22 MAY 2016
INTERNATIONAL DAY
FOR BIOLOGICAL DIVERSITY
Mainstreaming Biodiversity;
Sustaining People and their Livelihoods

उत्तर प्रदेश राज्य जैवविविधता बोर्ड
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Mainstreaming Biodiversity;

Sustaining People and their Livelihoods

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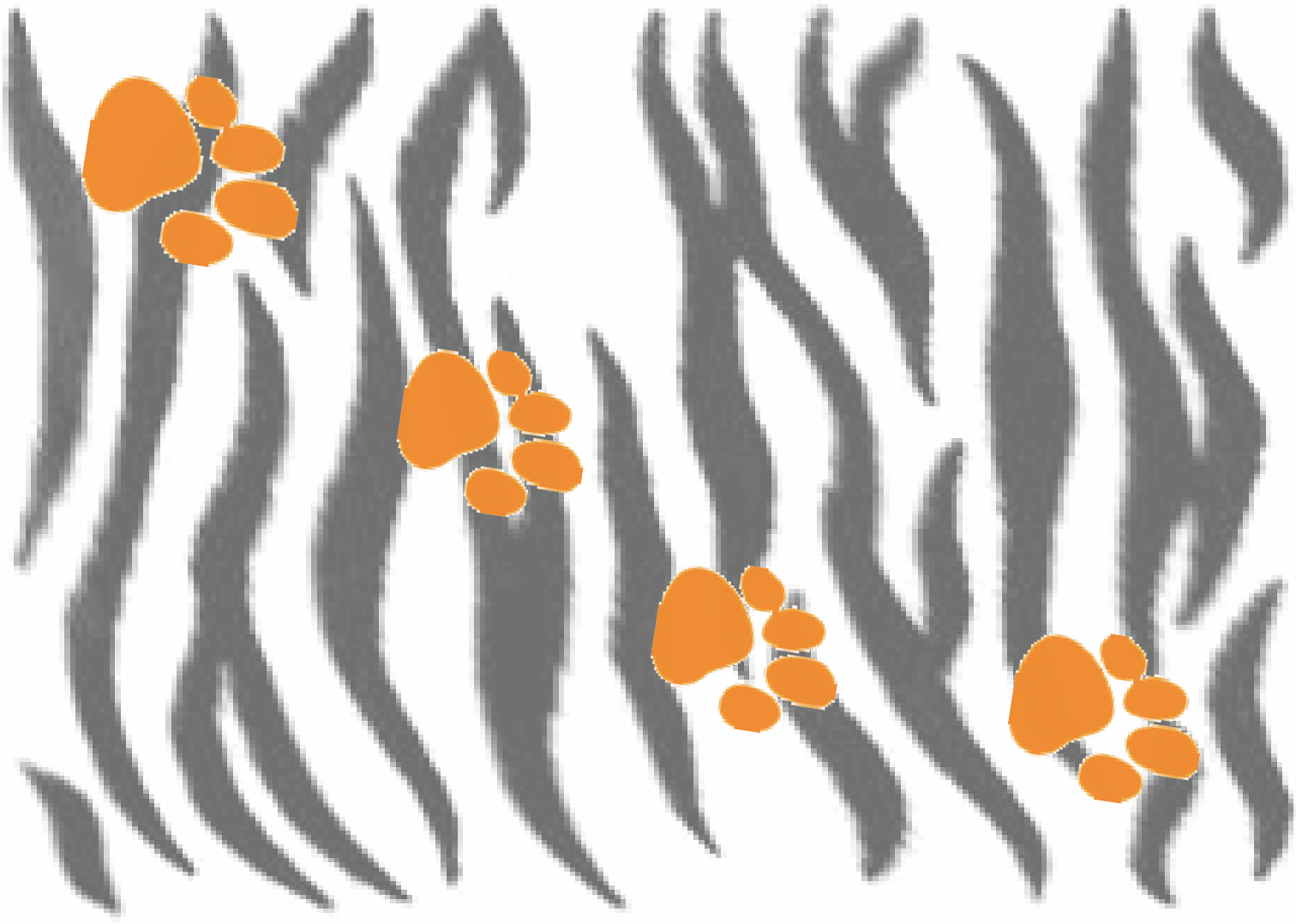

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National Conference on

Mainstreaming Biodiversity; Sustaining people and their livelihoods

Souvenir

International Day For Biological Diversity

22nd May, 2016

Organized by

UTTAR PRADESH STATE BIODIVERSITY BOARD

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United Nations Decade on Biodiversity

THE SECRETARY GENERAL

MESSAGE ON THE INTERNATIONAL DAY FOR BIOLOGICAL DIVERSITY
22 May 2016

Biodiversity and the ecosystem services it supports are the foundations for life on Earth and the livelihoods and well-being of people everywhere. Protecting biodiversity and preventing further losses is an essential investment in our collective future.

Biodiversity is an important cross-cutting issue in the 2030 Agenda for Sustainable Development. Goal 15 explicitly recognizes the importance of halting biodiversity loss, and other Goals recognize the importance of biological diversity for eradicating poverty, providing food and fresh-water, and improving life in cities. It is critical that we make progress in mainstreaming biodiversity and transforming how societies value and manage it.

Despite numerous commitments, biodiversity loss continues to accelerate in all regions. Only 15 per cent of countries are on track to achieve the Aichi Targets on biodiversity by the target date of 2020. In addition, the anticipated expansion of sectors that both depend on and affect biodiversity – including agriculture, forestry, fisheries and aquaculture – will pose a significant challenge to halting biodiversity loss in the coming decades.

Reversing these trends will require action by all sectors and stakeholders, from United Nations Member States and agencies to civil society, academia and business. We need better research, and we need to act on the evidence that biodiversity is integral to achieving social and economic goals.

The responsible use of natural resources is essential to sustainable development. Mainstreaming biodiversity will ensure that addressing development needs and protecting the environment are mutually supportive.

On this International Day for Biodiversity, I urge all Governments and stakeholders to preserve and sustainably manage the variety of life on Earth for the benefit of current and future generations. Preserving biological diversity is a vital part of our compact with each other and the planet that nurtures us.

Editorial

Biological diversity - or biodiversity - is the term given to the variety of life on Earth and the natural patterns it forms. The biodiversity we see today is the fruit of billions of years of evolution, shaped by natural processes and, increasingly, by the influence of humans. It forms the web of life of which we are an integral part and upon which we fully depend. It is the foundation of life. It therefore underpins peoples' livelihoods and sustainable development in all areas of activity, including economic sectors such as agriculture, forestry, fisheries and tourism, among others. By halting biodiversity loss, we are investing in people, their lives and their well-being.

The thirteenth meeting of the Conference of the Parties to the Convention on Biological Diversity (COP 13) to be held in Cancun, Mexico from 4 to 17 December 2016 will focus on the mainstreaming of biodiversity within and across sectors, which is closely linked to this year's IDB theme "Mainstreaming Biodiversity; Sustaining People and their Livelihoods".

Mainstreaming biodiversity was developed as a means of addressing the fact that biodiversity conservation goals are viewed as distinct from, and sometimes even contradictory to, the goals of development and economic growth. The higher priority put on development means that biodiversity work does not receive the political, social and financial support it needs to succeed (UNDP and UNEP, 2008). Though mainstreaming has been referred to as "integrating" biodiversity into development, it has the added meaning of modifying that into which it is integrated (e.g. changing the focus of development policies and intervention).

Mainstreaming biodiversity then has as its objective the integration of biodiversity conservation and related sustainable use principles into policies, plans, programs and production systems where the primary focus has previously been on production, economic activity and development, rather than on biodiversity conservation (Petersen and Huntley, 2005).

U.P. State Biodiversity Board, Lucknow celebrated the International Day for Biological Diversity (IBD-2016) on 22nd May, 2016 in collaboration with Federation of Indian Chambers of Commerce and Industry (FICCI) by organizing a conference on the theme "Mainstreaming Biodiversity; Sustaining People and their Livelihoods"

and the sub theme of the conference was "Connect Initiative between Bio Resource Growers and Industries". The aim of this conference was to have an overview and creating awareness of the role of biodiversity in sustaining people and their livelihoods. Hopefully, the discussions during the conference will bring out good management approaches in using biodiversity for sustainable development.

I would like to extend my sincere thanks to the Shri Sanjiv Saran, Chairman, U.P. State Biodiversity Board for his help and encouragement in organizing this conference. I would also like to express my gratitude to Shri Amit Gupta, Head, U.P. State Council, Federation of Indian Chambers of Commerce and Industry (FICCI) for the support. I am thankful to all the contributors of articles of this souvenir for sharing their ideas, work, research, experiences and pictures with us. I also thank the sponsors, contributors and donors who generously provided financial support for the nation building cause.

The whole editorial board that has worked hard in bringing out this endeavor needs special appreciation. Dr. Somesh Gupta, Shri K K Tiwari and Shri Hemant Srivastava of Uttar Pradesh Biodiversity Board deserve special appreciation for their valuable help in bringing out the souvenir. I sincerely hope that you find this souvenir useful, engaging an enlightening reading experiences.

– Editor

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INTERNATIONAL DAY FOR BIOLOGICAL DIVERSITY

Mainstreaming Biodiversity;

Sustaining People and their Livelihoods

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Contents

Biodiversity of India: Tribal People and their Livelihoods

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Introduction

Biodiversity, a contraction of "biological diversity," generally refers to the variety and variability of life on Earth. One of the most widely used definitions defines it in terms of the variability within species, between species, and between ecosystems. It is a measure of the variety of organisms present in different ecosystems. This can refer to genetic variation, ecosystem variation, or species variation (number of species) within an area, biome, or planet. Terrestrial biodiversity tends to be greater near the equator, which seems to be the result of the warm climate and high primary productivity. Biodiversity is not distributed evenly on Earth. It is richest in the tropics. It is an essential component of nature and it ensures the survival of human species by providing food, fuel, shelter, medicines and other resources to mankind. The richness of biodiversity depends on the climatic conditions and area of the region. All species of plants taken together are known as flora and animals known as fauna.

Biodiversity is not evenly distributed; rather it varies greatly across the globe as well as within regions. Among other factors, the diversity of all living things (biota) depends on temperature, precipitation, altitude, soils, geography and the presence of other species.

Biodiversity provides critical support for drug discovery and the availability of medicinal resources. A significant proportion of drugs are derived, directly or indirectly, from biological sources: at least 50% of the pharmaceutical compounds on the US market are derived from plants, animals, and micro-organisms, while about 80% of the world population depends on medicines from nature (used in either modern or traditional medical practice) for primary healthcare

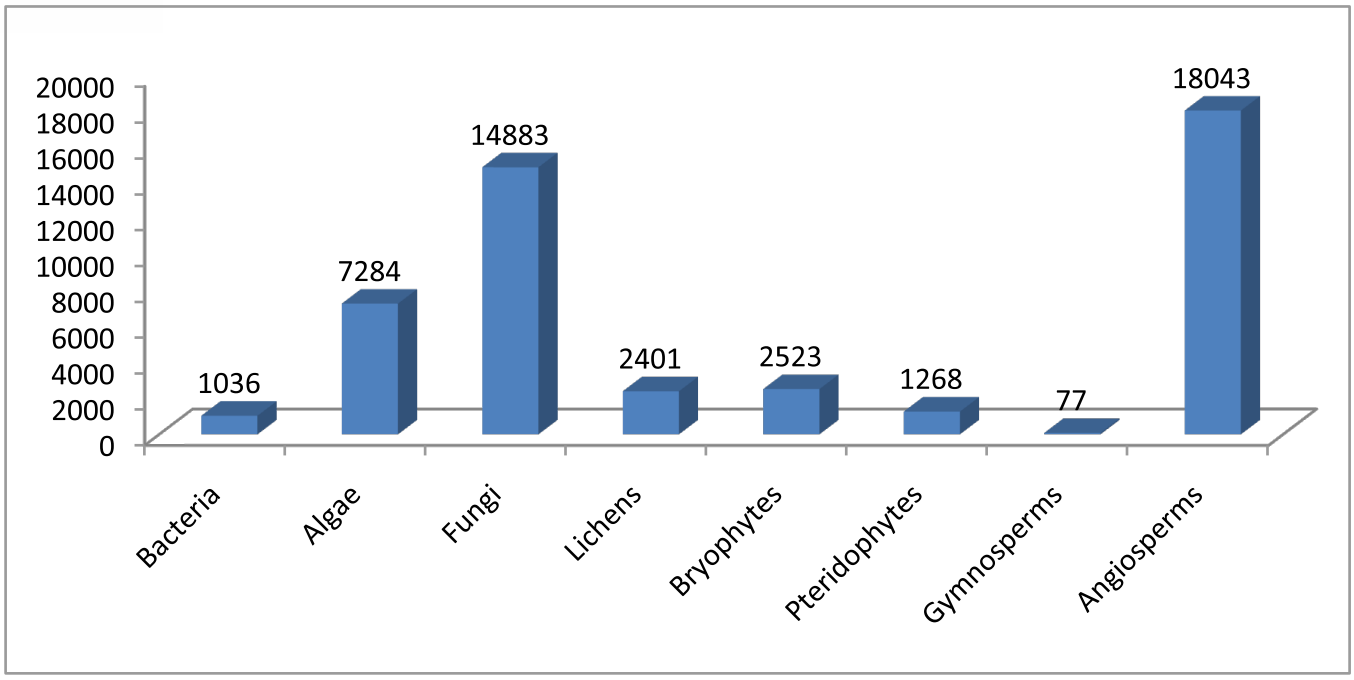
Biodiversity of India

The India is rich in biodiversity due to diversified climatic conditions that vary from the humid tropical Western Ghats and the hot desert of Rajasthan to diversified north east regions of the country, from the cold desert of Ladakh and the icy mountains of Himalaya to the warm coasts of Peninsular India, and the central fertile plains providing innumerous microhabitats. It is second largest country in the world in respect of population and 7th largest country in the world in area & 2nd largest in Asia. Occupied 7th ranks in the world in contribution of agricultural plants, 10th largest mega diversity country in the world and 4th largest country in Asia. It constitutes 2.4% land area in the world, containing 17.5% human population and 15% biodiversity. It has 18% Livestock population, 50% Tiger population, 60% Elephants population, 62% Amphibian species, 50% Lizards, 10% Bamboo, 50% Aquatic flowering plants and 7% Mangroves of the world occur in India.

India harbors more than 47515 plant species including lower plants. Out of which 18043 (38.01%) are flowering plants which represent more than 7 % of the known flowering plants of the world (Singh *et al*, 2015). Of these 5725 (33%) plants are endemic, confined to a restricted Indian boundary (Nayar 1996). About 1800 (10%) species of flowering plants are threatened. There is 2560 tree species (15%) occur in India. Out of 34 hotspots of the world, two hotspots viz. Western Ghats and Eastern Himalaya are found in India. It has been the centre of origin of cultivated plants.

Phytodiveristy of India

There are about 47515 species of plants are found within Indian boundary. Out of which 1036 species of Bacteria, 7284 species of Algae, 14883 species of Fungi, 2401 species of Lichens, 2523

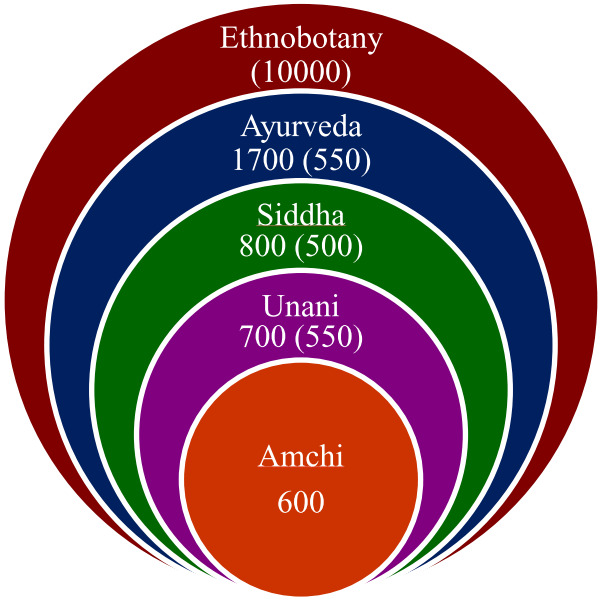


species of Bryophytes, 1268 species of Pteridophytes, 77 species of Gymnosperms and 18043 species of Angiosperms. These species are found in different life forms and various habitat conditions.

Indian System of Medicines

India has a glorious tradition of health care system dating back to several millennia. During the Vedic period and then the Samhita period, India had evolved highly sophisticated and codified systems with written treatises like Ayurveda and Siddha systems of medicine. The Indian systems of medicines functions mainly through two social streams:

1. **Classical Stream:** This comprises of codified and organized medicinal wisdom with sophisticated theoretical foundations and philosophical explanations expressed in several classical texts like *Charak Samhita, Susruta Samhita*, Bhel Samhita and hundreds of other treatises covering all branches of medicine and surgery. Systems like Ayurveda, Siddha, Unani, Amchi are expressions of these classical streams. Plant species used in different classical systems is given below.

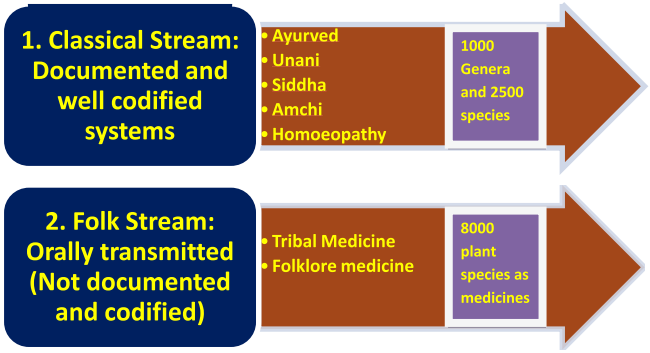


2. **Folk Stream:** This folk stream flow in two parallel directions i.e. (a) through rural villagers and (b) through tribal communities

(a) *Through Rural Villagers:* This folk stream comprising mostly the oral traditions practiced by the rural villagers. The carriers of these

traditions are millions of housewives, thousands of traditional birth attendants, treatment of snake bites and traditional village physicians/ herbal healers, the vaidyas. These streams of inherited traditions are together known as local health traditions.

(b) *Through Tribal Communities:* This level of folk medicine which exists purely as oral traditions practiced by the tribal communities who inhabit in and around the forests. This tradition is currently fast eroding due to the change of life style of the tribal people.



Cultural Diversity (Tribal Communities)

India has over 84.3 million tribal people belonging to 550 communities of 227 ethnic groups as per the classification made by anthropologists on linguistic basis. They inhabit in about 5000 forested villages. Each tribal community has a distinct social and cultural identity of its own and speaks a common dialect. There are about 116 different dialects and 227 subsidiary dialects spoken by tribal's of India. With great antiquity the rich and varied culture the colourful traditions of tribal's add to the texture and luster of the great civilization and the heritage of India.

India is the land of tribal people, the tribal people of India mostly live in forests hills, plateaus and naturally isolated regions and are differently termed as Adivasi (original settlers), Adim niwasi (oldest ethnological sector of population), Adimjati (primitive caste), Anusuchit Janjati (scheduled tribe) and several names signifying their ecological or economic or historical or cultural characteristic. Among these the most popular is 'Adivasi', while in India constitution name for them is 'Anusuchit Janjati' (Scheduled tribe) (Jain, 1987).

Tribal Population

India in South East Asian subcontinent is an abode of nearly 2000 ethnic groups of people that includes some 550 tribal communities found inhabited with their language and culture in 30 different States and Union Territories (except Punjab, Haryana, Delhi NCT, Chandigarh UT and Puducherry UT). As per the census 2011, the tribal population of India is 10, 42, 81, 034 (i.e. 8.2% of country population. The states and Union territories with tribal population in the descending order can be arranged as follow: Lakshadweep Islands UT (94.8%), Mizoram (94.4%), Nagaland (86.5%), Meghalaya (86.1%), Arunachal Pradesh (68.8%), Dadra Nagar Haveli UT (52.0%), Manipur (35.1%), Sikkim (33.8%), Tripura (31.8%), Chhattisgarh (30.6%), Jharkhand (26.2%), Odisha (22.8%), Madhya Pradesh (21.1%), Gujarat (14.8%), Rajasthan (13.5%), Assam (12.4%), Jammu & Kashmir (11.9%), Goa (10.2%), Maharashtra (9.4%), Andaman & Nicobar Islands UT (7.5%), Andhra Pradesh (7%), Karnataka (7%), Daman & Diu UT (6.3%), West Bengal (5.8%), Himachal Pradesh (5.7%), Uttarakhand (2.9%), Kerala (1.5%), Bihar (1.3%), Tamil Nadu (1.1%) and Uttar Pradesh (0.6). Table-2.

The study of tribal communities (Ethnobotany)

The term 'Ethnobotany' was first coined by Dr. J.W. Harshberger on 4th Dec. 1895, at a lecture in Philadelphia, to describe his field of inquiry, which he defined as the study of "plants used by primitive and aboriginal people." In 1896, Harshberger published the term and suggested "ethnobotany" be a field which elucidates the "cultural position of the tribes who used the plants for food, shelter or clothing" (Harshberger 1896).

The term quickly began to be used and a new field was opened. Until the turn of the 20th century, ethnobotany was primarily the study of native uses of plants. Prior to this term (ethnobotany), many

Fig. 1. Gond tribe women

Fig.2. Bhil tribe women

Fig.3. Kol and Mawasi tribe collecting Mahua and Chironji

Fig.4. *Abrus precatorius* L.

Fig.5. *Alangium salvifolium* (L.f) Wang.

Fig.6 *Alectra Chitrakutensis* (Rau) Prasad Dixit

Fig. 7. *Cordia maclodii* (Griff.) Hook. f. & Thom.

Fig. 8. *Gloriosa superba* L.

Fig. 9. *Trichosanthes tricuspidata* Lour.

Table-1. Region, Percentage and Important tribes of India

S. No.	Region	Percentage	Important tribes
1	Central and Eastern India (Bihar, Odisha, M.P., A.P., Andaman & Nicobar Islands)	54.73%	Gond, Bhil, Bhatra, Bharia, Kol, Halba, Kanwar, Baiga, Munda, Oraon, Santhal, Ho, Kondh, Lodha, Bhumij, Paroja, Sahariya, Bhillala, Chenchu, Sugali, Koya, Nicobarese, Onge, Jarawa etc.
2	Western India ((Rajasthan, MH, Gujarat, Damon, Diu & Dadra Nagar Haveli)	28.15 %	Bhil, Meena, Garasia, Dhodia, Dhanka, Bubla, Koli Mahadev, Varli, Kathodia, Konkna, Dubia, Naikda, Padhar etc.
3	North-East India (All 7 states)	12.5 %	Angami, Sema, Apatani, Monpa, Bhutia, Bodo, Kuki, Mao, Mikir, Adi, Naga, Chakma, Mizo, Khasi, Garo, Bhutia, Lepcha etc.
4	Southern India (T.N, Karnataka, Kerala, Pondichery and Lakshadweep)	4.22%	Malayali, Irular, Konda Reddi, Kadu Kurumba, Naikpod, Paniyan, Kuruchiyan, Koya etc.
5	Sub Himalayan region (H.P., J & K., U.K))	0.75%	Tharu, Jaunsari, Buksa, Bhotia, Bhoksa, Gaddi, Kinnaura, Gujjar, Balti, Bodh, etc.

botanists were already including the use of plants by people within their study. However, it was Harshberger who proposed that discipline of ethnobotany might be developed with its own definition, scope, objectives and methodologies. Although Harshberger's definition still provide the root of the ethnobotany, but to describe the field in broader sense ethnobotanists have given their definitions time to time.

- Jones (1941) defined it as "The study of interrelationship of primitive men and plants".
- Faulks (1958) "The total relationship between men and vegetation".
- Schultes (1962) "The study of relationship which exists between people of primitive society and their plant environment".
- Jain (1986) "The total natural relationship between man and plants".

Ethnobotany must have been the first knowledge, which the early man acquired by sheer necessity, intuition, observation and experimentation. Vast ethnobotanical knowledge exists in India from ancient time in Vedas and Samhitas. Work of Charak, Susruta and Dhanwantari's attracted serious attention of people in India even during the early centuries.

According to *Charaka Samhita* –

औषधीनाम् रूपाभ्याम् जानते ह्यज पावने ।
अविपाश्चैव गोपाश्च ये चान्ये वनवासिनरू ।।

(११८) च. स.

Cattle grazers, shepherds and forest dwellers have the deep knowledge of medicinal plants of the forest and identify them by name, morphology and properties. The Ayurveda students should learn the name, property and morphological characters of medicinal plants from these people with deep interaction.

Table-2. State/UT Tribal Population (Census of India 2011)

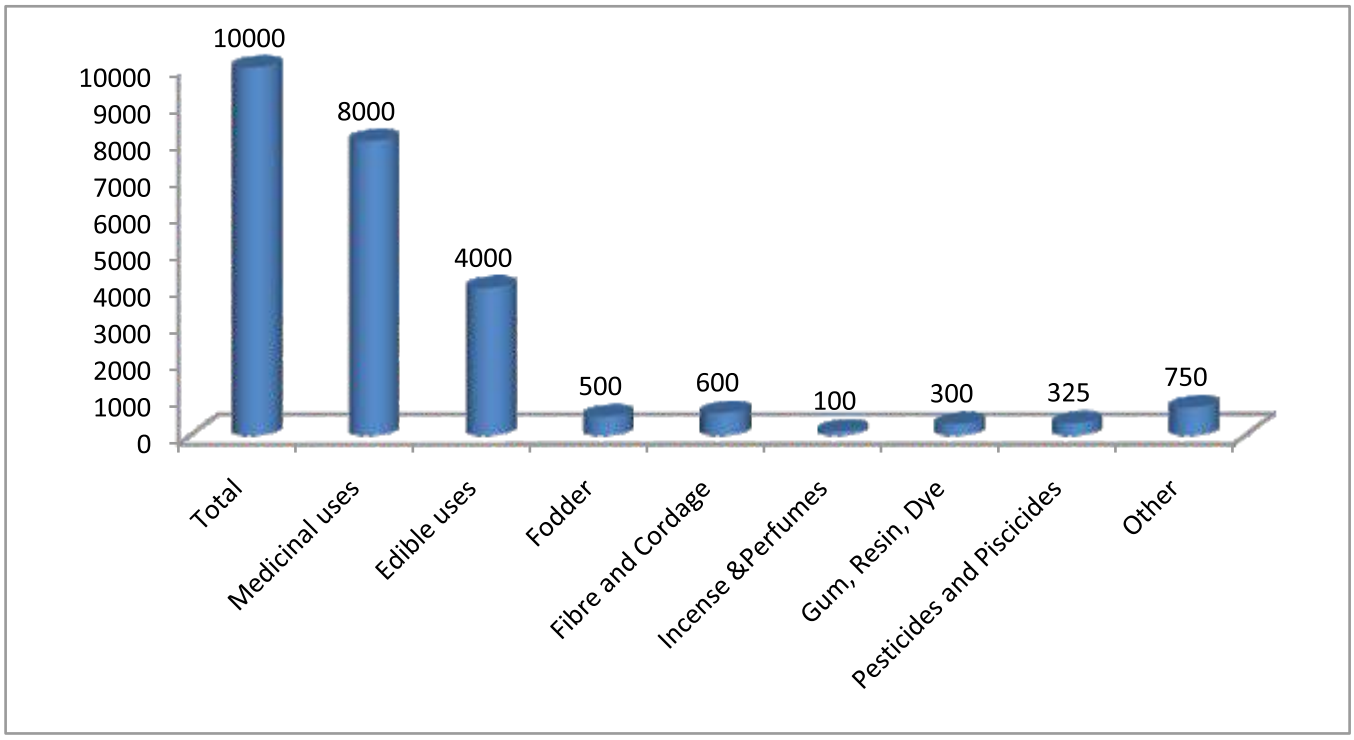
S.No.	Name of State/UT	Total population	Tribal population	% of Tribal Population	State Rank
1	Andaman & Nicobar Islands (UT)	379944	28530	7.5	20
2	Andhra Pradesh	84580777	5918073	7.0	21
3	Arunachal Pradesh	1383727	951821	68.8	5
4	Assam	31205576	3884371	12.4	16
5	Bihar	103804637	1336573	1.3	28
6	Chandigarh (UT)	1054686	0	0.0	0
7	Chhattisgarh	25545198	7822902	30.6	10
8	Dadra & Nagar Haveli (UT)	343709	178564	52.0	6
9	Daman, Diu (UT)	242911	15363	6.3	23
10	Delhi (NCT)	16753235	0	0.0	0
11	Goa	1457723	149275	10.2	18
12	Gujarat	60439692	8917174	14.8	14
13	Haryana	25353081	0	0.0	0
14	Himachal Pradesh	6864602	392126	5.7	25
15	Jammu & Kashmir	12541302	1493299	11.9	17
16	Jharkhand	32988134	8645042	26.2	11
17	Karnataka	61130704	4248987	7.0	22
18	Kerala	33387677	484839	1.5	27
19	Lakshadweep (UT)	64473	61120	94.8	1
20	Madhya Pradesh	72626809	15316784	21.1	13
21	Maharashtra	112374333	10510213	9.4	19
22	Manipur	2570390	902740	35.1	7
23	Meghalaya	2966889	2555861	86.1	4
24	Mizoram	1097206	1036115	94.4	2
25	Nagaland	1978502	1710973	86.5	3
26	Odisha	41974218	9590756	22.8	12
27	Puducherry (UT)	1244464	0	0.0	0
28	Punjab	27704236	0	0.0	0
29	Rajasthan	68548437	9238534	13.5	15
30	Sikkim	610577	206360	33.8	8
31	Tamil Nadu	72138958	794697	1.1	29
32	Tripura	3673917	1166813	31.8	9
33	Uttar Pradesh	199581477	1134273	0.6	30
34	Uttarakhand	10116752	291903	2.9	26
35	West Bengal	91347736	5296953	5.8	24

India is rich in tribal communities since ancient times, so study on Ethnobotany in India was initiated by Dr. S.K. Jain from tribals of Central India in 6th decade of 20th century which has resulted in the publication of above 1500 research papers, about 100 books and hundreds of Ph. D. thesis to develop a base for data bank on the subject (Sahoo, 2013).

The forests have been the home for many of these tribes and they have deep rooted association with the forests and nature around. Their relationship with the forest has always been harmonious and their whole life revolves around the forest resources. Tribal's depend on forests for their livelihood and food security. The tribal's also depend on forest flora for meeting their food, medicine and other material requirements. They collect many non timber forest products like gum, resin, dyes, honey, cane, reed, bidi leaves, fruits, fuel wood, fodder and material required for agriculture, household and thatching etc. They have acquired unique knowledge about the uses of many wild flora and fauna through generations most of which are either lesser known or hitherto unknown to the outside world. This treasure of traditional knowledge if subjected to scientific scrutiny could benefit them, the country and the human kind in many ways. The inroads of modernization are presently posing a threat to this traditional knowledge and these are in the imminent danger of losing out, this age old wisdom and expertise can be lost for all times to come. It was in this background that the Ministry of Environment and Forests, Govt. of India launched the "All India Coordinated Research Project on Ethnobiology" (AICRPE) from 1982-1998. During the ethnobotanical survey which was carried out by 20 different research centers, universities and colleges among the tribal communities of different states of India between 1982 to 1998. Over 10,000 plant species as used by tribal's for meeting their varied requirements have been recorded. The plants used for different purposes are given below:

Plants used by the tribal's for various purposes

1. **Plants used as medicine:** The medicinal plants used by the tribal communities for the treatment of their own ailments and diseases



Ethnobotanical uses of plants

and their domestic animals. The common plants used by them are *Abrus precatorius, Abutilon indicum, Acacia nilotica, Achyranthus aspera, Aegle marmelos, Alangium salvifolium, Alectra chitrakutensis, Ampelocissus latifolia, Aristolochia indica, Asparagus racemes, Blumea lacera, Boerhavia diffusa, Bacopa monnieri, Bombax ceiba, Caesalpinia bonduc, Cassia tora, Celastrus paniculatus, Centella asiatica, Cocculus hirsutus, Convolvulus prostratus, Cordia macleodii, Desmodium gangeticum, Euphorbia hirta, Grewia hirsuta, Helicteres isora, Holarrhena pubescens, Justicia adhatoda, Morina oleifera, Mucuna pruriens, Oroxylum indicum, Phyllanthus amarus, Plumbago zeylanica, Pueraria tuberose, Terminalia arjuna, T. Bellirica, T. chebula Tinospora cordifolia, Vernonia cinerea, Woodfordia fruticosa* etc.

2. **Plants used as food:** *Aegle marmelos, Amaranthus paniculatus, Basella rubra,Bauhinia vahlli, Buchanania lanzan, Carissa carandas, Cassia tora, Chenopodium album, Chlorophytum tuberosum, Coccinia grandis, Colocasia esculenta, Corchorus olitorius, Cordia dichotoma, Cucumis melo, Curcuma angustifolia, Dendrocalamus strictus, Dillenia pentagyna, Dioscorea alata, D. hispida, Diospyros melanoxylon, Eleusine coracana, Emblica officinalis, Grewia rothii, Lablab purpureus, Madhuca longifolia, Mangifera indica, Momordica charantia, M. Dioica, Moringa oleifera, Mucuna pruriens, Murraya koenigii, Paspalum scrobiculatum, Pithecellobium dulce, Portulaca oleracea, Syzygium cuminii, Tamarindus indica, Tamilnadia uliginosa, Zanthoxylum armetum, Ziziphus nummularia, Z. mauritiana* etc.

3. **Plants used as fibre:** *Abutilon hirtum, A. polyandrum, Bauhinia racemosa, B. vahlii, Butea monosperma, B. parviflora, Careya arborea, Crotalaria juncea, Desmostachya bipinnata, Grewia rothii, Helicteres isora, Hibiscus cnnabinus, H. sabdariffa, Ichnocarpus frutescens, Sesbania bispinosa, Sterculia urens* etc.

4. **Plants used for extracting oil:** *Argemone mexicana, Buchanania lanzan, Celastrus paniculatus, Cymbopogon martini, Guizotia abyssinica, Jatropha curcas, Madhuca longifolia, Pongamia pinnata, Ricinus communis, Schleichea oleosa, Shorea robusta, Terminalia bellirica, Vetiveria zizanioides* etc.

5. **Plants used for gum and resin:** Gum and resin is collected from *Acacia nilotica* ssp *indica, Anogeissus latifolia, Boswellia serrta, Buchanania lanzan, Gerdenia resinifera, Lannea coromandelica, Pterocarpus marsupium, Shorea robusta, Sterculia urens* etc.

6. **Plants used for dye and tannin:** *Acacia catechu* (heart wood), *Acacia nilotica* ssp. *indica* (bark), *Butea monosperma* (flowers), *B. superba* (flowers), *Careya arboreya* (bark) *Emblica officinalis* (leaf), *Pavetta tomentosa* (root), *Shorea robusta* (bark), *Terminalia alata* (bark), *T. arjuna* (bark), *Woodfordia fruticosa* (flowers) and *Ziziphus xylopyrus* (fruits) etc.

7. **Plants used for narcotics, drinks and intoxicants:** *Borassus flabellifer, Caryota urens, Elephantopus scaber, Hibiscus mutablilis, Madhuca longifolia, Neolitsea chinensis, Nicotiana tabacum, Trema orientalis* etc.

8. **Plants used as fish poison:** *Aegle marmelos* (root bark), *Barringtonia acutangula* (Stem bark), *Butea superba* (bark), *Caesalpinia bonduc* (Bark), *Careya arborea* (stem bark), *Casearia tomentosa* (fruit), *Cleistanthus collinus* (bark, leaves, fruits), *Diospyros malabarica* (fruits), *Milletia auriculata* (bark), *Strychnos potatorum* (seed), *Wrightia tinctoria* (leaves) and *Zanthoxylum armetum* etc.

9. **Plants used as food plates:** Leaves of *Butea monosperma, B. superba, Bauhinia vahlii, Macaranga peltata, Nelumbo nucifera, Shorea robusta* etc. are used for making pattal and dauna.

Besides, a large number of plants are used for tribal crafts, agriculture and household implements, thatching and magico-religious beliefs etc.

Drugs developed from plants

WHO estimated that almost 80% of the world population particularly those located in developing and under developed countries continue to depend on traditional medicine which is predominantly based on plant remedies. The importance of pant based medicine which was waned during the past 100 years has once again getting fully waxed and emerging with its full splendour and popularity. This resurgence in plant medicine is mainly due to the increasing evidence/realization of the health hazards associated with the indiscriminate use of modern synthetic medicines. According to WHO, the resurgence of greater public interest in plant based medicine is rapidly increasing because of green wave sweeping over the world. It is now opening an unprecedently as a new powerful market sector for plant based drugs. The scope of ethnobotany in drug research needs no elaboration. Folk medicine followed by critical scientific evaluation has produced new drugs to fight diseases. Some folk medicines are now in main stream and used for medicare programme. Of the 120 active compounds currently isolated from higher plants and used in medicine, 74 percent show a positive correlation between their modern therapeutic use and the traditional use of the plant from which they were derived (Maheshwari, 1996). Some of them plant derived modern medicine given in the table 3.

Table-3. Drugs developed from plant sources

Name of drug	Property	Name of plants
Artemisinine	Antimalarial	*Artemisia annua*
Caffeine	Stimulant	*Camelia sinensis*
Codeine	Analgesic	*Papaver somniferum*
L-Dopa	Antiparkinsonian	*Mucuna pruriens*
Digitoxin	cardiotonic	*Digitalis purpurea*
Ephedrine	Anti-asthmatic	*Ephedra vulgaris*
Gossypol	Male contraceptive	*Gossypium herbasium*
Quinine	Antimalarial	*Cinchona officinalis*
Reserpine	Hypotensive, Tranquilizer	*Rauvolfia serpentina*
Vicristine, vinblastine	Anti-neoplastic	*Catharanthus roseus*
Podophyllotoxin	Condiloma	*Podophyllum peltetum*
Digitoxin	Arterial fibrillation	*Digitalis purpurea*
Ephedrin	Brochodilator	*Ephedra sinica*
Eugenol	Toothache	*Syzygium aromaticum*
Psoralin	Vitiligo	Psoralea corylifolia
Sennoside A,B	Laxative	*Cassia angustifolia*
Papain	Attenuator of mucus	*Carica papaya*
Picrolive	Chronic hepatitis	*Picrorrhiza curroa*
Guggulipid	Hyperlipidaemic	*Commiphora wightii*
Taxol	Ovarian breast cancer	*Taxus baccata*
Jivaniya	Antifatigue	*Trichopus zeylanicus*

Minor Forest produces as source of livelihoods of tribal's

The economy of the tribal people mainly depend upon the collection of minor forest produces which they collect and sale in nearby local markets and earn some money for their livelihoods. The minor forest produces they collect such as fruits of Aonla (*Phyllanthus emblica*), Achar (*Buchanania lanzan*), Hard (*Terminalia chebula*), Baheda (*Terminalia bellirica*), Marorphali (*Helicteres isora*), Mahua Gulli (*Madhuca longifolia*),flowers of Mahua (*Madhuca longifolia*), Dhawai (*Woodfordia fruticosa*), Palash (*Butea monosperma*), Gum of Kullu (*Sterculia urens*), Gurja (*Lannea coromandelica*), Sal (*Shorea robusta*), Babool (*Acacia nilitica* ssp *indica*), Salai (*Boswellia serrata*), Gabdi (*Cochlospermum religiosum*), Dhawa (*Anogeissus latifolia*), Khair (*Acacia catechu*), Leaves of Tendu (*Diospyros melano-*

xylon), Palash (*Butea monosperma*), Purain (*Nelumbo nucifera*), Mahul (*Bauhinia vahlii*), Khajur (*Phoenix sylvestris*), Roots of Satawar (*Asparagus racemosus*), Safed musali (*Chlorophytum tuberosum*), Kali musali (*Curculigo orchioides*), Khas (*Vetiveria zizanioides*), inflorescence of Phoolbahari (*Thysanolaena maxima*), Barks of Arjun (*Terminalia arjuna*), Dalchini (*Cinnamomum verum*), Honey, Lac, Kosa etc.

The following small scale cottage industries/ units can be established in forest rich tribal areas for up liftmenent of their socio-economic status (Jain, 2013) such as:

- Food processing units
- Value addition units should be established in tribal areas such as fruits of Aonla (Phyllanthus emblica), Harra (Terminalia chebula), Baheda (Terminalia bellirica) processing etc.
- Food plats making units based on leaves of Butea monosperma, Bauhinia vahlii, Shorea robusta etc.
- Mats, baskets, brooms making units based on Leaves of Phoenix sylvestris, Dendrocalamous strictus, Vetiveria zizanioides, Desmostachya bipinnata etc.
- Toy making units based woods of Wrightia tinctoria, culms of Dendrocalamous strictus etc.
- Gum, lac, and kosa collection centres should be established in tribal areas
- Medicinal plants collection centres should be established in tribal areas
- Bidi making units (Leaves of Diospyros melanoxylon)
- Oil extracting units based on oil yielding plants
- Kattha making units (Heart wood of Acacia catechu)
- Liquor distillation units (Flowers of Madhuca longifolia)
- Cane furniture making units

Some recommendations for boost up of tribal's livelihoods

1. Landless tribals should be rehabilitated through a programme of settlements. Waste lands including the degraded forest lands should be allotted to such tribal families for raising social forestry plantations.
2. Multipurpose species of plants to meet the food, fodder, fuel wood, medicine and other traditional requirements of the local tribal's should be included in the social forestry operations in tribal areas.
3. Nursery raising activities by individual tribal families should be promoted as a source of income generation. The existing government extension facilities and that of the voluntary agencies should be utilized in promoting such activities.
4. Considering the great relevance of the minor forest produces in the economic development of forest dwellers, it is suggested that the tribal's may be trained to tap these forest resources in the scientific way to avoid their destruction. Value addition to such products shall be beneficial to the tribal's.
5. Contractor agencies at all levels of forestry operations especially in extracting minor forest produces should be eliminated so that it generates gainful employment to the local tribal's. Co-operative societies under the direct supervision of Tribal Welfare Departments or such organizations should monitor these activities.
6. When a drug is developed based on tribal knowledge suitable benefit sharing should be given to the particular tribal for their own use while transferring the production technology to any agency.

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Mainstreaming Biodiversity into Poverty Reduction Strategies

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Introduction

The challenges related to conservation of the our planet's rich biodiversity are plenty and daunting and pose a severe threat to overpower our collective efforts to minimize the loss of flora and fauna, degradation of our ecosystems and devastation of natural resources. The vital units or entities of biodiversity conservation have been protected areas (PAs), but they are becoming increasingly vulnerable due to developmental pressures connected to demand of land, water and related resources. In response to these emerging trends, environmental conservationists and international institutional, multilateral organizations have developed and promoted a new biodiversity conservation paradigm known as Biodiversity Mainstreaming.

In essence this process is related to implanting biodiversity concerns, considerations into statutory legislation, public policies, schemes, strategies, programmes and practices of key public and private actors for promoting conservation and sustainable development. Being a newly emerging paradigm, biodiversity mainstreaming is a conservation approach that has yet to make a significant impact on aligning biodiversity preservation with developmental planning and practices.

Mainstreaming Biodiversity

Biodiversity is defined by the CBD as "The variability among living organisms from all sources including, inter alia, 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" (CBD, 2014b).

The concept of mainstreaming was included in the Convention on Biological Diversity (CBD) article 6(b) which called on the contracting parties to "integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross sectoral plans, programs and policies" (CBD 2003, p. 6).

Mainstreaming also contributes toward fulfilling article 10(a), which calls on parties to "integrate consideration of the conservation and sustainable use of biological resources into national decision making" (CBD 2003, p. 11) (Petersen and Huntley 2005).

The Convention on Biological Diversity (CBD) acknowledges that "economic and social development and poverty eradication are the first and overriding priorities of developing countries". Its 2010 target to achieve "a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and the benefit of all life on Earth" was endorsed by the World Summit on Sustainable Development and, since 2006, also forms one of the targets within Millennium Development Goal 7, to ensure environmental sustainability.

The GEF-6 Programming Directions (2014b) states that "Biodiversity mainstreaming is the process of embedding biodiversity considerations into policies, strategies, and practices of key public and private actors that impact or rely on biodiversity".

Mainstreaming enables biodiversity to persist across entire landscapes and seascapes. The societal failure to adequately price the economic value of biodiversity has undermined the long-term sustainability of mainstreaming efforts, which have

Image 1 : Coexistence of Birds in Gomi Kheda

Image 2 : River Loni in Gomi Kheda, Lucknow
Source: Srivastava, Anurag. Priyadarshinini, Deepti.2016

often focused too narrowly on threat mitigation and palliative attempts to offset biodiversity loss.

As highlighted in Mainstreaming Biodiversity in Practice, Scientific and Technical Advisory Panel (STAP) Advisory Document, Mainstreaming biodiversity was developed as a means of addressing the fact that biodiversity conservation goals are viewed as distinct from, and sometimes even contradictory to the goals of development and economic growth. The higher priority put on development means that biodiversity work does not receive the political, social and financial support it needs to succeed (UNDP and UNEP, 2008).

Though mainstreaming has been referred to as "integrating" biodiversity into development, it has the added meaning of modifying that into which it is integrated (e.g. changing the focus of development policies and interventions toward incorporating the values of biodiversity). Economies and societies are dependent on biodiversity for clean water, soils, biomass, food, and other ecosystem goods and services. Conservation of natural ecosystems should be seen as a core part of development, as it provides valuable and cost-effective support to the development process, especially with respect to the poor (*Kosmus et al.*, 2012).

Mainstreaming biodiversity then has as its objective in the integration of biodiversity conservation and related sustainable use principles into policies, plans, programs and production systems where the primary focus has previously been on production, economic activity and development, rather than on biodiversity conservation (Petersen and Huntley, 2005). Biodiversity and poverty reduction are interdependent and achieving both sustainably requires integration in both the directions a process known as 'Reciprocal Mainstreaming'.

Mainstreaming promises the need to link biodiversity and development strategies is increasingly recognized within the global policy frameworks that guide action towards their major goals. For example the linking of biodiversity with poverty reduction appears to be distantly related concepts involving different sets of policies, institutions, factors and actors. However the deeper analysis and growing debate on climate change reveals that this linkage is real, comprehensive and substantive. These two concepts are intrinsically linked. Poor people often depend on biodiversity both for their livelihoods and as a safety net against deeper poverty. Biodiversity also deals with the provisioning of ecosystem services such as food, water, herbs, regulating climate and preventing disease outbreaks. Major Target areas for mainstreaming biodiversity are:

- Transportation
- Energy
- Agriculture and allied areas including forestry
- Private Sector-Corporate practices
- Developmental policies and planning at local,

Image 3 : Coexistence of Animals in Gomi Kheda

Image 4 : Agri- fields and tree diversity in Gomi Kheda (Mahesh Kheda village) Lucknow

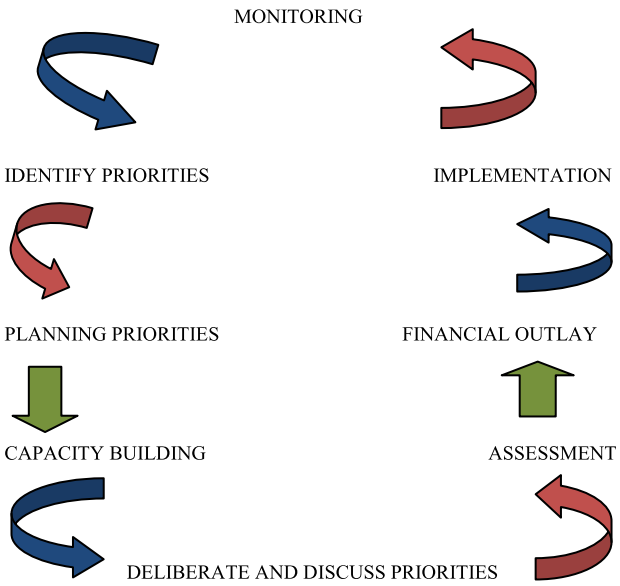
Source: Srivastava, Anurag. Priyadarshinini, Deepti.2016.

national and international levels

- Consumption patterns
- Economic, trade and taxation policies

Mainstreaming Biodiversity Framework

The mainstreaming biodiversity framework deals with identification of priorities which includes biodiversity–poverty mapping, critical input areas, spatial distribution patterns, demographic and climatic peculiarities etc. The planning priorities cover forecasting, visioning, scenario development, perspective analysis, resource mapping, and tabulation etc. The capacity development is related to development of institutional and individual capacity building. It is concerned with creating sensitization, awareness and understanding. Thereafter the deliberation and discussion on identified priorities is initiated to facilitate the listing of filtered priorities. The assessment deals with consolidating the inputs, priorities, streamlining the road map, considering temporal dimensions and financial intake. The financial outlay is structured to achieve the implementation objectives of mainstreaming. The monitoring and evaluation is constantly performed for achieving the intended outcomes.



