin, RBC, WBC counts were highly decreased which suggest the anemic condition in the body, and increased count was observed in group-III (Diabetic + *Curcuma lona*) treated rats.

4. Increased levels were observed in Albumin, Globulin, Total proteins, Creatinine, Urea and Cholesterol in group-II (Diabetic) rats indicating its impact on Soluble proteins, disturbance on immune mechanism etc, whereas the same were decreased in group-III treated with *Curcuma longa* plant extract of diabetic rats.

To conclude the present findings reveals that treatment with selected dosage of *Curcuma longa* extract is beneficial in countering the alterations in various blood and serum biochemical parameters. This study drawn a conclusion, stating that *Curcuma longa* treatment to diabetic rats may be beneficial to improve the metabolic efficiency and thereby improve the health status. Thus *Curcuma longa* may be useful in the formulation of herbal drugs which can be used in the treatment of diabetes.

REFERENCES:

1. Papadakis KA, Tabibzadeh S. 2002. Gastrointest Endosc Clin N Am. 12(3):433-49.
2. Kirtikar, K.R., Basu, B.D., (1975), Indian -Medicinal Plants, Vol 9, 2nd ed. 2435-2439.
3. Nadkarni, K. M. (1997), Popular Prakashan, pp, 1308-1315.
4. Sadak Basha S, Guru Sekhar M, Mannur Ismail S, Sree Vani P, Pushpa Latha B, Radha Madhavi YR and M. Bhaskar (2010a), Asian J. Exp. Biol. Sci. 1 (3): 627-632.
5. Sadak Basha S, Guru Sekhar M, Radha Madhavi Y.R, Mannur Ismail S and M. Bhaskar (2010b), Int. J. Pharmocol. Biol. Sci. 4 (1): 93-102.
6. Guru Sekhar M, Sadak Basha S, Radha Madhavi YR, Rama Krishna S, Mannur Ismail S and Bhaskar M. (2010), Adv. Phrmacol. Toxicol. 11(1): 95-105.
7. Osawa T. (2002), Nippon Rinsho. 60 Suppl 10:53-9.
8. Sreejayan, Rao MN. (1997), J Pharm Pharmacl. 49(1):105-7.
9. Ganada, OP., Simonson, DS. (1993), Diabetes Rev. 1,286-302.
10. Radha Madhavi Yeggnisetty Ramachaiahgari, Swapna Rekha Somesula, Pradeepkiran Jangampalli Adi, Ismail Shaik Mannur, Madhuri Enamalaa, Bhaskar Matcha. (2012), Digest J Nano. Biostru. 7(1): 175-184.

11. Omamto, H., Uchigata, Y. (1981), Nature. 294:284-286.
12. Gottried, S. P., Rosenberg, B. (1973), Clin, Chem. 19:107-108.
13. Low, P, A., Nickander, K. K., Tritscher. H. 1997. Diabetes. 46, S38-S42.
14. Vijay Kumar, M., Govindarajan, R., Rao, G. M. M., Rao, Ch. V., Shirwaikar, A., Mehrotra, S., Oushpangadan, P. (2006), J. Ethnopharma. 104:356-361.
15. Hunt JV, Dean RT and Wolf SP (1988), Biochem 256: 205-212.
16. Weaver DC, McDaniel ML, Naber SP, Barry CD, Lacy PE. 1978. Diabetes. 27(12):1205-14.
17. Boquist, L., Ericsson, I., Lorentzon, R. and Nelson, L. (1985), *FEES Lett.* 183, P. 173 – 176.
18. Malaisse, W. J., Lebrun, P. and Herchuelz, A. (1982), Pflugers Arch. 395(3), 201-203.
19. Tiedge, M., Lortz, S., Drinkgern, J. and Lenzen, S. (1997), Diabetes. 46(11), 1733-1742.
20. Lenzen, S. and Munday, R. (1991), Biochem Pharmacol. 42(7), 1385-1391.
21. Zhang, C. F., Zhu, X. H., Dong, F. T., Ye, J. J., Fei, P. F., Zhang, Q. N. and Du, H. (1992), Chin Med J Eng. 105(3), P. 234-236.
22. Lenzen, S., Tiedge, M. and Panten, U. (1987), Acta Endocrinol (Copenh), 115(1), P. 21-29.
23. Jiang, H., Xie, Z., Koo, H. J., McLaughlin, S. P., Timmermann, B. N. and Gang, D. R. (2006), Phytochemistry. 67, P. 232-244.
24. Ojewole, A. (2006), Phytother. Res. 20, P. 764-772.
25. Raju, J., Gupta, D., Rao, A. R., Yadava, P. K. and Baqucr, N. Z. (2001), Mol Cell Biochem. 224(1-2), P. 45-51.
26. Vats, V., Yadav, S. P. and Grover, J. K. (2003), J. Ethnopharmacol. 85(2-3), P. 237-242.
27. Khosla, P., Gupla, D. D., and Nagpal, R. K. (1995), Int.J. Pharmaco. 27, P. 89 93.
28. Puri, D., Prabhu, K. M. and Murlhy, P. S. (1995), Indian J Clin Bioehem. 9, 13-16.
29. Sarah, N., Oluwatosin, A. and Edith, A. (2009), Pak. J. Nutr. 8 (5), P. 625-628.
30. Shnkar, T. N. B., Shanta, N. V., Ramesh, H. P., Murthy, I. A. S. and Murthy, V. S. (1980), Ind. J. Exp. Bio. 18(1), P. 73-75.
31. Nishiyama, T., Mae, T., Kishida, H., Tsukagawa, M., Mimaki, Y., Kuroda, M., Sashida, Y., Takahashi, K., Kawada, T., Nakagawa, K. and Kitahara, M. (2005), J. Agri. Food and Chem. 53, P. 959-963.
32. Mahesh, T., Balasubashini, M. and Menon, V. (2005), J. Medicinal Food. 8, P. 251-255.
33. Neel, J. V. (1962), Am J Hum Genet. 14, P. 353–362.
34. Knowler, W. C., Pettitt, D. J., Bennett, P. H. and Williams, R.C. (1983), Am J Phys Anthropol. 62, P. 107 –114.
35. Ravussin, E. and Bogardus, C. (1990), Infusionstherapie. 17, 108 –112.
36. Sharma, A. M. (1998), J Mol Med. 76, P. 568-571.
37. Mokdad, A. H., Ford, E. S., Bowman, B. A., Dietz, W. H., Vinicor, F., Bales, V. S. and Marks, J. S. (2001), JAMA. 289, P. 76 –79.

38. Hu, F. B., Manson, J. E., Stampfer, M. J., Colditz, G., Liu, S., Solomon, C. G. and Willett, W. C. (2001), N Engl J Med. 345, P. 790 –797.
39. Olefsky, J., Reaven, G. M. and Farquhar, J. W. (1974), J Clin Invest. 53, P. 64 –76.
40. Pi-Sunyer, F. X. (1993), Ann Intern Med. 119, P. 722 –726.
41. Klein, S., Sheard, N. F., Pi-Sunyer, X., Daly, A., Wylie-Rosett, J., Kulkarni, K. and Clark, N. G. (2004), Am J Clin Nutr. 80, P. 257 –263.
42. Reno, J. and Leland, J. (1999), Newsweek. 134, P. 56-57.
43. Rajkumar, L. and Govindarajulu, P. (1991), Indian JExp Biol. 29, P. 1081-1083.
44. Al-Amin., Martha Thomson Khaled, K., Al-Qattan., Ritta Peltonen, S. and Muslim, A. (2006), British Journal of Nutrition. 96, P. 660-666.
45. Akbarzadeh, A., Norouzian, D., Mehrabi, M. R., Jamshidi,S. H., Farhangi, A., Allah Verdi, A., Mofidian, S. M. A. and Lame Rad, B. (2007), Ind. J. Cli. Biochem. 22, P. 60-64.
46. Mude Ravi Naik., Jangampalli Adi Pradeepkiran., Somesula Swapna Rekha. and Match Bhaskar. (2012), Digest Journal of Nanomaterials and Biostructures. 7 (2), P. 649 – 655.
47. Weiss, G. and Goodnough, L.T. (2005), Eng. J. Med. 352, P. 1011–1023.
48. Kolanjiappan, K., Manoharan, S. and Kayalvizhi, M. (2002), Clin Chim Acta. 326, P. 143–149.
49. Lee, C. D., Folsom, A. R., Nieto, F. J., Chambless, L. E., Shahar, E. and Wolfe, D. A. (2001), Am J Epidemiol. 154, P. 758–764.
50. Tong, P. C., Lee, K. F., So, W. Y., Ng, M. H., Chan, W. B. and Lo, M. K. (2004), Diabetes Care. 27, P. 216–222.
51. Radha Madhavi, Y. R., Swapna Rekha, S., Pradeepkiran, J. A., Ismail S. M., Maduri, E. Bhaskar, M. (2010), Digest Journal of Nanomaterials and Biostructures. 7(1), P. 175-184.
52. Lee, F. T., Cao, Z., Long, D. M., Panagiotopoulos, S., Jerums, G. and Cooper, M. E. (2004), J Am Soc Nephrol. 15, P. 2139–2151.
53. Shanmugam, N., Reddy, M. A., Guha, M. and Natarajan, R. (2003), Diabetes. 52, P. 1256–1260.
54. Kozlov, I. A., Novitski, V. V. and Baìkov, A. N. (1995), Biull Eksp Biol Med. 120, P. 33–35.
55. Betteridge, D. J. (1989), Brit Med Bull. 45 (1), P. 285-311.
56. Willatgamuwa, S. A., Platel, K., Saraswathi, G. and Srinivasan, K. (1998), *Nutr Res*. 18, P. 131-124.
57. Berg, T. J., Bangstad, H. J., Torjesen, P. A., Osterby, R., Bucala, R. and Hanssen, K. F. (1997), Metabolism. 46(6), P. 661-665.
58. Bangstad, H. J., Osterby, R. and Dal- Jorgensen, K. (1993), Diabetoiogia. 36, P. 523-529.
59. Cheng, A., Dube, N., Gu, F. and Tremblay, M. C. (2002), Eur J Biochem. 269, P. 1050-1059.
60. Bagdade, J. D., Root, R. K. and Bulger, R. J. (1974), *Diabetes*. 23, P. 9-15.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 5

COMPARATIVE ACCOUNT OF HEAVY METALS CONCENTRATION IN WATER, SEDIMENT AND FISH TISSUES FROM PANCHGANGA RIVER, KOLHAPUR (M.S., INDIA)

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ABSTRACT:

Analysis of water, sediment and fishes from the Panchganga River reveals that, the river is contaminated by several heavy metals. The heavy metal content from the non-polluted zone of the Panchganga River, Kolhapur (M.S.) water was found below detectable level. Samples from polluted zone showed variations in their heavy metal content in river water, sediment and fish tissues. Heavy metal concentrations varied significantly depending upon the type of fish tissues and locations. The study of heavy metal bioaccumulation in selected three species of fishes showed the highest heavy metal accumulation in liver followed by gill and muscle. From present study it is concluded that the higher concentrations of heavy metals at selected stations is due to the heavy load of industrial waste in addition to domestic and agricultural waste. The industrial waste contains high amount of textile mill waste includes dyes, untreated chemicals, which caused severe damage to the fisheries of Panchganga River.

KEY WORDS: Panchganga River, heavy metal, water, sediment, fish

INTRODUCTION:

The expanding measure of waste produced by over populace, urbanization and industrialization discovers its way in sea-going biological systems. A hefty portion of these diligent contaminations get secured natural way of life and reach at more elevated amounts

with expanding focuses, a few circumstances far from wellspring of contamination. Oceanic creatures are equipped for taking up and gathering substantial metals to a degree commonly than that present in encompassing medium [1].

The impact of substantial metals on oceanic living being is as of now drawing in across the board consideration, especially in the investigation of contamination. Overwhelming metals are being brought into a watery domain through modern and urban effluents, soil draining and precipitation. The across the board pollution of oceanic eco-framework with substantial metals is the expanding worry of ecological researchers. [2] exhibited that, lethal substantial metals from mechanical wastewater are impervious to biodegradation and get gathered in the water and silt and significantly influences the water quality and amphibian life. [3] Detected the overwhelming metal from modern wastewater on slop from Dandesara, GIDC zone of Surat. The grouping of substantial metals like copper, cadmium, nickel, lead, zinc, mercury and iron was resolved and few metal particle levels was found past the ISI allowable breaking points. [4] Reported that the waste water of electroplating industry contains nickel and chromium, of this chromium was more poisonous.

Considering the heap of overwhelming metals in the oceanic environment through numerous perspectives, the present review is meant to measure the level of some substantial metals in the stream water, dregs and tissues of monetarily vital fishes from Panchganga River at three chose locales.

MATERIALS AND METHODS:

Fortnightly sampling of water, sediment and fishes was done from three different stations (A, B and C) along the river Panchganga, near Kolhapur [5].

Station A – (Shiroli Bridge) is situated at boundary line of Kolhapur town and receives domestic and industrial wastes.

Station B - Near village Chandur 17 km. away from Kolhapur, it receives textile and agricultural waste.

Station C - is 1½ km. away from town Ichalkaranji, which is famous for textile industry in Maharashtra. Huge amount of textile mill waste is drained directly in river Panchganga from this town.

For present study three economically important fish species were selected i.e. *Cyprinus carpio, Cirrhina mrigala* and *Oreochromis mossambicus*. Gill, liver and muscle tissues were selected as target tissue for heavy metal bioaccumulation study.

From three stations water, sediment and fish samples were collected and polled samples of gills, liver and muscle tissues were acid digested by using perchloric acid and Nitric acid [6]. All samples were analyzed for heavy metal by using AAS (Chemito model). Results are expressed in mg/lit for water and mg/gm for tissue samples and sediment.

RESULTS AND DISCUSSION:

The results of heavy metal detection in water samples at three stations showed highest concentration of zinc (14.1 mg /l, 11.2 mg/l and 11.3 mg/lit) followed by copper, nickel, iron, manganese and lowest concentration of chromium (0.015 mg/lit, 0.02 mg/lit and 0.015 mg/lit). (Table 1)

Table 1: Heavy metal contents in water and sediments samples collected from polluted zone of Panchganga river

Station	Heavy Metals	Mean values	
		Water (mg/L)	Sediment (mg/g)
A	Mn	0.3	0.8
	Ni	1.3	2.7
	Fe	0.5	1.7
	Cu	1.4	4.4
	Zn	14.1	18.0
	Cr	0.015	0.4
	Hg	BDL	BDL
B	Mn	0.35	1.45
	Ni	0.3	3.15
	Fe	0.25	2.1
	Cu	0.35	4.5
	Zn	11.22	16.1
	Cr	0.002	0.4
	Hg	BDL	BDL
C	Mn	0.4	1.7
	Ni	0.3	1.1
	Fe	0.3	1.7
	Cu	0.85	2.3
	Zn	11.34	14.6
	Cr	0.015	0.7
	Hg	BDL	BDL

BDL = Below Detectable Level

The similar pattern was observed in sediment at three stations having highest concentration of zinc (18 mg/g, 16.1 mg/g and 14.6 mg/g) followed by copper, nickel, iron, manganese and lowest concentration of chromium (0,4 mg/g and 0.7 mg/g)(Table 1). Mercury Was found to be absent in water and sediment at all three stations.

The heavy metal content in fish tissue showed lowest concentration of zinc (0.025 mg/g to 1.8 mg/g) at three stations in liver followed by gill and lowest in muscles of three selected fish species. While the highest concentration of nickel (8.5 mg/g to 4.7 mg/g) at station A. and iron (12.6 mg/g to 9.2 mg/g) at station B and C were found in liver, gill and muscles of selected fish species, while mercury was at BDL. (Table 2)

Table - 2: Heavy metal contents in gill, liver and muscle of freshwater fishes from Panchganga River

Station	Heavy metal	Mean values (mg/g)								
		Oreochromis mossambicus			***Cirrhina mrigala***			***Cyprinus carpio***		
		Gill	Liver	Muscle	Gill	Liver	Muscle	Gill	Liver	Muscle
A	Mn	1.6	1.75	1.5	1.9	2.05	1.55	2.75	2.9	1.55
	Ni	5.4	6.3	4.7	7.4	8.5	6.2	6.2	6.7	5.8
	Fe	1.95	2.55	1.5	2.3	3.1	1.9	2.1	2.35	1.7
	Cu	0.5	0.6	0.2	0.8	1.0	0.3	0.5	0.7	0.3
	Zn	0.02	0.03	0.15	0.02	0.02	0.01	0.01	0.03	0.01
	Cr	2.25	2.4	1.5	3.05	3.35	2.65	3.25	3.25	2.85
	Hg	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
B	Mn	2.85	2.95	1.8	2.75	3.1	1.75	2.85	3.05	1.9
	Ni	10.0	11.9	5.8	10.5	10.6	9.5	8.4	8.5	7.3
	Fe	10.4	11.5	9.2	10.85	12.28	9.3	10.5	10.6	9.2
	Cu	1.75	2.05	1.2	1.45	1.5	1.2	1.85	2.05	1.0
	Zn	1.45	1.85	1.15	1.2	1.6	6.9	1.85	1.7	1.05
	Cr	4.0	4.8	3.0	3.95	4.2	3.3	1.82	0.2	1.1
	Hg	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

C	Mn	2.85	3.5	2.0	2.6	2.8	1.95	2.75	3.2	2.05
	Ni	10.8	11.25	9.25	10.5	10.8	9.55	8.8	8.5	8.0
	Fe	11.8	12.6	10.0	11.8	11.85	10.0	10.65	11.2	9.9
	Cu	2.25	2.25	1.7	1.85	2.2	1.05	1.75	2.15	1.1
	Zn	1.55	1.8	1.0	1.45	1.75	1.4	1.25	1.65	1.0
	Cr	4.2	4.7	8.2	4.9	5.0	3.0	1.9	2.2	1.8
	Hg	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

BDL = Below Detectable Level

From results the greatest bioaccumulation was found in liver at three stations took after by gill; while least bioaccumulation was found in muscles of three chose angle species. Most extreme bioaccumulation was found in Cyprinus carpio, trailed by Cirrhina mrigala and Oreochromis mosambicus. A progression of changes can be seen in the lotic water biological community, which may be because of assortment of components. Despite the fact that these biological systems are impacted by the regular changes and some man made exercises, for example, expansion of mechanical squanders, agrarian keep running off, sewage and so on [7].

Overwhelming metals are thought to be not kidding contaminants of oceanic framework because of augmented organic half-life, inborn dangerous nature at low conc. what's more, high rate of bio-amassing [8, 9].

Coordinate dumping of wastewater into water bodies causes the move of contaminations into normal ecological, thusly exasperating the environment [10, 11]. This is the means by which substantial metals are exchanged to oceanic framework in broke up from and by their connection with life forms and their buyers at last prompting to metal lethality by bio-amplification [12, 13].

Display think about demonstrated most astounding grouping of zinc in water and dregs tests. In present review contamination is for the most part because of accepting substantial heap of untreated sewage and modern waste at station A. At station B contamination is because of modern and agrarian waste. At station C release of different colors and untreated chemicals from material plants is found in major.

In all perceptions greatest bio-aggregation of substantial metals was at Station C took after by B and An, in three financially critical fish species from Panchganga.

From the above reviews unmistakably overwhelming metal substance from the water, residue and fish tissues from three monetarily vital fish species from Panchganga River is high in dirtied zone, which causes dangerous consequences for the fauna of waterway and may likewise influence the clients of stream water and fish shoppers in long run.

REFERENCES:

1. Riley, J. P. and Roth, I. Journal of the Marine Biological Association of the United Kingdom, 1971, 51, 63-72.
2. Mahapatra, S. P. Indian Journal of Environmental Protection, 1987, 41, 284-286.
3. Shrivastava, V. S. Indian Journal of Environmental Protection, 1996, 15(5), 328-329.
4. Singh, R. K. and Singh, S. P. Proceeding of 83rd session of Indian Science Congress, Patiala, 1996.
5. Trivedy, R. K., Goel, P. K. and Trisal, C. L. Enviro media Publication Karad (India), 1998.
6. Lithnor, G. FAO Rome, 1975.
7. Whitton, B. A. Zinc in the environment part II. Health affects (Ed. J.O. Narriagu) John Wiley, New York, 1980, 363-400.
8. Wong, M. H. Acta Anta, 1970, 99(4), 450-454.
9. Amundson, P A., Staldvik, F. J. and Lukin A. A. Science Total Environment, 1997, 18, 201(3), 211-224.
10. Vernberg, W. B. and Vernberg, F. J. Academic press, Inc, New York, 1974, 381-425.
11. Saikia, P. K. Indian Journal of Environmental Health, 1988, 31(1), 11-17.
12. Enk, M. D. and Mathis, B. J. Hydrobiologia, 1977, 52, 153-158.
13. Stern, W. and Bacchini, P. In lakes, chemistry, geology, physics, Edt. A. L. Herman Springer Verlog, New York, 1978, pp. 91.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 6

POLLINATION AND BIODIVERSITY

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ABSTRACT:

The procedure of transportation of dusts from stamens to the ovary in a similar blossom or starting with one bloom then onto the next in similar species is called fertilization. Plants must depend on dust vectors, from twist to bugs to feathered creatures, to transport their dust to another person. The investigation of fertilization unites many controls, for example, organic science, cultivation, entomology, and environment. Fertilization by bugs regularly happens on plants that have created hued petals and a solid aroma to draw in creepy crawlies, for example, honey bees, wasps and once in a while ants (Hymenoptera), insects (Coleoptera), moths and butterflies (Lepidoptera), and flies (Diptera). Fertilization is basic for nourishment generation and human employments, and straightforwardly interfaces wild biological communities with horticultural creation frameworks. Tropical timberlands are notable focuses of biodiversity. At the point when the quantity of blooming plant builds, pollinator creepy crawly assorted variety going to blossom likewise increments.

KEYWORDS: Pollination, Biodiversity, benefit.

INTRODUCTION:

Creepy crawly plant collaboration alludes to the exercises of two sorts of creatures: bugs that search out and use plants for sustenance, shield, egg-laying destinations, and the plants that give those assets. The collaborations can be gainful to both the plant and the creepy crawly, as outlined by pollination. The procedure of transportation of dusts from stamens to the ovary in a similar blossom or starting with one bloom then onto the next in

similar species is called fertilization Plants must depend on dust vectors, from twist to bugs to feathered creatures, to transport their dust starting with onto the next individual blossom or starting with one bloom then onto the next in similar species is called fertilization. Fertilization is the procedure by which plants sexually repeat. Plants and creatures have a nearby interrelationship for their survival, spread and control. [1] States that "Sexual generation is similarly as critical for plants as it is for creatures with regards to sex they can't simply get up and get themselves a mate.". Most organic product crops expect fertilization to guarantee that natural product sets. Dust grains get got on the sticky surface of the stigma, germinate and create a tube that becomes down the style and joins with the female cell in the ovary. This union is called preparation. After preparation occurs, seeds create and the organic product develops. The procedure is somewhat extraordinary in angiosperms (blossoming plants) from what it is in gymnosperms (other seed plants). In angiosperms, after the pollen grain has landed on the stigma, it creates a pollen tube which grows down the style until it reaches the ovary. Sperm cells from the pollen grain then move along the pollen tube and enter the egg cell through the micropyle and fertilise it, resulting in the production of a seed.

In gymnosperms, the ovule is not contained in a carpel, but exposed on the surface of a dedicated support organ, such as the scale of a cone, so that the penetration of carpel tissue is unnecessary. Flowers can attract pollinators by providing ample nectar of the right composition, and by advertising this nectar by deep shape and recognizable floral patterns, by providing excess pollen as food, or by providing shelter or a place to raise young [2]. The study of pollination brings together many disciplines, such as botany, horticulture, entomology, and ecology. The pollination process as an interaction between flower and pollen vector was first addressed in the 18th century by Christian Konrad Sprengel.

Types of Pollination:

Cross-pollination: The transfer of pollen between two different species or varieties

Self-pollination: The transfer of pollen within a single plant or among several plants of the same variety .

Abiotic: Abiotic pollination refers to situations where pollination is mediated without the involvement of other organisms. The most common form of abiotic pollination, anemophily is pollination by wind. Hydrophily is pollination by water

Biotic: More commonly, the process of pollination requires pollinators: organisms that carry or move the pollen grains from the anther of one flower to the receptive part of the carpel or

pistil (stigma) of another. This is biotic pollination. The majority of these pollinators are insects, but about 1,500 species of birds and mammals have been reported to visit flowers and may transfer pollen between them. Entomophily, pollination by insects, often occurs on plants that have developed colored petals and a strong scent to attract insects such as, bees, wasps and occasionally ants (Hymenoptera), beetles (Coleoptera), moths and butterflies (Lepidoptera), and flies (Diptera). In zoophily, pollination is performed by vertebrates. Ornithophily or bird pollination is the pollination of flowering plants by birds. Chiropterophily or bat pollination is the pollination of flowering plants by bats.

POLLINATING INSECTS:

Bees and wasps:

They have a place with arrange Hymenpotera. Bumble bees fly out from bloom to blossom, gathering nectar (later changed over to nectar), and dust grains. The honey bee gathers the dust by rubbing against the anthers. The dust gathers on the rear legs, in a structure alluded to as a "dust wicker container". As the honey bee flies from blossom to bloom, a portion of the dust grains are exchanged onto the disgrace of different blooms.

Butterflies and Moths:

Lepidoptera (butterflies and moths) likewise fertilize plants to different degrees. They are not real pollinators of nourishment crops, but rather different moths are imperative pollinators of other business harvests, for example, tobacco. Moth fertilizes night-time blooms.

Beetles:

Scarabs of species that spend significant time in eating dust, nectar, or blooms themselves, are imperative cross-pollinators of a few plants, for example, individuals from the Araceae and Zamiaceae that deliver massive measures of dust.

Thrips and Ants:

Various thrips are comparatively minor opportunist pollinators. Ants also pollinate some kinds of flowers, but for the most part they are parasites, robbing nectar without conveying useful amounts of pollen to a stigma. Ants have traditionally been considered as poor or ineffective pollinators [2, 3].

Hoverflies:

Hoverflies are important pollinators of flowering plants worldwide.

Diptera:

Some Diptera (flies) may be the main pollinators at higher elevations of mountains, whereas *Bombus* species are the only pollinators among Apoidea in alpine regions at timberline and beyond.

IMPORTANCE:

Pollination is a keystone process in both human managed and natural terrestrial ecosystems. Is an essential service that depends to a large extent on the symbiosis between species, the pollinated and the pollinator? Pollination is critical for food production and human livelihoods, and directly links wild ecosystems with agricultural production systems. Pollinators account for a major share of global biodiversity in their own right. Wild bees and flies are two very diverse groups of species responsible for pollinating many flowering plants. Damaged plants are less attractive to pollinators as a result of changes in floral characters [4].

Pollinating insects are sensitive to the area and richness of floral resources in patches, even at relatively small scales. Therefore, larger wild flower plantings with more diverse flower species mixes are more suitable for the conservation of wild pollinators. Insect pollinators play a critical role in the population dynamics and evolution of floral traits in many plant species. Tropical forests are well known centres of biodiversity [5] and recently much interest has been focused on the ecological processes responsible for generating and maintaining the diversity [6]. All floral visitors to a plant species are important, as in the-documentation of all visitors spatially and temporally. The vast majority of insects visits a range of flowers of different plant species according to availability and the majority of plants are visited several or many insects species [7], although not all may be effective pollinators. Bees and most butterflies are able to tackle a broad range of flower species and are responsible for the pollination of many insect pollinated plants.

ANTHROPOGENIC EFFECT:

There is a growing recognition that plant – pollinator interactions can be drastically influenced by anthropogenic changes to ecosystems, climate change, habitat fragmentation, agricultural intensification, urbanization, pollution, pesticides and species invasions all have the potential to affect plant pollinator interactions directly or indirectly. Various studies indicate that higher the number of flowering plants greater the diversity of pollinating insects. Fragmentation and destruction of natural semicultural habitats may result in the loss of bee diversity and disruption of plant pollinator interactions

Ecology of pollinating insects:

The important biological inquiries emerge were-the means by which and why are creatures pulled in to bloom, by what method would animals be able to and blossoming plants go about as particular specialists upon each other, bringing about co-development of a mutualistic relationship. Creepy crawlies are pulled in to blossoms since its a lifestyle, the blooms help them to survive. The piece of the plant that really pulls in creepy crawlies is the vivid petals, once they have arrived on it, the dust appended to the stamens make them stay gather. When the quantity of blooming plant expands pollinator bug decent variety going by blossom likewise increments. In this way, there is an immediate connection between them. A huge number of years of co-advancement between blossoming plants and their pollinators, with each taking part species populace going about as a specific operator on the other, have brought about finished whelming biodiversity of the two creepy crawlies and blooming plants. Scrounging pollinators ordinarily move short separations between blossoms, regularly going by neighbouring plants [8]. The shape and shades of the blooms, their fragrance, their area on the stalks, the season and day by day timetable of their dust and nectar offerings, are balanced absolutely to pull specifically types of creepy crawlies and those masters thus are hereditarily adjusted to react to specific sorts of blossoms [9].

REFERENCES:

1. Berenbaum, M. (1995), Addison Wesley Publishing Company.
2. Faegri, K. Van Derpijl, L. (1971), Ame. J. of Bot. 71, 421–426.
3. Strauss, S.Y., J. K. Conner and S.L. Rush (1996), American naturalist 147: 1098-1107
4. Beattie, A. J., Turnbull, C., Knox, R.B. (1984), Ant inhibition of pollen
5. Richards, A. J. (2001), Ann. Bot.88:165-172.
6. Hamer,K.C.,Hill,J.K.,Benedick,S.,Mustaffa,N.,Sherratt,T.N.,Maryatis,M. and Chey, V. K. (2003), J. Appl.Ecol.vol:40: 150-162.
7. Waser, N.M., L. Chittka., M.W. Price, N. Williams and J. Ollerton.(1996). Ecology 77: 1043-1060.
8. Bateman, A. J. *1951.* Heredity 5:271-278.
9. Wilson, E.O. (1999). Diversity of life. W.W. Norton and Company, New York-424.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 7

NATURAL GAS FLARING AND ADAPTIVE STRATEGIES OF PLANT AND INSECT

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ABSTRACT:

Growing anthropogenic tendency is supposed to responsible for the fluctuation of environmental components in recent days. Flaring of natural gas is a common practice of crude oil exploration units. Activities of flaring alter environmental composition by the addition of a huge amount of carbon dioxide and a number of hydrocarbons in to the surrounding atmosphere. Adverse effect of such activities was seen in living organisms of adjoining areas. Carbon dioxide is a prime gaseous product of such activities, interact both directly and indirectly upon the adjoining biota. Being a diverse group of organisms as well as their sensitivity to surrounding environmental condition, insect can respond quickly to such activities. Therefore, adaptive response of insect and their linked species can be applicable to document environmental perturbation caused by natural gas flaring in future.

KEYWORDS: Natural gas, Flaring, Adaption, Plant, Insect

INTRODUCTION:

Environmental oscillation resultant increase atmospheric carbon dioxide concentration is supposed to be a major cause of global warming. Global warming is an important issue of discussion among scientific community for sustaining biodiversity and managing food security of the biosphere [1], [2]. Drastic changes in concentration of carbon dioxide has been observed at Mauna Loa in Hawaii since 1958 and the concentration is likely to be raised up to 800µmol (CO_2) by 2100 according to some climate model forecast [3]. Petro-chemical companies are substantially responsible for this phenomenon (releasing 340

million tons of CO_2) by flaring natural gas into the atmosphere every year all over the world during crude oil exploration practices [4]. Gas flaring of natural gas during the crude oil production of oil companies is a common process and about 115 billion cubic meters of natural gas is flared or vented into the atmosphere in each year all over the world. Being a high temperature oxidation process, gas flaring combustible components, including natural gas as well as various hydrocarbons are burnt to protect the pipes or vessels from over pressure [5].Quantity of flared gas is dependable to the extent of gaseous hydrocarbons generated during the oil exploration.Petroleum sectors are supposed to be a major source of economy. However, emitting toxic and injurious gas to the atmosphere, these industries imbalance ecosystem process [6]. Although, flaring impact was supposed to focus primarily at local level, but global impact can be predicted in some extent with the addition of carbon dioxide concentration in the atmosphere during this process. The free disposal of gas through flaring generates greenhouse effect, temperature escalation, health hazards problems upon local community as well as poor agricultural production and acid rain effect etc. [6],[7], [8],[9],[10],[11],[12],[13],[14]. Gas flaring emits about 250 numbers of toxin (most of them are carcinogenic) with a numbers of greenhouse gases and may contribute to diverse numbers of environmental effect at local as well as global level [6], [15]. Recently, in a study conducted in Niger Delta revealed extension of these pollutants to the adjoining areas of gas flare [16]. Pollutants released during this process damages the quality of air, soil and water and has adverse effects on adjoining biota [17].

However, fluctuations of atmospheric carbon dioxide, temperature and changes patterns of precipitation have severe impact upon soil organic carbon. Carbon dioxide is the prime gaseous product of gas flaring. It is a greenhouse gas and has capability to absorb UV rays thus become a potential contributor of global warming. Apart from this, sulphur dioxides, carbon dioxides and oxides of nitrogen are a few greenhouse gases added to the air from such emission. Sulphuric acid and nitric acid also form after interaction of sulphur dioxide and nitrous oxide with atmospheric moisture, respectively. However, during the process a number of other pollutants contaminate air, soil and water at local and regional level [17]. Contamination of these pollutants is not only harmful to human, but also threatening for the existence of important biological resources. Large numbers of floral as well as faunal wealth of our ecosystem may be affected in this process [18]. Greenhouse gases, mostly CO_2 interacts within and between biotic and abiotic components of the ecosystem [19] as well as play a significant role in different biome including plant species and insect herbivores performance [20],[21]. Rising of CO_2 is a cause of concern for global

climate change as expected to induce physiological changes in plants, including reduction in foliar nitrogen, which are likely to affect herbivore densities [22],[23]. Scientists believe that increasing level of atmospheric CO_2 can have significant effect on plant suitability for insects due to deficient nitrogen concentration. Elevation of carbon dioxide is responsible for altering plant-insect herbivore interaction by changing leaf chemistry and nutritional quality of plant i.e. detrimental for plant defense chemicals and effect on leaf feeder performance [24],[25].

North East India is a hotspot of biodiversity. In this regard, Assam, a state of unique biodiversity as well as rich natural resources, there is an urgent need of study of gas flaring and its impact on adjoining biota. With a huge numbers of oil and natural gas reservoir it is one of the largest contributors of country's economy. Therefore a huge number of oil exploration units are come up in each year in the region and such operation creates havoc for biological system living in the proximity. Exploration of crude oil in North east India was started during colonial period at Digboi of Upper Assam region. With the increasing trend of modern civilisation, a huge numbers of crude oil exploration units have come up each year in the region. These units are mostly established in proximity to tea garden, agricultural fields and human habitation areas. Activities of these crude oil exploration units released a huge amount of carbon dioxide in the adjoining area and previous study reported higher level of carbon dioxide in those areas [18]. Apart from this pollutants released during crude oil exploration process contaminate air, soil and water at local and regional level [17]. Contamination of these pollutants is not only harmful to human, but also threatening for the existence of important biological resources. A numbers of studies were conducted in the adjoining areas of group gathering stations at Sivasagar District of Assam documented declination of butterfly and host plant diversity. Apart from this, low silk quality of some economic insects including Muga silk worm was reported in oil field pollution areas of upper Assam [18].

Gas flaring scenario in India:

Flaring of natural gas during crude oil production is a common process of oil exploration unit. About 150 billion cubic meters of natural gas flared or vented into the atmosphere annually all over the world during this process [26].Among the most gas flaring countries, Libya flares about 21% of its natural gases followed by Saudi Arabia (20%), Canada (8%) and Algeria [27]. In India, flaring of natural gas has been starting since 1957 while first drilling operation of oil was started during 1889 at Digboi of upper Assam. India contributes about 14 million tonnes of CO_2 by the gas flaring process while Assam

contributes about 3.14 million tonnes [28]. Being a state of rich natural resources, Assam has a long history of oil exploration with Digboi oil refinery. After exploration of oil in Digboi, a huge number of companies carried out the process and explored this liquid gold in the region. During pre-independent, oil and natural gas commission carried out the process. After few years, Assam Oil Company Limited played major role by discovering a large number of new oil exploration units in upper Assam area. During last few years, a huge number of oil exploration units have been come up, resulting more oil and natural gas production in the region. Today (2015-16), crude oil production in Assam raises to 36.950 Million Metric Tonnes (MMT) (Ministry of Petroleum and Natural Gas 2015-16 Report). Gross production of natural gas in India (including offshore and onshore) accounted to 33,657.44 MMSCM during 2014-15, where about 865.11 MMSCM was flared. During 2015-16, the natural gas production was 32,249.21 MMSCM, while flared quantity was 1006.35 MMSCM i.e. more than the previous one. India flared about 3.12% of total gas production during 2015-16 which was higher than previous years (Ministry of Petroleum and Natural Gas 2015-16 Report). Assam produced about 32.249 BCM of natural gas during 2015-16 and 33.657 BCM in 2014-15. Assam flared about 178.29 MMSCM of natural gas which is 6.07% of total natural gas produced in the region (Ministry of Petroleum and Natural Gas 2015-16 Report).

Effect of gas flaring:

Natural gas is mostly a composition of light hydrocarbon. Thus, flaring of natural gas added huge amount of carbon dioxide as a main gaseous product accompanied by other toxic components in our atmosphere. Gas flaring associated with crude oil exploration is a part of safety management process applied by various gas agencies all over the world. However, a number of factors including flare design, operating conditions, chemical composition of associate gas have great influence upon gas flaring and venting. However, in reality achievement of complete combustion is rare [29]. Combustion performance as well as efficiency of combustion of gas flaring are dependable to energy density of the flare gas stream, flare design, flare gas composition and condition of the abiotic environmental parameters including ambient temperature, wind speed and direction, stoichiometric mixing ratios, stack exit velocity and heating value [29],[30],[31]. Carbon dioxide is released during full combustion process of gas flaring while incomplete combustion lead to release of carbon monoxide. Addition of huge amount of greenhouse gases along with other noxious gases and hydrocarbons to the atmosphere during this process [32] has crucial effect on global warming as well as climate change. Previous studies conducted in some flares of Nigeria documented

effect of acid rain (6). Under high humid condition, burnt off combustible vapour may in turn form acid rain [33],[34] and thus degrading the aerial as well as aquatic environmental quality in the adjoining areas. More acidic water and corrosion rate of steel roof was recorded at close to the flare in some gas flaring sites of Nigeria (6). Thermal effect of gas flaring cannot be ignored with variation in temperature with respect to distance from flare in different seasons. Carbon dioxide released from flares makes environment warmer by absorbing infrared part of the solar radiation. Elevated temperature has harmful effect on human health, vegetation cover and soil quality via physical, biological and chemical process [14].In some studies conducted in the adjoining areas of gas flaring sites was reported microclimatic variation as well as disruption of physio-chemical properties of air, soil and water in the entire gas flaring sites in Niger Delta [13], [35], [36]&[14]. Many researchers revealed flaring of natural gas as a major cause of low agricultural productivity as well as alter socio economical pattern of local community in some gas flaring areas of Niger Delta[37],[38],[39]. In this context, reduction in productivity of some crops in the adjoining areas of flaring sites was reported by a numbers of scientific studies [40], [41].

Among organisms, insect attains more attention due to their natural interaction with diverse groups of plant communities as well as they are also sensitive to current escalation of ecosystem. Insect are easy to handle, have ecological faithfulness and possess fragility to small changes of atmosphere and thus make them more suitable as bio indicator of environment [42]. In this respect, butterflies [43],[44] and honey bee were applied as an ecosystem, biodiversity and pollution indicator during past years [45]. A number of authors have investigated the effects of plant quality upon herbivorous insects too [46]. In this regard, elemental stoichiometry adds new dimension to nutritional ecology of this sensitive organism [47]. Nutritional ecology primarily addresses feeding performance of insects e.g. food consumption, utilization and thus play crucial role in managing insects biology. Nitrogen is strategic for insect growth and development and plays crucial role in nutritional biology [48]. In spite of enormous variation in plant, insects maintain their requirements by means of flexible feeding behaviour as well as nutrient utilization [49]. However, by higher digestive efficiency phytophagous insects performs some compensatory responses to maintain their growth under limited nitrogen level in hosts. Elevated carbon dioxide has both direct as well as indirect influences upon invertebrates [50]. In such condition sometimes higher carbon and nitrogen ratios of host plant may stimulate greater feeding performance under. Prominent effects of climate change including stomata closure, higher leaf surface temperatures etc. finally has impact over insect herbivore performance [51]. Limited experimental evidence

exists on direct effects of CO_2 upon insect [52], while temperature plays crucial role [53],[54],[55], [56].

Elevation of carbon dioxide likely to effect on insect populations directly and indirectly through changing plant chemistry. Simultaneous effect of elevated CO_2 and increased temperature has been accelerated the growth and development rate in insect [57], [58] however interactive effect behind this phenomena is still unknown. Higher carbon accumulation enhanced total dry weight of the plant likely to impact on insect growth [59], [60]. Previous study revealed higher photosynthetic rate of plant growing under the elevated CO_2 condition which drive faster growth as well as accumulate more biomass at maturity of the plant[61],[62], [63]. Similar trend of results also observed in someC_3 plants under elevated CO_2 condition [64]. However, a few contradictory results were recorded in terms of increasing number of flowers and buds [65], whereas others reported decreasing trend of flowers and buds when exposed to elevated CO_2 level [64]. Dynamics changes of carbon and nitrogen ratio may be the outcome of elevated CO_2 and temperature interactive effect [66]. Nitrogen is the key element of growth and development of insect and limitation of nitrogen may alter growth and development of plant under elevated CO_2 condition [67], [68], [69]. Dilution effect of nitrogen under such condition may reduce nitrogen contents in plant according to the demand as well as uptake [70]. Changes in plant carbon, nitrogen as well as levels of defensive compounds including phenolics have [71] considerable impact on insect biology. Elevated level of greenhouse gases may upsurge the reproductive capabilities and altered distribution range of some insects; thus it could change the abundance of some pest species as well as a number of vectors of disease [71].

Elevated CO_2 accompanied by higher temperature accelerate photosynthesis process consequently promote faster and better development of plant [57], [58], [72] however their interactive effect is still a mysterious fact. Effect of elevated carbon dioxide is associated with temperature as well as weather pattern and has major influences upon plant biology [73] and several thousand scientific articles have been generated in this regards. Quality of plant as well as feeding performance of insect herbivore under higher carbon dioxide concentration performs no definite patterns of action. Existing literature based on plant insect performance under such condition outlined variable effects in terms of species specific responses. Reduction of nitrogen content in plant will limit growth, survival and food nutritional rate in insects under such condition. First study based on gas flaring was documented reduced chlorophyll content in *Eupatorium odoratum* living towards the flare point [74]. In Niger Delta, flaring of natural gas was supposed to be the prime cause behind poor agriculture

production [75]. In this respect, degradation of plant proteins and carbohydrates observed more on the crops that grown close to the flare. However, thermal fluctuation at gas flaring areas may also responsible for deteriorating microbes from organic matter decomposition and nitrogen formation [76]. Apart from this, properties of soil as well as nutrient cycles were found to be affected [77]. Perhaps, gas flaring influence on degradation of air, soil and water quality [78],[79] in the adjoining areas of gas flaring sites and thus reduced the productivity and yield of some farm crops. Harmful effects of gas flaring was documented over 10 hectares vegetation areas in Niger Delta [6], [80],[81]. Acid rain is a dangerous outcome of gas flaring produced within the flaring area [82],[83],[84]. However, no reasonable studies have been done so far to authenticate the impact of gas flaring upon physical, chemical, biological, atmospheric, soil and social environment [85].

Response of plant and insect under elevated carbon dioxide condition:

In ecosystem functioning, diversity of plant as well as insect play significant role. However, changes in atmospheric composition due to various anthropogenic activities may lead to influence in the interaction of both the organisms. Among the atmospheric composition, drastic changes in carbon dioxide concentration supposed to lead global warming with severe effects upon plant and insect diversity. Terrestrial arthropods are mostly dominant in trophic level. Therefore, impact upon them may lead to hamper overall trophic level interaction as well as ecosystem structure. It can be assumed that poor nutritional qualities of plant may lead to increases rate of mortality of many herbivores in upcoming century [86]. In plant, elevated carbon dioxide is responsible for altering plant physiological process thus indirectly leads to poor nutrition and development of insect. Among insect, butterflies have strong habitat specificity. However, fluctuation in atmospheric composition may reduce their habitat as well as mobility and restrict them in some specific geographic locations [87]. Combined effects of climate change at lower tropic level and stresses of abiotic factors makes higher tropic level species more sensitive to such condition [88]. However, narcoleptic and behavioural changes of insect unlikely to affect because of elevated carbon dioxide [89]. Specificity of resources, geographical distribution and dispersal capability are the potential life history traits to study the response of insect under climate change [90]. In this regard, being a radioactively active greenhouse gas as well as their drastic fluctuation trend, carbon dioxide was supposed to go along with the large swings in global climate over the Phanerozoic [91]. Thus against this effect of atmospheric fluctuation of carbon dioxide concentration, evolution of land plant community is likely to be

interlinked. Fluctuations in atmospheric CO_2 have direct impact over physiological processes of plant. Stomatal closer was found to be more active under elevated carbon dioxide (92) which caused reduction in transpiration of plant. A number of studies [93],[94] reported 45% reduction in stomatal conductance as result of decrease density of stomata as well as stomatal aperture under carbon dioxide elevation. In this context, [95] also reported decreased stomatal conductance under same condition. Rate of photosynthetic in elevated carbon dioxide is well documented in literatures. Direct effect of elevated carbon dioxide upon rate of photosynthesis in C_3 plant has already been established in a numbers of studies [96]. It was observed that photochemical efficiency was reduced [97] and thus further leading to increase exposure of photo inhibition under elevated carbon dioxide condition [98]. Stomatal conductance is another impact; however, their magnitude is supposed to vary between species to species. In general, elevated carbon dioxide leads to increase photosynthetic carbon (C) in leaves for which leaf area, canopy transpiration, contradicting water gains as well as demand for plant nutrient increase. Development of stomata is associated with atmospheric carbon dioxide level. Woodward [99] stated that sensitivity of stomata in some fossil plant in the background of elevated carbon dioxide. Suppression of respiration is assumed to interrelate the reduction of nitrogen content in plant tissue. Apart from this, direct effect of carbon dioxide upon plant respiration was reported, but their response is still under debate. However, in this context a numbers of studies reported reduced respiration rate in plant under in elevated CO_2 [100], [101].

Carbon dioxide elevation has crucial role over physiology, distribution and overall all dynamics of plant community. However, interactions between diversity of plant, level of carbon dioxide and carbon cycling are very difficult process to predict. In this regard, elevation of carbon dioxide supposed to be play important role in plant diversity via a number of indirect pathways. Structural alteration of plant community under enriched CO_2 condition get more emphasise in this context. Long term effect of carbon dioxide can be assumed as the reduction in whole plant respiration [102] as well as crucial for photosynthesis capacity. Current global change supposed to reduce overall productivity of ecosystem as result of species loss. With N_2-fixing capacity legumes can exchange carbon (C) for nitrogen (N) and thus advantageous over non-leguminous species under enriched carbon dioxide condition [103], [104], [105]. In this regard, legumes are supposed to be more sensitive under enriched carbon dioxide condition in a controlled environment [106].

CONCLUSION:

Carbon dioxide emits mostly at gas flaring sites. Being a greenhouse gases it involves in determining the earth's average temperature within the atmosphere as well as contribution in global warming. Myriad effects of elevated CO_2 upon insects comes via alteration of plant chemistry i.e. accumulation of more carbon, dilution of nitrogen, increases in levels of defensive compounds such as phenolics etc. Under such warming environmental condition reproductive capabilities of some insectsmay enhance as well as change their distributional ranges. Further, these effects may lead to abundance of some pest and disease vectors. Thus for a profound understanding of gas flaring effect on biological system originated from these operation of oil companies, it will helpful to focus the environmental status and accountable for maintaining ecological economics in future context.

REFERENCE:

1. Beddington, J. (2010), Trans. R. Soc. B365, P. 61-71.
2. Hillebrand, H. Matthiessen, B. (2009), Ecol. Lett. 12, P. 1405-1419.
3. Urban, O.Klem, K. Holisova, P. Sigut, L. Sprtova, M. Navratilova, P.T. Zitova, M.Spunda, V. Marek, M.V. Grac, J. (2014), Environ. Pollut. 185,P. 271-28.
4. Boden, T.A. et al. (2012), CO_2 Information Analysis Centre.
5. Beychok, M.R. (2005), Milton R Beychok, 4th edition. ISBN-13: 978-0964458802.
6. Efe, S.I. (2010), Nat. Haz. 55 (2), P. 307-319.
7. Ikelegbe, A.O. (1993), Minna, Nigeria, P. 17-18.
8. Oyekan, A. (2000), Gas Exploration and Production operation.
9. Nduka, J. Orisakwe, O. Ezenweke L. Ezenwa, T. (2008), The Sci. World J. 8, P. 811-818.
10. Dung, E. Bombom, L. Agusomu, T. (2008), Geojournal. 73 (4), P. 297-305.
11. Ekpoh, I. Obia, A. (2010), The Environmentalist. 30 (4), P. 347-352.
12. Gobo, A. Richard, G. Ubong, I. (2009), J. App. Sci. Environ. Manage. 13 (3), P. 27-33.
13. Julius, O.O. (2011), Arch. App. Sci. Res. 3 (6), P. 272-279.
14. Anomhanran, O. (2012), Energy Policy. 45, P. 666-670.
15. Ismail, O.S. Umukoro, G.E. (2012), Energy Power Eng. 4(4), P. 290-302.
16. Anejionu, O. Whyatt, J. Blackburn, G. Price, C. (2015), Atmos. Environ. 118, P.184-193.
17. Sharma, K.K. Hazarika, S. Kalita, B. Sharma, B. (2011), J. Environ. Sci. Eng. 53, P. 289-298.
18. Bhattacharyya, P.R. (1994), Ph.D thesis, Gauhati University, Assam, India.
19. Harrington, R. Woiwood, I. Sparks, T. (1999), Trends. Ecol. Evolut. 14, P. 146-150.
20. Traw, M.B. Lindroth, R.L. Bazzaz, F.A. (1996), Oecologia. 108, P. 113-120.
21. Hughes, L. and Bazzaz, F.A. (1997), Oecologia. 109, P. 286-290.

22. Stiling, P. Rossi, A.M. Hungate, B. Dijkstra, P. Hinkle, C.R. Knott, W.M. Drake, B. (1999), Ecol. App. 9(1), P. 240-244.
23. Stiling, P. (2003), Academic Press, Elsevier Science, USA. P. 486-489.
24. Coviella, C.E. Stipanovic, R.D. Trumble, J.T. (2002), J. Exp. Bot. 53, P. 323-331.
25. Niziolek, O.K. Berenbaum, M.R. DeLucia, E.H. (2013), Insect Sci. 20, P. 513-523.
26. Andersen, R.D. Assembayev, D.V. Bilalov, R. Duissenov, D. Shutemov, D. (2012), Norwegian University of Science and Technology, Trondheim.
27. Atevure, B.S.V. (2004), J. Environ Analys. 2, P. 76-85.
28. Uppal, J. and Raje, N. (2007), Carbon Emissions Reduction in Assam. New Delhi.
29. Leahey, D.M. Preston, K. Strosher, M. (2001) J. Air Waste Manage Assoc. 51(12), P. 1610-1616.
30. Strosher, M.T. (2000), J. Air Waste Manage Assoc. 50 (10), P. 1723-1733.
31. Kostiuk, L.W. Johnson, M.R. Thomas, G. (2004), University of Alberta.
32. Osuji, L.C. Avwirib G.O. (2005), Chem Biodivers. 2, P. 1277-1289.
33. Nwankwo, C.N. and Ogagarue, D.O. (2011), J. Geol Min Res. 3 (5), P. 131-136.
34. Hassan, A. Kouhy, R. (2013), Accounting Forum.37, P.124-134.
35. Oseji, J.O. (2007), Environmentalist. 27 (2), P.ba 311-314.
36. Odjugo, P.A.O. and Osemwenkhae, E.J. (2009). Int. J. Agri Biol. 11 (4), P. 408-412.
37. Odjugo, P.A.O. (2007), Nigerian Geograph J. 5, P. 43-54.
38. Aregbeyen, B.O. Adeoye, B.W. (2001), African J. Environ Stud. 2, P. 8-14.
39. Daudu, O.D. (2001), Imo State University, Owerri, Nigeria.
40. Udoinyang, G.U. (2005), J. Ecosyst. 10, P. 77-86.
41. Akpabio, Z.K.A. (2006), Environ Perspect. 10, P. 1-11.
42. Rocha, J.R.M. Almeida, J.R. Lins, G.A. Durval, A. (2011), Holos Environ. 10(2), P. 250-262.
43. Beccaloni, G.W. Gaston, K.J. (1995), Bio Conserv. 71, P. 77-86.
44. New, T.R. Pyle, R.M. Thomas, J.A. Hammond, P.C. (1995), Annu. Rev. Entomol. 40, P. 57-83.
45. Celli, G. Maccagnani, B. (2003), Bull Insect. 56, P. 137.
46. Awmack, C.S., Leather, S.R. (2002), Annu. Rev. Entomol. 47, P. 817-844.
47. Sterner, R.W. and Elser, J.J. (2002), Princeton Univ. Press.
48. Mattson, W. (1980). Annu. Rev. Ecol. Syst. 11, P.119-161.
49. Slansky, F.J. (1993), Chapman and Hall, New York, P. 29-91.
50. Chown, S.L. Addo-Bediako, A. Gaston, K.J. (2002), Comp Biochem Physiol. B.131, P. 587-602.
51. Porter, J. (1995), Academic Press, San Diego, London, P. 93-123.
52. Argel, P.J. Humphreys, L.R. (1983), Aus. J. Agric. Res. 34, P. 261-270.