Source: Srivastava, Anurag. Priyadarshinini, Deepti.

Fig.1. Mainstreaming Biodiversity Framework

Dependence of the Poor on Biodiversity

Briefly the need for linking Biodiversity Conservation and Poverty Alleviation is based upon two basic premises:

- The poor are dependent on biodiversity for their day-to-day livelihoods;
- The biodiversity conservation can promote poverty reduction.

The biodiversity provides the poor a form of cost effective and readily accessible insurance

against risk, particularly food security risks, risks from environmental hazards, and health risks. As per the evidences the poor have few alternative sources for protecting themselves, they have a higher dependency on biodiversity for dealing with risk. The poor tend to depend disproportionately on relatively low value or inferior' goods and services from biodiversity, similarly, risk dependence of the poor on biodiversity takes the form of a last resort, due to absence of viable alternatives. This dependence of the poor on low value activities (and on biodiversity as a last resort against various forms of risk) may lead towards the 'debt and poverty trap'. To further substantiate the argument the Technical Series No.55 publication of Secretariat of the Convention on Biological dealing with dependence of various regions of the globe on biodiversity resources is worth mentioning.

The Table shows that the depth of dependence reported in these studies is high, although there is some variation when this is broken down by wealth class, with the poor typically showing higher levels of dependence.

Poverty Reduction

Similarly, "poverty reduction" implies lifting people beyond a defined poverty line—transforming them from poor to non poor. But often poverty is alleviated (i.e. some of the symptoms or poverty are addressed but people are not actually transformed from "poor" to "non-poor") or it is prevented (i.e. people are prevented from falling into or further into poverty) rather than actually being reduced. The beneficiaries of conservation activities are often not "the poor" (i.e. those identified as living below a defined threshold of income or well-being) but simply rural communities or those who live local to conservation areas or who are primary users of living natural resources (who may or may not be poor) (Roe *et al.* 2010).

The World Bank, describes poverty as 'a pronounced deprivation in well being. To be poor is to be hungry, to lack shelter and clothing, to be sick and not cared for, to be illiterate and not schooled. But for poor people, living in poverty is more than this. Poor people are particularly vulnerable to

Source	Region	Evidence	Resource type
Coomes *et al.* 2004	Latin America	66% of households depend on resource extraction	Fish, palm products, timber, hunting
Dovie *et al.* 2007	Southern Africa	98% of households use NTFPs	NTFPs
Dovie *et al.* 2007	Southern Africa	91% of households use wild herbs	Wild herbs
Glaser 2003	Latin America	68% of households depend on mangroves	Mangrove resources, especially crabs and fish
Jha 2009	South Asia	70% of households depend on beedi making or firewood	Forests
Jodha 1990	South Asia	84-100% of poor depend on CPRs	Common pool resources
Jodha 1990	South Asia	10-19% of rich depend on CPRs	Common pool resources
Levang et al. 2005	South-east Asia	72% of households depend on forest products	Forests
Mamo *et al.* 2007	East Africa	42% of households depend on forest for grazing	Forests
Narain *et al.* 2008a	South Asia	Quartile1: 77.5%, Quartile 2: 81.5%; Quartile 3: 72.8%; Quartile 4: 61.4% of households collect NTFPs	Fuelwood, dung for fuel, manure, fodder, construction wood
Shackleton and Shackleton 2006	Southern Africa	96-100% of households purchase NTFPs	NTFPs
Shackleton and Shackleton 2006	Southern Africa	8% (rich), 15% (middle), 36% (poor) households sell NTFPs	NTFPs
Sharma *et al.* 2009	South Asia	75% of household fuel and fodder needs from forests	Forests

Table 1 : Evidence on depth of dependence on biodiversity resources

Image 5 : Biodiversity and Livelihood linkage: A Software Engineer practicing Agro-Biodiversity and providing livelihood opportunity to the poor villagers in Gomi Kheda(Mahesh Kheda village), Lucknow.

Source: Srivastava, Anurag. Priyadarshinini, Deepti.2016.

adverse events outside their control. They are often treated badly by the institutions of state and society and excluded from voice and power in these institutions' (World Bank 2001, p15).

One of the most important strategies to mitigate poverty is to create employment opportunities for the poor specially the rural poor in rural areas by pushing and promoting sustainable practices in the agriculture. As depicted in the image number 5, the Agro-biodiversity has brought a new wave of opportunity, even the highly educated professional are pursuing farming to create employment opportunities for poor people and reducing poverty and higher economic returns.

Conclusion

Mainstreaming is a social experiment involved in changing the value proposition of organization and people. It has vital consequences for the world and the entire humanity. Enhancing the quality of governance and creating accountable institutions are key determinants of success or failure of mainstreaming. The countries with strong support for Good governance would have higher possibility of achieving mainstreaming objectives and to enhanced capacity to tackle the most pressing mainstreaming challenges.

Good governance and strong institutions are recognized as perhaps the key determinants of project success or failure. A balance needs to be struck between working in countries and sectors where there is sufficiently strong governance capacity for mainstreaming outcomes to have a good chance of success, and tackling the most pressing mainstreaming challenges in situations where globally valuable biodiversity is threatened but capacity is often lacking.

Mainstreaming approaches should be inclined towards to country specific and regional contexts for achieving clearly defined objectives and desired outcomes. These objectives and outcomes should operate in global broad based framework for targeting global environmental concerns and benefits, along with serving the national priorities. Mainstreaming in all its forms and settings will only work if people change their behaviors (Schultz, 2011). Yet recent work shows conclusively that increasing knowledge by itself does not lead to a change in behavior (McKenzie- Mohr *et al.*, 2012). Effective work could be done to assess the most effective ways to promote behavioral change toward biodiversity using methods such as social marketing and community empowerment (Wilhelm-Rechmann and Cowling, 2011, Bolderdijk *et al.*, 2013, Clayton *et al.*, 2013, Wilhelm-Rechmann et al., 2013).

One of the vital aspects of mainstreaming is to identify national, regional or local environment concerns on the development agenda and thereafter mainstreaming the public policies and planning process with the overall developmental initiative. There could be situations when more often than not the conflict emerges between biodiversity conservation and poverty reduction however balancing is required through prioritizing. The role of political and administrative leadership is of immense significance in mobilizing the popular support and promoting people's participation for biodiversity conservation and development.

The political will at national and international forums is required to push for providing a facilitative framework. Integrating biodiversity and development approaches by focusing on economic factors that have significant impact on food, energy, tourism, water and energy. There is a need to promote deliberation and discussion involving various platforms for raising the voices and also

making them to be heard in policy mainstreaming. It is equally important to give space to the community and learn from their perspectives on common problems. Strengthening legislative and policy frameworks at national and sub-national levels; promoting biodiversity-friendly policies and facilitating their implementation, through by biodiversity-driven physical, economical, social and spatial planning will promote biodiversity mainstreaming.

It is hoped that this paper will facilitate the improved understanding of the concept of biodiversity mainstreaming in to Poverty Reduction Strategies and highlight the implementation challenges and opportunities, and will thereby strengthening the richness of biodiversity and ensuring sustainable development.

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Sustainable Utilization of Biodiversity: Role of Pteridophytes in Livelihoods of Tharu Tribes of Uttar Pradesh

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Introduction

Biodiversity is perceived as variability among living organism of a particular area at certain time. It includes plants, animals, including microbial diversity. All the individuals in plants, animals and microbes kingdom impart significant role in ecosystem by production and transfer of energy to different tropic level. Such role of the plants, animals and microbes signify their potential importance. Human depend on plant kingdom including pteridophytes for fulfilling of their needs from immemorial period. Pteridophytes (commonly called as vascular cryptogams) evolved in Silurian period and dominated the earth in Carboniferous period of Mesozoic era. Therefore, Carboniferous period is also known as "ages of pteridophytes". In evolution point of view, the pteridophytes get place between bryophytes and gymnosperms for the reason of phylogenetic relationship. In morphology, pteridophytes are comprised of rhizome, scale, frond, sorus, spore, and reproduce through spore. Their life cycle is comprised of gametophyte and sporophyte. Both the gametophytes and sporophytes are potential to synthesise food materials, thus are equally important for utilization. Broadly, the pteridophytes are divided into fern-allies and ferns. The fern-allies (*Lycopodium, Huperzia, Selaginella* and *Equisetum*) are distinct in having rhizomatous roots, reduced scaly leaves and microspore as well as megaspore, thus called as heterosporous ferns. The ferns (*Polypodium, Dryopteris, Asplenium, Nephrolepis, Pteris* and *Cyathea*) exhibit rhizome, scale, frond, similar spores, therefore called as homosporous ferns. Different tribal communities utilize pteridophytes for various purposes. However, the sustainable utility of these plants are done by the tribes and men residing in the proximity of forests. They use the pteridophytes for food, fodder, medicines and house-hold articles. They meet out their needs either from entire plants or parts (roots, rhizome, stripe or fronds) of plant. The valuable knowledge about pteridophytes uses in traditional practice remains with the tribes, local communities, herbalist or society living in terrai areas. These traditional knowledge needs to be documented and disseminated. Many pteridophytes like *Selaginella bryopteris* (Sanjeevani), *Dryopteris cochleata* (Jatashankar) and *Helminthostachys zeylanica* (Kamraj) are sold in local markets of Terrai region. *Helminthostachys zeylanica* is potential plant and prescribed in treatment of sexual disorders. Previously, scattered contributions (Sah *et al.* 2005, Benjamin & Manickam 2007, Khare & Kumar 2007, Rao *et al.* 2007, Srivastava 2007, Mannan *et al.* 2008, Poonam & Singh 2009, Shil & Choudhury 2009, Rout *et al.* 2009, Singh *et al.* 2010, Sen & Ghosh 2011, Singh & Khare 2011) on potential uses of pteridophytes by different tribes in India was made. These contributions provided information about useful aspects and potentiality of pteridophytes to cure many diseases.

Tharu tribes hold a huge traditional knowledge about sustainable utilization of pteridophytes for their livelihood. Tharu community is spread all along the Indo-Nepal border of Uttar Pradesh, more particularly in Terrai regions of Pilibhit, Lakhimpur Kheri and Bahraich districts. Plant resources of Dudhwa National Park, Kishanpur Wildlife Sanctuary and Katarniaghat Wildlife Sanctuary in Lakhimpur Kheri and

Fig. 1. (a–b) Residence of Tharus; (c–d) Tharus going for fishing and agriculture; (e–f) Collecting information from Tharu tribe.

Baharaich districts provide needful materials including food, fodder, medicines and other house-hold articles to Tharus.

The forests of terrai regions are comprised of mixed deciduous forests and savanna grassland with an altitudinal range of 500-600 ft. Terrai regions in Uttar Pradesh is connected with Bardia National Park of Nepal in north. It is spread up to Katarniaghat Wildlife Sanctuary in east, Upper Gangetic Plain in south, Kishanpur Wildlife Sanctuary and forests of Pilibhit district in the west. Geographical expanse of terrai regions begins from the foothills of Himalayas. Terrai regions are unique for varied environment, climatic conditions, natural resources, distinctive cultural practices and livelihood of Tharu tribes. The useful aspects of flowering plants by the Tharu tribes were investigated time to time (Acharya & Acharya 2009, Bhattarai *et al.* 2009, Joseph *et al.* 2003, Kumar *et al.* 2006, Kumar *et al.* 2012, Kumar *et al.* 2013, Kumar & Bharti 2014, Singh *et al.* 2011, Verma 2011). Nevertheless, no any attempt was made to document the useful aspects and sustainable utilization of pteridophytes by the Tharu tribes of terrai regions. Present study provides significant information about pteridophytes used by Tharu tribes in their daily life. Study also document detailed information of each pteridophytes to explore indigenous knowledge on food, fodder, medicines, house-hold articles, sustainable utilization and role in livelihood of Tharu tribes.

Materials and Methods

Survey and collection of pteridophytes from terrai regions in Dudhwa National Park, Kishanpur Wildlife Sanctuary, Katarniaghat Wildlife Sanctuary of Lakhimpur Kheri and Bahraich districts in Uttar Pradesh were made. Samples of each species were collected to prepare herbarium. Information about common name, uses of plants and their parts by Tharu tribes for various purposes were gathered. Interviews with the Tharus, herbalists, forest guards, watchers, medicine men, witch-men (ojha) and common men were conducted to retrieve information about sustainable utilization of pteridophytes. Knowledge about process of preparation of decoction and application for useful purposes was also gathered. In total 14 species were found to be potentially utilized by the Tharu tribes for different purposes. Information about common name, ailments, medicinal uses, methods of preparation of pastes and dosage of cure were also recorded. A detailed account on sustainable utilization and useful aspects of pteridophytes in the livelihood of Tharu tribes are provided below.

Results

Survey on sustainable utilization of Pteridophytes in livelihoods of Tharu tribes residing near Indo-Nepal border and various localities of Lakhimpur Kheri and Bahraich districts of Uttar Pradesh was made. The information gathered from the Tharu tribes (Fig. 1 a-f; Fig. 2 a-f) has revealed that they utilize 14 species for a variety of purposes. A detailed account on 14 species of pteridophytes utilized by the Tharu tribes for various purposes are enumerated with their botanical name, family, common name, mode of use, part of the plant used, photo-plates (Fig. 3 e-f; Fig. 4 a-d) and locality of occurrence.

1. ***Adiantum capillus-veneris*** L. Sp. Pl. 1096. 1753 (Fig. 3 a).

   Family: Adiantaceae; Common name: Hansraj.

   Sustainable utilization: Stipe and rachis is used for piercing the ears. It is also used as ear studs by girls and women. Entire plant is used in witchery and jadu-tona. It is used in cough syrup (Singh & Khare 2011). Leaves with honey are used for treatment of catarrh, throat and bronchial disorders. Decoction of the leaves mixed with tea is given for curing irregularity in menstrual period. Extract of fronds with honey is applied in eye ailments, respiratory problem and menstrual disorders (Sen & Ghosh 2011, Singh & Khare 2011).

   Distribution in study area: Uttar Pradesh: Bahraich: Katarniaghat Wildlife Sanctuary: Mihipurwa.

2. ***Adiantum philippense*** L. Sp. Pl. 2: 1094. 1753. (Fig. 3 b).

   Family: Adiantaceae; Common name: Hanswati, Kaante Jhar, Kali Sundhiya.

Fig. 2. (a–d) Collecting information from Tharu tribe; (e–f) Tharu tribes exploiting woods.

Sustainable utilization: Stipe and rachis are used as ear ornament (studs). Paste of the plant mixed with mustard oil is used as ointment for cure of the boils. A fresh leaf is used for cure of fits (Khare & Kumar 2007). Rhizome used for anti-fertility, fronds used as a decoction for the pulmonary infections. Rhizome is used for treating dysentery and glandular swelling (Sen & Ghosh 2011). Leaf paste is used in treatment of leprosy and hair fall. It is used to remove obsession. Rhizome is administered to women for sterility. Whole plant crushed and applied around navel region in flatulence. Fresh leaf (2 gm) paste is taken orally on empty stomach twice a day for ten days for relief from indigestion (Rout *et al.* 2009, Singh & Khare 2011).

Distribution in study area: Uttar Pradesh: Lakhimpur Kheri: Dudhwa National Park: Gauriphanta road, Chandan Chauki, Dudhwa, Sonaripur, Kila, Kakraha, Belrayan, Belapersua, Salukapur, Bankati; Kishanpur Wildlife Sanctuary: Jhaadi Taal; Bahraich: Katarniaghat Wildlife Sanctuary: Nishangarha: Chaphria Chowk, Tigda Beet, Rampurwa; Murthia; Kakraha; Motipur.

3. ***Ampelopteris prolifera*** (Retz.) Copel., Gen. Fil. 144. 1947. (Fig. 3 c).

Family: Thelypteridaceae; Common name: Kochiya, Macchi-neure.

Sustainable utilization: Entire plant but usually new frond is used as delicious vegetable. Juice of rhizome diluted with water is prescribed to cure sexual disorders in male. Diluted juice of rhizome is taken as aphrodite to tensile male sex organ.

Distribution in study area: Uttar Pradesh: Lakhimpur Kheri: Dudhwa National Park: Gauriphanta, Bankati, Sathiyana, Belaghat, Nishatnagar, Salukapur, Lodaria, Belrayan, Kila, Sonaripur, Chandan Chauki.

4. ***Ceratopteris thalictroides*** (L.) Brongn., Bull. Soc. Philom. Paris 1821, 186. 1822. (Fig. 3 d).

Family: Parkeriaceae; Common name: Sewali Jhar.

Sustainable utilization: Paste of entire plant is boiled in mustard oil and used as ointment for treatment of burn, fresh wounds and to stop bleeding. Cooked leaves are eaten as food (Sen & Ghosh 2011). Fronds are used as poultice in skin diseases (Rout *et al.* 2009), however leaf powder along with turmeric is applied to unhealed wounds (Rao *et al.* 2007, Singh & Khare 2011).

Distribution in study area: Uttar Pradesh: Lakhimpur Kheri: Dudhwa National Park: Digria, Bankati, Belrayan, Kakraha Taal, Belapersua, Salukapur, Dudhwa, Gauriphanta; Bahraich: Katarniaghat Wildlife Sanctuary: Semar Chowk Nishangarha.

5. ***Christella dentata*** (Forssk.) Brownsey & Jermy in Brit. Fern Gaz. 10: 338. 1973. (Fig. 3 e).

Family: Thelypteridaceae; Common name: Makargorwa.

Sustainable utilization: New and juvenile frond is used as vegetable. Paste of the rhizomes and leaves are used for boils treatment. Rhizome and sporophyll used as antibacterial agent (Parihar & Parihar 2006, Singh & Khare 2011).

Distribution in study area: Uttar Pradesh: Lakhimpur Kheri: Dudhwa National Park: Bankati, Jauraha Nala Setu near Chandan Chauki, Gajraula Chauki near Sathiyana, Sonaripur, Belrayan, Gauriphanta, Belaparsua, Dudhwa.

6. ***Christella parasitica*** (L.) Lev., Fl. Kouytescheon 475. 1915. (Fig. 3 f).

Family: Thelypteridaceae; Common name: Macchi-neure, Limra.

Sustainable utilization: Juvenile fronds used as vegetable, however entire plant is used as fodder. Paste of rhizome is used to get rid of evil spirits (Rao *et al.* 2007). Fresh rhizome (5 gm) along with fresh root (1 gm) of *Asparagus racemosus* and sugar (5 gm) boiled in water (250 ml). The decoction orally administered for 10 days to cure spermatorrhoea, gout and rheumatism (Sen & Ghosh 2011).

Fig. 3. (a) Adiantum capillus-veneris; (b) Adiantum philippense; (c) Ampelopteris prolifera; (d) Ceratopteris thalictroides; (e) Christella dentata; (f) Christella parasitica; (g) Diplazium esculentum; (h) Equisetum ramosissimum subsp. debile.

Distribution in the study area: Uttar Pradesh: Lakhimpur Kheri: Dudhwa, Bankati, Belapersua, Gauriphanta (15 km from Dudhwa), Sathiyana, Kila, Lodaria compartment Belrayan, Salukapur, Belaghat near Kema Chauki, Dudhwa; Kishanpur Wildlife Sanctuary: Jhaadi Taal; Bahraich: Katarniaghat Wildlife Sanctuary: Girijapuri, Bicchia Beet, Semar Chowk Nishangarha, Sadar Beet, Murthia in Dharampur range.

7. ***Diplazium esculentum*** (Retz.) Sw. in Schrad. Journ. Bot. 180(1): 312 (1803). (Fig. 3 g).

   Family: Athyriaceae; Common name: Kochiya, Lukda, Dheki, Pani-neure.

   Sustainable utilization: New fronds are used as vegetable. Entire plant is used as fodder for cow and goat. Crozier or tender leaf is used as salad and pickles (Sen & Ghosh 2011). Young and fresh frond is boiled with salt and taken for maintain all-round health (Shil & Choudhury 2009). Rhizome is used as insect inhibiter in seed storage. Decoction of rhizome along with 2 ml of honey is taken in empty stomach to cure spermatorrhoea (*Rout et al.* 2009, Singh & Khare 2011).

   Distribution in the study area: Uttar Pradesh: Lakhimpur Kheri: Dudhwa, On the way to Gauriphanta, On the way to Chandan Chauki, on the way to Sathiyana, Bankati, Sonaripur, Kila, Lodaria compartment Belrayan range, Belapersua, Salukapur; Kishanpur Wildlife Sanctuary: Taar Kothi, Jhaadi Taal; Bahraich: Katarniaghat Wildlife Sanctuary: Sadar Beet, Morahwa Badkhadia Beet, Bicchia, Semar Chowk Nishangarha range, Chapharia Chowk Nishangarha range.

8. ***Equisetum ramosissimum*** Desf. subsp. debile Hauke. Amer. Fern Journal. 52: 33. 1962. (Fig. 3 h).

   Family: Equisetaceae; Common name: Jod-Tod, Ankhchimka.

   Sustainable utilization: Macerated plant mixed with red-mud is applied topically for treatment and joining of fractured bone (Singh & Khare 2011). Plant paste prepared in water is applied twice a day in bone fracture. Used for polishing wood and brass. Shoot and rhizomes is used in gonorrhoea (*Rout et al.* 2009). Plant paste is topically applied to cure scabies, itches and skin infections. Powdered stem dissolved in water is used for enema in children (*Rout et al.* 2009, Singh & Khare 2011).

   Distribution in the study area: Uttar Pradesh: Lakhimpur Kheri: Kishanpur Wildlife Sanctuary: Jhaadi Taal; Bahraich: Katarniaghat Wildlife Sanctuary: Sadar Beet, Bichhia Beet.

9. ***Helminthostachys zeylanica*** (L.) Hook. Gen. Fl. t. 47. 1840. (Fig. 4 a).

   Family: Ophioglossaceae; Common name: Kamraj, Majurkutti, Majurpair, Bankand, Jhotphokri.

   Sustainable utilization: Strobilus of the plant is used as vegetable. Extract of rhizome and entire plant is used as aphrodite. Rhizome mixed with other plants is used as tonic for the cure of waist pain. Plant and its part is a potential herbal formulation in sexual disorders. It has anodyne properties and prescribed as tonic (Poonam & Singh 2009, Singh & Khare 2011). Rhizome is used as memory enhancer, to promote strength and vitality and cure impotency or erectile dysfunction (Singh & Khare 2011, Kumar & Bharti 2014).

   Distribution in the study area: Uttar Pradesh: Lakhimpur Kheri: Gauriphanta, Bankati, Sonaripur, Lodaria compartment Belrayan range, Belaparsua, Chandan Chauki; Kishanpur Wildlife Sanctuary, Kataiya Chauki, Taar Kothi; Bahraich: Katarniaghat Wildlife Sanctuary: Bicchia, Semar Chowk Nishangarha range, Kakraha range, Murthia Dharampur range.

10. ***Lygodium flexuosum*** (L.) Sw., in Schrad. J. Bot. 1800 (2): 106. 1801. (Fig. 4 b).

    Family: Lygodiaceae; Common name: Dhengrajua, Neem-Jhar, Bisma.

    Sustainable utilization: Juvenile part of plants is used as vegetable. Rhizome extract is boiled with mustard oil to make thick paste, which is

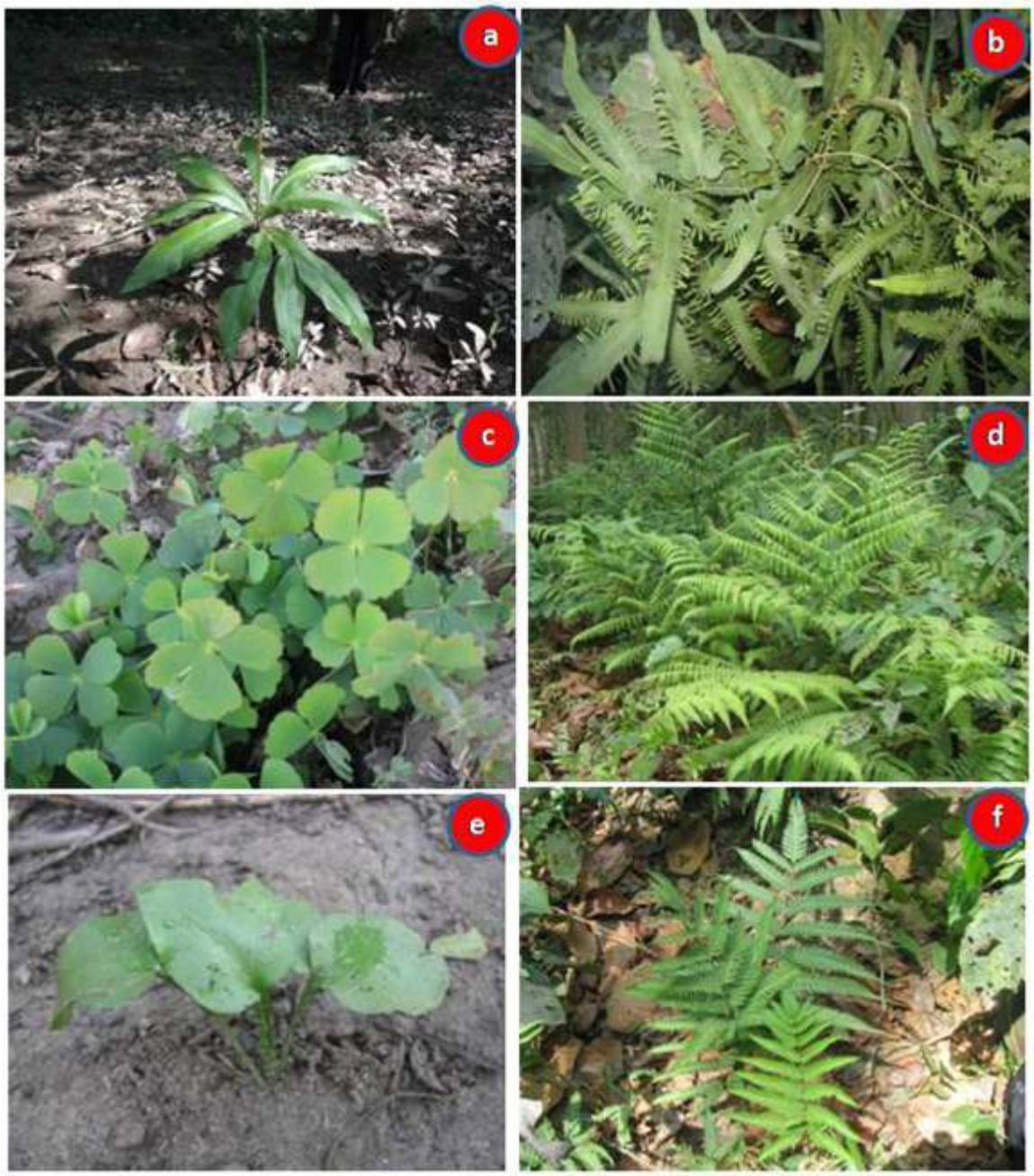

Fig. 4. (a) Helminthostachys zeylanica; (b) Lygodium flexuosum; (c) Marsilea minuta; (d) Microlepia speluncae; (e) Ophioglosum reticulatum; (f) Pteris biaurita.

topically applied for the treatment of arthritis and sore discharging water. Decoction of leaf cures jaundice (Sen & Ghosh 2011). Fresh rhizome boiled with mustard oil is used in rheumatism, sprains, scabies, ulcers, eczema, cut wound, however aqueous extract is used to cure spermatorrhoea. Leaf paste is used in skin diseases, however rhizome powder mixed with cow urine is potential formulation of skin diseases. Rhizome and black pepper paste given twice a day for dysmorrhoea. Rachis tied over forehead reduces headache, while on arm secure from evil spirit (Shil & Choudhury 2009). Leaf powder mixed in milk is prescribed to enhance memory (Rao et al. 2007). One

teaspoonful plants juice given twice a day to relief fever (Rout et al. 2009, Singh & Khare 2011). Rhizomes extract (100 ml) twice daily for 2 weeks given orally for premature ejaculation (Kumar & Bharti 2014).

Distribution in the study area: Uttar Pradesh: Lakhimpur Kheri: On the way to Gauriphanta, Chandan Chauki, Choti Paliya Sonaripur, Dudhwa, Bankati, Sonaripur, Lodaria compartment Belrayan range, Belapersua, Salukapur, On the way to Sathiyana; Kishanpur Wildlife Sanctuary: Jhaadi Taal, Kataiya Chauki; Bahraich: Katarniaghat Wildlife Sanctuary: Nishangarha, Kakraha range, Girijapuri, Karikot, Rampurwa, Tigda beet, Murthia (Dharmpur range).

11. ***Marsilea minuta*** L. Mant. 308, 1771. (Fig. 4 c).

Family: Marsileaceae; Common name: Chilchilejhar.

Sustainable utilization: Leaves mixed with mint are macerated to prepare extract, which is used for pacification of heat stroke. Plant juice is used in treatment of eye disease. Stalk and leaves are used as vegetable, consumed as tonic after fever and in insomnia and mental problems (Sen & Ghosh 2011, Singh & Khare 2011). Cakes of sporocarp called 'nardoo' are eaten. Decoction of leaves mixed with ginger is used in cough and bronchitis. Juvenile leaves juice is applied in the nostrils twice a day for cure of migraine (Rout *et al.* 2009).

Distribution in the study area: Uttar Pradesh: Lakhimpur Kheri: Dudhwa National Park: On the way to Chandan Chauki, Kaima Chauki Sathiyana, Sonaripur, Kakraha Taal Salukapur range, Nighasan Road, Nishatnagar near Sathiyana, Gauriphanta; Bahraich: Katarniaghat Wildlife Sanctuary: Morahwa Badkhadia Beet, Semar Chowk Nishangarha range, Kakraha range.

12. ***Microlepia speluncae*** (L.) Moore, Index Fil. 93 (1857). (Fig. 4 d).

Family: Dennstaedtiaceae; Sustainable utilization: Plant is used as fodder for cow feed. Dried plants are also sprayed in the cattle shed as supplementary fodders and also to protect the animals from extreme cold acting as absorbent of urinal excreta (Singh & Khare 2011).

Distribution in the study area: Uttar Pradesh: Lakhimpur Kheri: Dudhwa National Park: On the way to Sathiyana, Lodaria compartment Belrayan range, Dudhwa; Bahraich: Katarniaghat Wildlife Sanctuary: Bicchia Beet.

13. ***Ophioglossum reticulatum*** L., Sp. Pl. 2: 1063, 1753. (Fig. 4 e).

Family: Ophioglossaceae; Common name: Jibhi, Jibra, Ekpatiya, Jibiya.

Sustainable utilization: Leaves used as delicious vegetable (Sen & Ghosh 2011), remedy against headache (Singh & Khare 2011). Fresh plant is used as tonic for treatment of worms and inflammation (Sen & Ghosh 2011). Fresh leaf along with rice is made into a cake and the boiled cake is taken orally in empty stomach for 15-20 days against menstrual disorders. Paste of fresh leaves and tubers are applied topically for treatment of boils, burns and as cooling agent (Rout *et al.* 2009).

Distribution in the study area: Uttar Pradesh: Lakhimpur Kheri: Dudhwa National Park: On the way to Gauriphanta, Dudhwa, Sonaripur, Mohraiya Belrayan, Belapersua, Sathiyana, Bankati; Kishanpur Wildlife Sanctuary: Kataiya Chauki, Jhaadi Taal, Taar Kothi; Bahraich: Katarniaghat Wildlife Sanctuary: Bicchia, Semar Chowk Nishangarha, Chaphria Chowk Nishangarha, Kakraha, Girijapuri Sadar Beet, Motipur.

14. ***Pteris biaurita*** L., Sp. Pl. 2: 1076. 1753. (Fig. 4 f).

Family: Pteridaceae.

Sustainable utilization: Entire plant is used as fodder. Dried plants are sprayed in the cattle shed as supplementary fodders and to protect the animals from extreme cold acting as absorbent of urinal excreta. Paste of the plants is applied on cuts and bruises (Rout et al. 2009).

Distribution in the study area: Uttar Pradesh: Lakhimpur Kheri: Dudhwa National

Park: Dudhwa, On the way to Sathiyana, On the way to Kila, Salukapur, Lodaria Compartment Belrayan, Bankati; Bahraich: Katarniaghat Wildlife Sanctuary: Sadar Beet, Murthia Dharampur.

Discussion

Tribal communities from various enthral of the world depend on plant resources for their food, fodder, shelter and useful articles. India is considered one amongst twelve mega-biodiversity countries of the world having Himalayas and Western Ghats as two hot spot for biological species. Geographical expanse of Indian territories is rationally occupied by a number of tribal communities. Amongst plant kingdom the flowering plants are largely utilized in the livelihood of tribes, however non-flowering plants (algae, lichen, fungi, bryophytes and pteridophytes) are poorly known to be utilized by the tribal communities. There are few records that the species of pteridophytes like *Selaginella bryopteris* (Sanjeevani), *Helminthostachys zeylanica* (Kamraj), *Dryopteris cochleata* (Jatashankar) are potential taxa and in traditional use of many tribal communities (Singh and Khare 2011). Nevertheless, the role of pteridophytes in the livelihoods of tribal communities are less documented and known, as a result, the sustainable utilization of these plants are scantily known. As in above three species, the scattered documentation (Acharya & Acharya 2009, Bhattarai et al. 2009, Joseph *et al.* 2003, Khare & Kumar 2007, Kumar *et al.* 2006, Kumar *et al.* 2012, Kumar & Bharti 2014, Kumar et al. 2013, Singh *et al.* 2011, Verma 2011) on traditional knowledge about sustainable utilization of pteridophytes has provided potential data. Knowledge about the potentiality of pteridophytes has opened an opportunity to isolate new molecules for future applications. For the reason of proximity with foothills of Himalayas, the terrai regions exhibit reasonably favourable climatic condition for growth and development of pteridophytes. As a consequence of favourable climate, the geographical areas of terrai region harbour about 26 species of pteridophytes (Singh *et al.* 2014), which directly or indirectly are sustainably utilized by the people residing in the areas. Tharu tribes have long been utilizing pteridophytes for various purposes, but this information was never documented and reported. Present study on pteridophytes and interactions with Tharus revealed that the pteridophytes were sustainably utilized for various purposes. Detailed study on the relationship of pteridophytes in the livelihood of Tharu tribes revealed that above 14 species belonging to 12 genera under 10 families were medicinally important. Many species were used in treatment of asthma, arthritis, improving memory, diarrhoea, fever, cut, wounds, cold, cough, sprains and sexual disorders. The *Ampelopteris prolifera, Christella dentata, Christella parasitica, Diplazium esculentum, Lygodium flexuosum, Ophioglosum reticulatum* were used as food and vegetable. Some potential species like *Adiantum capillus-veneris, Ampelopteris prolifera, Ceratopteris thalictroides, Helminthostachys zeylanica, Lygodium flexuosum, Marsilea minuta* were used for treatment of diseases. Interaction with the Tharu tribes also revealed that the juvenile fronds, coiled leaves (crosiers), extract of rhizomes and entire frond of *Adiantum capillusveneris, Adiantum philippense, Ceratopteris thalictroides, Christella dentata, Christella parasitica, Diplazium esculentum, Helminthostachys zeylanica, Lygodium flexuosum, Ophioglossum reticulatum* and *Pteris biaurita* was used as vegetable and potential medicines. Study revealed that Tharu tribes solely depend on plant and sustainably utilize plant resources for their livelihoods (Fig. 1 a-f; Fig. 2 a-f). There were extreme pressure on the forests by the tribal people for food, fodder, shelter, house-hold articles and wood (Fig. 1 a-f; Fig. 2 a-f). For these unavoidable needs, tribal people exploit plant resources in unsustainable manner. Such unsustainable utilization causes habitat fragmentation, deforestation and loss of valuable species. Few of the species viz. *Ophioglossum reticulatum, Helminthostachys zeylanica, Marsilea minuta, Dryopteris cochleata* are largely exploited by the Tharu tribes for their medicinal and food values. For the reason of overexploitation, a number of species are decreasing from their natural habitat. Such species requires special attention of conservation and mass multiplication. Study revealed that the knowledge about traditional uses of these plants is handed over from generation to generation. Tharu tribe uses a variety of pteridophytes in their traditional practices and this useful information is confined to

their community only. It is felt that if such valuable information is not documented well in time, there would remain a high risk for its loss. It is urgently required that this knowledge should be documented and validated with utmost priority. In this regard a few contributions (Acharya & Acharya 2009, Bhattarai *et al.* 2009, Joseph et al. 2003, Khare & Kumar 2007, Kumar *et al.* 2006, Kumar *et al.* 2012, Kumar & Bharti 2014, Kumar *et al.* 2013, Singh *et al.* 2011, Verma 2011) on useful aspects of plants by different tribes of India was also made. Nevertheless, no such documentation on sustainable utilization of pteridophytes in the livelihood of Tharu tribe is available. Above 14 species of pteridophytes are largely used by Tharus tribes, therefore present study signify their large scale utilization and role in livelihoods amongst tribes of terrai regions.

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Observations on Useful Underutilized Wild Food Plants Among the Tharu Tribal of Uttar Pradesh for Sustaining Local People, their Livelihood and Maintaining Biodiversity

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Introduction

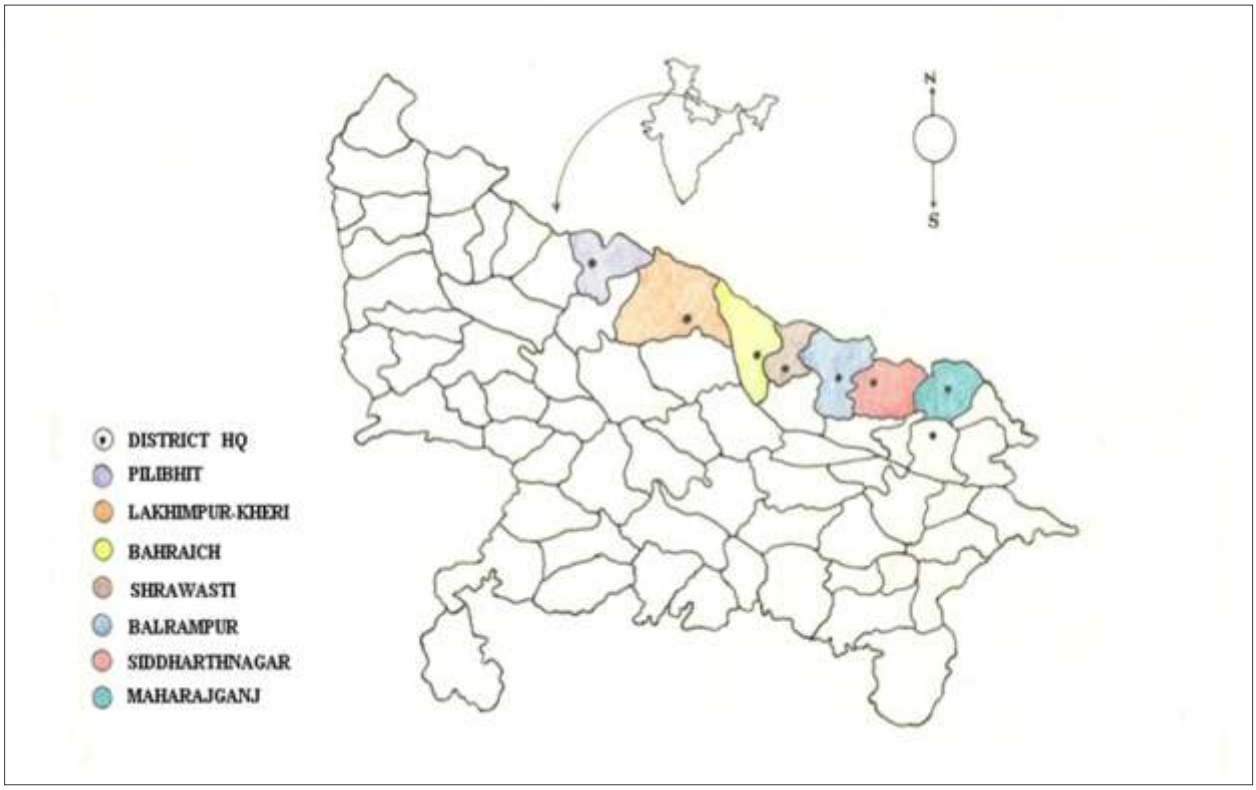
Millions of people, mostly in developing countries, derive a substantial part of their subsistence and income from wild plant products. Underutilized wild edible plants (UWEP) in the forests provide staple food for indigenous people, serve as complementary food for non-indigenous people and offer an alternative source of cash income. The underutilized WEP of Indian origin is directly connected with the socio-economic conditions and tribes living in the remote and close proximity to the forests and fragile ecosystems. They are important nutrient and vitamin supplements for indigenous people, need their full utilization in precedential times may also serve as need of the future. In the times of food shortage, UWEP resources reduce the vulnerability of local communities to food insecurity and provide a buffer. For the development of new food crops through domestication they have substantial potential for hybridization and selection and provide a genetic resource pool.

Many valuable wild food plants are familiar to certain areas or to certain communities but are unknown to others. In view of the rapid decline of traditional knowledge on UWEP and increased reliance on processed food, documentation and evaluation of the traditional knowledge related to the diversity, usage, and status of UWEP, its conservation are crucial and urgent need of the hour. UWEP species are still largely ignored in land use planning and implementation, in the economic development, and in biodiversity conservation endeavours.

The state of Uttar Pradesh is botanically rich on account of its diverse forests, rivers, valleys and hillocks. It has unique physical and ethnic diversity. Large numbers of tribal and aboriginal populations like Tharus, Gond, Kols, Baiga Cheros, Kharwar, Korwa, Ghasiya, Agaria, Panika, Oraon, Mushar and Shaharia etc. inhabit in the state. Tharu tribes are the important tribe chiefly inhabited in the districts like Lakhimpur-Kheri, Pilibhit, Bahraich, Balrampur Shrawasti, Siddharthnagar and Mahrajganj of the terai region in the foothills of Himalaya, Uttar Pradesh. They collect and utilize various plants, leaves, roots, rhizomes, tubers, flowers, fruits and seeds of many wild as well as cultivated plant species grown in ambient vegetation for their dietary requirements, nutrition and food supplements. (Ambasta, 1986; Jain, 1980; Maheshwari *et al.* 1981, 1986; Singh *et al.* 1994; Singh & Prakash 1994). Considering this, the study was undertaken to gather data on diversity, traditional knowledge, economic potential, and conservation value of UWEP in the forests of terai region of the state.

Geology, Soil and Climate

Uttar Pradesh is a state located in the northern part of India. With an area of 243,290 km^2, Uttar Pradesh covers a large part of the highly fertile and densely populated upper Gangetic plain. It shares an international border with Nepal to the north. Other states along Uttar Pradesh's border include Uttarakhand, Haryana and Delhi to the north and northwest; Rajasthan on the west; Madhya Pradesh on the south; Chhattisgarh and Jharkhand on the south east; and Bihar on the east. The climate of Uttar Pradesh is predominantly subtropical; however, weather conditions change significantly



The MAP of Uttar Pradesh showing study area in Terai Forests

with location and season: Temperature: Depending on the elevation, the average temperatures vary from between 12.5–17.5 °C in January to 27.5–32.5 °C in May and June. The highest temperature recorded in the state was 49.9 °C at Gonda on 8 May 1958. Rainfall: Rainfall in the state ranges from between 1,000–2,000 mm in the east to 600–1,000 mm in the west. About 90 percent of the rainfall occurs during the southwest monsoon, lasting from approximately June to September. With most of the rainfall concentrated during this four-month period, floods are a recurring problem and cause heavy damage to crops, life and property. Agriculture is a significant part of Uttar Pradesh's economy. (Map-1)

Tharus Tribal: Lifestyle and Culture

The Tharus are one of the tribes of Utter Pradesh mainly inhabiting the forest areas in the Himalayan foothills of Mahrajganj, Balrampur, Bahraich and Lakhimpur-Kheri districts in close vicinity to the territory of Nepal. They are one of the important tribe in the Dun valley Someshwar ranges of west champaran in Bihar in a compact belt, extending from Nainital in west to Darjeeling in the east. The Tharus and Bhoxas are the only tribes who could survive in the malaria affected area of the Terai region. Infact, they have been struggling hard to survive against the natural force for centuries and have led a secluded life. Even today, the Tharus depend upon the outside world for only such articles as salt, kerosene oil and cloth. They make use of many plant species to meet with their day-to-day needs.

The Tharus are divided into a number of endogamous sects. While the Tharus of Nainital and a majority of them in the Lakhimpur Kheri are Ranas; the Dangurias are the dominant group of the Bhabhar areas of Gonda and Bahraich districts. The Kathuria are found in small number in Lakhimpur-Kheri, Bahraich and the Balrampur district. In Maharajganj districts, most of the Tharus, however, come from Kathuria stock. There are many other sects found in small number in Utter Pradesh but in Nepal in sizeable numbers like Kumhar, Jogi,

Malhauria, saunea, Khunka, Garauhra and Pochila can be located. The Tharus celebrate most of the Hindu festivals; worship Hindu Gods along with the pantheon of their ancient gods. The Hindu Gods, popular among the Tharus, are, Shankar (Lord Shiva), his consort parvati and Hanuman, the Monkey god, while some of the tribal gods, deities and spirits worshiped by the Tharus are Mote Baba, Katiar Baba, Bhuinya, Nagnihai, Jwala, Meri Masan and other. Usually, there is a small place of worship both inside and outside the house. The witch doctor that drives away the evil spirits by his 'Mantras' (enchantment) responsible for animals is called the 'Bharra'. In order to ward off an evil spirit, he hold some ash of cow dung, or grains of mustard seed or wild nuts in his left hand, and after breathing some mystical virtue into them by the utterance of a spell, he force the patient to eat them or have them tied to his arm. The Tharus worship a piece of 'Saku' (*Shorea robusta*) wood in the shape of 'lingam' or phallus, symbolic of Lord Shiva or Mahadeva, near which a long stick is pitched with a bit of red cloth fastened to the object of worship. They worship Shiva (known chiefly among them by the name of 'Bhirava' and 'Thakurs') as the God of reproduction, the stone lingam being the symbol. It is usual practice of a. Tharus to erect a mud mound in fronts of his house, and fix an upright pole in the centre to represent the presence of this phallic divinity. Tharus also believe in Supreme Being, they call Narayana, who gives them sunshine, rain and crops, but they don't have proper idea, how this great far off being is to be approached and worshiped. Nature worship among them represented by two main deities of importance, namely Madhu, the god of intoxicating drink, especially of the rice wine ('Jaund') made by themselves and Dharchandi; the patroness of cattle. The mound dedicated to 'Dharchandi' is studded with the short wooden crosses, on which rice, pulses and other grains are offered on leaf plates. Her shrine is so placed that all the cattle of village together with the swine, sheep and goats pass by it on going out to graze, and repass it on their return. When the cattle are sick or die, more valuable offering are made in large quantity. They also worship plants, such as 'Pipal' (Ficus religiosa.) and 'Aam' (*Mangifera indica*.) and animals, like, cows, serpents and monkeys. The usual age of the marriage for men and women is about fifteen to eighteen. The father of either side arranges the marriage contract, and the couple, for which the negotiation is made, has no say in the matter. The father of groom goes over to the village or where the bride's fathers reside and after making his proposal for the price to be paid for the bride, offer him a drink of wine. If the present is accepted the bargain is the struck. Both the parties faithfully keep the contract once made. In some, regions, the infant marriage is also arranged. Except the Tharus of Nainital, all other Tharus freely intermarry in Nepal. Divorce is easy and widow marriage is permissible. The Tharus community celebrates festivals before harvesting any crop and has a ritual before eating the new grains. In the spring, they observe the annual festivals fire resembling the many respects, the Holi festival (festival of colors). A mound of earth is prepared, and a pole is fixed in its centre in a vertical position. The assembled people offer 'hardi' (*Curuma longa*), hemp (*Cannabis sativa*) 'Dhatura' (*Datura metel*, *D. innoxia*) and other odorous herbs upon the pole placed and mound. The straw, stubble and sticks are then piled around the pole, and the oldest or most respected man in the assembly puts fire to it. Thereafter, they amuse themselves with the dancing, playing the drums and 'mridang' pelting each other with colored powder, signing amorous songs and cracking on lascivious jokes. In the evening they eat fish, meat rice and drink liquor. The festival is also celebrated for seven days. An other festival Mesh Puja is also celebrated during the later part of the rainy season by cutting grasses, which is followed a month later by harvesting of rice crop. In general the festivals are celebrated with a series of ceremonies and sacrifices. During these occasions plants like, 'Bel' (*Aegle marmelos*) 'Neem' (*Azadirachta indica*), 'Tulsi' (*Ocimum sanctum*), 'Paras, Dhak' (*Butea monosperma*), 'Peepal' (*Ficus religiosa*) 'Bargad' (*F. benghalensis*), 'Aam' (*Mangifera indica*), 'Kela' (*Musa paradisiaca*), 'Ber' (*Ziziphus mauritiana*) and 'Jamun' (*Syzygium cumini*) are used to decorate the house and front yard. The Tharus live by hunting and fishing, gathering forest herbs, fruits and vegetable grazing cows and buffaloes making ghee (clarified butter) and rearing pigs, fowls and goat. The animals which they chiefly

Some popular underutilized wild food plants in the area

Nymphaea nouchali

Nelumbo nucifera

Physalis minima

Helminthostachys zeylanica

Agaricus campestris

Ipomea aquatica

Carissa opaca

Dillenia pentagyna

hunt are the wild boar, deer, antelope and hares. Some time on scarcity of food, or pressurized to eat they eat field rats. They eat fowls, fish and tortoises. If there stock of meat is more than that they can consume at a time they preserve it by cutting it into strips and the drying in the sun. The small fish is dried, powded and mixed with rice to form a delicacy. Usually, lentil (*Lens culinaris*.) is used as pulse. The Tharus have their traditional dance performed by both the sexes of all age groups. They dress themselves in colorful clothes and dance to the beats of the drums and 'mridangs' and make great amusements.

Result

100 Underutilized wild edible Plant species used by the tribal population for meeting their nutritional, minerals, fats, carbohydrates and vitamins requirements in the terai area of the state have been arranged in tabular form (Table-1) with their botanical names, family, local names, brief ecology, uses and conservation status etc.

Discussion and Conclusion

The study revealed that there are 86 under-utilized wild edible plant species under 83 genera belongs to 3 fern family, 1 fungal and 54 angiosperm families found in the terai area, such as Pilibhit, Lakhimpur, Bahraich, Balrampur and Shrawasti districts of Uttar Pradesh adjacent to the foothills of Himalaya. The tribal consume these plants either raw or after cooking, roasting or frying. These available plant species are chief source of essential nutrients such as proteins, vitamins, minerals, fats and carbohydrates.

The younger leaves and shoots of *Diplazium esculentum, Marsilia minuta, Ipomea aquatica, Boerrahavia diffusa, Helminthostachys zeylanica, Hemidesmus indicus, Curculigo orchioides, Bauhinia purpurea, Centella asiatica, Ficus virens, Leucas aspera, Phyllanthus fraternus, Rumex dentatus, Solanum nigrum, Trianthema portulacastrum*, are cooked as delicious leafy vegetable in the area. The rootstock of *Nymphaea nouchalii*, is eaten by the children with taste among the tharu tribal in the area. The leaf pup of *Aloe vera*, is roasted with butter, dry nuts or dry fruits and sugar is added to a taste eaten as sweets in the area. The small buds and flowers of *Bombax ceiba, Crotolaria juncea* are fried with mustard oil, chillies, condiments, added salt to a taste and eaten as a vegetable. The fruits of *Xeromphis uliginosa, Capparis zeylanica* are light boiled, rind separated, cut into pieces, fried with mustard oil, chillies, condiments, added salt to a taste and eaten as a vegetable. The seeds of Holoptelea integrifolia are peeled and eaten as tasty nuts. The roots of *Pueraria tuberosa*, *Costus speciosus, Asparagus racemosus,* are light boiled, rind separated, cut into pieces, fried with mustard oil, chillies, condiments, added salt to a taste and eaten as a vegetable.

S. No.	Botanical Name	Family	Local Name	Uses	Ecology	Conservation Status
1	*Agaricus campestris* L.	Agaricaceae	Dharti Ka Phool	Cooked with mustard oil, and eaten as vegetable	Occurs frequently in Sal forests as ground flora	Common
2	Alangium salvifolium (L.f.) Wang.	Alangiaceae	Dhera, Ako	Ripe fruits eaten	Occurs in open areas near the village side	Common
3	*Aloe vera* (L.) Burm .f.	Liliaceae	Gheekwar	The pulp cooked and eaten as sweet Halwas	Found throughout the state	Common
4	*Amaranthus spinosus* L.	Amaranthaceae	Kataili chorai	Tender shoots and leaves eaten as vegetable.	Common in open waste land	Common
5	*Amaranthus viridis* L.	Amaranthaceae	Chaulai	Shoots and leaves used as vegetable	Occurs commonly on wasteland	Common
6	*Amorphophallus paeoniifolius* Dennst.	Araceae	Elephant foot, Zimi Kand	The corms boiled along the leaves of Tamarindus indica and fried with spices and eaten as vegetable.	Occurs commonly on wasteland	Common
7	Ampelocissus *latifolia* (Roxb.) Planch.	Vitaceae	Panibel, Jungli Angoor	The berries eaten either raw or cooked and used as vegetable.	Occurs occasionally along with the edges of Sal forests.	Common
8	*Anthocephalus chinensis* (Lam.) A. Rich.ex Walp.	Rubiaceae	Kadamba	Ripe fruits eaten	Throughout the terai areas.	Common
9	*Antidesma acidum* Retz.	Euphorbiaceae	Banmusari	The ripe fruit eaten by children and local people.	Occasionally along with the edges of Sal forests and in open areas.	Common
10	*Arisaema tortuosum* Schott.	Araceae	Jhagpapri	Stems cooked and eaten as vegetable	Occasionally in the terai area of the state	Common
11	*Artocarpus lacucha* Ham.	Moraceae	Barahar	The sweet ripe fruits eaten	In asociación with Mallotus phillippinensis and Mitragyna parvifolia etc.	Locally threatened
12	*Asparagus racemosus* Willd.	Liliaceae	Shakakul Satavari	Tuberous roots and fried used as food.	Climbing on small trees	Common
13	*Averrhoa carambola* L.	Oxalidaceae	Kamrakh Amrakh	The ripe and unripe fruits eaten	Occurs frequently in moist open areas and sometimes planted	Locally threatened
14	*Basella alba* L.	Basellaceae	Poi, Poy	Leaves used as vegetable.	Found in mixed forests climbing on the shrubs and trees	Common
15	*Bauhinia vahlii* W. & A.	Caesalpiniaceae	Mohlain	Seeds eaten	Climbs on Sal trees	Common
16	*Bauhinia variegata* L.	Caesalpinaceae	Kachnar, Koylar	Shoots and buds boiled, squeezed, fried and eaten	Associated with Ziziphus mauritiana and Trewia nudiflora etc. occurs in the mixed forest	Common
17	*Boerhavia diffusa* L.	Nyctaginaceae	Punarnawa, Patharchatti, Gadahpurna	Tender shoots and leaves fried and eaten as vegetable	Occurs on wasteland and in the out skirts of the forests	Common
18	*Bombox ceiba* L.	Bombacaceae	Semal, Semar	Flower buds fried and eaten as vegetable.	Common in the grassland.	Common

S. No.	Botanical Name	Family	Local Name	Uses	Ecology	Conservation Status
19	*Borassus flabellifer* L.	Arecaceae	Tar	The pulp of ripe fruit eaten. The tree largely tapped for the 'toddy' beverage.	Common in the grassland and open areas in the area.	Common
20	*Bridelia squamosa* Gehrm.	Euphorbiaceae	Khaja	The ripe fruit eaten by locals and children.	In association with Aegle marmelos and Adina cordifolia etc. found in Sal forests	Common
21	*Buchanania lanzan* Spreng.	Anacardiaceae	Chironji, Piyar	The ripe fruits eaten by the local community	Plants associated with Terminalia species.	Locally threatened
22	*Butea monosperma* (Lamk.) Taub.	Fabaceae	Paras, Parasa, Chiula	Flower buds and inflorescence base boiled, fried and eaten as vegetable.	Found in grassland, and mixed forests	Common
23	*Caesulia axillaris* Roxb.	Asteraceae	Panisag	Tender shoots and leaves eaten as vegetable.	Found near marshy places	Common
24	*Capparis zeylanica* L.	Capparaceae	Bhagnaha, Jakham bel	The fruits eaten as vegetable. Also used for pickling.	Found in open area straggling on trees.	Common
25	*Carissa opaca Stapf* ex Haines	Apocynaceae	Karaunda, Karawan	Ripe berries popularly eaten. Unripe fruits made into pickles and chutneys	Occurs in the mixed forest in association with Murraya koenigi, Glycosmis pentaphylla etc.	Common
26	*Centella asiatica* (L.) Urban	Apiaceae	Brahmmi	Tender shoots and leaves eaten as vegetable.	Occurs in shades and marshes	Common
27	*Chenopodium album* L.	Chenopodiaceae	Bathua	Leaves and delicate shoots used as dry vegetable.	Occurs throughout. Cultivated too.	Common
28	*Chlorophytum tuberosum* Bak.	Liliaceae	Safed Musli	Light boiled roots, fried and eaten as vegetable.	Occurs near marshy places and in open	Locally threatened
29	*Coccinia grandis* (L.) Voigt	Cucurbitaceae	Kunduru	Unripe fruits eaten as vegetable	Trailing herb associates with trees like Morus alba and Emblica officinalis etc.	Common
30	*Commelina benghalensis* L.	Commelinaceae	Kantivla	The leaves eaten as vegetable curries and salad.	Occurs in grassland and forest out skirts	Common
31	*Cordia dichotoma* Forst.	Boraginaceae	Lasora	Unripe fruits, sun dried and pickled. Also eaten as vegetables.	Occurs in mixed forests in association with Ziziphus oenoplea and Murraya paniculata	Common
32	*Costus speciosus* (Koenig) Smith	Zingiberaceae	Kewa	Flower buds and young leaves eaten as vegetable.	Occurs in shady and moist places.	Locally threatened
33	*Crotolaria juncea* L.	Fabaceae	Sanai	Light boiled buds eaten as vegetable.	Occurs in grassland and forest out skirts	Common
34	*Curculigo orchioides* Gaertn.	Amaryllidaceae	Kalimushli	Light boiled roots eaten as vegetable.	Occurs in association with Uraria neglecta and Elephantopus scaber in the Sal forests	Common
35	*Curcuma angustifolia* Roxb.	Zingiberaceae	Tikhur	Starch rich corm eaten by the locals	Found in grasslands of terai forests	Common

S. No.	Botanical Name	Family	Local Name	Uses	Ecology	Conservation Status
36	*Dendrocalamus strictus* (Roxb.) Nees	Poaceae	Bans	Delicate shoots made into vegetable and pickles. Seeds edible	Occurs in grassland and out skirts.	Common
37	*Digera muricata* (L.) Mart.	Amaranthaceae	Lehesua	Tender shoots and leaves are fried and eaten	Found near marsh and water bodies	Common
38	*Dillenia pentagyna* Roxb.	Dilleniaceae	Agaii	Lightly boiled unripe fruit fried and eaten as vegetable	Occurs frequently associated with Terminalia bellierica, Bridelia squamosa and Carissa opaca etc. in the Sal forests.	Common
39	*Diospyros exsculpta* Buch.-Ham.	Ebenaceae	Tend, Tendu	The ripe fruits eaten by children and local peoples.	In the Sal forest associated with Holarrhena pubescens and Aegle marmelos etc. of Katarniaghat, sohelwa, sirsia and other terai areas of the state.	Common
40	*Diplazium esculentum* Sw.	Athyriaceae	Lengur, Lunguru	Tender shoots and leaves fried and eaten as vegetable	Occurs in Sal forest and marshy places in the terai region.	Common
41	*Dioscorea bulbifera* L.	Dioscoreaceae	Ratalu	The bulbils boiled, fried eaten as vegetable.	Found along the edges of the forest twining on small trees like Ziziphus maurtiana	Common
42	*Dioscorea glabra* Roxb.	Dioscoreaceae	Ratalu	Tubers cooked and eaten as vegetable	Found along the edges of the forest	Common
43	*Dioscorea hispida* Dennst.	Dioscoreaceae	Bank	Bulbils boiled, fried and eaten as vegetable.	Found in open places	Common
44	*Dioscorea pentaphylla* L.	Dioscoreaceae	Khaniakand	The bulbils used as vegetable.	Found in open places and along the edges of the forest twining on the small trees like Ziziphus maurtiana, and Cassia fistula etc.	Common
45	*Ehretia laevis* Roxb.	Ehretiaceae	Chamror	The ripe fruits eaten by the children	Association with Cassia fistula, Aegle marmelos and Mallotus philippensis in Sal forest.	Common
46	*Emblica officinalis* Gaertn.	Euphorbiaceae	Aonla	Fruits eaten and preserved.	Occurs adjacent to Sal forest in association with Mallotus philippensis and Lagerstroemia parviflora	Common
47	*Erioglossum rubiginosum* Bl.	Sapindaceae	Anga-banga	Ripe fruits eaten by locals and tribals	Occurs frequently in shades. Associated with Shorea robusta and Mallotus philippensis etc.	Common
48	*Ficus benghalensis* L.	Moraceae	Bargad	Receptacles eaten	Found in the open areas of forest.	Common
49	*Ficus hispida* L.f. (Moraceae)	Kathgularia	Kathgularia	Receptacles eaten as vegetable.	Found frequently in waste land adjacent to the mixed forest of the terai areas.	Common

S. No.	Botanical Name	Family	Local Name	Uses	Ecology	Conservation Status
50	*Ficus palmata* Forsk.	Moraceae	Jungli Anjir, Dudhla	Ripe fruits eaten by local people and children	Found commonly associated with Adina cordifolia, Tectona grandis and Mitragyna parvifolia	Common
51	*Ficus racemosa* L.	Moraceae	Gular	Unripe receptacles used as vegetable.	Found frequently in the open areas of mixed forest.	Common
52	*Ficus virens* Ait.	Moraceae	Pakar Pilkhan	Buds eaten as vegetable.	Found frequently in the open areas of mixed forest.	Common
53	*Flacourtia indica* Merr.	Flacourtiaceae	Katai	Ripe fruits eaten by children and local people	Frequently found in association with Emblica officinalis, Trewia nudiflora and Ziziphus mauritiana etc. at the edge and in the open situation.	Common
54	*Flacourtia jangomas* (Lour.)	Salicaceae	Paniyala	Ripe fruits eaten by the locals.	Found at edge of forest.	Common
55	*Grewia hainesiana* Hole	Tiliaceae	Phalasa, Pharsa	Ripe fruits eaten	Common in the mixed forest area in association with Murraya koenigii and Glycosmis mauritiana.	Common
56	*Grewia hirsuta* Vahl	Tiliaceae	Gursakari	Ripe fruits eaten by locals and children	Commonly grown at the edge of the mixed forest and grassland of the area.	Common
57	*Glycosmis mauritiana* Tanaka	Rutaceae	Makranda, Ban Nibu	Fruits eaten by local people and children	Found commonly associated with Murraya paniculata, Clerodendrum infortunatum and Holoptelea integrifolia etc.	Common
58	*Helminthostachys zeylanica* Hook. f.	Ophioglossaceae	Kamraj	Tender shoots and leaves eaten as vegetable	Occurs occasionally in the sal and mixed forest in association with Glycosmis species.	Common
59	*Holarrhena pubescens* Wall. ex G. Don	Apocynaceae	Koraya, Kurchi, Dudhi	Flower buds and inflorescence base boiled, fried and eaten as vegetable	Occurs commonly associated with Terminalia bellirica and Dillenia pentagyna in the Sal forest of the terai area.	Common
60	*Ipomea aquatica* forsk.	Convolvulaceae	Karamua	Shoots and leaves fried and eaten.	Common in marshy, muddy places and ponds.	Common
61	*Leucas aspera* Spreng.	Lamiaceae	Goom	Young leaves and shoots eaten	Occurs as weed in cultivated fields	Common
62	*Limonia acidissima* L.	Rutaceae	Kaintha	Sweet sour pulp of the fruit used in sauce & pickle. Leaves used as aroma enhancer.	Occurs in the mixed forest asocited with Acacia catechu and Adina cordifolia etc. in the terai forest.	Common
63	*Luffa cylindrica* (L.) Roem.	Cucurbitaceae	Ghia taroi	Fruits cooked and used as vegetable	A common trailing herbs on the waste land	Common
64	*Madhuca longifolia* (Koen.) *Macbride* var. *latifolia* Chev.	Sapotaceae	Mahua	Flowers are used for beverage locally called "Tharra". Fruits eaten as vegetable. Seeds good source of oil	Occurs commonly in the mix forest in the terai area in association with Adina cordifolia, Dalbergia sissoo and Mitragyna parvifolia etc.	Common
65	*Manilkara hexandra* (Roxb) Dub	Sapoataceae	Khirini	The fruits edible and best sources of pickles & sauces.	Often planted near tribal habitats and villages in the terai areas.	Common

S. No.	Botanical Name	Family	Local Name	Uses	Ecology	Conservation Status
66	*Marsilia minuta* L.	Marsiliaceae	Tinpatiya Sag	Young leaves and shoots fried and eaten as vegetable	Occurs along with forest roads and at the edges of the forests.	Common
67	*Miliusa velutina* (Dunal) Hook.f.	Annonaceae	Beri	Fruits cooked and used as vegetable	Common with in the Sal forest of terai region.	Common
68	*Momordica dioica* Roxb. ex Willd.	Cucurbitaceae	Kheksa, Golkandra	Unripe fruits eaten as vegetable.	Occurs occasionally on the edge of the forest	Common
69	*Moringa oleifera* Lam.	Moringaceae	Sahjan	Young fruits boiled and eaten as vegetable. Also preserved as pickles	Occurs commonly in the mixed forest and grassland near the villages.	Common
70	*Morus alba* L.	Moraceae	Tut	The ripe fruit eaten	Occurs in the mixed forest in association with Glycosmis maurtiana, Aegle marmelos and Ehretia leavis.	Common
71	*Murraya koenigii* (L.) Spreng.	Rutaceae	Kathnim	The leaves used for frying the pulses and making Raita & Kadhies	In association with Glycosmis mauritania, Flemingia strobilifera and Carrisa opaca in the mixed forest of terai area	Common
72	*Nelsonia canecsens* (Lamk.) Spreng.	Acanthaceae	Jara	The roots mixed in cooked rice and fermented to prepare liquor.	Occurs frequently in marshy and moist places in Sal forests	Common
73	*Nelumbo nucifera* Gaertn.	Nelumbonaceae	Kamal	Rhizome eaten as vegetable. Unripe Seeds popularly eaten in the area.	In association with Nymphaea pubescens and Trapa natans found in ponds	Common
74	*Nymphaea nouchali* Burm. f.	Nymphaeaceae	Chhota Kamal	Butter roasted seeds mixed with sugar eaten. Rhizomes cooked as a vegetable.	In association with Nelumbo nucifera and Trapa natans found in the ponds of the terai region in state	Common
75	*Nymphaea stellata* Willd.	Nymphaeaceae	Kumud	Rhizome collected kept in the shadows and cooked as a vegetable.	Found in the ponds in association with Nelumbo nucifera and Trapa natans in the terai region of state	Common
76	*Ophioglossum reticulatum* L.	Ophioglossaceae	Jivia	Tender shoots and leaves fried and eaten as vegetable	Occurs occasionally in the marshy places	Locally threatened
77	*Oxalis corniculata* L.	Oxalidaceae	Khatti Buti	The younger leaves & shoots fried in edible oil with chilies and salt to a taste used as vegetable.	In moist places and waste land in the forest area	Common
78	*Phoenix sylvestris* Roxb	Arecaceae	Chindi, Khajuri	Sap is trapped and fermentation to prepare alcoholic drink. Ripen fruits edible after removing crown the soft pith	Occurs frequently in open places and grassland in the area	Common

S. No.	Botanical Name	Family	Local Name	Uses	Ecology	Conservation Status
79	*Phyllanthus fraternus* Webster	Euphorbiaceae	Bhui Aonla	Younger leaves and shoots light boiled, squeezed, and fried with edible oil, chilies and salt eaten as vegetable.	In association with Cassia tora, Lecus aspera etc.in shady and marshy places, as weed in cultivated field near the Sal forest	Common
80	*Physalis minima* L.	Solanaceae	Makoicha, Rasbari	Ripe fruit edible, sweet in taste.	Occur occasionally in moist places and waste land near swamps	Common
81	*Pithecellobium dulce* (Roxb.) Benth.	Mimosaceae	Jungle Jalebi	The pulp of ripe fruit largely eaten	In association with Adina cordifolia, Mallotus philippenensis and Aegle marmelos.	Common
82	*Portulaca oleracea* L.	Portulacaceae	Kulfa	Younger leaves and shoots fried and eaten as vegetable.	Weed in association with Centella asiatica, Eclipta prostrata and Oxalis corniculata.	Common
83	*Portulaca quadrifida* L.	Portulacaceae	Chota lonia	Eaten as vegetable.	Common weed in moist soils	Common
84	*Pueraria tuberosa* (Roxb ex Willd.) DC	Fabaceae	Vidari kand	Tubers boiled, fried and eaten as vegetables.	In mixed forest in association with Flemingia chapper, Desmodium hetrocarpon and Glycosmis mauritiana etc.	Locally rare
85	*Rumex dentatus* L.	Polygonaceae	Jungli Palak	Tender leaves, light boiled and eaten as a vegetable.	In marshy places near the swamp forest in the terai area of the state.	Common
86	*Schleichera oleosa* Oken	Sapindaceae	Kosum	The unripe fruit pickled	In the Sal forest in association with Aegle marmelos, Cassia fistula and Holarrhena pubescens etc.	Occasional
87	*Semecarpus anacardium* L.f.	Anacardiaceae	Bhinwala,	Ripe receptacles eaten by tribal.	Found frequently in the Sal forest	Common
88	*Shorea robusta* Gaertn.	Dipterocarpaceae	Sakhu, Sal	Seed eaten. The seed oil is used for cooking purpose.	Frequently in the Sal forest in association with small trees	Common
89	*Solanum nigrum* L.	Solanaceae	Makoi	Leaves and shoots fried and eaten	Occurs frequently in moist shady places	Common
90	*Spondias pinnata* (L.f.) Kurz.	Anacardiaceae	Ambara	Unripe fruits grinded and eaten as chutany and unripe fruits pickled	Occurs in association with Holoptelea integrifolia, Terminalia bellirica and Cassia fistula etc.	Common
91	*Sterculia villosa* Roxb.	Sterculiaceae	Udarkand	Seeds eaten as such and roasted	Along the edge of the Sal forest with Butea monosperma and Ziziphus mauritiana.	Common
92	*Syzygium cerasoides* (Roxb.)	Myrtaceae	Bhadar Jamun	The fruit eaten.	In association with Drypetes roxburghii & Bombax ceiba etc.	Common

S. No.	Botanical Name	Family	Local Name	Uses	Ecology	Conservation Status
93	*Syzygium cumini* (L.) Skeels	Myrtaceae	Jamun	The fruit eaten	Found in the grassland and the mixed forest	Common
94	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	Behera	The kernels eaten by the tribe.	In the forest associated with Aegle marmelos and Adina cordifolia.	Common
95	*Trianthema portulacastrum* L.	Aizoaceae	Patharchatti	Young leaves eaten as vegetable.	Commonly in the wasteland	Common
96	*Vicia sativa* L.	Fabaceae	Eklir, Ankra	Young leaves eaten as vegetable	Commonly in the cultivated field near the forest edge.	Common
97	*Xeromphis uliginosa* (Retz)	Rubiaceae	Pedar, Pindar	Unripe fruits boiled, fried and eaten	In the terai forests throughout the state.	Common
98	*Ziziphus mauritiana* Lamk.	Rhamnaceae	Ber	Fruit largely eaten	In association with Flacourtia indica, Cordia dichotoma etc. in the scrub forest in the terai area	Common
99	*Ziziphus oenoplia* (L.) Mill.	Rhamnaceae	Jharber	The ripe fruit eaten.	In the scrub forests in association with Ventilago denticulata and Embelica officinalis	Common
100	*Ziziphus rugosa* Lamk.	Rhamnaceae	Bair	Fruits eaten raw or ripe	Found in association with Flacourtia indica, Xeromphis uliginosa.	Common

The fruits of *Cordia dichotoma, Schleichera oleosa, Spondias pinnata, Xeromphis uliginosa, Dillenia pentagyna* are utilized for making pickles of excellent tastes need standardization and commercialization in trades. The fruits of *Dillenia pentagyna* have been found as most anti tumour cancerous activity in a study (Rosangkima *et. al.* 2010).

The habitat loss due to some factors like, modernization, overgrazing, animal husbandry has resulted in the loss of diversity. Endangered species have particularly suffered from lack of effective pollinators, viable seed formation and natural regeneration, diseases etc. resulting in the depletion and erosion of the genetic diversity in many plant species. (Prakash and Singh, 2001, Goel, 1992, Jain, and Sastry 1980) The population of some plant species like *Artocarpus Lakucha, Averrhoa carambola, Costus speciosus, Flacourtia jangomas, Manilkara hexandra, Mimusops elengi, Schleichera oleosa, Spondias pinnata, Xeromphis uliginosa Helminthostachys zeylanica, Hemi-desmus indicus, Pueraria tuberosa* having restricted distribution and scarce population are decling in the area considered locally threatened need both, in-situ and ex-situ conservation for their sustainable utilization in trade and commerce.

The plant resources of the area of the state are quite rich in raw materials needed for development of nutritional food and food stuffs with newer tastes and flavor. Extraction of edible and non edible oils from raw material through establishing plant based industries may provide economic development of the area. The organized collection, storage and processing of wild edible plant species for further nutritional validation and investigation will provide employment to the rural and tribal population of the state for economic development and tribal empowerment.

Conservation Strategy

No conservation strategy can be effective unless taken care of the basic needs of the local communities. A good deal of biodiversity is also

protected through folk traditions. Considering the prevailing situation and diverse plant wealth of the area, emphasis must be laid on the conservation measures, both *in-situ* and *ex-situ*. The in-situ approach, however, needs priority for the protection of endangered species, which have already lost the diversity and are not able to adjust. For effective conservation of forest biodiversity *in-situ*, preservation plots in different forest ecosystems can be established. Preservation plots are precise example of local level management norms of biodiversity plots as "demarcated forest areas set aside in perpetuity for the preservation of the forest with no human interference beyond what is necessary for their protection and maintenance". The preservation plots serve as "ecological reference centre or ecological labs" for studying natural ecological processes in isolation from human interference and pressure, thus dealing with wise management of biodiversity. Researches on various ecological habitats of endangered species should also be undertaken. Afforestation of fuel and fodder species under social forestry programmes may be encouraged in the surrounding areas so that the pressure on protected forest is checked. Studies on reproductive behaviour and population dynamics of threatened and rare species should be carried out over a period of time in-situ. The area management should initiate a programme or develop a strategy to examine conservation status of vegetation, communities, habitats and species that are threatened and need protection.

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Sensitizing Biodiversity Conservation at School-College Level. An Experiment with Workshops of Uttar Pradesh State Biodiversity Board

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Introduction

India is one of the 12 mega-biodiversity countries in the world, however its biodiversity is under threat due to several factors including climate change, deteriorating ecological conditions, habitat loss, unhealthy agricultural practices, tourism, urbanization, industrialization and many other anthropogenic activities. Indian government is already running several conservation programmes such as Protected Area Networks, botanical gardens, zoological parks, recording indigenous knowledge, REDD+ (Reducing Emissions from Forest Degradation) project (Gokhale, web link 1) etc. It is realized that the official program suffers from total reliance on authoritarian management arrangements in which decisions are made centrally and coercion is used to implement them. Gadgil (1992) is of the opinion that conservation programme to be more successful they should be involve local people in every stage starting from documenting the biodiversity to planning and implementing. Further, Gagil (1996) set a unique example by involving school-colleges in documenting the biodiversity of Western Ghats for planning conservation strategies.

Apart from field based actions, undoubtedly, the first tool for biodiversity conservation is awareness raising. Because effectively conveying uniqueness of biodiversity creates interest among the audience while threats to biodiversity builds concern. Convention on Biological Diversity (CBD, web link 2) believes that lack of awareness means less public support for the conservation and sustainable use of biodiversity. CBD's Communication, Education and Public Awareness (CEPA) programme helps governments, educators and others create the tools and networks of experts needed to answer biodiversity and sustainability questions, raise public awareness and integrate biodiversity into education systems worldwide. The International Day for Biological Diversity, every 22 May, is one such effort which provides an excellent opportunity to celebrate biodiversity.

Efforts of Uttar Pradesh State Biodiversity Board in spreading awareness

Uttar Pradesh is one of the highly populated states of India harbours rich biodiversity within its 9% of forested areas and also in the form of domesticated animals and cultivated plants (Anonymous 1). Uttar Pradesh State Biodiversity Board (UPSBB) from the day of its inception actively involved in various programmes of documentation and conservation biodiversity. The Board has given a high priority to awareness activities. Most importantly such awareness programmes are being conducted for school-college children who are leaders of tomorrow. These programmes are conducted by series of lectures, seminars, power point presentations, display of posters and banners, distribution of handbills, booklets, play, field visits, photograph exibhition, tree planting (Van Mahotsav), oath taking, workshops on various topics and various educational competitions (rangoli, power-point, painting, poster making, quiz, essay, collage making, face painting, nukkad natak, greeting card making, frog leap). Some of the popular awareness activities of the UPSBB are as follows; 'World Wetlands Day'. is celebrated on 2nd

Biodiversity Awareness Workshops. 1. Forest Training Centre, Hastinapur, Meerut, Department of Environmental Science, Bareilly College, Bareilly, 3. Shri Gandhi Mahavidhyalaya, Sidhauli, Sitapur, 4. Dudhwa Tiger Reserve, Dudhwa, 5. Mewalal Ram Dulari Vidhya Mandir Inter College, Majhagain, Kheri, 6. Department of Botany, University of Allahabad, Allahabad

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Biodiversity Awareness Workshops. 7. Shri Shakti Degree College, Shankhahari, Ghatampur, Kanpur, 8. Department of Botany, Bappa Sri Narain Vocational P.G. College (KKV), Charbagh, Lucknow, 9. Sree Nagar Jee Vidhyalay Inter College, Krishna Nagar, Kanpur, and 10. Sacred Heart Degree College, Sitapur

February; 'World Sparrow Day' is celebrated on 20th March; 'Save the Frogs Day' is the world's largest day for amphibian education and conservation is celebrated on 26th April; 'World Environment Day' is celebrated on 5th June with predefined themes, by distributing biodegradable bags and planting trees; 'International Day for Vulture Awareness' is celebrated every year on 05th September; and 'Wildlife Week' (1st -7th October 2014). These activities are mostly conducted in association with Department of Zoology, University of Lucknow and Regional Science City, Lucknow. 'International Day for Biological Diversity' is celebrated every year on 22nd May with the predefined theme. Various competitions are conducted for students prior to the Biodiversity Day and on 22nd May one day conference is organized in a large scale by inviting learned academicians, foresters, researchers and students. 'Prakriti Bus', a mobile exhibition on biodiversity of Uttar Pradesh programme is a successful awareness programme being implemented by CEE North educated more than 2 lakh visitors in two years. Occasionally the UPSBB also launches 'Wildlife Awareness Car' that visits place to place with biodiversity conservation message. UPSBB also carries out training programmes on "Biodiversity and Its Conservation" in association with Lucknow University and "Biodiversity Laws and Policy" with Dr. R.M.L. National Law University.

UPSBB sponsored Biodiversity Awareness Workshops by CSIR-NBRI

Scientists at CSIR-National Botanical Research Institute (CSIR-NBRI), Lucknow are of the opinion that knowledge generated inside the four walls of the laboratory should be communicated to common man. This is more applicable to the research related

Table 1: Biodiversity Awareness Workshops conducted

	Workshop place	No. of Participants	Categories
1.	Forest Training Centre, Hastinapur, Meerut	40	Foresters
2.	Department of Environmental Science, Bareilly College, Bareilly	100	Graduate and Post Graduate student of Botany and Environmental Science
3.	Shri Gandhi Mahavidhyalaya, Sidhauli, Sitapur	100	B.Ed. Students
4.	Dudhwa Tiger Reserve, Dudhwa	53	Foresters
5.	Mewalal Ram Dulari Vidhya Mandir Inter College, Majhagain, Kheri	98	Students of class 9th and 11th
6.	Department of Botany, University of Allahabad, Allahabad	124	Post Graduate students and Ph.D. Scholars
7.	Shri Shakti Degree College, Shankhahari, Ghatampur, Kanpur	58	Graduate and Post Graduate students
8.	Department of Botany, Bappa Sri Narain Vocational P.G. College (KKV), Charbagh, Lucknow	84	Graduate students
9.	Sree Nagar Jee Vidhyalay Inter College, Krishna Nagar, Kanpur	60	10th and Inter Mediate students
10.	Sacred Heart Degree College, Sitapur	134	Students of Inter Mediate and Graduation

to taxonomy or biodiversity. CSIR-NBRI has successfully completed a project sponsored by UPSBB entitled "Enumeration of lichens from Uttar Pradesh" where eastern Uttar Pradesh was surveyed and 135 lichen taxa were listed. Extension of the same study is carried out for another two years but with slight modification. In the current project western part of the Uttar Pradesh was surveyed for lichens as well as awareness regarding the biodiversity, especially of lower plants was spread. A total of 10 'Biodiversity Awareness Workshops' were conducted to the forest officials, school-college children who are direct stakeholders of the biodiversity (Table 1). The awareness regarding lesser known plant such as lichens are added as special topic in the workshop.

To begin with relevant literature in Hindi were gathered, some handbills/ folder (pamphlets) and posters were prepared for display and distribution purpose. As many as 19 resources persons within CSIR-NBRI, Lucknow and host organizations are delivered lecture on range of topics and interacted with the participants. The LCD projector and screens were hired for the workshop whenever it was unavailable at host organization. The specimens of most common lichens of India and Uttar Pradesh are mounted and displayed at the venue of workshop. The participants of the workshop are provided with envelope containing notepad, pen, pencil, eraser, sharpener, name badge and clip, and reading material. Also, all the participants of the workshops are distributed with 'participation certificates'. Sometimes Biodiversity Quiz' competition were also held and prizes were distributed. In some workshop most active participant was recognized and felicitated with mementoes. Whenever possible written feedback was collected from the participants of the workshop.

In all the workshops emphasis was given to explain the importance of biodiversity and threats. Biodiversity uniqueness of Uttar Pradesh was explained with beautiful pictures and presentations. Also, a lecture regarding simple steps that students can take for conservation of biodiversity is provided. The mode of presentation was bilingual (Hindi-English) or only Hindi for all the workshops. The workshop was usually interactive type where both facilitator and students exchanged their views on biodiversity conservation.

Conclusion

It can be noted that more than 750 students of school-college and about 100 foresters were benefited by the workshops. The participants are curious to know about biodiversity and are highly interactive. During the interaction with the students expressed their concern regarding biodiversity loss and informed commitment for conservation. For example, when they shop, buy products from companies that value the environment and people, because companies sell what people want to buy. The students promised to share their experiences with family, friends and community members and encourage them for caring biodiversity. The student would keep their surrounding clean, actively participate and extend cooperation in any environmental or biodiversity related activities happening at their neighbourhoods. The students also promised to follow 3 R formula (reduce, reuse, recycle) whenever possible. Students not only plant a local tree species, but also care for it. They stop buy or eat endangered species, avoid pesticide in family forming and start composting at home for home garden or community garden.

The Biodiversity Workshops were successful in sensitizing school-college children for conservation of biodiversity. There is a need for more such workshops, particularly for the children residing close to forested area. Such extracurricular activity not only creates interest in studies but also gives hopes for effective conservation of biodiversity.

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Ecotourism: An Opportunity for Biodiversity Conservation and Livelihoods

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Introduction

Biodiversity is the variety of life, in all of its many manifestations encompassing all forms, (plants, animals and microorganisms) and at all levels of biological organization which includes genetic diversity, species diversity and ecosystem diversity (Christ *et al.*, 2003;Gaston and Spicer, 2004; Meduna *et al.*, 2009; CBD, 2012). The earth's biodiversity constitutes valuable natural resources in economic, cultural, aesthetic, scientific and educational terms, providing enormous amounts of both monetary and non-monetary benefits to humankind.

Ecotourism- Global Scenario

Ecotourism is defined as responsible travel to natural areas that conserves the environment and improves the well-being of local people. Ecotourism has been considered as the impetus and economic investment for management of natural resources (Kolahi *et al.*, 2013). Another important aspect of ecotourism is the encouragement of active participation by the local population in the conservation and education dimensions (Aramde *et al.*, 2012). Currently, ecotourism is becoming the fastest growing segment of tourism. On a global scale, ecotourism is

Ecotourism represents a set of principles that have been successfully implemented in various global communities, and are supported by extensive industry and academic research. Ecotourism is about uniting conservation, communities, and sustainable travel. This means that those who implement and participate in ecotourism activities should follow the following ecotourism principles

- â Minimize impact.
- â Build environmental and cultural awareness and respect.
- â Provide positive experiences for both visitors and hosts.
- â Provide direct financial benefits for conservation.
- â Provide financial benefits and empowerment for local people.

Ecotourism first grew out of the global environmental movement in the late 1970s. While the development and growth of ecotourism took various paths in different parts of the world, by the early 1990s, ecotourism, along with nature-based, cultural, heritage and adventure tourism, had become among the fastest growing sectors of the tourism industry worldwide.

Sustainable Tourism and Ecotourism

There is just a thin line of differentiation between sustainable tourism and ecotourism, which also shows that there is as such no absolute boundary between sustainable and unsustainable tourism (Eriksson, 2003). According to Weaver; Ecotourism exists within the broader classification of tourism types which, at an initial level, can be divided into 'mass tourism' and 'alternative tourism' (Fig.1). The differences between mass tourism and ecotourism are shown in Table 1.

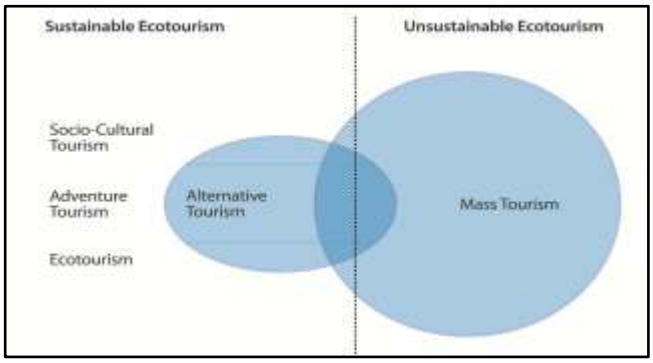

Fig. 1. Conceptual model of tourism (Eriksson, 2003)

Table 1: Distinct characteristics between mass tourism and ecotourism (Dorobantu & Nıstoreanu, 2012)

Characteristics of Mass Tourism	Characteristics of Ecotourism
Large groups of visitors	Small groups of visitors
Urban	Rural
Touristic general marketing activities	Eco-marketing activities.
Average prices for purposes of market penetration	High price with purpose of filtering the market
Impact on natural environment	Little impact on the natural environment
Advanced control options	Limited possibilities of control
Management based on macroeconomic principles	Management based on local economic principles
Anonymous relationship between visitors and local community	Personalized relationships between visitors And local community
General development goals	Local development objectives
Behavior-oriented leisure activities/entertainment, opponents to education and training actions	Loyalty in the process of training and education for appropriate conduct for the natural environment
Intensive development of tourism facilities	Reduced development of tourism facilities

Ecotourism is a component of sustainable tourism

Ecotourism is a component of sustainable tourism. In many ways, sustainable tourism exemplifies the relationship between ecotourism and sustainable development (Bansal & Kumar, 2011); Sustainable tourism will focus on three areas:

- **Quality** – valuable experience for visitors and increased life quality for host communities through cultural identity, poverty reduction and environmental quality;
- **Continuity** – exploitation is made at the optimum level that allows the preservation and regeneration of the natural resources;
- **Balance-** between the needs of tourism industry, environmental protection, and local communities by an equitable distribution of benefits among stakeholders.

Importance of Ecotourism

1. Ecotourism occurs in natural areas (most often protected areas) and/or places of unique ecological or cultural interest.
2. Ecotourism contributes to conservation or preservation of the natural resources and promotes stewardship of natural and cultural resources.
3. Ecotourism should create necessary funds to promote permanent protection of ecological and socio-cultural resources.
4. The local residents accrue economic and social benefits thereby contributing to project's long-term success.
5. Ecotourism incorporates environmental and cultural education.
6. Ecotourism should be effectively managed for the long-term through minimal negative impacts on the host environment.
7. Ecotourism should provide a quality tourism experience.

Biodiversity Conservation through Ecotourism

Common approaches to protecting biodiversity include creation of parks and protected areas, establishment of natural reserves, and implementation of integrated conservation and development projects (ICDP), Establishment of Butterfly Parks, Sparrow Parks, Vulture safe zones, Vulture Restaurants etc. They vary in strictness of conservation in terms of human consumptive uses.

Protected Areas

Protected areas (PAs) play critical roles in safeguarding biodiversity and maintaining the crucial services provided by the natural systems. They have an important role in the evolving challenge of maintaining a sustainable world (Borrie *et al.*, 1998; Groombridge, 1992). Currently, more than 161,991 areas have been reported as PAs in the World Database of Protected Areas and the number continues to increase (Kolahi *et al.*, 2013). PAs have long been the only way to conserve ecological regions from the other forms of land These areas are therefore the cornerstone of most national strategies to protect Biodiversity and Natural resources (Hockings *et al.*, 2005; Leverington *et al.*, 2010) playing a key role in the sustainable utilization and attainment of natural resources. The success of the Ecotourism initiatives reflects the concern for achieving a balance between conservation of the sanctuary and livelihood of people living in and around it.

Zoo as Tourist Attraction

A zoo is a collection of wild animals in captivity and may include 'zoological gardens, biological parks, safari parks, public aquariums, bird parks, reptile parks, insectariums, and other collections of wildlife primarily for public exhibition, education, scientific, and conservation purposes'. The World Association of Zoos and aquariums states that, a zoo is a 'venue for researchers and visitors to meet, thus assisting with the public understanding of science and offering opportunities to raise awareness about research and its conservation implications' and has a 'powerful part in achieving global sustainability and should inspire people. As a tourist destination, zoos are the 'primary institutional location of wild animal presentation' and are very much part of the 'tourist trail'. Zoos as a tourist attraction are controversial because of the perceived conflicting roles of zoos (Harrison, 2004; Mazur, 2001).

Zoo's Role in Conservation

The mission of the World Association of Zoos and Aquariums, an international organization of zoos and aquariums, is to 'set standards for increasing achievement of conservation' among zoos worldwide. Integrated conservation consists of ex situ breeding of threatened species, public education, training and research, and support for in situ conservation of species (especially those with small among zoos and broader collaboration of zoos with other relevant organizations and institutions in various conservation initiatives.

Captive Breeding

Well-managed captive breeding programs in zoos are essential in maintaining a good collection of threatened species. On way to address this concern is for zoos to carefully select and prioritize the species that have to be bred in captivity. For each species, a genetic management strategy that is built on the genetic and demographic characteristics of the captive populations should be developed to avoid inbreeding, early mortality, and consequently population loss (Ellis & Seal, 1996).

National Parks and Sanctuaries

National Parks provide ample opportunities to the visitors to have a close encounters with the wilds. But what is so exquisite about the Indian National Parks is the variance that they are equipped with. Whether it comes to the flora, avifauna, and aqua fauna, or witnessing various wild forms in their natural surroundings on an elephant or inside a jeep, wild ventures in are simply amazing!. Some of the best jewels of Indian wilderness include the Great Himalayan National Park, Dachigam National Park near Srinagar, Corbett National Park in Uttar Pradesh, which is also a famous tiger reserve, Ranthambore National Park in Rajasthan, and Sundarbans National Park in Wildlife sanctuaries are established by IUCN category II protected areas. India has 515 animal sanctuaries referred to as wildlife sanctuaries category IV protected areas. Among these, the 48 tiger reserves are governed by Project Tiger, and are of special significance in the conservation of the tiger. Some wildlife sanctuaries are specifically named bird sanctuary, e.g., Keoladeo National Park before attaining National Park status. West Bengal. Worth visiting in the East Indian part in "The Land of Rhino" Assam is Kaziranga. Wildlife sanctuaries in India are as a desired Eco-system for rich wildlife and natural habitats

Butterfly Parks

Bannerghatta National Park, near Bangalore,

Fig.2: Butterfly parks to promote Butterfly Ecotourism

Fig. 3: Butterflies observed during Mud-puddling in Butterflies Park

Karnataka, was founded in 1971 and declared as a national park in 1974. In 2002 a portion of the park, became a biological reserve, the Bannerghatta Biological Park. It is a popular tourist destination with a zoo, a pet corner, an animal rescue centre, a butterfly enclosure, an aquarium, a snake house and a safari park. There are ancient temples in the park for worship and it is a destination for trekking. On 25 November 2006, Kapil Sibal, the Union Minister of Science and Technology opened India's first butterfly enclosure at the Bannerghatta National park. It occupies 7.5 acres (30,000 m^2) and houses a butterfly conservatory, a museum, and an audio-visual room. It is a humid tropical climate, with an artificial waterfall and appropriate flora to attract butterflies. The conservatory leads to a second and third dome, which house a museum containing dioramas and exhibits of carefully preserved butterflies (Fig.2). A successful Butterfly Garden/ Park has been set up in the KFRI Sub Centre Campus at Niambur.The prime objective of this project viz., setting up of an insectariums and butterfly house to facilitate education of the public on the significance of nature conservation (Fig.3).

Vulture Safe Zones

Vultures are a critical part of the food chain because they maintain a balanced ecosystem and prevent the unnecessary spread of disease. The dramatic decline of the Indian vulture population is directly linked to animal husbandry practices, namely the use of the painkiller Diclofenac, which is used to treat cattle. With this in mind, the concept of creating a, "Vulture Safe Zone" has been emerged. The Vulture Safe Zone area falls in the Bundelkhand geographic region of Madhya Pradesh, India, which comprises of Chattarpur, Tikamgarh, Ashoknager, Vidisa, Sagar, Damoh, Panna and Satna districts. Expected out-comes of this program include the reintroduction of vultures into the wild from captive breeding centers and the expansion of areas designated as Vulture Safe Zones.

Vulture Restaurants

A vulture restaurant is an undisturbed area where non-toxic, poison-free meat and carcasses are provided for vultures and other scavengers. This

Fig.4: Vulture Restaurant :Vultures feeding on non toxic, poison free carcass

supplementary feeding supports the vultures in times of food scarcity and when young birds fledge as well as provide a safe food source, vulture restaurants provide land owners with a clean and cost-effective way of disposing of waste and unwanted carcasses. (Fig.4). In the last decade, vulture feeding stations have been set up in South Asia (India, Pakistan and Nepal), South-East Asia (Cambodia) and similar programmes also exist in Africa and Europe (Bird Conservation Nepal 2009). In Namibia, the first vulture restaurant was established in 1987 in the Waterberg Plateau Park. The aim was to provide a regular, uncontaminated food source for the Waterberg's declining population of Cape Vultures, a globally threatened species. South Africa developed feeding stations for the Bearded Vulture in 1966 and for Cape Vultures from 1978 Vulture Restaurants at Nepal has been established at Ghachowk , Pokhra in Central Nepal during 2010, Pithauli Navalparsi in 2007 and Gaindahwa Lake established in 2009 . All these were established by Bird Conservation Nepal. The four new Vulture Restaurants were open one in Maharashtra and three in Punjab.In Nagpur Currently, there are six 'vulture restaurants' in Gadchiroli — Marakbodi, Made-tukum, Nimgaon, Yeoli, Navegaon, Krupala and Porla. The first Vulture restaurant was established in Uttar Pradesh in 2013 within Mahavir Swami sanctuary,Lalitpur. Tourist visits directly help to conserve the vultures by providing a sustainable way of feeding the birds. This may ultimately increase vulture breeding success and survival of fledglings once they are independent of their parents.

Sparrow Parks

The House Sparrow (*Passer domesticus*) is closely associated with human habitation and cultivation throughout the world from historic time. House sparrows are opportunist and are able to live wherever there are suitable nesting and roosting sites and enough food, predominantly seeds in winter and invertebrates in summer. The Sparrow is a human habitat companion. House Sparrows play an important role in our ecosystem like they feed their young ones the larvae of the alfalfa weevil and cut-worms, both of which harm alfalfa crops, bio-indicators, seed dispersals and pest control etc. A number of hypotheses have been put forward as possible causes of the decline of House Sparrows in Rural, urban and suburban habitats. Some of the observed and known threats like nests destruction by cats, interspecific and intraspecific competitions, blocking of nesting sites during renovation and predation etc. After concerning about the threats posed by House Sparrow and about their role in our ecosystem, various types of conservational measures are opted and in this, various types of artificial nests are also introduced. These artificial nests can easily be installed on houses for sparrows. The construction is quite simple and it can be used as an alternative for livelihood.