53. Bale, J.S. Masters, G.J. Hodkinson, I.D. Awmack, C. Bezemer, T.M. Brown, V.K. and Butterfield, J. et. al. (2002), Global Change Biol. 8, P. 1-16
54. Convey, P. Block, W. (1996) Eur. J. Entomol. 93, P. 113.
55. Hodkinson, I.D. Bird, J. Miles, J.E. Bale, J.S. Lennon, J.J. (1999), Funct. Ecol. 13(1), P. 83-95.
56. Karolewski, P. Grzebyta, J. Oleksyn, J. Giertych, M.J. (2007), Pol. J. Ecol. 55 (3), P. 595-600.
57. Bazzaz, F.A. (1990) Annu. Rev. Ecol. System. 21,P.167-196.
58. Sage, R.F. Santrucek, J. Grise, D.J. (1995), Vegetatio. 121, P. 67-77.
59. Poorter, H. and Navas, M.L. (2003), New Phytol. 157, P. 175-198.
60. Zhou, Z. Shangguan, Z. (2009), Agri. Sci. China. 8, P. 424-430.
61. Coll, M. Hughes, L. (2008), Agric. Ecosyst. Environ. 123, P. 271-279.
62. Hughes, L. and Bazzaz, F.A. (1997), Oecologia. 109, P. 286-290.
63. Owensby, C.E. Auen, L.M. Knapp A.K. and Ham, J.M. (1999), Global Change Biol. 5, P. 497-506.
64. Reekie, E.G. and Bazzaz, F.A. (1991), Can. J. bot. 69, P. 2475-2481.
65. Reekie, J.Y.C. Hicklenton P.R. and Reekie E.G. (1997), Ann Bot. 80, P. 57-64.
66. Himanen, SJ, Nissinen, A. Dong, W.X. Nerg, A.M. Stewart, C.N. Poppy G.M. Holopainen J.K. (2008), Global Change Biol. 14, P. 1437-1454.
67. Cotrufo, M.F. Ineson, P. Scott, A. (1998), Global Change Biol. 4, P. 43-54.
68. Curtis, P.S. Wang, X.Z. (1998), Oecologia. 113, P. 299-313.
69. Goverde M. Erhardt, A. (2003), Global Change Biol. 9, P. 74-83.
70. Taub, DR. Wang, X. (2008), J. Integer Plant Biol. 50 (11), P. 1365-1374.
71. Stiling, P. et al. (2003), Oecologia. 134, P. 82-87.
72. Li, J. Zhou, J.M. Duan, Z.Q. Du, C.W. Wang, H.Y. (2007), Pedosphere. 17, P. 343-351.
73. IPCC (2014), Cambridge University Press, P.1-32.
74. Isichei, A.O. Sanford, W.W. (1976), J. App Ecol. 13 (1), P.177-187.
75. Lawanson, A.O. Imevbore, A.M. Fanimokun, V.O. (2006), Niger Delta Regions of Nigeria. P. 239-245.
76. Benka-Coker, M.O. Ekundayo, J.A. (1997), Environ Monit Assess. 45(3), P. 259-272.
77. Akpojiri, R.E. Akumagba, P.E. (2005), Effurum, Nigeria.
78. Abube, M. (1988), J Environ Stud. 9(3), P. 102-111.
79. Ekanem, I.N. (2001), Lagos State University, P. 153.
80. Odilison, K. (1999), Ecol. Environ. 5(3), P. 204-215.
81. Abara, D. (2009), J. Environ Chem. 2(1), P. 28-34.
82. Adesanya, A.O. (1984), M.Sc. Thesis, University of Ibadan, Nigeria.
83. Efe, S.I. (2002), Afr. J. Environ Stud. 3, P. 160-168.
84. Efe, S.I. (2003), Int. J. Environ. 1(1), P. 91-101.

85. Ologunorisa, T. E. (2001), Int. J. Sust. Dev. World Ecol. 8 (3), P. 249-255.
86. Coviella, C.E. Trumble, J.T. (1999), Conserv. Biol. 13, P. 700-712.
87. Warren, M. S. Hill, J.K. Thomas, J.A.et. al. (2001), Nature. P. 65-69.
88. Voigt, W. Perner, J. Davis, A.J. Eggers, T. Schumacher, J. et. al. (2003), Ecology. 84, P. 2444-2453.
89. Ziska L.H.Runion G.B. (2007), Boca Raton, FL: CRC Press, P.261-287.
90. Pelini, S.L. Dzurisin, J.D.K. Prior, K.M. Williams, C.M. Marsico, T. D. Sinclair, B. J. et. al. (2009), Proc. Natl. Acad. Sci. USA 106, P. 11160-11165.
91. Crowley, T.J. and Berner, R.A. (2001), Flora. 109, P.100-143.
92. Clifford, S.C. Black, C.R. Roberts, J.A. Stronach, I.M. Singletonjones, P.R. Mohamed, A.D. Azamali, S.N. (1995), J. Exp. Bot. 46, P. 847-852.
93. Beerling, D.J. McElwain, J.C. Osborne, C.P. (1998), J. Exp. Bot. 49, P. 1603-1607.
94. Knapp, A.K. Hamerlynck, E.P. Ham, J.M. Owensby, C.E. (1996), Vegetatio 125, P. 31-41.
95. Hall, D.O. Rao, K.K. (1999), Plant Cell Environ. 14, P.729-40.
96. Roden, J.S. and Ball, M.C. (1996), Plant Physiol. 111, P. 909-19.
97. Woodward, F.I. (1987), Nature. 327, P. 617-618.
98. Drake, B.G. Gonzalez-Meler, M.A. Long, S.P. (1997), Annu Rev Plant Physiol Plant MolBiol 48, 609-639.
99. Curtis, P.S. and Wang X.Z. (1998), Oecologia 113, P. 299-313.
100. Soussana, J.F. Hartwig, U.A. (1996), Plant Soil. 187, P. 321-332.
101. Farrar J.F. Williams M.L. (1991), Plant Cell Environ. 14,P. 819-830.
102. Zanetti, S. Hartwig, U.A. Luscher, A. Hebeisen, T. Frehner, M. Fischer, B.U. Hendrey, G.R. Blum, H. Nosberger, J. (1996), Plant Physiol. 112, P. 575-583.
103. Rogers, A. Gibon, Y. Stitt, M. Morgan, P.B. Bernacchi, C.J. Ort, DR. Long, S.P. (2006), Plant Cell Environ. 29, P. 1651-1658.
104. Ainsworth, E.A. Long, S.P. (2005), New Phytol. 165, P. 351-371.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 8

SACRED FORESTS AN ANCESTRAL BELIEFS AND CONSERVATION: SPECIAL REFERENCE OF PITHORAGARH DISTRICT, KUMAUN HIMALAYA, UTTARAKHAND

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ABSTRACT:

Sacred natural sites are part of a broader set of cultural values that different social groups, traditions, beliefs or value systems attach to places and which 'fulfil humankind's need to understand, and connect in meaningful ways, to the environment of its origin and to nature'. The term 'sacred natural sites' implies that these areas are in some way holy, venerated or consecrated and so connected with religion or belief systems. Various anthropogenic pressures due to developmental activities, urbanization, exploitation of resources and increase in human population have threatened many sacred forests of the country. The study was conducted in Pithoragarh district of Uttarakhand, India. Eight sacred forests were observed during present study. During survey 28 villages were studies and 18 local communities were recorded around sacred forests. Importance of the sacred forests in maintaining the biological diversity and meeting the basic livelihood needs of the village community has continued and will be maintained for the future generations.

KEYWORDS: Sacred Forests, Belief, Biodiversity conservation, Uttarakhand

INTRODUCTION:

Those places where nature and humanity meet, and people's deeper motives and aspirations are expressed through what is called 'the sacred'. 'Sacred' has different meanings to different communities. At the basic level it denotes deep respect and 'set aside' for

purposes of the spiritual or religious. Sacred natural sites are part of a broader set of cultural values that different social groups, traditions, beliefs or value systems attach to places and which 'fulfil humankind's need to understand, and connect in meaningful ways, to the environment of its origin and to nature' [1].The term 'sacred natural sites' implies that these areas are in some way holy, venerated or consecrated and so connected with religion or belief systems, or set aside for a spiritual purpose. The growing recognition of the political status of indigenous peoples provided in 2007 by the United Declaration on the Rights of Indigenous Peoples [2] has significantly increased awareness of the deeper dimensions of oppression and also of resilience. The first scholar to document sacred forests of the State was D. Brandis, the first Inspector General of Forests, who wrote about occurrence of sacred forests in 1897 [3]. The first authentic report on the sacred forests is the Census report of Travancore of 1891 in which Ward and Conner (1927) reported 15,000 sacred forests in Travancore. Historical records, legends and the folk songs, particularly certain devotional songs like "Thottampattu" sung in praise of Lord Ayyappan throw light on sacred forests of ancient Kerala. "Thottampattu" (believed to have been composed during 500-600 AD) names 108 major "Ayyappan Kavus" and mention about numerous "Ayyappan Kavus" distributed all over Kerala. According to surveys, most people believe that we have an obligation to avoid the extinction of species and races and the destruction of ecosystems caused by our own actions (WWF, 2005). A symbiotic relationship exists between biological and cultural diversity. This relationship is an important factor for ensuring sustainable human development. Nature provides light, air, food, and water through living process of creative renewal. This awareness of life in nature as a precondition for human survival led to the worship of light, air, food, and water. Centuries of religious colonialism in various degrees extirpated traditional spiritual beliefs and practices. At a landscape level, anthropologists have long recognized the sacred status that cultures have given to nature not only in specific sacred sites[4] but also in larger areas of cultural significance and entire landscapes. After the 2003 Congress, IUCN's Specialist Group on the Cultural and Spiritual Values of Protected Areas (CSVPA) that had formed in 1998 continued the work on guidelines for the management of sacred natural sites [5]. CSVPA has since advanced a significant amount of work on sacred natural sites and species including this volume[6]. The urge for the protection of sacred natural sites have also been recognized by the Convention on Biological Diversity (CBD) and the UN Permanent Forum on Indigenous Issues. The CBD in 2004 developed the Akwe Kon voluntary guidelines for the conduct of cultural, environmental and social impact assessments regarding proposed developments that may affect sacred sites and on lands and waters traditionally

occupied or used by indigenous and local communities (Secretariat of the Convention on Biological Diversity, 2004). At the political level, as described before, the adoption of the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) is an important benchmark. Article 12 in particular provides significant political leverage for developing appropriate policies for the protection and recognition of sacred natural sites at the national level. It states:

Traditional African religions often viewed land and its resources as communal property that belonged not only to the living but to their ancestors and to future generations [7]. In many cases, the relationship between people and the land was a matter of spiritual concern, and such religions have been called "profoundly ecological" [8]. Traditional conservation practices in the form of nature worship have played an important role in protection and conservation of biodiversity in India [9].

They may also represent important traditions that are being lost as new generations do not continue oral histories and cultural practices. In addition, sacred forests conserve habitats that are not represented within the current PA system, Bhagwat & Rutte 2006) and may serve as refugia for endemic species [9]([10].These are reported to be relict forests and may be the only remaining climax vegetation of an area. Sacred sites, areas and geographies are nearly universal phenomena [11]. Throughout the world, cultures recognize sites endowed with religious, historical, geophenomenal and cultural significance [12]. Sacred sites have variously been attributed as having resident deities and spirits, storing rare and extraordinary flora and fauna [12]; [14], inducing exceptionally vivid or lucid dreams [15] [16] and heightening meditative states [17]. Many of these sites occur within natural settings, and the interrelatedness of sanctity and the environment is a frequent theme.

Global scenario:

Sacred forests are a very ancient and widespread phenomenon in the old world cultures. References about sacred forests have been made in Greek and Sanskrit classics. Sacred forests also feature prominently in many Asian and African mythologies and cultures, most notably in India, Japan, West Africa, and Anatolia. In Syria, some sacred forests are believed to have been made during Assyrian times. The most famous sacred forest in mainland Greece was the oak forest at Dodona. The forest was designated as an UNESCO World Heritage Site in 2005. The Seifa-Utaki consisting of a triangular cavern formed by gigantic rocks was designated as a UNESCO World Heritage Site in 2003, contains a sacred forest with rare, indigenous trees like the Kubanoki (a kind of palm) and the Yabunikkei (the

wild cinnamon, Cinnamomum japonicum). Direct access to the forest is forbidden. Globally, sacred forests often have associated myths and taboos on the use of specific plants and hunting of certain species of animals within the area. These traditions can serve a conservation role because some of the sacred forest fragments represent the sole remaining forests and the last remaining locations with potential for conservation of flora and fauna. For example, church forests in Ethiopia protect some of the last remaining fragments of tropical afromontane forests [18].

Indian Scenario:

In India, as in other countries of the world, many communities practice different forms of worship of nature. One such significant tradition of nature worship was that of providing protection to patches of forests designated as sacred forests dedicated to deities or ancestral spirits. Sacred forests were dedicated by local communities to their ancestral spirits or deities. The concept of sacred forests in India has its roots in antiquity, even before the Vedic age, the Vedas representing the only recorded remains of the thoughts of the ancient Aryans who migrated into this sub-continent. Sacred forests have preserved many rare and endemic wild plant species, many of which hold potential benefit to man in medicine, agriculture and industry. In fact, sacred forests represent the ancient Indian way of in situ conservation of genetic diversity. In India, the sacred forests were reported earlier from the Himalayas, North-east India, highlands of Bihar, Orissa, Madhya Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu and Kerala. Earlier workers have studied floristic and ethnobotanical aspects of sacred forests and provided detailed scientific account of the sacred forests in India [19] [20] [21] [22].

In India, biodiversity outside protected areas is rich because of close relationships between religious, socio-cultural beliefs and conservation. Rapid decline in biological diversity – species, ecosystems, and genetic diversity is one of the critical challenges of the 21st century. Indian culture evolved in the forest, first during the Vedic period and later during the times of Buddhaand Mahavir. Religion aids the conservation of natural biodiversity in several different ways. The first is by providing ethical and social models for living respectfully with nature. For most cultures, religion is a primary means of judging right and wrong. These ethical beliefs and religious values influence our behaviour toward others, including our relationship with all creatures and plant life. Forests in India remain central to its civilizational evolution. In India, 'Aranya Sanskriti' or a forest culture evolved during the ancient times as education was primarily given in the forest called "ashramas". These were

the places where most of the scientific research and cultural writings were done. In the Rig Veda, forests are described as Aranyani or mother goddess, who ensures the availability of food to human kind and takes care of wild life. Some researchers believe that there may be as many sacred sites as protected areas (WWF, 2005). However, many of them are threatened due to fragmentation, habitat degradation, infrastructure development, disputes over land, and a general lack of respect for their intangible value [23] The combined effects of such activities have led to the degradation of areas that have been held sacred by particular cultures for hundreds or even thousands of years. The practice of biodiversity conservation is deeply rooted in science along with the associated secular and materialistic world view.

The finest sacred forests of India presumably occur in the Sarguja district of Madhya Pradesh. Here every village in the area has a forest about 20 hectares in extent. What is remarkable is that not only plant, but also animal life receives absolute protection in these forests. The forests therefore serve as sanctuaries for herds of ungulates as well. These forests are locally known as "Sarana" forests, a word that probably derives from the Sanskrit "Sharana" or sanctuary. These community-protected India has a well established ancient tradition, more in the highlands, of protection of patches of forests as sacred. Though these forests are devoted to gods with many taboos associated with tree felling in such areas, the intimate association of such sacred forests or sacred forests with water bodies, in the form of streams, rivers, ponds and lakes, swamps or springs, is a well acknowledged fact. Based on studies in the Himalayan states of Himachal Pradesh and Meghalaya, Khiewtam & Ramakrishnan (1993) and Singh et al. (1998) reported the role of forests in reducing run-off and soil erosion, preventing landslides and in conferring ecosystem stability [24] [25]. Vertical stratification in the untrammelled humid tropical forests along with the extensive root network covered with leaf litter are linked to increased soil percolation, recharge of ground water [44]. Sacred forests on the southeast coast of India are the only remnants of dry evergreen forest habitat [26]. One region in India, the Western Ghats not only has a very high number of sacred forests [27], it is also recognized globally as a 'biodiversity hotspot,' meaning that it simultaneously has a high concentration of unique species and is under extreme resource use pressure (The first authentic report on the sacred forests appeared in the Census report of Travancore in which. Lt. Ward and Lt. Conner reported the presence of 15,000 sacred forests in Travancore [28].

These forests sanctify the vegetation of the area already existing there, or planted at the time of creation of the forest [20] [29] had stated that holy forests of India are so important to Indian life and this institute is very ancient, before humans had settled down and

raised livestock and arable land. Sanctity of a place as sacred forest is older than awareness of man for ecosystem. When the burning problem of biodiversity conservation is discussed about, sacred forest which is an indigenous mean of conservation should not be kept untouched [30]. It has been emphasized as the role of a culture and religion towards environment. It is a folk conservationist strategy which should be revived as social forestry programme by the Government [19] [31] have studied cultural and ecological dimensions of sacred forests, but the SGs of Uttarakhand are mentioned in brief and are to be studied carefully, as not only tribal but the common man is also in kin with the deity and SG. Some of the documented SGs in Uttarakhand are Bughyals, Hariyali, Debvans etc. [32] and some of the preliminary study were also conducted [33]. The traditional worship practices show the symbiotic relation of human beings and nature. Gadgil and Vartak (1975) have traced the historical link of the sacred forests to the pre- agricultural, hunting and gathering stage of societies [19]. The area of sacred forests ranges from few square meters to several hectares. Sacred forests provide the inextricable link between present society to the past in terms of biodiversity, culture, religious and ethnic heritage.

Various traditional communities of our country follow nature worship in their own ethnic ways, based on the premise that all creations of nature have to be protected. The concept of sacred forests could be traced to such communities as have preserved several virgin forests in their pristine form by dedicating them to the ancestral spirits or deities. Gadgil and Berkes (1991) have mentioned that various traditional approaches to conservation of nature require a belief system which includes a number of prescriptions and proscriptions for restrained resource use [34]. Dafni (2006) elaborated the typology and worship status of sacred trees in the Middle East and mentioned about 24 known reasons for the establishment of sacred forests [35]. All forms of vegetation in the forests are supposed to be under the protection of reigning deity of that forest, and the removal of even a small twig is a taboo [36]. Sacred forests can be used as indicators for potential natural vegetation [37] and are vital for well being of the society. Karanth (1998) opined about the alternative concept of ‘sustainable landscapes’ in combination with the ideas of the emerging discipline of ecological economics and may provide useful tools for protecting the sacred forests in which our wildlife has to survive into the 21st century [38].

Besides, the sacred forests provide a number of ecosystem services such as reduction in erosive force of water, conservation of soil, maintenance of hydrological cycle, availability of water of desired quality and natural dispersal of seeds of useful species. Existence of Sacred Forests across the Globe in India as well as in parts of Asia and Africa, care and

respect for nature has been influenced by religious beliefs and indigenous practices. The existence of sacred forests has been reported in many parts of Asia, Africa, Europe, Australia and America by Hughes and Chandra (1998). Forests are also reported from Ghana, Nigeria, Syria, Turkey and Japan [20]. A document of MAB (1995) has described the sacred forests present in Ghana, Senegal, and Sumatra. Several small size sacred forests were reported from Nepal by Ingles (1994). In Afghanistan, after advent of Islam, the creation and conservation of sacred forest became a part of historical and geographical tradition of the rural people. Sacred forests are found all over India especially in those regions where indigenous communities inhabit. In India the earliest documented work on sacred forest is that of the first Inspector General of Forests, D. Brandis in 1897. Later, [20][21] traced the historical link of sacred forests with the pre-agricultural, hunting and gathering stage, before human being had settled down to raise livestocks or till land.

Most of the sacred forests reported from India are in the Western Ghats, North Eastern India and Central India [21] [39] Sacred forests have been reported in Meghalaya [40] [41], [42] also reported the occurrence of sacred forests in Meghalaya, Bihar, Rajasthan and the states along the Western Ghats. Their existence along the Himalaya, from northwest to northeast, was described by [43]. The forests in Karnataka have been protected in the names of 165 different deities and perhaps this state has the highest density of the forests in the world and could be regarded as the 'hotspot' of sacred forest tradition in the world [27]. These monasteries are mainly in West Kameng and Tawang districts of the state and 58 GFAs were reported from these two districts [31] and a few sacred forests from Lower Subansiri and Siang district of the state [44]. Dimasa tribes in the North Cachar hills in Haflong district of Assam call sacred forests as "Madaico". The size of Madaico is generally not more than one acre. The biodiversity of Indian Himalayas has been well known as an important source of traditional medicines since million of years and has been explored by people from across the world. In fact, the association of religion with ecosystem management is interwoven in the symbiotic network of the Himalayan communities [45].

The international organizations such as United Nations Educational, Scientific and Cultural Organization (UNESCO), Man and Biosphere (MAB) and the World Heritage Convention (WHC) clearly recognize the importance of sacred forests or sites and place them into the context of sustainable development. Therefore, the international organizations continue to play a leading role to conserve and benefit from biodiversity through protection of sacred forests and sites [46]. In India, it is estimated that there are between 100,000 and 150,000 sacred forests throughout the country [31]. These forests have higher richness and

regeneration of medicinal plants than reserve forests [47]. They also serve as rich repositories of biodiversity of endemic, endangered and rare species flora and fauna. Several studies have documented the role of sacred forests in protection and conservation of biodiversity all across India [48][49][50].

Uttarakhand Scenario:

Kumaun Himalayas form an important part of the Uttarakhand state in north India. It is one of the major centres for cultural and traditional diversity, herbal medicines and rich floristic wealth including many endemic and rare plants. The rural communities of this region are very much dependent on biological resources for their sustenance. Sacred forests in Kumaon Himalaya are rich in biodiversity and a number of such forests are present in every village or a group of few villages having own deity, often surrounded by a forest patch considered as sacred [51]. Earlier, reports on Nakuleshwar, Haat Kali, Malya Nath and Patal Bhuvenshwar,Chamunda devi, Thal kedar, Pasupatinath, Golu devta sacred Forests [52][53][54][55][56] limited their studies with conservation of biodiversity and some ethnobotanical uses. Soil characteristics of sacred forest (Chamunda devi, Thal kedar, Pasupatinath, Golu devta) were also done in Pithoragarh district of Uttarakhand[57]. It is notable that, the sacred forests harbouring rich medicinal plant growth but scanty studies have been carried out to document these resources and their importance with respect to the local people. Keeping in view the need for highlighting the role of sacred forests as repositories of medicinal plants and their applications by the local people.

ECOLOGICAL SERVICES OF SACRED FORESTS:

Biodiversity keeps the ecological processes in a balanced state, which is necessary for human survival. Therefore, the biodiversity-rich sacred forests are of immense ecological significance. They also play an important role in the conservation of flora and fauna. Besides, several rare and threatened species are found only in sacred forests, which are, perhaps, the last refuge for these vulnerable species. Several ecological studies have been carried out in these sacred forest patches. Several ecological investigations have been made in sacred forests of Meghalaya [58][59].

ETHNOBOTANICAL IMPORTANCE OF THE SACRED FORESTS:

Sacred forests are the good source of a variety of medicinal plants, fruits, fodder, fuel wood, spices, etc. The study of interrelationship between the human beings and plants and

animals in their surrounding environment (i.e. ethnobiology) is very revealing. Some interesting ethnobotanical studies were conducted [36] in the sacred forests of Maharashtra. A study of the tree wealth in the life and economy of the tribal people in Andhra Pradesh revealed that various species are used by the different ethnic groups for various purposes including the treatment of common diseases and disorders[60]. There is a need to record and document their knowledge of various medicinal plants, which are used for treating different ailments by local practitioners [61].

DEGRADATION OF THE SACRED FORESTS:

Belief and taboos are the constructive tools for conserving the sacred forests, and erosion of belief and taboos has led to deterioration of forests [21]. It has been seen that religious beliefs and taboos that were central to the protection of sacred forests are being eroded over the years due to various reasons and thus the present status of sacred forests is rather precarious. Various anthropogenic pressures due to developmental activities, urbanization, exploitation of resources and increase in human population have threatened many sacred forests of the country. A study on the status of some sacred forests in the Himalayan region indicated that the economic forces are influencing the traditional communities to discard the community-oriented protection to these forests and they are now being exploited [62][25]. Totey and Verma (1996) argued that the rural poor depend upon biological resources for meeting 90% of their day-to-day needs [63]. So, until and unless viable option is provided to these people for sustaining their economic condition, any step for the conservation of the sacred forests will not be successful.

Following significant points emerge from the foregoing review:

- It is very important to uphold traditions and beliefs in order to protect and conserve these unique forest patches which represent the relict vegetation of the concerned area.
- These forest patches are no longer free from anthropogenic pressure. The disappearance and/or degradation of sacred forests not only symbolize the loss of the rich relict flora and fauna but also its rich tapestry of culture associated with the forest [27].
- Management of sacred forests and sacred sites through the traditional local system is now being challenged by a number of economic and social issues, and thus the traditional methods are rendered less effective. This calls for external intervention taking the local people into confidence.
- Important sacred forests should be brought under the 'Protected area Network' to ensure their proper conservation.

- Ecological services rendered by sacred forests needs to be highlighted and people should be made to realize that the conservation of forests is crucial for their sustenance.

These forests have traditionally been conserved in the past, however, in the recent times, the scenario has changed due to decline in traditional value systems. With improved accessibility and urbanization, sacred areas have turned into tourist places to serve economic interest [62]. Sacred forest in hills of Garhwal and Kumaon (Uttarakhand) are mentioned in old Hindu scriptures like the Puranas. Believing trees to be abode of gods and ancestral spirits, patches of forests near villages are established, where deity/deities are worshipped. There are some well known sacred forests which truly represent the wealth of a religion based conservation traditions as reported by [64] [65].Even though the biological diversity of Himalaya is very rich, there is little information available on the sacred forests and the conservation of biodiversity in Garhwal Himalaya [32]. It is very difficult to report the exact number of sacred forests in Uttarakhand, however, efforts made by some authors like 32 sacred forests by [32] are appreciable. The exclusion of local people is believed to be one of the reasons why protected areas are ineffective, despite the large sums of money and manpower invested in them [66].

The Convention on Biological Diversity, adopted at the 1992 Earth Summit in Rio de Janeiro, acknowledged the need to protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements (Article 10). A number of international gatherings have since been held in relation to this issue, such as the 1998 UNESCO symposium on "Sacred sites, Cultural Diversity and Biological Diversity". They reflect a growing realization of the importance of sacred sites as a component of protected area networks.

MATERIAL AND METHODS:

Site:

The study was conducted in Pithoragarh district of Uttarakhand state, India. Survey was done during year 2015-16. In order to achieve authentic information, an extensive dialogue with the inhabitants of Villages around sacred forests conducted.

RESULTS:

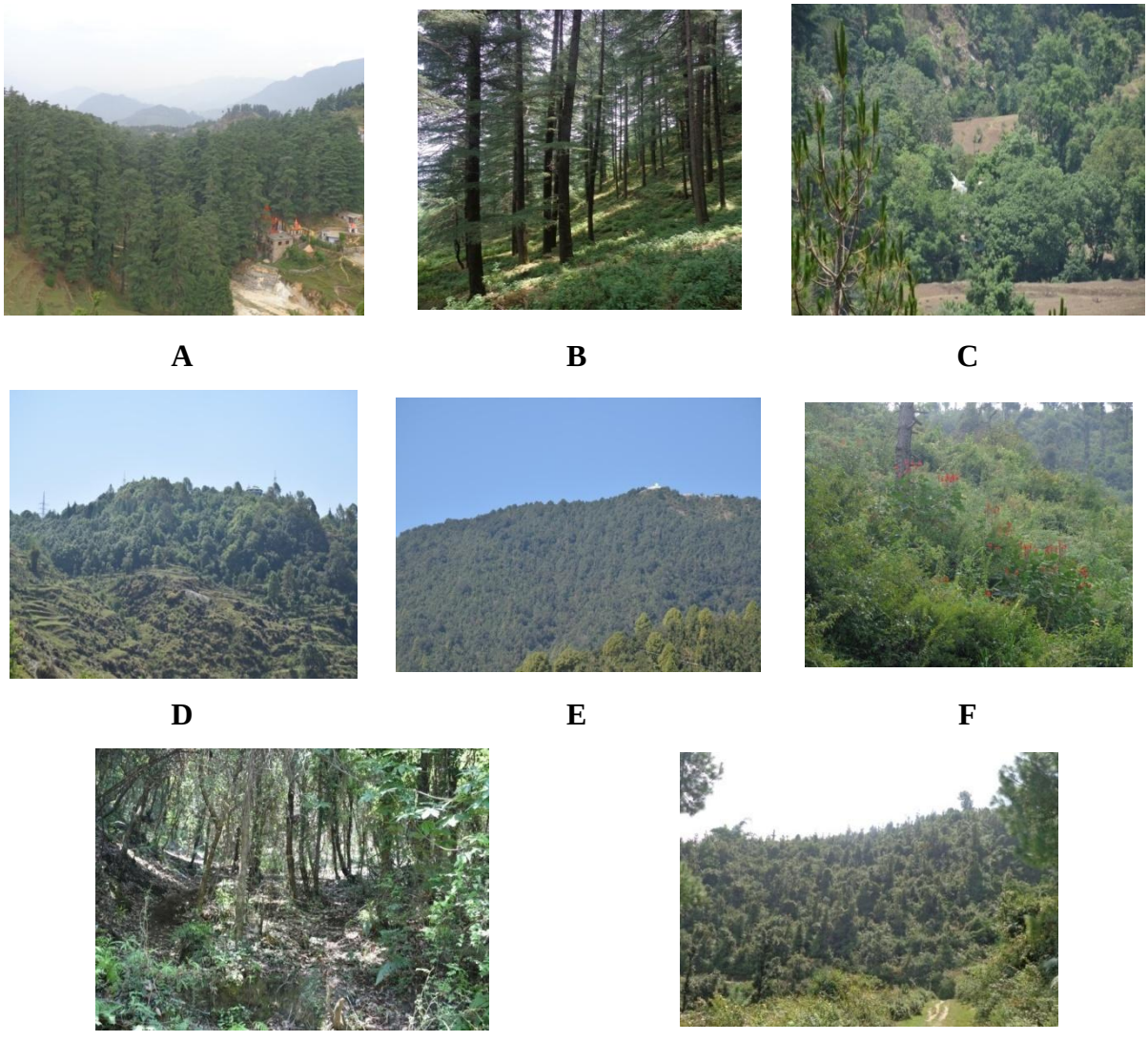
Eight Sacred forests were recorded during present study. Eight sacred forests represents: (1) Haat Kalika sacred forest, Gangolihaat (2) Chamunda Devi sacred forest,

Gangolihaat (3) Betal devta sacred forest, Kanalichina (4) Thal kedar sacred forest, Badabe (5) Psupatinath sacred forest, Chandak (6) Golu devta sacred forest, Ratwali (7) Thakil Dev sacred forest, Pithoragarh (8) Veshno Devi Sacred forest, Gangolihaat (Figure 1&2).The approximate elevation of the six sacred forests ranges from 1465 m to 2602m above sea level (Table1).

Table 1: Detail Description about Sacred Forests, Pithoragarh district, Uttarakhand

Sacred forest	Altitude (m asl)	Forest type	Name of Villages	Communities
Kalika	1695m	*Cedrus deodara*	Haat, Rawal gaon	Rawal, Pant, Joshi, Pathak, Mehta, Bhandari, Karki, Negi
Chamunda	1795m	*Cedrus deodara*	Hanera, Chodhiyar, Churiyager	Joshi, Upreti, Pant, Tamta, Pathak
Betal Devta	1504m	*Querques leucotrichophora*	Satgad, Bhandarigaon, Palli, Kandali, Gudoli, Siroli	Sirola, Upadhyay, Joshi, Bhandari, Arya, Ram
Thal kedar	2602m	*Querques leucotrichophora* & *Rhododendron aeboreum*	Marsoli, Devdar, Bilai, Soungaon, Badabe, Toil, Khatera	Bhatt, Negi, Oli, Joshi, Ram, Kohli
Psupatinath	1906m	*Rhododendron aeboreum*	Chhera, Dhunga, Chandak	Joshi, Bisht
Ratwali	1807m	*Querques leucotrichophora*	Ratwalli, Silloni, Majhera	Joshi, Pandey, Mehta
Thakil Dev	1465m	*Querques leucotrichophora*	Khatera, Badabe	Bhatt, Joshi, Pant
Veshno Devi	1836m	*Querques leucotrichophora*	Chodhiyar, Gangolihaat	Joshi, Bisht

During research survey of 28 village around sacred forests (Haat, Rawal gaon, Hanera, Chodhiyar, Churiyager, Satgad, Bhandarigaon, Palli, Kandali, Gudoli, Siroli, Marsoli, Devdar, Bilai, Soungaon, Badabe, Toil, Khatera, Chhera, Dhunga, Chandak Ratwalli, Silloni, Majhera, Khatera, Badabe, Chodhiyar and Gangolihaat) 18 local comunites were observed (Rawal, Pant, Joshi, Pathak, Mehta, Bhandari, Kaeki, Negi, Upreti, Tamta, Sirola, Upadhyaya, Arya, Ram, Bhatt, Oli, Kohli and Pandey) Table1. Sacred forests were dominated by three major tree species, *Cedrus deodara*. *Querques leucotrichophora* and *Rhododendron aeboreum.*



A **B** **C**

D **E** **F**

G **H**

Sites of Sacred Forests, Pithoragarh district, Uttarakhand

A: Chamunda devi, B: Haat Kalika, C: Kanalichina Betal, D: Pasupatinath, E: Thal Kedar, F: Golu Dev, G: Thakil Dev, H: Veshno Devi

A

B

C

D

E

F

G

H

A: Chamunda devi Temple, B: Kalika Devi Temple, C: Pasupatinath Temple, D: Betal Devta Temple, E: Thal Kedar Temple, F: Thakal Dev Temple, G: Golu Dev, H: Veshno Devi

CONCLUSION:

On the basis of above studies we can say that sacred forests have a significant role in biodiversity conservation through ritual beliefs. Eight sacred forests were observed during present study in Pithoragarh district of Uttarakhand. Results shows that 28 villages were studies and 18 local communities were recorded around sacred forests. Hence, the importance of the sacred forests in maintaining the biological diversity and meeting the basic livelihood needs of the village community has continued and will be maintained for the future generations.

ACKNOWLEDGMENT:

Authors are grateful to the Head, Department of Botany, D. S. B. Campus, Kumaun University, Nainital for providing necessary facilities.

REFERENCES:

1. Putney, A. (2005), Friends for Life, IUCN, Gland, Switzerland and Cambridge
2. UNDRIP (2007), 61st session, agenda item 68, Report of the Human Rights Council
3. Rao. P. (1996), WWF-india Quarterly 7, P. 4-8.
4. Frazer, J.G. (1890), The Golden Bough, Macmillan, London
5. Wild, R. and McLeod, C. (2008), Best Practice Protected Area Guidelines Series 16.
6. Mallarach, J.M. and Papayannis, T. (eds) (2007), IUCN Gland, Switzerland
7. Omari, C.K. (1990), University of Arizona Press, Tucson
8. Schoffeleers, J.M. (1978), Mambo Press, Harare, Zimbabwe
9. Bhagwat, S.A. and Rutte, C. (2006), Front. Ecol. Environ. 4 (10), pp519–524
10. Jamir, S.A. and Pandey, H.N. (2003), Biodiver. Conser. 12, pp1497–1512
11. Berkes, F. (1999), Taylor & Francis, Philadelphia
12. Devereux P. (2000), Cassell, London, U.K.
13. Nair N.C. (1981), J. Econ. Taxon. Bot. 2: 233–234
14. Baker I. (2004), The Penguin Press, New York.
15. Mulvaney K. (1999), George Wright Forum 16(4): 37–49.
16. Stanley K., Paul D. and Adam F. (2003), Dreaming 13(2): 95–105.
17. Huber, T. (1999), Oxford University Press, Oxford
18. Aerts, R., Van Overtveld, K., Haile, M., Hermy, M., Deckers, J. and Muys, B. (2006), Plant Ecology, vol 187, pp127–142
19. Gadgil, M. and Vartak, V.D. (1975), J. Bom. Nat. Hist. Soc. 72, no 2, p313–320
20. Gadgil, M. and V.D. Vartak. (1976), Economic Bot. 30:152–160.
21. Gadgil, M. and Vartak, V.D. (1981), Oxford and IBH Publishing, Delhi, pp279–294
22. Chandran, M.D.S., Gadgil, M. and Hugues, J.D. (1998), Science Publishers, New Hamphire, USA
23. Khumbongmayum AD (2004), PhD Thesis, North-Eastern Hill University, Shillong, India.
24. Khiewtam, R.S. and Ramakrishnan, P.S. (1993). Forest Ecol. Manag. 60: 327-344.
25. Singh, G. S., K. S. Rao & K. G. Saxena. (1998), Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, Kolkata.
26. Mani, S. & Parthasarathy, N.(2005), Systematics and Biodiversity 3: 1–12.
27. Kushalappa, C.G. and Bhagwat, S.A. (2001), Oxford and IBH Publishing, New Delhi.

28. Ward and Conne (1927), Memmoirs of the survey of Travancore and Cochin states. cited from census report of Travancore, 1891
29. Kosambi, D.D., (1962), Popular Press, Bombay.
30. Arora, V. (2006), Conservation and Society 4(1): 55–83.
31. Malhotra KC, Gokhale Y, Chatterjee S & Srivastava S (2001), INSA, Delhi, 2001.
32. Sinha, B. and Maikhuri, R.K. (1998), Oxford and IBH Publishing Co., New Delhi, pp. 289-300.
33. Anthwal A, Sharma RC, Sharma A (2006), The J Am Sci 2(2):35–43
34. Gadgil, M. and Berkes, F. (1991), Research Management and Optional 8: 127- 141.
35. Dafni, A. (2006), J. Ethnobiol. Ethnomed. 2(26).
36. Vartak V.D. and Gadgil M. (1973), Abstract, Proc. Indian Sci. Cong. 60: 341.
37. Schaaf, T. (1998), UNESCO and Oxford-IBH Publishing, New Delhi.
38. Karanth, K.U. (1998), IUCN/ SAC Cat Specialist Group - Digital Cat Library.
39. Burman R.J.J. (1992), J. Indian Anthropol. Soc. 27: 219– 238.
40. Boojh R. and Ramakrishan P.S. (1983), Dept. of Science and Environmental of Uttar Pradesh, Lucknow, pp. 6–8. 13.
41. Mishra, B.P., Tripathi, O.P., Tripathi, R.S. and Pandey, H.N. (2004), Biodiversity and Conservation 13: 421-436.
42. Mitra, A. and Pal, S. (1994), Down to Earth, January 31.
43. Rodgers, W.A., (1994), City Book, Soc. Calcutta.
44. Chatterjee, S., Sastry, A.R.K., Roy, B.N. and Lahon, R. (2000), Indira Gandhi Rastriya Manav Sanghralaya, Bhopal
45. Joshi. (1992), Current Science 62: 608-616.
46. UNESCO and Oxford-IBH Publishing, New Delhi. Singh, H.B.K., Singh, P.K. and Elangbam, V.D. (1996), J. of Hill Res. 9(2): 359-362.
47. Boraiah, K.T., Vasudeva, R., Bhagwat, S.A. and Kushalappa, C.G. (2003), Current Science, vol 84, pp804–808
48. Vartak VD, Kumbhojkar MS, Nipuge DS (1987), B Medi Ethno Bot Res 8:77–78
49. Bhakat, R.K. and Pandit, P.K. (2003), Indian Forester 129(2): 224- 232.
50. Bhakat, R.K. and P.K. Pandit. (2004), Indian Forester. 130:37-43.
51. Bisht S, Ghildiyal JC. (2007), Current Science; 92(6):711–2.
52. Singh, Harsh., Husain, T. and Agnihotri, P.(2010a), Current Science, 10: 298.
53. Singh, Harsh., Sahu, Vinay., Husain, Tariq. and Asthana., A. K. (2010b), Journal of Bryology, 32: 232-241.
54. Singh Harsh (2011), Ph. D. Thesis submitted to Kumaun University Nainital
55. Singh, H., Agnihotri, P., Pande, P. C. and Husain, T., (2011), Environmentalist 31, 246–253.
56. Upreti B. M., Tewari L., Tewari A. (2017), Biolife. 5(1), pp 7-11. doi:10.17812/blj.2017.5102

57. Upreti B. M., Tewari L., Tewari A and Joshi N.(2016), J. Chem. Eng. Chem. Res. Vol. 3, No. 11, 2016, pp. 989-992
58. Barik, S.K. (1992), Ph.D. Thesis, North-Eastern Hill University, Shillong, India. Pp 160
59. Rao, P. (1992), Ph.D. Thesis, North-Eastern Hill University, Shillong, India. 159 pages.
60. Rani, S.S., Murthy, K.S.R., Goud, P.S.P. and Pullaiah, T. (2003), Journal of Tropical Forest Science 15(2): 259-278.
61. Maikhuri, R.K., Nautiyal, S., Rao, K.S. and Saxena, K.G. (1998), Current Science 75(2): 152-157.
62. Saxena, K.G., Rao, K.S. and Maikhuri, R.K. (1998), UNESCO and Oxford-IBH Publishing, New Delhi.
63. Totey, N.G. and Verma, R.K. (1996), Indian Forester 4: 7-10.
64. Anthwal A, Gupta N, Sharma A, Anthwal S, Kim KH (2010), Resour Conserv Recy 54:962–997
65. Gokhale, Y. & N. A. Pala. (2011), Journal of Biodiversity 2: 107-115.
66. Brown K. (2003), Global Ecol Biogeogr 12: 89–92.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 9

PATTERN OF DISTRIBUTION AND SUBSTRATE SPECIFICITY OF MACROLICHENS IN SHIMOGA DISTRICT OF SOUTHERN INDIA

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ABSTRACT:

The species richness is a fundamental measure of biodiversity and current trends of declining species richness in many regions of the world are major ecological, economical and cultural problem. Understanding the pattern of diversity and distribution of organisms is a key aspect in conservation and management. The study area is situated at 13°27' and 14°39' N latitude to 74°38' and 76°4' E longitude and represent 8465 sq. km with a forest cover of 3270 sq.km. The temperature varies from 19 to 32°C and the mean annual rainfall is 2800 mm. The study site was selected by random sampling method and the lichen species were collected form different substrates and identified. The area is harbored with different types of forests supports luxuriant growth of lichens. The present study investigates 944 individuals belong to 95 species and they represent 31 genera among 14 families. The corticolous lichens were abundant (71 species). The Parmeliaceae (41.6%) is dominated family followed by Physciaceae (33.5%). The pattern of distribution of lichens varies with forest type and altitude. The tree main trunk represts 44.4%, branches (27.7%), fallen twigs (16.6%) and others 11.2%. Out of 95 species 75 percent were foliose and 20 percent were fruticose lichens. The important host trees were *Terminalia paniculata, Ficus tsjahela, Tectona grandis, Rhandia dumetorium etc*. Majority of the lichen species are found to favors the wood. This brings out the importance of woody microhabitats in promoting lichen species

diversity. Some important macro lichen species of the study area are *Bulbothrix* spp, *Coccocarpia* spp, *Dirinaria* spp, *Heterodermia* spp, *Leptogium* spp, *Parmotremia* spp, *Usnea* spp, *Ramalina* spp etc. Out of these parmelioid lichens were highly diverse. *Ramalina pacifica* was high in abundance and *Pseudocyphelaria aurata* were low in number.

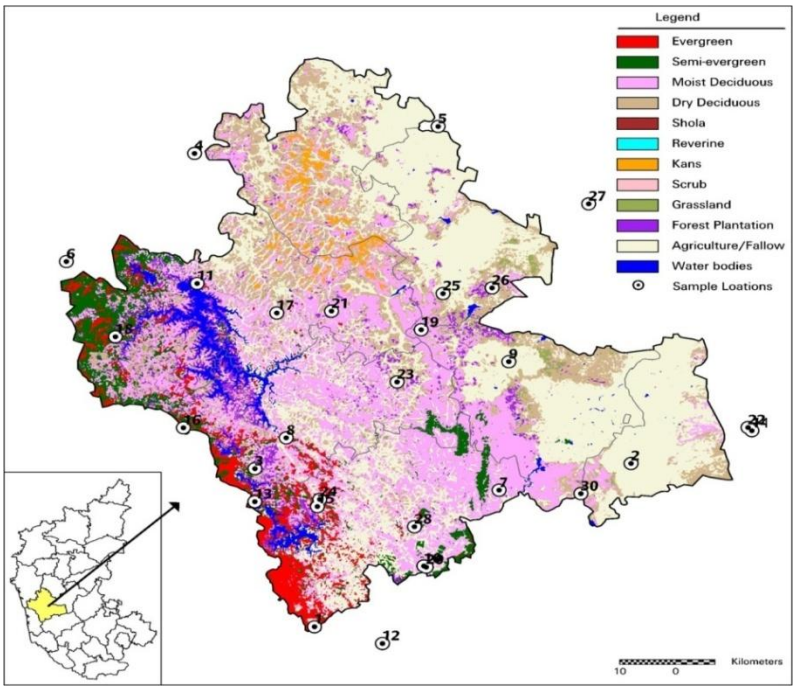
KEYWORDS: Macrolichens, Tropical lichens, Parmotrema, Western Ghats.

INTRODUCTION:

Lichens are among the most widely distributed and dominant groups of organisms in the world, and cover as much as eight per cent of the earth's surface [1]. These little plants are the most successful symbiotic organisms on earth and can grow on almost anything and anywhere. They are found colonizing on rocks, soil, trunks and branches of tree, animal shells, bones, insect's backs, humus, synthetic material, bricks, cement, concrete roofs and walls, glass and iron [2,3,4].

Although there are several publications available on the lichen-phorophyte relationships from European and other countries, only scanty information [5,6] is available for Indian lichens. The aim of this paper is to elucidate the microhabitat and host specificity of macrolichens and to evaluate the important host species exploited by them. In a heterogeneous forest land the diversity of lichens is variable as the supporting host trees provide space for different types of lichens. Some lichens show preference for certain trees mostly based on the nature of bark and its microclimatic and chemical conditions. Understanding the host preference is an important aspect in lichen ecology as these organisms play an essential functional role in forest ecosystem. In addition knowledge of degree of host specificity of lichens serves as a useful purpose in the estimation of their diversity and conservation [5,7]. Microhabitat differences play an essential role in explaining patterns of species composition and diversity at the scale of individual trees. Microhabitats vary primarily along the height of the tree, from the base of the trunk to the tree crown [8,9]. Lichens are widely used as indicators of continuity and health of the forest [10,11,12,13]. Lichens have strongest correlation emerged between tree density and host tree diversity on lichen distribution. Lichens have efficient mechanisms for accumulation of nutrients from the environment and also given the brief account on lichen distribution and identification methods [14]. Studied Epiphytic lichens and bryophytes with their host specificity [15,16]. The difference in species diversity on different substrates and the effect of both substrate and site variation [17].

METHODOLOGY:



1.	Agumbe	2.	Bhadravathi	3.	Chakra	4.	Chandragutti	5.	Chikkerur
6.	Gerusoppa	7.	Hanagere	8.	Haniya	9.	Harnahalli	10.	Herambapura
11.	Honnemaradu	12.	Hosahalli	13.	Hulikal	14.	Idlumane	15.	Kavaledurga
16.	Kodachadri	17.	Kodluthota	18.	Kogar	19.	Konehosur	20.	Kuppalli
21.	Mupanne	22.	Nittur	23.	Rippenpet	24.	Shankaraghatta	25.	Shettihalli
26.	Shikaripura	27.	Sorba	28.	Thirthahalli	29.	Ullur	30.	Umblebilu

Figure 1: Map of Shimoga district in Karnataka showing sampling sites

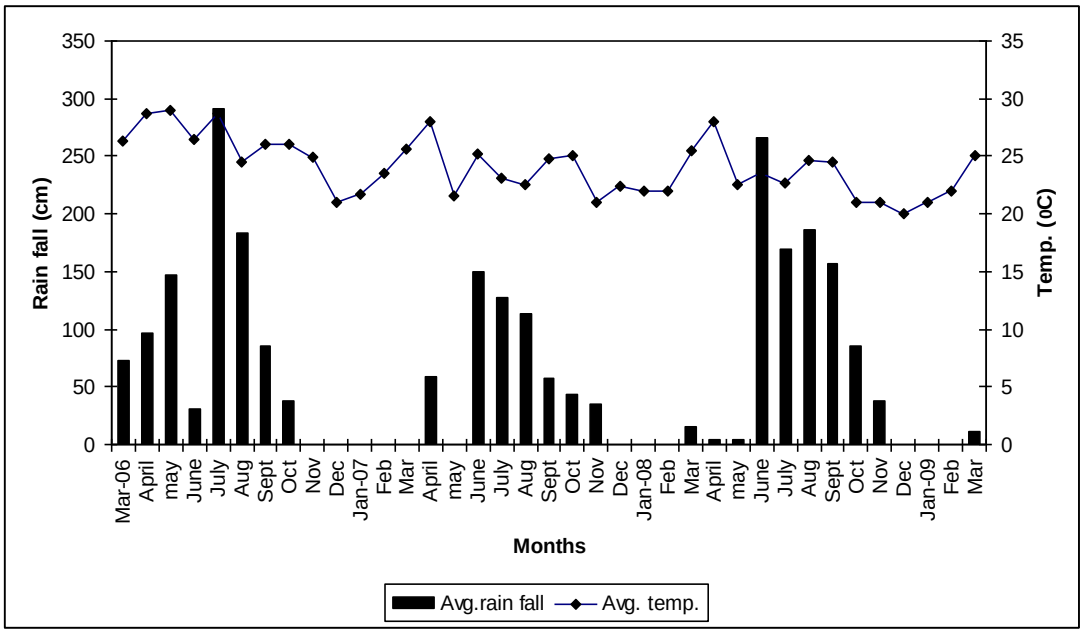


Fig. 2 : Graph representing Avg. rainfall & temperature in study sites

Survey had been carried out by using transect method. Each transects measuring 50x10 m laid in different forest locations of study site. Again each transects were divided into subquadrats of 20 x 20cm for collection and identification of lichens. Along with this we have also collected random samples as opportunistic collection which encounters other than quadrats. The representative lichen specimens were collected along with their substratum irrespectively of their growth form. The three major substrates rock, soil and wood were considered as the microhabitats. The woody substrates included tree trunks, branches, twigs, wood logs and stumps. To study the tree host-lichen association a total of 35 tree species were selected each from deciduous and semi-evergreen forests of three districts. All the host trees which were above 10 cm GBH (Girth at Brest Height) were noted and collected lichens from them and the host tree species were identified with the help of published floras [18,19]. Canopy cover was noted down by observation and light intensity was record by using LUX meter. Approximate 10 cm^2 size of bark was separated carefully from stem of tree at 1.5 m level from ground and collected. The wound of the trees was treated with plaster of paris to avoid microbial and insect damage. About 0.5g of bark sample weighed and soaked with 0.25M KCl solution. Later they were kept in oven for one hour at 80˚c and then P^H was determined by using pH meter. The pH of the tree bark was estimated by the procedure of [20] using digital pH meter (Multi-Parameter PTTestr^{TM} 35 Oakton, USA) and also recorded the texture. The barks were grouped as rough, smooth and moderate based on their texture to correlate association of lichens.

RESULTS:

The present study investigates 944 individuals belong to 95 species and they represent 31 genera among 14 families. The corticolous lichens were abundant (71 species). The Parmeliaceae (41.6%) is dominated family followed by Physciaceae (33.5%). The pattern of distribution of lichens varies with forest type and altitude. The tree main trunk represts 44.4%, branches (27.7%), fallen twigs (16.6%) and others 11.2%. Out of 95 species 75 percent were foliose and 20 percent were fruticose lichens. The lichens growth is influenced by substrates and microclimate. In the study area distribution pattern of lichen varies with the availability of substrates like bark, wood, rock, twig and soil. Most species of lichens were dominated on the main stem (49%) followed by twig (25%) and leaves supported for less number of lichens. Among the terricolous lichens *Cladonia* and *Cetraria* were represented. Saxicolous lichens *Dirinaria applanata*, *Endocarpon* sp., *Parmotrema grayanum*, *Leptogium pichneum* were found here. Some macrolichen species showed specificity to a particular host

tree which could be attributed to various ecological conditions. *Physma byrsaeum* is specific to host *Mangifera indica* and bamboo in semi-evergreen forest, *Roccella montagnei* reported only from *Mangifera indica* tree in deciduous forest. *Punctelia* sp., *Unsea undulata* were corticolous species reported from deciduous forests only. *Coccocarpia erythroxyli* and *Heterodermia speciosa* hosted by *Litsea floribunda* and some *Usnea* species were supported by branches of *Tectona grandis* and *Syzygium* species. *Leptogium chloromelum, Coccocarpia palmicola*, *C. erythroxyli* and *Collema* sp. were distributed in evergreen forest of Agumbe, Kodachadri and Hulikal of Shimoga district. *Bulbothrix isidiza*, *Phyllopsora* sp. *Heterodermia incana* and *Parmotrema stuppeum* were occurred in semi-evergreen forests of Hosanagar, Rippenpet, Kuppali, Kogar, Sigandur and Jog of Shimoga district. Association of the algal partner in the distribution of lichen is *Trebouxia* (61%) which is the dominant algal partner followed by *Nostoc* (19%) and *Trentephollia* (8%). In Shimoga district, *Parmotrema cristiferum* and *P. tinctorum* is having high importance value (IVI) i.e., 5.29 and 5.19 respectively and it is followed by *Dirineria applanata* (5.13).

The indicator species analysis with respect to forest types indicates that several species were strongly co-relate with a particular forest type (Table 1). Diversity and distribution of epiphytic macrolichens on tree trunk in rain forest of Gran Piedra was studied by [21]. They reported that 21 species of macrolichens species composition is varies with slopes, but frequency of lichen change with cardinal orientation. The proportion of foliose and fruticose lichens increase with altitude [22]. Our study also reveals similar results indicate the *Usnea* and *Ramalina* species occurred at higher altitudes. Microhabitat differences play an essential role in explaining patterns of species composition and diversity at the scale of individual trees.

Diversity of epiphytic lichens in boreo-nemoral forest was studied by [23]. They reported 74 species of lichens from 13 study sites, most of them were crustose and most frequent species is *Graphis*. The DCA analysis found that 36 percent variation between compositions of lichen communities. The CCA ordination of the lichen species and environmental variables revealed more specifically the influence of the measured environmental factors on the composition of lichen species. When compared with other study sites, the malnad area of Karnataka is having high diversity with 106 species from three main sites. DCA analysis results indicate variation of 40 per cent with lichen composition in different forests.

Table 1. Study sites of Shimoga with species richness:

Study sites	Latitude	Longitude	Altitude	Species richness	Corti colous	Terri colous	Saxi colous	Cort/ Sax	Sax/ Ter
Agumbe	13 28.194	75 7.718	643	46	36	1	5	4	0
Bhadravathi	13 50.146	75 41.533	630	24	20	0	2	2	0
Chakra	13 47.59	75 0.179	632	34	25	0	6	3	0
Chandragutti	14 26.61	74 51.5	625	43	29	1	7	5	1
Chikkerur	14 31.27	75 18.26	628	19	17	0	1	1	0
Gerusoppa	14 12.40	74 38.06	530	28	25	1	2	0	0
Hanagere	13 46.17	75 27.17	643	21	18	0	3	0	0
Haniya	13 51.597	75 3.427	624	35	31	0	3	1	0
Harnahalli	14 02.25	75 27.48	673	17	15	0	0	2	0
Herambapura	13 36.339	75 19.351	705	26	23	0	3	0	0
Honnemaradu	14 10.386	74 52.629	580	45	42	0	1	2	0
Hosahalli	13 26.468	75 15.281	680	39	39	0	0	0	0
Hulikal	13 43.47	75 0.38	581	41	38	0	2	1	0
Hidlumane	13 54.811	75 54.653	647	26	22	0	4	0	0
Kavaledurga	13 43.193	75 07.29	847	34	16	2	12	4	0
Kodachadri	13 52.30	74 52.05	1230	34	29	1	3	1	0
Kodluthota	14 7.125	75 01.60	634	36	34	0	2	0	0
Kogar	14 3.28	74 43.97	712	29	26	0	1	2	0
Konehosur	14 5.786	75 17.627	642	58	55	0	0	3	0
Kuppalli	13 36.198	75 19.62	696	27	26	0	1	0	0
Mupanne	14 07.65	75 7.623	675	19	19	0	0	0	0
Nittur	13 55.19	75 54.21	623	21	21	0	0	0	0
Rippenpet	13 59.15	75 15.29	684	28	26	0	2	0	0
Shankaraghata	13 44.101	75 7.505	675	53	46	0	5	2	0
Shettihalli	14 10.42	75 19.815	730	38	34	0	0	4	0
Shikaripura	14 11.375	75 25.194	622	18	17	0	1	0	0
Sorba	14 22.35	75 35.36	650	23	22	1	0	0	0
Thirthahalli	13 41.18	75 18.08	635	28	25	0	3	0	0
Ullur	13 08.03	75 06.36	647	17	17	0	0	0	0
Umblebilu	13 46.145	75 36.187	650	37	33	0	1	3	0

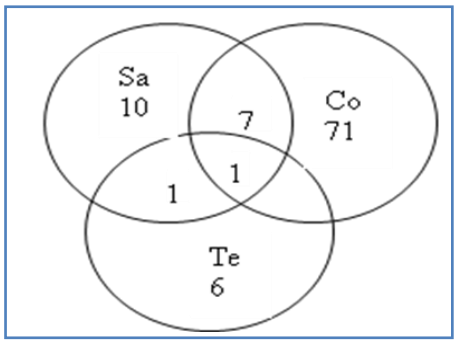


Figure 3: Venn diagram showing distribution of lichens on different substrates Shimoga district

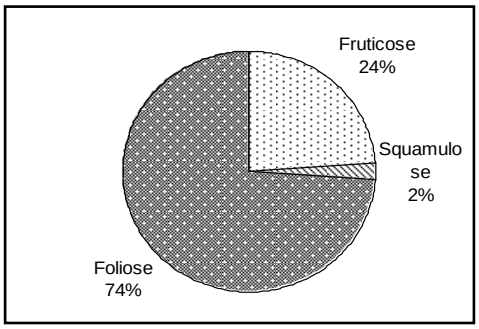


Figure 4: Growth forms of macrolichens recorded in Shimoga district

Lichens constitute a significant portion of the biodiversity of forests worldwide. In many forests, lichen diversity exceeds that of the trees and shrubs, and often that of all vascular species in a forest stand [24]. Our study sought to quantify differences in lichen communities and lichen diversity among three sites with common forest vegetation types.

Distinctive lichen communities that appears to be enhanced by the structural diversity within these stands. Species richness of lichens differed with respect to vegetation type, with sand pine scrub plots being the most diverse. The tropics are supposed to host the biologically richest land ecosystems in the world. In terms of lichen diversity, however, they seem to be so far the least-explored regions, as many new species are still being described every year [25,26,27,28,29]. For most organism groups, both local, alpha diversity and regional, beta diversity is higher in tropical than in temperate areas [30,31,32]. Similar results were occurring in the present study. Few studies are available in which lichen species diversity, specifically microlichens, has been assessed for tropical vegetation. Also, the available studies all used somewhat different sampling techniques, included different forest strata and identified the lichens to various taxonomic levels depending on growth form.

A transect of 47 mature trees was studied within an Atlantic rain-forest plot in northeastern Brazil to determinate effects of phorophyte specificity and environmental parameters vs. stochasticity on the structure of corticolous, crustose microlichen communities. A total of 150 lichen species was found, most being rare to extremely rare. Multivariate analysis of sample plots indicated subtle phorophyte preferences among certain lichen species, corresponding to differences in bark pH, degree of bark shedding, density and size of bark lenticels, and presence of milk sap. Individual and multiple regressions revealed correlations between lichen species richness.

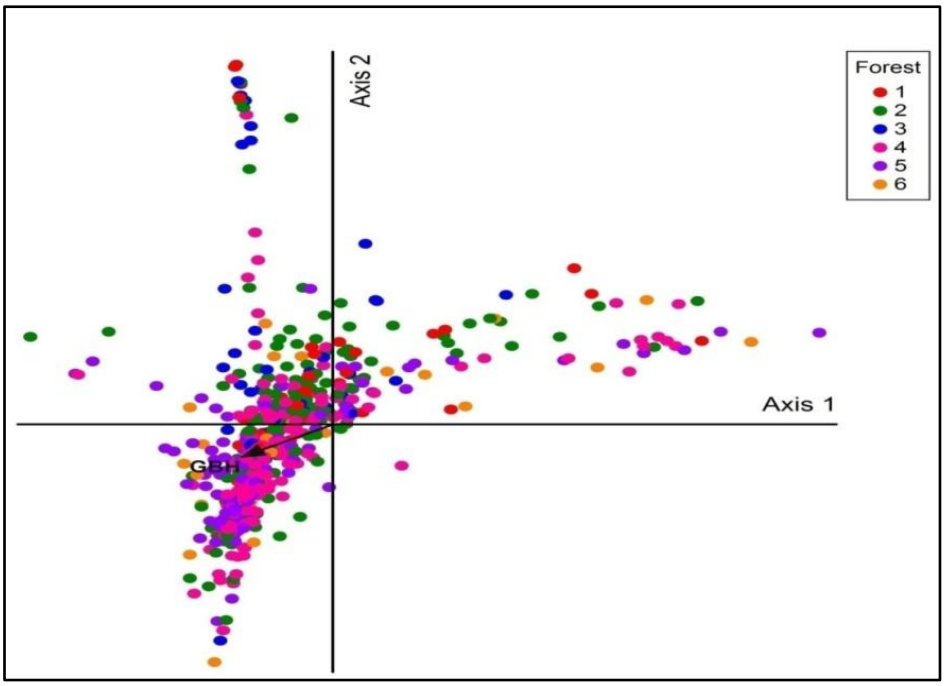


Figure 5: Ordination DCA analysis lichen diversity with different forest types (1= Evergreen, 2= Semi-evergreen, 3 = (Shola) Montane, 4 = Deciduous, 5 = Scrubby, 6 =open areas)

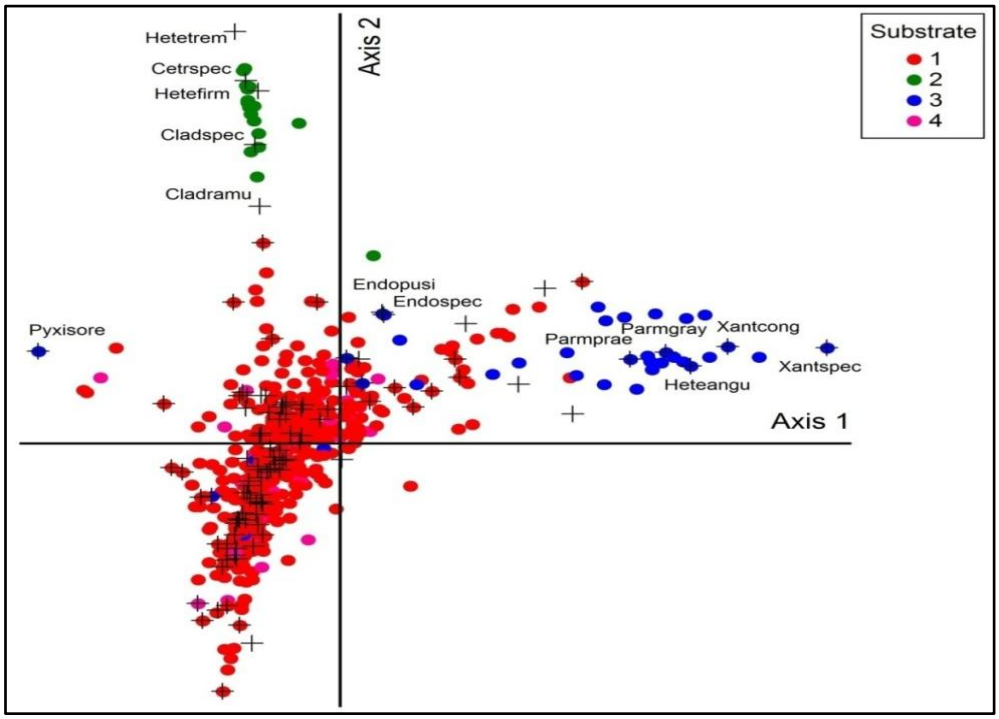


Figure 6: Ordination DCA analysis of lichen diversity in relation with different substrate (1= bark, 2= soil, 3= rock, 4= twig/wood/branch

Table 2. Macrolichens of Shimoga districts with their diversity indices:

Species	Family	S	GF	I	II	III	DEN	FRE	AB	RD	RF	IVI
Bulbothrix isidiza (Nyl.)Hale	Parmeliaceae	Cort	Fo	18	30	13	0.6	0.43	1.38	1.9	2.41	4.31
Candelaria concolor (Dicks.) Stein	Candeleriaceae	Cort	Fo	6	30	2	0.2	0.07	3	0.63	0.37	1.01
Canoparmelia sp. Elix and Hale	Parmeliaceae	Cort	Fo	12	30	7	0.4	0.23	1.71	1.27	1.3	2.57
C. texana (Tuck.) Elix and Hale	Parmeliaceae	Cort	Fo	5	30	3	0.17	0.1	1.67	0.53	0.56	1.08
Cetraria sp. Ach.	Parmeliaceae	Ter	Fr	4	30	1	0.13	0.03	4	0.42	0.19	0.61
Cladonia sp. P.Browne	Cladoniaceae	Ter	Fr	15	30	9	0.5	0.3	1.67	1.59	1.67	3.25
C. ramulosa (With.) J.R. Laundon	Cladoinaceae	Ter	Fr	6	30	4	0.2	0.13	1.5	0.63	0.74	1.38
Coccocarpia palmicola (Spreng.) Arvidss. & D.J.Galioway	Coccocarpiaceae	Cort	Sq	18	30	11	0.6	0.37	1.64	1.9	2.04	3.94
C.erythroxyli (Spreng.) Swinsc.& Krog	Coccocarpiaceae	Cort/ Sax	Sq	17	30	10	0.57	0.33	1.7	1.8	1.85	3.65
Collema sp. G.H.Web. In Wigg.	Collemataceae	Cort	Fo	6	30	4	0.2	0.13	1.5	0.63	0.74	1.38
C. leptaleum (Mont.) Degel	Collemataceae	Cort	Fo	5	30	2	0.17	0.07	2.5	0.53	0.37	0.9
*Dirinaria aegialita (*Afz.in Ach.) Moore	Physciaceae	Cort	Fo	8	30	2	0.27	0.07	4	0.85	0.37	1.22
D. applanata (Fee) D.D. Awasthi	Physciaceae	Sax	Fo	24	30	14	0.8	0.47	1.71	2.54	2.59	5.13
D. confluens (Fr.) D.D. Awasthi	Physciaceae	Cort	Fo	4	30	3	0.13	0.1	1.33	0.42	0.56	0.98
D. consimilis (Stirton) D.D. Awasthi	Physciaceae	Cort	Fo	6	30	4	0.2	0.13	1.5	0.63	0.74	1.38
D. papillulifera (Nyl.) D.D. Awasthi	Physciaceae	Cort	Fo	4	30	3	0.13	0.1	1.33	0.42	0.56	0.98
Endocarpon sp. Hedw.	Verrucariaceae	Sax	Fo	6	30	4	0.2	0.13	1.5	0.63	0.74	1.38

E. pusillum Hedw.	Verrucariaceae	Sax	Fo	5	30	2	0.17	0.07	2.5	0.53	0.37	0.9
Everniastrum nepalense (Taylor) Hale	Parmeliaceae	Ter	Fr	8	30	5	0.27	0.17	1.6	0.85	0.93	1.77
Heterodermia incana (Stirton) D.D. Awasthi	Physciaceae	Cor	Fo	13	30	8	0.43	0.27	1.63	1.38	1.48	2.86
H. microphylla (Kurok.) Skorepa	Physciaceae	Sax	Fo	17	30	8	0.57	0.27	2.13	1.8	1.48	3.28
H. Leucomela (L.) Poelt	Physciaceae	Cor	Fo	8	30	4	0.27	0.13	2	0.85	0.74	1.59
H.albidiflava (Kurok.) D.D. Awasthi	Physciaceae	Cor	Fo	18	30	11	0.6	0.37	1.64	1.9	2.04	3.94
H. angustiloba (Mull.Arg.) D.D.Awasthi	Physciaceae	Cor	Fo	10	30	7	0.33	0.23	1.43	1.06	1.3	2.35
H. dendritica (Pers.) Poelt	Physciaceae	Cort	Fo	18	30	10	0.6	0.33	1.8	1.9	1.85	3.76
H. diademata (Taylor) D.D.Awasthi	Physciaceae	Cort/ Sax	Fo	15	30	12	0.5	0.4	1.25	1.59	2.22	3.81
H. dissecta (Kurok.) D.D.Awasthi	Physciaceae	Cort	Fo	25	30	10	0.83	0.33	2.5	2.65	1.85	4.5
H. firmula (Nyl.) Trevis.	Physciaceae	Ter	Fo	9	30	4	0.3	0.13	2.25	0.95	0.74	1.69
H. comosa (Eschw.) Follman and Radon	Physciaceae	Cort	Fo	9	30	4	0.3	0.13	2.25	0.95	0.74	1.69
H.obscurata (Nyl.)Trevis.	Physciaceae	Cort	Fo	11	30	7	0.37	0.23	1.57	1.16	1.3	2.46
H. speciosa (Wulf.) Trevis.	Physciaceae	Cort	Fo	6	30	2	0.2	0.07	3	0.63	0.37	1.01
H.tremulans (Mull. Arg.) W. Culb	Physciaceae	Ter	Fo	11	30	4	0.37	0.13	2.75	1.16	0.74	1.9
Hyperphyscia adglutinata (Florke) Mayerh. and Poelt	Physciaceae	Cort	Fo	9	30	5	0.3	0.17	1.8	0.95	0.93	1.88

Hypotrachyna infirma (Kurok.) Hale	Parmeliaceae	Cort	Fo	8	30	2	0.27	0.07	4	0.85	0.37	1.22
H. crenata (Kurok.) Hale	Parmeliaceae	Cort	Fo	4	30	3	0.13	0.1	1.33	0.42	0.56	0.98
Leptogium aurstroamericanum (Malme) Dodge	Collemataceae	Cort	Fo	3	30	2	0.1	0.07	1.5	0.32	0.37	0.69
L. burnetiae Dodge	Collemataceae	Cort/ Sax	Fo	10	30	7	0.33	0.23	1.43	1.06	1.3	2.35
L. cochleatum (Dikson) P. M. Jorg. and James	Collemataceae	Cort	Fo	5	30	4	0.17	0.13	1.25	0.53	0.74	1.27
L. denticulatum Nyl.	Collemataceae	Cort	Fo	9	30	4	0.3	0.13	2.25	0.95	0.74	1.69
L. indicum D.D.Awasthi and Akhtar	Collemataceae	Cort	Fo	5	30	3	0.17	0.1	1.67	0.53	0.56	1.08
L. pichneum (Ach.) Malme	Collemataceae	Sax	Fo	3	30	3	0.1	0.1	1	0.32	0.56	0.87
L. ulvaceum (Pers.) Vain.	Collemataceae	Cort	Fo	17	30	7	0.57	0.23	2.43	1.8	1.3	3.1
L. chloromelum (Sw.) Nyl.	Collemataceae	Cort	Fo	16	30	10	0.53	0.33	1.6	1.69	1.85	3.54
Myelochroa xantholepis (Mont.&Bosch) Elix & Hale	Parmeliaceae	Cort/ Sax	Fo	9	30	6	0.3	0.2	1.5	0.95	1.11	2.06
Parmelia sp. Ach.	Parmeliaceae	Cort	Fo	7	30	3	0.23	0.1	2.33	0.74	0.56	1.3
Parmelinopsis sp. Elix and Hale	Parmeliaceae	Cort	Fo	5	30	2	0.17	0.07	2.5	0.53	0.37	0.9
Parmelinella wallichiana (Taylor) Elix&Hale	Parmeliaceae	Cort/ Sax	Fo	10	30	7	0.33	0.23	1.43	1.06	1.3	2.35
Parmotrema austrosinense (Zahlbr.) Hale	Parmeliaceae	Cort	Fo	8	30	5	0.27	0.17	1.6	0.85	0.93	1.77
P. crinitum (Ach.) Choisy	Parmeliaceae	Cort	Fo	15	30	6	0.5	0.2	2.5	1.59	1.11	2.7
P. cristiferum (Taylor) Hale	Parmeliaceae	Cort	Fo	22	30	16	0.73	0.53	1.38	2.33	2.96	5.29

P. grayanum (Hue) Hale	Parmeliaceae	Cort	Fo	11	30	10	0.37	0.33	1.1	1.16	1.85	3.02
P.hababianum (Gyeln.) Hale	Parmeliaceae	Cort	Fo	10	30	7	0.33	0.23	1.43	1.06	1.3	2.35
P. mellisii (C.W. Dodge) Hale	Parmeliaceae	Sax	Fo	4	30	4	0.13	0.13	1	0.42	0.74	1.16
P. praesorediosum (Nyl.) Hale	Parmeliaceae	Sax	Fo	7	30	5	0.23	0.17	1.4	0.74	0.93	1.67
P. reticulatum (Taylor) Choisy	Parmeliaceae	Cort	Fo	17	30	10	0.57	0.33	1.7	1.8	1.85	3.65
P. stuppeum (Taylor) Hale	Parmeliaceae	Cort/ Sax	Fo	14	30	5	0.47	0.17	2.8	1.48	0.93	2.41
P. tinctorum (Despr.ex Nyl.)Hale	Parmeliaceae	Cort/ Sax	Fo	21	30	16	0.7	0.53	1.31	2.22	2.96	5.19
P. vartakii Hale	Parmeliaceae	Cort	Fo	3	30	2	0.1	0.07	1.5	0.32	0.37	0.69
Phaeophyscia orbicularis (Neck.) Moberg	Physciaceae	Cort	Fo	4	30	4	0.13	0.13	1	0.42	0.74	1.16
Phyllopsora buettneri (Mull. Arg.) Zahlbr.	Biatoraceae	Cort	Fo	6	30	3	0.2	0.1	2	0.63	0.56	1.19
P. corallina (Eschw.) Mull.Arg.	Biatoraceae	Cort	Fo	6	30	3	0.2	0.1	2	0.63	0.56	1.19
P. haemophaea (Nyl.) Mull. Arg.	Biatoraceae	Cort	Fo	5	30	3	0.17	0.1	1.67	0.53	0.56	1.08
P. parvifolia (Pers.) Mull. Arg.	Biatoraceae	Cort	Fo	4	30	1	0.13	0.03	4	0.42	0.19	0.61
Physcia dilatata Nyl.	Physciaceae	Cort	Fo	4	30	2	0.13	0.07	2	0.42	0.37	0.79
Physma byrsaeum (Ach.) Tuck.	Collemataceae	Cort	Fo	15	30	6	0.5	0.2	2.5	1.59	1.11	2.7
Pseudocyphellaria aurata (Sm.ex Ach.)Vain.	Lobariaceae	Cort	Fo	15	30	7	0.5	0.23	2.14	1.59	1.3	2.88
Punctelia sp. Krog	Parmeliaceae	Cort	Fo	5	30	2	0.17	0.07	2.5	0.53	0.37	0.9
Pyxine coccifera (Fee) Nyl.	Physciaceae	Cort	Fo	16	30	10	0.53	0.33	1.6	1.69	1.85	3.54
P. cocoes (Sw.) Nyl.	Physciaceae	Cort	Fo	9	30	6	0.3	0.2	1.5	0.95	1.11	2.06

P. minuta Vain.	Physciaceae	Cort	Fo	6	30	4	0.2	0.13	1.5	0.63	0.74	1.38
P. petricola Nyl.	Physciaceae	Cort	Fo	6	30	3	0.2	0.1	2	0.63	0.56	1.19
P. reticulata (Vain.) Vain.	Physciaceae	Cort	Fo	7	30	3	0.23	0.1	2.33	0.74	0.56	1.3
P. sorediata (Ach.) Mont.	Physciaceae	Cort	Fo	6	30	5	0.2	0.17	1.2	0.63	0.93	1.56
Ramalina hossei Vain.	Ramalinaceae	Cort	Fr	2	30	3	0.07	0.1	0.67	0.21	0.56	0.77
R. pacifica Asahina	Ramalinaceae	Cort	Fr	20	30	15	0.67	0.5	1.33	2.12	2.78	4.89
Ramalina sp. Ach.	Ramalinaceae	Cort	Fr	2	30	1	0.07	0.03	2	0.21	0.19	0.4
R. conduplicans Vain.	Ramalinaceae	Cort	Fr	12	30	6	0.4	0.2	2	1.27	1.11	2.38
R. hossei var. *divericata* H.Magn. & G. Awasthi	Ramalinaceae	Cort	Fr	14	30	7	0.47	0.23	2	1.48	1.3	2.78
R. nervulosa (Mull. Arg.) Abbayes	Ramalinaceae	Cort	Fr	17	30	9	0.57	0.3	1.89	1.8	1.67	3.47
R. pollinaria (Westr.) Ach.	Ramalinaceae	Cort	Fr	8	30	3	0.27	0.1	2.67	0.85	0.56	1.4
R. taitensis Nyl.	Ramalinaceae	Cort	Fr	10	30	6	0.33	0.2	1.67	1.06	1.11	2.17
Relicina abstrusa (Vain.) Hale	Parmeliaceae	Cort	Fo	8	30	4	0.27	0.13	2	0.85	0.74	1.59
Roccella montagnei Bel.em. D.D. Awasthi	Roccellaceae	Cort	Fr	19	30	8	0.63	0.27	2.38	2.01	1.48	3.49
Teloschistes flavicans (Sw.) Norm.	Teloschistaceae	Cort	Fr	13	30	10	0.43	0.33	1.3	1.38	1.85	3.23
Usnea aciculifera Vain.	Parmeliaceae	Cort	Fr	8	30	3	0.27	0.1	2.67	0.85	0.56	1.4
U. eumitrioides Mot.	Parmeliaceae	Cort	Fr	8	30	4	0.27	0.13	2	0.85	0.74	1.59
U. galbinifera Asahina.	Parmeliaceae	Cort	Fr	9	30	6	0.3	0.2	1.5	0.95	1.11	2.06
U. ghattensis G. Awasthi	Parmeliaceae	Cort	Fr	12	30	6	0.4	0.2	2	1.27	1.11	2.38
U. picta (J. Steiner) Mot.	Parmeliaceae	Cort	Fr	4	30	3	0.13	0.1	1.33	0.42	0.56	0.98
U. pictoides G. Awasthi	Parmeliaceae	Cort	Fr	10	30	3	0.33	0.1	3.33	1.06	0.56	1.61
U. stigmatoides G. Awasthi	Parmeliaceae	Cort	Fr	16	30	9	0.53	0.3	1.78	1.69	1.67	3.36

U. undulata Stirt.	Parmeliaceae	Cort	Fr	6	30	5	0.2	0.17	1.2	0.63	0.93	1.56
U. vegae Mot.	Parmeliaceae	Cort	Fr	12	30	8	0.4	0.27	1.5	1.27	1.48	2.75
Xanthoparmelia sp. (vain.) Hale	Parmeliaceae	Sax	Fo	12	30	6	0.4	0.2	2	1.27	1.11	2.38
X. congensis (B.Stein) Hale	Parmeliaceae	Sax	Fo	9	30	5	0.3	0.17	1.8	0.95	0.93	1.88

Abbrevations: S - Substrate, G - growth forms, I - Number of individuals, II - Number of transects studied, III - Number of transects occurred, Sax - Saxicolous, Ter -Terricolous, Cort - Corticolous, Fr - Fruticose, Fo - Foliose, Sq - Squamolouse, RD - Relative density, RF - Relative frequency, IVI - Importance value index, DEN - density, Fre - Frequency, AB - abundance.

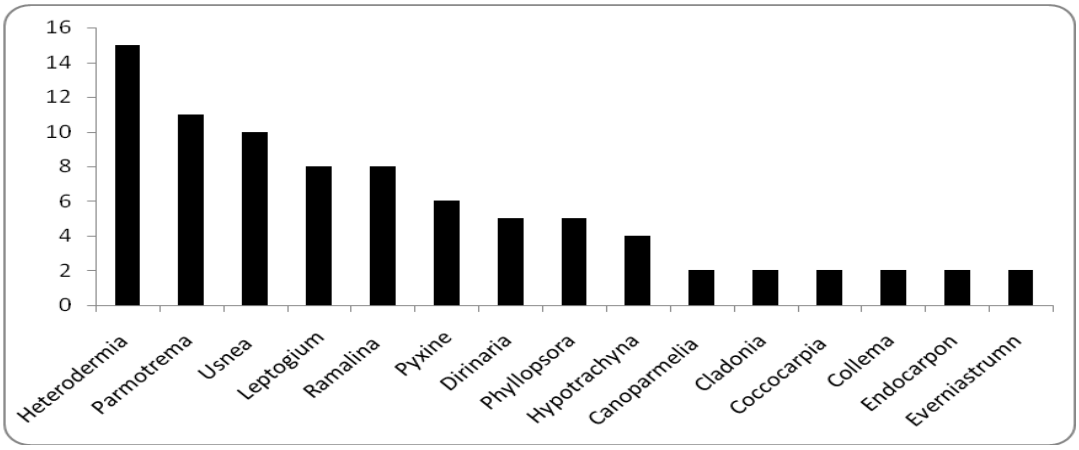


Figure 7: Genus level lichen diversity

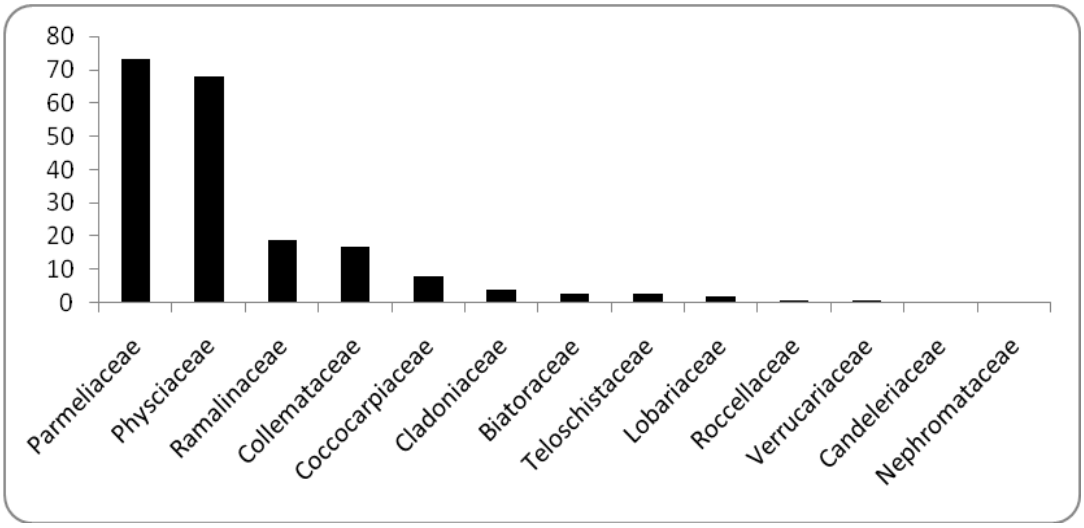


Figure 8: Number of individuals of macrolichens with their family importance value (FIV)

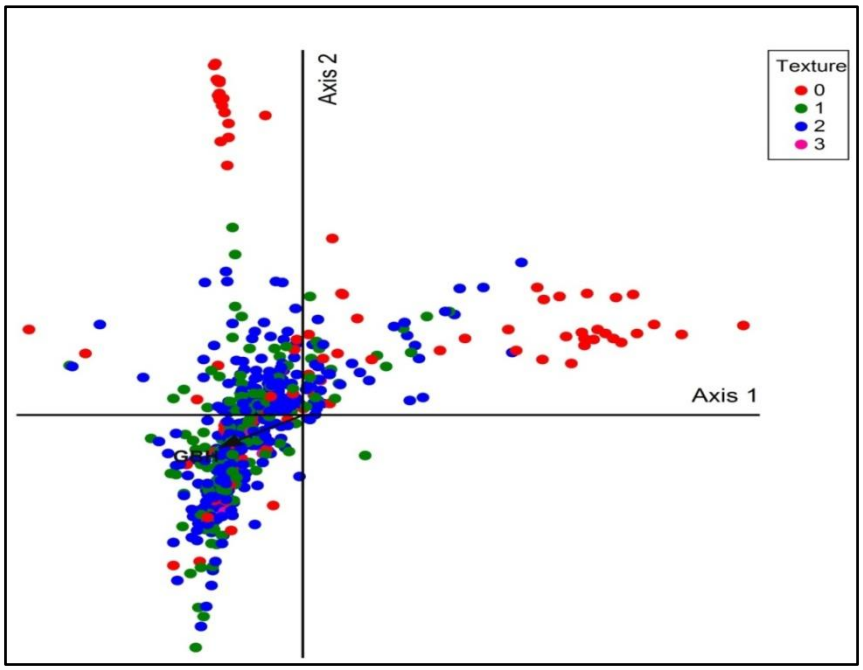


Figure 9: Ordination DCA analysis in relation to bark texture (0=smooth, 1=moderate, 2=hard, 3=extremely hard)

The lichen diversity of New Guinea is almost completely dependent upon primary forest. Some species appear to be able to maintain themselves on planted trees and in secondary vegetation [33]. In the present investigation it has been found that large number of lichens are corticolous, so it is very necessary care should be taken that not only the tree diversity is maintained, but also that the forest structure is preserved, including the presence of large hardwood trees. Selective logging of such valuable trees greatly reduces the lichenological value of the forest, as can be observed regrettably in nature reserves worldwide. While lichen species tend to have wide ranges, and are consequently of low protection priority, Western Ghats has an unusually high number of endemic species that are restricted to the region and therefore deserving of more attention.

We had carried out the quantitative estimation of lichens diversity in the three forests and six vegetation types a report of 106 species. Quantitative transect sampling yielded three times as many species as non-quantitative opportunistic sampling. Similar to our study support the 456 lichen species collected and identified across the 22 studied localities by quantitatively sampled transect [34].

Species diversity tends to decrease with increasing elevation. The species at higher altitudes supports less number of lichens in Kodachadri and Kemmannugundi higher peaks, as evidenced by occurrence of *Usnea*, *Parmotrema* and *Leptogium* species only. It was

emphasized that altitude and humidity play a significant role in the diversity and distribution of lichens [35].

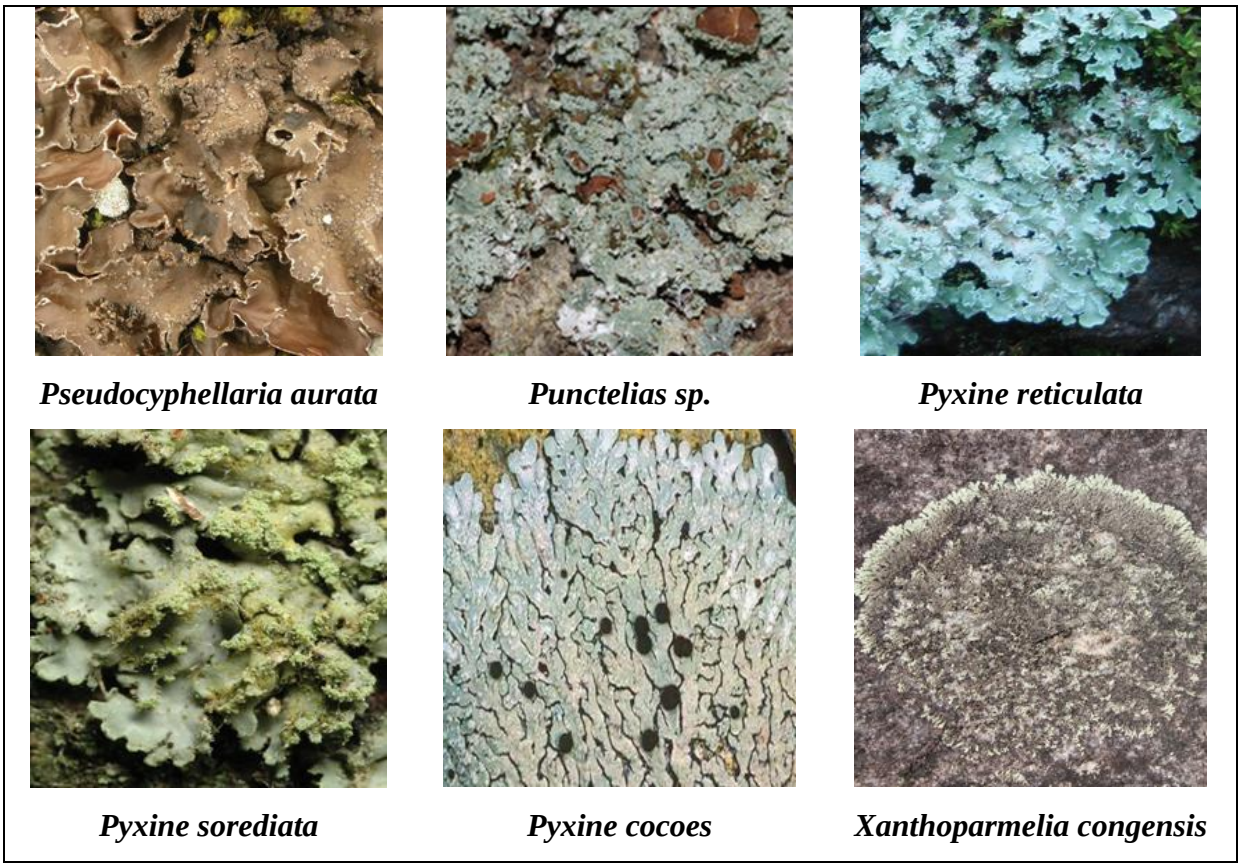


Plate 1: Pictorial representation of some foliose lichens occurring in the study area

Epiphytic lichens change hosts in different climatic regimes, even when the same host trees are present. Similar host specificity pattern of lichens in the upland forests of Wisconsin [36]. Macro and micro climatic conditions and bark characteristics of trees vary depending on the forest types and altitude. Although, light factor is important in the distribution of lichens, the availability of light is low inside evergreen forests when compare to deciduous forests. Bruiteg [37] observed that frequency, duration and form of precipitation are important for the distribution of lichens. In addition to precipitation, mist and fog may cause humid condition even where precipitation is low. This study is further useful for understanding distribution of bioresources of lower plants in the area. The baseline information on lichens in district will be useful for conservation policy making and biomonitoring studies keeping in view of global warming and climatic change.

ACKNOWLEDGMENT:

Authors are thankful to the Chairman, Department of Applied Botany, Kuvempu University, Shankarghatta, Shimoga and Management, Swamy Vivekananda Vidya Samsthe, Shikaripura, Shimoga and Karnataka Forest Department for permitting to carry out the present work.

REFERENCES:

1. Ahmadjian V. (1995), Bioscience, 45: 124.
2. Hale. M.E. (1983), Arnold Publishers Limited, London.
3. Schroeter, B. and L.G. Sancho. (1996), Lichenologist, 28(4): 385-390.
4. Sipman H.J.M. (1994), Lichenologist, 26: 311-312.
5. Upreti D.K. (1996), Flora and Fauna, 2: 159-161.
6. Upreti D.K. and S. Chatterje. (1999), Trop. Ecol., 40(1): 41-49.
7. Sequiera S and Muktesh Kumar. (2008), Trop. Ecol., 49(2): 211-224.
8. Cornelissen J.H.C. and H. Ter Steege. (1989), J. Trop. Ecology, 5: 131-150.
9. Komposch H. and J. Hafellner. (2000), Selbyana, 21: 1-24.
14. Negi H.R. (2003), Resonance, 8(1): 51-58.
10. Rose C.I. and D.L. Hawksworth. (1988), Nature, 289(5795): 289-292.
11. Wolsely P.A. and B.A. Huadson. (1997), J. Biogeography, 24: 327-343.
12. Burgaz A.R., E. Fuertes and A. Escudero. (1994), Vegetatio, 112: 73-86.
13. Wolseley P.A. and K.V. Peyor. (1999), Lichenologist, 31: 41-6.
15. Schmitt C.K. and N.G. Slack. (1990), Bryologist, 93: 257-274.
16. Cleavitt N.L., A.C. Dibble and D.A. Werier. (2009), The Bryologist, 112(3): 467-487.
17. Pipp A., C. Henderson R. and Callaway. (2001), Northwest Science, 75(1): 12-24.
18. Gamble J.S. and C.E.C. Fischer. (1997), Flora of the Presidency of Madras. Dehra Dun, India, Vol. I-III.
19. Neginhal S.G. (2004), Navbharath Press, Seshadripurum, Bangalore, 1-447.
20. Kricke R. (2002), Academic Publishers, Netherlands, 333-336.
21. Rosabal D., A.R. Burgaz and R.D. Masa. (2010), Bryologist, 113(2): 313-321.
22. Sipman H.J.M. and R.C. Harris. (1989), Ecosystems of the Word 14B, Elsevier, U.K.
23. Juriado, Liira J and Paa J. (2009), The Lichenologist 41(1): 81–96
24. Lesica P., B. McCune, S.V. Cooper and W.S. Hong. (1991), Canadian J. Bot., 69: 1745-1755.
25. Aptroot A. (1997), Lichenol., 68: 203- 213.

26. Aptroot A., P. Diederich, E. Serusiaux and H.J.M. Sipman. (1997), Lichenologica, 64: 1-239.
27. Kalb K. (2001), Lichenol., 78: 141–167.
28. Lucking R. and M. Matzer. (1996), Nova Hedwigia, 63(1-2): 109-144.
29. Sipman H.J.M. and A. Aptroot. (2001), Mycol. Res., 105(12): 1433-1439.
30. Brown J. H. and M. V. Lomolino. (1998), Biogeography. Sinauer Associates. USA.
31. Groombridge B. (1992), Chapman and Hall, London.
32. Schulze C.H., K.E. Linsenmair and K. Fiedler. (2001), Pl. Ecol., 153: 133-152.
33. Rosenzweig M.L. (1995), Cambridge University Press, New York, New York.
34. Schoener T.W. (1976), Australian Academy of Science, Canberra, pp. 629-642.
35. Pinokiyo A., K.P. Singh and J.S. Singh. (2008), The Lichenologist, 40(1): 47-62.
36. Hale M.E. (1955), Ecol., 36: 45-63.
37. Bruiteg I.E. (1993), Annals Botanic Fennici, 30: 161-179.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 10

BIODIVERSITY CONSERVATION WITH SPECIAL REFERENCE TO ORCHIDS

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Biodiversity is a composite word originated from 'biological diversity'

Biodiversity or 'Biological diversity' refers to the variations existing among living organisms (plants and animals) including terrestrial, epiphytic, marine and other aquatic habitats and the ecological composites to which they belong. These complexes include intra-specific (diversity within a species) and inter-specific (between species) variations [1]. The term 'biodiversity' encloses a wide range of variation in all biological life forms with diverse magnitude. The diversity of fauna and flora differs in various habitats, geographical regions and ecosystems. The variety of life exists at every hierarchical level in an ecosystem for instance genes within populations, populations within species, species within communities, communities within landscapes, landscapes within biomes, and biomes within the biosphere [2].

Broadly, the biodiversity is described by three indices as follows:-

1. Alpha (α) Diversity
2. Beta (β) Diversity
3. Gamma (γ) Diversity

Alpha (α) Diversity:

Alpha diversity refers to the species diversity within a habitat or community. It has two components, (a) species richness and (b) species evenness. Occasionally, the dominance of one vegetation layer may affect the α-diversity of the other strata.

Beta (β) Diversity:

Beta diversity refers to the variety is the inter-community diversity, articulating the rate of species turnover per unit alteration in the habitat.

Gamma (γ) Diversity:

Gamma diversity is the totality of the diversity at landscape level holding both α and β diversities. The relationship between α and β diversity is expressed by the following equation:-

g =++ a b Q

Where,

Q = Total number of communities or habitats

a = Average value of α diversities

b = Average value of β diversities

Levels of Biodiversity: Theoretically there are three levels of biodiversity.

These are:

1. Genetic Diversity; 2. Species Diversity; 3. Ecological diversity

Genetic Diversity:

Variation of genes within the species is referred as genetic diversity. This constitutes distinct population of the same species or genetic variation within population or varieties within a species.

Species Diversity:

Species diversity is the variety of species within a habitat or a region. In other words, the total number of species in a region is known as species diversity. Some habitats, such as rainforests and coral reefs, harbour variety of species. Many others, such as salt flats or a polluted stream, have fewer species. For instance, in Australia, there are more than 80% of animal and plant which are endemic to that region which means that they occur naturally only in Australia. According to shared or common features, a large number of species are clustered together into families. It is not just that individual species are endemic; entire families of plants and animals are endemic. The Australian continent embraces maximum number of families of mammals, four of birds and twelve of flowering plants that are endemic. No other country shows as many endemic flowering plant families as Australia.

Ecological Diversity:

The ecological diversity refers to the interaction among different species present in local ecosystem and the dynamic interplay between them, is known as ecological diversity. An ecosystem consists of numerous species living together in a locality that are linked with each other by flow of energy, nutrients, and matter of different species interact with one another.

THE MEGA-DIVERSITY REGIONS IN THE WORLD:

There are seventeen mega-diversity countries which are recognized by the World Conservation Monitoring Centre including Australia, Brazil, China, Colombia, Democratic Republic of the Congo (DRC), Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Papua New Guinea, Peru, the Philippines, South Africa, the United States of America (USA), and Venezuela. These countries have sheltered more than 70 % of the earth's species. To introduce diversification in agriculture (horticulture, floriculture etc.) business world over, valuable "gene pool" from these mega diverse regions are meticulously and judiciously utilized.

BIODIVERSITY HOTSPOTS IN INDIA:

India is exceptionally rich reservoir of biodiversity. In our country, floral diversity is mainly concentrated in the four major biodiversity hotspots, the Eastern Himalayas, Western Ghats, North-east India and Andaman Islands (Indo-Burma) and Nicobar Islands.

Bio-geographic Zones in India:

In India, there are 10 bio-geographic zones and 26 biotic provinces identified (Table 1)

Table 1. Bio-geographic Zones in India:

Sr. No.	Bio-Geographic Zones	Biotic Provinces
1.	Trans Himalaya	Tibetan Plateau, Ladakh Mountains
2.	Himalaya	North-west, West, Central and Eastern Himalaya
3.	Desert	Thar Kutch
4	Semi arid	Gujarat Rajputana, Punjab Plains
5	Western ghats	Western Ghats, Malabar Plains
6	Deccan- Penninsula	Central highlands, Central plateau, Chotta-Nagpur, Eastern highlands, Deccan south
7	Gangatic plains	Upper and lower gangetic plains
8	Coast	West and East coast, Lakshadweep
9	North east	North-east hills, Brahmaputra valley
10	Islands	Andaman and Nicobar islands

Total number of plant species in India:

India has only 2% total landmass of the world, still it constitutes one of the most significant biodiversity region in the world. Approximately 2,50,000 plant species are found in the world, out of which India harbours a total of approximately 45,000 species (Table: 2)

Table 2. Total number of plant species:

Plant Group	Number of species*[3]
Angiosperms	15,000
Gymnosperms	64
Pteridophytes	1,022
Bryophytes	2,584
Algae	2,500
Fungi	23,000
Bacteria	850
Lichens	1600

Table 3. Some angiosperm families depicting genus and species

Angiosperm family	Number of Genera and species [4]
Poaceae	263 genera / 1291 species
Orchidaceae	184 genera /1229 species
Leguminosae	173 genera / 1192 species
Asteraceae	167 genera / 950 species
Rubiaceae	113 genera / 616 species
Cyperaceae	38 genera / 545 species
Euphorbiaceae	84 genera / 528 species
Acanthaceae	92 genera / 510 species
Rosaceae and	40 genera / 492 species
Lamiaceae	72 genera / 454 species

In India, angiosperms comprise of 15,000 species including herbs, shrubs, trees, and climbers, trailers etc. which are grouped into monocotyledons and dicotyledons. The family Poaceae (= Gramineae) is the largest in India being represented by 263 genera containing

1291 species, followed by family Orchidaceae comprising (184/1229) and others [4]. Some of the angiosperm families with their genus and species count is represented in Table – 3.

The Eastern Himalayas encases approximately 8000 species of angiosperms of which 40% are endemic. The flora distinctively comprises of *Rhododendron*, *Alnus*, *Betula*, *Magnolia*, etc. Owing to the humid tropical climate, the Western Ghats is also a major biodiversity enriched area of the country. According to an estimate approximately 4,500 angiospermic flowering plants species occur in the Western Ghats. The Botanical Survey of India (BSI) has enlisted 518 endangered species which are endemic to the Peninsular India and most of them occur in the Western Ghats.

Predominantly, the angiosperm families such as Acanthaceae, Compositeae, Graminae, Labiatae, Leguminoseae, Orchidaceae, and Rubiaceae flourish well in the Western Ghats. Over 200 species of rare orchids are found here. Numerous other plants of economic importance such as banana, rice, black pepper, ginger, etc. grow as dense populations in the Western Ghats.

Figure 1A-D Orchids as cut-flowers and pot plants A. *Vanda cristata*, B. *Vanda coerulea* (a famous blue orchid), *Dendrobium* species, *Coelogyne ovalis*.

Among the monocot angiosperms, the family orchidaceae is a highly diverse group of flowering plants. The orchid are habitat specific and still in an active state of speciation. They are popular for their gorgeous and long-lasting flowers. They are amenable to variety

improvement and have added tremendously to the expansion of international trade in cut-flowers and potted plants (Figure 1 A-D).

The orchids are cultivated as a cash crop in various countries. They have carved a niche for themselves among top ten cut-flowers in the floriculture industry in the world. Besides enjoying the status of cut-flowers, the orchids as monocot herbs are also employed as folklore medicine in different parts of the world, to treat a variety of human ailments. The orchid species are also used as food. They are great 'nutraceuticals' since they harbour a variety of phytochemical compounds for instance alkaloids, flavonoids, phenenthrene derivatives, terpenoids, etc. Their bioactive compounds display immune-modulatory, hepatoprotective, anti-carcinogenic, antioxidant and neuroprotective activities. Many orchid species are valuable herbs such as *Angraecum*, *Bulbophyllum*, *Lissochilus*, *Listrostachys*, *Orchis mascula*, *O. maculata*, *Polystachya*, and *Spiranthes* are great aphrodisiacs [5]. Several orchids have been used in local system of medicines to cure nervous (*Cypripedium pubescens*, *Cymbidium elegans*, *Epipactis latifolia*), haematologic (*Habenaria edgeworthii*, *H. intermedia*, *H. pectinata*), dermal disorders (*Dendrobium alpestre*), digestive (*Dendrobium nobile*), reproductive (*Coelogyne* cristata, *Malaxis acuminata*) and rheumatic (*Rhynchostylis retusa*, *Vanda testacea*) ailments and for cooling purposes (*Coelogyne cristata*, *Saccolabium papillosum*) [6],[7]. Their additional uses as restorative drugs, gums, glues, narcotics and poisons are also indicated [5]. *Goodyera pubescens* and *Ansellia humilis* are used as antidote for snakebite and bad dreams respectively. *Vanda parviflora* and *Dendrobium chrysotoxum* have shown positive tests for its anti-cancerous properties and *Epipactis helleborine* and *Liparis ovata* as an antidote to HIV [8],[9]. *Malaxis acuminata* also known as 'Rishbhak' possess great therapeutic property.

Its dried pseudobulbs are used as an important ingredient of 'Ashtavarga' drugs used in the preparation of an ayurvedic medicine 'Chyavanprash'. The species is used to cure tuberculosis and is a great aphrodisiac [6]. This medicinally important orchid is faced with extensive collections and habitat destruction. The essence 'Vanillin', obtained from unripe pods of *Vanilla planifolia*, is the most important commercial produce of orchids. Curiously enough, the milch cattle in north-eastern India are fed on dendrobes and other orchids to enhance their milk yield [10]. A kind of tea is prepared from dried flowers of *Dendrobium chrysotoxum* that is effective in treating diabetes and strengthening reproductivity. www.natureproducts.net/Dendrobium/Dendrobium_chrysotoxum.html). Figure 2 A-B depicts some of the medicinal orchid species.

Figure 2 A – B. Medicinal Orchids

A. Plant of *Epipactis helleborine*, B. Plant *Habenaria edgeworthii*

In India, the orchids are represented by over 1,300 species, but their commercial cultivation is still in its infancy due mainly to non-availability of proper planting material and cultivation procedures. Being highly versatile, there is progressive loss of orchid diversity due to:

1. Unregulated collections which are made stealthily from their natural habitats
2. Forest destruction pressures.

As a result, they have become rare and figure among other endangered and threatened plant species in the Red Data Book prepared by IUCN.

Biodiversity Hotspots of Orchids in India:

The botanical hotspots of orchid flora in India include:

1. North-East Indian Himalayas
2. Western Himalaya
3. Western Ghats
4. Andaman and Nicobar Islands

These hotspots typically support a substantial ratio of biodiversity and endemic species of orchids. The orchid species diversity has yielded the significant insights into the evolutionary

and ecological processes in terms of speciation and extinction. Since the orchids have stringent habitat requirements which adds up to the status of their being rare and endangered.

PHYTOGEOGRAPHY AND DISTRIBUTION OF ORCHIDS IN INDIA:

In India, the orchid-rich spots are confined to North-Eastern region, chiefly the Eastern Himalaya, Meghalaya, Naga Hills and the Mizo or Lushai Hills and Sikkim; the North-Western Himalaya and the Western Ghats (the detached Pulney, Nilgiri and Biligirirangan Hills) [11]. In the Himalaya, Nepal and Bhutan also exhibit very rich orchid diversity. The distribution of orchids is not only restricted to the aforementioned regions but they have also spread in other parts of the country at different altitudes ranging from 150 m. to 2500 m. Most of them dwell extremely well in warm humid weather, preferring dense tropical rain forests, and also preferring temperate forests areas as well. Generally maximum diversity of orchid species is met within tropical region.