Fig. 5: Sparrow Nest-box helpful from both conservational aspects of House Sparrow and providing the livelihood to local people

Fig. 6: Putting up bat houses creates needed Bat roosting sites for these beneficial insect-eaters

A new theme of Sparrow Park should be initiated which is very easy to setup with the installation of numerous artificial nests in and around the park and plantation of numerous bushy plants such as *Bambusa vulgaris* (Bamboo), *Nerium indicum* (Kaner), *Vachellia nilotica* (Babool) etc. where the little sparrows can roost upon. The place must be ensured with special provision of food (Kakun is the most preferred food) and water. Sparrow Parks can thus make a perfect place for tourists where they can enjoy the sighting of House Sparrow in their natural habitat and help in their conservation. Conservational organizations can appoint various individuals for the regular monitoring of the birds and construction of artificial nests. This will be helpful from both conservational aspects of House Sparrow and providing the livelihood to local people (Fig.5).

Palm-Tree Barn Owl Park

Barn owls are found throughout most of the World, but populations are declining in eastern states. They inhabit every continent except Antarctica. The Barn owl is a cavity nester, preferring large tree cavities or shallow caves in cliffs as historical nesting sites. Due to lack of suitable nest cavities, barn owls often nest in a variety of unsuitable places that are not acceptable to landowners. These places include crevices between hay bales, air vents, window ledges, and open stairways. As a very opportunistic species, Barn owls will nest in unsuitable sites that offer promise, but end up with limited nesting success such as palm tree nests. Artificial nest box is put up on Palm Tree in an area and that area considered as palm tree Barn owl Park (Fig.7). Nest boxes will create more and better nesting sites, increasing the reproductive success of local owls, as well as helping to keep the nest sites in acceptable.

Amphibian Husbandry

Amphibians comprise a group of vertebrates that display an enormous diversity of natural histories. Within the three orders, anurans (frogs and toads), salamanders, and caecilians, there are more than 6,900 species (www.amphibiaweb.org) with potentially many hundreds more awaiting discovery and description. There are many reasons to keep amphibians in captivity including for purposes of exhibition, education, conservation, preservation, and for hobby and personal interests. Historically, zoos have included amphibians within their herpetology programs and displays; however, as they become more conservation-oriented (versus the menageries of the past), zoos will have to alter their collections to reflect their resources and capacities to carry out this work (Rabb, 2004) (Fig.8). The Amphibian Ark (www.AmphibanArk.org) has estimated that approximately 500 species of amphibians are in need of carefully managed *ex situ* help;

Fig.7: Palm Tree Provide a suitable place for the Nesting and breeding of barn owl

yet, today likely fewer than 31 species are in managed programs.

Construction of Amphibian Enclosures: Regardless of the size, material, or brand, all enclosures should be satisfy the physiological and behavioral needs of the animal, Prevent escape of specimens and food item, Be easy to maintain and Make it easy to monitor the animals.

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Fish Aquariums & Aquaculture

An Aquarium is a transparent tank or a bowl or an artificial pool where live fishes and other aquatic animals are kept.

Fig.8: Woodland Park Zoo uses large Rubbermaid tanks for developing embryos, eggs, and froglets and exhibit and dedicate the space to Amphibian Conservation

The Fish House at ZSL London Zoo- the first Public Aquarium: ZSL London Zoo's `Fish House' opened in May 1853, it was revolutionary for its time, the possibility of making tanks from large sheets of plate glass enabled visitors to have an underwater view of the life in tanks. Additionally it had only recently been recognized that fishes absorbed oxygen from water and replaced it with carbonic acid. Plants absorb this and return oxygen to the water leaving a more balanced system within the tanks. Although fairly simple in principle it was more difficult in practice to maintain a balance. These developments and the opening of the Fish House led to a Victorian craze for aquaria in the home (Fig.9).

Aquaculture includes fish farming in both fresh and saltwater. The term mariculture is often used for aquaculture that occurs in brackish and saltwater. Aquaculture products are grown in ponds on land or along the coast, and in the ocean in pens and cages or on lines.

Fisheries Have Critical Social and Economic Impacts: Fisheries long have played an historical, cultural, and economic role in coastal communities. For many, fishing isn't just a job— it's a lifestyle. Commercial and recreational fishers alike have deep cultural, social, and financial ties to fishing. Fisheries management strategies affect not only how many fish are allowed to be caught but also who gets what share of the total catch. Seafood is an important source of protein globally. More than 3.5 million vessels currently fish the ocean waters worldwide, and NOAA (the National Oceanic and Atmospheric Administration) projects that the global seafood demand will more than triple by 2025. Recognizing the need to continue to engage a broad and diverse group of people in the development of standards for responsible aquaculture, the World Wildlife Fund initiated eight roundtables, called Aquaculture Dialogues, to create standards that will minimize the key negative environmental and social impacts for selected species.

Turtle Based Ecotourism

The Queensland state government began the process of creating Mon Repos Conservation Park for the conservation of sea turtles in 1981. It offers a unique opportunity for visitors to catch a glimpse of a turtle's world. Turtle watching takes place at night under the guidance of QPWS rangers and volunteers. During the turtle season, evening visitors to Mon Repos Conservation Park pay a small fee for entry. The fee enables visitors to see the display on sea turtles at the information centre, participate in the presentation at the outdoor amphitheatre and join a group of up to 70 persons to be guided to the beach to

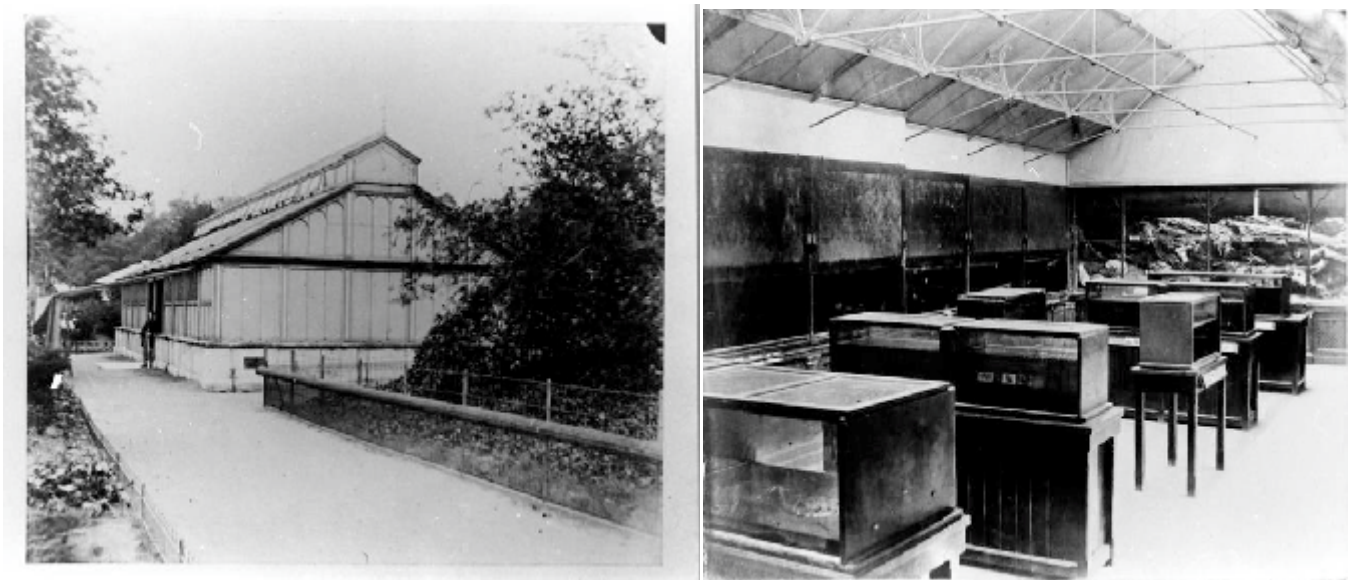

Fig. 9: Fish House: Exterior from the South,Circa 1875 and Inside the Fish House

see turtles nesting, if they appear, or to see hatchlings emerging at times when this occurs. Tourist operations are combined with collection of data about turtles which is used for scientific purposes.

Reptile Rehabilitation & Research Centre

There are various organizations, NGO's and conservational societies are working for their conservation like in India Kukrail breeding centre, Katerniaghat crocodile breeding centre, Kane crocodile sanctuary, Turtle survival alliance, WARCO, Madras crocodile trust etc. and International reptile conservation foundation, Wildlife SOS and Reptile conservation international etc. are few international associations working for their conservation. For turtles, conservation programs are being ran by organizations and breeding centers are established in different cities for providing the breeding space to lay eggs, especially to fresh water turtles, red-crowned roof turtle, spotted pond turtles etc.

Kukrail Reserve Forest / Picnic spot

The centre at Kukrail came up in the year 1978, in which there is a Gharial Centre. It is funded by Uttar Pradesh forest department (Fig.10). The Crocodile Sanctuary and breeding centre is the most renowned centres in India. Apart from breeding crocodiles in the park, crocodile eggs are also collected from the amganga, Suheli, Girwa and Chambal river banks. When young crocodiles come out of these eggs after artificial hatching at the center, they are fed and looked after till they become capable of defending themselves against other predators. This programme has contributed to the rapid improvement in the gharial's status not only in Uttar Pradesh but also in the neighboring states of Madhya Pradesh and Rajasthan. In fact, the captive-breeding programme for gharial is one of the two such successful wildlife conservation programs in the country. The Crocodile Rehabilitation and Research Centre is a crocodile breeding and rearing park at Neyyar, a popular tourist destination near the city of Thiruvananthapuram in Kerala, India. A crocodile farm was started at the site in 1977, accommodating around 44 mugger crocodiles. The number of crocodiles varies as muggers are raised and released to the Neyyar river and lake near the dam site.

Snake Park

There are 270 species of snakes in India out of which about 60 are highly venomous. The King Cobra found in India is one of the most beautiful snake and the largest venomous snake in the world. The big four member of highly toxic snakes in India are Nag “Indian cobra”, krait, Russell's viper and Saw-scaled viper. Snake Park in Badu Kolkata and Nehru Zoological Park Hyderabad also refer as snake parks for conservation and educational purposes.

Fig.10 : Ghariyal Rehabilitation Centre,Kukrail Picnic Spot,Lucknow. (Source:Lucknow)

Snake Park: A well-appointed place for snake

Katraj Snake Park, Pune

One of the best of the few snake parks in India, Katraj Snake Park is housed in the much more modest Rajiv Gandhi Zoological Park. There is a plenty of reptiles including Indian rock python, king cobra and Russell's viper. There are over 22 species of snakes. Bannerghatta Snake Park, Near Bangalore: Located in a huge biological park, this snake park is famous for kraits and monitor lizards. Parassinikkadavu Snake Park, Kannur: There is a large variety of both venomous and non-venomous snakes including python, spectacled cobra, king cobra, kraitand pit vipers. There's also a live show where trained experts play and interact with snakes to try and eradicate various myths about snakes. Guindy Snake Park, Chennai: Formerly known as the Madras Crocodile Bank Trust, Guindy Snake Park is home to a varied collection of snake species like king cobra, pythons and vipers.

Wetlands Ecotourism

Bird watching has become a particularly important form of ecotourism and one that is particularly common for wetlands (Fig. 11). Canoeing, kayaking, and fishing also take place in wetlands. Ecotourism can educate landowners and businesses with regard to the functions and values of wetlands. It can provide landowners, local governments, and local businesses with economic and cultural incentives for conservation of wetlands and other resources. Wetland-related facilitates can, if properly sited and designed, both meet the needs of ecotourists while protecting resources. They also include interpretive centers, picnic facilities, parking lots, and food and lodging facilities on adjacent lands if properly sited and constructed. Even limited wetland-related facilities may play an important part in meeting regional needs.

At present stage, researches on wetland ecotourism mainly focused on status analysis and characteristic description and there have been no systematical theoretical method or research method for wetland ecotourism and research methods in landscape ecology and wetland ecological system were adopted as reference. Wetland ecotourism has a promising development prospect and constant

Fig.11: Ecotourism can educate students, landowners and tourists with regard to the functions and values of wetlands

exploration needs to be conducted by relevant researches to promote its development.

Recommendations

Ecotourism has become an important economic activity in natural areas around the world. It provides opportunities for visitors to experience powerful manifestations of nature and culture,

and to learn about the importance of biodiversity conservation and local cultures. Ecotourism also generates income for conservation and economic benefits for communities living in rural and remote areas.

- Joint research in ecotourism is a necessary tool in management of ecotourism activities.
- There is a need for long-term research on issues, as well as the investigation of other sites experiencing tourist pressures.
- Research is also needed to determine what levels and rates of tourist traffic trigger negative impacts on wild life. This will enable park managers to set levels that will minimize the impacts on the biodiversity the parks are established to protect.
- Promoting community-based enterprises that benefit the local communities, including carrying capacity of ecotourism sites are also important aspects that should be looked into future.
- In effect, science-based management of ecotourism and biodiversity conservation would make sound decision-making.
- Investing in research makes good business sense since the information generated in such activities pay off in customer satisfaction, value of the final tourist product, long-term economic sustainability, and appeal to mass media.
- Economic activity is one of the major drivers of biodiversity loss; Successful ecotourism requires maximizing its environmental and economic benefits while minimizing ecological damage. But unfortunately all the eco - tourism projects are not completely successful in attaining their objectives. Environmental deterioration and inequitable development, many a times has been found as ill impacts of eco- tourism.

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Importance and Scope of Lesser Known Tree Species in Livelihood and Biodiversity Conservation

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Introduction

Rural men and women, especially in poor households, engage in diverse and multiple activities to improve their livelihoods by maximizing income-generating activities, while minimizing vulnerability and risk, and achieving other household objectives (improved health, nutrition and education, etc.) (Shoji Lal Bairwa *et al.* 2014). The livelihoods of forest communities depend largely on the renewable goods and services from the natural resources as well as activities that impact the integrity of the forests and disrupt the livelihoods of the dependent communities. As one of the oldest civilizations of the world, India has kaleidoscopic multiethnic society, the forest being an integral part of its rich socio-cultural heritage. Traditionally, the Indian society depended on a large number of plant species for its subsistence and sustenance needs.

However, with the advent of so- called "Scientific Forestry", the emphasis shifted mainly on a few timber species, which were essentially required by the British government for its industrial development. As all the management plans focused on a few commercially important species like Teak and Sal, coupled with increasing biotic interference, over–exploitation and consequent forest degradation, other important species gradually became lesser known. Besides, there are a large number of species, which have traditionally been used for food and nutritional supplements and are consumed at local levels only. Species like *Ficus, Averrhoa carambola* and *Cordia myxa* etc. are gradually disappearing from the forests although they have a good potential for commercial exploitation (Tomar, 2008). These species are rarely planted in afforestation and agro forestry programmes, as a result of which these are disappearing from the natural habitat. Many of these species are widely used in Ayurvedic preparations. These species are very valuable to the local communities for meeting their day-to-day requirements for food, fodder, fuel, medicines, tans, dyes etc., and can provide cash returns to the villagers.

Such many species useful for contributing to food security, health (nutritional / medicinal), income generation, and environmental services. In past, these species were cultivated and their used were harvested up to their potential. And they were well known among the people. But with time, due to lack of awareness and research in field of their biology, silviculture, management, utilization and marketing aspects, these species have become vulnerable and less common to common man.

Being less known these rarely planted in afforestation and agro forestry programmes, as a result of which they started disappearing from natural habitat and included into the category of plants which are less known to common man and hence the term lesser known originate. Though it is difficult to define just what qualifies as a 'lesser known'. Terms such as 'underutilized', 'neglected', 'orphan', 'minor', 'promising', 'niche' and 'traditional' are often used interchangeable in different countries of the world.

"Lesser Known Tree Species those which are little known or known only locally, their existence is ignored because better known or more commercial important tree species predominate in the forest. LKTS though more viable and potential, drawn less attention in past, now needs recognition, awareness and focus.

The lesser known tree species represent an enormous wealth of agro biodiversity and have great potential for contributing to improved incomes, food security and nutrition and for combating the 'hidden hunger' caused by micronutrient (vitamin and mineral) deficiencies. They are strongly linked to the cultural heritage of their place of origin. Also many are mainly local and traditional crops or wild species whose distribution, biology, cultivation and

uses are poorly documented. These species have weak or no formal seed supply system. They are collected from wild or produced in traditional production systems with little or no external inputs. Also these species receive little attention from research, extension services, farmers, policy and decision makers, donors, technology providers and consumers. They may be highly nutritious and/ or have medicinal properties or multiple uses (Tomar *et al.* 2006)

In particular those currently identified as 'lesser known', can contribute significantly to improved health and nutrition, livelihood, household food security and ecological sustainability, these tree species offer enormous potential for contributing in combating hidden hunger and offering medicinal and income generation options. They are also closely tied to cultural traditions, and therefore have an important role in supporting social diversity. (Hoeschle-Zeledon, I. and Jaenicke, H. 2009).

In recent years, LKTS have come out of the shadows and are moving fast into the limelight of rural development. Several national research systems are supporting work on these plant species, though not to the same extent as research on other timber species like Teak, Poplar, Eucalptus, Sisoo, etc. Policy makers and funding agencies are now recognizing the value of LKTS for diversification of biodiversity, which will in turn help to buffer the risks of environmental and economic disasters. However, these efforts need direction and focus.

LKTS can contribute significantly for up scaling livelihood such as :

1. For providing fuel, fodder, medicines, fruits, vegetables, gum, oils, lac, dyes, lac, tannins fibers, flosses, honey, host for silkworm, lac insect, bees, etc. for numerous domestic requirements.
2. For providing small wood, timber, etc. for agricultural implements, house construction, furniture, mats, baskets, packing boxes, etc. for household use.
3. For income generation.
4. For conserving cultural heritage.
5. For improving aesthetic view and conserve environment.

Factors responsible for interest in the lesser known trees :

1. Their role as alternative sources of income.
2. Collapse of commodity prices.
3. Greater appreciation of bio-diversity's role in setting research agendas.
4. Stronger national agricultural research systems, willing to invest beyond primary commodities.
5. Search for cultural identities in a globalised, more mobile world.
6. Demand for traditional food in large multi-ethnic cities.
7. Better understanding of the limits of the green revolution

Conclusion

Scientifically much more work is required to be carried out in Lesser Known tree species, facing various degrees of threats. Authors strongly feel that there is an urgent need to document the inventory of their habitats; uses and cultivation practices since many such treasures being ignored and some of these have started disappearing. We must arrest this trend. Adoption of such an approach will go a long way in conservation of lesser known tree species, their planting and maintenance is recommended.

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Sustainable Management and Biodiversity Conservation

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Introduction

The variety of life on Earth and its biological diversity is commonly referred to as biodiversity. The number of species of plants, animals and microorganisms, the enormous diversity of genes in these species; the different ecosystems on the planet such as deserts, rainforests and coral reefs are all part of a biologically diverse Earth. Biological diversity means the variability among all living organisms from all sources including inter alias, terrestrial, marine and other aquatic ecosystems and biological diversity within a species and of ecosystems. *Biodiversity is the degree of variety in nature and not nature itself.* Indian cosmology estimates 84 lakh species of living organisms in the entire universe.

Biodiversity of India

Out of the 1.4 million known species of living organisms only about 2,50,000 are higher plants and 1.03 million are animal (WWF, 1989). According to another estimate, worldwide there are 2,70,000 known species of vascular plants.

Estimated number of known species worldwide

S. No.	Taxonomic Group	Number of Species
1.	Blue Green Algae	1700
2.	Bacteria	3600
3.	Fungi	46983
4.	Bryophytes	1700
5.	Gymnosperms	750
6.	Angiosperms	2,50,000

India is a mega diverse nation, housing around 10% of world's species. India also has a rich cultural heritage going back thousands of years. Much of Indian biodiversity is intricately related to the socio-cultural practices of the land. Unfortunately, due to population explosion, climate change and lax implementation of environmental policies, several species are facing the threat of extinction. Not only does this affect the food chain, but also the livelihood and the culture of millions of Indians who depend on local biodiversity. Nature has endowed India with a rich biological diversity, which includes over 40,000 species of plants and 75,000 species of animals. India has about 12% of the global plant wealth amongst which there are nearly 3,000 tree species.

Estimated number of plant species in India

S. No.	Taxon Group	Number of Species	Percentage
1.	Bacteria	850	1.87
2.	Fungi	23000	50.79
3.	Algae	2500	5.52
4.	Bryophytes	2843	6.2
5.	Pteridophytes	1022	2.25
6.	Gymnosperms	0.64	0.14
7.	Angiosperms	15000	33.1

(Source: BSI, 1994)

Salient Features of Indian Flora

Amongst the various families of flowering plants in Indian the dominant are –

Orchidaceas, Leguminanceae, Gramineae, Rubiaceae, Euphorbiaceae, Acanthaceae, Compositae, Cyperaceae, Labiatae and Urticaceae. Amongst the families, Labiatae and Compositae are

more abundant in the temperate regions while the rest are largely tropical in distribution. One interesting feature of the Indian flora is that Composite, which is the richest family of flowering plants in the world, has a relatively low position in Indian flora. There are hundreds of species of grasses, over 100 species of Bamboos and more than 25 species of conifers in India.

Endemic Flora in India

S.no.	Dicots	Total number
1.	Species	11124
2.	Genera1	1813

Due to Green revolution in India, India become self sufficient in food production but now a days the productivity of most of the food crops- paddy ,wheat, sorghum, pearlmillet, soyabean, sugarcane etc. is stagnant or declined in spite of heavy input cost. Today, more food is produced per person than ever before in earth's history. This success however has come with the costs of the sustainability of agriculture and biodiversity.

Loss of Crop and Genetic Diversity

Crop diversity has declined on most of farms over the last century due to mechanization because mechanization requires farms to have uniform crop types, structure and management practices. For example, traditional farm includes grains, pulses, vegetables, spices, medicinal plants, livestock and trees. In contrast, most modern farms are monocultures – one crop species planted over a large area. The genetic diversity of crops has declined with industrial agriculture. Although hundred of edible plant species have been important in traditional crop systems, today only three crops- Rice (Paddy), Wheat and Maize provide 60% of our plant based diet worldwide.

Agricultural Biodiversity

Agricultural Biodiversity includes all components of biological diversity of relevance to food and agriculture. The variety and variability of plants, animals and micro-organisms at genetic, species and ecosystem level which are necessary to sustain key functions in the agro-ecosystem.

Agriculture Biodiversity includes:-

- Higher plants, wild plants harvested and managed for food, tree on farm, pasture and rangeland species
- Higher animals-domestic animals, wild animals hunted for foods, wild and farm fish
- Arthropods- mostly insets including pollinators e.g. bees, butterflies, pest (beetles, wasps) and insect involved in the soil cycle (termite)
- Micro-organisms (rhizobia, fungi, disease producing pathogens)
- Other macro-organisms e.g. earthworms

Agricultural biodiversity is essential to the world for the following functions:

- Wider ecological services provided by agro-ecosystems, such as landscape protection, soil protection and health, water cycle and quality, and air quality.
- Sustainable production of food and other agricultural products, including providing the building blocks for the evolution or deliberate breeding of useful new crop varieties.
- Biological support to production via, for example, soil biota, pollinators and predators.

Components of Agricultural Biodiversity

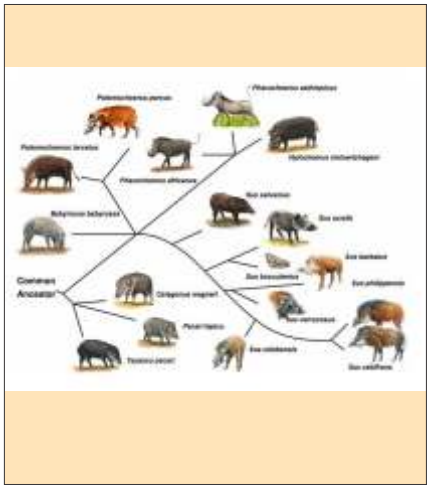
Wild Plant Biodiversity:

Foods from wild species from an integral part of the daily diets of many poor rural households. They are important source of vitamins, minerals and other nutrients and also represent ready sources of income for cash-poor households.

Crop Diversity:

Of the 2,70,000 species of higher plants, about 7000 species are used in agriculture but only three (Wheat, Rice and Maize) provide half of the world's plant-derived calorie intake. Genetic diversity is vital for the evolution of agricultural species and their adaptation to particular environments through a mixture of natural and human selection. In crop agriculture, for some species, this selection has led to the development of many thousands of landraces or farmer's varieties.

Aquatic Diversity:



Live stock Diversity:

Arthropod Biodiversity:

Aquatic Diversity:

Fish and other aquatic species are integral parts of several important farming systems.

Live stock Diversity:

Of about 50000 known mammal and bird species, only about 40 have been domesticated. These species provide people not only with food but also clothing, fertilizer and fuel (from manure) and draught power. From these species farmers and breeders have developed about 5000 identified breeds to fit local environment conditions and to meet specific needs.

Below-Ground Biodiversity:

In tropical systems, the contribution of roots to soil organic matter is proportionately larger than from above-ground inputs. The effect of roots on soil biophysical properties is particularly critical in impoverished farming system where crop residues are at a premium for fuel and fodder.

Arthropod Biodiversity:

It is well known that insects, spiders and other arthropods often act as natural enemies of crop pets. Insects and arthropods are also important pollinators of many crops. Bees and other pollinating insects are essential agents for the production of many crops.

Microbial Diversity:

Microbes contribute a wealth of gene pools that could be a source of material for transfer to plants to achieve traits such as stress tolerance and pest resistance and large scale production of plant metabolites.

Conservation and Enhancement of Agricultural Biodiversity

To achieve such transformations for the conservation and enhancement of Agricultural biodiversity, the following strategic principles are as follows:

- Conservation of plant and animal genetic resources-especially in situ efforts- help protect biodiversity for current livelihood security as well as future needs and ecosystem functions.
- Application of agro ecological principles helps conserve uses and enhance biodiversity on farms and can increase sustainable productivity and intensification, which avoids extensification, thereby reducing pressure on off-farm biodiversity.
- Adaptation of methods to local agro ecological and socio-economic conditions, building upon existing successful methods and local knowledge, is essential to link biodiversity and agriculture and to meet livelihood needs
- Conservation of plant and animal genetic resources-especially in situ efforts- help protect biodiversity for current livelihood security as well as future needs and ecosystem functions
- Reforming genetic research and breeding

programs for agricultural biodiversity enhancement is essential and can also have production benefit.

- Creating a supportive policy environment-including eliminating incentives for uniform varieties and for pesticides and implementing policies for secure tenure and local rights to plant genetic resources-is vital for agricultural biodiversity enhancement and for food security.
- Participation and empowerment of farmers and indigenous peoples and protection of their rights are important means of conserving agricultural biodiversity in research and development.
- Practices for soil fertility/health and nutrient recycling also make use of agricultural biodiversity. Example,
    1. Intercropping and cover crops, particularly legumes, which add nutrients, fix nitrogen and pump nutrients to the soil surface.
    2. Use of mulch and green manures (through collection and spread of crop residues, litter from surrounding areas and organic materials).
    3. Elimination or reduction of agro-chemicals-especially toxic nematicides-that destroy diverse soil biota, organic material and valuable soil organism.
    4. Compost from crop residues, tree litter and other plant /organic residues.
    5. Integration of earthworms (vermiculture) or other beneficial organisms and biota into the soil to enhance fertility, organic matter and nutrient recycling.

Conclusion

It is vital that the common man is made aware of the domino effect of species loss and what we stand to lose. *Project Brahma* aims to create such awareness, by increasing participation of the people in biodiversity documentation and conservation. In addition, there are several organizations carrying out notable conservation work in India. The aim is to create a central resource where such organizations can access all kinds of knowledge about Indian biodiversity.

Non-Timber Forest Produces for Livelihood Security

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Introduction

Forests provide significant social and economic benefits at all level, especially in developing countries. Economics of people living in forest has traditionally been dominated by subsistence agriculture. However, non-timber forest products (NTFPs) play vital role among the tribal people and provide a source of subsistence, income and livelihood security (Peters *et al.* 1989; Hegde *et al.*1996). The broad term "non-timber forest resources" (NTFR) or "non-timber forest products" (NTFP) refers to natural resources collected from forests apart from sawn timber. Chamberlain et al. (1998) provides a definition: non-timber forest products are plants, parts of plants, fungi, and other biological materials which are harvested from within and on the edges of natural, manipulated or disturbed forests. NTFP may include fungi, moss, lichen, herbs, vines, shrubs, or trees. Forest is an important renewable, natural resource, which greatly influences the socio-economic development in any rural community (Ghosal, 2011). NTFPs like fuel-wood, medicinal plants, wild edible vegetables, house building materials etc. are an integral part of day-to-day livelihood activities, especially for tribal people (Sarmah *et al.* 2006).

The harvest of NTFPs remains widespread throughout the world. People from a wide range of socio-economic, geographical and cultural contexts harvest NTFPs for a number of purposes, including but not limited to: household subsistence, maintenance of cultural and familial traditions, spiritual fulfillment as well as physical and emotional well-being, scientific learning and income (Kala, 2013). Other terms synonymous with harvesting include wild-crafting, gathering, collecting and foraging. NTFPs are used in industries for different variety of activities.

The Present Plights and Importance of NTFPs

NTFPs provide important products for local, national and international markets. These markets are growing rapidly and steadily (Wilkinson & Elivitch, 2000). Non timber resources have great potential for enhancing sustainable rural development and diversified economic growth, cultural endurance, and environmental health. Few NTFPs have low cash values and hence are used for consumption, rather than for sales whereas rest NTFPs have highly commercial value. NTFPs are significant especially for poor, because they are available at low cost on common property lands. They are used by 3 people because they have less alternative access to food and income. In a country like India, which has more than half of its population in rural areas and a large tribal population reliant on forest produce for their sustenance, NTFPs play a major role (Sawhney and Engel, 2003).

Types of NTFPs

The important NTFPs of economic value in India can be categorized as following:

1. Grasses, bamboos and canes
2. Tans and Dyes
3. Oils
4. Gums and Resins
5. Fibres and Flosses
6. Leaves
7. Drugs, spices and poisons
8. Edible products
9. Animal products

Role of NTFPs in livelihood security

At global level, more than two billion people are dwelling in forest, depending on NTFPs for subsistence, income and livelihood security (Vantomme, 2003). NTFPs are considered to be important for sustaining rural livelihoods, reducing rural poverty, biodiversity conservation, and facilitating rural economic growth (Global NTFP partnership, 2005). An estimated 80 % of the

population of the developing world uses NWFP (Non-Wood Forest Products) to meet some of their health and nutritional needs (FAO, 2008). It is an important source of income for the poor in many developing countries. In addition, several opportunities for improved rural development are linked to NTFP (Adepoju, 2007). In India over 50 million people are dependent on NTFPs for their subsistence and cash income (Hegde *et al.*, 1996). This provides 50 % of household income for 20 to 30 % of rural population particularly for tribal. Potentially around 3000 species of forest products are found to be useful, but only 126 have developed marketability (Maithani 1994). Around 50 % of forest revenues and 70 % of forest based export income of the country comes from NTFPs. Thus it can be depicted that NTFPs form one of the mainstays of income and sustenance for many tribal communities (Rao, 1987; Gauraha, 1992; Chopra, 1993; Mallik, 2000). Forests are associated with socio-economic and cultural life of tribals in India. These tribal groups inhabit wide ecological and geo-climatic conditions in different concentrations throughout the country. Tribal livelihood systems vary considerably between different regions as also among the various ethnic groups, depending on ecological, historical and cultural factors. These tribal communities largely occupy the forest regions since time immemorial, living in isolation from the mainstream life, maintaining harmony and a symbiotic relation with nature. The collection of NTFPs by tribals was primarily for meeting their subsistence needs. Over time, these NTFPs acquired commercial value resulting from huge trade transactions and income levels due to rising demand. Trade in NTFPs can act as an incentive for forest conservation by providing a source of income from resources that might otherwise appear to have little financial value (Cottray *et al.*, 2003).

Constraints in development of NTFPs for Livelihood

The tribal communities living on the edge of the forests have developed a unique system to make sustainable use of food and biomass for their survival. In the absence of assured supply of these NTFP, particularly food products, tribals migrate to urban and semi-urban areas to meet their basic needs. In spite of such a critical demand for these products, no serious efforts are being made to enhance the productivity of these NTFP and ease the supply of these commodities for local communities. Furthermore, in spite of severe shortage of NTFP, most of the local communities are reluctant to procure commodities such as fuel wood, charcoal and forage from alternate sources, due to poor buying power and chronic poverty.

With regard to the other two categories of NTFP such as medicinal herbs, aromatics, dyes and oilseeds, there has been a good demand for many commodities, not only in India but from all over the world. Systematic collection, value addition and marketing can help in enhancing the cash income of the local population and promoting international trade. However, there is a significant gap between the demand and supply situation. Generally, the demand for these products has been fluctuating due to the availability of alternatives, which are cheaper, although inferior in quality. As the NTFP collectors are located in remote areas, a large number of middlemen are involved in taking the products to processors and consumers. In such a situation, the NTFP collectors neither receive correct information about the product demand and uses nor do they get a fair price to even cover their labour charges for the collection of the products. These problems should be taken into consideration while developing a strategy for promotion of NTFP for providing sustainable livelihood to the local communities.

In spite of huge forest resources and abundant production of NTFP, most of these products are not optimally utilised by the local communities. In case of non-edible oilseeds such as Neem, hardly 20% of the total production is collected and utilised while the remaining quantity is wasted. With regard to aromatics, dyes and medicinal plants, there has been total neglect about their utilization in general, barring a few species, which have been over exploited. It is therefore necessary to understand the problems of NTFP and develop a strategy to optimise their collection and utilisation.

The products like *Terminalia bellerica, Terminalia chebula* and *Emblica officinalis* are available in plenty and they have good demand in the local market. Nevertheless, the tribals are finding it very difficult to collect the available NTFP due to poor price realisation and hurdles faced by them due to adverse Government policies. Furthermore, the collection of these products alone will not be able to provide them sustainable livelihood. Realising the above problems, BAIF has initiated the promotion

of NTFP in selected locations in Maharashtra (Thane, Nandurbar and Nashik districts) and Gujarat (Valsad and Navsari districts) in India. These districts located in the Western Ghat hill ranges are dominated by different types of tribals. As in other parts of the country, these tribals who were mainly dependent on NTFP for their livelihood, have also been deprived of their income due to denuding forest resources and poor price realisation for NTFP. In the absence of alternative sources of livelihood, BAIF has promoted the establishment of agri-horti-forestry on the degraded lands owned by these tribals, while arranging the collection of locally available NTFP as a supplementary activity.

Fruits, leaves, nuts, gums, mushrooms, roots, tubers etc. are important source of food from the forest species. For tribals, these forest products are important sources of emergency food during scarcity. Most of these plants find popular utilization throughout the country. The tribals collect these food in their respective seasons and besides their own consumption, they sell them in the local markets too. The range of food used by local communities varies from locality to locality depending on the availability of resources.

NTFPs collection for livelihood security in Indian scenario

Non- Timber Forest Products play a vital role in livelihood of people in and around the forests (Quang, 2006). Studies in India have revealed that, NTFPs provide substantial inputs to the livelihoods of forest dependent population, many of whom have limited non agricultural income opportunities (Chandrashekaran, 1994; FAO, 1991). About 70 % of the NTFP collection in India takes place in the tribal belt of the country (Mitchell *et al.*, 2003). It would be seen from the literature that the NTFP based small scale enterprises provide up to 50 % of income for 20 to 30 % of the rural labour force whereas 55 % of employment in forestry sector is attributed to the sector alone (Joshi, 2003). Therefore collection of NTFPs was a major source of income and employment for forest dwellers. For instance, tendu leaf collection was observed to provide about 90 days of employment to about 7.5 million people every year in India (Mistry, 1992).

Conclusion

Non-timber forest products (NTFPs) or non-wood forest products (NWFPs) have been considered as minor forest products in many countries. Production and consumption of NTFPs have never appeared as resources of great economics and ecological importance at macro level, but contribute a minor share to the national economy in comparison to commercial timber. However, at micro level, tribal people living in and around forests for centuries have recognized NTFPs as important forests resources. Non-timber forest products refer to all biological materials other than timber, which are collected from natural forests for human use. A study was conducted by Chaudhury (1986) who recorded over 500 plants as being significantly used by the tribals as food, dyes, tannins, drugs, narcotic, drinks, housing instruments, weapons, fibers and medicine etc. NTFPs may provide local job opportunity to two million people every year and contribute significantly to rural economy as more than half of the products are consumed by the tribals living in and around the forest area to meet their basic needs. Thus, the role of NTFPs is very important in the livelihood security of people living in and around the forest areas. Thus, on the one hand, the systematic harvesting of NTFPs will increase employment opportunities among forest- dwellers and on another hand, it may also reduce their over dependence on timber collection which might be efficient to resolve the problem of dry-deciduous forest degradation. Sustainable collection, use and commercialization are the main drivers in the promotion of NTFP's for community development, poverty reduction and livelihood socio- economic improvement in the tribal communities (Shit and Pati, 2012).

It is likely, however, that as forest people broaden their livelihood portfolios, certain aspects of aboriginal forest based culture are likely to be lost. In order to protect forests and forest culture, it is necessary to identify and promote the regeneration of those plants which provide different types of NTFPs, as well as those species which are used primarily for timber production. This will help forest people to maintain their indigenous culture through the harvesting of NTFPs without destroying the resource base. India is a developing country where millions of people are still living at the forest fringe areas and depend on forest products for their livelihoods. The conservation of both forests and forest-based culture coupled with the scientific

harvesting of NTFPs thus can create an attractive opportunity for resource poor forest dependent villagers. In the end, it can be said that presently NTFPs are receiving more and more importance as it is becoming clear that their management can help in creating more employment and income generating opportunities to the socio-economically downtrodden forest communities. With the increasing of scientific and sustainable harvesting of NTFPs, the poverty can be reduced to some extent. Since there is immense potentiality of NTFPs in various forest areas of the south-western part of West Bengal, therefore the economic value of NTFPs should receive proper consideration from government as well as non-governmental bodies. Thus, on the one hand, the systematic harvesting of NTFPs will increase employment opportunities among forest dwellers. At the same time, it will also reduce their over dependence on timber collection which might be efficient to resolve the problem of dry-deciduous forest degradation (Ghoshal ,2011).

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Utility Value for the Sustenance of Local people in the Selection of Species for Bio-reclamation of Silica Mining Area

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Introduction

The Shankargarh area of Allahabad District of Uttar Pradesh State in India has been gifted with huge resources of high quality Silica sand. It is one of the most versatile industrial minerals of the present century being used as glass sand, foundry sand, abrasives, fillers and hydraulic fracturing sand. In view of the good variety and soaring value of the Silica sand deposits found here, it has gained wide economic importance and recognition as a major source of Allahabad district revenues.

Mining operation, undoubtedly, has brought wealth and employment opportunity in the area but simultaneously it has also led to extensive environmental degradation and erosion of traditional values in the society. Therefore, a holistic integrated organic and socioeconomic approach is required to bioreclaim the site which involves restoration of soil health, nutrient supplementation through intelligent and optimum use of biofertilizers, judicious choice of tree species and active willing community participation.

Bioreclamation primarily aims to accelerate natural vegetation succession processes by assisting natural regeneration and artificial regeneration or plantation of selected site with specific suitable socioeconomically beneficial species, so that the entire plant community develops in the desired way over a period of time. The decision of what species to plant is, therefore, most important. Deciding what species to plant has two main aspects. The first aspect of species choice is knowledge about the purpose for which the trees are intended for viz. timber, fodder, fuelwood and softwood etc. This influences the choice because each species has specific blend of attributes and utilities to bring forth. The second aspect of species choice is identification of species which would grow well on the site in question. The selection of species should, therefore, be based on the site conditions and local populace needs. Ignoring perceptions of local people in the beginning of planning phase, which includes the selection of planting species for afforestation, is one of the major impediments for successful implementation of afforestation programmes (Maikhuri *et. al.*, 1997).

Nitrogen fixing native leguminous tree species in a mined land system can result in better soil structure and increased soil nutrient availability. For bioreclamation purposes, indigenous species are preferable to exotics because they are most likely to fit into a fully functional ecosystem and be climatically adapted too (Singh *et al.* 2002). Moreover, vegetative material used in bioreclamation should consist of trees which are consistent with site capabilities such as soil structure and composition, soil depth, pH, available nutrients, drainage and climate. Such vegetation should be so designed as to provide a protective land cover consistent with the stated land-use objectives and which does not constitute a health hazard as well. At the same time, the selected plant species must also fulfill the basic sustenance needs and multiplicity of socio-economic demands of the local people.

Methodology

In the above backdrop, it is now very clear that the most critical element in any bioreclamation project is the cautious selection of appropriate plant species. If the plants are not adapted to the site conditions and do not provide for local inhabitants' basic daily needs and utilities, all bioreclamation efforts are bound to fail. Accordingly, a variety of factors like site conditions, knowledge of indigenous floral diversity of the site and preferential choices of

Table 1: Utility Value of Leguminous Tree Species in Local Forests of Shankargarh Silica Mining Area:

Tree species	Utility Value	Ranking (according to utility value)
Pongamia pinnata	1. Fodder, 2.Apiculture, 3.Fuelwood, 4.Paper pulp, 5.Timber (for cabinet. making, cartwheels, posts, agricultural implements, tool handles and combs), 6. Tannin and dyestuff, 7.Seed oil of commercial use (as a lubricant, varnish, water-paint binder and in soap making and biofuel), 8. Pesticidal activity, 9. Medicine, 10. In India, the tree is a host for the useful lac insect, 11. As a windbreak, 12. Shade , landscape, and moisture conservation.	1st
Albizia procera	1. Fodder, 2. Fuelwood, 3. Paper pulp, 4.Timber, 5.Gum and resin, 6.As Medicine, 7. Insecticidal property, 8. Acts as a wind and firebreak	5th
Pithecelobium dulce	1.Food, 2.Fodder, 3. Fuelwood, 4. Medicinal	7th
Acacia nilotica	1.Fodder ,2. Apiculture, 3. Fuelwood, 4.Charcoal, 5.Paper and pulp, 6.Timber, 7.Gum and resin, 8.Tannin and dyestuff, 9. Have Algicidal and Fungicidal activity, 10. As Medicine, 11. As ideal windbreak and firebreak	2nd
Acacia catechu	1. Fodder, 2. Fuelwood, 3. Charcoal, 4. Timber, 5. Tannin and dyestuff, 6. Gum and resin, 7. Fungicidal activity, 8.Medicine, 9.Extraction of katha, 10.Used for lac cultivation	3rd
Dalbergia sissoo	1. Fuelwood, 2. Fodder, 3. Paper pulp, 4. Timber, 5. Apiculture	6th
Prosopis juliflora	1. Fodder, 2.Fuelwood, 3.Charcoal production, 4.Apiculture.	7th
Acacia leucophloea	1.Fuelwood, 2.Charcoal production, 3.Medicinal	8th
Butea monosperma	1. Fodder, 2. Fuelwood, 3. Gunpowder Charcoal, 4. Fibre for making paper, 5. Gum or resin, 6.Orange-red dye , 7. Bactericidal and Fungicidal activities, 8. As Medicine, 9. Important host for Lac cultivation.	4th

local people should be considered in the selection of species for Bioreclamation. Site characteristics, soil properties and its fertility status are very important factors to consider while selecting plants for Bioreclamation.

Since the study site is low in soil nutrients, self-propelling Nitrogen fixing tree species are ideal candidates for afforestation of such lands. Moreover, the selected species should be able to establish themselves in poor soil and moisture stress conditions of the site. The native species possess adaptations to extreme substrate, moisture and climatic conditions of ruined mine sites resulting in fast recovery of the degraded ecosystem. Therefore, only native leguminous tree species were preferentially selected. The choice of the local people is also an important factor in the selection of species. For local needs, a tree species with several attributes or a mixture of tree species can be planted to obtain multiple utility benefits e. g., ability to enrich soil fertility, wood suitable for fuel and poles and nutritious leaves for fodder etc. The selected species should be of multiple utility value features and should also be able to ease the economics of local people especially the poor, living below poverty line (BPL). Subsistence utility benefits and preferences of tree species guided by the local people were the major acclaimed and convincing reasons in the selection of tree species. Thus, Utility Value concept was developed so as to identify species preferred and also highly valued for sustaining their enduring livelihoods by the local people.

For the above purposes, Phytosociological Study of the fringe forests and Socioeconomic Survey were carried out in the nearby villages of Silica mining area to study the existing resources of the area, social structure of the community, employment patterns, income generation, dependence on forest and species preferred by the local people along with information on other related socioeconomic aspects. The study was performed in Shankargarh area by using Participatory Rural Appraisal (PRA) exercise. The Utility Value of all the leguminous tree species reported in local forest areas of the site was prepared according to various multifarious utility needs of these species for sustaining the livelihoods of local people (Biggelaar and Gold, 1996, Kumar and Bhatt, 2006; Guerrero *et. al.*, 2008). Ranking of each of the species was done according to their Utility Value to local people, as obtained from sum total of all the constituent attributes of every species as shown in the Table 1.

Results and Discussion

Shankargarh is a backward area despite the rich Silica sand mineral resources it has and revenues the Uttar Pradesh State receives from mining of these rich mineral resources. Mining is a capital intensive activity of the area having a rather low level of other economic activities, e.g., agriculture, horticulture and forestry etc. The socioeconomic profile of the local people was obtained from Participatory Rural Appraisal (PRA) technique. The majority of the people are Schedule Tribes (ST) by caste popularly known as Kol. Most of them are landless labourers and therefore, they are placed at the bottom of the social heap and rely mainly on mining and exploitation of available natural resources to somehow drive their household economy. For their recurrent subsistence needs of fuel wood and fodder, they mainly depend on nearby forests. The source of fuel wood is basically dry branches of *Butea monosperma, Acacia nilotica* and *Prosopis juliflora* species etc. from local forests and homemade dried up cow dung cake. The main livestock were cows and goats. Due to non availability of agriculture products, the fodder sources for livestock are wild grasses, leaves of *Zizyphus* sps. *Acacia* sps., *Carissa carandus* etc. and in dry seasons, leaves of *Pongamia pinnata* and *Butea monosperma* from nearby forest or by free grazing and browsing in the forest areas. The unrestricted collection of fuel wood, fodder and grasses is affecting the natural ecological succession and restoration. Fruits of *Emblica officinalis, Carissa carandus* and *Zizyphus mauritiana* were consumed by local people. Leaves of Butea monosperma, locally known as Dhak or Palash, were used for making country cups and plates by the local people for their daily sustenance. A bright orange coloured natural dye is prepared from the flowers of *Butea monosperma*. Its seeds were used in folk medicine. This tree is also used as host plant for lac cultivation.

Despite a natural wealth of Non Timber Forest Produces (NTFPs) in the adjoining forests, people were generally found to be ignorant of their utilization values. They were not satisfied with the availability of fuel wood, fodder and small timber. Therefore, fulfillment of people's daily basic requirements of fuel, fodder and small timber were highlighted as the most important considerations among the respondents for taking up any plantations and vegetation establishment in the area. So, the species meeting these subsistence requirements were preferred by most of the people. Acacia nilotica locally known as Desi Babool was accepted by local people as a good source of tree based fodder, fuel wood and small timber. Its seeds have commercial value. *Acacia catechu*, locally known as Khair, was preferred because of its economic importance of NTFPs. *Pongamia pinnata*, locally known as Karanj or Kanji, was preferred for bio fuel, fuel wood, fodder, small timber, shady nature and as lac host etc. Local people typically narrated all these several utility criteria in Socioeconomic Survey interviews and discussions conducted for Bio-reclamation so as to choose and select people's preferential tree species for planting. Almost all tree species found in nearby village areas were rated as basically preferred species for firewood, fodder as well as for small timber values only, because of little or no choice available for any viable timber yielding species in the study area. This is also supported by the findings of Grundy et. al. (1993), Lykke (2000) and Kala (2007).

The local floristic composition is an important deciding factor in the selection of species to be planted. In the local forest area, a total of nine leguminous species were reported which were *Butea monosperma* with highest predominance, followed by *Acacia leucophloea, Prosopis juliflora, Dalbergia sissoo, Acacia catechu, Acacia nilotica, Pithecelobium dulce, Albizia procera* and *Pongamia pinnata*. These leguminous tree species may be selected for bioreclamation depending on their site suitability, NTFP values and preferential choices of the local people. The Use Value of each of the nine leguminous species was portrayed as per their local uses and commercial values and ranked according to their utility values as shown in Table 1. Accordingly, *Pongamia pinnata* has maximum local utility value followed by *Acacia nilotica, Acacia catechu, Butea monosperma, Albizia procera, Dalbergia sissoo, Prosopis juliflora, Pithecelobium dulce* and *Acacia leucophloea*.

These species are native, ecologically viable, environmentally suitable symbiotic Nitrogen fixing tree species and, since these species are important part of the livelihood of local populace, socially acceptable also. Their high use value has an added socioeconomic advantage to competently support the livelihoods of the local community too. All these species are having fuel wood, fodder and small timber values which are most important subsistence forest products for most of those local people who predominantly depend on forests. They use dry branches of these species as fuel wood. *Acacia catechu* is considered to be a good fodder tree and is extensively lopped by local people to feed their livestock. Branches of *Acacia nilotica* are also commonly lopped for fodder and its dry pods are used as a supplement to animal diet. Young leaves of *Butea monosperma* are good fodder and green leaves of *Pongamia pinnata* were used as fodder in scarce dry seasons. Being symbiotic leguminous trees, they have the capacity to enrich soil with Nitrogen and help in the establishment of natural biological systems that cycle important mineral nutrients of soil which is extremely critical to the development of permanent vegetation and stable forest ecosystems on mined sites. Leguminous trees are being suggested for reclamation programmes due to their ability to develop associations with Rhizobia and Mycorrhizal fungi (Marques *et al.* 1997). Moreover, selecting the native species has certain unique advantages as these are well adapted to the local environment and thus may be less susceptible to site stresses, serious disease and pest damage. Local people are more familiar with their native plants and have more use values from them also (Hoskins, 1979). Similarly, the timber of native species is likely to be known to local wood based industries too. Further, use of native trees contributes to the conservation of native flora and fauna (Evans, 1982). Local native species are the best options for reclamation as they are adapted to

the low soil fertility and variable climatic conditions of the degraded site and persist during summers and droughts too (Windsor *et al.* 2000). Moreover, native species may also be preferred in support of restoration for ecological and economic reasons, as they may require less long term maintenance (Kramer *et al.* 2000). Kala (2007) studied ethno-botanical species of local preferences in the Indian Himalayas for a holistic environment around human settlements and re-vegetation of degraded lands through community involvement in the selection of key species and their conservation.

It is now a well-known recognized fact that environment, ecology and development must be optimally harmonized and balanced in order to meet the progressive Socioeconomic and ever increasing safe Environmental Subsistence needs of the society. Involvement of the local people in the beginning of the planning stage itself is a key step for the successful implementation of Bio-reclamation programmes for any degraded land rehabilitation. Therefore, Sustainable Bio-reclamation of mined areas invariably needs a participatory community approach and without involving the local people, it is very difficult to reclaim such degraded mining sites. Selection of native Nitrogen fixing leguminous species, with high utility value i.e. the Utility Value Index (UVI), will also be much helpful for sustainable bio-reclamation of such Silica mining sites. Local community should also be properly informed about all the characteristic utility values of these species, so that Bio-reclamation objectives and socioeconomic development of people inhabiting nearby mining areas can be achieved simultaneously.

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Importance of Conserving Wetlands in the Context of Climate Change and Adaptation Strategies

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Introduction

Wetlands are one of the most productive ecosystems on Earth that provide many important services to human society. These are transitional areas between aquatic and terrestrial ecosystems where the water table is at or near the surface, or the land is covered by shallow water. Wetlands cover 6% of the world's land surface, 4 per cent of the earth's ice-free land surface and 12% of the global carbon pool (Prigent, 2001). The wetlands encompass diverse and heterogeneous assemblage of habitats ranging from lakes, estuaries, river flood plains, mangroves, coral reef and other related ecosystems. Wetlands are important breeding areas and nursery for wildlife and provide a refuge for migratory birds. However, they are also ecologically sensitive and adaptive systems (Turner *et al.*, 2000). Floodplain wetlands are among the most important ecosystems on earth and function as the "kidneys" of the earth, which play an important role in maintaining ecological service functions. In Asia, sizable fishermen population is dependent on such fresh water ecosystems for their livelihood. Given likely climate warming scenarios, water problems in the river basins will increase and may be critical in terms of the ecosystem goods and services derived from these water bodies.

India has a wealth of wetland ecosystems that support diverse and unique habitats. In India floodplain wetlands are spread across 5.54 lakh ha area (Sugunan *et al.*, 2000, Pathak *et al.*, 2014) and the state wise distribution and other details have been shown in (Table 1). The majority of the inland wetlands are directly or indirectly dependent on the major rivers like Ganga, Bhramaputra, Narmada, Godavari, Krishna, Kaveri and Tapti. These wetlands support a rich diversity of fish and about

Fig. 1: A typical water stressed floodplain Wetland

85 belonging to 33 families is reported (Table 2). Other than biodiversity conservation these wetlands provide numerous ecological goods and services to mankind but are currently under tremendous stress due to overexploitation and degradation. In India, so far only 26 of these numerous wetlands have been designated as Ramsar Sites (Ramsar, 2013). However, many other wetlands which perform potentially valuable functions are continued to be ignored in the policy process. As a result many freshwater wetlands ecosystems are threatened and many are already degraded and lost due to urbanization, population growth, and increased economic activities (Central Pollution Control Board, 2008). The fishery potential and present production are depicted in figure 2. Globally, riverine floodplains are among the most biologically diverse and threatened ecosystems due to the impact of dams, levee systems, and other modifications to rivers. Global climate change is expected to become another important driver of loss and change in wetland ecosystem (MEA, 2005 and UNESCO, 2007). It is expected that India will lose about 84% of coastal wetlands and 13% of saline wetlands with climate change induced sea water rise

Table 1. Floodplain wetland resources of India
(Source: CIFRI, Barrackpore)

Sr. no	State	Area (ha)	Local names
1	Uttar pradesh	152000	Tal, Jheel
2	Bihar	240000	Maun, Chaur, Dhar
3	West Bengal	42500	Beel, Charha, Baor
4	Arunachal Pradesh	2500	Beel
5	Assam	100000	Beel
6	Manipur	16500	Pat
7	Meghalaya	213	Beel
8	Tripura	500	Beel
	Total	**554213**	

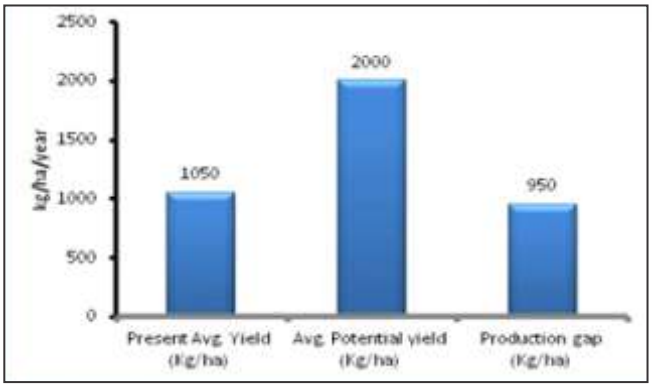

Figure 2. Present and potential fish yield from floodplain wetlands in India *(Source: CIFRI, Barrackpore)*

of 1m. High altitude wetlands and coastal wetlands (including mangroves and coral reefs) are some of the most sensitive classes that will be affected by climate change in India (Patel *et al.*, 2009). This communication deals with importance of wetlands, ecosystem goods and services provided by them, growing threats to wetland ecosystem with special reference to fisheries, climate change scenario in India, it's possible impact on these valuable resources and suggests mitigation and adaptation strategies for increasing their resilience to climate change.

Importance of Wetlands

Wetlands provide many valuable services at population, ecosystem and global levels. Their significant functions, values and attributes of wetlands are depicted in Figure 2, 3 and Table 2.

Environmental Importance of wetlands

Wetlands store flood water and carbon: Wetlands serve as a huge sponge storing 30% of freshwater on earth. During dry seasons, the water stored in wetland is discharged slowly towards nearby habitats to regulate the water levels. Plants near the wetlands can be safeguarded from wilting, and animals can access to water supply. In addition, aquatic plants absorb water and enhance the water storing capability of wetlands.

Table 2. Functions, values and attributes of wetland

Functions	Values	Attributes
• Water storage • Storm protection and flood mitigation • Shoreline stabilization • Ground water recharge and discharge • Water purification • Retention of sediments, nutrients and pollutants • Stabilization of local climate particularly temperature and rainfall	• Water supply - maintenance of quantity and quality • Fisheries • Agriculture - through maintenance of water table • Grazing • Timber production • Energy sources such as peat and plant matter • Wildlife resources • Recreation and tourism opportunities	• Biological diversity: wetlands support avifauna, especially waterfowl; fish, reptiles, and invertebrate species as well as several plant species, besides a variety of micro-organisms like plankton of both phyto and zoo origin • Cultural heritage: open landscapes, wildlife and local traditions

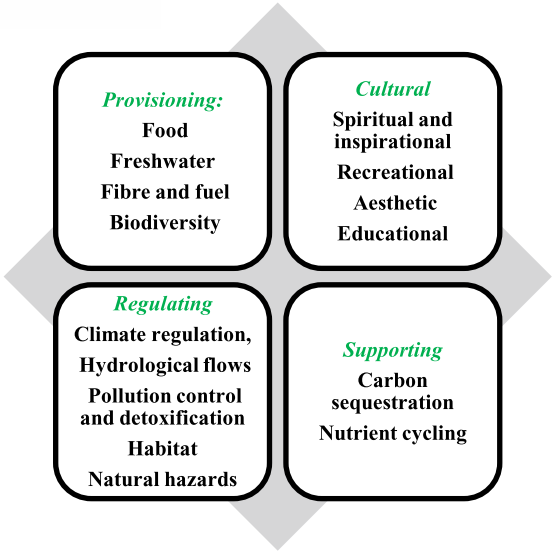

Figure 3. Goods and services provided by the wetlands

During monsoon season prolonged rainfall results in rise of water levels, causing rapid flow in rivers and flooding. Some wetlands such as the marshes and ponds, can store large amounts of water releasing releasing the pressure of flooding. Naturally wetlands serve as a deterrent to the occurrence of flood and as opined by Boyd and Banzhaf, 2007.

Wetland store carbon: Wetlands act as the major carbon reservoirs in earth. They play an important role in the circulation of different resources. Plants in the wetland take up atmospheric CO2 during photosynthesis and convert them into carbo-hydrates. In this way, atmospheric carbon dioxide will enter the food web and be consumed by other organisms. According to Ramsar secretariat about 1/3 of the worlds terrestrial carbon is trapped and stored in wetlands, double of that of forests. As per the estimations, carbon sequestration potential of restored wetlands (over 50year period) comes out to be about 0.4 tonnes C/ha/year (IPCC, 2001). Coastal wetlands in India especially the mangrove wetlands in eastern region and west coast serve as carbon sink sequestering approximately 1.5 metric tonne of carbon per hectare per year, and the upper layers of mangrove sediments have high carbon content, with conservative estimates indicating the levels of 10% (Kathiresan and Thakur, 2008).

Wetland sustain fisheries and wild life: Wetlands are cradle of many lives They live in different types of wetlands and rely on them, either in their entire or part of life history. In tropical or sub-tropical areas, mangroves have developed complex root systems to adapt to the unstable environment. This provides ideal nurseries which attract many animals to live and breed in the mangrove swamps. The inland water bodies like lakes, wetlands, rivers and other freshwater bodies support a rich diversity of biota.

The wetlands are known for their rich biodiversity reserves in the form of wildlife, plants and animals but presently this significant characteristic is losing grounds at an alarming pace. Fisheries and aquaculture is a high priority area of economic gain and rural livelihood upliftment. This has lately suffered a great deal adversely affecting the rural economy. The wetlands of Ganga floodplain have been subjected to indiscriminate and disproportionate exploitation to the extent that many fish species have either became endangered or a number of them have already vanished from the habitat. Lopsided growth of fish food organisms affecting the food chains has engineered significant alteration in the composition of fish catch structure. The present trend of fisheries productions from wetlands may be attributed towards eutrophication, aquatic weed proliferation and sedimentation.

Wetlands improve water quality: When water rushes down from upstream to downstream, it removes soil from the river bank, increasing the soil and suspended particles in water. However, when water flows through the aquatic plants, stems, roots of the plants act as a physical filter to trap the suspended particles and other pollutants to clean up the water. Nitrogen, phosphorus and potassium are essential nutrients for plant growth. However too much nutrient in water will cause pollution and trigger the rapid growth of algae. Aquatic plants growing in wetlands act like a filter, which uptake excessive nutrients and organic matter in water and remove pollutants including heavy metals.

Wetlands provide livelihood security: It has been observed that the pressure on fishing in these water bodies has increased many fold increase in population and changed land use patterns. This has

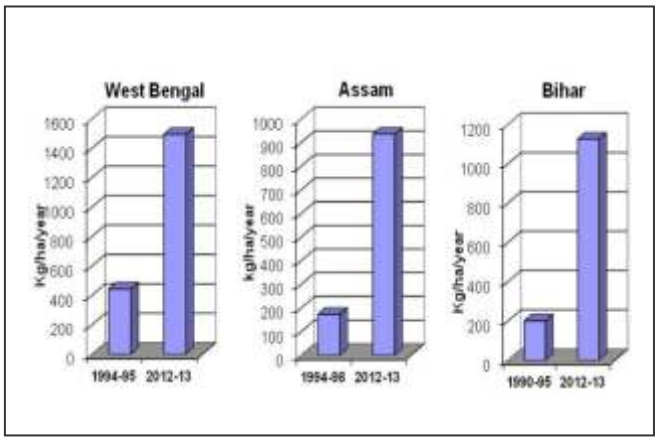

Figure 4. Improvement in fish yields due to culture based fisheries in wetlands of India (Source: CIFRI, Barrackpore)

led to a situation of over exploitation and accordingly once held popular belief that Wetlands are renewable source of energy in the form of fish biomass is losing its meaning very fast. The highly lucrative fish and fishery from such waters of earlier years has become almost a subsidiary occupation leading to large scale disguised unemployment.

Fisheries enhancement in Wetlands

Culture based fisheries: It is an effective management tool in enhancing fish yield from open waters when recruitment of desired species is lesser than the carrying capacity of the water body. It is solely based on the artificial stocking of fishes for their recruitment and recapture. Auto stocking of the desired fish species in most of the Indian wetlands is inadequate due to failure of breeding owing to habitat degradation and over fishing. Selection and stocking of right species of the right size at right time based on fish food resources available in the system, and stocking density after assessing the production potential, growth and mortality rates are very critical. Harvesting at the right size and time can significantly greatly improve the fish production from both reservoirs and wetlands. Proper stocking and harvesting schedules, including staggered stocking and harvesting, allowing maximum grow-out period, taking into account the critical water levels will be beneficial in management of small open water bodies. The impact of culture based fisheries on fish production enhancement in Indian wetlands in presented in figure 4.

Pen culture: can be an ideal technology for enhancing fish production from shallow, macrophyte choked and multitasked floodplain wetlands in India. Pen is an enclosure that can be used for holding and producing fingerlings and table fish in open waters. Shallow and marginal areas of wetlands having water depth of 1-1.5m , retaining water at least 4-8 months in a year can be utilized for pen culture. Pens can be easily fabricated using locally available, cheap materials, which can be re-used. Cost benefit ratio of carp seed, table size carp and prawn production in pen are 1.34, 1.46 and 1.26, respectively. The following figure (figure 5) highlights some of the features of pen culture in wetlands.

Threats to Wetland ecosystem

Wetlands have been under constant threat of environmental degradation due to natural as well as anthropogenic activities. Wetlands perform several economic, social, and ecological functions .The negative economic, social, and environmental

Figure 5. Pen culture activities in wetland. (a. a battery of pen, b. harvest of fingerlings from pen, c. harvest of table size fishes from pen)

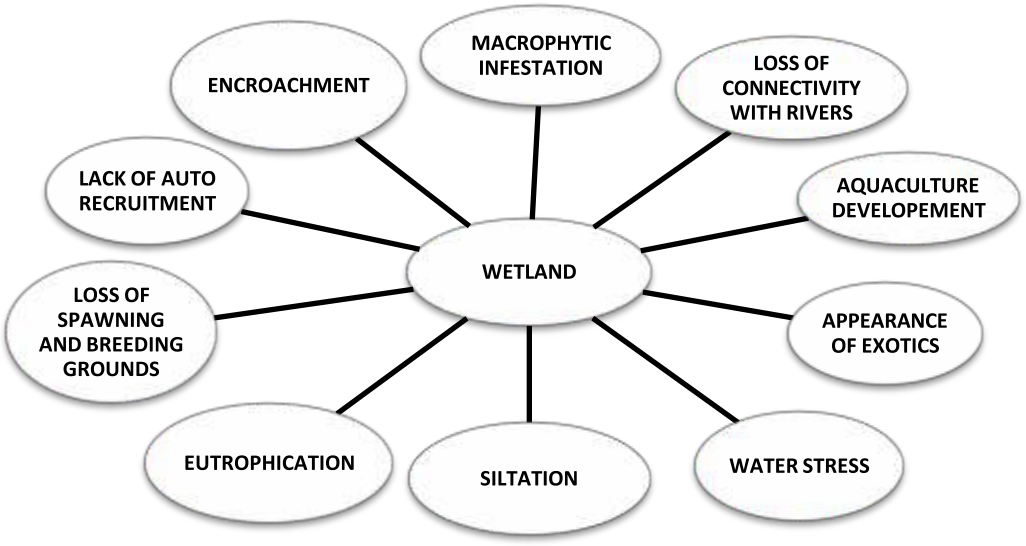

Figure 6. Threats leading to wetland degradation

consequences of declining water quality in wetlands are also an issue of concern for India. These freshwater bodies are often subject to changes in land use in their catchments leading to reduction in inflows and deteriorating quality of the "runoff" traversing through agricultural fields and urban areas. On the other hand, many of them act as the "sink" for untreated effluents from urban centers and industries. Encroachment of area for urban development, excessive diversion of water for agriculture is yet another major problem. Every one claims a stake in them, as they are in the open access regime, but rarely are willing to pay for this extractive use (Verma, 2001). Lack of conformity among government policies in the areas of economics, environment, nature conservation, development planning is one reason for the deterioration of these water bodies (Turner et al., 2000). Lack of good governance and management are also major reasons (Kumar et al., 2013). Some of the major threats faced by wetlands are given in the figure 6.

Climate change scenario and it impact on wetlands

India's large population depends upon climate-sensitive sectors like agriculture and forestry for its livelihood. Any adverse impact on water availability due to recession of glaciers, decrease in rainfall and increased flooding in certain pockets would threaten food security, cause dieback of natural ecosystems including species that sustain the livelihood of rural households. The observed changes of climate in India as reported by Indian National Communication (NATCOM) to United Nations Framework Convention on Climate Change (UNFCCC) indicate an increase of 0.4◦C in surface air temperature over the past century. Regional monsoon variations recorded though the monsoon rainfalls at the all India level do not show any significant trend. There is a trend of more frequent multi-decadal drought followed by fewer droughts and an overall increase in severe storm incidence especially in the states of Gujarat and West Bengal in India. There are indications of recession of some of the Himalayan glaciers which are the source of water for the perennial rivers such as Ganga, Indus and Brahmaputra, but the trend is not consistent across the entire mountain chain. In a developing country like India, climate change could represent an additional stress on ecological and socioeconomic systems like wetlands that are already facing tremendous pressures due to rapid urbanization and economic development. Investigations carried out by ICAR-CIFRI on impact climate change in major river basins have also reported shift in seasonal pattern of rainfall and changes in annual

Table-3. Summary of investigations on climate change across major river basins (Source: CIFRI, Barrackpore)

River Basin	Station/Place	Observations
Ganga	Haridwar	The annual mean minimum water temperature in the upper colder stretch of river Ganga at Haridwar during the period 1980-2009 increased by 0.99ºC
	Allahabad	Percentage of total rainfall in the monsoon period and declined by 7% whereas it increased by 4% in the post- monsoon period at Allahabad
	Patna	The rainfall pattern a decreasing trend in the last four decade. The annual rainfall has decreased by 52.58 mm during time period 1976-2015. The seasonal rainfall pattern has decrease from 6.22% to 4.30 % in the January- April months, increased from 66.96% to 74.94% during May-August whereas decreased from 26.82% to 20.76% during September - December in last four decades 1976-2015. The mean maximum temperature has increased by 0.54ºC and minimum increased by 0.66ºC last three decades
	Farraka	The seasonal pattern at Farakka shows changes in rainfall pattern has decrease from 78.34% to 74.80% during the months in May - August, but during the pre and post monsoon season months rainfall shows increasing trend from 7.33% to 8.19 in January to April and 14.33% to 14.01% in September - December during the last four decades 1985-2014. The mean maximum temperature at Farakka has increased by 0.32ºC and minimum temperature increased by 0.54ºC last four decades (1972-2014)
Brahmaputra	Assam	Alterations in the seasonal rainfalls resulting in sudden high floods and drought-like situations in recent years have been observed for this river basin
Mahanadi	Odisha	The maximum temperature is decreasing across the districts where as the minimum temperature is increasing. The maximum temperature has decreased by 1.24% (0.73°C) whereas the minimum temperature has increased by 0.86% (0.19°C). The average yearly rainfall variation in the Odisha state is about 667mm among the districts. In river Mahanadi basin a decrease in rainfall has been evident in majority of the districts during the monsoon months and an increase in rainfall in the post monsoon period
Cauvery	Karnataka	Mean maximum surface air temperature in January decreased in river basin by 0.6°C in 100 years while mean minimum temperature increased by 0.12°C. Mean maximum and mean minimum air temperature in June increased by 0.8° and 0.16 °C respectively. Increasing trend in monsoon and post monsoon rainfall has been observed for the period 1901-2005.

trends in mean minimum and maximum temperature at various stations in major rivers basins. The major observations are listed in table 3 and figure 7.

Climate change is an important driver of loss and change in wetland ecosystem. Changes in temperature and precipitation trends across major river basins will have direct impact on wetlands. It is expected that climate change will have a pronounced effect on wetlands through alterations in hydrological regimes. Climate induced rising temperature and declining rainfall pattern in Indian subcontinent presents a potential danger to the already disappearing wetlands in the Gangetic plains. Decreased precipitation will aggravate water stress and hence alter the freshwater inflows to

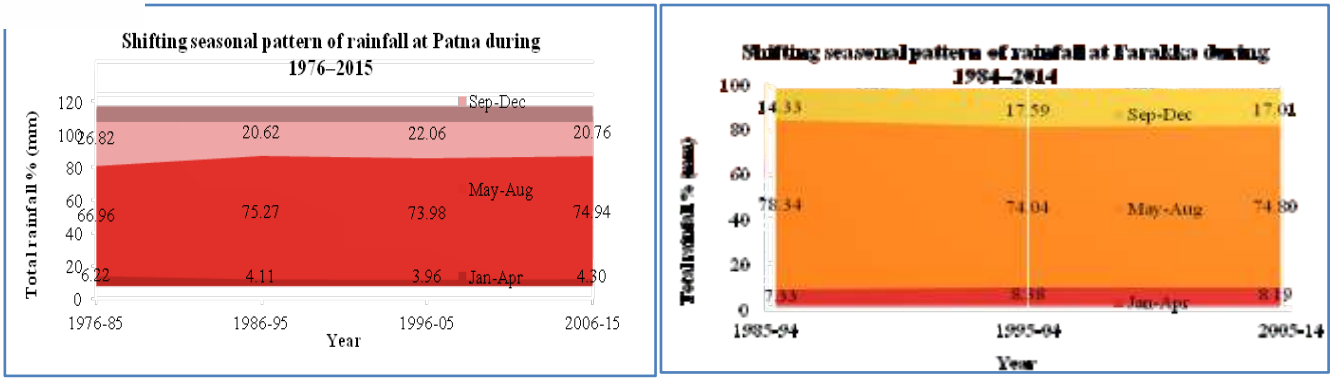

Figure 7. Shifting seasonal pattern of rainfall at Patna (1976-2015) and Farakka(1984-2014).

Table 4. Mitigation and adaptation strategies for coping up climate change in wetlands

Mitigation	Adaptation
l De-silting of wetlands, l Opening and widening of linkage channels l Prevention of additional anthropogenic stress l Maintaining hydrology l Control of exotics l Ecosystem approach for wetland management	l Pre-summer enclosure l Deep pool based fishery l Refuge/weed based fishery l Submerged branch pile based fishery

wetland ecosystems while rise in temperature will intensify the problem of eutrophication, algal blooms, fish kills, and hypoxia in the wetlands. It is expected that India will lose about 84% of coastal wetlands and 13% of saline wetlands with climate change induced sea water rise of 1m. Direct and indirect impacts will be the alterations in temperatures, hydrology, and increased heat stress in wildlife, pest and disease vectors, soil erosion, and flood runoff resulting in a decreased recharge of floodplain aquifers (Sarkar *et al*, 2016). It is expected that in future wetlands and their functional capacity within most ecoregions will decline and the geographic location of certain wetlands may shift. Under currently predicted future climate scenarios, the spread of exotics will probably be enhanced, which will increase pressure on watersheds and ecosystems.

Adaptation and mitigation strategies

Wetland habitat responses to climate change and the implications for restoration need to be realized on a regional and mega-watershed level with specific restoration and management plans. Considering the uncertainties of the climate change it is necessary to introduce climate resilient development strategies that both support general development and climate adaptation in the vulnerable region. Protection of wetland biological diversity and integrity are important activities to improve the resiliency of wetland ecosystems so that they continue to provide important services under changed climatic conditions. Some of the strategies for adapting to impending threats of climate change are suggested in table 4 and figure 8.

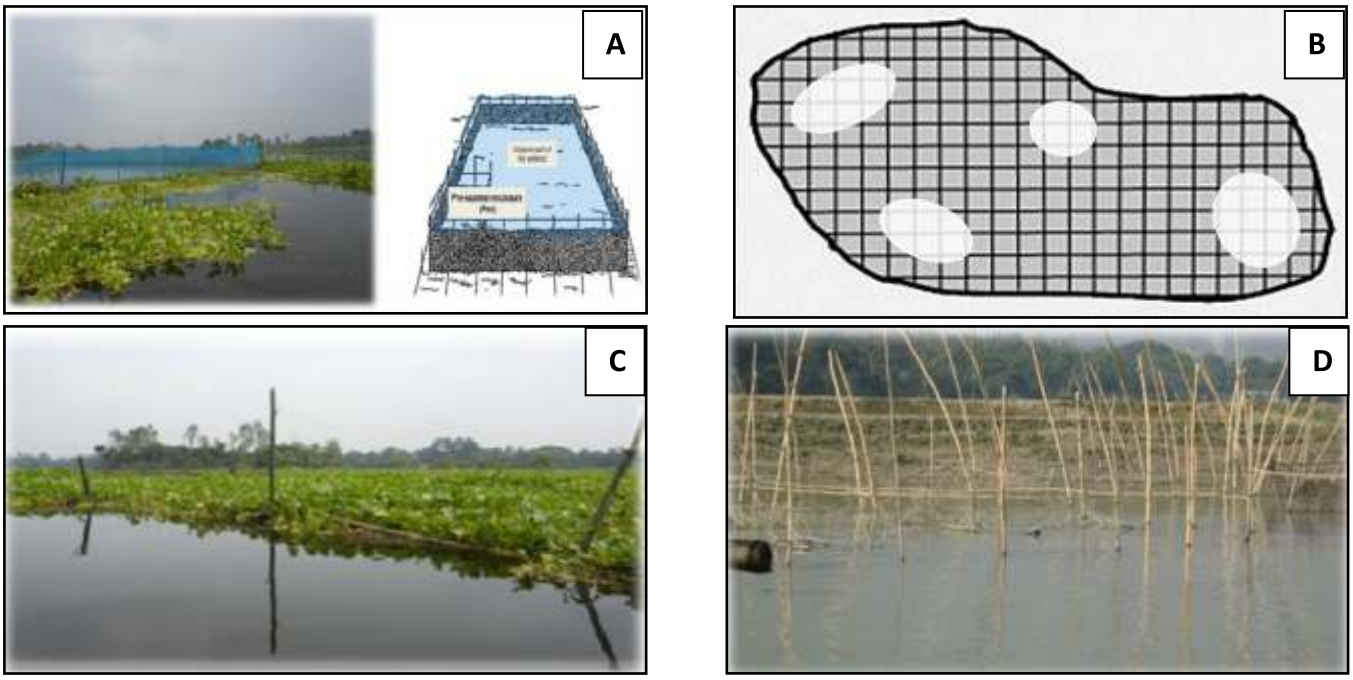

Figure 8. Climate change related adaptation strategies for wetland fisheries [a. Temporary pre-summer enclosure, b. Deep pool refuge based fishery, c. Weed refuge based fishery, d. submerged branch pile based fishery.]

Conclusion

Wetlands provide multiple services to mankind such as water for irrigation, domestic supply, fisheries, recreation etc and also play important role in ground water recharge, flood control, carbon sequestration and pollution abatement. They are being lost and degraded faster than any other ecosystem type in the world due to anthropogenic activities. This trend will magnify in coming years and degradation will be further exacerbated by climate change. The combined impact will increase vulnerability of the poor to climate change that depends on these resources for their nutritional and livelihood security. Timely implementation of mitigation and adaptation strategies is necessary for increasing resilience and adaptive capacity of the stakeholders. Conservation, restoration and wise use of wetlands will be a cost effective strategy for climate change adaptation with strong benefits for poverty reduction and biodiversity conservation. Public awareness and capacity building of stakeholders on climate change will aid in effective implementation of the policies and to respond effectively to the threats or opportunities posed by climate change.

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Wetlands : A Matter of Dollar Value

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Introduction

Wetlands are priceless ecosystems that occupy about 6% of the world's land surface (Fig.1). They comprise both land ecosystems that are strongly inclined by water, and aquatic ecosystems with special characteristics due to shallowness and proximity to land (www.iucn.org/themes/wani). Although various different classifications of wetlands exist, a useful approach is one provided by the Ramsar Convention on Wetlands. It divides wetlands into three main categories of wetland habitats: (1) marine/coastal wetlands; (2) inland wetlands; (3) man-made wetlands. Figure 1 shows the distribution of wetlands around the world.

Status of wetlands in India was assessed by Anon (1990) and Garg et. al (1998). According to Garg (1998) nationwide wetland inventory carried out 7.6 million ha of wetland units in the country of which 4.0 million ha are coastal wetlands and 3.6 million ha are inland wetlands. The livelihoods of millions of people in India also depend on wetlands ecosystem. According to Wild Life Institute of India some 70-80% of individual fresh water marshes and lakes in the indo-gangetic plain have been lost in the past 50 years. Most of the world's civilizations have developed and flourished near wetlands. Wetlands of India, estimated to be 58.2 million hectares, are important repositories of aquatic biodiversity while Uttar Pradesh had approximately 1145178 hectares wetland area. Wetlands have accessible significant economic, ecological and cultural values. Some wetlands are exclusively used by people for food, fodder and building materials.

Services provided by wetlands

Wetland ecosystems are often undervalued. A small number of people become conscious the range of products derived from freshwater habitats like wetlands: food such as fish, rice and cranberries; peat for fuel and gardens; medicinal plants; poles for building materials; and grasses and reeds for making mats and baskets and thatching houses. These complex habitats act as giant sponges,

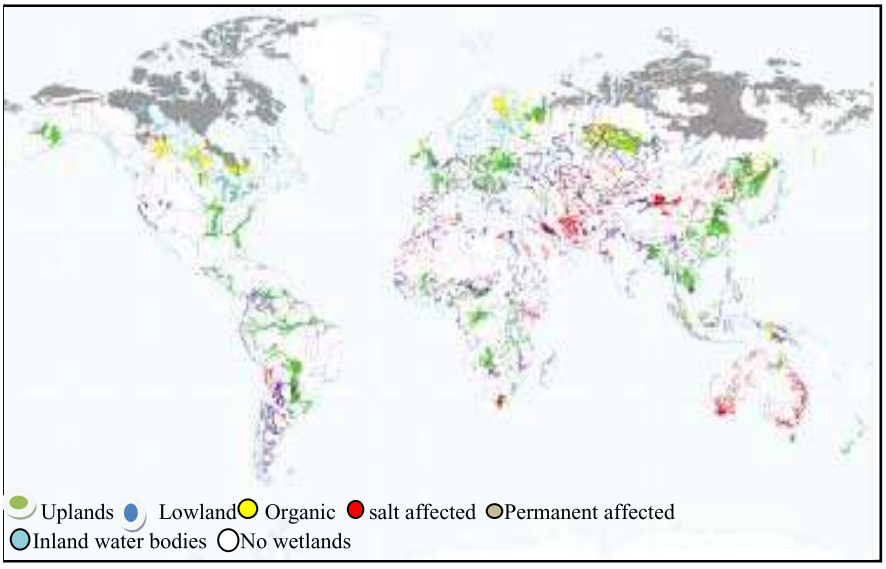

Fig. 1: Global Distribution of Wetlands

(Source: US Department of Agriculture, Natural Resources Conservation Services, 1997)

Table 1: Services provided by inland and coastal wetlands

Source: Millennium Ecosystem Assessment (Finlayson et al. 2005)

Scale is low •, medium ●, to high: ⬤; not known = ?; blank cells indicate that the service is not considered applicable to the wetland type. The information in the table represents expert opinion for a global average pattern for wetlands; there will be local and regional differences in relative magnitudes.

Services	Comments and Examples	Permanent and Temporary Rivers and Streams	Permanent Lakes, Reservoirs	Seasonal Lakes, Marshes, and Swamps, Including Floodplains	Forested Wetlands, Marshes, and Swamps, Including Floodplains	Alpine and Tundra Wetlands	Springs and Oases	Geothermal Wetlands	Underground Wetlands, Including Caves and Groundwater Systems
Inland Wetlands									
Provisioning									
Food	production of fish, wild game, fruits, grains, and so on	●	●	●	●	•	•		
Fresh water	storage and retention of water; provision of water for irrigation and for drinking	●	●	•	•	•	•		●
Fiber and fuel	production of timber, fuelwood, peat, fodder, aggregates	●	●	•	●	●	•		
Biochemical products	extraction of materials from biota	•	•	?	?	?	?	?	?
Genetic materials	medicine; genes for resistance to plant pathogens, ornamental species, and so on	•	•	?	•	?	?	?	?
Regulating									
Climate regulation	regulation of greenhouse gases, temperature, precipitation, and other climatic processes; chemical composition of the atmosphere	•	●	•	●	•		•	•
Hydrological regimes	groundwater recharge and discharge; storage of water for agriculture or industry	●	●	•	●	•	•		•
Pollution control and detoxification	retention, recovery, and removal of excess nutrients and pollutants	●	●	•	●	•	•		●
Erosion protection	retention of soils and prevention of structural change (such as coastal erosion, bank slumping, and so on)	●	•	•	●	?	•		•
Natural hazards	flood control; storm protection	●	●	●	●	●	•		•
Cultural									
Spiritual and inspirational	personal feelings and well-being; religious significance	●	●	•	●	•	●	•	•
Recreational	opportunities for tourism and recreational activities	●	●	•	•	•	•	•	•
Aesthetic	appreciation of natural features	●	●	•	●	•	•	•	•
Educational	opportunities for formal and informal education and training	●	●	•	●	•	•	•	•
Supporting									
Biodiversity	habitats for resident or transient species	●	●	•	●	•	•	•	•
Soil formation	sediment retention and accumulation of organic matter	●	•	•	●	•	?	?	
Nutrient cycling	storage, recycling, processing, and acquisition of nutrients	●	●	●	●	•	•	?	•
Pollination	support for pollinators	•	•	•	●	•	•		

Services	Comments and Examples	Estuaries and Marshes	Mangroves	Lagoons, Including Salt Ponds	Intertidal Flats, Beaches, and Dunes	Kelp	Rock and Shell Reefs	Seagrass Beds	Coral Reefs
Coastal Wetlands									
Provisioning									
Food	production of fish, algae, and invertebrates	●	●	•	●	•	●	•	●
Fresh water	storage and retention of water; provision of water for irrigation and for drinking	•		•					
Fiber, timber, fuel	production of timber, fuelwood, peat, fodder, aggregates	●	●	●					
Biochemical products	extraction of materials from biota	•	•			•			•
Genetic materials	medicine; genes for resistance to plant pathogens, ornamental species, and so on	•	•	•		●			•
Regulating									
Climate regulation	regulation of greenhouse gases, temperature, precipitation, and other climatic processes; chemical composition of the atmosphere	●	●	●	•		•	•	●
Biological regulation (C11.3)	resistance of species invasions; regulating interactions between different trophic levels; preserving functional diversity and interactions	●	●	●	•		•		•
Hydrological regimes	groundwater recharge/discharge; storage of water for agriculture or industry	•		•					
Pollution control and detoxification	retention, recovery, and removal of excess nutrients and pollutants	●	●	●		?	•	•	•
Erosion protection	retention of soils	●	●	•				•	•
Natural hazards	flood control; storm protection	●	●	•	•	•	●	●	●
Cultural									
Spiritual and inspirational	personal feelings and well-being	●	•	●	●	•	•	•	●
Recreational	opportunities for tourism and recreational activities	●	•	•	●	•			●
Aesthetic	appreciation of natural features	●	•	●	●				●
Educational	opportunities for formal and informal education and training	•	•	•	•		•		•
Supporting									
Biodiversity	habitats for resident or transient species	●	●	•	●	•	●	•	●
Soil formation	sediment retention and accumulation of organic matter	●	●	•	•				
Nutrient cycling	storage, recycling, processing, and acquisition of nutrients	●	●	●	•	•	•		●

soaking up rainfall and slowly releasing it over time. Wetlands are like extremely efficient sewage treatment works, absorbing chemicals, filtering pollutants and sediments, breaking down suspended solids and neutralising harmful bacteria.

Wetland systems directly support millions of people and provide goods and services to the world outside the wetland. People make use of wetland

soils for agriculture, they catch wetland fish to eat, and they cut wetland trees for timber and fuel wood. Direct use may also take the form of recreation, such as bird watching or sailing, or scientific study. For example, peat soils have preserved ancient remains of people and track ways which are of great interest to archaeologists. (http://wwf.panda.org/about_our_earth/about_freshwater/intro/value/)

The diversity in functions that wetlands perform makes them incredibly valuable ecosystems. They have a very high ecological value, as long as the water and primary productivity upon which countless species of plants and animals depend. Wetlands support high concentrations of birds, mammals, reptiles, amphibians, fish and invertebrate species. It has been estimated that freshwater wetlands hold more than 40% of the entire world's species and 12% of all animal species (www.ramsar.org). Many wetlands also have an important socio-cultural value. Although this value is still relatively unexplored, it is known that wetlands have religious and historical values for many local communities.

Apart from using the wetlands directly, people benefit from wetland functions or services. As flood water flows out over a flood plain wetland, the water is temporarily stored; this reduces the peak river level and delays the time of the peak, which can be a benefit to riparian dwellers downstream. Wetlands serve a number of important functions and provide benefits to humans and wildlife.

A list of the main services provided by different types of wetland (both inland and coastal) and their general relative magnitude. Depending on the intricacy of the wetland being valued, the services should be described for each of the main ecosystem components (e.g., constituent river, lake, marsh etc.) table: 1.

Economic value of wetlands

Cultural values and their social welfare indicators are as a subset of economic values and spiritual values and cultural identity which are in many cases closely related to ecosystem services. Economic and monetary valuation are therefore treated individually from socio-cultural valuation, whereby it is emphasized that ecological, socio-cultural, and economic values all have their separate role in decision-making and should be seen as basically balancing pieces of information in the decision-making process.

Numerous studies have assessed the economic value of ecosystems (e.g., Hartwick 1994; Barbier et al. 1997; Asheim 1997; Costanza *et al.* 1997; Daily 1997 a&b; Pimentel & Wilson 1997; Hamilton & Clemens 1999), and the concept of Total Economic Value (TEV) (Fig. 2) has become a widely used framework for assessing the utilitarian value of ecosystems. This framework typically disaggregates TEV into two categories: use values and non-use values.

Use values: are collected of three elements: direct use, indirect use, and option values. Direct use value is also known as extractive, consumptive or structural use value and mainly derives from goods which can be extracted, consumed or enjoyed directly (Dixon & Pagiola 1998). Indirect use value is also known as non-extractive use value, or functional value, and mainly derives from the services the environment provides. Option value is the value attached to maintaining the option to take advantage of something's use value in future.

Non-use values: derive from the benefits the environment may provide which do not involve using it in any way, whether directly or indirectly. The most important such benefit is existence value: the value that people derive from the knowledge that something exists, even if they never plan to use it. Thus people place value on the existence of blue whales or the panda, still if they have never seen one and probably never seen in future. Though, if blue whales became extinct, many people would feel a definite sense of loss (Dixon & Pagiola 1998). Bequest value, finally, is the value derived from the desire to pass on values to future generations, that is, our children and grandchildren.

Estimation of wetlands forms one of the many types of wetland assessment which can and should be used for different purposes and at different scales in support of wetland wise use, management and decision-making. These, their purposes, and the relationships between them have been brief in the

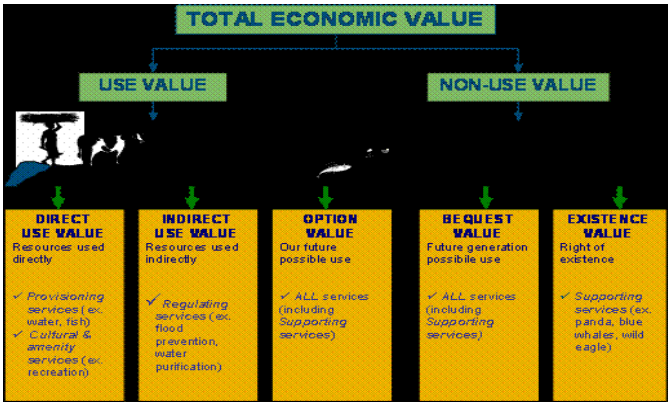

Fig. 2: The Total Economic Value Framework. Adapted from Millennium Ecosystem Assessment (2003), based on Pearce & Warford (1993) and Dixon & Pagiola (1998).

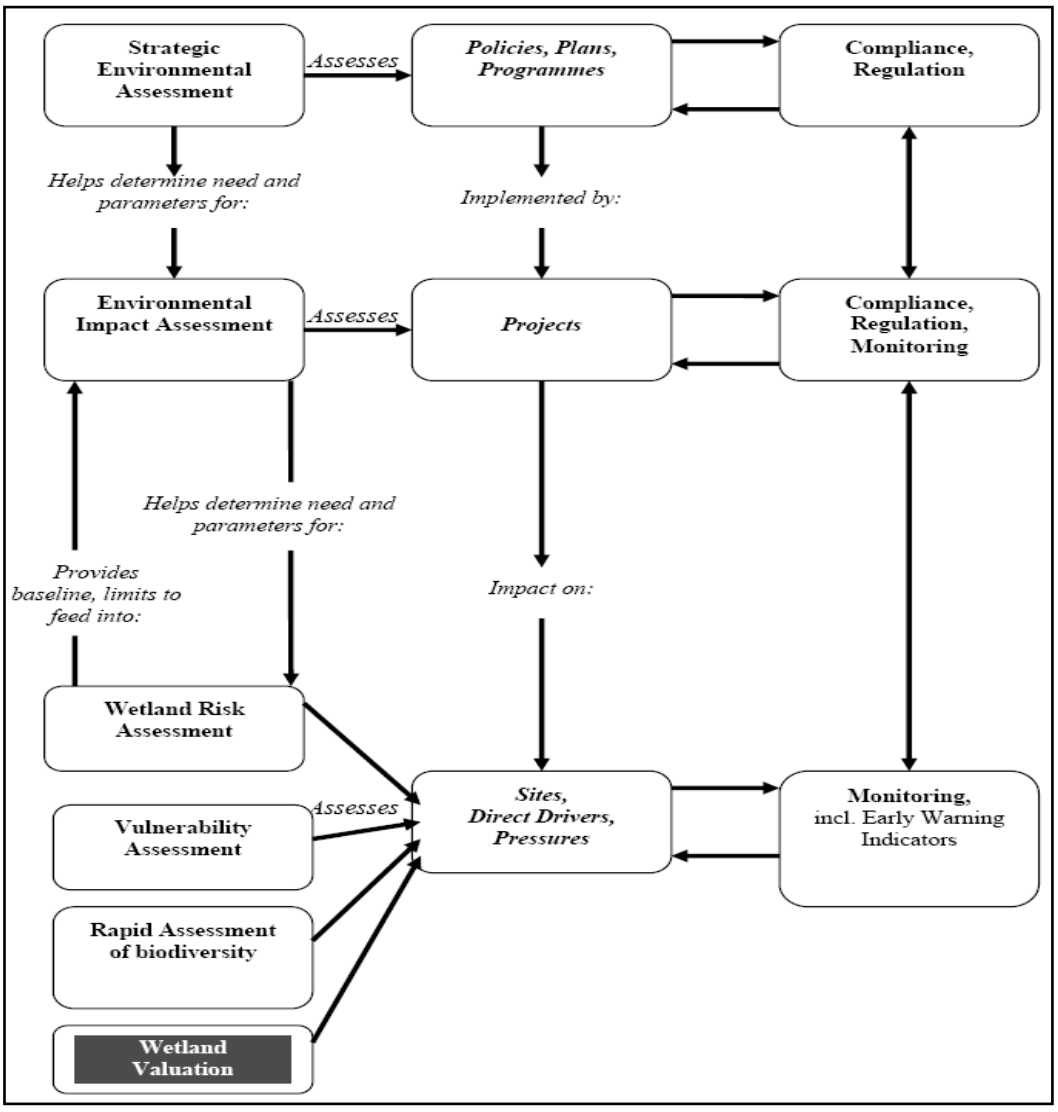

Fig. 3: The relationships between wetland valuation and the other wetland assessment tools available through the Ramsar Convention (from Ramsar Resolution IX.1 Annex E).

Table 2: The relationship between ecosystem functions and services and monetary valuation technique (source: de Groot 1992)

ECOSYSTEM FUNCTIONS	Maximum monetary values (US$/ha Year)	Direct Market Pricing	Indirect Market Pricing					Contingent Valuation	Group Valuation
			Avoided Cost	Replacement cost	Factor Income	Travel cost	Hedonic pricing		
Regulating services									
1.Gas regulation	265		+++	o	o			o	o
2. Climate regulation	223		+++	o	o		o	o	o
3.Disturbance regulation	7,240		+++	++	o		o	+	o
4. Water regulation	5,445	+	++	o	+++		o	o	o
5. Water supply	7,600	+++	o	++	o	o	o	o	o
6. Soil retention	245		+++	++	o		o	o	o
7.. Waste treatment	6,696		o	+++	o		o	++	o
8. Pollination	25	o	+	+++	++			o	o
9. Biological control	78	+	o	+++	++			o	o
Supporting services									
10. Refugium function	1,523	+++		o	o		o	++	o
11. Nursery function	195	+++	o	o	o		o	o	o
12. Soil formation	10		+++	o	o			o	o
13. Nutrient cycling	21,100		o	+++	o			o	o
Provisioning services									
14. Food	2,761	+++		o	++			+	o
15. Raw materials	1,014	+++		o	++			+	o
16. Genetic resources	112	+++		o	++			o	o
17. Medicinal resources		+++	o	o	++			o	o
18. Ornamental resources	145	+++		o	++		o	o	o
Cultural services									
19 Aesthetic information	1,760			o		o	+++	o	o

ECOSYSTEM FUNCTIONS	Maximum monetary values (US$/ha Year)	Direct Market Pricing	Indirect Market Pricing					Contingent Valuation	Group Valuation
			Avoided Cost	Replacement cost	Factor Income	Travel cost	Hedonic pricing		
20 Recreation & tourism	6,000	+++		o	++	++	+	+++	
21 Cultural & artistic	25	o			o	o	o	+++	o
22 Spiritual & historic						o	o	+++	o
23 Science & education		+++			o	o		o	o

- **(** In the columns, the most used method on which the calculation was based is indicated with +++, the second most with ++, etc.; open circles indicate that that method was not used in the Costanza *et al.* (1997) study but could potentially also be applied to that service.**)**
- **(**Maximum Dollar values are based on Costanza *et al*. (1997) and apply to different ecosystems (e.g., waste treatment is mainly provided by coastal wetlands and recreational benefits are, on a per hectare basis, highest in coral reefs). These monetary values are examples for illustrative purposes only: actual values will vary from location to location, depending on ecological, bio geographic and socio-economic conditions.
  Direct market pricing based on added value only (i.e., market price minus capital and labour costs, typically about 80%).

Convention's Integrated Framework for Wetland Inventory, Assessment and Monitoring, as Resolution IX.1 Annex E (http://www.ramsar.org/res/key_res_ix_index_e.htm). Fig.3 shows how wetland valuation fits into this Framework, and this is also described in Finlayson *et a*l. (2005).

Monetary valuation of wetland services

The comparative importance people attach too many of the values and their associated wetland services can be measured using money as a common denominator. Monetary or financial valuation methods fall into three basic types, each with its own repertoire of associated measurement issues. An overview of which methods are most often used to determine the monetary value for different services (Table 2).

1. Direct market valuation;
2. Indirect market valuation; and
3. Survey-based valuation (i.e., contingent valuation and group valuation)

Table 3 presents the global economic values of wetlands, aggregated by wetland type and continent. The table also illustrates that, wetlands in Asia have the absolute highest economic value at $1.8 billion per year. The high value given to Asian wetlands in this study could be explained by the high population density in most Asian countries. Large populations are accountable to mean high demand for wetland goods and services, and hence higher economic values.