The North-Eastern region of India receives an annual rainfall ranging from 700 to 6,500 mm making the climate of the region highly humid. The warm and humid environment favours the growth of dense tropical evergreen rain forests which support luxuriant growth of diverse tropical orchid species. In the Eastern Himalaya, depending upon the orchid habitat, fundamentally four orchid-rich regions are recognized (Table 4) [12]

Table 4. Orchid rich zones and altitudes:

Orchid-rich Zone	Altitude
Tropical Evergreen rain-forest zone	170 - 900 m
Sub-tropical Forest zone (a) Mixed wet forest belt (b) Mixed or Pine (partially dry) forest belt	900 -1800 m
Temperate forest zone	1,800 - 3,500 m
Alpine forest zone	3,500 -5,000 m

In the tropical evergreen rain-forest area, both epiphytic and terrestrial genera such as *Bulbophyllum*, *Coelogyne*, *Dendrobium*, and *Eria* are commonly found. The *Bulbophyllum* species present in this zone are: *B. capillipes*, *B. clarkeanum*, *B. delitescens*, *B. hirtum*, *B. reptans*, *B. sikkimense*, *Dendrobium* species such as *D. acinaciforme*, *D. aduncum*, *D. anceps*, *D. aphyllum*, *D. cathcartii*, *D. cumulatum*, *D. lituiflorum*, *D. moschatum*, *D. nobile* etc.

The subtropical forest area receives relatively less rainfall. The climate remains cool and humid. Both epiphytic and terrestrial species thrive well in this zone. Besides terrestrial and epiphytes, some saprophytic orchid species, for instance *Cymbidium eburneum* and *Eulophia zollingeri* are also known to occur in mixed wet forest of this area. The mixed wet forest belt of this area is also known to be the home of 'Lost Lady Slipper Orchid' *Paphiopedilum fairieanum* where it thrives sporadically in West Kameng district [12] (Hegde, 1984). Some epiphytic species of *Bulbophyllum*, *Coelogyne*, *Cymbidium* and *Dendrobium* are invariably found in subtropical forest zone. The *Dendrobium* species present here are *D. chrysanthum*, *D. falconeri*, *D. wardianum*. The species grouped under *Bulbophyllum* are *B. acutifolium, B. affine, B. cauliflorum, B. leopardianum* etc.

The temperate forest area receives moderate rain-fall with frost forming heavy fog and short-period snowfall. A few of epiphytic and terrestrial orchid species grow in this forest. Among epiphytes, the *Bulbophyllum* species, and terrestrials such as *Calanthe mannii* and *Satyrium nepalense* grow. A saprophytic species *Galeola falconeri* grows very well in this zone.

The alpine area is snow-laden for almost 4-6 months. A few of terrestrial orchids are found growing in this zone. Nearly 700 species have been reported from North-Eastern India [13]. Approximately 18 genera are monotypics, represented by single species [14]. Epiphytic species are found in abundance in Darjeeling and Sikkim area due to high humidity and heavy rainfall as compared to the western Himalaya. The epiphytic orchids that grow at the lower altitudes in Darjeeling and Sikkim area are *Coelogyna cristata*, *C. uniflora*, *Cymbidium devonianum*, *C. elegans*, *Pholidota imbricata*, and *Thunia alba*. A survey of literature indicates that nearly 244 species grows in the North-West and Western Himalaya [15]; the genera that prevails in this region are *Bulbophyllum* (11), *Dendrobium* (15), *Eria* (9), *Habenaria* (17 spp.), *Liparis* (10), *Oberonia* (10), and *Peristylus* (10). *Dendrobium* Sw. is considered to be the largest genus containing 104 species and followed by *Bulbophyllum*. Sikkim alone harbours 532 orchid species out of 1229 that occur in India [16].

In the tropical Sikkim Himalaya, epiphytic species thrives best. These are *Bulbophyllum cornucervi*, *B. leptanthum*, *B. roxburghii*, *B. tortuosum*; *Dendrobium aphyllum, D. farmerii*, *D. formosum, D. jenkinsii*, *D. moschatum* [16] (Lucksom, 2007); are also distributed in this zone. In sub-tropical Sikkim Himalaya some epiphytic species such as *Bulbophyllum reptans, B. guttulatum, B. hirtum, Dendrobium chrysanthum, D. densiflorum, D. moschatum* are distributed.

The orchids have also adapted well in the tropical rain forests of Western Ghats. Due to heavy rainfall, the climate of western coastal plains has high moisture content besides high temperature that promotes the lush growth of epiphytic orchid species namely *Acampae praemorsa*; *Bulbophyllum acutiflorum*, *B. aureum*, *B. elegantulum*, *B. fimbriatum*, *B. fuscopurpureum*. *B. neilgherense*, *B. keralense*, *B. mysorense*, *B. nodosum*, *B. orezii*, *B. proudlockii*, *B. rheedei*, *B. rosemarianum*, *B. silentvalliensis*, *B. tremulum*; *Cymbidium aloifolium*; *Dendrobium macrostachyum*; *Luisia zeylanica*; *Pholidota pallida*; and a terrestrial orchid, *Eulophia epidendraea* [17]. As we get nearer to the mountain ranges there is an increase in density of orchid population. In the Western Ghats, the altitude of 300-600 m supports the growth of *Aerides ringens*, *Dendrobium ovatum*, *Oberonia brunoniana* and *Polystachya flavescens*. Going higher at an elevation of 600-1300 m in the rain forests does not allow enough light penetration in the dense canopy of trees, as a consequence, a few epiphytes and terrestrial orchids such as *Acanthephippium bicolor*, *Calanthe masuca* and *Eulophia macrostachya* grow in this zone. At the elevations of 1700-2300 m., the weather is quiet cold and dry; the terrestrial orchid *Habenaria* spp. thrives well. The orchid species above 2300 m gradually disappears [17].

Apart from the hotspots of orchid biodiversity in our country, some orchid species are also found dwelling in the Eastern Ghats. Although, the Eastern Ghats are not among the hotspots, they, as well, indicate the occurrence of orchids. The orchids growing here are *Bulbophyllum albidum*, *B. fusco-purpureum*, *B. neilgherrense*, *B. putidum*, *B. tremulum*; *Dendrobium aqueum*, *D. herbaceum*, *D. heyneanum*, *D. graminifolium*, *D. macrostachyum*, *D. microbulbon*, *D. ovatum*, etc.

The Indian peninsular region is endorsed with a high degree of endemism. The angiospermic flora of India is mostly endemic, which is next to Australia. It is considered to be the second richest endemic centre after the Himalaya [18]. The genus *Bulbophyllum* (15 species) and *Dendrobium* (11 species), *Habenaria* (25 species) *Oberonia* (17 species) are endemics to this region. The Peninsular region supports the highest degree of endemism as compared to the Western Ghats and even less in Eastern Ghats of India[19].It has been reported that 19 orchid species are endemic to the Himalayan region whereas 63 species are extensively distributed in the adjacent countries such as Bhutan, Nepal, Tibet, Pakistan and Afghanistan [15].

GEOGRAPHICAL AFFINITIES:

The orchid flora of India show geographical affinities with other regions of the world. Literature study indicates that the Western Himalaya orchid flora shows similarity with the Eurasian and Mediterranean species whereas Eastern-Himalayas also show prevalence of Indo-Malayan species. Alternatively, orchids of southern India show resemblance with the African as well as South-East Asian species. Some orchids of Southern India, such as *Cottonia peduncularis*, *Diplocentrum recurvum*, *Ipsea malabarica*, *Seidenfadeniella chrysantha*, *Sirhookera lanceolata*, and *S. latifolia* etc., also grow in Sri Lanka [20]. There are some orchids very common in India as well as other parts of Asian countries. The Burmese-Thai orchids for instance *Bulbophyllum crassipes, B. rufinum, Cleisostoma elegans* and *Coelogyne quadratiloba* also grow in the Andamans. Likewise, the orchids such as *Appendicula reflexa*, *Dendrobium pensile*, *Phalaenopsis tetrapsis* and *Schoenorchis minutifolia* growing in Malaysian region are also reported to be growing in Nicobar islands. The *Bulbophyllum* and *Dendrobium* are reported from both Andaman and Nicobar islands and Papua New Guinea.

THREATS TO BIODIVERSITY:

The major threat to biodiversity is the population explosion leading to the development of pressures such as construction of residential areas and setting up of industries, irrigation / hydel projects, clearing forests for agriculture purposes, firewood collection and unsustainable use of natural resources consecutively leads to severe habitat.

The International Union for Conservation of Nature and Natural Resources (IUCN) has contributed immensely in converging the world wide attention towards the extinction of species and has introduced the first Red Data Book in 1966 listing rare, endangered and threatened plant species by recognizing three threatened categories which are as follows:-

Critically Endangered (CR):

Those species having high risk of extinction in their natural habitat are categorized as critically endangered. It is the highest risk category assigned by the IUCN Red List for wild growing species.

Endangered (EN):

The taxa whose number has been reduced to a critical level or whose habitats have been so drastically reduced that they seemed to be in immediate danger of extinction.

Vulnerable (VU):

Species can be placed into endangered category in a condition when conservation measures are not followed.

Threatened:

Those species that are categorized under any one of the above categories is designated as "threatened."

Rare:

Those species which exists as a small population in restricted area and presently are not endangered or vulnerable but are at risk, are said to be rare.

The IUCN Red list is revised on annual basis. In India, for the first time, a list of threats to orchid species was prepared [21],[22],[23]. The first red data sheet on Indian orchids was prepared which supplemented the IUCN Plants Red Data Book [24,25,26]. A list of nearly 58 threatened species was also produced [27],[28],[29].

Under IUCN in 1984, the orchid conservation groups, such as the Orchid Specialist Group (OSG) was established. Since then, there are many regional groups like 'ISROSG' — 'Indian Subcontinent Regional Orchid Specialist Group' which have been established that embraces the Indian sub-continent region and gathers the information about the status and conservation of orchid species. Apart from IUCN, at the international level, several other treaties, have been established for the protection of biodiversity as a whole, encompassing the protection of wild orchids as well. The Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES), ratified by India, places whole family Orchidaceae under the Appendix II, meaning thereby that their trade will be only through export permits and few endangered species of orchids in Appendix I. The Appendix -1 orchid species are represented in Table 6.

Table 6. Orchid Genus and species categorized in Appendix I of CITES* (2017):

Sr. No.	Orchid species
1	*Aerangis ellisii*
2	*Dendrobium cruentum*
3	*Laelia jongheana*
4	*Laelia lobata*
5	*Paphiopedilum spp*
6	*Peristeria elata*

7	*Phragmipedium spp*
8	*Renanthera imschootiana*
* (https://cites.org/eng/app/E-Apr27.pdf)	

STRATEGIES TO CONSERVE BIODIVERSITY:

Conservation refers to preservation and utilization of the species. In broader term, the conservation is to protect wild plant and animal species in their natural habitat. Biodiversity conservation can be successfully accomplished following the proper scientific approach and society involvement. Basically, the conservation of plant genetic diversity is achieved by the following:-

1. *In-situ* conservation
2. *Ex-situ* conservation

***In-situ* conservation:**

In situ conservation is exclusively concerned with the conservation of wild growing plant species. The conservation is achieved through protection of the species in nature. A species that is conserved in its natural habitat or native place where it thrives naturally is known as *in-situ* conservation. It includes Biosphere reserves, cultural landscapes, national parks, sacred sites, sacred grooves, wild-life sanctuaries, gene banks and forest protected areas etc. In nature, plant diversity, can be conserved on long-term basis at the genetic, species and ecosystem level. The establishment of protected area network has become central in all policy decision processes that are related to the biodiversity conservation at national and international level.

Conservation strategies are also adopted for orchids. The orchid sanctuaries, biosphere reserves, National Orchid and Biodiversity Park are established (Table 7).

Table 7. Sites of *in situ* conservation of orchids:

Sr. No.	Sites	State
1.	Kaziranga National Orchid and Biodiversity Park	Golaghat & Nagaon district, Durgapur, Assam
2.	Sessa orchid sanctuary	West Kameng District, Arunachal Pradesh
3.	Deorali orchid sanctuary	Gangtok, Sikkim
4.	Nilgiri Biosphere Reserve*	Western Ghats & Nilgiri Hills, South India.
5.	Pachmarhi Biosphere Reserve	Madhya Pradesh

**An International Biosphere Reserve. 175 species of orchids are found in the Nilgiri Biosphere Reserve of which eight are endemic. These include endemic and endangered species of Bulbophyllum, Liparis, Thrixspermum and Vanda.*

The success of any conservation programme depends upon meticulous supervision of the protected areas. In India, a large population resides in nearby forests areas which are declared as protected areas by the state forest department. Therefore, it becomes necessary to sensitize the local communities about the need to protect the plant species. This could be achieved by conversing with them about the value of plants in our day to day life. This approach would generate their interest in conservation activities by their active participation

***Ex-Situ* Conservation**:

Ex-situ conservation refers to the conservation external to the natural habitat. It is accomplished, by cultivating and maintaining endangered plants in the botanic gardens, parks, farmer's field, R&D research centres, universities, Botanical Survey of India etc. and through long term *in vitro* conservation of plant germplasm in the gene banks, seed banks, and pollen banks, DNA libraries, and also through cryopreservation and plant tissue culture techniques (Figs.3A-C).

Figure 3A-B. A. *In vitro* asymbiotic seed germination of *Dendrobium* species; B. Protocorm and leaf stage; C. Seedlings maintained in liquid medium

Some of the laboratories/centres of national repute are actively engaged in *ex situ* conservation of orchid research in the country are:-

- Centre for Orchid Gene Conservation of eastern Himalayan Region, Manipur
- Department of Plant Breeding and Genetics, Assam Agricultural University, Johrat, Assam

- National Research Centre for Orchids, Pakyong, Sikkim
- National Bureau of Plant Genetic Resources, New Delhi
- Orchid Laboratory, Department of Botany, Panjab University, Chandigarh
- Orchid Laboratory, Department of Botany, Karnatak University, Dharwad, Karnataka
- Orchid Biology and Conservation Unit**,** Jawaharlal Nehru Tropical Botanic Garden and Research Institute Palode, Kerala

Botanical gardens support *ex situ* conservation of plants, especially those facing extreme threat of extinction. Several gardens in the world are specialised in orchid cultivation such as:-

- National Orchid Garden, Singapore, Chicago Botanic Garden, USA
- Missouri Botanic Garden, USA
- Soroa Orchid Botanical Garden, Havana
- Botanical Garden, Panjab University, Chandigarh, India

REFERENCES:

1. Convention on Biological Diversity. (1992), Conv. Biol. Div. P. 28.
2. Wilson, E. O. (1988), Biodiv. P. 538.
3. Rao, R.R. (1994),Biodiversity in India. P. 315.
4. Singh, P. and Dash, S.S. (2014), B S. I. Kolkata.
5. Arditti, J. (1992), *John Wiley* & *Sons* Inc. U.S.A. P. 704.
6. Chauhan, N. S. (1990), J. Orchid Soc. India. 4, P. 99–105.
7. Lawler, L. J. (1984), Cornell University Press, NY. P. 27–149.
8. Chen, Y.Y., Li, Q., Chen, Y.Z., Liu, Y. (2008), Food Chem. 108, P. 973-976.
9. De clercq E.1994. Eur. J. Pharm. Sci. 2, P.4-6.
10. Pempahishey, K.T. (1974), Amer. Orchid Soc. Bull. 43, P. 716-725.
11. Rao, A.S. (1979), National Book Trust. P.104.
12. Hegde, S.N. (1984).Orchids of Arunachal Pradesh. Forest department, Itanagar.
13. Kataki, S.K., S.K. Jain and A.R.K. Sastry. (1984), Plant Conserve. Bull. 5.1-38.
14. Singh, D.K. (2001), Orchids Science and Commerce. P. 35–65.
15. Samant, S. S. (2002), J. Orchid Soc. India. 16. 65-74.
16. Lucksom, S.Z. (2007). The Orchids of Sikkim and North East Himalaya. P. 984.
17. Abraham, A. and Vatsala, P.(1981), Introduction to Orchids. St Joseph's Press. Trivandrum, India

18. Jalal J.S., and Jayanthi, J. (2012), J. Threatened Taxa, 12, P. 3415-3425.
19. Nayar, M.P. (1996), Hot Spots of Endemic Plants of India, Nepal and Bhutan. P. 252pp.
20. Kumar, C.S. and Manilal, K.S. (1994). A Catalogue of India Orchids. Dehradun. P.162.
21. Pradhan, U.C. (1971). American Orchid Society Bulletin, 40:4
22. Pradhan, U.C. (1975a). Proceedings of Eigth World Orchid Conference. 555pp.
23. Pradhan, U.C. (1975b). Proceedings of Eigth World Orchid Conference. 555pp
24. Pradhan, U.C. (1978a), *Dendrobium pauciflorum*. IUCN Plant Red Data Book, P. 363.
25. Pradhan, U.C. 1978b. *Diplomeris hirsuta.* IUCN Plant Red Data Book, P. 365.
26. Pradhan, U.C. 1978c. *Paphiopedilum druryi*. IUCN Plant Red Data Book, P. 377.
27. Nayar, M.P., and Sastry, A.R.K. (1987). Red Data Book of Indian Plants. Volume I. B. S. I., P.1-1371
28. Nayar, M.P., and Sastry, A.R.K. (1988). Red Data Book of Indian Plants. Volume II. B.S. I., P.1-273.
29. Nayar, M.P., and Sastry A.R.K. (1990). Red Data Book of Indian Plants. Volume III. B. S. I., P.1-279.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 11

PLANT DIVERSITY ASSESSMENT IN *CUPRESSUS TORULOSA* D.DON FOREST IN NAINITAL, CENTRAL HIMALAYA'S

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ABSTRACT:

The study of plant community structure is called plant sociology or phytosociology and this study is important for understanding the functioning of community. *Cupressus* Linn. Commonly known as cypress is one of the important genus of family Cupressaceae. The genus has wide and discontinuous distribution in Northern Hemisphere. It consists of 20 species growing at different altitude at different places. *Cupressus torulosa* D.Don commonly known as Himalayan cypress is an evergreen conifer tree species distributed throughout the Himalayan region along an elevation belt of 1800 to 2800 m asl. In Nainital, cypress is found wild at the slopes of china hill on shale but not far from limestone. In the present study plant diversity assessment is assessed in a *Cupressus torulosa* D.Don forest of Nainital, Kumaun Himalaya.

KEYWORDS: Community, phytosociology, distributed, assessment.

INTRODUCTION:

Study of plant community structure is called plant sociology or phytosociology and it is important for understanding the functioning of community [1]. *Cupressus* Linn. Commonly known as cypress is one of the important genus of family Cupressaceae. The genus has wide and discontinuous distribution in Northern Hemisphere. It consists of 20 species growing at different altitude at different places

Cupressus torulosa D.Don commonly known as Himalayan cypress is an evergreen conifer tree species distributed throughout the Himalayan region along an elevation belt of 1800to 2800 masl [2]. In Nainital, cypress is found wild at the slopes of china hill on shale but not far from limestone.

In the present study plant diversity, population structure, biomass and carbon stock was assessed in a *Cupressus torulosa* D.Don forest of Nainital, Kumaun Himalaya.

MATERIALS AND METHODS:

Study Area:

Figure 1. Bird eye view of *C. torulosa* forest

- The study sites were selected between 2200-2300m above mean sea level (between 29°19'-29°28' N latitude and 79°22'-79°38' E longitude) in Nainital, Kumaun Himalaya.
- This area mainly lies in the hilly tract of the district Nainital in Uttarakhand.
- Originally, the study area was dominated by *C. torulosa* forest.

Site was further divided into three sub sites viz. Hill base, Hill slope and Hill top

Hill base area **Hill slope area** **Hill top area**

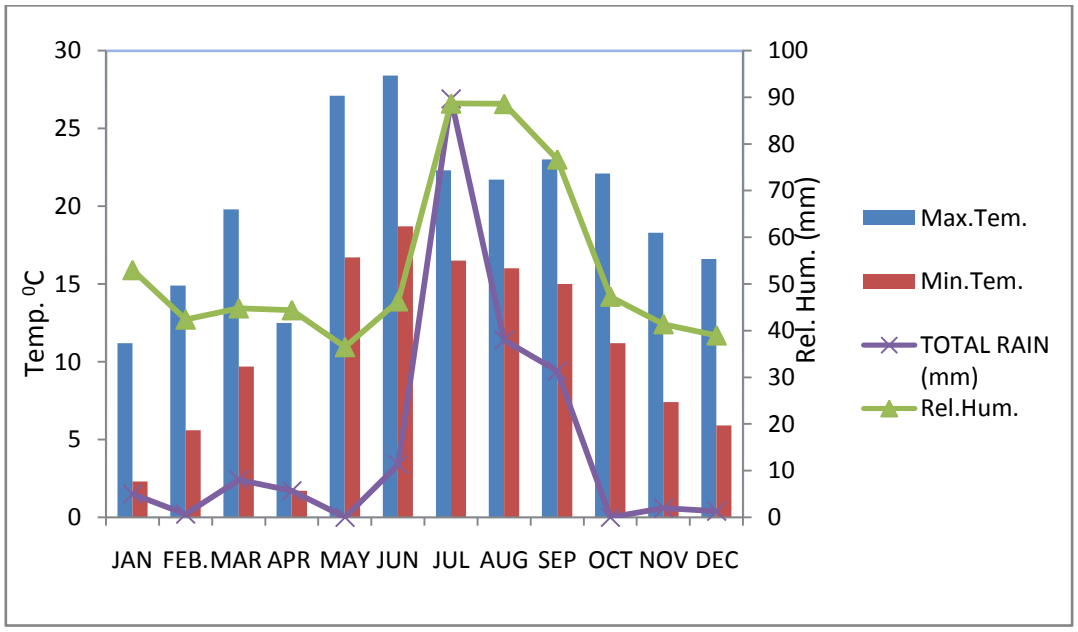

Figure 2. Monthly metrological observations of 2012 (source: GIC Nainital)

METHODS:

- The number and size of the quadrats were determined by the running mean method [3] and species area curve [4].
- Ten plots of 10 x 10m were randomly established at hill base, slope and top for determination of species richness and other vegetational parameters.
- Trees and saplings were analysed in 10x10 m, shrubs in 5x5 m and seedlings and herbs in 10, 1x1m quadrat within each plot [5].
- Circumference at breast height (cbh at 1.37m from the ground) of all the trees and saplings was measured in each plot.
- The vegetational data were quantitatively analysed for frequency, density, abundance, basal area, IVI, species richness, diversity, concentration of dominance by using standard ecological mehods [5].

RESULTS AND DISCUSSION:

Tree Layer:

Table 1. Phytosociology of tree layer in *C. torulosa* forest:

Position on Slope	A	D (ind ha-1)	F (%)	A/F	MBA (m2 ind-1)	TBA (m2 ha-1)	IVI
Hill Base							
Cupressus torulosa	4	360.00	90.00	0.04	0.038	13.55	205.40
Cedrus Deodara	1	40.00	40.00	0.03	0.102	4.10	55.15
Quercus floribunda	2	60.00	30.00	0.07	0.024	1.46	39.43
Total		**460.00**				**19.11**	
Hill Slope							
Cupressus torulosa	4.1	410.00	100.00	0.04	0.050	20.50	225.37
Cedrus deodara	1.83	110.00	60.00	0.03	0.035	3.85	74.52
Total		**520.00**				**24.35**	
Hill Top							
Cupressus torulosa	6	**600.00**	100.00	0.06	0.097	**58.20**	300.00

Sapling Layer:

Table 2. Phytosociology of sapling layer in *C. torulosa* forest:

Position on Slope	A	D (ind ha-1)	F (%)	A/F	MBA (m2 ind-1)	TBA(m2 ha-1)	IVI
Hill Base							
C.torulosa	4.44	400	90	0.05	0.0034	1.35	209.4
P.cerasoides	0.8	60	50	0.02	0.0021	0.12	45.71
Q. floribunda	0.8	40	50	0.02	0.0044	0.17	44.86
Total		**500**				**1.65**	
Hill Slope							
C.torulosa	4.57	320	70	0.06	0.0034	0.78	154.09
P.cerasoides	1	20	20	0.05	0.0035	0.07	19.37
Q. floribunda	3	90	30	0.10	0.0022	0.19	46.66

Q. leucotrichophora	1	20	20	0.05	0.0014	0.02	15.80
C.deodara	1.4	70	50	0.028	0.0049	0.34	64.06
Total		**520**				**1.4**	
Hill Top							
C. torulosa	1.6	80	50	0.03	0.0035	0.28	141.54
P.cerasoides	1	30	30	0.03	0.0013	0.04	52.14
F.nemoralis	2	20	10	0.20	0.0033	0.06	32.11
R.purpurea	7	70	10	0.70	0.0023	0.16	74.19
Total		**200**				**0.54**	

Seedling Layer:

Table 3. Phytosociology of seedling layer in *C. torulosa* forest:

Position on Slope	A	D (ind. ha-1)	F (%)	A/F	PV
Hill Base					
P.cerasoides	2.88	230	80	0.04	94.37
C. torulosa	2.60	130	50	0.05	55.86
Q. floribunda	0.75	50	40	0.03	27.87
Q.leucotrichophora	2.50	30	20	0.13	21.88
Total		**440**			
Hill Slope					
C. torulosa	2	60	30	0.07	41.42
Q. floribunda	3.66	110	30	0.12	58.08
P.cerasoides	1.625	130	80	0.02	100.47
Total		**300**			
Hill Top					
C.torulosa	1.2	60	50	0.02	45
P.cerasoides	2.14	150	70	0.03	85
F.nemoralis	1	50	50	0.02	41.66
R. purpurea	1	40	30	0.04	28.33
Total		**300**			

Table 4. Phytosciological characterstics of the three study sites:

Parameters	Sites		
	Hill Base	**Hill Slope**	**Hill Top**
Tree layer			
Species richness	**03**	**02**	01
Density	460.00	520.00	600.00
TBA	19.11	24.35	58.20
H'	0.96	0.74	-
CD	0.64	0.67	-
Equability(e)	0.88	1.07	-
Sapling layer			
Species richness	3	5	4
Density	500	520	200
TBA	1.65	1.4	0.54
H'	0.86	1.60	1.80
CD	0.74	3.31	1.31
Equability(e)	0.98	1.00	1.29
Seedling layer			
Species richness	4	3	4
Density	440	300	300
H'	1.62	1.51	1.88
CD	0.39	0.36	0.42
Equability(e)	1.18	1.39	1.35
Shrub layer			
Species richness	6	8	6
Density	5380	3046	1303
Herb layer			
Species richness	15	12	18
Density	5110.8	10320	15480

Index of similarity:

- Index of similarity (IS) was calculated [6] as:
- **IS= 2C x 100 / (A+B)**
- Where, A the number of species in stand A, B the number of species in stand B and C common species in both the stands.
- On the basis of percent similarity, HB and HS were 80 % similar in tree layer.
- 85.7% similar in shrub layer.
- 81.4% similar in herb layer.
- The HS and HT were 66.6% similar in tree layer.

- 50% similar in shrub layer.
- 80% similar in herb layer.
- The HB and HT were 50% similar in tree layers.
- 57.1% in shrub layer.
- 66.6% similar in herb layer.

SUMMARY:

- A total of 29 species were reported, of these 03 were trees, 08 were shrubs and 18 were herbs.
- The total density value of trees was 460-600 trees ha^{-1} and the total basal area between 19.11 to 58.31m^2 ha^{-1} of which *C.torulosa* contributed 70% to 100%.
- The sapling density ranged between 200 and 520 individual ha^{-1} and it was maximum at hill top.
- The Seedling density ranged between 300-400 individual ha^{-1} and it was maximum at hill base.
- The density of shrubs in the present study ranged between 1303 ind.ha^{-1} and 5380 ind. ha^{-1}.
- In this forest the number of herbs species varied from 12 at hill base 18 at hill top while herb density ranged from 5110 ind ha^{-1} to 15,480 ind ha^{-1}.
- The diversity (H') raged between 0.28 and 0.38 at Hill Base and 0.27 and 0.47 at Hill Slope.
- Concentration of dominance ranged between 0.007 and 0.61 at Hill Base and 0.05 and 0.62 at Hill Slope
- At Hill Top only one tree species i.e. *C.torulosa* was present so diversity parameters could not be calculated
- Most of the species showed random or contagious type of distribution pattern.

REFERENCES:

1. Sing, E. and Singh, M. P. (2010), Int. J. Biol. Life sci., 6(2): 77-82
2. Shahni KC (1990), Gymnosperms of India and addjacent countries. Dehradun, India
3. Kershaw KA (1973), Edward Arnold Ltd. London.pp 308.
4. Misra R (1968), Ecology Work Book.Oxford Publishing Company, Calcutta.
5. Curtis JT,McIntosh RP(1950),Ecol.31:434-455.
6. Mueller-Dombois D, Ellenburg H (1974), J. Wiley and Sons, Inc.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 12

BRYODIVERSITY, DISTRIBUTION, THREATS AND CONSERVATION OF LIVERWORTS AND HORNWORTS FROM FORTS OF KOLHAPUR DISTRICT

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ABSTRACT:

Bryodiversity, including liverworts and hornworts strongly concentrated in the humid tropics is ecologically very significant. The present paper provides the first hand consolidated account 41 species of liverworts and hornworts belonging to 18 genera and 12 families from forts of Kolhapur District which includes detailed account of the bryodiversity and distribution. Also causes of threats and action plan for their conservation, monitoring and management has been suggested.

INTRODUCTION:

Liverworts and hornworts are small terrestrial plants that grow closely packed together in mats or cushions found in all habitats and climatic conditions except marine environment. In India there are about 930 species of liverworts and hornworts belong to 140 genera and 59 families out of which 834 species, 16 subspecies, 39 verities and 2 forma belong to 134 genera, 56 families of liverworts and 39 species belong to 6 genera in 3 families of hornworts. As far as Maharashtra is concerned 72 species of liverworts and hornworts belong to 25 genera and 18 families were reported of which 52 species are of liverworts, 20 species are of hornworts [1].

BRYODIVERSITY AND STATUS:

Kolhapur is the southernmost district of Maharashtra state with geographical area of about 7685 sq kms located between 17° 17′ to 15° 43′ North latitudes and 73° 40′ to 74° 42′

East longitudes at an average elevation from 390 to 900 meters entirely in the Panchganga basin. It includes the main range of Sahyadri running North-South on Western Side and large spurs which stretch North-East and East from Sahyadris and valleys with about 16 forts of historical and botanical interest *viz*., Aajra, Bhudargad, Chandgad, Gagangad, Gandharvgad, Hanumantgad, Kalanidhigad, Mahipaalgad, Paargad, Paavangad, Panhala, Saamangad, Shivgad, Vallabhgad, Vilasgad and Vishalgad [2].

The present comprehensive survey from forts of Kolhapur District records 41 species belonging to 18 genera of liverworts and hornworts [2].

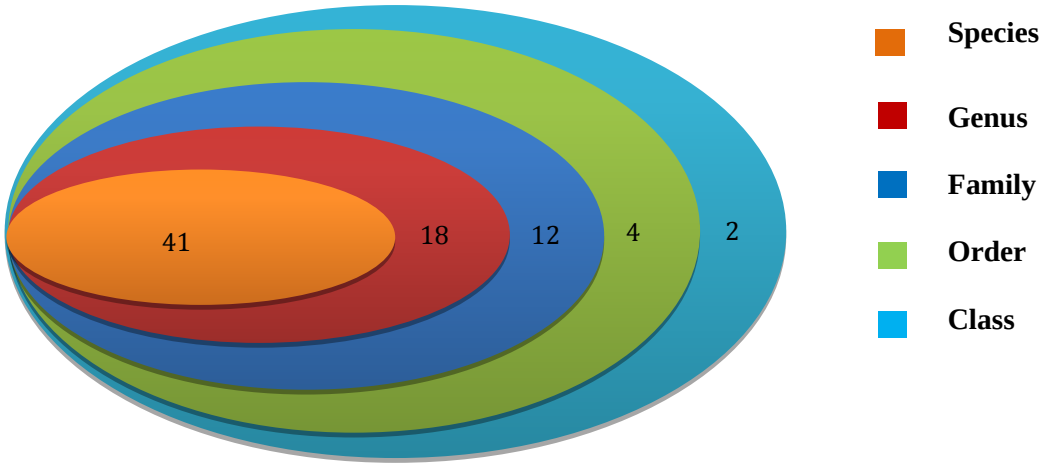

Figure 1. Diversity of Liverworts and Hornworts in from few forts of Kolhapur District

These 18 genera are spread over 10 families of 04 orders **(Fig. 1).** 14 genera and 31 species were belonging to the group Hepaticopsida while 04 genera and 10 species were belonging to the group Anthocerotopsida. Amongst these 07 species were reported as new distributional records for Maharashtra. Amongst the order Marchantiales had maximum number of genera **(Table 1 and 2)**.

Table 1: Distribution of genera and species of Liverworts and Hornworts from forts of Kolhapur District

Sr. No.	Orders	Families	Genera	Species
1.	Jungermanniales	2	4	07
2.	Metzgeriales	4	5	07
3.	Marchantiales	4	5	17
4.	Anthocerotales	2	4	10
TOTAL		12	18	41

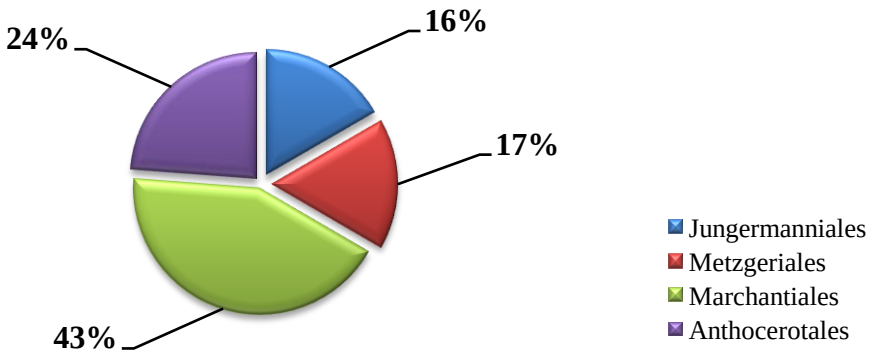

Fig. 2: Pie chart showing number (in %) of species in various orders of Liverworts and Hornworts from few forts of Kolhapur District

It was also the most specious order **(Fig. 2).** Marchantiales is the most dominant order in on forts of Kolhapur District, followed by Anthocerotales, Metzgeriales and Jungermanniales.

The present study revealed the occurrence of 41 taxa (31 liverworts and 10 hornworts) belonging to 3 orders, 10 families and 14 genera of Hepaticae and 1 order, 2 families and 4 genera of Anthocerotae in the Kolhapur District of Maharashtra (Table 1.1 and 1.2). This accounts for 4.1 percent of total Indian liverworts and hornworts.

Marchantiales with 17 species belonging to 5 genera and 4 families is the largest order within the study area followed by Anthocerotales with 10 species belonging to 4 genera and 2 families. The order Jungermanniales and Metzgeriales are represented by 7 species each belonging to 4 genera and 2 familess and 5 genera and 4 families respectively. Ricciaceae and Anthocerotaceae are the largest families each with 8 species followed by Lejeuneaceae (5 species), Aytoniaceae (4 species), Aneuraceae and Cyathodiaceae (each with 3 species) whereas Jungermanniaceae, Fossombroniaceae, Targionaceae and Notothyladaceae are represented by 2 species each. Two families *viz*., Metzgeriaceae and Pallaviciniaceae are represented by just a single species.

At lower taxonomic level, genus *Riccia* L. with 8 species is the largest genus followed by *Anthoceros* L. (4 species), *Cyathodium* Kunze, *Lejeunea* Lib., *Plagiochasma* Lehm. & Lindenb. and *Phaeoceros* Prosk.(3 species each) and *Fossombronia* Raddi, *Notothylas* Sull. *Riccardia* Gray, *Solenostoma* Mitt., *Targionia* L. (2 species). Seven genera viz., *Aneura* Dumort., *Archilejeunea* (Spruce) Schiffn., *Asterella* P. Beauv., *Cheilolejeunea* (Spruce) Schiffn., *Folioceros* D.C. Bharad., *Metzgeria* Raddi., and *Pallavicinia* Gray, are represented by just a single apecies.

Table 2: Number of genera and species in each family of Liverworts and hornworts on forts of Kolhapur District

Sr. No.	Name of order/ family	Number of	
		Genera	Species
I.	**Jungermanniales**		
1.	Jungermanniaceae	1	2
2.	Lejeuneaceae	3	5
II.	**Metzgeriales**		
3.	Aneuraceae	2	3
4.	Metzgeriaceae	1	1
5.	Fossombroniaceae	1	2
6.	Pallaviciniaceae	1	1
III.	**Marchantiales**		
7.	Aytoniaceae	2	4
8.	Cyathodiaceae	1	3
9.	Targioniaceae	1	2
10.	Ricciaceae	1	8
11.	**Anthocerotales**		
12.	Anthocerotaceae	3	8
13.	Notothyladaceae	1	2

DISTRIBUTION OF LIVERWORTS AND HORNWORTS:

DISTRIBUTION ON THE BASIS OF ALTITUDE:

The altitudinal gradient is a complex one and varied in climate, edaphic and biotic factors. With increasing elevation, there is decrease in temperature and an increase in precipitation, relative humidity and increases soil moisture [3]. The composition of liverworts and hornworts varies along the altitude. Some species are strictly growing at high altitude whereas some are growing at low altitude. The maximum composition of liverworts and hornworts was observed at high altitude. Therefore, it is one of the limiting factor on which distribution of liverworts and hornworts is greatly depends. The maximum height of Kolhapur district is 1000 m. The observed liverworts and hornworts at various altitudes are given below,

a. Foothills Zone (below the 500 m): The zone is occupied by following liverworts and hornworts: *Asterella wallichiana, Cyathodium cavernarum, C. tuberosum C. epiphytens, Riccia cavernosa, R. crystallina, R. discolor, Targionia hypophylla, Anthoceros erectus etc*.

b. Middle Hill Zone (between 500 –750 m): The zone occupied by the following liverworts and hornworts: *Anthoceros bharadwajii, A. crispulus, A. erectus, A. subtilis,*

Asterella wallichiana, Cyathodium cavernarum, C. tuberosum, C. epiphytens, Notothylas indica, Phaeoceros laevis, Plagiochasma appendiculatum, P. intermedium, P. pterospermum, Riccia cavernosa, R. crystallina, R. discolor, R. frostii, R. plana and Targionia hypophylla, etc.

c. High Elevation Zone (above 750 m): Here, the climate is very cool with high atmospheric moisture and high soil moisture which helps liverworts and hornworts to proliferate extensively. Maximum number of liverworts and hornworts found here *e.g. Aneura pinguis, Anthoceros bharadwajii, A. crispulus, A. erectus, A. subtilis, Archilejeunea minutiloba, Asterella wallichiana, Cheilolejeunea intertexta, Cyathodium cavernarum, C. tuberosum, C. epiphytens, Fossombronia himalayensis, Folioceros dixitianus, Lejeunea discreta, L. flava, L. tuberculosa, Metzgeria himalayensis, Notothylas indica, N. levieri, Phaeoceros laevis, Plagiochasma appendiculatum, P. intermedium, P. pterospermum, Riccardia levieri, R. santapaui, Riccia. crystallina, R. fluitans, R. melanospora, Pallavicinia lyellii, Solenostoma fossombronioides, S. tetragonum, Targionia hypophylla, T. hypophylla* var. *sinhgarhii etc.*

DISTRIBUTION ON THE BASIS OF RAINFALL:

The average rainfall of Kolhapur district is 1645 mm per year. Eastern part of the district like Shirol, Haatkangle and part of Kagal tehsils experiences very low rain (500 mm per year) while, the Western part of a district like Chandgad, Ajara, Bhudargad, Radhanagari, Gaganbawda, Panhala is having high rainfall (6000 mm per year) and rest of having moderate rainfall (2000-3000 mm per year). On this basis liverworts and hornworts of Kolhapur district were grouped into three categories as follows:

a. High Rainfall Zone (more than 3000 mm per annum): It is one of the important climatic factors that restrict the distribution of liverworts and hornworts because liverworts and hornworts are water loving plants, grow well where the water content is high in the atmosphere and soil. Maximum numbers of liverworts and hornworts were collected from this region. They are as follows: *Aneura pinguis, Anthoceros bharadwajii, A. crispulus, A. erectus, A. subtilis, Archilejeunea minutiloba, Asterella wallichiana, Cheilolejeunea intertexta, Cyathodium cavernarum, C. tuberosum, C. epiphytens, Fossombronia himalayensis, F. indica, Folioceros dixitianus, Lejeunea discreta, L. flava, L. tuberculosa, Metzgeria himalayensis, Notothylas indica, N. levieri, Pallavicinia lyellii, Phaeoceros laevis, Plagiochasma appendiculatum, P. intermedium, P. pterospermum, Riccardia levieri, R. santapaui, R. cavernosa, R. crystallina, R. discolor, R. fluitans, R. frostii, R. glauca, R.*

melanospora, R. plana, Pallavicinia lyellii, Solenostoma fossombronioides, S. tetragonum, Targionia hypophylla, T. hypophylla var. *sinhgarhii etc.*

b. Moderate Rainfall Zone (above 1000 mm but below 3000 mm per annum): The liverworts and hornworts growing in this zone are as follows: *Anthoceros bharadwajii, A. crispulus, A. erectus, Archilejeunea minutiloba, Asterella wallichiana, Cyathodium cavernarum, C. tuberosum, C. epiphytens, Folioceros dixitianus, Lejeunea discreta, Notothylas indica, N. levieri, Phaeoceros laevis, Plagiochasma appendiculatum, P. intermedium, P. pterospermum, Riccardia levieri, Riccia crystallina, R. discolor, R. fluitans, Solenostoma fossombronioides, Targionia hypophylla* etc.

c. Low Rainfall Zone (below 1000 mm per annum): Very few species were adapted to this region they are, *Anthoceros erectus, Asterella wallichiana, Cyathodium tuberosum, Notothylas indica, Plagiochasma appendiculatum, P. articulatum, P. pterospermum, Riccia crystallina, R. discolor, R. frostii, R. glauca, Solenostoma fossombronioides* and *Targionia hypophylla* etc.

DISTRIBUTION BASED ON TEMPERATURE:

It is one of the important climatic factors on which distribution of liverworts and hornworts depend. A very little change in temperature affects the diversity of liverworts and hornworts. During the present investigation liverworts and hornworts were grouped into three different categories based on the temperature as given below:

a. Low Temperature Zone: (below 20^0 C): Species growing are: *Aneura pinguis, Anthoceros bharadwajii, A. crispulus, A. erectus, A. subtilis, Archilejeunea minutiloba, Asterella wallichiana, Cheilolejeunea intertexta, Cyathodium cavernarum, C. tuberosum, C. epiphytens, Fossombronia himalayensis, F. indica, Folioceros dixitianus, Lejeunea discreta, L. flava, L. tuberculosa, Metzgeria himalayensis, Notothylas indica, N. levieri, Pallavicinia lyellii, Phaeoceros laevis, Plagiochasma appendiculatum, P. intermedium, P. pterospermum, Riccardia levieri, R. santapaui, R. cavernosa, R. crystallina, R. discolor, R. fluitans, R. frostii, R. glauca, R. melanospora, R. plana, Pallavicinia lyellii, Solenostoma fossombronioides, S. tetragonum, Targionia hypophylla* and *T. hypophylla* var. *sinhgarhii* etc.

b. Moderate Temperature Zone (above 20^0 C but below 28^0 C): The liverworts and hornworts growing in this zone are as follows: *Anthoceros bharadwajii, A. crispulus, A. erectus, Archilejeunea minutiloba, Asterella wallichiana, Cyathodium cavernarum, C. tuberosum, C. epiphytens, Folioceros dixitianus, Lejeunea discreta, Notothylas indica, N.*

levieri, Phaeoceros laevis, Plagiochasma appendiculatum, P. intermedium, P. pterospermum, Riccardia levieri, Riccia crystallina, R. discolor, R. fluitans, Solenostoma fossombronioides, and *Targionia hypophylla* etc.

c. High Temperature Zone (above 28^0 C): Very few species were adapted to this region. They are *Anthoceros erectus, Asterella wallichiana, Cyathodium tuberosum, Notothylas indica, Plagiochasma appendiculatum, Riccia crystallina, R. discolor, Solenostoma fossombronioides* and *Targionia hypophylla* etc.

DISTRIBUTION BASED ON ATMOSPHERIC HUMIDITY:

Liverworts and hornworts are very sensitive to the change in atmospheric humidity. On this basis liverworts and hornworts are grouped into 3 perspective categories as follows

a. High Humidity Zone (above 70%): The liverworts and hornworts which grow in this zone are: *Aneura pinguis, Anthoceros bharadwajii, A. crispulus, A. erectus, A. subtilis, Archilejeunea minutiloba, Asterella wallichiana, Cheilolejeunea intertexta, Cyathodium cavernarum, C. tuberosum, C. epiphytens, Fossombronia himalayensis, F. indica, Folioceros dixitianus, Lejeunea discreta, L. flava, L. tuberculosa, Metzgeria himalayensis, Notothylas indica, N. levieri, Pallavicinia lyellii, Phaeoceros laevis, Plagiochasma appendiculatum, P. intermedium, P. pterospermum, Riccardia levieri, R. santapaui, R. cavernosa, R. crystallina, R. discolor, R. fluitans, R. frostii, R. glauca, R. melanospora, R. plana, Pallavicinia lyellii, Solenostoma fossombronioides, S. tetragonum, Targionia hypophylla* and *T. hypophylla* var. *sinhagrhii* etc.

b. Moderate Humidity Zone: The liverworts and hornworts grow in this zone are: *Anthoceros bharadwajii, A. crispulus, A. erectus, Archilejeunea minutiloba, Asterella wallichiana, Cyathodium cavernarum, C. tuberosum, C. epiphytens, Folioceros dixitianus, Lejeunea discreta, Notothylas indica, N. levieri, Phaeoceros laevis, Plagiochasma appendiculatum, P. intermedium, P. pterospermum, Riccardia levieri, Riccia crystallina, R. discolor, R. fluitans, Solenostoma fossombronioides* and *Targionia hypophylla* etc.

c. Low Humid Zone (below 25 %): Very few species were adapted to this region. They are *Anthoceros erectus, Asterella wallichiana, Cyathodium tuberosum, Notothylas indica, Plagiochasma appendiculatum, Riccia crystallina, R. discolor, Solenostoma fossombronioides* and *Targionia hypophylla etc.*

DISTRIBUTION BASED ON FOREST TYPE:

The liverworts and hornworts grow in extensive range of forests. The following types are elaborated on the basis of forest type in Kolhapur district:

a. Evergreen Forest: It is a forest consisting entirely or mainly of evergreen trees that retain green foliage all year round. The liverworts and hornworts species found in this forest are as follows: *Aneura pinguis, Anthoceros bharadwajii, A. crispulus, A. erectus, A. subtilis, Archilejeunea minutiloba, Asterella wallichiana, Cheilolejeunea intertexta, Cyathodium cavernarum, C. tuberosum, C. epiphytens, Fossombronia himalayensis, F. indica, Folioceros dixitianus, Lejeunea discreta, L. flava, L. tuberculosa, Metzgeria himalayensis, Notothylas indica, N. levieri, Pallavicinia lyellii, Phaeoceros laevis, Plagiochasma appendiculatum, P. intermedium, P. pterospermum, Riccardia levieri, R. santapaui, R. cavernosa, R. crystallina, R. discolor, R. fluitans, R. frostii, R. glauca, R. melanospora, R. plana, Pallavicinia lyellii, Solenostoma fossombronioides, S. tetragonum, Targionia hypophylla* and *T. hypophylla* var. *sinhagarhii* etc.

b. Semi Evergreen Forest: Semi-evergreen forests (west coast semi-evergreen forests) are generally considered as a transitional stage between evergreen and moist deciduous forests. The liverworts and hornworts species found in this forest are as follows: *Anthoceros bharadwajii, A. crispulus, A. erectus, Archilejeunea minutiloba, Asterella wallichiana, Cyathodium cavernarum, C. tuberosum, C. epiphytens, Folioceros dixitianus, Notothylas indica, N. levieri, Phaeoceros laevis, Plagiochasma appendiculatum, P. intermedium, P. pterospermum, Riccardia levieri, Riccia crystallina, R. discolor, R. fluitans, Solenostoma fossombronioides* and *Targionia hypophylla etc.*

c. Dry Deciduous Forest: The canopy of the trees does not normally exceed 25 meters. The common trees are the Saal, a variety of *Acacia*, and Bamboo. The liverworts and hornworts species found in this forest are as follows: *Anthoceros erectus, Asterella wallichiana, Cyathodium tuberosum, Notothylas indica, Plagiochasma appendiculatum, Riccia crystallina, R. discolor* and *Targionia hypophylla etc.*

DISTRIBUTION BASED ON HABITAT:

The liverworts and hornworts grow in extensive range of habitats. The following types are elaborated on the basis of habitat given by [4], [3].

a. Open Plateau Region: The zone is fully covered by various types of grasses or herbaceous flora. Only few terrestrial species, viz. *Aneura pinguis, Anthoceros bharadwajii, A. crispulus, A. erectus, A. subtilis, Cyathodium cavernarum, C. tuberosum, Notothylas*

indica, N. levieri, Riccia billardieri, R. cruciata, R. crystallina, R. discolor, R. fluitans, R. frostii, R. melanospora, R. plana and *Targionia hypophylla* were found in this region.

b. Epiphytes: The liverworts and hornworts grow over tree trunks/branches. These are totally autotrophic and only for the sake of shelter they grow on tree trunks. The most common trees in Kolhapur district are *Mangifera indica, Ficus religiosa, Ficus benghalensis, Ficus racemosa, Terminalia* spp., *Syzygium* spp., *Cassia fistula, Bauhinia* spp., and *Dalbergia sissoo* serves as host for *Archilejeunea minutiloba, Cheilolejeunea intertexta, Cyathodium epiphytens, Lejeunea discreta, L. flava* and *L. tuberculosa.*

c. Ravine liverworts and hornworts: The liverworts and hornworts along the water channels, streams, rivers, and rivulets among rocks and boulders. The common ravine species are of *Aneura pinguis, Asterella wallichiana, Cyathodium cavernarum, C. tuberosum, Pallavicinia lyellii, Plagiochasma appendiculatum* and *Riccia fluitans.*

d. Liverworts and hornworts near the domestic areas: The liverworts and hornworts grow on houses or neighboring areas. These are *Anthoceros bharadwajii, A. crispulus, A. erectus, C. tuberosum, Notothylas indica, Plagiochasma appendiculatum, P. intermedium, P. pterospermum, Riccardia levieri, Riccia cruciata, R. crystallina, R. discolor, R. frostii* and *Targionia hypophylla etc.*

e. Liverworts and hornworts along the bridal path, roadsides, border and cut-edges of the forests: They are *Anthoceros bharadwajii, A. crispulus, A. erectus, A. subtilis, Asterella wallichiana, Cyathodium cavernarum, C. tuberosum, Fossombronia himalayensis, Folioceros dixitianus, Notothylas indica, N. levieri, Plagiochasma appendiculatum, P. intermedium, P. pterospermum, Riccia billardieri, R. cruciata, R. crystallina, R. discolor, R. frostii, Solenostoma fossombronioides* and *Targionia hypophylla.*

f. Aquatic liverworts and hornworts: Very few species are adapted to aquatic ecosystem e.g. *Pallavicinia lyellii* and *Riccia fluitans.*

Habitat wise classification of the Liverworts and hornworts taxa given in the table 1.4 It seems to be general rule that liverworts and hornworts flourish well in the crevices where shade and moisture available more frequently.

Liverworts and hornworts from few forts of Kolhapur District can be divided in diverse habitats. The table 1.4 shows that 2 species are found in water (aquatic), 32species are terrestrial out of which 23 species are found on rocks (Lithocolous), 26 on moist soil floors on clayey slopes on ditches (Terricolous), 13 on brick walls (Calcicolous) and 07 species are epiphytic growing on angiospermic plants (Phycocolous). Broadly speaking Thalloid liverworts shows their presence in lithocolous, terricolous and calcicolous habitats except

leafy liverworts *Archilejeunea minutiloba, Cheilolejeunea intertexta, Lejeunea discreta, Lejeunea flava, Lejeunea tuberculosa, Cyathodium* sps. and *Riccia fluitans*. Hornworts mostly grow on moist shady places. The increasing urbanization, removal of shady habitats and niches, changed topography has all posed a threat to its survival.

Table 3: Distribution of the Liverworts and hornworts in different habitats in Kolhapur District

Name of the taxa	Habitat				
	Aq-uatic	Terrestrial			Epi-phytic (Physco-colous)
		Litho-colous	Terri-colous	Calci-colous	
Solenostoma fossombronioides	-	+	+	-	-
Solenostoma tetragonum	-	+	+	-	-
Archilejeunea minutiloba	-	-	-	-	+
Cheilolejeunea intertexta	-	-	-	-	+
Lejeunea discrete	-	-	-	-	+
Lejeunea flava	-	-	-	-	+
Lejeunea tuberculosa	-	-	-	-	+
Aneura pinguis	-	+	+	+	-
Riccardia levieri	-	+	+	+	-
Riccardia santapaui	-	+	+	+	-
Metzgeia himalayensis	-	-	-	-	+
Fossombronia himalayensis	-	+	+	-	-
Fossombronia indica	-	+	+	-	-
Pallavicinia lyellii	+	+	+	-	-
Asterella wallichiana	-	+	+	+	-
Plagichasma appendiculatum	-	+	+	+	-
Plagichasma intermedium	-	-	-	+	-
Plagichasma pterospermum	-	+	-	+	-
Cyathodium cavernarum	-	+	+	-	-
Cyathodium epiphytens	-	-	-	-	+
Cyathodium tuberosum	-	+	+	+	-
Targionia hypophylla	-	+	+	+	-
Targionia hypophylla var. *sinhgarhii*	-	+	+	+	-
Riccia cavernosa	-	+	+		-
Riccia crystalline	-	+	-	+	-
Riccia discolor	-	+	+	-	-
Riccia fluitans	+	+	+	-	-
Riccia frostii	-	+	-		-

Riccia glauca	-	+	-	-	-
Riccia melanospora	-	+	+		-
Anthoceros bharadwajii	-	-	+	+	-
Anthoceros crispulus	-	+	-	-	-
Anthoceros erectus	-	-	+	+	-
Anthoceros subtilis	-	-	+	-	-
Phaeoceros carolinianus	-	-	+	-	-
Phaeoceros himalayensis	-	-	+	-	-
Phaeoceros laevis subsp. laevis	-	-	+	-	-
Folioceros dixitianus	-	-	+	-	-
Notothylas indica	-	-	+	-	-
Notothylas levieri	-	-	+	-	-
Total	02	23	26	13	07

ENDEMISM:

In Maharashtra 14 species of liverworts and hornworts are endemic out of which 6 endemic species *viz., Archilejeunea minutiloba, Riccardia santapaui, Metzgeia himalayensis, Anthoceros bharadwajii, Folioceros dixitianus* are present on forts of Kolhapur district [1].

THREATS TO THE WEALTH OF LIVERWORTS AND HORNWORTS FROM FEW FORTS OF KOLHAPUR DISTRICT:

Anthropogenic pressure on the wealth of liverworts and hornworts may lead to decline in their diversity and species may become rare, endangered and threatened (RET).

Forest fragmentation:

Liverworts and hornworts are highly sensitive to the changes in microclimatic conditions caused by forest fragmentation and environmental pollution. Habitat fragmentation is anticipated as one of the main threats to bryodiversity. It is the process of breaking up large patches of forest into smaller pieces. This can be caused by many things, from clearing forest for roads or developmental activities *viz.,* Construction of buildings, colleges, hotels and restaurants. Above activities were common at Panhala, Amba, Radhanagri, Ajara, Gagangad, and Chandgad. If this process continues, the ability of the remnant forests to maintain their original diversity of liverworts and hornworts and ecological processes will be significantly reduced.

Tourisms:

Similarly, large number of tourists visiting to Panhala, Vishalgad, Pargad, Shivgad, Paavangad, Kalanidhigad and Bhudargad every year. Hence there is tremendous anthropogenic pressure on liverworts and hornworts growing on roadside walls and plateaus.

Four species of liverworts *Riccardia levieri, Riccardia santapaui, Riccia fluitans* and *Anthoceros subtilis* are rare in the study area as they were collected just once during the extensive survey in the Kolhapur District. In addition there are species like *Riccardia levieri, Riccia fluitans* and *Solenostoma fossombronioides* which are confined to just a single location *viz.,* Panhala, Bhudargad and Gaganbavada respectively within the study area. *Riccia fluitans* was also collected from Panhala in 1998-99, but since 2004 it has been not seen from Panhala but collected from Bhudargad.

SUGGESTIONS FOR THE CONSERVATION OF LIVERWORTS AND HORNWORTS FROM FEW FORTS OF KOLHAPUR DISTRICT:

Many forts are showing some remarkable occurrence of liverworts and hornworts. But some unavoidable activities for the better management of these areas, such as construction of inspection paths, roads *etc*., may cause threat to the habitats where the species grow. To avoid these threats and to ensure more effective conservation of the liverworts and hornworts, the areas in and around the forts *viz*., Panhalgad, Gaganbavada, Pargad, Shivgad, Bhudargad, Vishalgad and their surrounding areas having luxurious growth may be declared and protected as, "Liverwort and Hornwort Sites", in different altitudinal zones. In Kolhapur District, such bryophyte luxuriant areas are Aamba Ghat, Amboli Ghat, Anuskura Ghat, Karul Ghat, Bhudargad, Gaganbavada, Panhalgad, Pargad, Patgaon, Pavangad, Radhanagari WLS, Vishalgad *etc.* which would also act as 'benchmark' sites for monitoring the health of species populations over a period of time. As the liverworts and hornworts plays an important tool for monitoring the health of forest ecosystem, periodical monitoring of the species populations in these areas would help to assess the impact of various management practices on the overall biodiversity of the Kolhapur District. Besides, these areas can be used for creating awareness among the people, academicians, researchers and the foresters about this interesting group of plants, their role in ecological balance and functions and the threats faced by them. Aamba Ghat, Amboli Ghat, Anuskura Ghat, Karul Ghat, Bhudargad, Gaganbavada, Panhalgad, Pargad, Patgaon, Pavangad, Vishalgad, Panhalgad are ideal habitats for the growth of liverworts and hornworts. Again Panhalgad would also be prudent to closely

monitor the populations of the species which are represented by just a single collection or multiple collections from just a single location within the Kolhapur District.

The local inhabitants from the liverwort-hornwort luxuriant forts with interest in environment and conservation may be trained as parataxonomists to help in the effective monitoring of the species and their habitat on different forts in Kolhapur District. Besides, declaring the endemic species as "National Natural Heritage" for their environment in the conservation drive of such taxa of liverworts and hornworts will motivate people residing on the forts.

i) There is an urgent need to carry out a systematic bryfloristic studies of liverworts and hornworts from all other forts of Maharashtra.

ii) Identify areas from the forts of Maharashtra with luxuriant growth of liverworts and hornworts to understand their ecology and their role in the microenvironment.

iii) It is necessary to ban new constructions of residential, commercial buildings and industries to minimize environmental pollution and interference in the microhabitats of the liverworts and hornworts on the forts by strictly enforcing the laws.

iv) Panhalgad and Paavangad are the ideal habitats for the luxuriant growth of the liverworts and hornworts *viz*., *Aneura pinguis, Anthoceros bharadwajii, A. crispulus, A. erectus, A. subtilis, Asterella wallichiana, Cyathodium cavernarum, C. tuberosum, Folioceros dixitianus, Fossombronia himalayensis, F. indica, Lejeunea flava, L. discreta, Notothylas indica, N. levieri, Phaeoceros carolinianus, P. himalayensis, P. laevis, Plagiochasma appendiculatum, P. intermedium, P. pterospermum, Riccardia levieri, Riccia cavernosa, R. cruciata, R. crystallina, R. discolor, R. fluitans, R. frostii, R. melanospora, R. plana, Targionia hypophylla, and T. hypophylla var. sinhagarhii.* Thus these two forts are rich in bryodiversity. Hence it is necessary to declare these two forts as "National Natural Heritage". There is an urgent need to ban new constructions of residential, commercial buildings and industries to minimize environmental pollution and interference in the microhabitats of the liverworts and hornworts on the Panhala and Paavangad by strictly enforcing the laws as early as possible.

v) There is an urgent need to conserve the natural habitats of liverworts and hornworts on the forts by developing bryophyte gardens under the guidance of experts.

Finally it is necessary to take initiatives to conserve rare, endangered, threatened, endemic liverworts and hornworts through *ex-situ* and *in-situ* conservative methods.

CONCLUSION:

The fast increasing urbanization with its monasteries and recreation on the forts is putting extreme pressure on bryo-flora to the limits of their patience. Exploration, collection and conservation are one of the urgent needs of the day.

The extraordinary varied and rich bryo-flora of our vast country is not thoroughly explored. Besides Western Ghats, South-Western Maharashtra region abounding in moss or liverwort-covered valleys and hillsides, ridges and slopes still awaits exploration. A great deal of interesting information is shrouded in darkness. Moreover it has been an urgent call to bryologists and floristic researchers of these areas that un-explored regions deserve first priority for exploration. The need for more and more bryo-exploration in the still very inadequately known parts of the South-Western Maharashtra is absolutely essential otherwise many a species would perish and would disappear before being documented form these unexplored areas.

The present work could form a "starting point' and foundation in our region on which more comprehensive qualitative and quantitative studies could rest in future with the response of liverworts and hornworts to mineral elements and their sources of supply and the factors influencing availability and uptake.

ACKNOWLEDGEMENTS:

Author is thankful to UGC, New Delhi and WRO, Pune for sanctioning minor research project.

REFERENCES:

1. Singh, D.K., Singh, S.K. and Singh, D. (2016), BSI, Kolkata. P. 439.
2. Lavate, R.A. (1915), MRP submitted to UGC, WRO Pune. P. 118.
3. Patil, S.M. (2014), Ph.D. thesis submitted to Shivaji University, Kolhapur.
4. Chaudhary, B.L., Sharma, T.P. and Bhagora, F.S. (2008), Himanshu Publications, Udaipur and New Delhi (India) P. 326.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 13

DIVERSITY AND ETHNOMEDICINAL VALUE OF LIANAS IN EAST NIMAR OF MADHYA PRADESH, INDIA

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ABSTRACT:

Man has surveyed remote galaxies and has stood on the suface of moon but has not so far come anywhere near to comleting taxonomic of the fewer than half a million species of higher plants that grow on our planet. According to present study 65 lians are naturalized in all parts of East Nimar blonging to families 16 and 53 genera. A family - wise analysis of all the 65 lians is carried out. Fabaceae emerges as the largest family that contributes (14 species), followed by Cucurbitaceae and Asclepiadaceae (10 species each), Convolvulaceae shares (8 species), Vitaceae and Dioscoriaceae (4 species each). The other families, such as Liliaceae shares (3 species), Aristolochiaceae (2 species), Pssifloraceae, Polygonaceae, Basellaceae, Capparaceae, Sapindaceae, Celastraceae and Combretaceae(1 species each).

KEYWORDS: Diversity, Ethnomedicinal, Lianas, East Nimar

INTRODUCTION

From the advent of the human life on earth, human community has been depending on the natural resources especially the plants for their basic needs such as food, cloth, shelter and medicine. Plants and plant based medicines have been employed since dawn of civilization for prolonging life of man by combating various ailments. Ancient tribal societies around the world have learnt to utilize their neighborhood herbal wealth for curative as well as offensive purposes. Due to lack of literacy their knowledge of plants developed often at the cost of their dear life in their 'Human Latoratories' this centuries old experience could not be perfectly

documented and it had rather descended from one generation to the next by oral communication. As the ethnic groups migrated from place to place in search of their livelihood, their folklore knowledge also became fragmented and traveled with them often with 'additions' and 'deletions'.

Out of 7500 ethnomedicinal plants used by Indian tribals, 65 lians species are collected from the study area. The common diseases of the tribals from this area are respiratory disorders, stomach and abdominal disorders, flatulence, diarrhoea and dysentery, malaria fever tuberculosis, skin diseases, venereal diseases, conjunctivitis. Besides, there are some diseases reported as specific to men, women or children in tribal communities. Men occasionally suffer from liver problems, possibly due to consumption of country liquor, typhoid, headache, eczema and venereal diseases. Constipation and appendicitis are not common among them because of consumption of large amount of leafy vegetable.

The common female diseases are intestinal worms, anaemia, leucorrhoea, hysteria, dysmenorrhoea (painful menstruation) etc. The abortion practice is not uncommon. The common diseases among children are blood dysentery, teething, intestinal worms, cough and cold, measles, dental caries, scabies, rickets, eye disease, amoeboisis etc. Malnutrition and diarrhoea is sometimes lethal in children of this region. Disease like conjunctivitis assumes epidemic proportion in children during the festivals associated with dancing and singing. Most of the diseases are treated by single plant species.

MATERIAL AND METHODS:

STUDY AREA:

East Nimar is situated in the South West corner of Madhya Pradesh. It lies between 21^0 05' and 22^0 25' N Latitude and between 75^0 57' and 77^0 13' E Longitude and 304 M above sea level. It is bounded by Betul, Hoshangabad and Amravati districts of Maharastra on the East, Buldhana and Amravati district on the South West and Khargone and Dewas district on the West and North. The total geographical area is 10779 sq. Km. out of which forest occupies 8307 sq. Km. It lies between the valleys of Narmada and Tapti rivers and occupies a strip of mixed hill and plain Country.

THE PEOPLE:

The aboriginal and hill tribes met within this region are the Korkus, Gonds, Nihals, Bhils, Pradhans, Pardis, Bhujiya, Orans and Bayare etc. The 1991 census records 5,08,532 Adiwasi (tribal) population. The number of Korkus is maximum (78.41%) in the district.

The Gonds are second (16.01%) and Nihals are third in number (4.14%). The major tribes taken for study are Korkus, Gonds and Nihals.

Field observation on plants, the vernacular names and information, their uses were recorded in the field book. Voucher specimens were brought to laboratory and prepared according to the conventional herbarium technique [1]. All specimens were identified with the help of standard floras [2, 3, 4]. The important plant parts like underground tubers, corms and fruits etc. were preserved in 4% formalin.The present work mainly covers the tribal villages situated at the foothills of Satpura, which inhabited by Korku, Gond and Nihal, tribes of East Nimar. The tribes are original inhabitants of this region. There are about six more tribes like Bharia, Bhil, Bhunjia, Oraen, Pradhan and Pardhi etc., who reside in this region.

Generally the medicines are prepared by crushing, boiling, shade drying. The preparation of tablets, syrups are made indigenously. Dry plant parts are usually made into powder. Local medicine men (padihar) prepare drug by decoction, infusion, mixture and paste. Tribals store either whole plant or a part of it after shade drying. Gond tribe stores plant parts making sort of garland after drying in shade.

CONCLUSION:

Korku, Gond and Nihal tribe of East Nimar use a good number of plant for material culture and economic lively hood. Present observation clearly includes that besides ethnomedicinal uses. Tribals are well aware of multifarious uses of plants in agriculture and fodder etc. The ethnomedicinal (human & veterinary) plants are used to treat wide range of discomfort of human beings and cattle. The tribals system of medicine is an elaborate and specialized one. It gives preferable to fresh drugs. Some of the drugs are exclusive treasures of Parihars, Bhopas and other medicine men, while other members of the tribes are also aware of the therapeutic properties of plants from their day to day experience. Nowadays, the useful plant resources are becoming scarce due to ruthless destruction of habitats, deforestation, climate change, global worming, industrialization, construction and pollution etc. It is necessary that the tribal knowledge and practice about plants are to be recorded before they are lost permanently.

Through native medicine still plays a significant role among the tribals, it is observed that the traditional knowledge of medicinal plants among the youths in tribal communities has been disappearing because of the ability to meet their own needs at present and for future. The pressure of ruthless exploitation without adequate regeneration measures is endangering may useful ethnomedicinal plants, plant species like *Abrus precatorius*, *Asparagus*

racemosus, *Aristolochia bracteolata*., *Celastrus paniculatus*, *Ceropegia bulbosa*, *Cissus quadrangularis*, *Gloriosa superba* L., *Gymnema sylvestris*, *Hemidesmus indicus* (L.) R.Br. *Momordica dioica, Mucuna pruriens and Pueraria tuberosa* ect. among the tribals.

The plant species used exclusively by Korkus are 26 and Gond 4. Common species used by Korku, Gond and Nihal are 34 while Korku and Gond used 6 and Korku and Nihal use 6. The present study revealed that Korku is more knowledgeable about the plant wealth and their surroundings followed by Gond and Nihal. The plants like *Ampelocissus latifolia* (Roxb.) Planch, *Aristolochia bracteolata* Lamk.,*Celastrus paniculatus* Willd., *Cissus quadrangularis* L., are commonly used by all the tribal groups. This shows a cross cultural relationship between the tribal groups of this area. It can also be assumed that the indigenous knowledge about the plant wealth has come from a common origin but in course of time some knew informations and practices has found in place into the day to day plant usage of the tribal groups.

SOME SUGGETIONS:

- The tribe here developed the reuse of conservation but the exploitation of plant resources is inversely proportional to the conservation and regeneration efforts.
- The traditional knowledge and resource management practices of the indigenous people should be applied in modern development strategies.Traditional knowledge of indigenous people with modern tools of genetic engineering to get the desired results.
- Government should also provide indigenous people with suitable technology and infra structure to increase the efficiency of their resource management.
- Exhaustive study may be conducted in future to explore, identity, record and indigenous knowledge which can serve as a data bank for strategies for health care system.
- Search for alternate substitute plants should also be given immediate attention.
- Medicinal garden and Nursery should be established to maintain constant supply of material to reduce pressure an wild populations.
- Some of the noble plant species should be scrutinized for their propagation through tissue culture techniques.
- Traditional customs and religious beliefs should also be utilized in technologies for conservation of vegetation
- The indigenous knowledge of the tribal people should be promoted for the development of their economy.

- Steps should be taken for in-situ / ex-situ conservation of rare and endangered plants.
- A detailed and systematic study may be conducted in future to explore record and preserve indigenous knowledge and information which can serve as data bank for strengthening and evolution of low cost, indigenous and sustainable plant based medicine for health care system.

Table 1. List of Lians species and used in ethno-medicine:

Scientific Name	Family	Vernanacular Name	Category	Climbimg Mode	Medicinal Uses
Abrus precatorius Linn.	Fabaceae	Ratti/Gunja/Gunchi (K and N); Jurumti Velly (G)	WV	HC	Contraceptive,diabetes, cough,cold,colic pain, scorpion sting,sciatica, and paralysis.
Acacia sinuata (Lour.) Merr.	Fabaceae	Kochi (K); Sitakali to Marra (G); Shikakali (N)	WV	HC	Dandruff and boils.
Ampelocissus latifolia (Roxb.) Planch.	Vitaceae	Dokarbel/Kandvel/Nardel(K); Randrakshi/Devdhar ta Marra(G);Popasvel(N)	WV	TC	Muscular pains, sores, bone fracture and pneumonial fever.
Ampelocissus tomentosa (Heyne ex Roth) Planch	Vitaceae	Dhotto(K)	WV	HC	----
Antigonon leptopus Hook. & Arnott	Polygonaceae	Madan-Mast ta Marra (G)	WV	TC	Aphrodisiac and in weakness.
Argyreia nervosa (Burm. f.) Boj.	Convolvulaceae	Vidharya Bela/Phanguda (K); Samundar ti Vely (G); Samundar Palak (N)	WV	ST	Tonic against anaemia, digestive and cardiac tonic.
A. sericea Dalz. & Gibson	Convolvulaceae	Kali Phang (K and N)	WV	ST	Conjunctivitis, swelling, bone fracture and irritation.
A. strigosa (Roth) Rober.	Convolvulaceae	Bhaisvel/Bhaislae/Meswal (K)	WV	ST	Tonic against anaemia.
Aristolochia bracteolata Lamk.	Aristolochiaceae	Kidamar/Gidhan/ Chandbela (K, G and N)	HV	ST	Skin diseases and abortifacient.

A. indica L.	Aristolochiaceae	Sapsan/Kidamari/ Gidhan/ Chandbela (K and N); Isharmuli ti Veli (G)	HV	ST	Antivenom and used in dyspepsia.
Asparagus gracilis Royle	Liliaceae	Saslyamusli (K)	WV	HC	To cure urinary problems, mental disorders and malaria.
A. racemosus Willd.	Liliaceae	Saslyamusli (K)	WV	HC	Sexual debility in men.
Basella alba L., Sp.	Basellaceae	Poi/Pasalei (K)	HV	HC	To cure general debility and anaemia.
Butea superba Roxb.	Fabaceae	Tunang/Raisitom (K); Palasvel (G); Belia palas (N)	WV	ST	To remove pimples and acne.
Caesalpinia bonduc (L.) Roxb.	Fabaceae	Sagargoti (K); Cutter ta Marra (G); Chirchirgoti (N)	WV	Str-A	To cure liver disorders.
Cajanus scarabaeoides (L.) du Petit.-Thouars	Fabaceae	Ban-tuar(K)	WV	ST	_____
Canavalia gladiata (Jacq.) DC.	Fabaceae	Ban-sem, Makhansem(K)	WV	ST	_____
Capparis zeylanica L.	Capparaceae	Pachika (K); Jakhambela/Ardanda to Marra (G)	WV	Str-A	To cure rheumatic pain.
Cardiospermum halicacabum L.	Sapindaceae	Phatphatej/Ghanphod (K); Phutphutya/Wasanna Veli (G); Charmathari (N)	HV	HV	Hemicranias (adhasisi) and epilepsy.
Cayratia trifolia (L.) Domin	Vitaceae	Ambatvel (K)	WV	TC	Antidote for snakebite.
Celastrus paniculatus Willd.	Celastraceae	Pinguel (K); Malkangni ta Marra (G); Malkangni (N)	WV	Str-UA	To cure beri-beri in children (vit, B1 deficiency).
Ceropegia bulbosa Roxb.	Asclepiadaceae	Gakerkund/Gakaryakand/ Khatmarya (K)	ST	HV	General debility and bodyache.

Cissampelos pareira L.	Menispermaceae	Paharvel (K); Patha ti Veli (G); Patha/Venivel (N)	WV	Str-UA	To reduce high blood pressure.
Cissus rependa Vahl.	Vitaceae	Dekrabela(K),Pani-veli(G)	WV	RC	To cure sprain and bone fracture.
Cissus quadrangularis L.Mant.	Vitaceae	Hadjora (K, G and N)	WV	RC	To cure sprain and bone fracture.
Citrullus colocynthis L.	Cucurbitaceae	Ghorkakde (K); Tumba ti Veli (G)	HV	TC	Stomach pains and sciatica.
Clitoria ternatea L.	Papilionaceae	Gokarni ti Veli (G)	HV	TC	To hasten delivery during labour pains.
Coccinia grandis (L.) Voigt	Cucurbitaceae	Dhorkakri (K); Indravan ti Veli (G); Kundru (N)	WV	TC	To cure weakness and impotency in male
Cocculus hirsutus (L.) Diels	Menispermaceae	Aseen Zara/Bochan (K); Vasani ta Palla/Barmipalla/ Patalgarudi/ Bosan (G); Wasanel/Pathari (N)	WV	ST	Brain tonic.
Combretum albidum G.	Combretaceae	Rhetbel/Retel (K)	WT	ST	To cure mental disorder, mania and insomnia.
Corallocarpus epigaeus (Rottl. & Willd.) Hook.	Cucurbitaceae	Mirichkand (K)	HV	TC	It is applied on swelling caused after snakebite.
Cryptolepis buchanani Roem. & Schult.	Asclepiadaceae	Kaovel/Kawavel/ Nagbel (K)	HV	ST	Useful in insect bites and scorpion sting.
Cyphostema auriculatum (Roxb.) P.Singh & Shetty	Vitaceae	Jongali-ongoor,Kajorny(K)	WV	TC	Used as a tonic.
Desmodium triflorum (L.) DC.	Fabaceae	Kudalya (K)	HV	ST	Applied on wounds twice a day for fast healing.
Dioscorea bulbifera L.	Dioscoriaceae	Kalyakand/Gathalu (K); Noska ti Velli (G); Gogdu/Bayal (N)	HV	ST	To cure abdominal pains (gripe).

D. hispida Dennst.	Dioscoriaceae	Kulu Kand (K); Baichandi ti Velli (G); Bhuikand(N)	HV	ST	Against bite of rabid dog.
D. oppositifolia L.	Dioscoriaceae	Dardee (K); Jangali Shakarkand (N)	HV	ST	To cure general debility.
D. pentaphylla L.	Dioscoriaceae	Babra/Suarkand/Suaralu (KandN); Kantaalu ti Velli (G)	HV	ST	To relieve rheumatoid arthritis.
Diplocyclos palmatus (L.) Jeffrey	Cucurbitaceae	Chatargoti/Chirchirgoti (K); Shivlingi ti Velli (G); Dangari (N)	HV	TC	To cure double pneumonia and convulsions in children.
Gloriosa superba L.	Liliaceae	Kallavi/Karihari/Singmudya/Karkari (K and N);Kadve ti Veli (G)	HV	TC	Joint pains and rheumatism.
Gymnema sylvestris (Retz.) R.Br.	Asclepiadaceae	Medsinghi/Gudmar (K and N)	WV	ST	To reduce glycosuria.
Hemidesmus indicus (L.) R.Br.	Asclepiadaceae	Anantvel (K); Anantmul ti Veli (G); Lahan (N)	HV	ST	Applied on eczema.
Holostemma ada-kodien Schulte	Asclepiadaceae.	Palkhevel (K and N); Morewan ti velli (G)	WV	ST	Spermatorrhoea.
Ipomoea eriocarpa R.Br.	Convolvulaceae	Ratlya (K)	HV	ST	Rheumatic pains.
I. pes-tigridis L.	Convolvulaceae	Panchpanya (K)	HV	ST	Sores, boils and pimples.
I. obscura (L.) Ker-Gawl.	Convolvulaceae	Pilaibonvari (K)	HV	ST	Cold, cough and coryza.
Lagenaria siceraria (Mol.) Standl.	Cucurbitaceae	Tumdi/Tumba (K)	WV	ST	For stomachache, kidney stones and appendix.
Luffa acutangula (L.) Roxb.	Cucurbitaceae	Jungali dodka/karu dodka (K); karu turai (N)	HV	TC	Applied in leprosy
Marsdenia tenacissima (Roxb.) Moon	Asclepiadaceae	Dudhia-bela (K); Sansbela (G)	WV	ST	To treat jaundice.

Melothria maderaspatana (L.) Cogn.	Cucurbitaceae	Kakadbhutta (K)	HV	TC	Toothache.
Momordica dioica Roxb. ex Willd.	Cucurbitaceae	Kartola/Karotla/Kankoda/Katlya (K)	HV	TC	To check bleeding from piles.
Mucuna pruriens (L.) DC.	Fabaceae	Kenwanch/Kanchkuri/Kaunch (K and G)	WV	ST	To expel intestinal worms (Dose depends upon age of patient).
Oxystelma esculentum (L.f.) Smith	Asclepiadaceae	Dodiyari/Dudhialata (K); Hirankhuri (G)	WV	ST	Used for gargle in mouth ulcers.
Passiflora foetida L.	Passifloraceae	Mukkha peera ti Veli (G)	HV	TC	Insomnia and hypertension.
Pergularia daemia (Forssk.) Chiov.	Asclepiadaceae	Dudhi/Dudhivel/ Utaranvel/Ankodi (K and N)	HV	TC	To remove grittiness from eyes.
Pueraria tuberosa (Roxb. ex Willd.) DC.	Fabaceae	Ghorbel/Bharda/Paharbel (K)	WH	ST	Used in constipation, bodyache and as a tonic.
Rhynchosia minima (L.) DC.	Fabaceae	Jangli Urad (K)	HV	TC	Abortifacient.
R. rothii Benth	Fabaceae	Jangli Kulthi (K)	HV	TC	Scabies.
Rivea hypocraterifo rmis (Desr.) Choisy	Convolvulaceae	Phang/Phangi/Phanvel (K and N)	WV	ST	An antidote to snakebite.
R. ornata Choisy in Men.	Convolvulaceae	Phang (K)	WV	ST	Used to cure piles.
Teramnus labialis (L.f.) Spreng.	Fabaceae	Mashani (K)	WV	ST	Stomachache, rheumatic pains and bodyache.
Tinospora cordifolia (Willd.) Miers	Menispermaceae	Gulvel/Gudvel (K); Karial/Usnaideveli (G); Gahutakli (N)	WV	ST	Gonorrhea, leucorrhoea, malaria and synochus.
Trichosanthes anguina L.	Cucurbitaceae	Karjari(K)	HV	TC	To treat jaundice.
T. bracteata (Lamk.) Voigt.	Cucurbitaceae	Gaulan/Kaundal (K); Gangagaulan (N)	HV	TC	Haemorrhoides and and gonorrhoea.
Vinga trilobata (L.) Verdc.	Fabaceae	Mungia(K)	HV	TC	Used as a diuretic.

Wattakaka volubilis (L.f.) Stapf	Asclepiadaceae	Nakchhikni/Ghaidudhivel/Dudhi (K and N); Bakar/Jamlasi ti Veli (G)	WV	ST	Urticaria, scabies, itching and psoriasis.

Abbreviations: ST: Stem twiner; WV: Woody vines; HV: Herbaceous vines; TC: Tendril climber; RC: Root climber; HC: Hook climber; Str-A: Stragglers-armed; Str- UA: Stragglers-unarmed and K-Korku, G-Gond and Nihal.

ACKNOWLEDGEMENT:

The authors are sincerely thankful to the UGC, Central Regional Office, Bhopal (M.P.), for financial support in the form of a Teacher Research Fellowship, under faculty improvement program. We sincerely and gratefully acknowledge Knowledgeble person Shri Prabhuji Solanki, Dr. C.M. Solanki, Gujarati Science College, Indore and Dr. Neelprabha Kolhe, Principal, S.N. P.G. College, Khandwa, for providing facilities and encouragemen

REFERENCES:

1. Jain, S.K. & Rao, R. R. (1977), Today & Tomorrow's Printers and Publishers, New Delhi
2. Singh, G., Singh, H. B. & Mukherjee, T. K. (2001), National Institute of Science Communication and Information Resources.
3. Verma D.M., Balakrishan N.P. and Dixit R.D. (1993), Flora of Madhya Pradesh,Vol. I, BSI, Calcatta.
4. Madgal V, Khanna K.K. and Hajra P.K. (1997), Flora of Madhy Pradesh, Vol. II. BSI. Calcutta.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 14

BIODIVERSITY FOR SUSTAINABLE LIVELIHOOD

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Biodiversity is *"the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems." It is the foundation of life on Earth* -International Union for Conservation of Nature, 2011[1].

A persons livelihood refers according to the Oxford Dictionary of English[2] is that "*means of securing the basic necessities –food, water, shelter* and *clothing* of life". It is also defined as *a group of endeavors including attainment of food, shelter, cloth, medicine to encounter the necessities of the self on a sustainable basis with dignity*. A livelihood is an endeavor of making living. It comprises of abilities, wealth, and deeds to obtain the requirements of life.

Sustainable livelihood was proposed earlier by the Brundtland Commission on Environment and Development and this thought was broadened the aim of eradicating poverty and supporting the accomplishment of sustainable livelihood by the United Nations Conference On Environment and Development in 1992 [3].

Sustainable livelihood at household (rural) level was defined by Robert Chambers and Gordon Conway in 1992 [4] as" *A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term*".

In recent times the British Department for International Development and the Institute for Development Studies (IDS) have been exercising approach on the concept of sustainable livelihood. Ian Scoones, an eminent exponent of IDS propounded altered definition on sustainable livelihood that "*A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks maintain or enhance its capabilities and assets, while not undermining the natural resource base*" [5].

The assets of sustainable livelihood are identified as human capital, natural capital, financial capital, physical capital, social capital [5],[6].

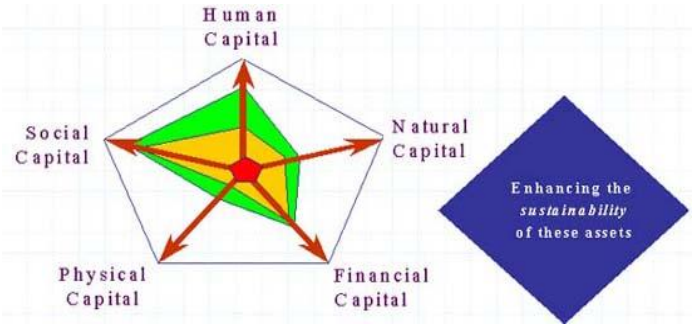

Figure 1. The Pentagon of Assets

It is all about the purposeful accomplishment of work or employment opportunities to the public particularly the youth people. However the work may be expected in terms of gratification, good payment, equalizing the employment and life. It also includes social involvement which also comprises financial involvement.

Sustainability provides a correspondence relation between human and nature. It is a Systematic and adaptable means which connects the matters of continuity and approaches of empowerment. 'Sustainable development' refers to the holistic approach and temporal processes that lead us to the end point of sustainability [7].

Essentiality of sustainable livelihood:

This concept provides scope, preference and objectives for betterment of humankind. It is essential to recognize the assets expansion for sustainable livelihood. By this it aids to solve the restraints in utilizing the resources. Thus it is multidimensional [8].It provides more income, retrieves Excellency, and enhances food security.

Consociation of biodiversity and sustainable livelihood:

Human lineage leans on both animals and plants for their basic needs. Moreover humankind expanded close association with the ambient green vegetation. This tight relationship has diverse racial, tribal, nomadic communes till today also. Cultural difference provides the information on novel chemicals for showing various human health complications. Sustainable development is maintained only by balancing of taking advantage of misuse of nature appliances for the financial development society and protecting the sustenation of ecosystem services, which are vital to welfare of livelihoods. People get various benefits from ecosystem services, which were furnished by ecosystem. It is proved that debasement of ecosystems will leads to reduction of services provided by them. Degradation of biodiversity sometimes becomes irreversible [9]. Hence there is essential of maintaining ecosystem services through biodiversity for attaining sustainable livelihood. Ecosystems are a part of biodiversity which provides diversified benefits or services for obtaining livelihood. These ecosystems are interlinked with each other. As these ecosystem services are exploiting by the public impetuously the rate of these livelihood services also diminishing at progressive rate [6] [21]. Thus by conserving the biodiversity we can seek ecosystems services, which provide livelihoods for human beings [4].

Hence the impact of biodiversity on sustained livelihoods and ecosystems are interlinked associated system. Biodiversity underpins the sustainable livelihood development in various methods by the reduction of poverty, securing food resources; fresh water procurement, soil sustenation and welfare of humankind directly rely on conservation of global, biological diversity [13].

There is an essentiality to conserve the biosphere by proper maintenance of biodiversity for sustainable livelihood. Biodiversity is the virtual life support for human survival. Biological diversity is abbreviated as biodiversity adduces that it is the variability among living organisms. It can be defined in tags of gene, species and ecosystems regarding to three essential characteristically of a hierarchical stages of the biota. In the present times progression and urbanization leads to massive devastation and transformation of natural biosphere, which causes frightening and appalling situation [14]. Biodiversity promotes adaptations at all stratums of ecosystems. Deletion of one or more species can not generate any threat to complex ecosystem. But certain species can cause distinguishable alterations in ecosystems; hence they are unique and called as “key stone species”. Disturbances in the ecosystems can also destruction of biodiversity, which in turn reflects the livelihood threat.

Degradation of forest and woodlands biodiversity reflects the migration of the people, who depend on the livelihood drawn from the biodiversity [15].

Biodiversity includes the ecosystem goods like fodder and fuel and services like climate changes. Most of the rural and poor people are directly rely on these and makes disturbances in biodiversity. Hence it weakens the food security which results in poor nutrition consequently disturbances of health especially among the rural and in addition to this the chance for vulnerability to external shocks will be increased [16].

Importance of biodiversity maintenance:

It may be represented in the following ways. It facilitates financial advantages in terms of sustenance, therapeutics and crude material and it has capacity to produce abundant cores. It also provides multitude of vital ecosystems services like purified air, altered weather conditions, devastation, composing different soils, regulating ailments and controlling organic and inorganic nutrient cycles, protects inherent moral and esthetic ethics of nature. Diversified untamed fauna and flora, which are constituents of the nature and they are indispensable. They afford amazing bliss, holiness and enthusiasm to mankind. Sustainable livelihood can be attained by exposing livelihood response by the alterations in ecosystem pressures [17], [18], [19].

Accordig to Valli Moosa, IUCN President and former Minister of Environmental Affairs and Tourism, Republic of South Africa [20]-*"Biodiversity and development are so intrinsically interrelated that it makes no sense to suppose that progress can be achieved separately. We can only achieve the Millennium Development Goals when we also take care of our environment".*

The grater the diversiform of species the grater will be the persistence of ecosystem and can endure pressures exerted by environment. Therefore biodiversity is important for maintaining the typical ecosystems. The mankind and total entity of life rely on biodiversity for sustainable livelihood. Now a days biodiversity and poverty are the critical challenges. Globally biodiversity is under impendence due to the Activities of humankind and also by climatic changes.

What we are doing to the forests of the world is but a mirror reflection of what we are doing to ourselves and to one another. - Mahatma Gandhi

Benefits of biodiversity - the basis for livelihood:

The following are the important uses of Biodiversity:

1. Food and drink: Biodiversity provides food (fruit, fish, meat, crops) for humans.
2. Medicines: A significant proportion of drugs are derived, directly or indirectly, from biological sources
3. Industrial materials: A wide range of industrial materials are derived directly from biological resources. These include building materials, fibers, dyes, resins, gums, adhesives, rubber and oil, nature based fish industry
4. Research, education and monitoring
5. Recreation & tourism
6. Cultural values
7. Fuel
8. Timber, rattans
9. Biochemicals
10. Diminution of global destitution by sustaining their livelihoods and economy
11. Food from animals of varied habitats. [16], [21], [22].

Threats for biodiversity:

Public concurrence is crucial to sustain livelihood by conserving biodiversity. There are various threats behind the conservation. They are

- A forestation on grazing areas
- Hazards caused by forest fires
- Threat caused by exotic and alien species to indigenous species
- Continuous utilization of firewood
- Overexploitation of natural resources
- Decline of forest areas into pasture
- Overgrazing
- Competition between wild and domestic animals for consumption of resources [22].

Mitigations to conserve biodiversity:

- Discouraging a forestation
- Supporting non conventional practices of using fuel, LPG, electricity for domestic activities

- Cultivating awareness on indiscriminate use of natural resources
- Practicing celebrations of world forestry day, World Environment Day, Van Mahotsava, Water Conservation Day, Biodiversity day etc
- Encouraging plantation of fodder yielding plants
- Encouraging aquaculture in local water reserves
- Encouraging utilization of biofertilisers and organic farming
- Practicing and usage of manure drawn by vermicomposting
- Creating awareness on laws of conservation of biodiversity [22].

Biodiversity: natural resources (NR) and their application with beneficence to urban livelihoods:

Natural Resources can be used for the production of:

Cereal crop cultivation, Vegetable production, High value fruit via hydroponics (e.g. strawberries), Mushroom production, Cut flowers, Ornamental flowers/plants/shrubs,

Cattle: Small stock – sheep, goats, pigs; Smaller stock – rabbits, guinea pigs, chickens etc, and in Vermiculture, Sericulture, Aquaculture.

Natural Resources can be consumed: Food from rubbish bins can be eaten, Wood from trees can be burnt, and Rocks can be used to construct the houses.

Natural Resources can be traded: Selling of land, rocks, sand selling of products e.g. vegetables, flowers.

Natural Resources can create employment opportunities:

Labouring for vegetable production, Selling labour for extracting sand for building [23].

Biodiversity- rural livelihood beneficiaries

Scoonesand Wolmer believed livelihood outlook suggest an important vision on intricate growth in the rural domain [24].Poverty and deficiency of supportable livelihoods are considered as threats for biodiversity. Sustainable livelihood approach is focused mainly on participation development. It is dynamic and exhibits social and environmental sustainability. Around 70% of the poverty of the world lies in rural areas and these people rely directly on biodiversity for the attainment of their livelihood. Nearly 60 million indigenous people are completely depending on forests and approximately 1.2 billion people depend on agro forestry farming system [25], [26]. Rural people depend on forests for their daily fundamental needs like food, shelter, clothing.Most of the rural population rely on

forests and its surroundings for its derived products to earn their economy and to create self employment [27].

According to M.S. Swaminathan, Robert Chambers and others viewed the perspective on people oriented development which laid importance on the rural poor people. it was analyzed during the discussion done on Food 2000 report for the Bruntdland Commission the term sustainable livelihood was used in 1986 [28],[29].

Sustainable livelihood approach and frame work:

The sustainable livelihood approach supports to enhance the livelihoods of poor people. It systematizes the causes that force or comprehend the livelihood chances and also exhibits how they are connected. It encourages to establish and also to maintain the activities of sustained livelihood. It supports to recognize the preferential activities. Moreover it builds the link between people and complete environment that affect the livelihood consequence approaches. It brings inner ability of people in terms of talent, and approach of public network to material and economy appliances and the capacity to access the institutions [30].

Sustainable lively hood framework is a tool for analyzing the poverty. Different kinds of frame work tools are adopting by different Institutions and Organizations, but the underlying aim is preparing of structural ground work to attain sustainability in livelihoods. According to Scoones [31] the checklist of the sustainable livelihood framework is as follows

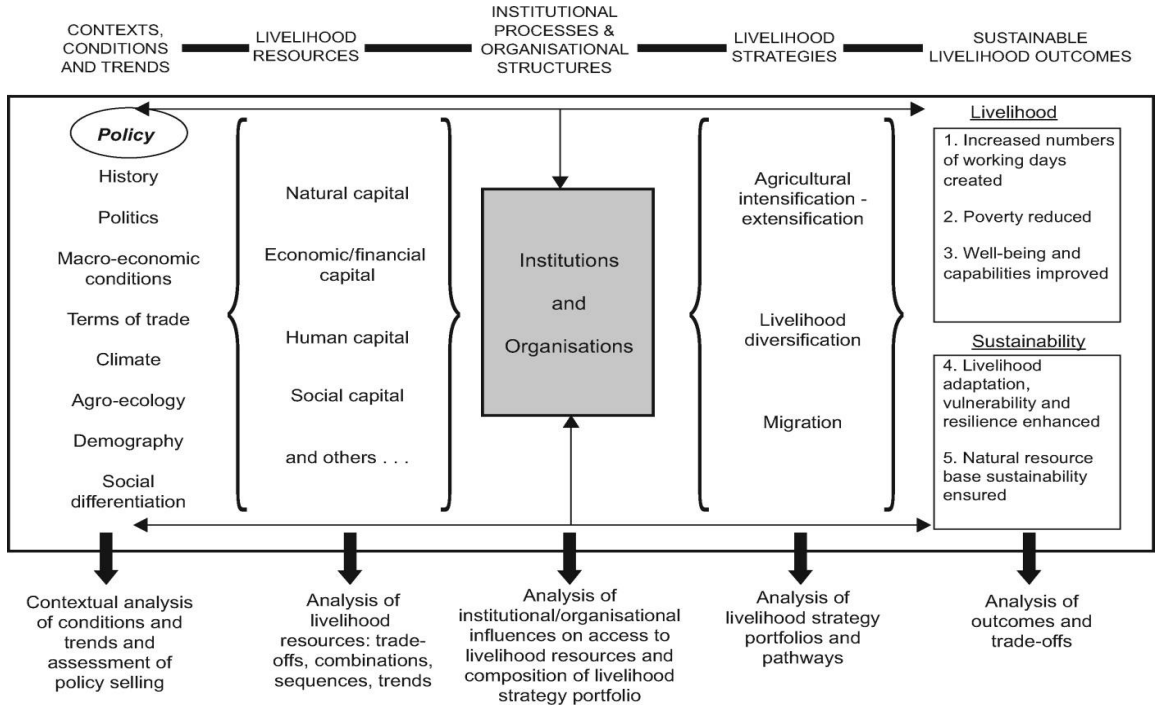

Figure 2. Sustainable livelihoods framework: A checklist

INDIAN SCENARIO:

India is marked for prodigious biodiversity. It is one of the twelve countries that wholly contain 60-70% of entire biodiversity of world. It has amazing 8.1% of global biodiversity, though it comprises of 2.4% of landmass on the earth. Moreover it also supports 16% of anthropoid population along with 18% of world's livestock. Actually 70% of approximated populations of India regionally rely on biodiversity for the survival of provisions for daily life, consisting of food, shelter, fabric, water and for safety of health. This impels extreme pressure especially on rural areas [22].

India is acknowledged as one of the eight Vavilovian centers of origin and diversity of crop plants, and more than 300 wild ancestors of cultivated plants which are now emerging under normal circumstances. India is one of 17 mega diverse countries, as recognized by Conservation International, it has 4 biodiversity hotspots. India also includes 668 protected areas which consist of national parks, wild life sanctuaries, tiger and elephant reserves, and also community and conservation reserves. India archives bioresources linked with traditional knowledge [32].

Major part of the population of India relies on forests for the attainment of livelihood. This population is varied approximately 200 to 350 millions. They acquire livelihood by amassing of different kinds of non-timber forest products. And livelihood intents also served by fuel and fodder collection and by nature dependent activities like shifting cultivation or pastoral nomadism. In the mean while some local communities are also trying to own the rights and concessions on forest and all biodiversity resources forming concomitance with the ecosystem of India. Indian government aims to launch a project named, Biodiversity Conservation and Rural Livelihood Improvement Project (BCRLIP). It improves rural livelihoods. This project envisages the recommendation of the Tiger Task Force, organized by Government of India, which will protect the Indian wild life, forests and people can coexist [33].

In India Biodiversity Management Committees are to be established under Section 41 of the act at local level. The BMC s plays an important role in documenting biodiversity, their sustainable use and in dealing with Access and Benefit Sharing (ABS) issues. [34].

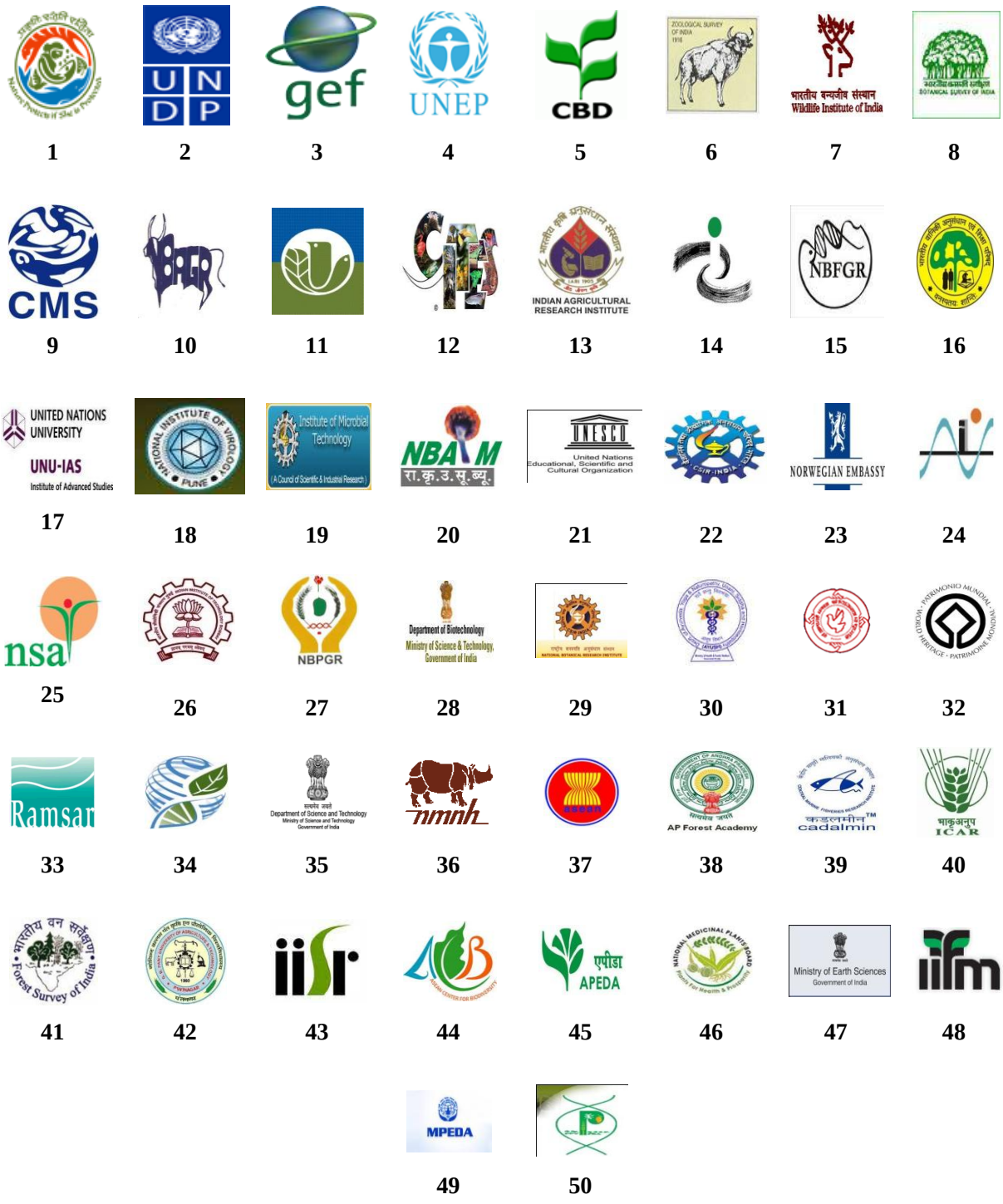

Figure 3. Partners of the Biodiversity Management Committees and their Logos [12]

1. Ministry of Environment, Forest and Climatic change, New Delhi, India
2. United Nations Development Programme, New York City
3. Global Environment Facility, United States of America
4. United Nations Environment Programme, Kenya
5. Convention on Biological Diversity, Rio de Janeiro
6. Zoological Survey of India, Kolkata, India

7. Wildlife Institute of India, Uttarakhand, India
8. Botanical Survey of India, Kolkata, India
9. Convention on the Conservation of Migratory Species of Wild Animals, Germany
10. ICAR-National Bureau of Animal Genetic Resources, Haryana
11. Norwegian Directorate for Nature Management, Norway
12. The Convention on International Trade in Endangered Species of Wild Fauna and Flora, Washington, D.C.
13. Indian Agricultural Research Institute, Delhi
14. National Innovation Foundation, India
15. The National Bureau of Fish Genetic Resources, U. P., India
16. Indian Council of Forestry Research and Education, Uttarakhand, India
17. United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS), Tokyo, Japan
18. National Institute of Virology, Pune, India
19. CSIR-Institute of Microbial technology, Chandigarh, India
20. ICAR-National Bureau of Agriculturally Important Microorganisms, Kusmaur, U.P.
21. United Nations Educational, Scientific and Cultural Organization, Paris, France
22. CSIR- The National Institute of Oceanography, Goa, India
23. Norway in India-The Royal Norwegian Embassy, New Delhi, India
24. National Institute of Oceanography, Goa, India
25. National Seed Association of India: NSAI, New Delhi, India
26. Indian Institute of Technology (IIT), Bombay, India
27. National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India
28. Department of Biotechnology, New Delhi, India
29. CSIR-*National Botanical Research Institute*, Uttar Pradesh
30. The Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy, AYUSH, India
31. Research and Information System for Developing Countries (RIS), New Delhi, India
32. United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Committee, France
33. The Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat, Ramsar (Iran)
34. International Treaty on Plant Genetic Resources for Food and Agriculture at Madrid
35. Department of Science & Technology (DST), New Delhi, *India*
36. National Museum of Natural History, New Delhi, India
37. Association of Southeast Asian Nations (ASEAN) Jakarta, Indonesia
38. A.P Forest Academy, India

39. Central Marine Fisheries Research Institute. Kerala, India
40. Indian Council of Agricultural Research, New Delhi, India
41. India Forest Survey of India
42. Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, U.P, India
43. ICAR- Indian Institute of Spices Research, Kerala, India
44. ASEAN centre for biodiversity, Philippines.
45. The Agricultural and Processed Food Products Export Development Authority India
46. The National Medicinal Plants Board, India
47. Ministry of Earth Sciences, India
48. The Indian Institute of Forest Management (IIFM), Madhya Pradesh, India
49. Marine Products Export Development Authority, Kerala, India
50. Protection of plant variety & Farmer's Authority, India

CONCLUSION:

Biodiversity conservation is the only solution for the maintenance of sustained livelihood. It plays an important role in promising food security and uplifting the poor [35]. Sustainable livelihood is holistic, self empowering, cooperative, supportive, gender sensitive. Accelerated globalization, altered environmental conditions are the threats to sustainable livelihood development. Effective usage of crop and livelistock genetic resources play vital role in enhancing food production in order to achieve sustainability [24]. By maintaining forest cover, developing the characteristic of habitat sustainable local livelihoods can be obtained. Through community forestry, alternative energy, plantations and reducing the threat to key species we can conserve biodiversity consequently sustainable livelihood.

REFERENCES:

1. http://iucn.org/what/tpas/biodiversity/about at 11/14/2011.
2. Oxford Reference Online (2010), Oxford University Press. Malmo hogs kola.
3. United Nations Conference on Environment & Development, (1992), 3 to 14 June 1992 Rio de Janeiro, Brazil AGENDA 21.
4. Chambers, R. and Conway, G.R. (1992), Practical Concepts for the 21st Century.
5. Lasse Krantz (2001), The Sustainable Livelihood Approach to Poverty Reduction.
6. Dervla Cleary (2003), ftp://ftp.fao.org/docrep/fao/006/AD682E/AD682E00.pdf
7. Shaker, R. R. (2015), Applied Geography, 63: 304–314.
8. Thorne, P. (2013), http://hdl.handle.net/10568/27934.
9. Science for Environment Policy (2015), http://ec.europa.eu/science-environment-policy.