The Millennium Ecosystem Assessment gave wetlands a value of US$15 trillion in 1997.A study of the role of coastal wetlands in reducing the severity of impacts from hurricanes in the United States found that they provided storm protection services with an estimated value of US$23.2 billion per year. The annual economic value of the remaining Danube River floodplains, including their flood mitigation function, was assessed in 1995 at EUR650 million. New York City found that it could avoid spending USD$3-8 billion on new waste water treatment plants by investing USD$1.5 billion in the purchase of land around the reservoirs upstate. This land purifies the water supply for free. In the Caribbean, the shoreline protection services provided by coral reefs are valued at up to US$2.2 billion annually. (http://wwf.panda.org/about_our_earth/about_freshwater/intro/value/)d services, and hence higher economic values.

Economic Valuation of Wetland as Numerous Use Systems in India

Economic valuation of wetland has been carried out in different parts of India to capture both use and non-use values of wetlands. Das *et al.*

Table 3: Total Economic Value of Global Wetlands by Continent and Wetland Type (Thousands of US$ per year, 2000)

	Mangrove	Unvegetated Sediment	Salt/Brackish Marsh	Freshwater Marsh	Freshwater Woodland	TOTAL
N America	30,014	550,980	29,810	1,728	64,315	676,846
Latin America	8,445	104,782	3,129	531	6,125	123,012
Europe	0	268,333	12,051	253	19,503	300,141
Asia	27,519	1,617,518	23,806	29	149,597	1,818,534
Africa	84,994	159,118	2,466	334	9,775	256,687
Australasia	34,696	147,779	2,120	960	83,907	269,462
TOTAL	185,667	2,848,575	73,382	3,836	333,223	3,444,682

Fig. 4: communities use the wetlands for various livelihoods purposes

Fig.5: Livestock are freely move during dry season in wetlands

Fig.6: Wetlands supply resources which are very useful raw materials for housing

(2002) estimated the economic value of ten wetlands in the Gangetic flood plain in Bardhaman district of West Bengal. The area of the wetlands varies from 10 ha to 275 ha with an average area of 66 ha. The estimated economic benefit from fisheries operation varies from Rs. 500 to Rs. 16,000 per ha per year; average irrigation benefit is Rs. 3.543 with a maximum of Rs. 16,000; average benefit of using wetland for jute retting is Rs. 200 per ha per year with a maximum of Rs. 625 per ha per year. Average benefit from fisheries operation varies from Rs. 2,484 per household, irrigation benefit - Rs. 1,105 per acre and jute retting Rs. 483 per household per year. Chattopadhyay *et al.* (2002) estimated the potential losses due to conversion of 1500 ha of East Calcutta Wetlands in the year of 1999-2000 as Rs. 338.90 million. The willingness to pay of the stakeholders to conserve the East Calcutta Wetland, the amount varies from Rs. 60/per household/year to Rs. 1200/per household/year, with an average of Rs. 380/per household/year.

Wetlands and Livelihoods

The livelihood concept argues that people have resources (natural, physical, financial, human and social) which they must to access and use. For wetland residents, the assets would comprise land and other wetland resources and the means of taking out. Wetlands are a multitude of resources; the wetland users similarly have a large number of communities for specific wetland resource and or use. The totality of all these communities is what modifies the wetland resources within the situation of trends and amazement to generate livelihood strategies. These livelihood strategies are simply composed of various activities of the wetland users including but not limited to fishing, farming, livestock keeping, extraction of medicinal plants and cultural activities (Fig.4).

Wetlands and Livestock farming:

Livestock are kept virtually by all the communities found in the wetlands. They keep cattle for meat, milk, skins, ploughing, and as social security, and as shelter nets or “banks” during floods or drought, source of income for school fees, and for customary activities like marriages and specific actions during funerals, Fig.5 (Kibwage *et al.*, 2008).

Everybody has free access to the grass, however, during wet seasons, livestock have to be accompanied by men or women or they are tethered to put a ceiling on their movement because they can damage crops. During dry seasons, livestock are left to move freely without being watched. Due to lack of control on the number of animals one should maintain and uncontrolled grazing, over-grazing is a common phenomenon within and around wetland leading to resource over-use.

Extracting wetland resources for housing and other construction activities:

Wetlands supply resources which are very useful raw materials for housing for example, roofing materials, clay for making bricks and or walls for thatched houses and reeds for making windows and even doors (Kibwage *et al.*, 2008). In wetlands, the resources extracted for housing and other construction activities are Cyprus, clay, grass, ropes, poles and sand. Papyrus, poles and grass are extracted for animal sheds, fencing, and housing respectively. Collection of grass, ropes and poles is done by women and children (Fig. 6).

Wetland fishing activities:

Fishing is one of the most regulated activities in some of IBA wetlands. Riverine fisheries have however not been closely monitored by the fisheries authorities although they have been used to fish for indigenous fish species and for baits. At the local Fishing committees are set up in order to resolve conflicts, receive visitors to the wetlands/villages, maintain law and order in the villages among others. The fishermen involved in these committees indicated that it the fishermen themselves who decided to protect the fishery resources and that the government only came in later to help them carry out enforcement of regulations on illegal and harmful fishing methods (Fig. 7).

Wetland cultural activities:

Cultural activities are founded on community's cultural values which are an important factor in sustaining wetland resources for community livelihoods. Human beings are known to be social beings whose behaviour is entrenched within a set of socio-cultural values, norms and knowledge defined by the community in which they belong and where

Fig. 7: A large number of people depend on the fishing for their livelihoods

they attain their identities, faith and deeds (Kurien, 2001; Hanna and Jentoft, 1996; Granovetter, 1992; Polany, 1957; Coser and Rosenberg 1957). These values define their supremacy structures and are what they bring to and guide their actions as they relate to natural resources such as wetland resources (Hanna and Jentoft, 1996). Understanding of these values is important in sustaining the resources (Kibwage *et al.*, 2008).

In the wetlands, religion as a cultural activity tends to take precedence among the residents. Religious groups believes that by praying in a cultural site within the wetland, the people seek blessings or protection, for or from fish catch, death, sickness, richness, bad wishes to neighbours, and good weather conditions. The keeping of sacred places has a very positive effect to the resources found in the sacred place (Fig. 8).

Fuel wood collection:

The use of wood as fuel among the households from the wetlands is most common activities. In most of the wetland there are no rules governing collection of fuel wood. Fuel wood collection is mainly the work of women and children in the three wetlands. Splitting of firewood is done by young males, adult males and females for their daily needs as well as livelihood (Fig.9).

Wetland craft industry and pottery:

Craft making provides employment and incomes to a number of inhabitants in and around wetlands. The most common craft items made using the wetland resources are mats which are made from Cyprus by both men and women and wetland materials extracted are mainly for making decoration mats, baskets, trays, floor and ceiling mats. Extraction of wetland resources for making crafts have a positive effect on the community livelihoods, however insufficient to control the extraction as well as confirm for the sustainable extraction of the resources.

Wetland water use:

Water is however used for domestic purposes in

Fig.8: peoples praying in a cultural site within the wetland, the people seek blessings or protection, for fish catch, death, sickness, richness, bad wishes to neighbours, and good weather conditions

Fig.9: Wood collection by people for their daily needs

Fig. 10: Use of wetlands water for domestic as well as agricultural purposes

Fig. 11: Gathering and extraction of medicinal herbs are completely free access to everyone within the wetlands

particular by all the residents of the wetlands and for rice cultivation and small irrigation for vegetable growing. Collection of water for domestic use was mainly by the women and children and access to it is free to all for both the residents and non residents in the wetlands (Fig. 10).

Wetland hunting, gathering (fruits and wild vegetables) and extraction of medicinal herbs:

Little residents of wetlands are involved in extraction of medicinal herbs from wetlands. Gathering of wild vegetables is undertaken by all households in the wetlands. Both gathering and extraction of medicinal herbs are completely free access to everyone whether a resident or non-resident (Fig.11). There is also free access to natural medicinal resources within the wetland. Extraction of herbs, preparation, processing and their administration to the sick, are all done by either adult males or adult females. The herbs are scarce in the wetland due to destruction of the vegetation in the wetland especially through clearing and burning of land in order to expand the area for cultivation and human settlement.

Wetlands Tourism and Livelihoods:

Tourism in and around wetlands can bring significant benefits, both economic and environmental, at site, regional and national levels. Local communities and local government can and often do benefit economically in terms of income and employment. At the national level, the income from tourism can be significant. The wetland itself can benefit directly when the income from tourism (entry fees, local products, etc.) is used directly for conservation measures at the wetland, thus linking tourism with long-term conservation. Income can be effectively used for training local guides and tour operators so that they understand the key features of the wetland and can explain simple conservation measures to the tourists they are responsible for and at the same time modify their own operations to minimize their impacts on the natural resource. Appropriate signage at wetlands, simple pamphlets, etc., can also demonstrate to tourists the values of wetlands and the benefits they deliver to us all. Tourism businesses can give a great deal of support to sustaining biodiversity in wetlands and other ecosystem.

Sustainable livelihoods: Wetlands already sustain a vast range jobs globally:

- Almost a billion households in Asia, Africa and the Americas depend on rice growing and processing for their main livelihoods.
- More than 660 million people rely on fishing and aquaculture for a living; most commercial fish breed or spawn in coastal wetlands, and 40 % of all fish consumed are raised in aquaculture.
- An estimated half of international tourists seek relaxation in wetland areas, especially coastal zones. The travel and tourism sectors support 266 million jobs, and account for 8.9 % of the world's employment.
- Rivers and inland waterways play a vital role in transporting goods and people in many parts of the world. In the Amazon basin, 12 million passengers and 50 million tons of freight are moved each year by 41 different shipping companies.
- Vast networks deliver fresh water and treat wastewater around the world, while employing significant workforces. For example, Bangkok's Metropolitan Waterworks Authority employs over 5,300 staff.
- The bottled water industry delivered over 70 billion gallons of water worldwide in 2013. Danone sells major brands such as Evian and Volvic, Bonafont and Mizone, and employs more than 37,000 people in its water businesses worldwide.
- Harvesting and processing plants, fruits, reeds and grasses also provide significant employment directly in or near wetlands, especially in developing countries.

Conclusions

Wetlands are a very important source of natural spring of resources upon which many rural economies and entire societies depend. Wetlands perform very significant functions that supply goods and services that have an economic value, including food, medicine, building materials, water treatment and climatic stabilization. Notwithstanding this

importance, though, wetlands all over the world have been modified and reclaimed - since 1900, more than half the world's wetlands have departed.

This article has addressed the economic values of global wetlands. The prerequisite by wetlands of recreational opportunities and amenities, and flood control and storm buffering are the wetland functions with the highest Median economic values at $492 and $464 per hectare per year respectively.

The economic value of wetlands per geographical region was showed that Asian wetlands have the highest economic values at $1.8 billion per year. The estimates derived in this article illustrate the magnitude of economic value of wetlands in addition to their biodiversity, scientific, ecological, socio-cultural and other important wetland values.

These estimates can be used to raise awareness with decision-makers about the economic profit of conserving and sustainably managing wetlands as per the principles and objectives of the Ramsar Convention as opposed to their reclamation and ultimately the need for their costly reinstallation. In order to recognize the range of values of wetlands and for decision-makers to include these values in their decision-making processes, efforts must be directed at such inventories of wetlands all over the world. Lastly, it is important that more economic valuation studies on wetlands be carried out to improve our knowledge and awareness of economic values of wetlands, including a comparative evaluation on the cost of humiliating and restoring these ecosystems and their natural functions.

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Ramsar Resolution IX.1 Annex E.

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Sustainable Use and Conservation of Basil's Diversity in Upper Gangetic Plains of Uttar Pradesh

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Introduction

The basil (*Ocimum* spp., Fam. Lamiaceae) is an economically important medicinal herb due to presence of essential oils which contains monoterpenes, sesquiterpenes and phenyl-propanoids (Paton *et al.*, 1999). Its essential oil is the natural source of methyl chavicol, methyl cinnamate, camphor, neral, geranial, linalool, eugenol, thymol, methyl isoeugenol, etc. which are used in pharmaceutical, cosmetic and flavouring industries. Besides these chemicals beta-carotene (vitamin-A precursor) is also present in the leaves of basil. The leaves of holy basil (*Ocimum tenuiflorum* L.; syn. *O. sanctum* L.) are used against various ailments and diseases like cough, cold, fever, constipation, stomach pain, vomiting, loose motions, headache, nose and lung problems, arthritis, memory and tranquility problems, nerve disorders, general weakness, anemia, etc. The basils are capable in removing the negative ions present in the atmosphere and thus purify the airs. Such novel functions of the basils enable human beings to be resistant against several bacterial diseases. The tea prepared from leaves of sacred basil is used to check vomiting, rheumatic pain and loose motions. Tea prepared from basil leaves and black pepper can reduce high fever. Basil contain anti-oxidants in good quantity may help to maintain good health and long life. Basil is characterized by great diversity among its constituent species including morpho-physiological characters, colour of flower, leaf and stem and chemical constituents of essential oil. On the basis of multiple practical uses of various species of *Ocimum* have been locally named as 'Kapur Tulsi' (*O. kilimandscharicum*), 'Rama and Shyama Tulsi' (*O. tenuiflorum*), 'Nimboo Tulsi' (*O. africanum*), 'Babui Tulsi' (*O. basilicum*), 'Van Tulsi' (*O. gratissimum*), 'Pudina Tulsi' (*O. canum*; syn, *O. americanum*), etc. In addition to these uses, *Ocimum* is widely cultivated as a pot herb for culinary uses, and for the fresh herb market, the export of *Ocimum* from Israel alone is worth 4 million US dollars per year (Darrah, 1980). In India as well it constitutes an important component of ever growing herbal market. Holy basil is commercially cultivated in hot and humid region of the India for production of leaves by growers/farmers. Eugenol is the major chemical constituent of essential oil present in the leaves, having various uses in flavouring and pharmaceutical industries. Indian basil is extensively cultivated in Indonesia, Egypt, Morocco, France, Greece, Hungary and USA (Bahl *et al.*, 2000). In India, *O. basilicum* (source of methyl chavicol) and *O. gratissimum* (source of eugenol) are mainly cultivated in Assam, West Bengal, U.P., Bihar, Haryana, Punjab, M.P., Maharashtra and Jammu (Prakasa Rao *et al.*, 2007) in about 3000ha area with annual essential oil production of 250-300t (Singh *et al.*, 1998; Varshney, 1997). An estimated production of basil oil is 250 tonnes in India; the bulk of this oil has methyl chavicol (75%) and linalool as the major constituent (Maheshwari, 1995; Bahl *et al.*, 2000). In a study of essential oils of different geographical origins, Lawrence (1988) found that the main constituents of the essential oil of basil are produced by two different biochemical pathways, the phenylpropanoids (methyl chavicol, eugenol, methyleugenol and methyl cinnamate) by the shikimic acid pathway, and the terpenes (linalool and geraniol) by the mevalonic acid pathway. Basil is an important essential oil crop with around 350 tonnes of essential oil being produced throughout the world annually and about half of this is produced from *Ocimum basilicum* L. and its close relatives. About 30 species of genus *Ocimum* are distributed in the tropical and subtropical regions of the world and few species are commercially cultivated in temperate regions

(Paton, 1992). Among 30 (Paton, 1992) -160 (Pushpangadan and Bradu, 1995) species of *Ocimum*, mainly 5 species are either wild or commercially cultivated in Upper Gangetic plains of India viz. *Ocimum basilicum*, *O. tenuiflorum*, *O. africanum, O. kilimandscharicum,* and *O. gratissimum*. In this regard, CSIR-Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow has put successful R & D efforts to develop various improved high yielding varieties like Kusumohak, Vikarsudha, CIM- Saumya, CIM-Sharada and CIM- Surabhi of *O. basilicum*, CIM-Ayu (green type), CIM-Angana (purple type) and CIM- Kanchan of *O. tenuiflorum*, CIM- Jyoti of *O. africanum*, etc.

Methodology

Extensive surveys and explorations of the Lucknow, Barabanki, Raebareli, Amethi and Sultanpur were undertaken for the collection of voucher specimens of the aromatic plant species from different areas at regular intervals in different seasons. Collected voucher specimens were processed, preserved, accessioned and deposited in the herbarium of our institute for the future reference and study following the technique of Jain and Rao (1977). Identification of the aromatic basils was done based on taxonomical characters with the help of available flora and local herbaria.

Taxonomical Key

1a. Throats of fruiting calyx closed by the up curved 2 median teeth of anterior lip, anterior much shorter than posterior; mostly shrubs or undershrubs. . . . . *O. gratissimum*

1b. Throats of fruiting calyx open, the 2 median teeth of anterior lip as long as or longer than posterior; mostly herbs with stems woody at base:

2a. Calyx tube glabrous or thinly covered with minute glandular hairs inside; nutlets unchanged when wet . . . . . *O. tenuiflorum*

2b. Calyx tube with a ring of hairs at throat inside; nutlets producing mucilage when wet . . . . . .

3a. Flower with pedicel nearly as long as calyx; appendage of posterior stamens hairy . . . . *O. kilimandscharicum*

3b. Flower with pedicel much shorter than calyx; appendage of posterior stamens glabrous

4a. Fruiting calyx up to 5 mm long; corolla 4-5.5 mm long

5a. Fruiting calyx 2-3 mm long; stem internodes with short adpressed or retrose hairs . . . . . *O. americanum*

5b. Fruiting calyx 4-5.5 mm long; stem internodes with long, spreading and sometimes retrose hairs . . . . . *O. africanum*

4b. Fruiting calyx up to 6-8 mm long; corolla 7-8 mm long . . . . . *O. basilicum*

The phenological data and the status of species were also being assessed. Assessment and selection of *Ocimum* species were undertaken based on their distribution and popular utilization pattern in the area. Potentially, *Ocimum* species were selected and conserved in our herbal garden for future reference and sustainable utilization.

Results and discussion

Owing to vast diversity of edapho-climatic condition prevailed in India, a large number of basils occur in wild habitats. Only a limited number of commercially valued plants both from its natural vegetation and cultivation are produced. Survey and excursions were made in all five districts of Uttar Pradesh during January 2013 to March 2015 at different intervals in different season. Voucher specimens of *Ocimum* species were collected, preserved and mounted on herbarium sheets for accession and incorporation in the herbarium of

CSIR-CIMAP. The brief description of following 5 wild, naturalized and cultivated *Ocimum* species along with latest botanical name, common name (s), family, habitat, major chemical constituents, biological activity, etc. have been provided:

MAP shows surveyed and project area of 5 districts of Uttar Pradesh.

After exhaustive survey and collection of *Ocimum* species in India, we have found various genetic and chemotypic diversities in natural population. Some species of *Ocimum* are citral rich, camphor rich, methyl cinnamate, methyl chavicol and linalool rich. On the basis of chemotypic variability various authorities named it as *Ocimum basilicum* and *O. americanum* (syn. *O. canum*). The populations of *O. americanum* and *O. africanum* are often intermixed and erroneously identified as *O. americanum* in most of herbaria in India. The taxonomy of *Ocimum* is in a state of confusion. In the literature concerning *Ocimum*, particularly the work pertaining to economic and industrial fields, same species is often referred to by more than one name or vice- versa. The circumscription of *Ocimum* itself is also a matter of dispute among taxonomists. Estimates of species in the world vary from 30 to 160 (Paton, 1992; Pushpangadan and Bradu, 1995).

Ocimum africanum (Lemon basil) was described by Joao de Loureio in 1970. Over the next 50 years separate systematic botanists gave it two names, *O. citriodorum* Vis. and *O pilosum* Willd. The same species is also found as *O. basilicum* var. *anisatum*, *O. americanum* sensu Pushpangadan & Sobti non L., etc. Although *O. americanum* is well known in Indian Floras, the following nomenclature (author citation), dichotomous key and description will facilitate to distinguish it from other closely related species. It is hoped that the present report will attract other Indian taxonomists for the correct appraisal of *O. africanum* in India.

Ocimum africanum Lour., Fl. Cochinch. 2; 270. 1790; Suddee, S. et al. in Kew Bull. 60: 28–29. 2005. *O. citratum* Rumph. in Herb. Amboin. 5: 266, t. 93, f.1. 1747. *O. pilosum* Willd., Enum. Pl. 2: 629. 1809. *O. basilicum* L. var. anisatum Benth., Labiat. Gen. Sp. 4. 1832. *O. basilicum* L. var. *pilosum* (Willd.) Benth., Prodr. 12:33. 1848. *Ocimum* × *citriodorum* Vis. in Linnaea 15: Litt. Ber. 102. 1841. *Ocimum americanum* L. var. *pilosum* (Willd.) A. J. Paton, in Kew Bull. 47:426. 1992. *O. americanum* sensu Pushpangadan & Sobti non L. in Cytologia 47: 575. 583.1982. 'Lemon basil'.

1. ***Ocimum africanum*** Lour.; Mamiri, Lemon Basil, Nimboo Tulsi; Lamiaceae.

   Description: An aromatic, annual or short lived perennial herb, up to 50 cm high; stems densely pubescent with long, spreading and sometimes retrorse hairs. Leaves elliptic-lanceolate or ovate-lanceolate, 0.8-3.5 × 0.6-2 cm, entire or shallowly serrate at margins, apex acute, base cuneate or obtuse, glandular punctuate, glabrescent above, hairy on veins beneath, sometimes pubescent on both surfaces with longer hairs on veins beneath; petioles 0.2-1.8 cm long, pubescent. Verticels up to 1 cm apart; axis densely pubescent with retrorse hairs; bracts ovate, up to 5 mm long; pedicels 1-2 mm long, recurved, finely pubescent. Calyx campanulate, 2-2.5 mm long, 4 – 5.5 mm long in fruit; posterior lip rounded, decurrent on tube; anterior lip with 2 median lanceolate teeth; tube with a ring of dense hairs at throat. Corolla white or light purple, 4-5.5 mm long; posterior lip with 4-lobed with oblong obovate villous lobes, anterior lip boat-shaped; tube straight, glabrous. Stamens 4, slightly exserted, posterior 2 shorter. Nutlets oblong, 1-1.5 mm long, black, minutely tuberculate (Fig 1).

Fig 1. *Ocimum africanum* field view

Close up of Inflorescene

Fig 2. *Ocimum africanum* Lour. variety CIM-Jyoti

Fig 3. *Ocimum basilicum* L. variety CIM-Saumya

Fig 4. *Ocimum basilicum* L. variety Vikarsudha

Fig 5. *Ocimum basilicum* L. variety Kusumohak

Fig 6. *Ocimum basilicum* L. variety CIM- Sharada

Fig 7. *Ocimum basilicum* L. variety CIM- Surabhi

Fig 8. *Ocimum basilicum* (camphor rich)

Fig 9. *Ocimum gratissimum*

Fig 10. *Ocimum kilimandscharicum*

Fig 11. *Ocimum tenuiflorum* (green type: CIM- Ayu)

Fig 12. *Ocimum tenuiflorum*
(Purple type: CIM- Angana)

Status: Common in waste places along roadsides.

Flowering and Fruiting: September - December.

Parts Used: Aerial parts

Medicinal Uses: Plant- carminative, diaphoretic, stimulant; leaf- in fever, skin diseases, cold, catarrh and bronchitis in children, bechic (Husain *et al.*, 1992).

Major Chemical Constituents: Essential oil: Citral (71.9%: 31.7% neral and 40.2% geranial), methyl chavicol (3.5%), citronellal (2.8%), geraniol (2.3%), β- ocimene (0.6%), 1, 8-cineole (1.3%), linalool (2.3%).

Biological Activity: Plant- effect on CNS, hypothermic; leaf extract- antibacterial; essential oil- antifungal (Husain *et al.*, 1992).

CSIR-CIMAP, Lucknow has developed on one high yielding improved variety CIM-Jyoti in O. africanum (Fig 2.). The average herb yield is 200 q/h and oil yield 150 kg/ha with 68-75% citral content in variety CIM- Jyoti against parental check having herb yield 175 q/h and oil yield 100 kg/ha with citral content 10-15 %, respectively. This variety has produced citral in a short duration of 70-80 days. It also fits in crop rotation/intercropping between wheat and paddy and with other vegetables crops of small farmers.

2. Among *Ocimum* spp., *O. basilicum* is the most economically important essential oil bearing aromatic crops because its leaves/herb are used in flavour, fragrance and pharmaceutical industries. Inter-specific hybridization and polyploidy is the most important cause for natural diversity in *O. basilicum* which created a lot of taxonomical confusion and challenges for taxonomists (Harley and Heywood, 1992; Tucker, 1986). Therefore, taxonomy of *O. basilicum* is complicated by existence of numerous varieties, cultivars, chemotypes and landraces within the species that do not differ significantly in morphology (Simon *et al.*, 1990). Due to presence of more diversity in chemical constituents and morphology, CSIR-CIMAP, Lucknow has developed many varieties in *O. basilicum* for commercial cultivation.

2a. ***Ocimum basilicum*** L. var. CIM-*Saumya*; Babui Tulsi, Sweet Basil; Lamiaceae.

Description: Basil is a low-growing annual herb 30-100 cm long. Stem square, slightly hairy; leaves ovate, entire to slightly toothed leaves; flowers whitish- pink, appear along the leaf axils in verticillasters; fruit consist of 4 nutlets; seeds small, black and mucilaginous.

Status: Grown for medicinal as well as experimental purposes. This variety has been developed by CSIR-CIMAP, Lucknow (Fig 3.).

Flowering and Fruiting: August - September.

Parts Used: Aerial parts

Herb yield: 290 q/ha, Oil Yield: 190 Kg/ha; Methyl chavicol (55%) and Linalool (40%).

Medicinal Uses: Flower- carminative, diuretic, stimulant, demulcent; seed- anti-odontalgic, anti- gonorrhoeic, anti-dysenteric; root- in bowel complaints of children (Husain et al., 1992). In Homoeopathy, the fresh mature leaves are used to treat spermatorrhoea, blood dysentery, haematuria, inflammation and congestion of kidney. Basil cures headaches, aids digestion and is a mild laxative. In Ethiopia, leaves are used against malaria, headaches and diarrhoea (Anonymous, 2003).

Major Chemical Constituents: Essential oil contains 1, 8- cineole, eugenol, limonene, ocimene, geranial, cis-3-hexenol, citronellol, alpha- terpineol, camphor, methyl eugenol, methyl cinnamate as minor and linalool, methyl chavicol (estragole) as major components. Methyl cinnamate may be a major constituent in some chemovars (Husain et al., 1992).

Biological Activity: Essential oil- antibacterial, antifungal (Husain *et al.*, 1992). The essential oil showed moderate repellent activity (Anonymous, 2003).

2b. ***Ocimum basilicum*** L. var. *Vikarsudha*; Babui Tulsi, Sweet Basil; Lamiaceae.

Description: Erect glabrous herb, 70-90 cm tall bearing ovate leaves with entire dentate margin having non-glandular uniseriate hairs on surface. White with bluish tinge flower, hermaphrodite, zygomorphic with bicarpellary syncarpous superior ovary. Fruits are dark brown nutlets measuring 2.5-2.7mm in length. Matures at 75-90 days after transplanting (DAT) with a seed rate of 120g/ha to raise seedling, planted at spacing of 45 x 30cm. It grows in February-March and May-June cropping seasons (Fig 4.). This variety was developed through hybridization between exotic basil from Australia (EC331886-CSIRO No. L6323) and local adaptive landrace (Badaun local) having essential oil yield potential about 261kg/ha with 0.7% oil content. The essential oil have methyl chavicol (78%) and Linalool (16%) as major and 1,8-cineole, L-camphor, Limonene, Eugenol, camphene germacrene-D, methyl eugenol as minor chemical constituents (Dwivedi et al., 1999).

2c. ***Ocimum basilicum*** L. var. *Kusumohak*; Babui Tulsi, Sweet Basil; Lamiaceae.

Description: Erect annual herb, green hard stem and simple dark green ovate brittle leaves, whole herb contain 0.38% essential oil content, whole herb has 45% linalool and 37% methyl chavicol but inflorescence contain 56% linalool and 17% methyl chavicol at mid flowering stage (Fig 5.). This variety was developed through half sib progeny selection from Argentina seed genetic stock having essential oil yield potential about 134kg/ha (Kumar et al., 1999).

2d. ***Ocimum basilicum*** L. var. CIM- *Sharada*; Babui Tulsi, Sweet Basil; Lamiaceae.

Description: The cultivar CIM EOH-1 basil has been developed by CSIR-CIMAP through intensive breeding efforts for high yield of herb and essential oil with desirable quality of higher Methyl chavicol 85-89 %. The variety CIM EOH-1 consistently shows higher herbage and oil content and methyl chavicol content in the field evaluation yield trials. The average herb yield is 280-290 q/h and oil yield 190-200 kg/ha in variety CIM EOH-1 V/S parental check CIM- Saumya herb yield 200 q/h and oil yield 122 kg/ha with methyl chavicol content 50-55 %, respectively. In these days essential oil having good amount of methyl chavicol is in high demand (Fig 6.).Hence, the planned breeding and selection process was undertaken at CSIR- CIMAP, Lucknow and developed variety CIM Sharada of *Ocimum basilicum*.

2e. ***Ocimum basilicum*** L. var. CIM- *Surabhi*; Babui Tulsi, Sweet Basil; Lamiaceae.

Description: Bushy growth habit, annual, tall having plant height 80-85cm, medium green leaves colour, leaf length 6.3cm, leaf width3.4cm having essential oil yield potential about 166kg/ha with 0.75% essential oil content and about 75% linalool content (Fig 7.). This variety is ready to harvest in 80-85 days after transplanting.

2f. ***Ocimum basilicum*** L.; Babui Tulsi, Sweet Basil; Lamiaceae.

Description: Basil is a low-growing annual herb 30-100 cm long; stem square, slightly hairy; leaves petiolated, ovate, 2.5-5.0 cm long, entire to slightly toothed leaves; flowers whitish- pink, appear along the leaf axils in verticillasters; fruit consist of 4 nutlets; seeds small, black and mucilaginous (Fig 8.).

Status: Commonly occur along waste places during monsoon.

Flowering and Fruiting: August- November.

Parts Used: Aerial parts.

Medicinal Uses: Stimulant, relaxant, headache, fever, carminative, etc.

Major Chemical Constituents: Essential oil- camphor (42.8%), limonene (7.3%), alpha-pinene (5.6%) and beta- pinene (4.6%), methyl chavicol (4.1%).

Biological Activity: Antibacterial, anti-fungal, antimicrobial (Saha *et al.*, 2013; Husain *et al.*, 1992).

3. ***Ocimum gratissimum*** L.; Van Tulsi; Lamiaceae.

Description: Erect perennial herb or soft shrub, up to 2 m; leaves opposite, ovate-lanceolate, variously pubescent on both surfaces, gland dotted below, margins often only dentate in the upper half; Inflorescences were terminal, simple or sparingly branched; calyx densely pubescent on the outside, lower lip often closing the mouth and obscuring the small white corolla (Fig 9.).

Status: Grown for experimental/medicinal purposes.

Flowering and Fruiting: August – December.

Parts Used: Aerial parts

Medicinal Uses: Plant- anti- rheumatic, anti-paralytic, anti- gonorrhoeic, in aphthae of children, seminal weakness; seed- anti-cephalalgic, in neuralgia (Husain *et al.*, 1992). In Ethiopia, the leaves are used for the treatment of headache. In Madagaskar, the herb or shoot is put in boiled water and the resulting vapour is inhaled for the treatment of blocked nose (nose) and headache. In Homoeopathy, the fresh mature leaves are used in constipation, nasal catarrh, cough and fever. They are also used in gonorrhoea with difficult urination and burning sensation and sometimes pus in the urine (Anonymous, 2003).

Major Chemical Constituents: Essential oil from leaves and flowers contains alpha - and beta-pinene, camphene, alpha- terpinene, delta-3-carene, myrcene, 1,8- cineole, p-cymene, limonene, camphor, linalool, alpha - terpineol, thymol, methyleugenol, methyl isoeugenol, caryophyllene, humulene, alpha-selinene, clovene, longifolene and a sesquiterpene alcohol, gratissimol. A variety rich in eugenol is also known as 'Clocimum' developed by CSIR-IIIM, Jammu. Seed mucilage contains pentoses, hexoses, uronic acids and lipids (Husain *et al.*, 1992; Anonymous, 2003).

Biological Activity: Essential oil- anti-bacterial, antifungal; plant- spasmolytic, diuretic, CNS active (Husain et al., 1992).

4. ***Ocimum kilimandscharicum*** Guerke.; Kapur Tulsi; Lamiaceae.

Description: Erect aromatic perennial evergreen undershrub; leaves ovate- oblong-elliptic, margin serrate, apex acute, narrowed at the base, green and pubescent; flowers whitish arranged in verticillasters, stamens much exserted; fruits one seeded and indehiscent (Fig 10.).

Status: Grown for experimental/medicinal purposes.

Flowering and Fruiting: August-November.

Parts Used: Aerial parts.

Medicinal Uses: Decamphorised oil-insecticidal (Husain *et al.* 1992). In Rewanda (Central Africa), the plant is used in traditional medicine to cure eye infection (Anonymous, 2003).

Major Chemical Constituents: Essential oil contains camphor, pinene, limonene, terpinolene, myrcene, alpha- phellandrene, linalool, camphene, p-cymene, borneol and alpha- selinene (Husain *et al.*, 1992).

Biological Activity: Essential oil- anti-bacterial, antifungal; aerial part- CVS and CNS active, spasmolytic (Husain *et al.*, 1992).

5. ***Ocimum tenuiflorum*** L.; Holy Basil, Tulsi; Lamiaceae.

Description: Erect annual herbs or under-shrubs; leaves 2.5-5 cm long, elliptic-oblong or ovate-oblong, entire or crenate-serrate, obtuse or acute at both ends; flowers purplish-pink, whorled, in racemes, often forming panicles; nutlets broadly ellipsoid and smooth.

Status: Commonly cultivated in gardens but seen as escape throughout. CIM-Kanchan, CIM-Ayu (green type) and CIM- Angana (purple type) varieties have developed by CSIR-CIMAP, Lucknow with an essential oil yield potential about 55 kg/ha, 110kg/ha and

91kg/ha, respectively (Kothari *et al.*, 2001; Lal *et al.*, 2003; Lal *et al.*, 2008). The CIM-Kanchan, CIM-Ayu (Fig 11.) and CIM- Angana (Fig 12.) herb contain essential oil content of 0.37%, 0.72% and 0.56%, respectively. Methyl eugenol (70%), beta- caryophyllene (15.7%) and beta- elemene (7%) in CIM- Kanchan, eugenol (83%) and beta- elemene (7.4%) in CIM- Ayu and eugenol (40%), beta- elemene (14%), beta- caryophyllene (9%) and germacrene-D (16.6%) in CIM-Angana are the major chemical constituents present in its essential oils.

Flowering and Fruiting: August- December

Parts Used: Aerial parts

Medicinal Uses: Leaves- expectorant; juice of leaves- diaphoretic, antiperiodic, in catarrh and bronchitis; dropped into the ear for earache, infusion of leaves- stomachache, in gastric disorders of children and in hepatic affections; dried leaves- powdered and used as snuff in ozaena; seeds- demulcent, given in disorders of the genitor-urinary system; root-decoction as a diaphoretic in malarial fevers; fresh roots, stems and leaves- bruised and applied to the bites of mosquitoes; plant- in snake - bite and scorpion- sting (Husain *et al.*, 1992).

Major Chemical Constituents: Major constituents of essential oil are eugenol, beta-elemene, carvacrol, nerol, eugenol methylether, caryophyllene, terpinen-4-ol, decylaldehyde, γ - selinene, alpha- and beta-pinene, camphor; leaves-ursolic acid, apigenin, luteolin, apigenin-7-O-glucuronide, luteolin-7-O-glucuronide, orientin, molludistin, rosmarinic acid, cirsilineol, gallic acid, its methyl and ethyl esters, protocatechuic acid, vanillic acid, caffeic acid, chlorogenic acid, 4-hydroxybenzoic acid, vanillin, 4-hydroxybenzaldehyde (Husain *et al.*, 1992 ; Rastogi and Mehrotra, 1998).

Biological Activity: Ursolic acid may have antiallergic potential (Rastogi and Mehrotra, 1998); leaves- hypoglycaemic, spasmolytic; plant- adaptogenic (Husain *et al.*, 1992).

Preparations and Formulations: Jwara-samharaka rasa, Tribhuvanakriti rasa, Muktapanchamrita, Mahajwarankusha rasa, etc. (Sharma *et al.*, 2000-2001).

Conclusion

Studied districts of upper Gangetic plain are a rich source of basil biodiversity. Conservation of Basil's diversity is very important for its important essential oil constituents, used by pharmaceutical, flavour and fragrance industries for preparation of various medicines and health supplements. Keeping in view of these importance, CSIR-CIMAP has developed so many varieties viz. CIM- Saumya, CIM- Jyoti, CIM- Sharada, CIM- Surabhi, CIM- Ayu and CIM- Angana, etc. for commercial cultivation and sustainable use of its herb for various pharmaceutical industries.

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Effect of Stone Mining Area Flora on Sustenance of Local People

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Introduction

From the prehistoric days man has been interested about earth's mineral wealth. The crude stone implements of the early Paleolithic period, post-Neolithic pottery, the Egyptian pyramids, iron and copper smelting in various civilizations, and the modern steel-age are all testimony of mining activities of man (Sarma, 2002). Plant species have long been used as principal ingredients of traditional medicine in the Vindhya region. Mining activities have caused the adverse effect on the medicinal plant as well as affected the whole flora of the region. (Anurag Singh *et al.*, 2014).Natural plant communities get disturbed and the habitats become impoverished due to mining. The Deverikala area - a part of Mirzapur District of Uttar Pradesh State of India - is known for its Stone mines. Stone, a mineral, is used in road, buildings etc. An extensive quarrying and open cast mining of the area have resulted into long barren, unproductive and deeply irregular sloppy lands, causing great damage to the forest as well as productivity of the region. Therefore the reclamation of this mining area becomes a priority to counter environmental hazards and to restore the ecological balance. Restorations of these mined areas are usually hampered by lack of basic information on the wide variety of native tree species that characterize these forests as well as insufficient understanding of the ecology of disturbance and natural recovery that can aid in the design of effective restoration programs (Dubey,K. *et al.*; (2013).stone mining area is refereed as the area where stone extraction can be done by the process of manual or mechanical. This stone is used as building material, road material basically, this mining process is exhaustively damage the floristic diversity, the flora of any area is the basic component of the rural livelihood. The local livelihood is dependent on flora for the food, fodder and fuel. Due to mining, degradation of the local forest has compelled thelocal populace to move to other alternatives forfood, fodder and fuel requirement. The present paper aimed to study the prevalent flora of mining area and its utility value to local people. The preference of local people for the species used for restoration of the area degraded due to mining and their preferred land uses have also been studied.

Ecosystem type

The forests of Mirzapur Forest belong to northern mixed dry deciduous forest type. The natural vegetation is dominated by *Butea monosperma, Anogeissus latifolia, Boswellia serrata, Lanneacoro mandelica, Hardwickia binata* and *Acacia catechu*. However, the project area is highly degraded and vegetation cover is very low.(Working plan report Mirzapur Forest Division Uttar Pradesh India)

Materials and Methods

The Mirzapur forest is natural, degraded and dry deciduous type of forest, located about 100 km in North east direction from Allahabad City, India. The soil is rich in stone, a major mineral used in road, buildings. Extensive open cast stone mining activities are being performed since over three decades, causing great damage to the forest as well as productivity of the region. An understanding of the impact of mining on the environment particularly on vegetation characteristics is a prerequisite for further management plan of these mining sites. Moreover, for reclamation works, proper selection of the species that will adapt with the climatic and local soil condition is a critical step. Since, the vegetation of the area is a direct expression of several important factors like altitude, rainfall, soil characteristics and biotic pressure, the

knowledge of floristic composition is valuable. The vegetation survey was conducted at undisturbed compartments of nearby forest of Stone mining site (at Deorikalan and Kotwa) and disturbed site both, by using standard quadrate method (Srivastava, 2001) during peak growth season in the month of September and October. For tree component a quadrate of 10m x 10m size was laid while for the shrub species it was 5m x 5m. For the herbaceous species the size of the quadrate was 1m x1m. The quadrates were laid randomly in nested form i.e. quadrates for shrubs and herbs were taken up inside tree quadrate. Ten replications were taken in both case i.e. disturbed and undisturbed. The species found in the quadrates were identified with the help of the taxonomists and herbaria of Botanical Survey of India, Allahabad and University of Allahabad. For studying the utility value of the species the questionnaire based method adopted and emphasized on the use of prevalent species as food, fodder and fuel by local people.

Results and Discussion

Climatic conditions

The climate of the Mirzapur forest is characterized by long and hot summers, monsoonal rainfall of about 800 mm and short winters. The project area mainly experiences three distinct seasons, the cold season starting from October to February, the summer starting from March to mid-June and the rainy season starting from June end to September. Average temperature in the region varies from 80 C in the month of December to 450C in the month of May. Maximum rains were observed during the month of July and August. While, from April onwards the region experiences severe heat. (Working plan report Mirzapur Forest Division Uttar Pradesh India)

Geographic conditions:

Most of the area is dry, hilly, and undulating with gentle slopes. The forest is broadly divided into three regions i.e. vast and fertile Gangetic plains, which spreads across north to south, Vindhyanhills and Kaimur plateau in the south of the forest division. Most of the hills in the region are undulating with gentle slopes towards the north as well as west direction. Towards the north in Gangetic plains, soil is fertile and suitable for agriculture practices, while towards the southern part the division has hilly and undulating terrains and soil is less fertile and unproductive. However, the entire land included in the project area is degraded on account of degraded land which is further exacerbated by excessive grazing. (Working plan report Mirzapur Forest Division Uttar Pradesh India)

Hydrology

Mirzapur is situated on the southern bank of River Ganga and many other perennial rivers i.e. Jargo, Chattar, Kalkaliya, Khajuri, Hrai, Kanravati, Belan etc. flow across the region. Ground water level at the river banks and surrounding areas are shallow. While, southern part of the forest is dry and face water scarcity for drinking as well as irrigation purpose. (Working plan report Mirzapur Forest Division, Uttar Pradesh India)

Soil conditions:

The major soil types in the region are black soils, sandy loam soil and red lateritic soil. In the northern part of the division at Gangetic plains the soil is fertile and alluvial type and suitable for agriculture practices. In the southern part of the region, the soil type is mostly quartzite. In alluvial plains with 0-1% slope, soil is deep, loamy, slightly eroded in some patches, which are moderately sodic and saline in nature. While, in active flood plains with 1-3% slope, soil is deep, sandy and stratified loamy in nature. (Working plan report Mirzapur Forest Division Uttar Pradesh India).

The vegetation characteristics of the disturbed area were compared with that of an adjacent undisturbed forest of the area. Plant species diversity at tree shrub, climber and herb levels was more in undisturbed forest of the area as compared to disturbed area. A total of 36 species representing 24 families of vascular plants (including trees, shrubs, climbers and herbs) occurred on the undisturbed forest site. At the undisturbed site the flora species like; *Boswellia serrata, Madhuca indica ,Acacia catechu, Haplophragma adenophyllum, Butea monosperma, Terminalia bellirica, Diospyros melanoxylon, Pongamia pinnata, Acacia nilotica,*

Table: 1 Prevalent Tree Vegetation of the Area and Utility Value:

S. No.	Tree	Common Name	Family	Food/ medicinal or commercial value	Fodder	Fuel	Utility Value
1	*Boswellia serrata*	Salai	Burseraceae	0	1	1	2
2	*Madhuca indica*	Mahua	Sapotaceae	1	1	1	3
3	*Acacia catechu*	Katha	Leguminosae	1	0	1	2
4	*Haplophragma adenophyllum*	Cut Sagwan	Lamiaceae	0	1	1	2
5	*Butea monosperma*	Dhak	Fabaceae	1	1	1	3
6	*Terminalia bellirica*	Behera	Combretaceae	1	1	1	3
7	*Diospyros melonoxylon*	Tendu	Ebenaceae	1	1	1	3
8	*Pongamia pinnata*	Karanj	Fabaceae	0	0	1	1
9	*Acacia nilotica*	Babool	Mimosaceae	0	0	1	1
10	*Azadirachta indica*	Neem	Meliaceae	0	1	1	2
11	*Lagerstroemia parviflora*	Asidh	Lythraceae	0	0	1	1
12	*Dalbergia sissoo*	Shisham	Fabaceae	0	1	1	2
13	*Albizia procera*	SafedSiris	Mimosaceae	0	0	1	1

Table 2 : Prevalent Shrub Vegetation of the Area and Utility Value

S. No.	Shrubs And Climbers	Common Name	Family	Food	Fodder	Fuel	Utility Value
1	*Nyctanthes arbor tristis*	Parijat	Oleaceae	0	1	1	2
2	*Ziziphus nummularia*	Jharber	Rhamnaceae	1	1	0	2
3	*Vernonia cinerea*	Sahdevi	Asteraceae	0	1	1	2
4	*Solanum nigrum*	Makoy	Solanaceae	0	1	1	2
5	*Sida cordifolia*	Bariyara	Malvaceae	0	1	1	2
6	*Indigofera tinctoria*	Sarphonk	Fabaceae	0	1	1	2
7	*Abrus precatorius*	Gumachi	Fabaceae	0	1	1	2
8	*Acacia concinna*	Shikakai	Fabaceae	0	1	1	2
9	*Dendrocalamus strictus*	LathiBaans	Poaceae	0	1	1	2
10	*Cocculus hirsutus*	Jamiti Ki Bel	Permaceae	0	1	1	2

Table 3 : Prevalent Herb Vegetation of the Area and Utility Value

S. No.	Herbs	Common Name	Family	Food	Fodder	Fuel	Utility Value
1	*Xanthium indicum*	Chotadatura	Asteraceae	0	1	0	1
2	*Tridax procumbens*	Musbhari	Asteraceae	0	1	0	1
3	*Semecarpus anacardium*	Bhilwa	Anacardiaceae	0	1	0	1
4	*Phyllanthus niruri*	Jaramla	Phyllanthaceae	0	1	0	1
5	*Oxalis corniculata*	KhatiButi	Oxalidaceae	0	1	0	1
6	*Evolvulus alsinoides*	Neeli Shankh pusphi	Convolvulaceae	0	1	0	1
7	*Eclipta prostrata*	Bhingraj	Asteraceae	0	1	0	1
8	*Cannabis sativa*	Bhang	Cannabaceae	0	1	0	1
9	*Boerhavia diffusa*	Punarnawa	Nyctaginaceae	0	1	0	1
10	*Cynodon dactylon*	Dub	Poaceae	0	1	0	1
11	*Digitaria adscendens*	Kreb Grass	Poaceae	0	1	0	1
12	*Solanum xanthocarpum*	Katai	Solanaceae	0	1	0	1
13	*Tribulus terrestris*	Gokhuru	Zygophyllaceae	0	1	0	1

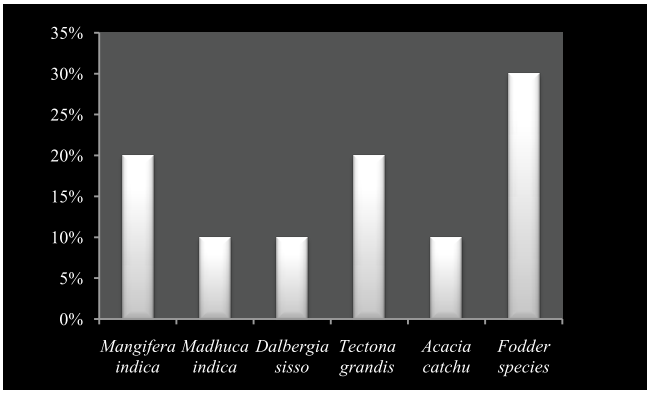

Fig 1: Species preferred by local people

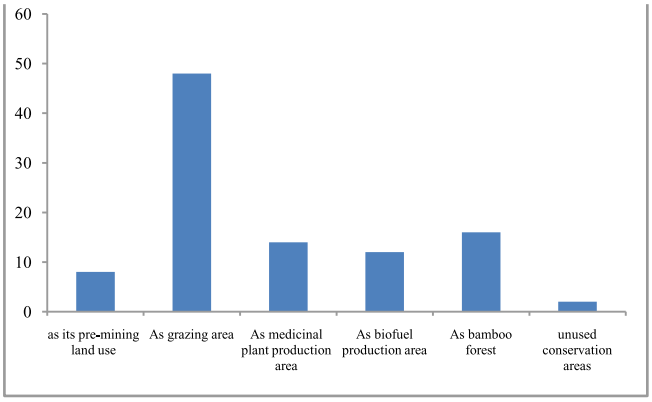

Fig 2: Preferred Land use after mining

Azadirachta indica, Lagerstroemia parviflora, Dalbergia sissoo, Albizia procera, Nyctanthes arbor tristis, Ziziphus nummularia, Vernonia cinerea, Solanum nigrum, Sida cordifolia, Indigofera tinctoria, Abrus precatorius, Acacia concinna, Cocculus hirsutus, Dendrocalamus strictus, Xanthium indicum, Tridax procumbens, Semecarpus anacardium, Phyllanthus niruri, Oxalis corniculata, Evolvulus alsinoides, Eclipta prostrata, Cannabis sativa, Boerhavia diffusa, Cynodon dactylon, Digitaria adscendens, Solanum xantho-carpum, Tribulus terrestris found (table 1, table 2 & table 3). Utility value of plant based on the based survey is also depicted in table 1, table 2 & table 3.As far as survey for utility of reported species in daily routine of local people was concerned, most of the shrubs and herbs are having fodder value to local people. Though these species are of

not having quality fodder value, in spite of that, due to absence of good fodder value grasses like stylo etc., theses locally available shrubs and herbs are being used as fodder for feeding/ grazing for their livestock.