10. Falkenmark, M.; Finlayson, M.; Gordon, L.J.; Bennett, E.M.; Chiuta, T.M.; Coates, D.; Ghosh, N.; Gopalakrishnan, M.; de Groot, R.S.; Jacks, G.; Kendy, E.; et al (2007), International Water Management Institute (IWMI)'. Pp. 233-277.
11. Matthew McCartney, Max Finlayson (2015), "Sustainable development and ecosystem services.
12. De Groot, R.; Jax, K. and P. Harrison (2016), ECFP7 Grant Agreement no.308428.
13. Sustainable Development Biodiversity and Convention on Biological diversity, (2010) https://www.cbd.int/doc/newsletters/news-sd-suplement-en.pdf.
14. Groombridge, B. (1992), https://archive.org/details/globalbiodiversi92wcmc.
15. Karl S. Zimmerer and Steven J. Vanek, (2016), Land, 5(2), 10.
16. Biodiversity and Poverty Reduction (2007), (Irish Aid Environment Key sheet 3).
17. Arun L K, Jayasankar B, Kurian Mathew Abraham, (2001), a case study of Periyar Tiger Reserve.
18. George Ledec and Robert Goodland (1988), World Bank ISBN-10: 0821311549.
19. Nicholas Landreth & Osamu Saito (2014), Australian Geographer, 45:3, 355-373.
20. http://www.birdlife.org/sites/default/files/attachments/people-and- biodiversity.pdf.
21. Economic Benefits of Biodiversity (2011), ConservationTools.org.
22. www.indiaenvironmentportal.org.in/files/ESA_main.pdf.
23. https://www.odi.org/resources/docs/2462.pdf.
24. Scoones I. W. Wolmer, (2003), Southern Africa IDS Bulletin 34: 3.
25. https://www.cbd.int/../doc/cbd-good-practice-guide-forestry-booklet-web-en.pdf.
26. United Nations Conference on Environment & Development (1992), 3 to 14 June 1992 Rio de Janeiro, Brazil AGENDA 21.
27. Food and Agriculture Organization of the United Nations. (2006a), Better forestry, less poverty: A practitioner's guide.
28. Ian Scoones (2009), The Journal of Peasant Studies, 36:1, 171-196.
29. Swaminathan, M.S. (1987), World Commission on Environment and Development. London.
30. Serrat, O. (2010), Asian Development Bank.
31. Scoones, (1998), Sustainable livelihoods framework: A checklist.
32. Ministry of Environment and Forests (2009), India's Fourth National Report to Convention on Biological Diversity.
33. The Report of the Tiger Task Force (2005), Joining the Dots, Government of India.
34. National biodiversity authority partners (2003), nbaindia.org.
35. Manika S.A and Tried.M (2002), IUCN, Gland, Switzerland and Cambridge.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 15

WETLANDS OF INDIA: BIODIVERSITY, ECOLOGICAL SERVICES AND STRATEGIES FOR CONSERVATION

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INTRODUCTION:

Biodiversity refers to the variety of life on earth. It is an index of a nation's wealth and basis of human survival and economic well-being. The word was coined by Walter G. Rosen in 1986 in the National Forum at Smithsonian Institute, Washington. It represents the totality of genes, species and ecosystems in any given region or ecosystem. It can be defined as "the diversity of life, which includes variety and variability within and among living organisms and the ecological complexes in which they occur". It encompasses community or ecosystem diversity, species diversity and genetic diversity. They provide many important services to human society [1]. Since the human beings are enjoying all the benefits from biodiversity, they should take proper care for the preservation of biodiversity in all its form and good health for the future generations. Many factors threaten the world's biological heritage such as the loss of habitat, fragmentation of habitat, over exploitation of resources, human sponsored ecosystems, climatic changes, pollution, invasive exotic spices, diseases, shifting cultivation, poaching of wild life, etc. One of the major environmental issues today is the conservation of biodiversity. Conservation of biodiversity is the proper management of the biosphere by human beings in such a way that it gives maximum benefits for the present generation and also develops its potential to meet the needs of the future generations. The three basic objectives of biodiversity conservation are i) to maintain essential ecological processes and life supporting systems ii) to preserve the diversity of species and iii) to make

sustainable utilization of species and ecosystems. Wetlands are one of the important and major ecosystems on the earth to be preserved for the well-being of human population.

I. Wetlands – Biodiversity:

Wetlands occupy 6% of the earth's surface and are highly fertile areas and are amongst the most productive ecosystems of the biosphere [2]. Globally, natural wetlands are gradually disappearing due to human interference mainly by way of agriculture or aquaculture. More than 50% of the world's production depends on the wetlands and this percentage is still higher in tropics [3].

Wetlands are the areas that are permanently or periodically inundated or saturated by surface or groundwater and support the growth of aquatic vegetation. Wetlands lie transitionally between terrestrial and aquatic systems and constitute the most complex of all ecosystems. Thus, wetland functions in a different way from either aquatic or dry habitats [4]. They are unique in many respects. The most important factor of wetlands is the presence of water for a significant time which changes the soil, microorganisms, plants and animal communities. The level of water saturation largely determines how the soil develops and the types of plant and animal communities living in and on the soil. The prolonged presence of water creates conditions that favour the growth of specially adapted plants (hydrophytes) and promote the development of characteristic wetland soils. A wetland of international importance is identified mainly based on three general criteria such as i) its biogeographical region ii) appreciable assemblage of rare, vulnerable or endangered species of fauna and flora and iii) inhabiting with water fowls.

A. Ramsar Convention on wetlands:

Ramsar Convention on Wetlands, which is an international treaty, signed in Ramsar of Iran in 1971 for national action and international cooperation for the conservation and wise use of wetlands and their resources. The delegates from various countries who attended the Ramsar convention [5] recognized the importance of wetlands as the richest and potential habitats among aquatic ecosystems, supporting a variety of flora and fauna. Considering them as heritage sites, the convention framed obligations to conserve and manage the wetlands based on sound scientific aspects. February 2nd is celebrated as the World Wetlands Day to raise public awareness about the wetlands and promote their conservation. This day marks the anniversary of signing of the convention of Wetlands in Ramsar. About 147 countries signed in this convention. In spite of the international efforts, national agreements and priorities for

wetland conservation, several natural wetlands and the species that exist in them are facing serious threat of extinction due to human intervention directly or indirectly.

Ramsar Convention defined wetlands (Article 1.1) as *"areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres"*[5]. There are several other definitions proposed by different workers. In USA, the definition of wetlands by Cowardin *et al.* [6] for US Fish and Wildlife Service is widely used. The U.S. Environmental Protection Agency (EPA) defined wetlands as *"areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions"* [7].

B. Biotic Communities:

Ramsar sites are well known for their unique biodiversity of plant and animal fauna in its specialized ecological conditions. Plants, known as saprophytes are the most conspicuous feature of wetlands. Microorganisms, although inconspicuous, are the most dominant aquatic organisms and play a significant role in the removal, transformation and recycling of nutrients and pollutants. Wetlands also support diversity of aquatic animals ranging from protozoans to mammals. Important among them are crustaceans (prawns, shrimp, crayfish,) insects, molluscs, fishes, frogs and birds. Aquatic invertebrates and fish are the important components of the food web and they provide potential food resources.

C. Types and extent of Wetlands:

Wetlands include different types of natural ecosystems like marshes, peat lands, sedge lands, reed beds, swamp forests, beels, small reservoirs, coastal lagoons, shallow lakes and rivers, mangroves, salt marshes, coral reefs and man-made ecosystems like ponds, tanks, irrigated fields, sacred groves, salt pans, reservoirs, gravel pits, sewage farms and canals. There are currently over 2,200 Ramsar Sites around the world. They cover over 210 million hectares (m ha) [8]. In India 46 major wetland sites are recognized [9]. Of these, 26 sites (689,131 ha) are recognized as Ramsar sites of international importance. The estimated total wetland area in India is 4.1 m ha [10].

India has a variety of wetland habitats and it is one amongst the 17 mega diverse countries.

Table 1. Ramsar sites of India:

Sr.No.	Wetland	Water Quality	States	Area (ha)
1	Ashtamudi Wetland	Estuarine water	Kerala	61,400
2	Bhitarkanika Mangroves	Brackish water	Odisha	65,000
3	Bhoj Wetland	Freshwater	Madhya Pradesh	3,201
4	Chandra Taal	Freshwater	Himachal Pradesh	490
5	Chilika Lake	Brackish water	Odisha	1,16,500
6	Dipor Beel	Freshwater	Assam	4,000
7	East Calcutta Wetlands	Freshwater	West Bengal	12,500
8	Harike Wetland	Freshwater	Punjab	4,100
9	Hokera Wetland	Fresh water	Jammu & Kashmir	13,750
10	Kanjli Wetland	Freshwater	Punjab	183
11	Keoladeo National Park	Freshwater	Rajasthan	2,873
12	Kolleru Lake	Freshwater	Andhra Pradesh	90,100
13	Loktak Lake	Freshwater	Manipur	26,600
14	Nalsarovar Bird Sanctuary	Freshwater	Gujarat	1,23,000
15	Point Calimere Wildlife and Bird Sanctuary	Marine water	Tamil Nadu	38,500
16	Pong Dam Lake	Freshwater	Himachal Pradesh	15,662
17	Renuka Lake	Freshwater	Himachal Pradesh	200
18	Ropar Wetland	Freshwater	Punjab	1,365
19	Rudrasagar Lake	Freshwater	Tripura	2,400
20	Sambhar Lake	Brackish water	Rajasthan	24,000
21	Sasthamkotta Lake	Freshwater	Kerala	373
22	Surinsar-Mansar Lakes	Freshwater	Jammu & Kashmir	350
23	Tsomoriri	Brackish water	Jammu & Kashmir	12,000
24	Upper Ganga River (Brijghat-Narora Stretch)	Freshwater	Utter Pradersh	2,659
25	Vembanad-Kol Wetland	Brackish water	Kerala	1,51,250
26	Wular Lake	Freshwater	Jammu & Kashmir	18,900

The wetlands of India are generally differentiated by region into following major categories: i) the reservoirs in the deccan plateau in the south, together with the lagoons and

other wetlands of the southern west coast; ii) the vast saline expanses of Rajasthan, Gujarat and Gulf of Kachchh; iii) freshwater lakes and reservoirs from Gujarat eastwards through Rajasthan (Kaeoladeo Ghana National park) and Madhya Pradesh; iv) the delta wetlands and lagoons of India's east coast (Chilka lake); v) the freshwater marshes of the Gangetic plain; vi) the floodplains of the Brahmaputra; vii) the marshes and swamps in the hills of north-east India and the Himalayan foot hills; viii) the lakes and rivers of the montane region of the Kashmir and Ladakh; and ix) the mangroves and other wetlands of the island arcs of the Andaman and Nicobars. Among all varieties of Indian wetlands, freshwater lakes, rivers and coastal mangroves dominate the Indian wetlands. The Ramsar sites recognised in India with their location and extent are given in Table1 & Fig.1

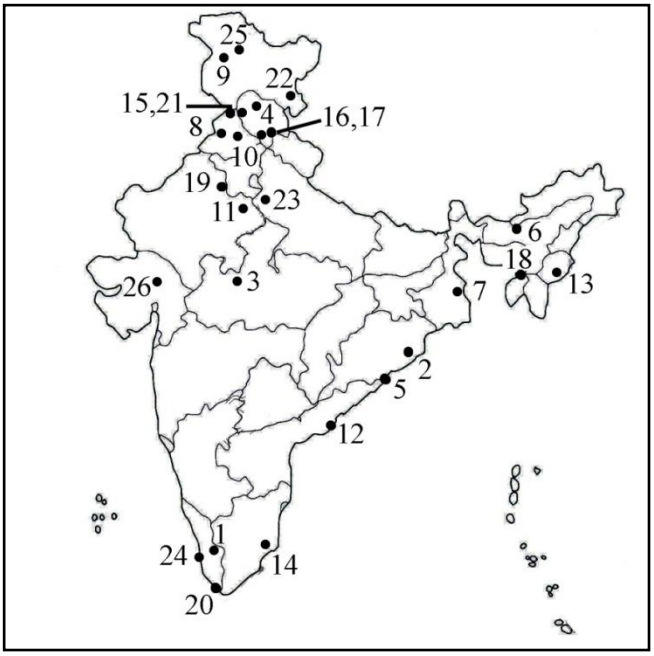

Figure 1. Map showing 26 Ramsar sites in India

The Space Application Centre (SAC), Ahmedabad prepared a National Wetlands Atlas-2011 which recognised around 2,01,503 wetlands in India with an extent of 7.6 m ha based on Ramsar Convention definition. In addition, 555557 wetlands (< 2.25 ha) have also been identified. Total wetland area estimated is 15.26 m ha, which is around 4.63 per cent of the geographic area of the country (Table 2). In terms of the proportion of the geographical area of all states, Gujarat has the highest proportion (17.56%) and Mizoram has the lowest proportion (0.66%) of the area under wetlands. Among Union Territories, Lakshadweep has the highest proportion (96.12%) and Chandigarh has the least proportion (3%) of geographical area under wetlands.

Table 2. Area estimates of wetlands in India:

Sr. No	Wett-code	Wetland Category	No. of wetlands	Total wetland area (ha)	% of wetland area (ha)	Open Water	
						Post-monsoon area (ha)	Pre-monsoon area (ha)
1	1100	Inland Wetlands - Natural	45658	6623067	43.40	4100766	3115701
2	1200	Inland Wetlands - Man-made	142812	3941832	25.83	3267602	1654170
		Total - Inland	188470	10564899	69.23	7368368	4769871
3	2100	Coastal Wetlands – Natural	10204	3703971	24.27	930663	750339
4	2200	Coastal Wetlands – Man-made	2829	436145	2.86	301767	281010
		Total - Coastal	13033	4140116	27.13	1232430	1031349
		Sub-Total	201503	14705015	96.36	8600798	5801220
5	3100	Wetlands (<2.25 ha)	555557	555557	3.64	-	-
		Total	**757060**	**15260572**	**100**	**8600798**	**5801220**

Source: National Wetland Atlas, MoEF, Govt. of India (Space Application Centre (ISRO), Ahmedabad, Mar.2011

D. Classification of wetlands:

The Ramsar classification was initially developed as a simple tool for describing Ramsar sites. It serves as a broad framework to aid rapid identification of the main wetland habitats represented at each site, and to provide units for mapping and comparability of concepts and terms in national or regional wetland inventory. The classification of wetlands is based on water regime, water chemistry, soil properties and anthropogenic factors.

The classification proposed by Cowardin *et al*. [6], Gopal [9] and Gopal and Saha [11] are in use. Gopal and Saha [11] proposed a classification of wetlands of India attaching greater significance for hydrological and vegetation types. The following is the classification proposed by Cowardin *et al*. [6] which is recognized at international scenario.

Classification of wetlands:

I. Marine: Open ocean overlaying continental shelf

1. Subtidal: Substrate continuously submerged.
2. Intertidal: Substrate exposed and flooded by tides.

II. Estuarine: Deep water tidal habitat with freshwater runoff from land

1. Subtidal: as under I (1)
2. Intertidal: as under I (2)

III. Riverine: Include all wetland and deepwater habitat contained within a channel (1)

1. Lower Perennial: gradient low, no tidal influence
2. Upper Perennial: gradient high, velocity of water fast
3. Intermittent: non-tidal flowing water for only part of the year

IV. Lacustrine: Topographic depression, lacking tree, shrub and exceed 8 ha.

1. Limnetic: all deep water above 2m depth
2. Littoral: all wetland below 2m depth or non-persistent emergent

V. Palustrine: All wetland dominated by trees, shrubs and tidal wetland with salinity below 0.5%

The following Man-made wetlands are also classified as Ramsar sites by Ramsar convention [12].

1. Aquaculture ponds including small tanks (generally below 8 ha).
2. Irrigated land including irrigation channels and rice fields.
3. Seasonally flooded agricultural lands.
4. Salt exploitation sites, salt pans, etc.
5. Water storage areas like reservoirs/barrages/dams/impoundments (above 8 ha).
6. Excavations such as gravel/brick/clay pits, mining pools, etc.
7. Waste water treatment areas like sewage farms, settling ponds, oxidation basins, etc.
8. Canals and drainage channels, ditches.

II. Wetlands - Ecological services

Wetlands provide several critical functions that are essential for sustainable development in many areas. Ecosystem functions are defined as 'the capacity of natural processes and components of natural or semi-natural systems to provide goods and services that satisfy human needs" [13]. The ecological services provided by wetlands are described under the following categories.

A. Provisioning services:

The wetlands provide food, raw materials (wood, fuel), genetic resources, medicinal resources and ornamental resources (skin, shells, fish, flowers) for the man. Many wetlands such as agriculture fields and aquaculture systems contribute to food production. Detritus in the wetlands especially form a rich source of food for organisms of lower trophic levels which inturn form food for higher organsisms. As the wetlands act as food reservoirs, they are called "Biological Supermarkets". Mangrove wetlands harbour unique micro fauna, a great source of various bioactive microbial compounds. For example, Actinomycetes are the best examples for diverse applications like Industrial enzyme production, anti-microbial activity, anti-cancer activity, enzyme inhibition potentiality, probiotic activity and anti-angiogenesis activity, etc. [14]

B. Regulating services:

Wetlands maintain the essential ecological processes and life support systems like gas, climate, water supply and flood regulation, water purification, waste treatment, pollination, etc. Because of their capacity to store and purify the water, wetlands are called "Nature's Kidneys" [15]. Wetlands function as hydrological buffers (natural sponges) that they collect and hold water during floods, and release it gradually thereby regulating water flows and ensuring consistent supply [16]. Trees, root mats and other wetland vegetation also reduce the speed of flood waters and distribute more slowly over the floodplains. This helps in lowering the flood heights and erosion (Fig.2).

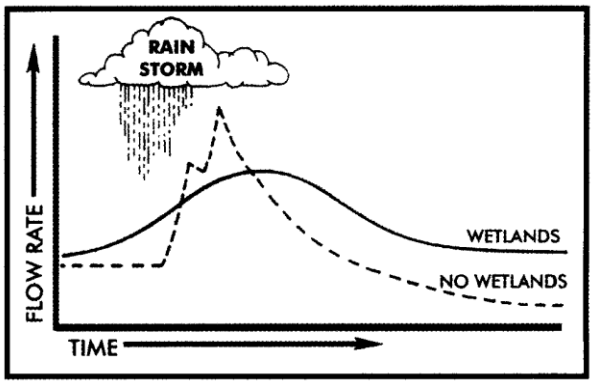

Figure 2. Role of wetlands in reducing the peak storm water flows (Source: Kusler, 1983)

They undertake the role of Disaster Risk Reduction (DRR) by providing resilience during water-related hazards such as floods, droughts and storm surges. Integrating wetlands as natural infrastructure for DRR alone or in conjunction with traditional "hard"

infrastructure can mitigate hazards and increase the resilience of local communities and those living in the river basin areas or coastal zones. Healthy peat lands acts as good source for carbon storage and thereby mitigate the impacts of climate change.

C. Cultural and Amenity services:

Wetlands are a source of inspiration to human culture and education. These are a source of delight for those who admire the beauty of nature and love. Wetlands are famous for popular tourism and recreational activities like hiking, fishing, bird watching, photography, boating and hunting so that it creates employment opportunities and livelihood for local people [17]. Wetlands provide aesthetic value to residential communities, reducing stream bank erosion, economic benefits and educational opportunities as an ideal "outdoor classroom" [18]. Wetlands have cultural significance [19] e.g. Pushkar Lake in Rajasthan and Ramappa Lake in Telangana are intrinsically linked to the local cultural aspects. They are revered by the masses in recognition of the fact that they are the means of sustenance of their livelihood.

D. Supporting services:

As the wetlands support rich aquatic vegetation and fauna, the detritus accumulation and decomposition and nutrient recycling in the sediment are major processes for nutrient retention and soil formation. Wetlands provide habitat for flora and fauna (eg. feeding and breeding ground for migrating birds) in order to maintain biological and genetic diversity. Coastal wetlands such as mangroves provide spawning and feeding grounds for fish and shrimp. The complex, dynamic relationships among the organisms inhabiting an ecosystem are referred to as food webs are unique to the wetlands across the world.

III. Wetlands - Factors causing imbalance of biodiversity:

Wetlands are perhaps the first target of human intervention and are among the most threatened of all natural resources. About 50% of the wetlands on the earth are estimated to have disappeared over the last hundred years by converting them for industrial, agricultural, aquacultural and residential developments. Even in the present day scenario, when the ecological services provided by wetlands are better understood, degradation and conversion of wetlands is still continuing worldwide. This is largely due to the ignorance of invaluable roles of wetlands in policy-making, plans and corporate evaluations of development projects. The biodiversity and heritage of wetlands are under great threat due to alarming rate of

species extinction, habitat degradation, invasive alien species, over exploitation, climate change, etc.

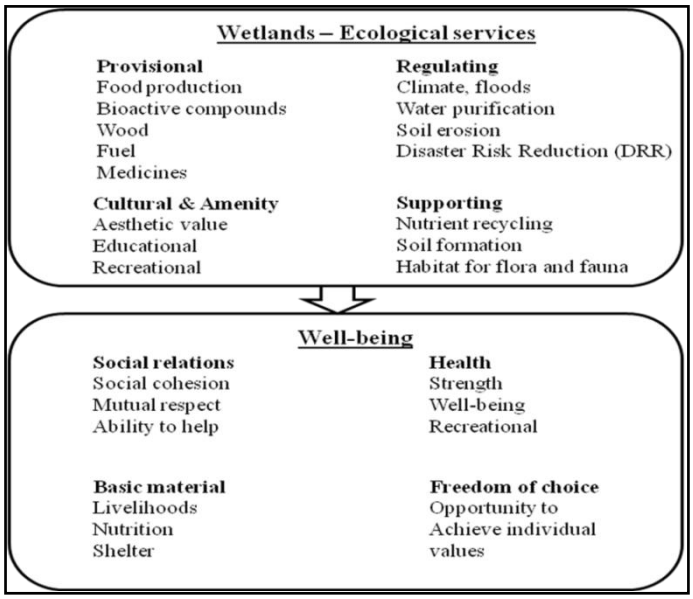

Figure 3. Wetlands – Ecological services and well-being

A. Climate change:

Climate change is a universal problem and is an important driver for loss and change of biodiversity in wetland ecosystem. Consequences of climate change are the rise in the sea level causing the loss of mangrove habitat, coral bleaching, change of water temperature, change in the northern latitudes and several hydrological effects [20]. India became the victim of climate change for last two decades. It experiences the Flood-drought-flood cycle which severely affects the wetland diversity. For example, climate change causes rise in water level of Tsomoriri Lake in Ladakh, a glacial fed high altitude lake, in which the important breeding islands get submerged where endangered migratory birds like the Black-necked Crane and Bar-headed Goose would breed. As per an estimate, India will lose about 84 percent of coastal wetlands and 13 percent of saline wetlands with a rise of 1 m sea level due to climate change [21].

B. Urban expansion and Habitat degradation:

With the advent of rapid population growth, several anthropogenic factors cause the degradation of wetland ecosystems. In the course of urbanization, urban population in India has increased tenfold since 1901. This magnitude of growth exerted tremendous pressure on

wetlands for meeting water and food demand of growing population. Construction of dams and bridges (Fig.4), resorts (Fig.5) and theme parks severely affect the habitat conditions by way of damaging, blocking and reducing the river and floodplain habitats [22]. Developmental activities like the construction of roads, ports, harbors, industries, aquaculture farms in mangrove forests and lake boundaries and shallow areas lead to habitat degradation and biodiversity of wetland ecosystem.

Figure 4. Construction of bridge across a wetland

Figure 5. Construction of resorts in Lake Kolleru

C. Pollution:

Water pollution by oil and petroleum spills, industrial acid deposits (release of effluents like Ammonium and Nitrate from fertilizer units at Kakinada bay, Andhra Pradesh), pesticide and fertilizer residues from agricultural paddy fields and immersion of idols and religious ritual waste, etc. damage the biodiversity of wetland ecosystems.

D. Acidification:

Acidification of wetlands takes place in two ways either by acid deposition in the form of industrial wastes or by acid rains. As a consequence, the levels of dissolved calcium get depleted in wetland waters [23]. Calcium is an essential element for aquatic organisms. Reproduction in *Daphnia* is compromised when calcium concentrations are lower than 1.5 mg/l [24].

E. Invasive Alien Species:

Invasive species, also called Alien species, are the non-native harmful species introduced naturally or manually and get established themselves in ecosystems. Wetland habitats are usually very productive and support a large number of threatened and endangered species. Invasive species can threaten the diversity or abundance of these native species as well as the ecological stability of the whole habitat. They compete with native plants and

animals for resources and subsequently change the ecosystem productivity and nutrient cycles [25]. They disrupt food webs and habitats causing alteration of biodiversity. Other economic oriented impacts of the alien species include reduced habitat quality including forage for wildlife and livestock and recreational opportunities [26, 27].

IV. Biodiversity: Strategies for Conservation:

The conservation of biodiversity is required at the national and international levels for developing a global system of protected areas, so that the biodiversity continues to remain available for the benefit and welfare of human population for all times to come. Restoration of the habitats and the rehabilitation of the endemic and threatened species has to be undertaken to promote biodiversity. Conservation of freshwater biodiversity of wetlands gained wide interest since the inception of the UN international decade for action on "Water for life 2005-15". UNO emphasized the importance of freshwater Lake Biodiversity under 15th goal (Life on land) of Sustainable Developmental Goals (SDG) to be achieved by 2030. This goal contains 12 targets, of which two are pertaining to wetland biodiversity conservation which are as follows: By 2020 (i) to ensure the conservation, restoration and sustainable use of inland freshwater ecosystems and their services, particularly wetlands, in line with obligations under international agreements, and (ii) to introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species.

Wetlands continue to decline globally, both in area and in quality. As a result, the ecosystem services of wetlands to the society are diminished. Contracting Parties and their policymakers are urged to take immediate action to meet the Ramsar Convention's objective to stop and reverse the loss and degradation of wetlands and services to people. Managing wetlands is a global challenge and the Ramsar Convention presently counts over 160 countries as Contracting Parties, which recognize the value of having one international treaty dedicated to a single ecosystem.

A. Environment policies and associated schemes in India:

- **National Wetland Conservation Programme (NWCP):** It was launched in 1985 to enable conservation and wise use of wetlands in the country so as to prevent their further degradation.
- **The Central Wetlands (Conservation and Management) Rules:** They were notified for the first time in 2010 for better management and regulation of wetlands across the

country. It saw the formation of Central Wetlands Regulatory Authority (CWRA) whose term ended on 31 March 2015 and it wasn't reconstituted since then.

- **National Environment Policy 2006:** Recognising the importance of wetlands, it calls for developing a national inventory of such wetlands and implementing a wide spectrum of policies and plans for wetland conservation and their environmental impact assessment (EIA).
- **National Plan for Conservation of Aquatic Ecosystems (NPCA):** It was unveiled in 2015 to provide for policy framework and support to State Governments for integrated management of wetlands. This initiative was launched by merging two separate Centrally Sponsored Schemes (CSS), namely the National Wetlands Conservation Programme (NWCP) and the National Lake Conservation Plan (NLCP).
- **Capacity Building:** In order to increase the capacity of wetland managers, upgradation of the existing Wetland Research and Training Centre of Chilika Development Authority at Barkul, Odisha into the National Capacity Development Centre for Wetlands is under consideration.

B. Five point Strategy for conservation of mangroves:

a. To understand the autecology (individual species ecology) of the mangrove species at the site, in particular the patterns of reproduction, propagule distribution, and successful seedling establishment.
b. Understand the normal hydrologic patterns that control the distribution and successful establishment and growth of targeted mangrove species.
c. Assess modifications of the original mangrove environment that currently prevent natural secondary succession.
d. Design the restoration program to restore appropriate hydrology and, if possible, utilize natural volunteer mangrove propagule recruitment for plant establishment.
e. Only utilize actual planting of propagules, collected seedlings, or cultivated seedlings after determining (through steps a-d) that natural recruitment will not provide the quantity of successfully established seedlings, rate of stabilization, or rate of growth of saplings established as objectives for the restoration project.

C. Molecular Barcoding technologies in wetland management:

a. DNA Barcoding: DNA Barcoding technology (Cytochrome Oxidase I gene (COI/ Cox) based technology) is being used extensively in aquatic diversity studies for the identification

of species [28, 29], strains and hybrids [30] as well as for species delimitation. With respect to wetland biodiversity, it is applicable for revealing cryptic species [31], calculating genetic divergence within and among the species and identification of Short Range Endemics (SRE's) [32] in lakes and mangroves (Fig.6). Moreover, it plays a crucial role in the rapid documentation of α-taxonomy for several precious faunal groups of wetland ecosystems before they get extinct [31] and accelerates the rate of species discovery. Availability of universal primers facilitates the broad application of technology across all hierarchical levels of many groups of aquatic invertebrates [33] and vertebrates [34].

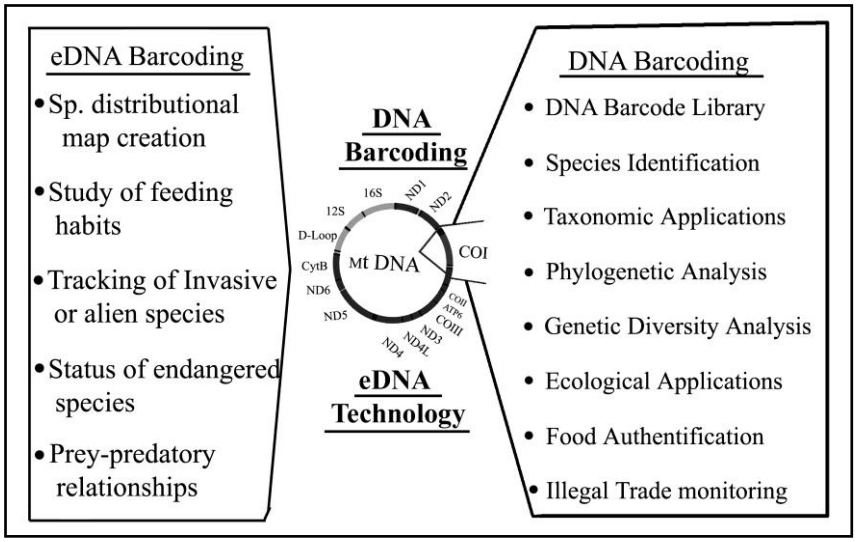

Figure 6. Applications of molecular barcoding in aquatic diversity

b. Environmental DNA (eDNA) technology: eDNA refers to genetic material from the environment in the form of whole microbial cells or shed from multicellular organisms *via* metabolic waste, damaged tissue or sloughed skin cells. eDNA technology is based on the DNA released into environment in various forms like feces or excrements, fish slime, scrapped-off tissue cells and cells released after the death or decay of organism. It can be done even with low quantities of DNA. This technique is being widely used in determining the presence or absence of an organism in a particular wetland ecosystem [35] which is critical to ecological management and conservation biology. It also estimates the abundance and biomass of a species in a particular environment [36], creating the distributional maps, determining the feeding habits of endangered species and finding the prey-predatory relationships.

The major ecological applications of eDNA technology include tracking of invasive species and monitoring endangered species (Fig. 6). eDNA technology helps in identifying the source species for whale meat, sturgeon eggs, shark fins and other high valued (and

imperiled) species which are subjected to illegal trade. It is possible to track the presence of invasive species in an ecosystem before it gets established and cause harm to it [37]. It can be applicable from the pond ecosystem level to the ocean ecosystem. Its application is expanded to many groups of animals including crustaceans, molluscs, fishes and amphibians [38]. Sometimes past data is required for the analysis of eDNA. It is also possible to characterize the diet contents of invasive species which helps in risk assessment of an ecosystem. Even small samples are sufficient for reliable identification.

REFERENCES:

1. Ten Brink, P., Badura, T, Farmer, A. and Russi, D. (2012), Institute for European Environmental Policy, London.
2. Turner R.K., Van der Bergh J.C.J.M., Soderqvist, T., Barendregt, A. and Van Ierland, E.C. (2000), Ecol. Econ., 35(1), P. 7-23.
3. https://www.epa.gov/wetlands/what-wetland Accessed on 17th July, 2017.
4. Barbier, E.B., Acreman, M., and Knowler, D. (1997), Ramsar convention Bureau, Gland, Switzerland.
5. Koester, V. (1989), The Ramsar convention in Denmark, P.23.
6. Cowardin, L.M., Carter, V., Golet, F.C. and LaRoe, E.T. (1979), U.S. Fish and Wildlife Service, Washington, DC. P.103.
7. Clean Water Act: Section 404- How Wetlands are Defined and Identified (by EPA),
8. http://www.ramsar.org/sites-countries/the-ramsar-sites Accessed on 05th Aug, 2017.
9. Gopal, B. (1995), Hand book of wetland management WWF – India, New Delhi.
10. Trisal, C.L. and Kaul, S. (1996), Conservation and management of Lake/reservoirs in India, ILEC P.254.
11. Gopal, B. and Saha, M. (1995), Vegetatio, 118, P.39-48.
12. Kabii, T. (1998), Ramsar wetland classification: implications on the conservation and wise use of wetlands in Africa. FAO
13. de Groot, R.S. (1992), Wolters-Noordhoff, Groningen.
14. Baskaran, R., Vijayakumar, R., and Mohan, P.M. (2011), Malaysian J Microbiol, 7(1), P. 1-7.
15. https://www.aswm.org/wordpress/the-compleat-wetlander-wetlands-%E2%80%93-nature%E2%80%99s-kidneys-and-other-specialized-services/ Accessed on 01st August, 2017.
16. Kusler, J.A., (1983), Environmental Law Institute, P.4.
17. MEA (Millennium Ecosystem Assessment) (2005), Ecosystems and human well-being, Washington DC: Island Press.
18. https://www.usda.gov/media/blog/2014/05/27/restored-wetland-doubles-outdoor-classroom-high-school-students Accessed on 05th Aug, 2017.

19. Maltby, E. and Acreman, M. C. (2011), Hydro. Sci. J., 56(8), P. 1341-1359.
20. Bergkamp, G. and Orlando, B. (1999), UN Framework Convention on Climate Change. IUCN, Gland, Switzerland.
21. Pangare, G., Pangare, V. & Das, B. (2006), Springs of Life: India's Water Resources. Academic Foundation.
22. Vörösmarty, C.J., McIntyre, P.B., Gessner, M.O., Dudgeon, D., Prusevich, A., Green, P., Glidden, S., Bunn, S.E., Sullivan, C.A., Liermann, C.R. and Davies, P.M. (2010), Nature, 467(7315), P.555.
23. Clair, T. A. and Hindar, A. (2005), Enviro. Reviews, 13(3), P. 91-128.
24. Riessen, H.P., Linley, R.D., Altshuler, I., Rabus, M., Söllradl, T., Clausen-Schaumann, H. and Yan, N.D. (2012), Proc.Nat. Aca. Sci., 109(38), P. 15377-15382.
25. Vilà, M., Espinar, J. L., Hejda, M., Hulme, P. E., Jarošík, V., Maron, J. L., & Pyšek, P. (2011), Ecology letters, 14(7), P. 702-708.
26. Zavaleta, E.S., Hobbs, R.J., & Mooney, H.A. (2001), Tre. Eco. & Evol. 16(8), 454-59.
27. Pimentel, D., Zuniga, R., and Morrison, D. (2005), Ecol. Econ., 52(3), P. 273-288.
28. Hebert, P.D.N., Cywinska, A. and Ball, S.L. (2003), Biol. Sci. 270(1512), P. 313-321.
29. Ward, R.D., Zemlak, T.S., Innes, B.H., Last, P.R. and Hebert, P.D.N. (2005), Biol. Sci. 360(1462), P.1847-1857.
30. Hebert, P.D.N. and Gregory, T.R. (2005), Syst. Bio., 54(5), P. 852-859
31. DeSalle, R., M.G. Egan and M. Siddall (2005), Biol. Sci., 360(1462), P. 1905-1916.
32. Erpenbeck, D., Weier, T., Voogd, N.J.D., Wörheide, G., Sutcliffe, P., Todd, J.A. and Michel, E. (2011), Mol. Phylo. Evol. 61(1), P. 231-236.
33. Folmer, O., Black, M., Hoeh, W., Lutz, R. and Vrijenhoek, R. (1994), Mol. Mar. Bio. Biotech., 3(5), P. 294-299
34. Ivanova, N.V., Zemlak, T.S., Hanner, R.H. and Hebert, P.D.N. (2007), Molecular Ecology Notes, 7(4), P. 544-548.
35. Rees, H.C., K.C. Gough, D.J. Middleditch, J.R. Patmore and B.C. Maddison (2015), J. App. Eco., 52(4), P. 827-831.
36. Pilliod, D.S., Goldberg, C.S., Arkle, R.S., Waits, L.P. (2013), Can. J. Fish. Aquat. Sci., 70, P.1123–1130.
37. Dejean, T., Valentini, A., Miquel, C., Taberlet, P., Bellemain, E. and Miaud, C. (2012) J. Appl. Ecol., 49, P. 953–959.
38. Secondi, J., Dejean, T., Valentini, A., Audebaud, B. and Miaud, C. (2016), Amphibia-Reptilia, 37(1), P. 131-136.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 16

FOREST AND FOREST FRINGE PROBLEMS IN ASSAM, INDIA

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INTRODUCTION:

Assam, the only plain state in entire Northeast India located almost at the central part of the region. Only Karbi Anglong and Dima Hassao are the two districts have hilly tracts among 33 districts in the state. Assam lies between 24º44' N to 27º45' N latitude and 89º41' E to 96º 02' E longitude and is geographically becomes most important state in the region mainly because it connects all the states of Northeast by land, air and train routes with rest of the country. Mighty Brahmaputra is flowing in east-west direction creating an extensive alluvial plain of very low gradient and divides the entire plain almost into two equal halves. Assam and the entire Northeast India fall in sub-tropical monsoon belt and the region as a whole becomes a part of one of the major global biodiversity hotspots. Having suitable climate, soil and other environmental conditions the state as a whole gets congenial conditions to support luxuriant growth of vegetation with immense diversity. As a result from time immemorial Assam was known as the 'land of jungles'. But increase of population at very high rate and due to many socio-economic and political activities in the recent years, a few patches of forests left out at present. In spite of massive deforestation Assam is still endowed with18 wildlife sanctuaries, 5 national parks (Table-1 & Table-2), and as many as 312 reserved forests which cover an area of 13,870 sq. km. i.e. 17.68 percent of the total geographical area of the state. Moreover, 145 reserve forests are proposed which will cover 3,103 sq. km. Unclassed forests in the state accounted 5,865 sq. km. The protected area network accounts 25 numbers, which cover 3,925 sq. km. i.e. 5 percent of the total geographical area. As such, altogether the forest area in Assam is 26,748

sq. km. But out of this forest cover area, very dense forest accounts only 1,684 sq. km., moderately dense accounts 11,358 sq. km. and rests are remain as the degraded or open forests [1].

Table 1. Wildlife Sanctuaries in Assam:

Sr. No.	Name of Wildlife Sanctuary	Year of Est.	Area in sq km
1	Garampani	1952	6.05
2	Lawkhowa	1972	70.14
3	Barnadi	1980	26.22
4	Porbitora	1987	38.81
5	Chakrashila	1994	45.56
6	Burachapori	1995	44.06
7	Pani-Dihing Bird	1995	33.93
8	Hollongapar Gibbon	1997	20.98
9	Sonai Rupai	1998	220
10	Bherjan-Borajan-Padumoni	1999	7.22
11	East Karbi Anglong	2000	221.81
12	Nambor	2000	37
13	Nambor Doigrung	2003	97.15
14	Marat Longri	2003	451
15	Amchang	2004	78.64
16	Barail	2004	326.25
17	Deepor Beel	2002*	4.14
18	Dihing Patkai	2004	111.19

*Ramsar site, Source – Wildlife Institute of India

Table 2. National Parks in Assam:

Sr. No.	Name of National Park	Year of Notification	Area in sq km
1	Kaziranga	1974	859.42
2	Manas	1990	500.00
3	Nameri	1998	200.00
4	Orang	1999	78.81
5	Dibru-Saikhowa	1999	340.00

Source – Wildlife Institute of India

FOREST PROTECTION POLICIES AND GOVERNANCE:

Assam had always been known for the rich forests. There was not much of commercial use in the Pre-British time. People used forests for its timber, mainly to build houses, boats and furniture. Forest dependent activities were not there in large scale. The ownership of forests was lies with the community living in the fringe areas located in the outskirts of the villages [2]. However, during the Ahom period, timber was used for earning revenue. The Ahoms never interfered the traditional practices of the tribal population and communal forest lands.

After the Ahoms, during the British colonial administration (in the early 18th and 19th century) the forests of Assam have been used primarily for revenue generation. From 1874 when the Scheduled Districts Act was enacted, until the India Act of 1935, the autonomy of the scheduled tracts was ensured, protecting the communities, indigenous governance structures, and the forest management practices of the tribes. But in the post-independence era, based on the recommendations of the Bardoloi Committee, a unique system of governance evolved in the sixth schedule states, where district or regional councils were given to legislate on issues like forest management. According to Darlong 'The autonomous councils were created to protect and promote customary traditional laws, including rights and privileges over the forests and its resources, and overall forest management in the Council areas'[3].

The geographical boundaries of the states changed over time. But the rules under the Assam Forest Regulation 1891, which were adopted, based on the Upper Burma Forest Regulation is still a relevant legislation in forest management in Assam. Till today, some of the provisions kept in the rules even after the changes in socio-economic and political situation of the state. Later Assam had designated sixth scheduled areas for which there were separate forest related laws. But the variations were there in implementing the Act and Rules. For example, though technically the forest department does not control the areas under the Autonomous Hill Councils, but the workers have been engaged to manage the Council forests. Subsequently, the Government of Assam has formulated certain policies to protect its forest resources by enacting special legislations. The Assam Forest Protection Force Act, 1986 is one such example. In this Act, the term forest includes all types of forests, reserve, forest village, proposed reserved forest, protected and unclassified forest areas etc. Even under the provision of this Act, in 1997 the Dibru-Saikhowa Sanctuary and certain adjacent areas were declared as a Biosphere reserve under the UNESCO's Man and Biosphere (MAB) Programme.

In 1998, The Assam Joint (People's Participation) Forestry Management Rules were made to secure active participation of local people for regeneration, maintenance and protection of degraded forests and plantation in areas outside reserved forests. In 2004 the Assam Joint Forest Management (JFM) Rules were released following the guidelines issued from Ministry of Environment and Forest in 2000 and 2001 for strengthening the JFM programme by incorporating legal backup to JFM committees. Prior to that, the 1988 Forest Policy envisaged for conservation of soil and environment, subsistence requirements of the local people etc. [4]. Thereafter, the Govt. of India issued guidelines on 1st June, 1990 and adopted Joint Forest Management under the National Afforestation Programme for conservation of forests with clearly identified duties and functions for ensuring protection of forests [5]. The policy was motivated by a desire to both reduce environmental degradation and also reduce rural poverty [6].

It is to be noted here that in November 2002, the Deepar beel (wetland) was given the status as one of the Ramsar sites; the only Ramsar site in the state. The Assam Forest Policy 2004 was adopted in light of the shortfalls which were discovered in the protection and conservation of forests in Assam. This policy came into force before the enactment of the scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006. Moreover, for ecological security and sustainable utilization of bamboo for economic development, protection and promotion of bamboo and rattan–'The Assam Bamboo and Rattan Policy came into light in 2005. The policy mandates the establishment of a separate Bamboo and Rattan Development Wing in the state forest department. It has an institutional structure to facilitate the implementation of the same, but does not envisage a role for the community based institutions and the Forest Development Agencies. The Assam Hill Land and Ecological Sites (Protection and Management) Act 2006 came into force more specifically in the hill areas of Guwahati to protect the hill land and ecological sites from unauthorized encroachers, earth cutting etc.

In spite of taking so many measures by enacting acts and rules during more than hundred years, the following challenges are still there in forest management in the state. These are-

1. Enforcement of the acts and simultaneous monitoring
2. Preventing encroachment of forest areas, consolidating and demarcating reserve forest boundaries.
3. Working with local communities for the sustainable management of forests.

4. Joint Forest Management emerges out of a circular and does not have legal sanctity. In other words, any activity done under a JFM program for a micro plan, any MoU framed is not enforceable in a court of law.
5. How best can both livelihood practices and forest conservation be accommodated in the wake of growing conflicts between agrarian and forest frontier, and
6. Balancing forestry programme with social realities.

ISSUES OF THE FOREST FRINGE:

If we try to examine the degradation process of a forest, usually we see the degradation first starts in its fringe. The causes of fringe degradation are mainly human induced; but natural causes could not be undermined. In this study the fringe issues have been highlighted from the study of three categories of forests. One is national park (Kaziranga), another is Wildlife Sanctuary (Laokhowa) and the other is Reserved Forest (Doboka & Jamuna Maudanga). The fringe problems in all three categories of forests are different.

The present status of socio-economic condition of the fringe villages of the Doboka and Jamuna Maudanga Reserved Forest areas has been analysed both on primary data and secondary information (Fig. 1). The economic condition of the villagers in the fringe areas is very poor. Except a few, villages are not yet connected with electric power supply (70 percent households have no power connection), roads are still earthen and people do not get purified water for drinking. To reach the nearest market at Akashiganga most of the villagers have to walk more than 10 km. Only about 14 per cent people in the fringe villages brought under study are getting pipe water while others have to use either tube well water or pond and open well water. But most dangerous problem in drinking water is high amount of fluoride content. The effect of fluorides on human health is prominent mainly in the Dikharumukh village. Blackish teeth, bends in bones and short life span (50 to 60 years only) of most of the people clearly indicate how the people have been affected by excessive fluorides in water (Photo 1 & 2).

One of the problems of recent origin in the villages is man- elephant conflict. Dikharumukh, Urdhagaon and Bheroni are the worst affected villages. Usually during the months April, May and June herds of elephants enter the villages and cause severe damage to standing crops and dwelling houses. With the degradation of forests and increasing encroachments in forest areas more damage has been caused by the elephants. Uncontrolled hacking of forest for fire wood and to some extent illegal selling is still continuing for which

forests have been depleting. Encroachments in recent years in Jamuna Maudanga Reserved Forest are causing more damage to the forests.

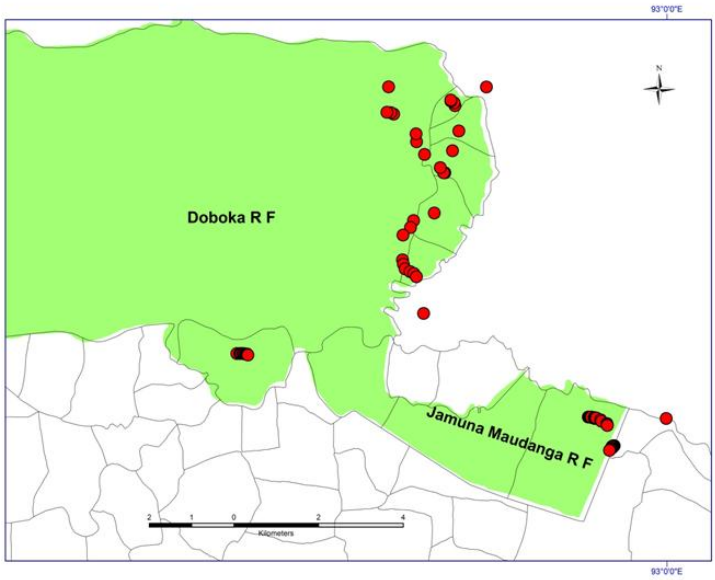

Figure 1. Fringe villages under study with GPS points in Doboka and Jamuna Maudangsa RF

Photo-1 Fluoride effect on bones

Photo -2 Fluoride effect on teeth

The fringe situation in Laokhowa WLS is different. The sanctuary is an ideal habitat of one horned rhinoceros. A few years back as many as 60 rhinos were there in Laokhowa WLS. But at present there is not a single rhino found in the sanctuary due to poaching. Human settlement figure in the Sanctuary has been significantly increased. In last few decades Khalihamari, Sarulani, Laterijan, Mowamari and Udmari wetlands have been encroached in a big way. A large tract of land inside the WLS were encroached upon by people coming from other parts of the country and mainly the suspected immigrants from Bangladesh. It has happened mainly due to encouragement by some of the politicians, who

are looking for votes to contest in election. Some forest villagers developed artificial fisheries within the sanctuary. In addition, huge area of the sanctuary brought under crop cultivation particularly in the southern part of the embankment at Singimari and Chunchahar area. Due to Assam movement and its consequence in between 1979 to 2000 AD, the political situation became very unstable and taking that advantage the forest cover of the fringe areas was destroyed and converted to agricultural land. The land use and land cover change in the maps of 1999 and 2013 clearly show how the tree cover area is depleting and how human interference is increasing the Sanctuary (Fig. 3 & Fig. 4)

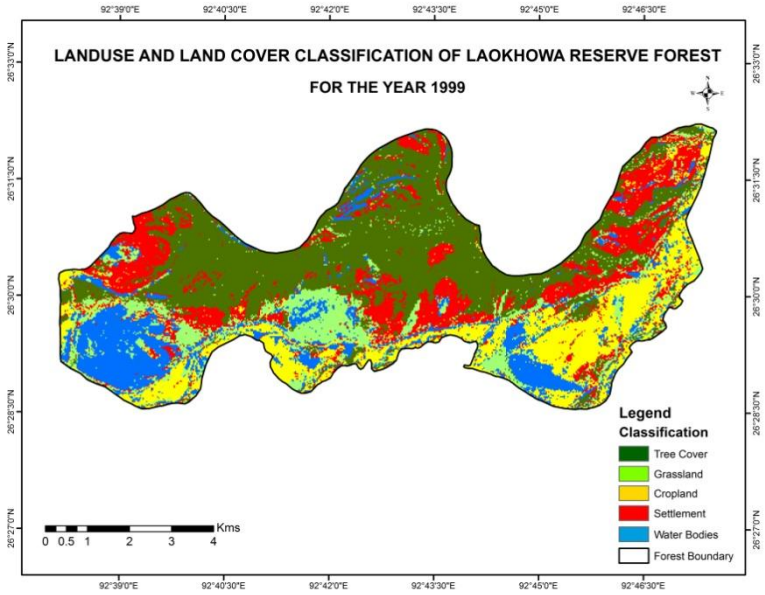

Figure 3. LULC map of Laokhowa WLS, 1999

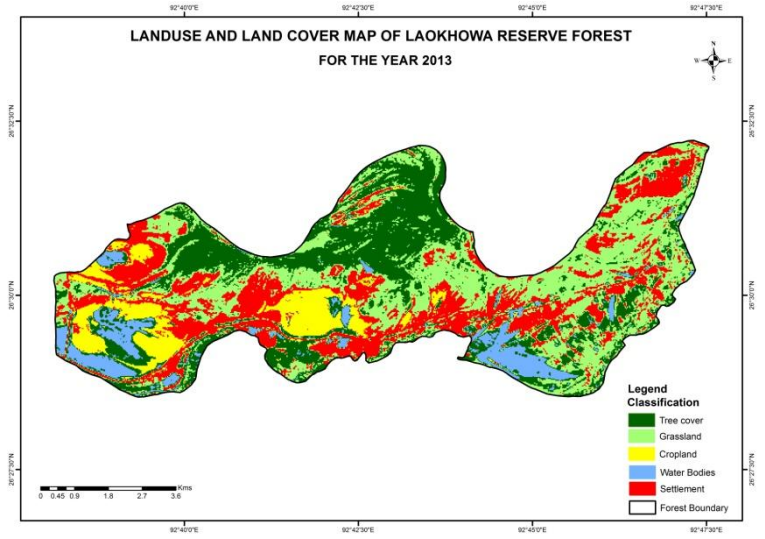

Figure 4. LULC map of Laokhowa WLS, 2013

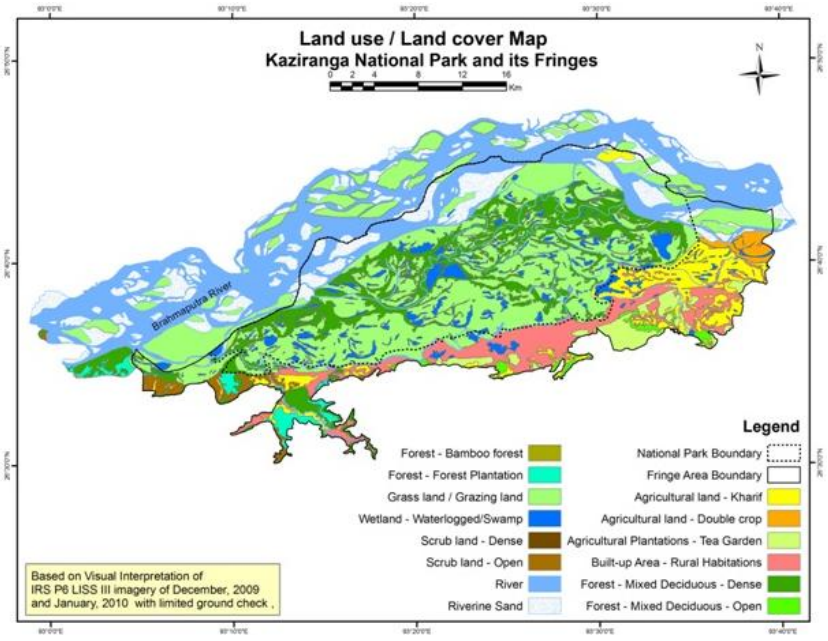

Fig. 5 LULC and Fringe area map of Kaziranga National Park (KNP)

The problems of fringe areas of Kaziranga National Park (KNP) are different from the other two habitats. The land use and land cover condition in the KNP and the fringe areas has been shown in the Fig. 5. The fringe issues of the Park could be summarized as follows-

1. Floods and erosion are two recurring phenomenon in KNP, which take a heavy toll of wildlife [7]. A substantial area (around 11 percent) was reduced due to the erosion by the river Brahmaputra. From 1912 till 2008 about 150 sq km area eroded away while 61.9 sq km newly built by the river Brahmaputra. As a result core area of the park is found to be decreased when compared with previous assessments [8].
2. At the time of migration of wild animals from KNP to Karbi Anglong Hills during the flood period cause a large number of animal death by speeding vehicles when they try to cross the National Highway 37 (Asian Highway-1) passing by the Park. Many of the animals are killed by the poachers when they move out of the Park in search of highlands to take shelter [9].
3. With the rapid increase of population in the fringe areas, the demand for land for crop cultivation, grazing and settlement has increased manifolds. Many tea gardens have developed close to the Park, which cause damage to the habitat directly or indirectly.
4. Infrastructure developed for the tourists all along the southern boundary of the Park hinder animal movement in wildlife corridor zones. There has been almost 7 times increase in inflow of tourists from 1996-97 to 2011-12. Tourists related activities like

jeep safari development of restaurants and related activities in the fringe areas are adversely affecting the wild habitat.

5. The forest fringe population are linked to the forest environment for a variety of forest products for food, fodder, agriculture, hunting and fishing and collection of non- timber forest products. Tribal people and forest is inseparable. Once subsistence livelihood support were become the profit making business to the villagers, which cause destruction of forests and over exploitation of forest resources. Ranching of buffalos and cattle in the fringe of the Park has been increased manifold which cause spread of diseases from household animals to the wild animals.
6. Human–wild animal interface in Kaziranga NP is increasing with the increase of population pressure in the Park fringe. About 184 villages and 4 numbers of tea gardens situated close to the Park. Reports of cattle depredation is increasing day by day. Only in one year i.e. in 2013 as many as 246 incidents of cattle depredation by tiger was recorded.
7. In the name of forest protection, the state government sometimes takes eviction from the encroached areas which lead to political unrest and create conflicting situation. For example in an eviction move on 19th September 2016 in Kaziranga, a violent situation was created. In that incident the police personals were forced to open fire for which two persons, including a woman were killed and caused injury to 19 others including 15 police personnel, due to stone pelting.

CONCLUSION:

In most of the fringe areas of forests in Assam "Empty Forest Syndrome" has been observed. Anthropogenic activities are the prime cause for creating such situation. Animal poaching has not been controlled in spite of taking many measures by the state government and untiring efforts made by the non-government conservationists. Recently some steps have taken to clear some of the encroached areas in Kaziranga NP and other wildlife habitats. The Nagaon Wildlife Division (Assam) with the help of "Laokhowa Burhachapori Conservation Society" (LBCS) and other organizations like WWF, Green Peace etc. are trying to revive the Laokhowa WLS. A few Eco Development Committees (EDC) and Local Protection Squads (LPS) have been formed. These organisations have been engaged in awareness exercises and conservation of wildlife. But such attempts are not found to be satisfactory. Therefore, a holistic approach has to be adopted to protect the wild habitats. Large scale afforestation, effective enforcement of protection laws, frequent holding of awareness programmes,

creation of alternative livelihood support to the fringe population, steps for population control among the fringe communities are found to be umpteen needs at this moment to save the forest and the wild habitats in Assam.

REFERENCES:

1. Govt. of Assam, Gazetteer of India, Assam State, Sibsagar district, Shillong (1967), p. 403.
2. Handique, R (2004), British forest policy in Assam, Concept pub. New Delhi, pp 3-5
3. Darlong, V.T., (2002), Food and Agriculture Organization of the United Nations, Bangkok, pp.119-124.
4. Ojah, Samarjit et al. (2012), Sustainable Natral Resource Management in Northeast India: Policies and Practices, EBH Pub. India pp 210-229
5. Saikia A (2011), Kaziranga National Park: History, Landscape and Conservation Practices, Economic and Political Weekly 46 (32): 12-13
6. Saharia, Sunil and Deka Dhanjit, (2011), Community Versus Forest: A case Study of Selected Forest Fringe Areas of Undivided Darrang District, Assam, Landscape: A Collection of Geo-environmental Studies, Abhijit Publications, New Delhi, pp 99-107
7. J. N. Sarma and S. Acharjee (2012), Earth Syst. Dynam. (ESD) Discuss. 3, pp.1085-1106.
8. D. J. Das, V. Kumar , H. R. Bora , P. K. Verma , P. Gogoi , G. Gogoi and N. K. Vasu (2014), The Indian Forester, Volume 140, Issue 1, 2014 pp.11-17.
9. Menon, V. (1996), Under siege: Poaching and Protection of Greater One-horned Rhinoceros in India, TRAFFIC International, Cambridge, UK; pp1-114

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 17

NEED TO PROTECT THE DEGRADED ECO-SYSTEM BY HABITATION PRESSURE IN WESTERN GHATS OF KARNATAKA STATE

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ABSTRACT:

Western Ghats is a magnificent mountain range next only to Himalayas and is a biological treasure trove with a high degree of endemism (11% in Karnataka compare to78% of India) and scenic beauty. This unique eco-system has been threatened by continuously increasing habitat pressures and declared as one of the world's hottest hotspots of biodiversity. The main objective of this paper is: to realize the needs for protection and rejuvenation of ecological system for sustainable development in Western Ghats. The eco-system of Western-Ghats is in need of urgent attention and action in the area of 164280 sq.kms of the Western-Ghats (spread in 188 taluks of six states). About 20,671 sq kms ESA region is located in 40 taluks of 11 districts of Karnataka state with natural rich landscape constitutes only 41 per cent. Out of 41 percent the area identified as ecologically sensitive is about 37 percent of its natural landscape. It is against to the backdrop of a fast dwindling unique ecosystem to emphasize that, there is a great sense of urgency for implementation of the tasks for sustainable development. This should be recognized and make the sincere commitment by Karnataka State government and other all 5 states in the context of protecting the rich Bio-diversity of this mountain range.

In the terms of unique geomorphological features of Western Ghats in Karnataka region is come under, the Ghats/Hill Development Programme of Planning Commission. For the sustainable development of Western Ghats the Planning Commission has create a special Western Ghats Sustainable Development Funds. This fund will be used to promote

programmes specifically designed to implement an effective environmental sensitive area and incentivize green growth in the region.

KEYWORDS: Unique eco-system, Habitat pressures, Environmental sensitive area, Protection and Sustainable development.

INTRODUCTION:

"Humans are fundamentally and to a significant extent irreversibly, changing the diversity of life on Earth and most of these changes represent a loss of biodiversity" - U S Dept. of Environment and Its Conservation.

Virtually all of Earth's ecosystems have been significantly transformed through human actions. Changes have been especially rapid in the last 50 years and today the fastest changes are taking place in developing countries. Ecosystems are particularly affected by large-scale fishing, freshwater use and agriculture. Ecosystems depend on fundamental environmental cycles such as the continuous circulation of water, carbon and other nutrients. Human activities have modified these cycles, especially during the last 50 years, through increases in freshwater use, carbon dioxide and other harmful chemical emissions and fertilizer use. This in turn has affected the ability of ecosystems to provide benefits to humans.

Many animal and plant populations have declined in numbers, geographical spread or both. For instance, a quarter of mammal species are currently threatened by extinction. Human activity has caused between 50 and 1000 times more extinctions in the last 100 years than would have happened due to natural processes. Increasingly, the same species are found at different locations on the planet and the overall biodiversity is decreasing, because some rare species are lost and common ones spread to new areas. Overall, the range of genetic differences within species has declined, particularly for crops and livestock. Ecosystem services, particularly food production, timber and fisheries, are important for employment and economic activity. Intensive use of ecosystems often produces the greatest short-term advantage, but excessive and unsustainable use can lead to losses in the long term. A country could cut its forests and deplete its fisheries, and this would show only as a positive gain to GDP, despite the loss of capital assets. If the full economic value of ecosystems were taken into account in decision-making, their degradation could be significantly slowed down or even reversed.

The main aim of this paper is to approach a holistic view of water and land resources and to prevent further degradation of these ecologically fragile areas. However, the development of people of these hilly areas in consonance with the fragility of their habitat demands an approach, which is more than just watershed development. More attention needs to be paid to economic activities which are sustainable, use of technologies which will reduce the burden of the people both in economic and household situations and ensure means of livelihood for the inhabitants with as little disturbance to the ecology. Thus, the approach has to be a watershed plus approach, which gives as much emphasis to ecology as to economic development.

STUDY AREA:

Karnataka has a geographical area of 1,91,791 sq.kms, constituting 5.83% of the total area of the country. It is the 8th largest state in India and has a population of 6.285 crores which is 5.48% of total population of the country as per 2011 census. It lies between 11^0 20' and 18^0 25' Northern latitudes and 74^0 10' and 78^0 35' Eastern longitude. Physiographically the State can be divided in to two-distinct region viz., the "Malanad" or hilly areas with awe-inspiring hills of 1500 meters above MSL comprising mainly the Western Ghats and Maidan or the plain region comprising of inland plateau of varying heights from 900 to 300 meters MSL.

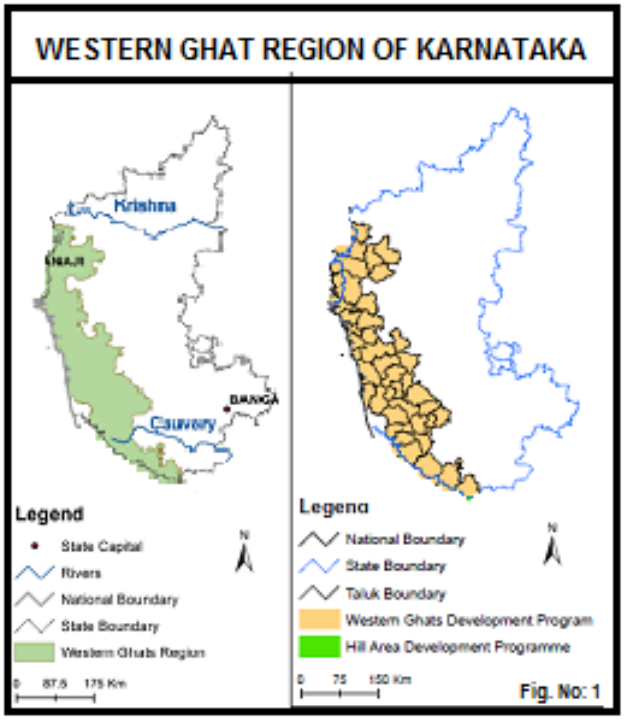


Figure 1. Map of study area

The major rivers of the State are Kaveri, Krishna, Kali, Sharavathy, Tungabhadra, Netravathi, Hemavathi, Kabini, etc., Karnataka may be called as land of two monsoons since both the South-West and North-East monsoon brings major part of the rainfall to the State. The Western Ghats region is the crowning glory of Karnataka and has an eco-system which governs the environmental conditions of the State. The lofty mountain belt regions of Western Ghats in Karnataka State occupy the lung-space and provide breathing air. Mullayyanagiri (1918 meters above MSL) Kudremukh (1982 meters) Bababudangiri majestically adorn the landscape of Karnataka as the highest hilltops. It also controls and governs the eco-system and guides the environmental conditions of the State. The Western Ghats region is endowed with dense forests and home of wide variety of flora and fauna. The high rainfall and soil fertility supports the growth of high income generating commercial crops.

The Western Ghats region is the main source of water for most of the West flowing and East flowing rivers of Karnataka. These rivers sustain plantation, Horticulture and Agriculture crops of the region and are also best suited for hydroelectric power generation. This has lured the increasing population to encroach from coastal belt to the hills and encroachment from the eastern plains is steadily increasing. The competing uses of land for plantation crops like coffee, cocoa, tea, cashew, areca and coconut other extractive industries like mining and hydroelectric power are adding their bit in increasing the pressure on forests. The practice of shifting cultivation, changed land use pattern, submersion of large area under major river valley projects and their diversion, deforestation etc has led to the degradation of the Western Ghats ecosystem.

The Hill Areas Development Programme (HADP) and Western Ghats Development Programme (WGDP) have been in operation since the Fifth Five Year Plan (1974-79) to supplement the efforts of the State Governments in the development of ecologically fragile designated hill areas/Western Ghats's taluks. The WGDP is being implemented in the States of Goa, Maharashtra, Karnataka, Kerala and Tamil Nadu. The Western Ghats taluks were identified in 1972 by a High Level Committee set up for this purpose by the Planning Commission, Government of India. For delineation of the area for coverage under the WGDP, the criteria of elevation (600 meters above MSL) and contiguity with taluka (a territorial administrative unit) have been adopted.

OBJECTIVES:

The main objectives of the programme are:

- To study the methods of Eco-preservation and eco-restoration of Western Ghats with a focus on sustainable use of bio-diversity.
- To study the status of implementation of the strategies for conservation of biodiversity and sustainable livelihoods.
- To know the Watershed based development programmes to ensure efficiency, transparency and accountability.

DATA BASE:

The necessary data is collected from secondary sources of various departments published and unpublished reports have been used for analyse the degraded ecosystem by habitation pressure in particular region.

METHODOLOGY:

Simple statistical techniques and methods have been used to analyse the data for delineate the outline scenario of degraded ecosystem in Western Ghats region of Karnataka.

STATUS OF ESA REGION IN WESTERN GHATS OF KARNATAKA:

The Western Ghats region spreads over an area of 1,64,280 sq kms and extends from North to South over a distance of 1,500 kms traversing Six States. Our analysis is restricted to Environmental Sensitive Area (ESA) of Western Ghats Region of Karnataka State covered about 20,671 sq. kms. geographical area spread in 40 taluks of 11 districts (see Table No: 1) and out of this ESA, already 59 percent of the ESA region in Karnataka state is converted into cultural landscape by human dominated land use for settlements, agriculture and plantations (other than forest plantations) and remaining 41 percent of the land area is currently classified as natural landscape. Out of the natural landscape, the biologically rich area with some measure of contiguity is roughly 37 percent of the Western Ghats which is about 7,648.27 sq. kms. The maximum ESA region is protected in Uttar Kannada (33.85%), Shimoga (18.68%) and Kodagu (10.07) district, but in remaining 8 districts the ESA areas are very less. This 37 percent of natural landscape area located in 3 districts having very high and high biological richness, low fragmentation, low population density, covered several Protected Areas (PAs), World Heritage Sites (WHSs), Tiger and Elephant corridors as Ecologically Sensitive Area (ESA) and recommend it to MoEF for notification. Because, the

unprecedented threats to natural landscape of Western Ghats region by development projects, urban growth, etc.

Table 1. District and Taluk-wise Western Ghats Coverage area in Karnataka State:

Sr. No	Name of District	District Geographical Area (in sq.kms)	Western Ghats Coverage Geographical Area (in sq.kms)	Name of Taluk Located in Western Ghats Area	Area of Taluk (in sq kms)	ESA (in sq kms)	Taluk-wise Total ESA	No of Villages in ESA	Taluk-wise Total No of Villages
1	Belgaum	13,415	5,481.10	1.Bailhongal 2. Belgaum. 3. Khanapur 4. Hukkeri 5. Soundathi	1,101 1,006 960 1,700 1,536	- 15 - 857 -	872 (4.22%)	- 1 - 62 -	63
2.	Chikmagalur	7,201	3,592.00	6. Chikmagalur 7. Mudigere 8. Koppa 9. N.R.Pura 10. Sringeri	1,586 1,139 568 800 445	579 571 251 566 337	2,304 (11.15%)	27 27 32 35 26	147
3	Dharwad	4,260	1,032.00	11. Dharwad	1,095	-	-	-	-
4	Dakshina Kannada	4,560	1,288.00	12. Puttur 13. Suliya 14.Belthangady	1,029 846 1,387	331 479 633	1,443 (6.98%)	11 18 17	46
5	Udupi	3,880	1,326.00	15. Karkala 16. Udupi 17. Kundapura	1,361 926 1,554	450 - 834	1,284 (6.22%)	13 - 24	37
6	Hassan	6,814	1,243.00	18. Alur 19. Belur 20. Hassan 21.Sakaleshpur	429 842 927 1,021	2 - - 408	410 (1.99%)	1 - - 34	35
7	Kodagu	1,102	1,272.69	22. Madikeri 23. Somwarpet 24. Virrajpet	1,441 1,013 1,661	963 193 926	2,082 (10.07%)	23 11 21	55
8	Chamarajanagar	5,101	1,485.00	25. Gundlupet	1,377	574	574 (2.78%)	21	21
9	Mysore	6,854	1,152.00	26. H.D.Kote	1,616	844	844 (4.09%)	62	62
10	Shimoga	8,475	1,468.00	27. Sagar 28. Hosanagar 29. Thirthahalli 30. Shikaripura 31. Shimoga	1,918 1,406 1,233 901 1,099	1,363 1,069 853 98 477	3,860 (18.68%)	134 126 146 12 66	484

11	Uttara Kannada	10,291	1.327.00	32. Karwar 33. Ankola 34. Bhatkal 35. Honnavar 36. Kumata 37. Siddapura 38. Sirsi 39. Joida	703 905 342 718 553 851 1,300 1,861	628 809 185 561 374 535 903 1,835	6,998 (33.85%)	39 43 28 44 43 107 125 110	626
Total	11- Districts	71,953	20,668.10	40 Taluks	44,448	20,671	20,671 (100%)	1,576	1,576

Note: ESA- Environment Sensitive Area. WG - Western Ghats.

Table 2. Area under natural and cultural landscapes, ESA and total area of taluks under Western Ghats region in different States of the Western Ghats Region (area in sq.kms):

Sr. No.	Name of State	Geographicl Area	Western Ghats Coverage Area	No. of Villages Located	Coverage of Natural Landscape Area	Coverage of Cultural Landscape Area	Villages Spared ESA	ESA in WG (%)
1	**Goa**	3,702	1,749	99	1,558	191	1,461	83.57
2	**Gujarat**	1,96,024	5,977	64	2,553	3,423	449	7.52
3	**Karnataka**	1,91,791	44,448	1,576	21,529	22,919	20,668	46.50
4	**Kerala**	38,863	29,691	123	12,477	17,214	13,108	44.15
5	**Maharashtra**	3,07,713	55,645	2,159	21,185	34,161	17,340	31.33
6	**Tamil Nadu**	1,30,058	27,069	135	8,947	18,122	6,914	25.54
		8,68,151	1,64,280	4,156	68,249	96,031	59,940	36.49

Note: ESA- Environment Sensitive Area. WG-Western Ghats.

The researcher has recommended a non-tolerance policy with respect to highly intervention and environmentally damaging activities like mining or polluting industries are prohibited and those that require high level of scrutiny and assessment before clearance within ESA. While recognizing the fact that list of non-permissible activities are identified to manage the environmental fallout of development and also being fully aware that management should prohibited and fiat is often detrimental to the interests of the every people towards the environment policy is aiming to protect. The balanced and nuanced approach to say no to the most damaging and high impact activities and at the same time

creating an enabling process to incentivize environmentally sound development that benefits local livelihoods and economies.

In Karnataka state Western Ghats region climate change is expected to increase species losses. Changes in phenology are expected to occur in many species. The general impact of climate change is that habitats of many species will move pole ward. Species that make up a community are unlikely to shift together. Ecosystems dominated by long-lived species will be slow to show evidence of change and slow to recover from the climate related stress particularly in Chikamagalur district in the Western Ghats region of Karnataka. The rivers Tunga and Bhadra originate from this district. The first coffee plantations in the country were established in this district. The Kudremukh National Park and Bhadra Wildlife Sanctuary are located in the area. The District is divided into seven talukas grouped into two Revenue Sub-Divisions viz., Chikmagalur and Tarikere. Out of seven talukas, five talukas namely Chikmagalur, Koppa, Mudigere, Narasimharajpura and Sringeri are part of the Western Ghats region delineated as, the forests in these taluks are of evergreen, semi evergreen, sholas and moist deciduous types.

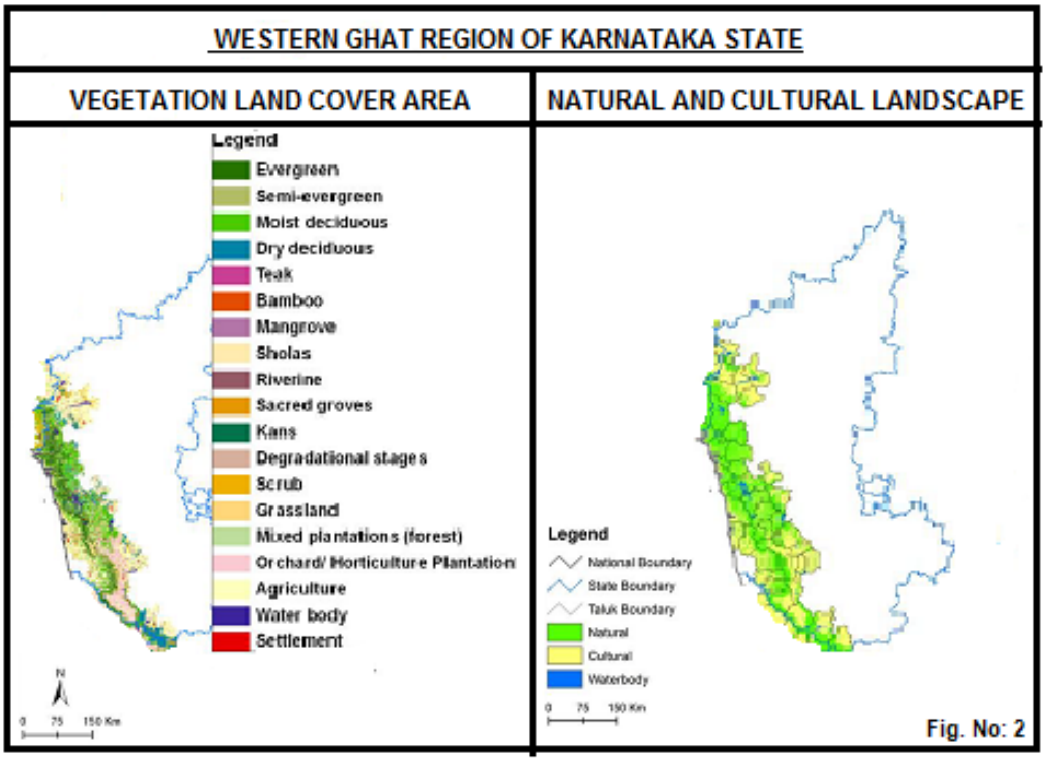
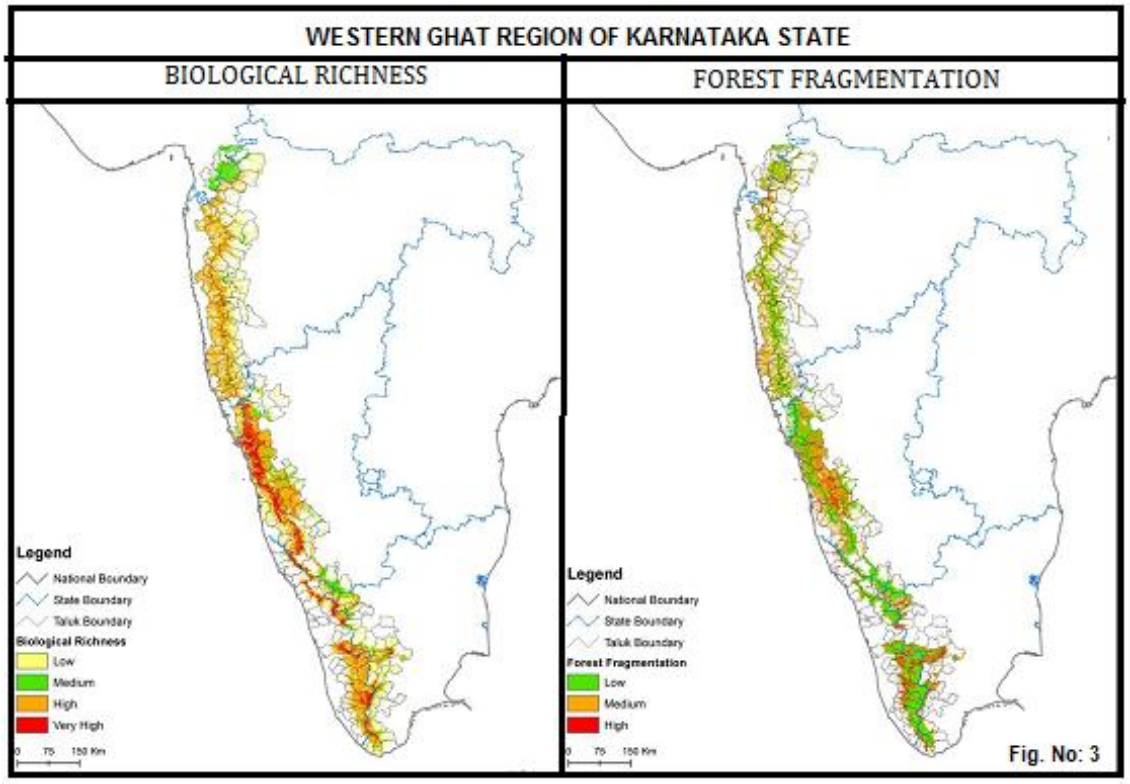


Figure 2. Vegetation lands cover area and landscape of study area

Table 3. Section-wise Allocation of Amount for Development of Western Ghats Region : 2012-13:

Sl. No.	Name of District	Total Amount Allocation (in lakh rupees)
	A. Management Component	
1	Administrative Cost	249.43
2	Monitoring	22.53
	Income generating activities	2.25
	Evaluation	5.38
	B. Preparatory Phase	
3	Entry point activities	114.38
4	Institutional and capacity building (Training / Community Organization)	131.60
5	DPR	34.88
	C. Watershed Works Phase	315.02*
6	Agriculture and soil conservation works	681.99
7	Forest	135.27
8	Agro forestry / social forestry	180.96
9	Spice Board	7.90
10	Horticulture	256.48
11	Foot bridges / Hanging bridges / vented dam cum foot bridges / PRED	635.26
	Livelihood Activities for Asset Persons	93.10*
12	Animal husbandry, Supply of Giriraja birds/ calfs / Development of small animals, supply of swing machines/ Masonry, Fodder, Carpentry, kits / Kitchen gardens / animal health camp / Fodder development.	131.53
13	Livestock management including Goatry, Piggery, etc.	39.33
	Production System and Micro Enterprises	92.80*
14	Crop diversification, Crop demonstration, Nutrition management, Organic fertilizer, etc.	53.36
15	WDGP Cell (State Level)	46.57
	Grand Total	**3,230.00**

Note: * Non allotted Expenditure.


WESTERN GHAT REGION OF KARNATAKA STATE
BIOLOGICAL RICHNESS
FOREST FRAGMENTATION
Legend
National Boundary
State Boundary
Taluk Boundary
Biological Richness
Low
Medium
High
Very High
Legend
National Boundary
State Boundary
Taluk Boundary
Forest Fragmentation
Low
Medium
High
Fig. No: 3

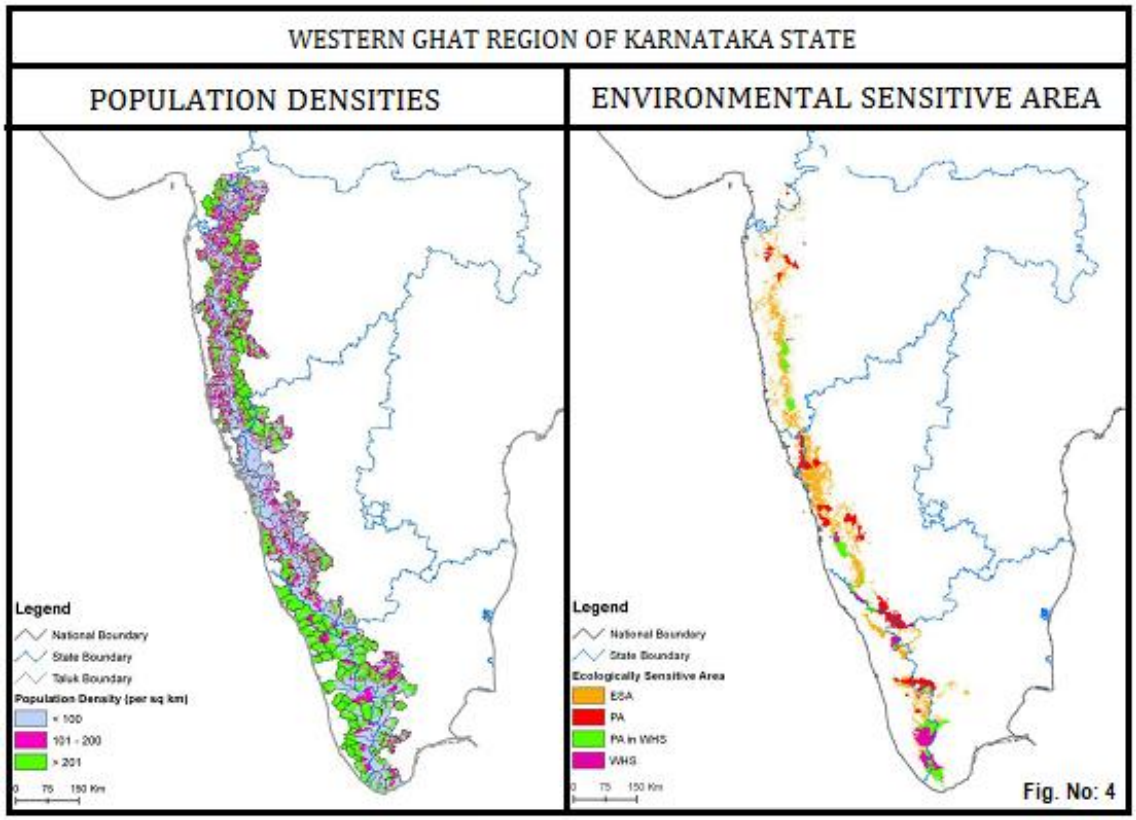

WESTERN GHAT REGION OF KARNATAKA STATE
POPULATION DENSITIES
ENVIRONMENTAL SENSITIVE AREA
Legend
National Boundary
State Boundary
Taluk Boundary
Population Density (per sq km)
< 100
101 - 200
> 201
Legend
National Boundary
State Boundary
Ecologically Sensitive Area
ESA
PA
PA in WHS
WHS
Fig. No: 4

Table 4. District-wise Amount Released for Development Activities in Western Ghats Region (2012-13):

Sr. No.	Name of District	Amount Allocation (in lakh rupees)
1	Belagavi	514.53
2	Chamarajanagar	94.82
3	Chikkamangalore	303.99
4	Dharwad	73.92
5	Dakshin Kannada	226.93
6	Hasan	243.82
7	Kodagu	272.69
8	Mysore	106.65
9	Shimoga	451.50
10	Udupi	326.54
11	Uttar Kannada	568.04
12	WDGP Cell	46.57
	Grand Total	**3,230.00**

Table 5. Allocation and Expenditure of Finance for Development of Western Ghats (Amount in Crores of rupees):

Years	Amount Allocation	Expenditure	Percentage of Achievement
2000-01	16.69	14.98	90
2001-02	15.57	14.30	92
2002-03	15.57	13.64	88
2003-04	15.57	15.57	100
2004-05	15.57	14.51	93
2005-06	15.57	14.13	91
2006-07	15.57	15.14	63
2007-08	24.18	18.43	76
2008-09	29.24	25.64	88
2009-10	29.24	20.40	70
2010-11	29.24	19.81	68
2011-12	32.30	22.65	70

DEGRADATION AND UNSUSTAINABLE USE OF ECOSYSTEM SERVICES:

Approximately 60% (15 out of 24) of the ecosystem services evaluated in this assessment (including 70% of regulating and cultural services**)** are being degraded or used unsustainably**.** Ecosystem services that have been degraded over the past 50 years include capture fisheries, water supply, waste treatment and detoxification, water purification,

natural hazard protection, regulation of air quality, regulation of regional and local climate, and regulation of erosion, spiritual fulfillment, and aesthetic enjoyment. The use of two ecosystem services capture fisheries and fresh water is now well beyond levels that can be sustained even at current demands, much less future ones (See figures on fisheries). At least one quarter of important commercial fish stocks are overharvested (high certainty). From 5% to possibly 25% of global freshwater use exceeds long-term accessible supplies and is now met either through engineered water transfers or overdraft of groundwater supplies (low to medium certainty). Some 15–35% of irrigation withdrawals exceeds supply rates and are therefore unsustainable (low to medium certainty). While 15 services have been degraded, only 4 have been enhanced in the past 50 years, three of which involve food production: crops, livestock, and aquaculture. Terrestrial ecosystems were on average a net source of CO_2 emissions during the nineteenth and early twentieth centuries, but became a net sink around the middle of the last century, and thus in the last 50 years the role of ecosystems in regulating global climate through carbon sequestration has also been enhanced.

Actions to increase one ecosystem service often cause the degradation of other services**.** For example, because actions to increase food production typically involve increased use of water and fertilizers or expansion of the area of cultivated land, these same actions often degrade other ecosystem services, including reducing the availability of water for other uses, degrading water quality, reducing biodiversity, and decreasing forest cover (which in turn may lead to the loss of forest products and the release of greenhouse gases). Similarly, the conversion of forest to agriculture can significantly change the frequency and magnitude of floods, although the nature of this impact depends on the characteristics of the local ecosystem and the type of land cover change.

The degradation of ecosystem services often causes significant harm to human well-being**.** The information available to assess the consequences of changes in ecosystem services for human well-being is relatively limited. Many ecosystem services have not been monitored, and it is also difficult to estimate the influence of changes in ecosystem services relative to other social, cultural, and economic factors that also affect human well-being. Nevertheless, the following types of evidence demonstrate that the harmful effects of the degradation of ecosystem services on livelihoods, health, and local and national economies are substantial.

CONCLUSION:

Western Ghats is a magnificent mountain range next only to Himalayas and is a biological treasure trove with a high degree of endemism (11% to 78%) and scenic beauty. This unique eco-system has been threatened by continuously increasing habitat pressures and declared as one of the world's hottest hotspots of biodiversity. Realizing the need to protect and rejuvenate the ecology of and for sustainable development in Western Ghats, the Ministry of Environment and Forests (MoEF) constituted a Western Ghats Ecology Expert Panel (WGEEP). The mandate of WGEEP was to demarcate ecologically sensitive zones and suggest measures to conserve protect and rejuvenate the ecology of Western Ghats region. Taking into account the comments and suggestions made by different stakeholders including State Governments and Central Ministries on WGEEP Report, the MoEF constituted a High Level Working Group (HLWG) to suggest an all-round and holistic approach for sustainable and equitable development while keeping in focus the preservation and conservation of ecological systems in Western Ghats.

To sum up, the HLWG recommends the following:

- The Central government should immediately notify the ESA area, as demarcated by HLWG in public interest. It must be noted that there is an urgency to protect and safeguard the remaining biodiversity rich areas of Western Ghats. In 2011, recognizing this imperative, the Central government had set up the Western Ghats Ecology Expert Panel under Professor Madhav Gadgil to recommend how this can be done. The Panel in its deliberations spread over 18 months had large number of public consultations across the different states of the Western Ghats. It recommended the need for effective action to protect the region.
- The HLWG has also had a number of consultations, particularly with state governments and their agencies. After extensive deliberations and efforts to determine the ESA, it has been found that the natural area of the Western Ghats is 41 per cent and ESA only 37 per cent. The need for action is evident. For this reason, HLWG is recommending for immediate notification, the identified area as ESA. In this notified area, development restrictions as recommended in this report will apply.
- State Governments will immediately put into place structures for effective enforcement of development restrictions and ensuring sustainable development in ESA. The MoEF will ensure that all projects located in the districts comprising the Western Ghats are required to submit information about distance and proximity to the ESA.

- The Planning Commission should create a special Western Ghats Sustainable Development Fund, which will be used to promote programmes specifically designed to implement an effective ESA regime and incentivize green growth in the region.
- The 14th Finance Commission should consider options for ecosystem and other service payments in the Western Ghats as well as allocation of funds to ESA areas. It should also consider how these funds for environmental management would be made available directly to local communities who live in and around Western Ghats ESA.
- MoEF should set up the Decision Support and Monitoring Centre for Western Ghats, with the mandate to assess and report on the state of ecology of the entire region. The Centre will be hosted by one state and will have joint management of all six states of the Western Ghats. The Centre will have a decision support function in the implementation of ESA. Its reports will be in the public domain.
- MoEF should put the ESA map in the public domain, which will enable scrutiny and transparency in decisions. 8. All development projects located within 10 kms of the Western Ghats ESA and requiring environment clearance (EC) shall be regulated as per the provisions of the EIA Notification 2006.
- The villages falling under ESA will be involved in taking decisions on future projects. All projects will require prior-informed consent and no-objection from the gram sabha of the village. The provision for prior informed consent under the Forest Rights Act will also be strictly enforced.

In the terms of unique geomorphological features of Western Ghats in Karnataka region is come under, the Ghats/Hill Development Programme of Planning Commission. At present by the push factor need to facilitate about 50 million peoples for their sustainable development outside the sensitive area of the whole Western Ghats region, which are inhabited within the sensitive zone. All other infrastructure development activities, necessary for the region, will be carefully scrutinized and assessed for cumulative impact and development needs, before clearance. Townships and area development projects should be prohibited. For the sustainable development of Western Ghats the Planning Commission has create a special Western Ghats Sustainable Development Funds. This fund will be used to promote programmes specifically designed to implement an effective environmental sensitive area and incentivize green growth in the region.

REFERENCES:

1. Gunnell, Y. and Radhakrishnan, B.P. (1967), Geological Society of India 47 (1):133-144.
2. Ministry of Environment and Forests, Government of India (2013), Report of the High Level Working Group on Western Ghats, Volume-I.
3. Rodgers, W.A. and Panwar, H.S., (1988), Ministry of Environment and Forests and Wildlife, Government of India.
4. Roy, P.S., Kushwaha, S.P.S., Murthy, M.S.R., Roy, A., Kushwaha, D., Reddy, C.S., Behera, M.D., Mathur, V.B., Padalia, H., Saran, S., Singh, S., Jha, C.S. and Porwal, M.C. (2012), Indian Institute of Remote Sensing, Dehradun, India, pp. 140.
5. Tewari, D.N. (1995), International Book Distributor, Dehra Dun.
6. Valdiya, K.S. (2010), Geological Framework and Tectonics of Western Ghats 1-32.
7. Wadia, D.N. (1975), Memoir Geological Society of India 47 (1): 87-88. 2001.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 18

SOL-GEL PROCESSED SUPERHYDROPHOBIC COATINGS ON NUMEROUS SUBSTRATES FOR SELF-CLEANING APPLICATIONS: A LOTUS LEAF EFFECT

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ABSTRACT:

Superhydrophobic surfaces are gaining high demand across the world due to their excellent self-cleaning ability. Superhydrophobic surfaces like lotus leaves strongly repel water with contact angle higher than 150º and roll off easily with rolling angle less than 10º. This low rolling angle of water drops help to self-clean the surface, where the dust particles are readily taken away by rolling droplets. Such superhydrophobic surfaces can be fabricated at room temperature by using simple sol-gel process. Sol-gel process is the one of the top rated method by the materials scientists working in coatings research. In general, the sol-gel coatings can be prepared in three simple steps namely, preparation of sol, application of sol on the substrate followed by gelation and removal of solvent through drying. The sol-gel parameters like quantity of each precursor, solvent, acid, and base in coating solution can be controlled to achieve high quality coating on the substrates. The gelation time, substrate withdrawal rate and drying process are the crucial parameters in sol-gel process which affects the thickness of the final coating. The sol-gel coating can be applied on various substrates including glass, metal, paper, plastic, fabric, wood, sponge, mesh and many. Here we discuss on the use of sol-gel processed superhydrophobic coating on numerous substrates for self-cleaning applications.

KEYWORDS: Sol-gel process, Lotus effect, Superhydrophobic, Contact angle, Surface roughness.

INTRODUCTION:

Contact with water is strictly prohibited on the superhydrophobic (SH) surfaces. The SH surfaces strongly repel water and remain always dry. In nature, often we see the shiny spherical water drops on the surface of particular plant leaves. Especially, on Lotus leaf, the spherical water drops get quickly rolled off under small disturbance or by slight tilting [1]. This rolling off of the water droplets under tiny disturbance give birth to new technology, where the dirt/dust particles present on the surface can be easily washed-off under the action of rolling water drops. This effect is famously known as a Lotus effect or self-cleaning effect. The surface of lotus leaf maintains a hierarchical micro/nanostructure with thin wax layer. Due to the combination of hierarchical rough structure and surface chemistry, they are highly non-wettable. In this rough structure, tiny air bags get trapped, which are responsible for the high water repellent property of SH surface. The tiny air bags/air pockets trapped in the rough structure do not allow water to wet the solid by pushing/holding the water drop upwards. So the actual interface is between air/liquid instead of solid/liquid. Even in contact mode, the water acquires the shape of sphere, resting on the layer of air and the tips of the rough structure. That's why, we always see this leaves fresh, green and dirt-free. Nature has many mysterious technologies in its store and mankind may still take thousands of years to expose them and make use in daily life. The development of surfaces with an excellent water repellency and lifelong durability like lotus leaves is still a dream. Self-cleaning surfaces are highly required in the day to day life including door and window glasses of the buildings, side and front windshields as well as mirrors of vehicles, traffic indicators, roadside convex mirrors, top glass of solar panels, goggles, fabrics, shoes, bags, bathroom tiles, wrist watches, aquariums and so on [2-4].

Inspired from the nature, the continuous efforts have been made to fabricate SH surfaces. Superhydrophobic surfaces can be achieved by either creating the rough surface using low surface energy material or surface modification of the rough surface by low surface energy material. Three parameters are essential for the development of ideal superhydrophobic surface; (i) rough surface morphology, (ii) low surface energy, and (iii) air pockets must be confined in rough structures. Air pockets formed in the rough structures is one of the important parameters in combination with rough structure and low surface energy. Numerous physical and chemical methods like electrospinning [5], phase separation [6], electrohydrodynamics (EHD) [7], plasma etching [8], electroplating [9], and sol-gel process [10-12] were utilized to fabricate self-cleaning SH coatings. Sol-gel chemistry has very ancient and rich history [13] and still attracting attention of numerous researchers working in

educational and industrial areas. Sol-gel process is one of the simple, easy and low-cost processes to achieve desirable coatings. A sol is homogeneous suspension of colloidal particles (nanosize) in solvent, whereas the gel consists of three-dimensional continuous solid porous network with solvent filled in it. This porous network is formed by covalent bonding between colloidal particles. The coatings can be derived from the sol before gelation. Diverse reports are available on the superhydrophobic coatings prepared by using sol-gel process. Mostly, sol-gel coatings were prepared by hydrolysis and condensation of alkoxysilane compounds and the roughness as well as low surface energy can be achieved by using organosilane compounds [14].

Sol-gel Processed Superhydrophobic Coatings:

Sol-Gel Processed Superhydrophobic Coatings on Glass:

A self-cleaning SH coatings on glass has high demand which can find useful applications in self-cleaning window and door glasses of buildings, windshields of cars, roadside convex mirrors and many. A research team of R. N. Lamb [15] have studied the novel "seeded" sol-gel coatings (thickness ~ 1 µm) to observe the effect of surface roughness on both superhydrophobicity and optical transparency. The hydrophilic fumed silica nanoparticles (12-40 nm) were successfully introduced into the growing gel matrix of methyltrimethoxysilane (MTES) and spin-coated 5 times on glass substrates. The prepared porous sol-gel coatings showed the varied optical transparency in the visible range from 82 to 100%, which was mainly originated from the domain size of clustered silica nanoparticles entrapped within the gel matrix. Liu et al [16] have adopted simple sol-gel processing of long chain fluoroalkylsilane (17 FTMS) to achieve transparent SH coating on glass substrate. **Fig. 1** shows the spherical water drops on the transparent SH coating which showed hill-like surface morphology.

Figure 1. Spherical water drops on transparent SH coating. Images reprinted from [16], with permission from Elsevier, Copyright 2015

Zhu et al [17] have prepared superhydrophobic-superoleophobic CNTs-SiO_2 composite coatings on glass slides by simple spray method. In typical sol-gel synthesis, an ethanol diluted TEOS was added slowly in ammonia contained CNTs suspension and aged for 12 h to complete hydrolysis reaction. The composite suspension of CNTs-SiO_2 was coated on glass substrate by spray coating technique. The as prepared coatings were black in color, while UV-visible optical transparency was achieved by annealing the coatings at 600 °C for 90 min. This transparent coating then modified by Trichloro(1H,1H,2H,2H-perfluorooctyl)silane to achieve both excellent superhydrophobicity and superoleophobicity. The CNTs-SiO_2 composite coatings showed highly repellent towards various surface tension liquids including water, n-dodecane, rapeseed oil, and n-hexadecane. Researchers conclude that CNTs-directed surface structure plays critical role in repelling low surface tension liquids. Zhang et al [18] have presented an easy way to achieve adherent and mechanically stable superhydrophobic coatings on glass by dip coating method. At first silica nanoparticles prepared from sol-gel processing of sodium metasilicate were hydrophobically modified by trimethylchlorosilane (TMCS). The ethoxyline resin pre-coated glass substrates were dip coated from the suspension of hydrophobic silica nanoparticles and vinyl terminated poly(dimethylsiloxane). The prepared coatings showed excellent water repellency with water contact angle of 169° and roll-off angle of 7°. Moreover, the superhydrophobic coatings were stable enough against corrosive liquids and tape-peeling tests. Manca et al [19] have prepared stable antireflective superhydrophobic coatings on glass substrates by embedding hydrophobic silica nanoparticles into the gel matrix using sol-gel process. At first, a thick and uniform organosilica gel film was spin coated on the glass substrate using sol-gel processed methyltriethoxysilane (MTES) sol and trimethylsiloxane (TMS) surface-functionalized silica nanoparticles were spin deposited on top of it. After thermal treatment, the hydrophobic silica nanoparticles migrate and get partially embedded into the gel matrix forming uniform film. These coatings showed both superhydrophobicity and antireflective properties.

Sol-Gel Processed Superhydrophobic Coatings on Metals:

Fan and researchers [20] have adopted sol-gel method to prepare anti-corrosive superhydrophobic coatings on copper wafer. The chemically etched copper wafers were coated from the coating sol prepared from vinyltrimethoxysilane (VTES). With increase in molar ratios of H_2O/VTES, the coatings showed pyramid-shaped, nipple-shaped and ball-shaped silica particles on copper wafer with water contact angle larger than 150°. The superhydrophobic copper wafer preserved its wetting properties even after held in corrosive

3.5 wt. % NaCl solution for almost half month. Rao and researchers [21] have fabricated mechanically robust and anti-corrosive superhydrophobic coatings on copper plates by sol-gel method. A base catalyzed methyltriethoxysilane (MTES) sol was applied on the copper plates by simple dip coating method. The interconnected rough spherical shaped silica particles (8 to 12 µm) forms hierarchical structure on the copper plate providing superhydrophobic state. The water drops maintain their spherical shape on both flat and bent (> 90°) superhydrophobic copper plates (**Fig. 2**). The prepared coatings showed excellent durability against acid treatment and humidity. Yang et al [22] have used sol-gel process to apply superhydrophobic-superoleophilic silica coating on stainless steel (SS) mesh. The coating sol was prepared by modified Stober method using tetraethoxysilane (TEOS) and methyltriethoxysilane (MTES) as precursors. The prepared coating sol was applied on the SS mesh through four times dip coating to achieve enough thickness. This silica coated SS mesh showed superhydrophobic behavior without surface chemical modification.

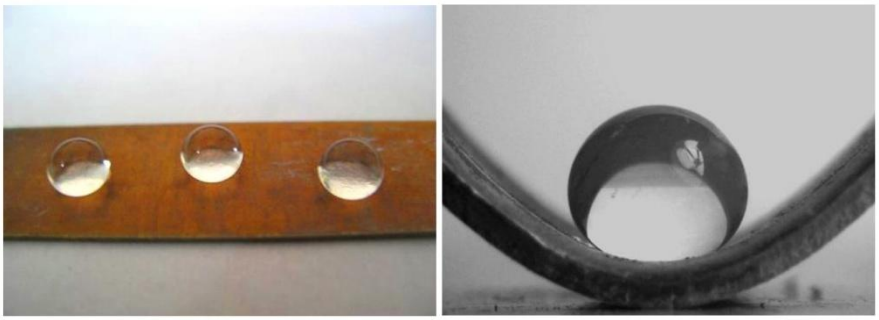

Figure 2. Shape of water droplets on the flat SH copper substrate (left) and on the bent (>90º) SH copper substrate. Images reprinted from [21], with permission from Elsevier, Copyright 2011

Sol-Gel Processed Superhydrophobic Coatings on Plastic:

Tadanaga et al [23] have prepared transparent superhydrophobic alumina coating on polymer substrate by low temperature sol-gel method. A coating sol was prepared by hydrolysis and condensation of aluminum-*sec*-butoxide precursor, and applied on poly(ethylene terephthalate) (PET) polymer substrate by dip coating technique. After hot water (60°C) treatment, the coatings were surface modified by partially hydrolyzed heptadecafluorodecyltrimethoxysilane. This optically transparent flowerlike alumina coating exhibited water contact angle in the superhydrophobic range.

Sol-Gel Processed Superhydrophobic Coatings on Wood:

Wang et al [24] have prepared superhydrophobic wood surface using sol-gel method. The base catalyzed tetraethoxysilane (TEOS) sol was applied on wood surface by simple immersion method and the coated wood surface was modified by 1H, 1H, 2H, 2H-perfluoroalkyltriethoxysilanes (POTS) to achieve superhydrophobicity. The superhydrophobic wood surface showed the water contact angle of 164° and sliding angle less than 3°.

Sol-Gel Processed Superhydrophobic Coatings on Fabric:

Y. Shi et al [25] have prepared superhydrophobic fabric by multiple deposition of sol-gel processed TiO_2 sol on cotton fabric and subsequent modification through low surface energy long chain alkyl groups. A TiO_2 sol was obtained by the sol-gel processing of tetra-n-butyl titanate and applied on cotton fabric through dip coating for four times to enhance the surface roughness. Finally, the surface of TiO_2 coated fabrics was modified by n-octadecylthiol (ODT) to achieve superhydrophobicity. Xu and researchers [26] have showed facile way to develop superhydrophobic polyester fabrics using sol-gel method. A hydrosol was prepared from the base catalyzed vinyltrimethoxysilane (VTMS) and fluorinated acrylic polymer (FAP)/SiO_2 nanocomposite solution was prepared by emulsion polymerization of acrylate monomers and fluoroacrylic monomer in the hydrosol. The fabrics were coated by FAP/SiO_2 nanocomposites using dip-pad-cure process and heat treated at 80 and 160°C. This nanocomposite treated fabrics showed excellent superhydrophobic properties. Daoud et al [27] have prepared optically transparent and superhydrophobic silica coatings on knit and woven cotton substrates by sol-gel process. The silica composite coating sol was prepared by sol-gel processing of tetraethoxyorthosilcate (TEOS), 3-glycidoxypropyltrimethoxysilane (GPTMS) and hexadecyltrimethoxysilane (HDTMS) mixture and the pre-cleaned knit and woven cotton substrates were dip coated from this coating sol. The water contact angle measured on these silica coated cotton substrates exhibited in superhydrophobic range. Li et al [28] have obtained superhydrophobic cotton substrates through sol-gel dip coating and subsequent surface chemical modification. An acid catalyzed sodium silicate (water glass) sol was applied on the cotton substrate by dip coating and finally treated with hydrolyzed hexadecyltrimethoxysilane (HDTMS) to lower its surface energy. The water drop acquires a water contact angle of 151° on this silica coated cotton substrate.

Sol-Gel Processed Superhydrophobic Coatings on various substrates:

Budunoglu et al [29] have successfully prepared optically transparent, flexible and heat resistant superhydrophobic porous aerogel coatings from organically modified silica (ORMOSIL). At first, acid-base catalyzed methyltrimethoxysilane (MTMS) gel was prepared. The homogeneous colloidal suspension was obtained by diluting and sonicating the obtained gel and spin coated on the glass slides. The as-prepared highly porous aerogel thin films showed very high static water contact angle (~179.9°), low roll off angle (<5°), thermal stability (up to 500°C), and optical transmittance of ~ 87.6% in the visible range. Interestingly, the aerogel coating prepared on glass, wood, wall tile, aluminum slab, cotton cloth, and plastics by dip, spin and spray technique showed superhydrophobic properties without any post surface chemical modification. **Fig. 3** shows the water droplets on a planar surface and rolling water droplets on bent polyethersulfone (PES) film, both coated with superhydrophobic aerogel thin film. Recently, Fei and researchers have also reported the sol-gel processed MTMS based superhydrophobic aerogel films on glass and fabric [30]. Wang et al [31] have fabricated superhydrophobic textile fabrics, electrospun nanofiber mats, filter papers, glass slides, and silicon wafers in single step dip, spray, and spin coat-technique using sol-gel process. A coating sol was prepared by base catalyzed hydrolysis and condensation of tetraethylorthosilicate (TEOS) and tridecafluorooctyltriethoxysilane (FAS). All the coated substrates showed superhydrophobic wetting behavior with water contact angle greater than 170° and roll off angle less than 7°.

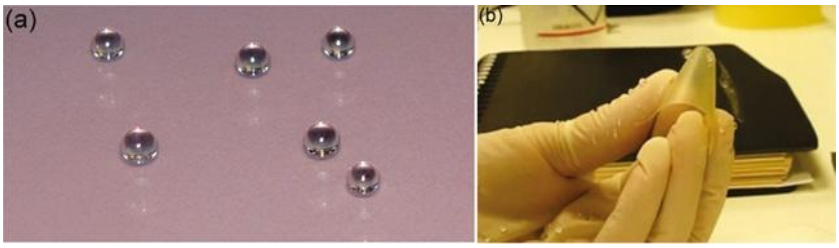

Figure 3. (a) Water droplets on a planar surface and (b) rolling water droplets on bent PES film, both coated with SH ORMOSIL aerogel thin film. Images reprinted from [29], with permission from ACS, Copyright 2011

CONCLUSION:

The cutting-edge technology can be learned from nature. The extreme water repellency like lotus leaves can be achieved on different substrates for self-cleaning purpose. The sol-gel method can be efficiently used to apply self-cleaning superhydrophobic coating on numerous substrates. The surfaces like glass, metal, paper, plastic, fabric, wood, sponge,

mesh having superhydrophobic coatings can be remained clean for long time. No need to use expensive detergents and manpower to clean them. For the efficient use of superhydrophobic surfaces by industry, they should be intact against bouncing and impacting water drops and water jet impacts. Answer to achieve superhydrophobic surfaces are well-known now; however, issues to keep this superhydrophobicity for lifelong against abrasion, scratch and mechanical damage are yet to answer. The sol-gel chemistry can be effectively used in future to achieve transparent, mechanically and chemically durable superhydrophobic coatings for self-cleaning applications.