As far as survey for preference of species for restoration was concerned, in the survey, plants species, preferred by local peopleare depicted in (Fig 1). Species preferred were *Mangifera indica, Madhuca indica, Dalbergia sissoo, Tectona grandis, Acacia catechu*, and any fodder grass species (Fig 1).These species are having food, fodder, fuel, timber and commercial values. The land use pattern of the local people preferred in the post mining activity use is depicted in (Fig. 2). The most preferred land use by local people was as grazing area for their livestock followed by bamboo forest and medicinal plant production area. These observations shows that major concern of local populace is fuel and fodder availability required for their sustenance of daily needs.

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Sustainable Utilization of Plant-diversity in Homestead Garden of Uttar Pradesh for Providing Nutrition Security in the Household

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Introduction

Homestead or home garden is one of the world's most ancient food production systems harboring the local agro biodiversity. Home gardens, sometimes referred to as mixed, backyard, kitchen, farmyard, rooftop, compound and homestead garden. This can be grouped into two basic categories as: "traditional garden"- those cultivated independent of any intervention and "promoted gardens"- those cultivated with intervention. Home gardens are often used to maximize the range of species and varietal diversity. The socio-economic value attached to home gardens has been reinforced by their important contribution to household food and primary healthcare security. Promotion of home garden among the local community will help in conserving the local biodiversity in a better way with an aim of providing household food security and economic benefit. The maintenance of home gardens and community gardens help to grow many crops, roots, tubers and grains. The plot of land around one's home is the only private land a family owns which can be sustainably utilized by cultivation of local and wild plants. Home gardening is one of the world's most ancient food production practices and is commonly practiced throughout the world. These gardens often vary in size, biodiversity and products and are adapted to local resources and cultural preferences.

Need and importance of home garden from Indian perspective

Household gardening and food security is a topic that has been under-research for a long period of time. More research is needed in several fields like agriculture, ecology, nutrition and socio-economics of home gardening. The home gardens play a valuable role in rural development. It plays an important role in contributing to the biodiversity in agro-ecosystems. Agricultural biodiversity is one of the most crucial of environmental riches and it has been eroding at an unprecedented rate in the past few decades. Much of the agricultural biodiversity that remains on farms today can be found on the semi-subsistence farms of developing countries and in the small-scale farms of developing countries and home gardens located in the marginalized areas of more developed countries. They provide daily nutritional needs for the family with following advantages:

i. Provide more income
ii. Increase food production
iii. Diversify food production
iv. Make the garden easy to care for waste recycle
v. Beautification of premises
vi. A stock of local wild germplasms
vii. Make use of all area available
viii. Food-supply in the lean seasons of the year

In rural India, various occupational and cultural groups depend on different caste segmentations for their sustenance upon the limited resources available in their surroundings. The dependency on these resource-base and constraints influence their socio-economic and cultural life. The optimal survival of the individual owes much to their prudent use of the natural resources to which they have free access. So, there is a need to include home garden systems as a component of national complementary conservation strategies.

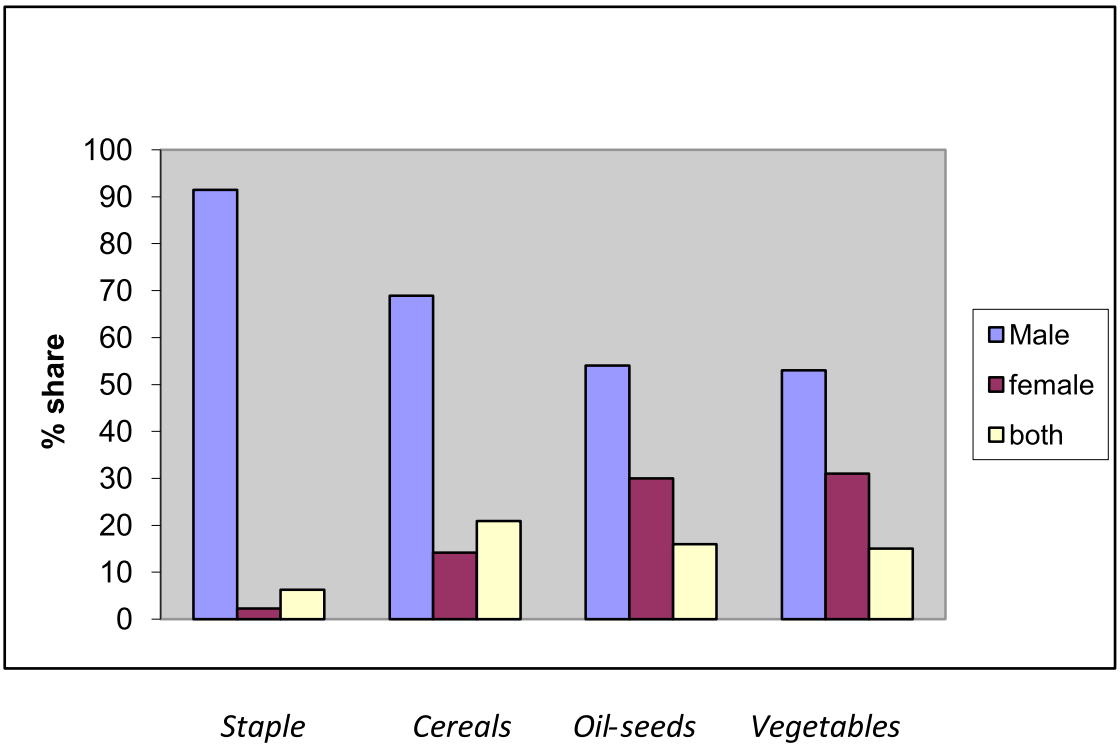

Fig. 1. Gender-analysis in decision-making of plant cultivation

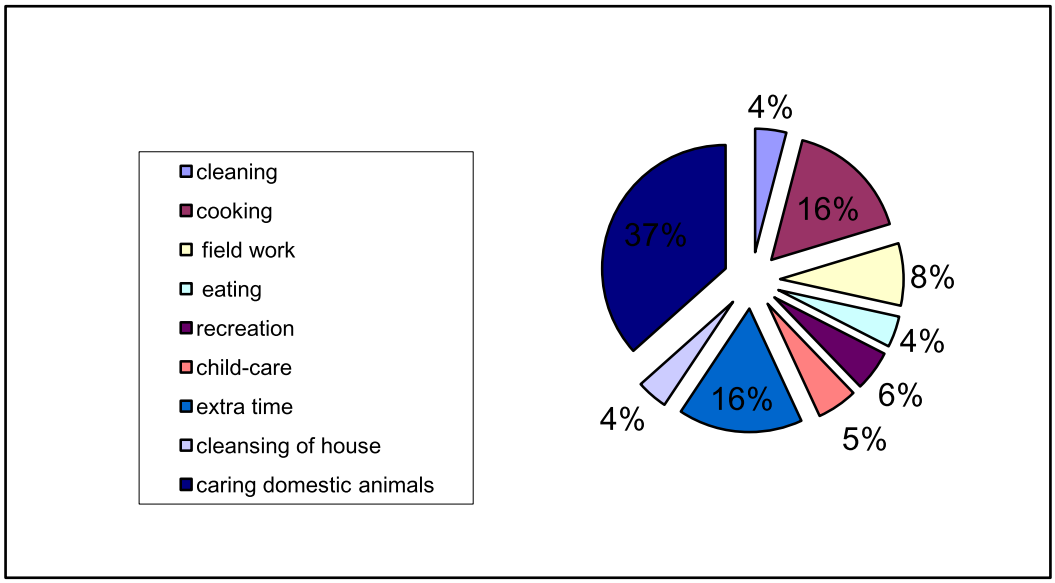

Fig. 2. Daily work-time schedule of a village woman in the studied villages

Home garden configuration

In an ideal home garden the wastes of one type of production provide inputs for other forms of production in a cyclical relationship and is known by the widely recognized designation GPC where, G = garden P = pond and C = cattle. Types of home gardens and their variants like: soil type, sloping land, time, money and available plantlets or seed materials play a crucial role in adopting home gardening. In India, they can be classified into general categories based on primary production systems, crop composition and structure. However, home gardening is an indigenous, integrated method of home production that often combines vegetable and fruit gardening with livestock. The various types of home gardens are:

- Home gardens with fruit trees
- Home gardens with fish-pond and covered livestock/poultry area
- Home gardens with vegetables
- Home gardens with forest trees

From a conservation biology perspective, one of the limiting features of home gardens is the very small population size for any single crop or tree species, which may make them particularly subject to genetic drift. They are also subject to strong selection pressures, given their importance to and use by the household. However, the home garden systems provide in situ conservation of particular crop landraces.

Home garden composition and structure in Uttar Pradesh

The state Utter Pradesh comes under the fertile soil of upper Gangetic plain with various occupational and cultural groups which may appropriately be called as small-scale society which inhabit in different ecological niches. They depend mostly on various ecological niches for their sustenance upon the limited resources available in their surroundings. The shelter on environment with its resource-base and constraints influence their socio-economic and cultural life. Their optimal survival owes much to their prudent use of the natural resources to which they have free access.

Species diversity in home garden

The concept of home gardening and intake of green vegetables are quite primitive in a typical village of North India, people used to go for planting of different climbers like: Pumpkin (Cucurbita pepo L.), Tinda (Citrullus vulgaris Schrad. Syn. Colocynthis citrullus (Linn.) Kuntze), Karela (Momordica charantia Linn.) etc. the households seldom grow any vegetables for their own consumption; rather they cultivate different seasonal vegetables for monetary-income as per the demand in the market. This is indicative of the fact that the rural housewives lack the basic knowledge about the nutrient content in the vegetables and its utility in the maintenance of a perfect body-physiology. Apart from some big fruit trees there are some plants which are planted for religious and beautification purposes as: Ocimum sanctum (F. Labiatae), Azadirachta indica (F. Meliaceae), Hibiscus rosa-sinensis (F. Malvaceae), Tagetes patula (F. Compositae), Dhatura alba (F. Solanaceae), Calotropis procera (F. Asclepidaceae) etc.

Cultural importance of home gardens

Home gardens are often used to maximize the range of species and varietal diversity, while providing easy access to species of cultural importance. The cultural value attached to home gardens has been reinforced by their important contribution to household food security. The composition of home gardens is rich with basic subsistence crops such as: roots, tubers and grains. The plot of land around one's home was the only private land a family controls. The socio-economic changes in Indian agriculture have been attached to the cultural significance of the home gardens.

Social dimension- gender analysis

The different values placed on diverse genetic resources and their environmental functions vary according to gender. The gender division of labour resources, knowledge and products reflect conflict, complementary or coincidence of men and women's interest in land use systems. Figure 1 indicates the decision-making capabilities of men and women in selection of plants and their planting pattern.

Men and women were asked to estimate the percentage of decisions made by the female or the male of the households. The data showed that, men usually takes most of the decisions relating to cultivation of cash crops like: wheat, rice, cereals, fruit trees and related cash-crops. As these plants, generate maximum monetary-return. But, the decisions of plantation of ornamentals and medicinal plants are largely in the domain of women. However, fig.2 indicates that a rural women get maximum extra-time after finishing her daily household chores and work in the field. Field-work includes: collecting fuel-wood, helping in cultivation activities like: transplanting the saplings, weeding, hoeing the land. Whereas, the household activities include cooking, cleaning the utensils, taking care of the children. So, the extra time left out by the rural housewives may sustainability be utilized.

Roots, tubers and vegetables, on the other hand, seem to be mostly in the domain of male. So, attempt had been made to train and sensitize these rural womenfolk about the cultivation of local traditional vegetables and their further consumption for health-benefits.

An analysis of the present scenario of rural India reveals that planned efforts are lacking for using the potential of women fully for rural development. The present study revealed the status of women's involvement, their capabilities and factors responsible for plant-based rural development. Lack of decision-making opportunity and low exposure to growth opportunity are some of the important socio-cultural constraints which affect the development of women in the villages.

Diet diversification is arguably the most sustainable and affordable strategy to improve nutrition for the majority of the population-particularly the poor. For poor households, vegetables and fruits are often the only source of micronutrients in the family diet. Homestead production of fruits and vegetables provides the household with direct access to important nutrients that may not be readily available or within their economic reach. So, motivation to the rural womenfolk through various effective training programmes by distributing booklets, seed packets and other accessories needed to carry out horticultural operations in the field will promote the programme of home gardening.

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Engaging Community for Sustainable Actions for Conserving Habitat of Ganges River Dolphin in Ganga River Basin

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Introduction

The strategies being discussed and adopted globally are now recognizing strong role of education for bringing substantial change in the way people are engaged in biodiversity conservation. The Convention on Biological Diversity has clearly affirmed and recognized the critical need to engage society individually and collectively through education and public awareness. This is critical time when we need to build strategies to move the society from awareness of biodiversity and sustainability issues to concerted action. Also recognition to the fact is important that biodiversity conservation is intrinsically linked to sustainable development.

This reflects in the recently drafted Sustainable Development Goals where Goal 15 emphasizes urgent need to act upon it. It states "Protect, restore and promote use of terrestrial ecosystem, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss". There are 09 targets under this goal and 03 sub-targets which clearly defines line of action.

In this context, people residing along River Ganga basin have opportunity of living on most fertile zone and also a challenge of sustaining the aquatic resources for human use and also flora-fauna dependent on the basin. River Ganga is known to be the most important river system, not only in India but also of the world. It is the 20th longest river of Asia and the 41st longest river in the world. Throughout its 2525 km long course from its origin at Gomukh in Himalaya to Gangasagar in Bay of Bengal, Ganga is the lifeline to millions of people. It has served as the cradle to the Indian civilization.

It has great importance in respect of culture, economy as well as ecology. The river has unique features due to the variation in altitude, climate, flora and fauna, land use and cropping pattern. The water resource of the river is used for agriculture, irrigation, power generation, human and cattle consumption, fish production, tourism, pilgrimage and recreation.

Apart from human population dependence, it is also lifeline for various species of animals and plants which thrive in and around river Ganga. The river sustains diverse group of flora and fauna supporting rich biological wealth. The river is symbolized pure with the presence of Ganges river dolphin (*Platanista gangetica gangetica*) in it. This endemic species was declared endangered in 1996 by IUCN where it was estimated that 2500-3000 individuals are left in rivers of India-Nepal and Bangladesh. Being on apex of the food chain, it is believed if the species is conserved it will not only safe guard other aquatic species but also help us in saving river ecosystem.

Ganges river dolphin *Platanista gangetica*
Courtesy Dr. Sandeep Behera

During last few decades, the river and its biodiversity is under severe danger. Instead of several efforts of government, the water quality is deteriorating day by day and developmental activities are changing course of river flow. This situation is putting danger to the survival of biodiversity found in Ganga.

Apart from rivers and river biodiversity being in danger, it is also communities which are dependent on rivers are facing major pressure from development activities such as large dams, growing pollution through point and non-point sources, encroachment of river banks, sand mining, deforestation etc. These activities are severely affecting the rivers ecological, social, economical aspects along with religious, cultural and aesthetic values. There are several factors of river water and nutrient quality which affects the freshwater aquatic biodiversity in rivers. Any development project focusing on trapping the river flow or utilizing the riverine resources directly and indirectly affects the livelihoods of poor community including farmers and fishermen in a major way.

The Ganga basin constitutes one fourth of the water resources of the India and more than 40 crore people of the country lives in the basin and they are directly or indirectly dependent on its aquatic resources. As a result there is strong pressure on the aquatic resources such as water for domestic use and irrigation along the river Ganges and its tributaries. Agriculture is a main source of livelihood of the large number of people living in Ganges river basin. People living close to river bank are also largely dependent on the fisheries for their livelihood.

After the green revolution agricultural production tremendously increased in the Ganges river basin, subsequently use of chemical fertilizer was also increased. In the year 1962-65 the average fertilizer consumption was 1.7 thousand tones per district of Ganges river basin. However, average level of fertilizer consumption per district of Ganges river basin grew up tremendously to a level of 102.6 thousand tones during the period 2003-2006. With the increase in consumption of chemical fertilizer, use of pesticide in Ganges basin was also increased many folds. These chemical fertilizers and pesticides are serious threat to the river Ganga and its aquatic biodiversity because they have become one of the main sources of river and ground water pollution. These chemical fertilizers are also threat to sustainable agriculture.

Sand islands of river Ganges and its tributaries are also very fertile for agriculture especially for growing cucurbits. Farming on the sand island is one of the main sources of livelihood for the large number of farmers living close to river bank. Farmers grow water melon, musk melon, cucumber and pumpkin on the sand islands in large scale especially in dry season (October to June). These farmers are also using large amount of chemical fertilizers and pesticides. Chemical fertilizers and pesticides are directly reaching to the river due to agricultural run-off and polluting the river water which is one of the major threats to the Ganges river dolphin and other aquatic species.

Fishing pressure is very high in river Ganga especially in lower Ganges. Fishing is a main source of livelihood for the large number of poor fishermen living close to the river. Use of monofilament nylon nets has been widely spread out in this region. Exploitation of small fishes through these nets is considered as a major cause of prey base depletion of Ganges river dolphin. Fish resources of river Ganga is also declined in last few decades due to over exploitation, river pollution and diversion of river water. The average catch of fishes per kilometer of the river Ganga at Allahabad was 1344 kg/km in the

Use of gill net to catch small fishes by fishermen which is food of dolphin and also gets trapped

year 1950 which is declined to 362 kg/km in the year 2000.

Understanding this grave situation and for giving due focus to its protection and conservation, Government of India has declared river Ganga as National river in year 2008. Being the only mammalian predator of the Ganga, the Ganges river dolphin occupies the apex of the food chain and plays a vital role in maintaining and balancing of the ecosystem. In year 2009, Ganges river dolphin has been declared as National aquatic animal to save its habitat along with biodiversity of the river.

Now conservation and protection of these national symbols is a mammoth task for government. It is widely accepted that it is important to involve people in conservation movement to not only build awareness and understanding but also to sensitize them towards adopting positive sustainable actions. Centre for Environment Education (CEE) felt a need of awareness and education about rivers and Ganges river dolphin among people living close to rivers so that they should utilize the riverine resources in a sustainable manner without disturbing its ecological balance.

The Initiative

In order to aware and educate the students and communities living close to Ganges river dolphin habitat, CEE initiated Ganges river dolphin-Conservation Education Programme with the support of Ministry of Environment and Forests (MoEF), Government of India in July 2010. This initiative was undertaken as part of "The Conservation Action Plan of Ganges River Dolphin - 2010-2020". Education and awareness was enlisted as one of the action component among 8 areas.

While working with schools, it was felt that riverside community needs to be reached out with the conservation education message for long term sustainable impact. Phase II was initiative in year 2014 with the support from National Mission for Clean Ganga (NMCG) an autonomous body of National Ganga River Basin Authority (NGRBA) under Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India. This phase envisaged to cover over 750 schools along Ganga basin in UP and Bihar and also looked in to engaging community which is dependent on riverine resources for their life and livelihood from both the States.

It was envisaged in the project, river eco-development will be done in dolphin project villages where fisherman, farmers, youth and women usually migrate in search of livelihood. Through skill based trainings and alternative option demonstration, community will be trained and adopt practices for generating income through various sustainable options.

Community Engagement

CEE with the support from NMCG is working with 10 Gram Panchayats at two selected sites of Ganges river basin in UP and Bihar. In Uttar Pradesh, these villages are located in Bahraich along Ghagra river and in Bihar, villages of Bettiah-West Champaran along Gandak river with potential Ganges river dolphin population was identified for interventions. Both the project areas are economically and socially backward where migration, illiteracy and poverty are very high. Thus focus was given to marginal farmers and fishermen of the project villages.

Advocacy and Empowerment

Reaching to unreached people with right kind of information and knowledge is need of the hour. This project began with this foundation and started its work by assessing needs of people in terms of livelihood and training needs. To find out the ground situation baseline and series of village level consultative meetings were conducted by CEE team. In order to get everyone's active and equal participation, a 'Souns Sanrakshan Samiti' (Dolphin Conservation Committee) was formed. A youth from each village was identified to anchor the meeting and to motivate stakeholders for adopting alternative livelihood options. Campaigns on environment related days involving local schools were conducted to spread the message and to encourage communities to come forward and take action for conservation of Souns and its habitat.

Sensitization of Community

River dependent communities during last few

Community training on organic faming

Vermi-compost ready for application

decades have been forced to adopt certain practices which have starting harming river biodiversity and its water quality. Farmers are now dependent on chemical based farming which ends up in the river with water runoff. This affects not only water quality but results into bioaccumulation in freshwater fishes. A fish catching calendar was followed traditionally by fishermen who have disappeared due to poverty and other social factors. CEE team in series of discussion and meetings with community have sensitized and convinced them for adopting organic farming and also going back traditional calendar of fish catching. Also traditional practices with present requirement were considered for adoption. Information, education and communication materials were designed, displayed and distributed among community to make them understand the species and purpose of the intervention.

Sustainable Livelihood Interventions

Organic agriculture is a way to fight with poverty and get better quality products. Introducing community with the concept of caring for its soil, adapting vermi composting practices, preparing bio-pesticides, using water management practices, etc. was helpful in making agriculture affordable to poor farmer families.

Riverbed farming can be used to increase household income and to improve the food security of landless and land-poor households in the Dolphin Project locations. The annually flooded riverbeds are seasonally dry (from September to May) and are a generally unused land resource. Landless and land- poor farmers can use this land to cultivate seasonal vegetables that are adapted to the environmental conditions prevalent on riverbeds. Several advantages of river bed cultivation, which includes: early yield, ease in irrigation, low cost, high net return per unit area and high yield, less mineral requirement due to high fertility, limited weed growth, easy in control of pest and disease by cultural, means, low cost labour facilities and additional crop.

Alternate Energy options is a way which directly helps improve the condition of rural women as it reduces drudgery and also reduces indoor air pollution. Smokeless stoves and solar energy lanterns help in improving living standards.

Alternative Livelihood options are being introduced among community members such as mushroom cultivation, integrated fish farming, animal husbandry, backyard vegetable cultivation, bamboo craft etc. These alternatives are introduced with skill based training which helps in building capacity as well empower riverside community.

Bio-shield plantation and river friendly practices are also being promoted to help conserve the river side villages and improvement in river ecology. Government schemes and skill development programmes are linked with the intervention villages to maximize the benefits of adopting other options.

Impact and Way Forward

This initiative is focused on education and communication for conservation of a species and its habitat through the involvement of river dependent community. As per national biodiversity education strategies, the possible action plan of India states "Train communities in innovative conservation practices and multiple skills to practice alternate livelihood options to enhance their role in conservation". The core idea of this intervention is to improve understanding of river side community about river ecology and its biodiversity in order to empower them for protecting and preserve their and river's future. We need to mainstream the river side community which faces much more grave danger than of losing their land and livelihood due to river floods and river bank erosion.

It is believed that Ganges river dolphin is like tiger of the Ganga river. Thus eco development plans made for Forest protection and conservation have consideration of the community residing around forest areas. To preserve aquatic biodiversity, it is important to adopt river focused eco-development which improves habitat for the biodiversity and also at the same time benefits local river dependent communities.

Alternative livelihood options introduced

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Innovative Capacity Building – The Radical Requirement for Mainstreaming Biodiversity and Sustaining people and their livelihoods

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Introduction

Mainstreaming of any venture or mission implies bringing their basic concepts and ideologies into the main focus of human valuation and evaluation. Thus mainstreaming biodiversity signifies the proper communication of all the essential ingredients of biological diversity not only to the intellectual elites but also to the hearts and minds of the masses and the commoners. Moving a little ahead of that we may assert that the knowledge and skills pertaining to Genetic Diversity, Species Diversity as well as Habitat Diversity has to be adequately and appropriately transmitted and transferred to the minds of the masses. As a natural consequence to this essential requirement, proper capacity building of all the classes of human beings is the most important call and message of the present times.

The Present Plights and Possible Remedies

Let us begin with the most severe plight and constraint of the modern human being which dwells in the salient truth that in the desire and pursuit of rapid development most of the human beings have moved away from 'Nature' and natural surroundings. Thus most of us hardly believe in observing and appreciating the beauty and knowledge embedded in our environment. Our capacity for the same has to be augmented to the desired level. All the schools and colleges have to play a prominent role in the mission. The celebrations of all the forest and environment days of the year for example the 'International Day for Forests' , 'World Wetlands Day', 'International Day for Biological Diversity' and the 'World Environment Day' have to systematically utilized to create at least five Master Trainers in at least twenty percent of all the schools of all localities of urban areas . They should be supplemented with technical discourses and practical demonstrations during the Annual Functions of the schools The charm and wealth of nature has to be laid bare before the mental eyes of even the most feeble minds. It has to concentrate upon the rivers, seas, oceans, lakes, hills, mountains, trees, shrubs, herbs and forests in the vicinity or within two hundred kilometers. The state, national and international standards have also to be conveyed and communicated. The funds available at the divisional, district and regional level should be used prudently for the purpose. The Non Government Organizations working in that direction have to be encouraged to the optimum.

Innovations within Timeless Traditions for Vegetative Knowledge and Skills

It always pays to be innovative and the most acceptable procedure and mode to innovate is to search for possibilities for innovations stored within traditions. It can be done concretely by familiarization with the most salient properties and values of prominent traditional trees and shrubs for each town, city and village. The most prominent ones have to be declared as the 'Vegetative Pride' of the place. It is advisable to classify and categorize them as the oldest, the tallest, the stoutest and one medicinally most precious ones. Thus even the most ignorant and uneducated persons and units would become conversant with biodiverse realities such as the majestically assertive Ficus, the incomparable and priceless Neem and the ever energizing and amazing Arjun. It may be extended to all the important medicinal herbs and shrubs that constitute the core of Ayurveda and Unani .The school authorities should motivate their teachers to constitute Specific Biodiversity Groups and to assign to each group a particular gene, species or a

specific habitat for observation, analysis and pragmatic conclusion. It shall augment the level of knowledge and pave the way for proper skill development. It is herein that the head of each family has to be sensitized and educated at the local level so that he or she can guide his or her children and other members of the family for that cause.

The Study Tours and the Educational Excursions

It is a universally accepted fact that seeing is believing. Thus educative biodiversity study tours, excursions and exposure visits deliver a commendable role in bringing the knowledge and skills related to biodiversity into the main focus. They may be nature tours of rivers, valleys, hills and mountains, planned visits to forests and sanctuaries, travels and halts within national parks and zoological gardens or else to modern Biological Parks. As a streamlining force we have to introduce within them presentations, paintings, essay writing and travelogues aptly conceptualized and drafted or implemented by the participants. To encourage such participation the efficient performers should be awarded, rewarded and honored. A salient output of one such excursion organized by a reputed institution to a nearby forest just few days before the Holi Festival, is quite noteworthy. It acquainted the entire group of participants with the basic properties of the 'Flame of the Forests' along with its local name 'Dhak' and 'Palaash' and the medicinal, traditional and ecological importance of its flowers and its other parts. These implementations can be easily supplemented with display of short movies and video-films along with systematic internet displays.

Arousing Awareness within the Masses

Nothing can be achieved without catering to the needs of the masses and to the individuals or families residing in the villages. Each person is a separate case study and each village is a distinct environment. As regards the villages, it is the duty of the village council and the village head as well as the individual and collective responsibility of all the villagers to keep its habitat pure and clean, maintain its ponds and water-bodies, know and identify all its flora and fauna and also to know each other as well as all the available livelihood options. The Joint Forest Management Committees and the Eco Development Committees constituted in several nations have motivated millions of minds for that noble cause. It is a common traditional belief that the situation and status of the village ponds and trees signify and mirror the health and potential strength of all the elements of its biodiversity.

Educating the students, parents and teachers

Several complex terms and technical jargons are often used at various national and international forums wherein they perform the undesirable task of confusing the common minds. This situation calls for the publication of the pertaining knowledge in vernacular languages with the usage of simple words and phrases. Much remains to be done and achieved in this direction. The most important target groups for this cause are all the students of primary education level. The teachers have to think and act in close collaboration with the parents of the students. The parents-teachers meetings would be the idle platform for building the capacities of parents for proper comprehension of biodiversity and its intimate relationship with sustained development. Herein a brief reference to the Children Forest Programme would be worthwhile. This programme which is presently being implemented in thirteen districts of Uttar Pradesh has concentrated entirely created awareness amongst the students of prudently selected schools of these districts through Nature Tours, growing mini forest, teacher's orientation and other planned activities. It serves to provide a working model for capacitating the posterity. (Action Handbook for Teachers Published By OISCA International, North India)

The Salient Need of the Hour

All of us whether living in cities, towns or villages, have to think about at least one aspect of Biodiversity each day. Each day we have to think, read, observe, converse, discuss and analyze the chosen aspect and trace its realistic relation with our past, present and future. Thus conservation of biological diversity has to be identified as an essential daily need. We may begin from the monthly mode, pass through the weekly deliverance and ultimately arrive at the daily disposition. We have to grasp several mutually associated modern concepts such as Ecological Balance, Protection of

Environment, Wetlands and Wetland-Conservation, Conservation of Biological Diversity, Habitat, Forests, Eco-tourism along with several others.

The path and the provisions

Adoption of the concept of minimizing the biotic pressure on 'Forests' is one of the safest mode for sustaining and mainstreaming biodiversity. This can be prudently done by making maximum choice of those livelihood options which are not dependent upon forests. Among the options having dependence upon forests, only those ones have to be chosen which do not hamper the sustainable utilization of our forest wealth. The same concept should apply to the options dependent upon 'Nature' and 'Natural Wealth'. This particular fact calls for all the members of the duly constituted 'Forest Users Group' to be well educated about its local biodiversity and the status and future possibilities of all its available livelihood options. Thus specific programmes for their capacity building ought to be organized at the local, district, regional, state and national level. National and State Awards and recognitions for the most aware participants of the year may serve as a morale booster for that cause of prime importance.

Augmenting the Technical Capability – An Illustration

Due reference to the Uttar Pradesh Participatory Forest Management and Poverty Alleviation Project would be reasonably apt at this juncture. The project is operational in three distinct habitat zones of Uttar Pradesh namely the Terai region, the Vindhyan area and the Bundelkhand portion. A case of the Lalitpur Division of the Bundelkhand region is quite enlightening. As per the provisions for capacity building for staff and the villagers and rejuvenating and mainstreaming their implementation capabilities, the Project officials contacted the India Grassland Institute at Jhansi and obtained seeds of *Stylo hemata , Penicum maximum* (Ginni) and *Dicanthium annulatum* (Dinanath) and the technology to plant these grasses in the Village Forest of Billa Village , to enable villagers to get palatable grasses for their milch cattle . Besides the grasses, medicinal plants like *Aloe vera, Cymbopogan flexuosus* (Lemon grass), *Withania somnifera* (Ashwagandha), *Calotropis procera* (Arka), *Strychnos nux-vomica* (Karaskara), *Achyranthes aspera* (Apamarg), *Rauwolfia serpentina* (Sarpgandha), *Chlorophytum tuberosum* (safed musli), *Ocimum basilicum* (Shyam Tulsi), *Andrographis paniculata* (Kalmegh), *Asparagus racemosus* (Satawar) , *Anacyclus pyrethrum* (Akarkara), *Tinospora cordifolia* (Giloy), *Solanum nigrum* (Makoy), *Cassia augustifolia* (Senna) were also planted/ sown. While the villagers are getting fuel wood, gum and honey as minor forest produce from the forest, the cultural operation in the plantation area is providing timber for use in construction of houses, thatched roof, shed for the animals and also for the agricultural implements. The JFMC is confident that once the medicinal plants start flowering, the conducive environment will favour the natural regeneration. (Compendium of Success Stories of Uttar Pradesh Participatory Forest Management and Poverty Alleviation Project, Year 2015, Page 61).

This particular example connotes a true example of the capacity building of implantation staff and the villagers through the conceptualization and actual realization of vegetative coherence and biodiverse realm.

Analysis of the self and the surroundings

Planners can plan and implementers can implement for a region, village or city only in that situation wherein they are having sufficient knowledge about its geographical, demographical and natural realities. They have to be mindful and adequately aware of the dwellings, the dwellers as well as the local ventures. It all begins from the self through proper self-realization. The maxim 'Know Thyself' conveys a perpetual message. Thus the capacity of all the planners, implementers and administrators have to be strengthened and streamlined, so that, they can transmit and transfer the guidelines and technologies down below to the grass-root level. It has to begin with a clean conscience through a concrete realization of 'What am I?' , pass through 'What they are?' and move towards 'What is best for them?' It is a clear case of approaching the problem in the simplest possible mode through convenient, simple methods and conceiving the essential needs of the poorest of the poor. Simple Living and High Thinking along with

the augmentation of knowledge and refining of livelihood option skills is the safest and the surest methodology.

Developing capacity for conducting non-forest activity- An illustration from UP-PFMPAP

Livelihood options prevalent in most of the villages involves extraction, debarking, plucking of flowers or leaves, heating or distillation of raw material ,uprooting, collection of seeds, herbs, shrubs and fruits or else stem-boring . For the proper tapping and optimum utilization of the available potential, the capacity and the capabilities of the members of active Self Help Groups needs regular augmentation and rejuvenation. They need to be empowered to the level of being able to prepare the pertaining business plans. A particular case of Allahabad Division of the Vindhyan region deserves special mention wherein in Mahuli village lying in Koraon Block of Allahabad District the Parvati SHG was formed on thirteenth of October, 2012. Traditionally the members of the group were engaged in vegetable cultivation; therefore, they decided to take up vegetation cultivation as their Income Generation Activity. The group was advised and empowered to prepare the Business Plan. The SHG started cultivating coriander, radish, spinach and onion. In the second cycle, cultivation of brinjal, chilli and lady finger was taken up on half the land and on the remaining land paddy was cultivated. The group is happy that the vegetable cultivation has not only improved their economic condition but also the overall health condition. of the family members. (Compendium of Success Stories of Uttar Pradesh Participatory Forest Management and Poverty Alleviation Project, Year 2015, Page 85-86) In this manner, the villagers have through acquirement of proper knowledge and skill prudently chosen a livelihood that has avoided putting biotic pressure upon the existing village forests having *Butea monosperma, Zizyphus mauritiana, Carissa carandus, Anogeisus latifolia,* etc. as their prime vegetative treasures.

Changing the Attitude

Having ensured the transmission and transference of Knowledge and the ample development of pertaining skills, we have to focus upon the prevailing attitudes and the modus operandi for bringing about the essential change required in the attitude of the villagers residing on the fringes of the forests, sanctuaries and the national parks towards Forest Protection and sustainable utilization of Biological Resources. It can be achieved only through regular village meetings, regional workshops, on the spot practical demonstrations and commendable catalysis of the benefit sharing of the proceeds of forest produce available to all the forest users. Ample funds for all these human resource development activities need to be allocated and allotted to the pertaining departments and concerned levels. The attitudes of several officers and personnel are also needed to be reviewed and put on periodical scanners.

The Concluding Note

Innovative capacity building implies and constitutes a proper assemblage and prudent combination of augmenting human knowledge, refining and rejuvenating human skills, transforming human attitude while sustaining the intrinsic innovative capabilities of the entire human race. It makes us aware of the available biological resources, streamlines our livelihood options and enlightens us to make sustainable utilization of Nature and natural surroundings. It practically amounts to preparing the proper foundation for Mainstreaming Biodiversity and sustaining people and their livelihoods.

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Diversity of Guanophilic Fungi of Frugivorous Bats

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Introduction

Bat guano supports a great diversity of organisms including arthropods that live on guano (Ferreira and Martins, 1998) and energy flow in these tropic cascades based on guano production by roosting bats (Hairston and Hairston, 1993). Interestingly, the diversity of organisms living on or in guano piles differs depending on the diet of the bat producing the guano. Guano from sangivorous bats is typically inhabited by fly larvae springtails, and beetles. Guano of insectivorous bats inhabited by mites, pseudocorpions, beetles, thrips, moths and flies lastly guano of frugivorous bats is inhabited by spiders, mites, isopods, millipedes, centipedes, springtails, bark lice, true bugs, and beetles (Ferreira and Martins, 1998). Although, several studies have compared the impact of guano from different bat species on cave ecology (Trajano, 1996; Ferreora and Martins, 1998; Shahack-Gross *et al.*, 2004), the composition of guano from bats consuming different diets has received little attention. Fungi are distributed worldwide, with particular species being endemic in particular regions. The species are grouped by natural environment as being primarily associated with humans (Anthrophilic), other animals (zoophilic), or soil and guanophilic (Brandt and Warnock, 2003).

Bat guano is rich substrates for fungi in the cave environment along with dung, plant debris, carcasses and other organic debris. Poulson (1972) reported that bat guano is simple in structure but just enough to constitute a complete ecosystem. The fungi present in guano commonly serve as saprotrophs andor pathogens as transient chemo-heterotrophic microorganisms (Northup *et al.*, 1997). Therefore, the present study was aimed to investigate the diversity of guanophilic fungi in the guano of fruit eating bats.

Materials and Methods

Guano samples of *Rousettus leschenaulti* were collected from the historical monuments of Ayodhya, Faizabad(26°45'58"N 82°08'40" E), Bara Imambara, Lucknow (26°86'85" N, 80°91'27" E) and Chunar Fort, Mirzapur(25°07'15.02"N 82°52'34.77" E) while the samples of *Cynopterus sphinxcollected* from Babasaheb Bhimrao Ambedkar University campus, Lucknow (26°76'57"N, 80°92'09" E) and Sidharth Nagar (27°27'16" N, 82°82'10" E). The samples of *Pteropus giganteus* were collected from Mohanlalganj (26°40'57"N, 80°59'1.49"E).The guano samples were collected aseptically using spatula and forceps, kept in sample vials and stored at -20°C for further analysis.

Isolation of fungus

The guano samples were diluted serially by following Aneja (2003). The diluted sample was inoculated in sterile petri dishes containing potato dextrose agar medium supplemented with chlorotetracycline. The plates were incubated at 28°C for 8days. Thereafter, the properly grown fungi were used for subculture in Czapck yeast agar plates and incubated at 25°C for 3-7 days.

Microscopic analysis

A small portionof mycelium and conidiophores were extirpatedfrom young colony, placed on a microscopic slide and gently spread it. A drop of lactophenol cotton blue was taken on a glass slide, observed under Light Microscope (OLYMPUS CX41) and photographs were taken at different magnifications.The fungal species were identified based on morphological features and by following Thom (1945) and Raper and Thom (1949)

Results and Discussion

A total of 13 fungal isolates were obtained from

Figure 01. Colony morphology of *Aspergillus niger* (A), *A. versicolor* (B), *Aspergillus* sp. (C), *Aspergillus* sp.(D), *Aspergillus* sp. (E), *Aspergillus* sp. (F), *Aspergillus* sp.(G), *Penicilliumcitrinum*(H), *Penicillum* sp.(I), *Penicillum* sp. (J), *Fusarium* sp. (K), *Mucor* sp.(L), *Alternaria* sp. (M).

the guano samples of three fruit eating bats. The guanophilic fungi such as Aspergillusniger, *A.versicolar* and *Penicilliumcitrinum*were identified to species level (Fig. 1). In addition four fungal isolates belong to genera Aspergillus, two isolates belong to Penicillium and each one isolate of genera Fusarium, Mucorand Alternaria were observed (Fig. 1).

The colony of *A. niger* attained an average diameter of 80 mm (Fig.1A), the conidial head wascarbon black, large and globose (Fig. 2A).The septate hyphae of *A. niger* were translucent. The colony of *A. versicolar* attained 17.52 mm at maturity, the hyphaeboar chains of rough conidia on

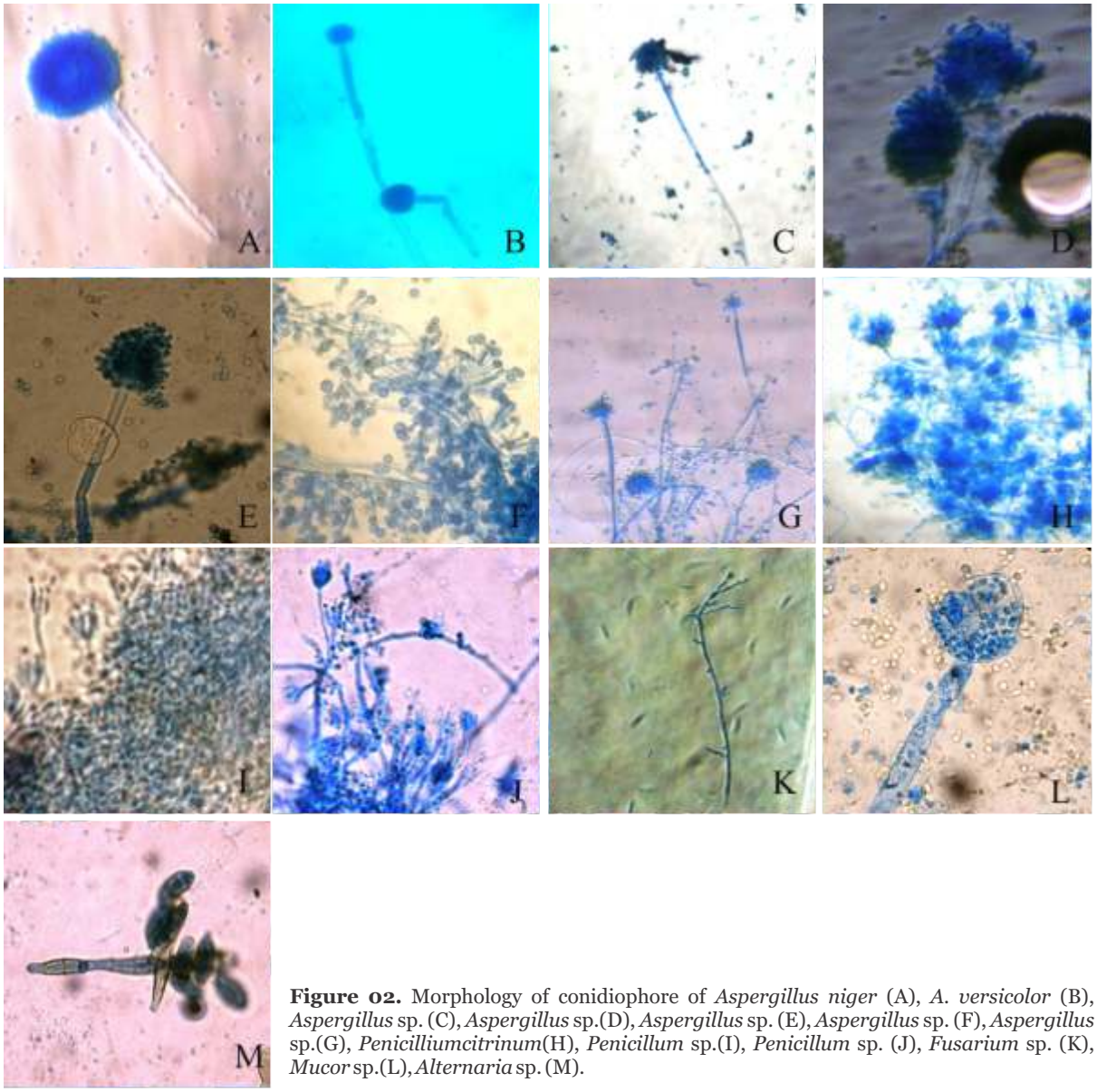

Figure 02. Morphology of conidiophore of *Aspergillus niger* (A), *A. versicolor* (B), *Aspergillus* sp. (C), *Aspergillus* sp.(D), *Aspergillus* sp. (E), *Aspergillus* sp. (F), *Aspergillus* sp.(G), *Penicilliumcitrinum*(H), *Penicillum* sp.(I), *Penicillum* sp. (J), *Fusarium* sp. (K), *Mucor* sp.(L), *Alternaria* sp. (M).

terminal ends (Fig. 2B). In addition,five isolates belong to genus Aspergillus were observed in the guano sample(Fig. 1C – 1G,Fig. 2C – 2G).

The colony of *Penicillium citrinum* was cottony, green with white margin, rounded and attained 16.04 mm (Fig. 1H). The conidiophore had alarge number of whip-like conidial chains withspherical spores (Fig. 2H). In addition, two isolatesof *Penicillium* were observed in the guanosamplesof fruit bats (Fig. 1I – 1J). The colony of *Fusarium* sp. was pale in color. The colony grown very fast and attained 90 mm diameter at maturity(Fig. 1K). The conidia are 1 to 2-celled, hyaline, fusiform to ovoid, curved (Fig. 2K). The colony of *Mucor* sp. was grey , attained 89 mm diameter at maturity (Fig. 1L). *Mucor* spores were simple and form apical, globular sporangia that were supported and elevated by column-shaped columella (Fig. 2L). The colony of *Alternaria* sp. was pale, attained 30 mmdiameter at maturity (Fig. 1L).

The results of present study revealed the existence of fungi in the frugivorous bat guano.

Further, the bat guano offers a suitable substratum and nutrients for the growth of fungus. Otomycosis (fungal ear infections), which causes pain, temporary hearing loss and damage to the ear canal and tympanic membrane caused by *A. niger*. *Aspergillus nigersecretes* toxic secondary metabolite which causes several ailments on almost all organs in human (Durakovic et al., 1989; Rai and Mehrotra, 2005). *Aspergillus versicolor* was known to cause severe lung problems (Aspergillosis) to human if inhaled in sufficient amount. *Fusarium* is a common soil fungus on a wide range of plants. Fungus belong to this genera causes hemorrhagic syndrome in humans (alimentary toxic aleukia) and characterized by nausea, vomiting, diarrhea, dermatitis and extensive internal bleeding.

Mucor sp. grow on living and dead plants. Since the frugivorous bats rely on various plant source for survival, accidentally they might have consumed the spores of Mucor sp. The mold of *Mucor* grown and spread quickly compared to other fungi. *Alternaria* is ubiquitous in the environment and it is one of the fungi which humans interact with most frequently, on a variety of levels. *Alternaria* species are a leading cause of crop blight, and they also cause allergies and infections in some people and animals.

Conclusion

The frugivorous bats such as *Pteropus giganteus, Rousettus leschenaulti* and *Cynopterus sphinx* are mainly rely on fruits, nectar, leaves and other plant resources. The guano of frugivorous bats harboured 13 fungal isolates such as *Aspergillus niger, A. versicolar* and *Penicillium citrinum,* four isolates belong to genera Aspergillus, two isolate belong to genus *Penicillium* and each one isolate belong to genera *Fusarium, Mucor* and *Alternaria*. Few species of fungi isolated from the guano of fruit batswere pathogenic to human and plants.The occurrence of plant fungal pathogen in the guano of fruit bats reveal that the frugivorous bats relied on the infected plant parts as source of food.

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Distribution and conservation issues of Indian flying fox, *Pteropus giganteus* in Uttar Pradesh

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Introduction

The mammalian order Chiroptera consists about 1,232 species which represents a quarter of the total 5,487 mammal species of the world (Schipper et al. 2008; Simmons 2010; Kunz et al. 2011). India has a rich diversity of bat fauna comprising approximately 119 species of bats, out of which 14 species are fruit-eating or megachiropteran (Pteropodidae) belongs to 8 genus and the remaining are insect-eating or microchiropteran bats (Bates and Harrison 1997). The megachiropteran bats are the Old World fruit bats relying on their visual acuity (Telling et al. 2000; Jones et al. 2002) and olfactory system to navigate and forage (Safi and Dechmann 2005).

The Indian flying fox, *Pteropus giganteus*, one of the largest fruit bats belongs to the family Pteropodidae is widely distributed and known as largest flying mammal in India. The IUCN red list of threatened species 2011 categorized this species as least concern (LC version - 3.1). *Pteropus giganteus* is generally a colonial species and roost in large trees often in area with topographic features that offer protection from strong winds, assist in thermoregulation and provide access to updrafts for easier flight (Cheke and Dahl 1981; Pierson and Rainey 1992; Richmond *et al.* 1998). They have a face that resembles that a fox, to some extent and also have good eye sight which helps in finding the food. The colonies were generally located in close association with human beings and observed in cities and villages. Ficus trees are the most favoured roosting trees, however they also known to roost on *Eucalyptus globulus, Mangifera indica* and *Tamarindus indica* (Vendan 2003). At dusk flying-foxes leave the roost to forage upon flower, nectar and fruit of trees in agroforest plantation as well as in primary and secondary forest (Pierson *et al.* 1996). These bats are economically important to our society. They benefit us pollination and seed dispersal and play crucial role in the maintenance of forest ecosystems worldwide (Wiles and Fujita 1992). The status and geographical limits of this taxon are still uncertain. This study has undertaken to find out the status and distribution of *P. giganteus* in state Uttar Pradesh.