REFERENCES:

1. Barthlott, W. and C. Neinhuis (1997), Planta, 202(1): p. 1-8.
2. Ganesh, V.A., et al. (2011), Journal of Materials Chemistry, 21(41): p. 16304-16322.
3. Blossey, R. (2003), Nature materials, 2(5): p. 301-306.
4. Xue, C.-H., et al. (2010), Science and Technology of Advanced Materials, 11(3): p. 033002.
5. Zhu, Y., et al. (2006), Advanced Functional Materials, 16(4): p. 568-574.
6. Wei, Z.J., et al. (2010), Applied Surface Science,. 256(12): p. 3972-3976.
7. Jiang, L., Y. Zhao, and J. Zhai (2004), Angewandte Chemie, 116(33): p. 4438-4441.
8. Kim, T.-Y., et al. (2007), Chemical Physics Letters, 436 (1–3): p. 199-203.
9. Xi, W., et al. (2009), Applied Surface Science, 255(9): p. 4836-4839.
10. Saison, T., et al. (2008), Bioinspiration & Biomimetics, 3(4): p. 046004.
11. Meng, Z., et al. (2011), Polymer, 52(3): p. 597-601.
12. Wu, L.Y.L., et al. (2012), Soft Matter, 8(23): p. 6232-6238.
13. Brinker, C.J. and G.W. Scherer, (1990): Gulf Professional Publishing.
14. Shirtcliffe, N., et al. (2003), Langmuir, 19(14): p. 5626-5631.
15. Wang, C., A.H.F. Wu, and R.N. Lamb (2014), The Journal of Physical Chemistry C, 118(10): p. 5328-5335.
16. S. Liu, et al. (2015), Applied Surface Science, 351: p. 897–903.
17. Zhu, X., et al. (2014), Journal of Colloid and Interface Science, 421(0): p. 141-145.
18. Zhang, X., et al. (2012), Applied Surface Science, 258(20): p. 7907-7911.
19. Manca, M., et al. (2009), Langmuir, 25(11): p. 6357-6362.
20. Fan, Y., et al. (2012), Applied Surface Science, 258(17): p. 6531-6536.
21. Rao, A.V., et al. (2011), Applied Surface Science, 257(13): p. 5772-5776.
22. Yang, H., et al. (2010), Applied Surface Science, 256 (13): p. 4095-4102.

23. Tadanaga, K., et al. (2003), Journal of Sol-Gel Science and Technology, 26(1-3): p. 705-708.
24. Wang, S., et al. (2011), Applied Surface Science, 258(2): p. 806-810.
25. Shi, Y., et al. (2012), Applied Surface Science, 258(20): p. 8134-8138.
26. Xu, L., et al. (2014), Journal of Applied Polymer Science, 131(11): p. n/a-n/a.
27. Daoud, W.A., J.H. Xin, and X. Tao (2004), Journal of the American Ceramic Society, 87(9): p. 1782-1784.
28. Li, Z., Y. Xing, and J. Dai (2008), Applied Surface Science, 254(7): p. 2131-2135.
29. Budunoglu, H., et al. (2011), ACS Applied Materials & Interfaces, 3(2): p. 539-545.
30. Fei, T., H. Chen, and J. Lin (2014), Colloids and Surfaces A: Physicochemical and Engineering Aspects,. 443: p. 255-264.
31. Wang, H., et al. (2008), Chemical Communications, (7): p. 877-879.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 19

A BRIEF INTRODUCTION TO SOME OF THE WATER QUALITY PARAMETERS

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ABSTRACT

Water is the most abundant liquid and is essential to the survival of every living thing. It gets affected both qualitatively and quantitatively by all kinds of human activities on land, in air or in water. The increasing industrialization, urbanization and developmental activities and consequent pollution of water have brought a veritable water crisis. Pollution of water is responsible for a very large number of mortalities and incapacitations in the world. Various water quality parameters (Physico-chemical) are checked to get an insight regarding status of the water quality. A regular monitoring of some of them not only prevents diseases and hazards but also checks the water resources from going further polluted. This chapter describes some water quality parameters which are useful in checking the pollution.

KEYWORDS: Water, Industrialization, Pollution, Monitoring, Quality

INTRODUCTION

Water is the most vital resource for all kinds of life on this planet. It is an essential component for the survival of life on earth, which contains minerals, important for humans as well as for earth and aquatic life [1]. Water, a prime natural resource and precious national asset, forms the chief constituent of the ecosystem. Water is a universal solvent and the most plentiful substance on earth. Due to its high specific heat, high dielectric constant, maximum density at 4°C, with a liquid range of 0-100°C, it is one of the most important chemicals. The aquatic chemistry is concerned with the chemical processes affecting the distribution and circulation of chemical compounds in natural waters and chemical behaviour of ocean waters, estuaries, rivers, lakes, ground waters. The natural aquatic environments are characterized by

a complexity seldom encountered in the laboratory. Natural waters indeed are open and dynamic systems with variable inputs of mass and energy. The flow of energy (solar radiations) from a higher to lower potential drives the hydrological and geochemical cycles. Water is a necessary resource for man and the availability of good and potable water has been one of the major factors influencing the development of civilization. Since the dawn of the civilization, efforts to remove wastes from natural environment have not been able to keep pace with the increasing amount of waste materials.

Today world is facing the problem of population, pollution and poverty. This has resulted in the conversion of water bodies into sewage depots. As a consequence, ecological balance of these ecosystems have been upset and in some cases totally disrupted. The adverse effects of waste materials have been acute in inland water systems due to their traditional role as receiving bodies for effluents. Besides, more areas have become dependent on surface waters for their water supply, due to depletion of natural ground water reserves and the difficulty encountered in exploiting new sources. Water sources may be mainly in the form of rivers, lakes, glaciers, rain water, ground water, etc [2]. Besides the need of water for drinking, water resources play a vital role in various sectors of the economy, such as agriculture, livestock production, forestry, industrial activities, hydropower generation, fisheries and other creative activities. The availability and quality of water either surface or ground, have been deteriorating due to some important factors like increasing population, industrialization, urbanization etc [3]. Water quality is considered the main factor controlling health and the state of disease in both man and animals. Surface water quality in a region is largely determined both by natural processes (weathering and soil erosion) and by anthropogenic inputs (municipal and industrial wastewater discharge) [4].

The anthropogenic discharges constitute a constant polluting source, whereas surface run-off is a seasonal phenomenon, largely affected by climate within the basin [5]. Lakes are subjected to various natural processes taking place in the environment, such as the hydrological cycle, silting etc. Storm water runoff and discharge of sewage into the lakes are two common ways that various nutrients enter the aquatic ecosystems resulting in the death of those systems. Water quality characteristics of aquatic environment arise from a multitude of physical, chemical and biological interactions. A regular monitoring of water bodies with required number of parameters in relation to water quality not only prevents the outbreak of diseases but also help to mitigate occurrence of hazards. Fresh water systems are critical for the sustainability of all life [6]. However, the declining qualities of the waters in these systems threaten their sustainability. Lakes and surface water reservoirs are the planet's most

important fresh water resources and provide innumerable benefits. They are used for domestic and irrigation purposes, and provide ecosystems for aquatic life especially fish, thereby functioning as a source of essential protein, and for significant elements of the world's biological diversity [7].

They have important social and economic benefits as a result of tourism and recreation, and are culturally and aesthetically important for people throughout the world. They also play an equally important role in flood control. However, the remarkable increase in population resulted in a considerable consumption of the water reserves worldwide. Nowadays the general population is getting aware of complicated nature of global ecosystem along with its balance. The human interference has been modifying the environment which resulted unlimited effects. The modern age of science and technology has increased the pollution tremendously. Smokes from the factories, residues of chemicals used to make soil fertile or to mitigate harmful pests and diseases, exhaust gases from automobiles, effluents from the factories, particulates of suspended solids and liquids pollute environment i.e. water, air and soil. Two groups of substances in particular have a lasting effect on the natural balance in aquatic ecosystems i.e. nutrients and synthetic chemicals. Nutrients promote unrestricted biological growth and sparingly degradable synthetic chemicals and other wastes include multiple effects on the aquatic environments. Therefore it is necessary to assess and measure the present condition of the environment to overcome the deterioration and to save the environment for our future.

The contaminations of water resources are of important issue particularly in many developing as well as developed countries due to their toxicity, persistence and bio-accumulative nature [8]. Dissolved constituents of water bodies are often determined as a major component of baseline limnological studies. The ions such as Ca, Mg, K, Cl, SO_4 (summed as total cations and anions), essentially constitute the total ionic salinity of fresh waters, while other ions make only minor contributions [9]. The investigation has been carried out on the water quality parameters (physical as well as chemical) to estimate the contamination of the ecosystem. It was reported in a study that human actions are the main factor for deteriorating the quality of the surface and ground water through atmospheric, domestic, industrial and agricultural waste contaminations [10]. Man has tried to cope up with this scenario and has rapidly advanced its efforts to counteract it. In past few decades, natural and polluted waters have been studied in detail all over the world and considerable data are now available on most kind of pollutants and their effects on ecosystems as well as

on organisms [11]. A large number of parameters signifying the quality of waters in various uses have been proposed.

OVERVIEW OF WATER POLLUTION:

The aquatic environment with its water quality is considered the main factor controlling the state of health and disease in both man and animals [12]. Water is a vital factor for the life on earth and also contains valuable nutrients which are very crucial for human life. The remarkable raise in community resulted in a huge consumption of the world's fresh water reservoirs. The pollution of water by natural resources is the consequence from the geological incidents. Conversely, it is observed that human actions are a major factor for deteriorating the quality of the surface and ground water through untreated agricultural, industrial and domestic effluents [13]. The industrial developments during the last few decades were accompanied by the problems of toxic waste management and metal release into the environment. Indeed, most cases of pollution to date are anthropogenic in nature. Among environmental pollutants, metals are of particular concern due to their toxic effect and ability to bio-accumulate in aquatic ecosystems. All over the world, many researchers emphasize their investigations on anthropogenic contamination of entire ecosystem. There is a clear cut limit between essentiality and toxicity of the water quality parameters, since impact depends largely on the concentration [14]. To evaluate the quality of the aquatic systems, micronutrients and metals are to be determined in aquatic environment (water). Studies on water quality parameters have been a main environmental focal point, particularly in the last decade. Sources of surface water pollution are generally grouped in two categories based on their origin.

a) ***Point Sources*****:** Point source water pollution refers to contaminants that enter a waterway from a single, identifiable source.

b) ***Non-point sources****:* It refers to diffuse contamination that does not originate from a single discrete source. Non-point source water pollution is often the cumulative effect of small amounts of contaminants gathered from a large area.

WATER QUALITY:

Water quality refers to the chemical, physical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and to any human need and purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. Environmental water quality, also called

water quality, relates to water bodies such as lakes, rivers and oceans. Water quality standards for surface waters vary significantly due to different environmental conditions, ecosystems and intended human use. Water quality characteristics of aquatic environment arise from a multitude of physical, chemical and biological interaction. A regular monitoring of water bodies with required number of parameters in relation to water quality not only prevents the outbreak of diseases but also helps to mitigate occurrence of hazards [15]. Lakes are vital and vulnerable freshwater systems that are critical for the sustainability of the life. However, the declining quality of waters in these systems threatens their sustainability. Lakes are waterways of strategic importance across the world, providing main water resources for domestic, industrial and agricultural purposes.

Discharge of pollutants into a water resource system from domestic sewers, storm water discharges, industrial waste discharge, agricultural runoff and other sources, all of which may be untreated, can have both short term and long term significant effects on the quality of lake water system. It is a common practice for people living along the lake water catchments to discharge their domestic waste as well as human excreta into it. Toxic substances and high populations of certain microorganisms can present a health hazard for non-drinking purposes such as irrigation, swimming, fishing, rafting, boating and industrial uses. These conditions may also affect animal life, which use the water for drinking or as habitat. Due to rapid urbanization, industrialization and unplanned use of fresh water resources, the quality of fresh water reservoirs is subjected to anthropogenic activities causing severe degradation and eutrophication. Anthropogenic activities affect biological diversity by altering the habitat. Quality and quantity of water are both very important and should be assessed and monitored frequently to ensure the availability of water in acceptable quality for the intended use. A significant number of recent studies have focused on water quality assessment and monitoring.

Water quality is significantly affected by natural processes as well as anthropogenic activities. Thus, continuous monitoring of water quality, especially in areas that witness accelerated urban development, is an essential task. The quality of surface water is commonly determined by selected physicochemical and biological analysis of water samples collected to represent the water body. Rapid population growth coupled with the rate of urbanization and economic development tends to impair the surface water resources and results in high variability for many water quality parameters. The possible variability may be due to anthropogenic activity and natural variance during different seasons through biochemical or chemical processes [16]. The quality of surface water within a region is governed by

anthropogenic influences like urban, industrial, agricultural activities and human exploitation of water resources and the natural processes like precipitation rate, weathering and soil erosion. Surface waters are the most susceptible and vulnerable water bodies to contamination because of their accessibility for disposal of various types of waste.

The rapid urbanization, industrialization, intensive agriculture, and growing demand for energy have adversely affected the physicochemical parameters of surface water through dumping of biodegradable organic pollutants, nutrient and bacteria. Industrial effluents discharge through release of organic and inorganic parameters or urban and agricultural through pollutants coming from the drainage of areas contain fertilizers, agricultural pesticides, animal faeces and suspended materials. The qualities of surface water vary from site to site and season to season due to variation in chemical composition, which is highly dependent on topography, climate and mineralogical composition. The most important natural influences on surface water are geology, hydrology and climate, since these affect the quality and quantity of water variable. Their influence is generally greatest when the available water quantities are low. Temperature is a major factor affecting almost all physicochemical equilibrium and biological reactions and also increases water temperature, which enhances dissolution, solubility, degradation and evaporation. Surface water pollution is a serious problem today, in spite of all efforts to control it. The Environmental Protection Agency (EPA) estimates that approximately one-third of all surface waters in the world are unsafe for various activities: this means that, water as a natural resource requires careful management and conservation, which must be universally recognized. The growing demand on water resources necessitates the professional application of fundamental knowledge to ensure the maintenance of water quality and quantity. Increasing attention has been paid to the surface water pollution source apportionment and water quality problem. Moreover, there has been an increased interest by researchers in analyzing variations of surface water quality mainly physicochemical parameters of water using statistical and mathematical tools.

WATER QUALITY PARAMETERS (PHYSICO-CHEMICAL PARAMETERS):

The composition of natural waters is the result of a variety of chemical reactions and physico-chemical processes acting in concert. These reactions include acid-base reactions, gas-solution processes, precipitation and dissolution of solid phases, coordination reactions of metal ions and ligands, redox reactions and adsorption at interface. Water quality parameters reflect the ‘goodness’ of the water. Water quality is determined by physical, chemical and biological properties of water. The water quality parameters are characteristic of water

bodies. The values or concentrations attributed to such parameters can be used to describe pollution status. Monitoring of the water quality parameters is a key activity in managing the water bodies, restoring polluted water bodies and anticipating the effects of man-made changes on the environment. The water quality characteristics throughout the world are characterized with wide variability. Therefore the quality of natural water sources used for different purposes should be established in terms of specific water quality parameters that most affect the possible use of water. Aquatic ecosystems are particularly vulnerable to environmental change and many are, at present severely degraded. The availability of good water quality is an indispensable feature for preventing disease and improving quality of life. The physico-chemical properties help in the identification of sources of pollution, for conducting further investigations and also for initiating necessary steps for remedial actions. The discharges of urban, industrial and agricultural wastes add the quantum of various harmful chemicals to the water body considerably altering their inherent physico-chemical characteristics. The monitoring of quality of surface waters by estimating the physico-chemical parameters is among that are exposed to deleterious anthropogenic factors. The alteration in physico-chemical parameters leading to pollution has become a widely recognized problem of water quality deterioration.

Physical Parameters:

Physical characteristics of water are determined by senses of touch, sight etc. Some physical parameters of water are:

a) **Temperature**: The parameter of temperature is important for its effects on the chemistry and biological reactions in the organisms in water. A rise in temperature of the water leads to the speeding up of the chemical reactions in water, reduces the solubility of gases and amplifies the tastes and odours. Temperature is also very important in the determination of various other parameters such as pH, conductivity, saturation of gases and various forms of alkalinity.

b) **Colour**: Colour in water is primarily a concern of water quality for aesthetic reason. Colour in natural waters may occur due to the presence of humic acid, fulvic acids, metallic ions, suspended matter, weeds and industrial wastes etc.

c) **Turbidity**: It is a measure of the light transmitting properties of water and is comprised of suspended and colloidal material. It is important for health and aesthetic reasons. Turbidity in natural waters is caused by clay, silt, organic matter and other microscopic organisms.

d) **Total Dissolved Solids (TDS)**: TDS mainly encompass various kinds of minerals present in the water. TDS do not contain any gas and colloids. In natural waters, dissolved solids are composed mainly of carbonates, bicarbonates, chlorides, sulphates, phosphates etc.

e) **Electrical Conductivity (EC)**: Conductivity is the measure of capacity of a substance or solution to conduct electric current. As most of the salts in the water are present in the ionic forms, capable of conducting current, therefore conductivity is a good and rapid measure of the total dissolved solids. Conductivity is highly dependent on temperature.

f) **Salinity**: Salinity is the saltiness or dissolved salt content of a body of water. Salinity is an important factor in determining many aspects of the chemistry of natural waters and is a thermodynamic state variable that governs physical characteristics of the water. Compounds like sodium chloride, magnesium sulphate, potassium nitrate and sodium bicarbonate contribute towards salinity.

Chemical Parameters:

The chemical characteristics of natural water are a reflection of the soils and rocks with which the water has been in contact. In addition, agricultural and urban runoff and industrial treated waste water impact the water quality. Microbial and chemical transformations also affect the chemical characteristics of water. Some of the chemical parameters are:

a) **pH**: It is a measure of the intensity of acidity or alkalinity and measures the concentration of hydrogen ions in water. It does not measure total acidity or alkalinity. In fact, the normal acidity or alkalinity depends upon excess of H^+ or OH^- over the other. It is generally expressed on a log scale and equals to negative $\log_{10}$ of hydrogen ion concentration.

$$pH = -\log_{10}[H^+]$$

Most natural waters are generally alkaline due to presence of sufficient quantities of carbonates. Significant changes in pH occur due to disposal of industrial wastes, drainage etc. pH has no direct adverse effects on health, however, a lower value below 4 produces sour taste and higher value above 8.5 gives an alkaline taste.

b) **Acidity**: Acidity of the water is its capacity to neutralize a strong base and is mostly due to the presence of strong mineral acids, weak acids and salts of strong acids and weak bases. These salts on hydrolysis produce strong acids and metal hydroxides which are sparingly soluble thus producing the acidity. Addition of waste waters having acidity producing substances also increases the acidity of waters. However, in natural waters most of the acidity is present due to the dissolution of carbon dioxide which forms carbonic acid.

$$CO_2 + H_2O \rightarrow H_2CO_3$$

The acidity determination of water is significant as it influences various reactions.

c) **Dissolved Oxygen (DO)**: Dissolved oxygen is one of the most important parameters in water quality assessment and reflects the physical and biological processes prevailing in the waters. Its presence is essential to maintain the higher forms of biological life in the water and the effects of a waste discharge in a water body are largely determined by the oxygen balance of the system. Non-polluted surface waters are normally saturated with dissolved oxygen. Oxygen can be rapidly removed from the waters by discharge of the oxygen demanding wastes. Oxygen saturated waters have a pleasant taste while the waters lacking oxygen have an insipid taste.

d) **Biochemical Oxygen Demand (BOD)**: BOD is the amount of oxygen utilized by microorganisms in stabilizing the organic matter. The demand for oxygen is proportional to the amount of organic waste to be degraded aerobically. Hence, BOD approximates the amount of oxidizable organic matter present in the solution and the BOD value can be used as a measure of the waste strength. Types of microorganisms, pH, presence of toxins, some reduced mineral matter and nitrification process are the important factors influencing the BOD. BOD in general gives a qualitative index of the organic substances which are degraded quickly in a short period of time.

e) **Chemical Oxygen Demand (COD)**: COD is the oxygen required by the organic substances in water to oxidize them by a strong chemical oxidant. The determination of COD values is of great importance where BOD values cannot be determined accurately due to the presence of toxins and other unfavourable conditions for growth of microorganisms. The COD test gives no indication of whether or not the waste is degradable biologically and nor does it indicate the rate at which biological oxidation would proceed and hence the rate at which the oxygen would be required in a biological system.

f) **Nitrite**: There are no mineral sources of this ion in natural waters. Nitrite represents an intermediate form during denitrification and nitrification reactions in nitrogen cycle. Nitrite is a very unstable ion and gets converted into either ammonia or nitrate depending upon the condition prevailing in the water. Nitrites may also be produced in distribution systems through the activities of microorganisms in ammonia.

g) **Alkalinity**: Alkalinity of the water is its capacity to neutralize a strong acid and is characterized by the presence of all the hydroxyl ions capable of combining with the hydrogen ion. Alkalinity in natural waters is due to free hydroxyl ions and hydrolysis of salts formed by weak acids and strong bases. Most of the alkalinity in natural waters is formed due

to dissolution of CO_2 in water. Carbonates and bicarbonates thus formed are dissociated to yield hydroxyl ions.

$$CO_2 + H_2O \rightarrow H_2CO_3$$

$$H_2CO_3 \rightarrow H^+ + HCO_3^-$$

$$HCO_3^- \rightarrow H^+ + CO_3^{2-}$$

$$CO_3^{2-} + 2HOH \rightarrow H_2CO_3 + 2OH^-$$

$$HCO_3^- + HOH \rightarrow H_2CO_3 + OH^-$$

System can be represented by the following equation:

Total alkalinity = $HCO_3^- + 2CO_3^{2-} + OH^- - H^+$

Alkalinity is also produced by the action of water on limestone

$$CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$$

In the natural and polluted waters, there are many other salts of weak acids such as silicates, phosphates etc. which cause alkalinity in addition to that of carbonates and bicarbonates. However, carbonates and bicarbonates outnumber other ions, sharing the most part of the total alkalinity. Naturally coloured waters also contain humates (salts of humic and fulvic acids) which also add to the alkalinity of waters.

h) Free carbon dioxide (Free CO_2): Carbon dioxide is present in water in the form of dissolved gas. Surface water contains less amount of free CO_2 than ground water. Carbon dioxide gas is present in the air to the extent of 0.03% by volume. As rain falls through the air, it absorbs some of this gas. The slightly acidic rain water absorbs additional amounts of carbon dioxide when it flows through the decaying vegetation due to aerobic and anaerobic decomposition of organic matter and it is intimately bound in the complex carbonate equilibria.

i) Total Hardness (TH): Hardness is the property of water which prevents the lather formation with soap and increases the boiling point of waters. Principal cations imparting hardness are calcium and magnesium. However, other cations such as iron and manganese also contribute to the hardness. The anions responsible for hardness are bicarbonate, carbonate, sulphate, chloride etc. Hardness is called temporary if it is caused by bicarbonate and carbonate salts of the cations, since it can be removed simply by boiling the water. Permanent hardness is caused mainly by sulphates and chlorides.

j) Calcium (Ca^{2+}): Calcium is one of the most abundant substances of the natural waters. Being present in high quantities in the rocks, it is leached from there to contaminate the water. The quantities in natural waters generally vary depending upon the types of rocks. Disposal of sewage and industrial wastes are also important sources of calcium. It has got a

high affinity to adsorb on the soil particles; therefore, the cation exchange equilibria and presence of other cations greatly influence its concentration in waters.

k) Magnesium (Mg^{2+}): Magnesium occurs in all kinds of natural waters with calcium, but its concentration remains generally lower than the calcium. The principal sources in the natural waters are various kinds of rocks. Sewage and industrial wastes are also important contributors of magnesium. The concentration of magnesium also depends upon exchange equilibria and presence of the ions like sodium.

l) Sodium (Na^{+}): Sodium is also one of the cations occurring naturally. The concentration in natural fresh waters is generally lower than the calcium and magnesium. In natural waters, the major source of sodium is weathering of rocks. Many industrial wastes and domestic sewage are rich in sodium and increase its concentration in natural waters after disposal. Sodium salts are highly soluble in water and unlike calcium and magnesium there are no precipitating reactions to reduce its concentrations. The water containing high sodium content is not suitable for agriculture, as it tends to deteriorate the soil quality.

m) Sulphate (SO_4^{2-}): It is a naturally occurring anion in all kinds of natural waters. Rain water has quite high concentration of sulphate particularly in the areas with high atmospheric pollution. Discharge of industrial wastes and domestic sewage in waters tend to increase its concentration. Most of the salts of sulphate are soluble in water and as such it is not precipitated. However, it may undergo transformations to sulphur and hydrogen sulphide depending upon the redox potential of the water.

n) Chloride (Cl^{-}): Chloride occurs naturally in all types of waters. In natural fresh waters, its concentration remains quite low. The most important source of chlorides in the waters is the discharge of domestic sewage. Chloride concentration serves as an indicator of pollution by sewage.

o) Phosphates (PO_4^{3-}): phosphorous in the natural fresh waters is present mostly in inorganic forms as PO_4^{3-}. Phosphorous, being an important constituent of biological systems may also be present in the organic forms. The major sources of phosphorous are domestic sewage, detergents, agricultural effluents with fertilizers and industrial waste waters. The high concentration of phosphorous, therefore, is indicative of pollution.

CONCLUSION:

Physico-chemical parameters are very important in respect of checking the pollution status of any water body. They provide as the first hand information in this regard. The physico-chemical parameters occur in the aquatic environment both as an outcome of natural

processes and as harmful waste from human activities like boating, landfill leachate, domestic, industrial waste water and water of rain storm runoff. The quality of surface water has been determined all over the world, contaminated both by the natural and anthropogenic processes. Pollution of water is responsible for a very large number of mortalities and incapacitations in the world. Polluted state of the water resources has led to a steady decline in fisheries and has also affected the irrigated land. Availability of clean water is going to become the greatest constraint for development tomorrow. Regular monitoring of water bodies with required number of parameters in relation to water quality not only prevents the outbreak of diseases but also help to mitigate occurrence of hazards. Monitoring of the water quality parameters is a key activity in managing the water bodies, restoring polluted water bodies and anticipating the effects of man-made changes on the environment.

REFERENCES:

1. Versari, A., Parpinello, G. P. and Galassi, S. (2002) J. Food Compos. Anal., 15, P. 251.
2. Pandit, A. K., Rather, S. A. and Bhat, S.A. (2001) J. Res. And Dev., P.22.
3. Li, J., Li, H., Shen, B and Li, Y. (2011) Int. J. of Sediment Res., 26, P.50.
4. Neal, C., Neal, M., Hill, L and Wickman, H. (2006) Sci. Total Environ., 360, P.272.
5. Vega, M., Pardo, R., Barrodo, E and Deban,L. (1996) Water Res., 32, P. 3581.
6. Zhou, Q., Zhang, J., Fu, J., Shi, J and Jiang, G. (2008) Anal. Chim. Acta, 606, P.135.
7. An, Y.J., Kampbell, D.H. and Sewell, G.W. (2002) Environ. Pollution, 118, P.331.
8. Fatoki, O.S and Awofolu, R. (2003) Water S. A., 29,P. 375.
9. Solak, M and Dogan, M and Fresen. (1995) Environ. Bulletin,P.35.
10. Ansari, M. I., Grohmann, E and Malik, A. (2008) J. Appl. Microbiol., 104, P.1774.
11. Tam, N. F. Y and Wong, Y.S. (2000) Environ. Pollution, 110, P. 195.
12. Virkutyte, J and Sillanpaa, M. (2006) Environ. Int., 32, P.80.
13. Censi, P., Spoto, S. E., Saiano, F., Sprovieri, M., Mazzola, S and Nardene, G (2006) Chemosphere, 64, P.1167.
14. Zhou, H.Y., Cheung, R. Y. H., Chang, K.M and Wong, M. H (1998) Water Res., 32, P. 3331.
15. Khalid, A., Malik, A. H., Waseem, A., Zahra, S and Murtaza, G (2011) *Int. J. Phys. Sci.*, 6, P.7480.
16. Awadallah, A.G and Yousry, M *Water Res. Manag.*, 26, 2039.

Biodiversity Assessment: Tool for Conservation
ISBN: 978-81-931247-3-4

CHAPTER 20

BIODIVERSITY IN AGRICULTURE, HORTICULTURE, FORESTRY AND FISHERY

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Biodiversity, the contraction of the word biological diversity, brainstormed in 1985, is the web of life that links all the organisms on the earth. This is a great idea with a long history that refers to the variety of life and the degree of variation of life representing the wealth of biological resources. Biodiversity, the result of over 3.5 billion years of evolution, varies globally and regionally. Soils, temperature, altitudes, precipitation and other factors affect biodiversity. Biodiversity can be studied at various levels. A common way to measure is the count of species in an area. Researchers have estimated that there may be over 100 million species on earth but for the time being we have identified only 1.9 million species, a long way to go. In general the tropics, particularly the tropical rain forests have more biodiversity than the temperate and boreal ecosystems. Also ocean biodiversity is 25 times less than terrestrial biodiversity. However, simply counting species is an incomplete measure of biodiversity as there is a lot of genetic variance within each species and the variety of ecosystems that each species create. Thus every life form can be specified and characterized by the taxonomic, genetic and ecological diversity.The way these dimensions of these diversities vary over time and place is the prime and paramount feature of biodiversity. Hence, biodiversity is the sum total of all biotic variation from genes to ecosystem. Diversity exemplified in all organizational levels – from genetic diversity within the populations to the diversity of ecosystems contribute to global biodiversity. Ultimately, biodiversity comprises both richness and evenness and is measured on three different organization levels viz., genome, assemblage or species, and landscape.

Human beings had extensively changed the global environment in the past few years, as a result great loss in the species diversity in terms of extinction has been observed. Also

the rate of extinction is several times faster than that of the previous ones. This is mainly due to the drastically changing environment, changing faster than the organism's' ability to adapt. Thus a large number of species are endangered or extinct. This loss is of critical concern as these directly affect the stability of the environment. Rapid loss of biodiversity became a global phenomenon.

The shortage of non-sustainable assets, for example, soils and composts and the outcomes of environmental change can drastically impact the nourishment security of future eras [1]. Advancement in horticultural creation frameworks acquaints the potential with give a critical wellspring of alleviation by expanding carbon stocks in earthly frameworks, with diminishing of emanations attributable to expanded effectiveness [2]. Environmental change, contamination, an Earth-wide temperature boost and over abuse of assets in the most recent century cause to annihilation of organic assorted variety and this circumstance is very genuine for human sustenance. Keeping in mind the end goal to feature the significance of biodiversity, 2010 has been chosen as the International Year of Biodiversity trying to teach individuals on biodiversity and how biodiversity underpins regular day to day existence. The truth of the matter is that every one of the types of vegetation, including people, are reliant on each other, and the elimination of any of these species can trigger a thump on impact on alternate species, which are straightforwardly or in a roundabout way subject to it. Biodiversity covers the decent variety of life on every one of these levels, the assorted variety inside species, amongst species and the inconstancy of living spaces. Created countries additionally depend on biodiversity for their survival and quality life. Decent variety of life advances the personal satisfaction. Along these lines earth's biodiversity is greatly significant and gives nourishment, wellbeing and safe house for people. Parts of biodiversity in various logical fields are condensed quickly underneath:

AGRICULTURAL BIODIVERSITY:

Agricultural biodiversity is a broad term widely used to include all components of biological diversity relevant to food and agriculture and all components of biological diversity that constitute the agro ecosystem. In fact biodiversity is the basis of agriculture and has enabled farming systems to evolve ever since agriculture was first developed (10,000 years ago). Thus it is the outcome of the interactions among genetic resources, environment and the systems practiced by farmers. In addition to plant and animal genetic resources, at the genetic, species and ecosystem levels, the term includes abiotic, socioeconomic and cultural factors as well. The wild relatives and their local varieties are significant components of

agricultural biodiversity. Biodiversity and agriculture are strongly interrelated as biodiversity is critical for agriculture, and also agriculture contributes to conservation and sustainable use of biodiversity. Indeed, sustainable agriculture promotes and enhances biodiversity. Maintenance of this biodiversity is of paramount importance in the production of food, fodder, fibre and fuel and thus sustains livelihood of rural people. Thus agricultural biodiversity plays a crucial role in food security, nutrition, economic, environmental and socio-cultural issues. Some of the risk factors associated with agriculture include misuse of agricultural inputs, overgrazing, inaccurate irrigation techniques as well as indiscriminate use of chemicals and fertilizers. Soil erosion, urbanization, industrialization, deforestation and global climate changes are also major threat to agricultural biodiversity.

Agro biodiversity is the part of Biodiversity which nurture people and which is nurtured by people [3, 4]. Human life and civilization have been more influenced by cultivated or domesticated plants. Harris and Hillman [5] defined domestication as human intervention in the reproductive system of the plant, which resulted in genetic and /or phenotypic changes. The transition from wild to cultivation as a 'form of intensification of plant gathering', involving a slow/ gradual domestication of the environment. Either directly or indirectly, all cultivated plants are evolutionarily derived from wild species through human imposed deliberate selection for desirable traits. During course of domestication, plants underwent more or less drastic morphological, physiological and other changes, thus creating vast differences between the wild ancestors and the derived domesticates termed as Domestication Syndrome.

Domestication syndrome in crop plants [5, 6, 7, 8, 9, 10]:

Character change	Significance
Gigantism	Affects the part utilized-seed, fruit, root, stem, tuber—an almost universal characteristic of domesticated crop plants.
Suppression of dispersal mechanism	Results in retention of seed In the fruit or inflorescence; reduction of stolon length in potatoes, resulting in concentration of harvestable product and facilitation of collection. Another virtually universal character.
Suppression of sexual reproduction	Crops reproduced vegetatively by tubers, e.g. potatoes, show this. In the special case of banana, its culture as an edible fruit depends on this suppression as it serves to concentrate assimilates in the production of the harvested product.

Changed growth form	May be a consequence of gigantism—larger fruit structural support, allometric growth changes may result. Plant growth habits become more restrained and less rampant, facilitating crop husbandry.
Changed life form	Short-lived perennials (e.g. *Phaseolus beans*) may become biennial or annual, often in response to selection for higher yield and earlier maturity. The energy required for perennation can be diverted to production of biomass usable by humans.
Changed breeding system	Self-pollination has advantages in reducing weather-dependence for pollination, promoting yield stability in areas with unpredictable weather conditions.
Loss of seed dormancy	Promotes predictability in production of good crop stands and highly advantageous in cultivation. Short-term dormancy is useful in moist climates, inhibiting sprouting in the ear of cereals and seeds in pods of legumes.
Biochemical changes	Commonly involve loss of toxic or distasteful compounds, glucosinolates In brassicas, cucurbitacin in cucurbits, cynogenic glycosides in lima beans and cassava, lectins and protease inhibitors in some legume crops
Changed ploidy level	May be auto-or allopolyploidy. Autopolyploid grasses (e.g. *Lolium spp*.) are cultivated. Allopolyploidy, more significant, has resulted in production of essentially new species such as the bread wheats and many soft fruit novelties (Rubus spp.).
Physiological changes	Photoperiod requirements can limit extension of the range of crops, which originate in low latitudes at high elevations. A change to day neutrality can enable this to occur as in Phaseolus vulgaris, the common bean.

The act of domestication may be a single or repetitive event in time and /or space. Most-seed-propagated species considered to have had only one domestication episode [11]. *Cotton, Capsicum, Chenopodium* and many vegetative propagated crops have had repetitive domestication [12]. Since the type of domestication has both historical and evolutionary significance, in restricting or expanding the genetic base of the cultivars. Based on detailed study of the geographic distribution of genetic diversity in various crop species, Vavilov [13, 14], a phyto geographer identified many areas as "Centers of Genetic Diversity likely to be

the centers of origin. Vavilov centers are regions where a high diversity of crop wild relatives can be found, constitute the natural relatives of domesticated crop plants. He recognized eight centers of origin of domesticated plants (fig) popularly called Vavilov centers or Germplasm treasures [15]. The "Centers of origin 'concept ignores phenomena such as trans domestication [16]. Archeological evidences from many parts of the world has shown that several cultivated species rapidly spread throughout the world mainly human activity.

The number of cultivated taxa increased as a result of diversification of human needs, only to be drastically reduced in the last century. Early man used at least 3000 -plant species as food, but resorted to active cultivation of only 150-200 species [17].Today the world is fed by about 15-20 plant species only [18]. Rice, Wheat, Maize and Potato are the four major crops providing more than 50 % of the food requirements of the people.

Although the total number of species of domesticated crops was reduced, efforts to increase the intraspecific diversity within the selected species were well underway i.e., variation within selected species increased immensely. For example, there was an estimated 130,000 distinct varieties with in the rice species *Oryza sativa* [19].

Land races are crop varieties of peasant farming initially derived due to the domestication process, which constituted the base for further diversification in modern cultivars. Land races of many major crops are now mainly used as donors of genes in order to enhance in some way the biological and /or economic adaptations of those crops; they are also used to improve the quality and quantity of yield of advanced cultivars. Wild relatives and species contribute substantially to expansion of the genetic base of cultivated taxa; hence they are invariably used to breed and improve the latter [6, 20, 21]. For breeding programme, knowledge about the genetic characteristics of a population is a fundamental and it involves the local farmers. This strategy allows improving and, at the same time, safeguarding the genetic reliability of landrace genetic resources [22].

Wild relatives often provide genes that are not available in domesticated plants. These are invariably genes affording resistance to diseases/pests and other environmental stresses. Such resistance genes have been acquired by the wild relatives through their long periods of coevolution with biotic and abiotic stresses. Wild plants are the taxa that live in the wild but are still used by man for various purposes. Many constitute life support taxa that help to sustain man in stress prone areas and under emergency situations [23]. More agricultural biodiversity is associated with higher agriculture production, nourishes people and sustains the planet.

Agrodiversity

HORTICULTURAL BIODIVERSITY:

Cultivation is a rich and bright train and part that incorporates ornamentals, manor crops, flavors, fragrant and therapeutic plants, tuber yields and mushrooms, natural products, blossoms and vegetables [24]. Calm, subtropical and tropical green yields are described by their appropriation to differing topographic, climatic, edaphic and arrive utilize designs. In the cultivation segment indigenous agricultural plants must be repositioned for their maximum capacity to be abused [25]. Man lives not for sustenance alone on nature, but rather additionally appreciates organic products, vegetables, blossoming plants, foliages, wood et cetera from nature. Qualities for attractive attributes are inserted in biodiversity and all things considered the present the volume tossed open agricultural bio assets to human profit. Agriculture has risen to end up noticeably the most dynamic remote trade worker and business in a few nations, yet the indigenous green yields have not been abused for existing fare markets. Lessen biodiversity misfortune is essential for present and future human prosperity. Individuals everywhere throughout the world attempted to defend these vital regular riches. Understanding the crucial part of biodiversity assumes a vital part in supporting life on Earth. As people are an essential piece of nature; our reality is firmly connected with biodiversity and their encompassing surroundings [24]. Biodiversity International mounted a worldwide mindfulness crusade - 'assorted variety forever' – which picked up energy amid the year.

Gardens and horticulture has special role to create the message of interdependence of human being on natural resources. Amenity horticulture is a quickly developing area comprising ornamentals and other plants connected with gardening and landscaping. 28,000 plant species have been estimated to belong to this group. The search for suitable resistance resources and traits is of great importance. New varieties and species are constantly entering

the market, thus driving breeder's interest in acquiring unrestricted access to well-documented and evaluated materials in internationally accessible gene banks. Apart from commercial breeding, propagation and trading, a large number of interest groups and private breeders also play an active role in biodiversity conservation and promotion. The amount of land used for commercial horticulture is dwarfed by the area given over to growing ornamental plants and shrubs.

Little is known about the status of and threat to genetic diversity in ornamental plants. It can however be assumed that very few traditional varieties remain available for commercial exploitation. The strategy developed by botanical gardens to establish conservation collections is thwarted by the fact that it relies heavily on cooperation from private collectors and their willingness to publish their data. There is a need for action as regards linking existing collections to ensure long-term conservation of biodiversity in horticultural plant species and varieties that are already used and those with potential for use. Thus, apart from their social and utility value, gardens harbor considerable biodiversity potential. This can evolve especially well when gardens are managed in environmentally sound ways, when plants are chosen to suit local conditions, gardeners refrain from using invasive plants, and species and varieties are used that have an ecological function beyond their ornamental and utility value.

FORESTRY:

Forestry is the science and art of forest management. Forest, a biologically diverse system with diverse set of habitats for animals, plants and microbes represent the richest biological areas and also provide social, economic, environmental and cultural benefits. Also, these provide more than 10% of GDP even in the poor countries. Forests stands as crucial renewable resources with multifunctional role as they yield timber, fuel, pulp and paper, providing several economic and employment benefits. These provide formal employment for over 10 million people and informal employment for nearly 50 million people in developing countries. India is one among the ten forests –rich countries of the world along with USA, China, Democratic Republic of the Congo, Australia, Indonesia and Sudan. India supports a huge variety of forest types viz., tropical evergreens, sub-tropical, tropical deciduous, swamps, mangroves, mountain, scrub, sub-alpine and alpine forests with protected areas – 96 National parks, 509 wildlife sanctuaries and several sacred groves.

Forest biodiversity, a broad term refers to all forms of life found in forests, including plants, animals, fungi, microbes, their genetic diversity and their role in nature. This diversity

both physical and biological can be considered at different levels – species, populations, genetics, landscapes and ecosystems with complex interactions within and among these levels. This complexity allows organisms to adapt to the continuous changing environment so as to maintain the ecosystem functions.

Forest biodiversity is due to the net result of evolutionary processes occurring over millions of years driven by competition, disturbance, fire and climate. The General assembly of UN in 2007 approved forest biological diversity as one of the seven thematic elements of the concept of sustainable forest management. The FAO forest program now focuses to maximize forest resources to ensure that the resources are conserved so as to meet the needs of future generations.

Forest biodiversity is threatened by rapid deforestation, forest fragmentation and degradation, hunting and the arrival of invasive species from other habitats. During the past century more or less 45% of original forest cover has disappeared. Many countries removed much of their forest cover to make room for agriculture, industrial development and urban development. The FAO of United Nations estimated that 13 million hectares of World's forests are lost due to degradation. The main cause of the loss of biodiversity is basically due to human intervention. Infrastructure development such as urban sprawl, construction of roads, hydroelectric projects, pollution, anthropogenic forest fires, mining, oil exploitation, conversion of forests to agricultural land, enhancing the mobility of biota, overgrazing, over exploitation of natural resources, climate change and unsustainable forest management - with dire consequences on forest biodiversity. However the effect size varied with the type of disturbance, the taxonomic group and with the region. Thus degradation, resource depletion, loss of biodiversity, and resilience in ecosystems are the major environmental issues we are facing today. Hence preserving the forest biodiversity is the need of the hour and all the countries of the world should come together to protect the biodiversity. United Nations Convention on Biological Diversity (CBD), held in Rio De Janeiro in 1992, emphasized the importance of prediction and prevention to eliminate the root causes of biodiversity reduction or loss and put forward specific requirements on the implementation of biodiversity monitoring and assessment.

The United Nations Environment Programme (UNEP) also urged all countries to enhance the construction of biodiversity monitoring system, establish biodiversity evaluation indices, and to carry out the corresponding assessments on biodiversity. New innovative forest management practices should be incorporated for a more sustainable forest management in terms of productivity and biodiversity. One novel research on mycorrhizal

fungi suggests that with appropriate management practices the mycorrhizal communities in middle aged ones are more similar to the old-growth ones and also more species survive the harvesting phase. Finally interaction among environmentalist, ecologist and economist is the need of the hour for better linkage of scientific understanding, policy development and forest practice for the sustainable use of forest resources and to preserve forest biodiversity.

FISHERIES:

Approximately 7,000 freshwater fish species [26] have been identified, over 20% of which are extinct, endangered or vulnerable [27]. There is clearly a need for the sustainable use of fish biodiversity. From an ecological perspective, any type of fishery, including the most selective (based on a single species), causes the alteration of ecosystems [28]. Multi-species fisheries, or less selective fishery methods, tend to catch species that have secondary or no economic importance, and small stock sizes, potentially leading them to extinction. Some management programs therefore strive to develop and enforce more selective fisheries methods. Many fish species have had their stocks reduced by overfishing and fisheries management has therefore been blamed for impacts to biodiversity. For example, in the Black Sea, 21 of 26 major species have become "commercially extinct" (not profitable for commercial fishery) [29].

Expansive tropical waterways speak to biological communities of verifiably tremendous esteem, regarding both the high biodiversity they bolster and the quantity of individuals whose occupations rely on that biodiversity. They likewise, sadly, speak to maybe the best cases of the disintegration of these regular resources by unseemly advancement, driven essentially by clashing requests upon water, and different assets caused by developing populaces. This is especially valid for territories where quick track monetary improvement has been favored. The general worldwide pattern of corruption of stream conditions has been discouraging. Biological community uprightness has regularly been undermined to such a degree, to the point that frameworks neglect to help average levels of sea-going life. Accordingly the jobs of individuals, beforehand bolstered by this oceanic life, are genuinely bargained [30]. While the verifiable connection between's financial flourishing and corrupted freshwaters is clear for all to see, there is a developing familiarity with maintainability alternatives for freshwater natural assets, where these assets are as yet critical. Genuine endeavors are additionally starting to be taken towards restoring debased frameworks, with extensive achievement [31]. Vital to this, in creating nations, is the developing valuation for the significance of living freshwater assets to provincial jobs; that is, basically to fisheries. In

spite of the fact that it is more unmistakable in a few regions than others, aquaculture is right now predominated by the catch fisheries division. Business aquaculture, including mechanical creation for the extravagance and fare markets, is expanding and confines culture of snakeheads (*Channa spp*) and p*angasiid* catfish in the Delta are getting to be plainly prominent ventures [32]. A great part of the creation of extravagance, higher esteem, angle depends on contributions of lower review angle from the catch fishery [33]. Culture and catch fisheries are additionally connected by the utilization of wild fish stocks in modern aquaculture [34]. Shrimp culture, as somewhere else, has detonated along the seaside zones causing the standard negative natural effects, most strikingly mangrove pulverization. The inspiration for aquaculture, as with the fishery, has a tendency to be benefit as opposed to sustenance.

Others activities, such as habitat alteration, species introductions and pollution, may have played an even more important role in the process. Several management techniques have been employed to minimize these problems. The history of natural resource management is full of spectacular mistakes and, unfortunately, managers rarely change their approaches according to past experiences [35]. These mistakes are unavoidable consequences of the contradiction between human aspirations (no limit on exploitation) and his/her capacity of achieving them (limited resources) [34]. The lack of information about the systems being managed, the absence or inadequacy of monitoring and the high natural variability of the resource abundance are, in general, the main problems that affect the efficiency of management [36]. In spite of this, the fishery is an important economic activity and an important source of protein for many people in several regions of Brazil. The fishery requires sound sustainable policies and management actions, but the paucity of accurate information makes evaluation of the resource difficult.

A few dangers to biodiversity, including over-misuse and the utilization of dangerous apparatuses, emerge from inside the fisheries area. One arrangement includes a move to co-administration approaches, which are as of now broad, and, in places, locally successful. The utilization of asset assignment frameworks (angling parts), at estuaries, waterfront zones, empowers the control of open get to and is, possibly, an imperative device in biodiversity protection, yet requires more research before being advanced all the more generally. Aquaculture, surely not an all inclusive solution for the issues of catch fisheries, includes its own particular arrangement of biodiversity impacts. Boss among these are territory misfortunes and the far reaching presentation of fascinating species and strains. A powerful answer for the issue of presented of species is the advancement and utilization of codes of

training for pre-presentation appraisals. The best danger to biodiversity emerges from different divisions, where exercises can advance broad loss of territory, biological system disentanglement and diminished water quality and amount. The flow financial advantages emerging from the stream fishery give the major monetary and social contention for enhancing coordinated normal assets administration to address the issue of general biological system rot. As of late, this thought is certifiably affecting advancement approaches. Excessively negative states of mind toward the effects of fisheries on biodiversity in waterways will undermine biodiversity protection.

CONCLUSION:

Apart from the *current* economic benefit, the diversity of used and usable life forms and their heritable traits provides a valuable resource for *future* uses and forms a basis for *innovation* and greater economic activity. But most of all, the associated biological diversity that is not directly used alongside biodiversity components has a fundamental ecological value. This includes the vital ecosystem services which ensure that the ecosystems we use and the processes they involve actually work: such things as metabolic cycles, regeneration of soil properties and the self-cleaning ability of water bodies. Apart from these ecological services, which society does not honor in its product pricing mechanisms, consideration must also be given to cultural and aesthetic values – the latter being of direct economic importance in the case of ornamental plants. Old livestock breeds and traditional species and varieties of ornamental plants lay testimony to the cultural services of earlier generations and to the historical development of farming and animal husbandry in a given region. Traditional forms of cultural landscapes influenced by agriculture activities, forest landscapes and coastal areas have great adventure and recreation value. Described as 'diversification' in agriculture and forestry, this in turn is of regional economic importance in attracting business investment.

Though knowledge on biodiversity has been increased by leaps and bounds in the last 10 years, there is still a lot to be learned and achieved. We should find a way to overcome the several threats, such as destruction, degradation and fragmentation of habitats, climate change, pollution, contamination, overexploitation and alteration in ecosystem composition. A new challenge for ecologists is determining the relationship between biodiversity and ecosystem functioning. This issue was identified as one of the top research trends for 1998 by Science magazine.

Conservation of biodiversity can be done by proper protection and management of biosphere. Priority should be given to preserve the unique ecosystems. Overexploitation of

natural resources should be prevented; environmental laws should be strictly followed, pollution at all levels should be eradicated. Finally as Biodiversity has ecological, economic, productive, consumptive, aesthetic, social, legal and ethical values utmost attention, importance and awareness should be created and interdisciplinary approach is needed for conserving the earth's biodiversity.

REFERENCES:

1. Mäder, P., Kaiser F., Adholeya, A., Singh, R. Uppal, H. S., Sharma, A. K., Srivastava, R., Sahai, V., Aragno, M., Wiemken, A., Johri, B. N. and Fried, P. M. (2011), Soil Biology and Biochemistry. 43, P. 609-619.
2. Mann, W., Lipper, L., Tennikeit, T., McCarthy, N. and Branca, G.(2009), FAO, Rome, Italy.
3. FAO (1995), Document CPGR-6/95 REP.FAO, Rome.
4. Virchow, D (1998), Springer-Verlag, Berrlin.
5. Harris, D.R. and Hillman, G.C (1989), Unwin Hyman, London, P. 1-8.
6. Harlan, J.R (1976), Crop.Sci.16, P. 329-333.
7. Hawkes, J. G. (1987) Report to IUC/WWF.
8. Schwanitz, F (1996), Harvard Uni.Press, Cambridge, MA.
9. Simmonds, N. W (1979), Principles of Crop Improvement. Lomgmans, London.
10. UNEP (1995), Cambridge Univ. Press, Cambridge.
11. Zohary, D (1989), Unwin Hyman, London, P. 358-372.
12. Pickersgill, B (1989), Unwin Hyman, London, P. 426-439.
13. Vavilov, N.I (1926), Bull. Appl. Bot. Gen. Plant Breed.16, P.1-248.
14. Vavilov, N.I (1949-50), Chronica Botanica 13, P. 1-366.
15. Khosohoo,T.N. (1991), Har-Anand Publications, New Delhi.
16. Hymowitz, T (1972), Econ.Bot.26, P.49-69.
17. Mangelsdorf, P.C (1996), Proc.Nat.Acad.Sci.USA56, P. 370-375.
18. Boyle, T.J.B. and Lenne, J.M (1997), CAB International, Wallingford, UK, P.31-53.
19. Chang, T.T (1995), Evolution of Crop Plants. Longmans, London, P.147-155.
20. Prescott-Allen, R. and Prescott-Allen, C (1988), Earthscan, London (2nd Edn.),
21. Stalker, H.T. (1980), Adv.Agron.33, P.111-147.
22. Kahraman, A and Önder, M (2009), Int. Syposium on Sustnable Devel. 3, P.13-19.
23. Paroda, R.S., Kapoor, P., Arora, R.K., Mal, B. (Eds.) (1988), NBPGR, New Delhi.
24. Peter, K.V. and Abraham, Z. (2007), Daya Publishing House, New Delhi, India.

25. Abukutsa, M.O.O. (2010), Jomo Kenyatta University of Agriculture and Technology (JKUAT), Nairobi, Kenya, 30 April.
26. Matthews, W. J. (1998) Kluwer Academic Publishers, Massachusetts, USA. P, 756.
27. McAllister, D. E. (1999), Brussels, ACP-EU Fisheries Research Initiative Report,
28. King, M. (1995), Oxford, Fishing News Books.P. 342.
29. McNeely, J. A. (1999), Brussels, ACP-EU Fisheries Research Initiative Report, 6.
30. Coates, D. (1995), Government of Japan. Document # KC/ FI/95/TECH/3. 85 p.
31. Cowx, I. G., and R. L. Welcomme. (1998), Fishing News Books, Oxford, United Kingdom. P, 260.
32. Nao Thuok, and Nuov, S. (1996), International Association for the Study of Common Property (IASCP), 5-8 June, 1996. Berkeley, USA. 9 p.
33. Sjorslev, J. G. (2001), Research Institute for Aquaculture No. 2, Ho Chi Minh City, VietNam.
34. Ludwig, D., Hilborn, R and C. Walters. (1993), Science 260, P.17-36.
35. Agostinho, A. A., and L. C. Gomes. (1997), perspectivas para oreservatório de Segredo. Pages 319-364, Maringá-PR, Brazil.
36. Agostinho, A. A. (1994), COMASE/Eletrobrás, Rio de Janeiro-RJ, Brazil. 61 p.