Study area

The study was conducted in different districts of Uttar Pradesh (Fig. 1), namely Tajpur, Tanda, Ambedkar Nagar (26°33'04.87"N, 82°39'20.61"E), Nasrullahpur, Tanda, Ambedkar Nagar (26°32' 53.11"N, 82°33'37.91"E), Mohanpur, Akbarpur, Ambedkar Nagar (26°26'57.80"N, 82°43'48.37"E), Chaturpatti, Gosaiganj, Ambedkar Nagar (26°28' 07.85"N, 82°41'38.49"E), Utharu, Gosaiganj, Ambedkar Nagar (26°28'07.85"N, 82°41'38.49"E), Lodhipur, Akbarpur, Ambedkar Nagar (26°29' 50.44"N, 82°33'48.14"E), Ishwarpur, Azamgargh (26° 0'26.61"N, 83° 47'49.74"E), Devipatan Temple, Tulsipur, Balrampur (27°32'13.06"N, 82°44' .45.28"E), Durgapur, Barabanki (27°06'12.92"N, 81°27'40.87"E), Basauri, Ram Sanehighat, Barabanki (26°48'21.49"N, 81°31'42.60"E), Lar Town, Deoria (26°12'05.04"N, 83°58'06.92"E), Khapra Deeh, Pandey ka pura, Tarun, Faizabad (26°47'09.71"N, 82°08'13.86"E), Bhada, Tarun, Faizabad (26°46'48.77"N, 82°08'34.56"E), Vankhandeshwar Temple, Sirshaganj, Firozabad (27°03'21.31"N, 78°40'50.62"E), Nawabganj, Gonda (26°52′00.00″N, 82°08′36.89″E),

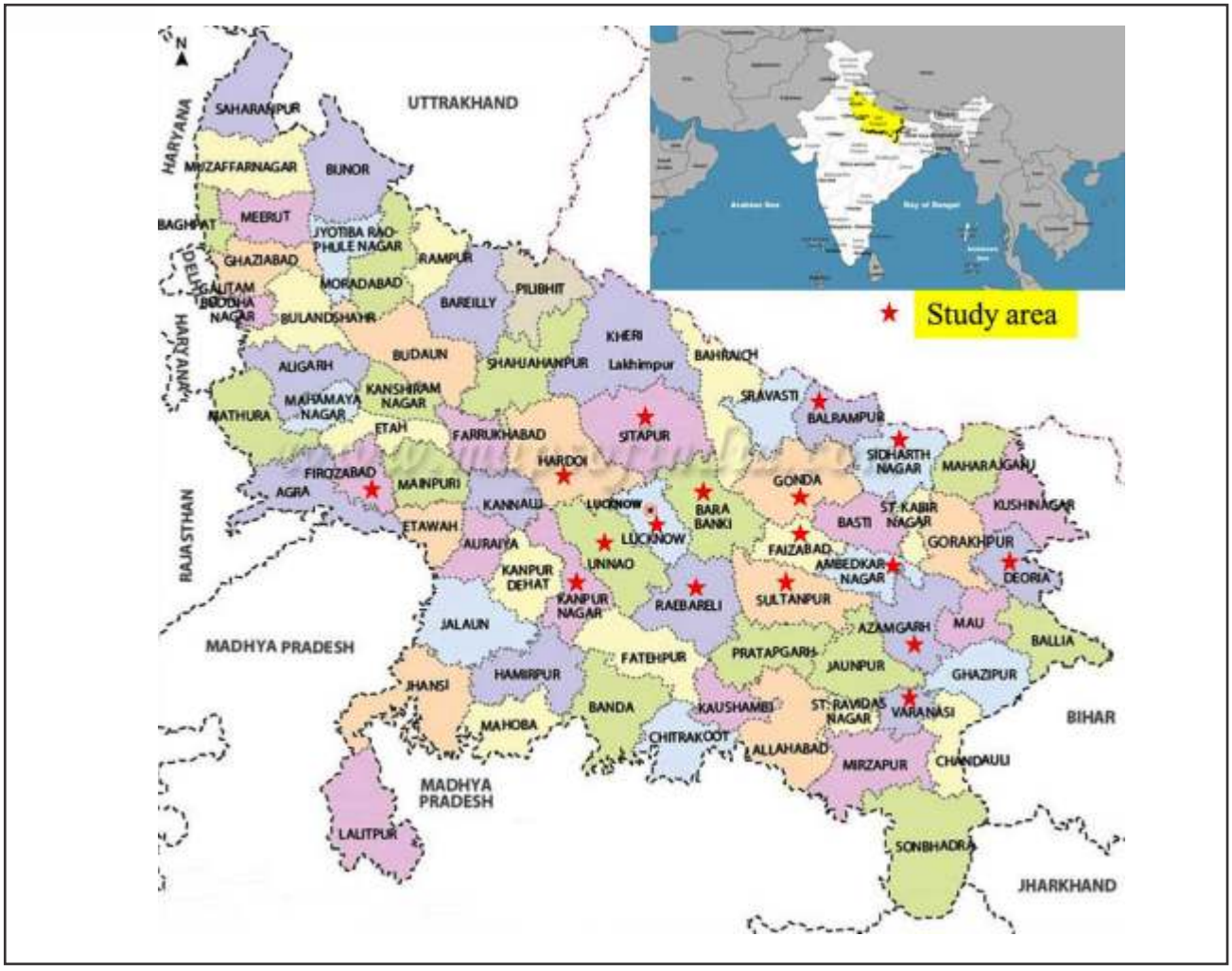

Fig. 1. Map of the study area

Kashipur, Hardoi (27°23′24.35″N, 80°07′17.27″E), R. A. Quidwai Inter College, Dharmasala Road, Hardoi (27°23′08.89″N, 80°07′37.55″E), Company bag garden, Kanpur (26°29'26.99"N, 80°18'58.30"E), Amova, Piparsand, Lucknow (26°45'00.09"N, 80°45'59.37"E), Behind Shitala Devi Temple, Kakori, Lucknow (26°51'46.88"N, 80°47'13.90"E), Utrawa, Mohanlal ganj, Lucknow (26°41'22.31"N, 80°59'03.64"E), Daudapur, Sultanpur road, Lucknow (26°47'20.46"N, 81°01' 28.08"E), North Railway garden, Mohanlalganj, Lucknow (26°41'10.59"N, 80°59'1.63"E), Shivpur, Raibareilly (26°13'59.84"N, 81°14'00.26"E), Sadhunagar, Siddharth Nagar (27°16'16.40"N, 82°49'28.04"E), Bhitiya, Sadhunagar, Sidharth Nagar (27°16'16.40"N, 82°49'28.04"E), Koiri, Sidharth Nagar (27°24'00.33"N, 82°57'14.11"E), Ganeshpur, Sidharth Nagar (27°16'14.86"N, 82°49'30.03"E), Kachehri, Sitapur (27°33'52.61"N, 80°41'13.56"E), Diyara Bazar, Diyra, Sultanpur (26°13'31.67"N, 82°17'03.07"E), Bahwa, Kalukheda, Unnao (26°33'17.73"N, 80°54'28.75"E), Shikarpur, Unnao (26°32'54.09"N, 80°29'09.09"E) and Near Sarnath, Varanasi (25°22'51.81"N, 83°01'17.14"E).

Materials and methods

The study was carried out between August 2009 and March 2014 to locate the distribution of *Pteropus giganteus* in Uttar Pradesh. The roost search was conducted during day hours. The tree roost characteristics such as duration of occupancy,

circumference, diameter at breast height (DBH), height of the roost, total number of roost trees, colony size, roost location (like near forest, road, bridge, residence, ponds, river etc.) and geographical location were recorded. The colony size was assessed through direct count using binocular and photographic methods (Tuttle 1979).

Results

Pteropus giganteus is a largest fruit bat and largest flying mammal in India. The snout is long and hairy. *P. giganteus* has well developed nostril and long pointed black ears. The pelage is chestnut brown on the crown of the head and relatively darker around eyes (Fig. 2). The average forearm length was 150.66 ± 3.08 mm. The morphological measurements of four bats died due to electrical shock were collected and given in Table 1. *Pteropus giganteus* camps were observed in the present investigation found in large diurnal roosts which comprise several hundreds of individuals usually located in well exposed larger trees such as *Azadirachta indica* (Neem), *Bambusa balcooa* (Bamboo), *Dalbergia sissoo* (Shisham), *Ficus bengalensis* (Baniyan), *F. glomerata* (Cluster Fig), *F. racemosa* (Gular), *F. religiosa* (Peepal), *Holoptelea integrifolia* (Chilbil), *Limonia acidissima* (Kaitha), *Madhuca indica* (Mahua), *Mangifera indica* (Mango), *Syzyium cumini* (Jamun), *Tamarindus indica* (Tamarind) and *Vachellia nilotica* (Babool). The colonies of *P. giganteus* generally located nearby water bodies, close association with human beings and in cities and villages.

Pteropus giganteus leaves the roost site about sunset and returns to its day roost at dawn. It commonly roosts with its head downward and wrapped wings around its body. During warm hours of the day individuals often cool themselves by fanning their wings. *Pteropus giganteus* roosts in trees and usually associated with forest fragments or linear patches of vegetation alongside the water bodies.

A total of 8447 individuals were recorded in 33 colonies of *P. giganteus*. The colony size ranged from 50 to 1650 individuals of *P. giganteus*. Out of 33 colonies, sum of 15 colonies were located nearby water bodies and rest of them located closest to agricultural field, road side and residential area. *Pteropus giganteus* selected larger and taller trees such as *F. bengalensis, S. cumini, M. indica, F. religiosa, D. sisoo, B. balcooa, E. tereticornis, T. indica* and *M. indica*.

The DBH of roost trees ranged from 14.15 – 185.93 cm. *Pteropus giganteus* preferred to roost in

Table 1. Morphological measurements of Pteropus giganteus (n = 4)

S. No.	Morphological parameters (mm)	Mean ± SD
1	Head and body length	209.00 ± 08.08
2	Head length	67.74 ± 02.31
3	Hind-foot length	40.17 ± 0.78
4	Tibia length	69.65 ± 04.72
5	Forearm length	150.66 ± 03.08
6	Ear length	35.10 ± 01.30
7	Ear width	16.74 ± 02.30
8	Wing span	962.50 ± 66.02
9	Thumb length	41.55 ± 08.46
10	Length of second metacarpal	83.77 ± 17.59
11	Length of third metacarpal	100.58 ± 06.21
12	First phalanx of the third metacarpal	76.62 ± 04.51
13	Second phalanx of the third metacarpal	103.55 ± 06.57
14	Fourth metacarpal	99.30 ± 07.55
15	First phalanx of the fourth metacarpal	59.25 ± 03.90
16	Second phalanx of fourth metacarpal	58.56 ± 04.53
17	Fifth metacarpal	104.23 ± 07.85
18	First phalanx of the fifth metacarpal	46.32 ± 02.65
19	Second phalanx of fifth metacarpal	44.66 ± 03.68
20	Body weight (g)	545.00 ± 40.41
21	Maxillary tooth-row	25.50 ± 0.52
22	Mandibular tooth-row	26.68 ± 0.42

* Data collected from dead male bats, female data not available

Table 2. Roost trees and roost characteristics of *Pteropus giganteus*.

S. No	Name of Tree	Circumference (cm)	DBH (cm)	Height of Roost Trees (m)	Height of Roost (m)	No. of colonies	No. of Roost Trees	No. of bats per tree
1	*Azadirachta indica* (Neem)	300.99 ± 77.23	95.80 ± 24.58	08.33 ±0.52	06.83 ± .75	03	06	29.50 ±34.01
2	*Bambusa balcooa* (Bamboo)	44.45 ± 5.12	14.15 ± 1.63	13.70 ± 2.45	11.50 ± 3.02	05	16	19.10 ± 11.15
3	*Dalbergia sissoo* (Shisham)	188.98 ± 47.48	60.15 ± 15.11	09.80 ± 2.25	8.50 ± 2.22	08	10	18.40 ± 13.01
4	*Eucolyptus tereticornis* (Eucolyptus)	82.02 ± 25.32	26.11 ± 8.06	15.98 ± 1.43	13.83 ± 1.48	13	119	25.93 ± 14.79
5	*Ficus bengalensis* (Baniyan)	477.52 ± 68.08	151.98 ± 21.67	11.04 ± 1.96	9.02 ± 1.93	14	22	61.63 ± 35.55
6	*Ficus glomerata* (Cluster Fig)	584.20	185.93	12	10	01	01	56
7	*Ficus racemosa* (Gular)	340.92 ± 104	108.50 ± 33.26	12.44 ± 1.33	10.67 ± 1.22	03	09	18.89 ± 14.80
8	*Ficus religiosa* (Peepal)	442.88 ± 86.30	140.95 ± 27.46	11.27 ± 1.55	9.18 ± 1.72	07	11	52.18 ± 40.14
9	*Holoptelea integrifolia* (Chilbil)	399.14 ± 39.77	127.03 ± 12.65	10.14 ± 0.69	8.14 ± .69	02	07	33.57 ± 16.36
10	*Limonia acidissima* (Kaitha)	224.37 ± 12.00	71.41 ± 3.82	08.33 ± 0.57	8.00 ± 0.12	01	03	50.00±25.00
11	*Madhuca indica* (Mahua)	411.48 ± 35.50	130.96 ± 11.30	11.75 ± 1.75	9.87 ± 1.88	06	08	29.75 ± 18.52
12	*Mangifera indica* (Mango)	182.30 ± 63.28	58.02 ± 19.82	08.45 ± 1.21	7.12 ± 1.10	14	44	28.52±22.82
13	*Syzyium cumini* (Jamun)	328.08 ± 55.84	104.42 ± 17.77	11 ± 2.19	9.25 ± 2.04	03	06	36.17 ± 19.14
14	*Tamarindus indica* (Tamarind)	385.06 ± 57.51	122.55 ± 18.30	11.40 ± 2.40	9.20 ± 1.64	05	05	60.20 ± 43.79
15	*Vachellia nilotica* (Babool)	429.26 ± 46.35	136.62 ± 14.75	08 ± 0.50	7.00 ± .12	01	03	40.33 ± 18.44

Note : Values are given as mean ± SD

larger *Ficus* trees compared to other tree species. Similarly, a maximum number of bats roosted in Ficus trees (Table 2). There was a positive correlation between population size and DBH of roost trees ($r = 0.634$, $n = 86$, $P < 0.001$), however the height of roost trees did not influence the population size ($r = -0.197$, $n = 86$, $P > 0.05$).

The distribution of *P. giganteus* was widespread in Ambedkar Nagar district. A total of six colonies of *P. giganteus* were observed in Ambedkar Nagar. The colonies were observed adjacent to water bodies and amid of agricultural field. At Ambedkar Nagar, *P. giganteus* occupied the larger trees such as *F. bengalensis, F. racemosa, S. cumini, M. indica, D. sissoo, B. balcooa, M. indica* (Mahua) and *E. tereticornis* (Fig. 3 & 4). Similar to Ambedkar Nagar, a large number of colonies were observed at Lucknow, Barabanki, Faizabad, Hardoi, Kanpur, Siddharth Nagar and Unnao districts (Fig. 5, 6, 7 & 8).

The highest population (1650 individuals) was observed at Amova, Piparsand, Lucknow while the lowest population observed at Utharu. During winter, the colony occupied the larger trees such as

Fig. 2. Indian flying fox, *Pteropus giganteus* (male)

Fig. 3. A colony of *Pteropus giganteus* roost on Ficus bengalensis trees at Lodhipur, Ambedkar Nagar

Fig. 4. Fig. 4. A colony of Pteropus giganteus roosts on *Mangifer indica* trees at Tajpur, Tanda, Ambedkar Nagar.

Fig. 5. A colony of *Pteropus giganteus* roost on *Limonia acidissima* tree at Pipersand, Lucknow

Fig. 6. A colony of Pteropus giganteus roosts on *Eucalyptus* sp. trees at Mohanpur, Faizabad

Fig. 7. A colony of *Pteropus giganteus* roosts on *Eucolyptus tereticornis* Behind Shitala Devi Temple, Kakori, Lucknow

Fig. 8. A colony of *Pteropus giganteus* roosts on *Holoptelea integrifolia* trees at Company bag garden, Kanpur

F. religiosa, M. indica, M. indica (mahua), *B. balcooa* and *E. tereticornis.*

A colony of *P. giganteus* observed at Shitala Devi Temple, Kakori shared the roost trees with snake bird. There were three ponds adjacent to this colony. As reported by the villagers, this colony is protected by the local residents, however sporadic hunting taking place at times.

During day hours, individuals of *P. giganteus* actively involved on squabbling, cleaning and scratching with claws, fighting for better roosting positions. At times, defecation was also observed during day hours. The wing fanning during summer and basking with stretched wings during winter were commonly observed. Reproductive behaviours such as pair bonding and mounting were observed between August and October, while infants were born from February to April.

The threats include netting, shooting for bush meat were recorded rarely. The major threats to *P. giganteus* were destruction of roosting habitats by tree felling. In addition, bat conservation programs were conducted at roosting sites of *P. giganteus* to create awareness about bats among public.

Discussion and conclusion

The Indian flying fox, *Pteropus giganteus* widely distributed throughout India. The current study reveals the occurrence of high population of *P. giganteus* in Uttar Pradesh. The distribution of *P. giganteus* was already reported in Philibhit (Wroughton 1914); Lucknow and Varansi (Sinha 1980); Allahabad (Bhatnagar and Srivastava 1974). However, the results of current study revealed the wide distribution of *P. giganteus* in Uttar Pradesh. The results showed that *P. giganteus* selected their roost trees in well exposed larger trees such as A. indica, *B. balcooa, D. sissoo, E. tereticornis, F. bengalensis, F. glomerata, F. racemosa, F. religiosa, H. integrifolia, L. acidissima, M. indica* (Mahua), *M. indica, S. cumini,* and *T. indica*. The possible reasons for selection of above roost trees due to long lasting and stable nature. Further, the tall trees in well exposed areas may support their flights during take-off and landing.

The behaviour such as wing fanning during summer and wing wrapping during winter associated with thermoregulation. The wide distribution and high colony size of *P. giganteus* show that the state Uttar Pradesh has suitable habitat for its survival. Further, the location of majority of colonies nearby water bodies suggests that the bats select their day roost to avoid high temperature at day hours during summer. The positive correlation between colony size and DBH of roost trees clearly suggests that the bats are selecting larger trees while many other trees are available. Fruit bats play a pivotal role as pollinators and seed dispersers for a diverse array of plants which were also reported earlier (Fleming and Estrada 1996; Banack 1998; Shilton et al. 1999;

Godinez-Alvarez *et al*. 2002).

Hunting of *P. giganteus* was not completely stopped in the study area as there were rare observations on netting, shooting for bush meat. However, the habitat destruction by tree felling was a major threat to *P. giganteus*. To ensure the survival of this species, roost habitat must be protected. The protection of roost habitat alone is insufficient to ensure the survival of this species. Further investigations on seasonal distribution, maternity roost and feeding sites are essential for survival of the species. Thus, it is critically important to preserve the existing roosting habitats of *P. giganteus* in Uttar Pradesh, because bats play vital roles in balancing the ecosystem, seed dispersal and regeneration of forests.

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Fish Diversity of Himalayan Region, India for sustainable development

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The coldwater fishery resource of India spread throughout 2500 km from Jammu & Kashmir in the west to Arunachal Pradesh in the east and 200-400 km from north to south comprise a mountainous area of 5,33,604 km^2 (FAO 2003). The geographical area of this region is about 16.2% and about 4% of total population of the country. The coldwater resources are distributed mainly in the form upland streams, rivers, high and low altitude lakes and reservoirs located in different hill states (Table 1). As the cold water resources are situated in difficult areas, it has not yet been exploited to its potential. Thus DCFR undertook exploration for the resource assessment of this sector both physical and faunal through different running projects.

Fish biodiversity

The water bodies of the Himalayan region inhabit diverse kind of fish fauna. Out of total fish fauna available in India 17% fishes were documented from the mountain ecosystem establishing the status of the area as a centre of origin and evolution of biotic forms (Ghosh, 1997). The vast mountain fishery resources of India inhabits around 258 fish species distributed in the Himalayan and peninsular region of the country of which indigenous mahseer, snow trout, exotic trout and common carp are commercially important (Singh *et al*, 2014). About 36 species of freshwater fishes (out of 1,300) are endemic to the Himalayan region (Ghosh, 1997). For the whole Himalayas, 218 species are listed (Menon, 1962).The distribution of fish species in the Himalayan streams depends on the flow rate, nature of substratum, water temperature and the availability of food. The species distribution in the upper reaches of the stream/river where water has a torrential flow is different from the mid and lower reaches of the stream where flow is moderate and water current is soft.

Hill states endowed with natural lakes and reservoirs could be utilized for the fish production under culture based capture fisheries programme. Introduction of composite fish farming using Chinese carps for mid-altitudes is a major success in increasing the fish production from the hilly regions. However, many endemic fish species of the Himalayan region can also be utilized for aquaculture and farming. Integrated fish farming for the hills could also be an important inexpensive aquaculture practice for the rural population residing in the mountain areas of the country as it is very popular in Arunachal Pradesh. The Directorate of Coldwater Fisheries Research has made significant contributions towards documentation of

Table 1: Fishery resources of Himalayan region, India

S.N	State Name	Lakes (ha)	Reservoirs (ha)	Rivers (km)	No of Fish Species recorded
1	Jammu & Kashmir	137275. 3	4087.3	10893.5	26
2	Himachal Pradesh	27.2	31320.2	10464.3	82
3	Uttarakhand	212	16864	10657.8	67
4	Sikkim	1004.5	--	3298.1	23
5	Arunachal Pradesh	2792.7	--	12351	167

Figure 1: Production of improved strain of *Hungarian mirror* carp in Hills

Figure 2: Rainbow trout *Oncorhynchus mykiss* farming in hills

Figure 3: Golden mahseer *Tor putitora* for culture propagation

Figure 4: Chocolate mahseer *Neolissocheilus hexagonolepis* of northeast Himalaya

Figure 5: Snow trout *Schizothorax richardsonii* for breeding in the DCFR farm

Figure 6: Minor carp *Labeo dyocheilus*, a candidate species for lower hills

fish fauna, breeding & culture practices of important fish species including technology dissemination.

The comprehensive initiatives of the ICAR-Directorate of Coldwater Fisheries Research aim to safeguard and improve the livelihood of the less privileged inhabitants of the access restricted geographic terrains, through technological interventions and knowledge transfer. Species diversification in upland aquaculture is necessary for enhancing fish production. We require more species for sustainable aquaculture. In order to meet the challenge, the DCFR has identified certain new candidate species and breeding protocol have been developed for *chagunius chaguni, Semiplotus*

nd ornamental fish; *barilius bendelisis*.

A. Aquaculture technologies

1. Carp farming

Owing to simpler farming techniques, low input requirements and possibilities of integration of available resources, culture of Chinese carps in small sized ponds (0.01 & 0.03 ha) is becoming popular in the region. Since existed common carp strains being old introductions did not perform well due to inbreeding and other reasons, Recently, DCFR introduced improved strains of Hungarian mirror (Figure 1) and scale carp which are performing well and its brood banks and seed banks are being established in different states. The composition of cultured species varies from monoculture of common carp to polyculture of grass, silver and common carp. The carp culture is more profitable by integration of fish culture if integrated with dairy, horticulture, agriculture and paddy. Grass carp emerged as a popular species for the low-cost hill aquaculture. In absence of aquatic weeds in the constructed ponds, the grass carp vigorously feeds on terrestrial soft plants and grass provided to the stock. DCFR, Bhimtal is trying to improvise the Chinese carp based composite fish culture along with endemic fish species e.g., Bangana devdevi, Labeo pangusia, L. dyocheilus in mid Himalayan regions (800-2000 msl).

2. Trout farming

Being a low volume high value commodity, rainbow trout has good potential for domestic consumptions as well as foreign export. However, there is ample scope for further enhancement of trout production in hill states through participatory approach. Trout farming has immense scope in the Himalayan and some peninsular regions, where sufficient quantity of quality water is available. Successful collaboration with European Economic Community (EEC) and Norwegian Government in last two decades has accelerated rainbow trout (Oncorhynchus mykiss) farming in the states of Jammu and Kashmir and Himachal Pradesh, respectively (Figure 2). Now, the trout farming is also developing in other hill states such as Uttarakhand, Sikkim and Arunachal Pradesh with concerted efforts of DCFR.

B. Breeding Technologies of Himalayan species

1. Flow-through hatchery for Mahseer

Golden mahseer *Tor putitora* is the most prized sport fish distributed in all the Himalayan waters. A flow through mahseer hatchery has been designed for seed production of this fish species (Figure 3). The system is simple and farmers friendly for breeding, egg incubation and larval rearing. Artificial mass seed production of this species would be helpful for the rehabilitation of this species through ranching in the uplands water bodies and also for enhancement of aquaculture production. Similarly seed production methodology for chocolote mahseer *Neolissocheilus hexagonolepis* has also been developed (Figure 4) and seed is regularly produced over the last five years. Technology is being disseminated to the different State Government and private agencies. Seed production and its ranching of both golden and chocolate mahseer in natural waters is the regular practice of the Institute.

2. Flow-through hatchery for rainbow trout

Seed availability is the main bottleneck in the rainbow trout culture in high altitudes areas. In order to achieve the goal of enhancing trout production, it is quite necessary to focus on seed production technology of this fish. DCFR has developed the flow through hatchery model for trout breeding. Flow through hatchery is comprised of an indoor structure having troughs, trays, nursery tanks and rearing tanks with continuous water flow. Technology has been transferred to the different State fisheries departments and private trout growers. DCFR is also technically associated with different state trout farms for the production of trout seed to meet out the state demand.

3. Seed production technique of Exotic carp in mid hills

Induced breeding of grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*) was standardized at DCFR. The maturation inducing hormones (MIH) like HCG and PG extract + Ovaprime at 18.0-26.0 °C were found

effective to reduce the maturation period. Technology developed for the breeding and larval rearing in climate of mid Himalayan region has a positive impact on the employment generation in these regions since the technology was taken as hot cake among the farmers in some areas of the hills. There is great scope for disseminating this promising technology in sub to mid Himalayan belt in order to upgrade the socio-economic conditions of the inhabitants.

4. Artificial spawning of Snow trout, Schizothorax richardsonii (Gray)

Snow trout is an important indigenous cold water fish species, endemic to the Himalayas and found in streams and lakes which receive snow melt water from the hills. Technology for artificial fecundation of pond raised brooders and rearing of young ones in controlled condition has been developed at DCFR (Figure 5). Previously seed was procured from the natural resources. This technique enables the production of pure and healthy seed in captive condition. This seed can be used for augmentation of natural stock and aquaculture of this species.

5. Induced Breeding of Indigenous minor carp

Indian minor carp, *Labeo dyocheilus*, widely distributed in streams and rivers of hill states and important species for culture practices in mid hills (Figure 6). Induced maturation and artificial breeding of this minor carp has been developed by DCFR, Bhimtal. Further, captive maturation and breeding technology for *Labeo pangusia* has also been developed.

Perspective Research programmes

There are several other important research programmes also undertaken at DCFR. Some of them are as follows:

- Genetic improvement programme have been taken up using genomics and transcriptome profiling. The institute is working on molecular genetic characterization of snow trout and mahseer from different geographical locations to identify the population with high genetic diversity which would be significant use in genetic improvement programme for improving strain to enhance growth and genetic management of the species.
- In changing climate scenario, there are opportunities to develop thermal tolerance strains that may thrive in wide range of water temperature. In order to comply the challenge the Directorate has initiated the work on exploring mechanism of thermal tolerance in major coldwater fishes. More emphasis is being given on intensifying the research in this direction using phenological responses and molecular modern tools.
- The Directorate has initiated breeding and rearing of local ornamental fishes at mid hills region that would be continued for livelihood security through small scale entrepreneurship.
- Eco-friendly carp based polyculture in low cost polylined tanks in mid hills would be out scaled for livelihood security and production enhancement. Directorate has initiated work on developing water conserving model for fish culture. In this context, plastics film lined ponds have been found very suitable for fish culture and overflow could be used for vegetable farming. The polylined act as a insulator which increases temperature of water resulted in enhanced fish production. The integrated model is very popular in mid hills and there is a need of upscaling the technology.
- GIS based resource mapping of the fishery resources in hill region has been taken up on priority for supporting planning.
- Development of location specific water conservation model for fish culture has been done. Further, research needs for developing location specific models for water conservation-cum- integrated fish culture and closed re-circulatory systems are being addressed.
- Maintenance of repository of important endemic fish has been initiated.
- Human resource development, technology transfer, knowledge sharing through networking
- Identification and introduction of new

candidate species and to develop their culture and breeding technology.

Conclusion

There is a vast scope and potential for enhancing fish production in hills by bringing natural Himalayan lakes located at different altitudes, newly created and existing upland reservoirs, under scientific management for fishery enhancement by bridging the gap between actual fish yield and production potentials utilising more endemic and local species. Research and development in coldwater fisheries and aquaculture has great potential for lateral as well as vertical expansion. In the hill regions, fish represents an essential, often irreplaceable source of high quality and inexpensive animal protein, crucial for the balanced diet of the marginally food secure communities. Keeping in view the global, national and ecological changes, the ICAR-DCFR is committed towards enhancing fish production in hills through intervention measures such as research, technological support, awareness programmes and frontline demonstration activities. In this milieu, the Directorate is continuously striving to document aquatic biodiversity in hill states and generate research information that helps in developing ecologically sustainable strategies for fish yield enhancement. It is also responsible for activities such as ranching in the deprived ecosystems and to develop model for sport and eco-tourism.

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Induced Spawning in *Pangasianodon hypophthalmus* and Hatching of Eggs in Three Different Types of Hatcheries at Raipur (Chhattisgarh for Mass Seed Production

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Introduction

Pangasianodon hypophthalmus, commonly known as striped (sutchi, iridescent shark) catfish, fetches high price in markets. Culture of this species is growing day-by-day in Bangladesh (Rahman *et al.*, 2006; Ahmed and Hasan, 2007; Ahmed *et al.*, 2013), Indonesia (Griffith *et al.*, 2010), India (Lakra and Singh, 2010; Singh and Lakra, 2012; Kumar *et al.*, 2013) and Vietnam (Phan *et al.*, 2009; Bui *et al*, 2010). Vietnam is the top producer and exporter of *P. hypophthalmus* (Phan *et al.*, 2009; Bui *et al.*, 2010). Contribution of the Indian major carps in Indian aquaculture is more as compared to those of catfishes and in Andhra Pradesh itself, major carps contribute about 85% of the total freshwater fish production while catfishes and murrels show the next to them (Laxmappa, 2004). *P. hypophthalmus* is native of river Mekong Basin and Chao Phraya river in Thailand, Cambodia and Vietnam. It has been introduced in Singapore, Philippines, Taiwan, Malaysia, China, Myanmar, Bangladesh, Nepal and India. In India, it was brought in West Bengal through Bangladesh during 1997 (Mukai, 2011). Initially, its culture was carried out in Andhra Pradesh and West Bengal in private sector but the Government of India permitted aquaculture of *P. hypophthalmus* in 2010-11. Young ones of the species are bottom feeder and carnivore while the fingerlings feed on snail, worm, insects, gastropods etc. This species attain maturity at the end of third year while male mature in two years (Phuong and Oanh, 2009; Griffith *et al.*, 2010; Vidthayanon and Hogan, 2013; Anon, 2014).

P. hypophthalmus is a promising candidate species for freshwater catfish culture (young ones also possess ornamental values) and has captured all the markets of India in shorter period (Lakra and Singh, 2010; Singh and Lakra, 2012). There exist reports that this species is being sold in more than 100 countries, mainly in European Union (EU), Russia, South-east Asia and USA in the form of white fillets (Nguyen, 2007; Phuong and Onah, 2009; Phan et al., 2009). For culture of this species in West Bengal, the seed were initially procured through Bangladesh. Though the species has been induced bred in West Bengal, Andhra Pradesh and Chhattisgarh and some hatcheries established in these states, the survival of offspring has been very poor. Sutchi catfish is highly fecund fish, seasonal spawner and breeds once in a year in flooded rivers. Recently, *P. hypophthalmus* has been bred successfully in Mekong Delta region of Vietnam by using high doses of human chorionic gonadotropin (HCG) (Bui *et al.*, 2010). Success has also been achieved in induced breeding of *P. hypophthalmus* employing GnRH-based drug and dopamine antagonist (ovaprim) at Raipur (Chaturvedi *et al.*, 2014). An attempt has been made to induce breeding in the sutchi catfish by exogenous pituitary gland extract (PGE) administration and larval rearing in different types of hatcheries for mass seed production under agro-climatic conditions of Raipur (Chhattisgarh). Since physico-chemical conditions of water like pH, dissolved oxygen, temperature, alkalinity as well as metabolites play important role in fish breeding (Dwivedi and Ravindranathan, 1982), these parameters were monitored regularly and kept optimal while

Fig. 1: Circular hatchery of *P. hypothalamus* at State Fisheries Department, Raipur.

Fig. 2: Circular hatchery of *P. hypothalamus* with hatching pool at State Fisheries Department, Raipur.

Fig. 3: Vertical jar hatchery *of P. hypothalamus*.

Fig. 4: Vertical jar hatchery of *P. hypothalamus* owned by private fish farmer at Raipur.

Fig. 5: Thailand model hatchery of *P. hypothalamus* at Raipur.

Fig. 6: Detailed view of Thailand model hatchery of *P. hypothalamus* at Raipur.

undertaking induced the breeding experiments.

Materials and Methods

Breeding and hatching experiments were carried out at State Fisheries Department and private Fish Farms at Raipur (Chhattisgarh). Male and female brooders of *P. hypophthalmus* (Family Pangasiidae) were reared at M/S Hemant Chaudrakar Fish Farm at Dhamtari. At this farm, vertical glass jar hatchery with 15 cemented vertical jars was developed in the year 2010-11. Physico-chemical parameters of the water during the breeding experiments were analyzed as per APHA (1998). For induced breeding experiments, mature and gravid brooders of both the sexes of age group 3 (+) years were collected and induced bred by varying doses of pituitary gland extract (PGE) depending upon the physiological status of fishes. Male brooders were also given PGE at the time of second injection to females. Injected brooders were kept in cemented breeding tanks of size (3 x 2 x 1 m) with flowing water. The stripping was done in the early morning (6 am) after 10-12 hours of the final injection as female were ready for spawning. After fertilization, separated eggs were transferred for incubation to the three type of hatcheries - (i) Circular Hatchery (Fig. 1, 2), (ii) Vertical Jar Hatchery (Fig. 3, 4) and (iii) Thailand Model Hatchery (Fig. 5, 6).

Results

Physico-chemical parameters of the water during the breeding experiments were found to be within the optimum range (Table 1). Details of the breeding trials conducted on *P. hypothalamus* at Raipur (Chhattisgarh) have been summarized in (Table 2). In the present experiment, 15 females and 15 males (15 sets, 1:1 sex ratio) were selected and induced bred by varying doses of pituitary gland extract (PGE) depending upon the physiological status of the brooders (after first injection , the second injection was administered after 6 hours) . In this study, male brooder were also given pituitary gland extract at the time of second injection to females (Table 2). The eggs of *P. hypophthalmus* were very small (diameter 1.4-1.8 mm), adhesive in nature while fertilized eggs were light creamy or brown in colour. For fertilization of one million eggs of *P. hypothalamus*, one ml milt was used. After fertilization, three type of solutions such as cow milk, multani soil (mitti) and black soil were used for removal of stickiness of eggs. Separated eggs were transferred to the three type of hatcheries - (i) Circular Hatchery (Fig. 1, 2), (ii) Vertical Jar Hatchery (Fig. 3, 4) and (iii) Thailand Model Hatchery (Fig. 5, 6) for incubation. Fertilization of eggs varied from 30-80% and survival of the hatchlings varied from 30-60% in all the three hatching systems. After incubation of fertilized eggs from vertical jar hatchery 17,30,400 hatchlings, in circular hatchery 14,08,000 hatchlings while in Thailand model hatchery, only 3,17,500 hatchlings were obtained. The hatching percentage were observed 60% in vertical jar hatchery, 50% in circular hatchery and 30% in Thailand model hatchery. After 2 days, yolk absorption was observed and from the three types of hatcheries - 9,88,740 fry were realised from vertical jar hatchery, 7,40,000 from circular hatchery and 65,550 from Thailand model hatchery. After rearing the fry in nursery ponds for 25-30 days, 5,93,244 fingerlings from Krundh-Liey Fish Farm, 4,22,400 fingerlings from State Fisheries Farm, Raipur and 65,550 from Deepak Mandal Fish Farm (Thailand model hatchery) (total 10,81,144) were obtained.

Discussion

Induced breeding of the Indian major carps has been achieved successfully by administration of pituitary gland extract (PGE) and different preparation of synthetic GnRH-based drugs and dopamine antagonists (Chaudhuri and Alikunhi, 1957; Chaudhuri, 1960; Chaudhuri *et al.*, 1966; Varghese *et al.*, 1975; Dwivedi and Ravindra-nathhan 1982; Chaudhuri and Singh, 1984; Peter *et al.*, 1988, 1993; Nandeesha *et al.*, 1989, 1990; Lakra *et al.*, 1996; Mahanta *et al.*, 1998; Pandey *et al.*, 1998, 2001, 2002a, b, 2009; Singh *et al.*, 2000). Even catfishes have also been induced bred through the similar preparations/drugs (Ramaswamy and Sundararaj, 1956, 1957; Khan, 1972; Devaraj *et al.*, 1972; Khan and Mukhopadhyay, 1975; Pathak *et al*, 1982; Zonneveld *et al,* 1988; Kohli, 1989, Kohli and Vidhayarthi, 1990; Rao and Janakiram, 1991; Alok *et al*, 1993, 1995; Tharakan and Joy, 1996; Goswami and Sarma, 1997; Kanungo *et al*, 1999; Nayak *et al*,

Table 1: Physico-chemical parameters during the breeding experiments at Raipur.

Sl. No.	Parameters	I 24.8.2014	II 25.8.2014	III 26.8.2014	IV 27.8.2014	V 28.8.2040	Remarks
1	Dissolved oxygen (mg/l)	4.8	4.8	5.2	4.8	5.0	Hatchery water
2	Free carbon dioxide (mg/l)	--	--	--	--	--	--
3	Iron (mg/l)	0.2	0.1	0.2	0.1	0.2	
4	Water temperature (Hatchery)	27.4 oC	27.6 oC	28.5 oC	28.4 oC	28.6 oC	Hatchery water
5	pH	7.4	7.5	7.8	7.5	7.4	
6	Salinity (ppt)	--	--	--	--	--	--
7	Total alkalinity (mg/l)	111	114	121	120	112	
8	Weather temperature (°C)	34.6	34.2	34.2	34.0	34.6	
9	Weather	Sunny	Sunny	Sunny	Sunny	Sunny	
10	Fertilization % (after removal of stickiness)	70%	60%	70%	80%	80%	After stripping and washing of eggs

2000; 2001; Singh *et al*, 2002; Pandey and Koteeswaran, 2004; Sahoo *et al*, 2005; Mishra *et al*, 2011; Yadav et al, 2011; Taslim and Ahemd, 2012; Chaturvedi et al, 2012a, b, c, 2013). There exist report that the striped catfish has been bred successfully in Mekong Delta region of Vietnam by using high doses of human chorionic gonadotropin (HCG) (Bui et al, 2010). We successfully induced bred P. hypothalamus through ovaprim administration under agro-climatic conditions of Raipur (Chhattisgarh) with better survival of fry and fingerlings (Table 2).

There exists a lot of scope for freshwater catfish farming in India for diversification of aquaculture and sustainable production (Dehadrai, 1978; Tripathi, 1990; Thakur, 1991; Nayak *et al.*, 2000). Since the culture of *P. hypothalamus* is more profitable among the catfishes, there exist more demand of this species for aquaculture in India and tropical regions of the America (Rahman *et al.*, 2006; Lakra and Singh, 2010; Mukai, 2011; Singh and Lakra, 2012; Hekimoglu *et al.*, 2014; McGee, 2015). Vietnam has shown the record production (1.0-1.5 million tonne per annum) of *P. hypothalamus* (Nguyen, 2007; Phuong and Onah, 2009; Phan *et al.*, 2009). Though the striped catfish is widely cultured in China, Vietnam, Thailand, Taiwan, Philippines, Cambodia, Indonesia, Lao People's Democratic Republic, Bangladesh, Nepal and India (Griffith *et al.*, 2010), this species has been declared Endangered in Vietnam due to over-exploitation, habitat degradation, changes in flow and water quality as well as over-harvesting of eggs, fry and juveniles for aquarium trade (Vidthayanon and Hogan, 2013; Anon, 2014). The success has been achieved earlier in induced spawning and seed production (10,50,000 fry and 6,30,000 fingerlings) of *P. hypothalamus* through ovaprim administration and hatchery development in Raipur (Chhattisgarh) (Chaturvedi *et al.*, 2014) for seed

Table 2: Induced breeding and larval rearing of P. hypothalamus in the three different model hatcheries at Raipur.

Sl. No.	Date	Weight of fish (kg)		Pituitary dose (mg/kg)		Injection time (hours)	Stripping time (hours)	Total eggs (in lakh)	Total number of good eggs (in lakh)	Fertili-zation (%)	Hatch-lings (in lakh)	Perce-ntage (%)	Fry	Finger-lings
		Male	Female	Male	Female									
Circular Hatchery														
1	24.8.2014	3.4	4.4	40	15, 20,	17.00	0.03	4.0	3.20	80	2,56	50	1,26,000	
2	25.8.2014	3.0	5.0	50	15, 25	17.00	0.03	6.0	4.80	80	3.84	50	1,92,000	
3	26.8.2014	4.2	6.5	64	20, 32	17.00	0.04	6.0	4.20	70	2.94	50	1,47,000	
4	27.8.2014	4.5	6.0	60	22, 30	17.00	0.04	6.0	4.20	70	2.94	50	1,57,000	
5	28.8.2010	4.0	5.50	40	20, 25	17.00	0.03	5.0	3.00	60	1.80	50	90,000	
								27.0	19.4		14,080		7,04,000	**4,22,400**
Vertical Jar Hatchery														
6	26.8.2014	2.9	3.5	30	10, 15	16.00	0.02	3.2	3.10	80	2.790	60	1,67,400	
7	27.8.2014	3.0	4.9	40	15, 20	16.00	0.02	4.2	3.36	80	3.024	60	1,81,440	
8	2816.8.2014	3.6	4.7	50	18, 25	16.00	0.01	5.0	4.80	80	3.840	60	2,30,400	
9	28.8.2014	3.0	5.2	50	17, 25	16.00	0.02	4.4	4.30	80	3.870	50	1,93,500	
10	30.8.2010	3.0	5.2	50	15, 25	16.00	0.02	5.0	4.00	80	3.600	60	2,16,000	
								21.8	19.56		17.304		9.88,740	**5,93,244**
Thailand Model Hatchery														
11	09.08.2014	3.5	3.8	40	20, 25	8.00	9.00	2.0	1.00	50	0.50	30	15,000	
12	10.08.2014	2.9	4.2	50	18, 30	7.30	8.30	4.0	1.20	30	0.60	30	18,000	
13	11.08.2014	3.2	5.4	60	18, 40	8.30	9.30	3.5	1.05	30	0.525	25	15,750	
14	12.08.2014	3.8	5.4	60	18, 40	8.30	9.30	3.0	1.20	40	0.60	30	18,000	
15	13.08.2014	3.8	6.0	70	25, 40	9.00	10.00	4.8	1.90	40	0.95	30	28,500	
								17.3	6.35		3.175		95,250	**65,550**
Total (fingerling production)														**10,81,194**

Table3: Description of three hatcheries used for hatching of eggs of *P. hypothalamus*.

Sl. No.	Parameters	Circular hatchery	Vertical Jar Hatchery	Thailand Hatchery	Specifications
1	Shape	Circular	Vertical Jar	Circular with Hatching trays	Eggs handling trays (45°) (3×1×0')
2	Inlet	Horizontal base	Vertical bottom	Horizontal	Ground water
3	Water flow	120 l/m	4-6 l/m	6-10 l/m	Ground water
4	Egg loading	14, 08,000	17,30,400	3,17,500	Ground water
5	Hatching (%)	60	50	30	Ground water
6	Spawn	7,040,000	9,88,740	65,500	Ground water
7	Water depth	3.0'	3.5'	3.0	Ground water

production of this species for conservation aquaculture (True *et al.*, 1996; Anders, 1998) which will reduce the pressure on collection of fry and juveniles from the wild natural habitats (Nguyen, 2009). In the present study, after rearing the fry in nursery ponds for 25-30 days, 5,93,244 fingerlings from Krundh-Liey Fish Farm, 4,22,400 fingerlings from State Fisheries Farm, Raipur and 65,550 from Deepak Mandal Fish Farm (Thailand model hatchery) (total 10,81,144) were obtained paving the way for mass seed production of the commercially important catfish under agro-climatic conditions of Raipur (Chhattisgarh).

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Induced Spawning and Larval Rearing of Climbing Perch, *Anabas testudineus* under Controlled Conditions of Raipur (Chhattisgarh)

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Introduction

Anabas testudineus, commonly known as "Koi/Kawai" or "climbing perch" is found in both fresh- and brackish water as well as estuaries of Pakistan, India, Nepal, Bangladesh, Sri Lanka, southern China, Myanmar, Thailand, Singapore, Indonesia, Malaysia, Laos, Vietnam, Brunei and the Philippines (Talwar and Jhingran, 1991; Chonder, 1999; Jayaram, 2010; Pal and Chaudhry, 2010). It fetches high price in the markets of India and south-east Asian countries. This species possesses accessory respiratory organs (Olson *et al.*, 1986; Munshi *et al.*, 1986) and cultured with Clarias batrachus (magur) and Heteropneustes fossilis (singhi) in swampy, derelict and sewage water as well as paddy fields unsuitable for carp culture (Dehadrai *et al.*, 1986; Dehadrai and Kamal, 1993). Demand of this species is growing day-by-day in different parts of the country but fish farmers are not getting enough seed for commercial aquaculture. Since enough seed is essential for diversification of aquaculture (Kutty, 2001), development and standardization of seed production technology of the candidate species is required (Khan 1972; Khan and Mukhpoadhyay, 1975; Thakur 1991; Tripathi, 1990; Nayak *et al.*, 2000, 2001; Pandey and Koteeswaram 2004; Singh and Pandey 2009; Chaturvedi *et al.*, 2012, 2013). Though the climbing perch is not a catfish but cultured with singhi and magur, however, culture of the species has not yet picked up in India due to poor seed availability owing to non-availability of brooders or lack of breeding and hatching technology (Dehadrai and Kamal, 1993; Kumar *et al.*, 2012). An attempt has, therefore, been made to induce breeding and larval rearing of the commercially important *A. testudineus* under agro-climatic conditions of Raipur (Chhattisgarh). Since physico-chemical conditions of water like pH, dissolved oxygen, temperature, alkalinity as well as metabolites play important role in fish breeding (Dwivedi and Ravindranathan, 1982), these parameters were monitored regularly and kept optimal while undertaking induced breeding and larval rearing experiments on the climbing perch.

Materials and Methods

For breeding experiments, mature and healthy brooders of Anabas testudineus were procured from Private Fish Farm (30 km away), transported to Chhattisgarh State Fisheries Department, Raipur, given bath treatment in KMn04 solution (3 ppm) and acclimatized in cemented cistern size (3x2x1 m) with water depth of 10-12" under hatchery conditions. Physico-chemical parameters of water such as pH, temperature, dissolved oxygen, alkalinity, nitrite and nitrate were monitored regularly and found to be within the optimum range (Table 1). Since body colouration in A. testudineus appears only during breeding season (Mookerjee and Mazumdar, 1946; Dehadrai et al., 1973; Banerjee and Prasad, 1974; Banerjee and Thakur, 1981; Behera et al., 2015), male and female brooders were identified based on secondary sexual characters - the males being darker in colour with oozing milt by applying slight pressure on the belly while females possessed light brown pigmented spot on body with bulging abdomen (Fig. 1-2) . Females were given intraperitoneal (i.p.) injection of ovatide @ 0.06 ml/100 g body weight while males were administered (i.p.) with the hormonal drug @ 0.04 ml/100 g body weight (Fig. 3). In one set, ovatide was also given intramuscular (i.m.) injection in the

Fig. 1: Brooders of *Anabas testudineus*.

Fig. 2: Checking of male brooders.

Fig. 3: Intraperitoneal injection to brooder.

Fig. 4: Intramuscular injection to female brooder.

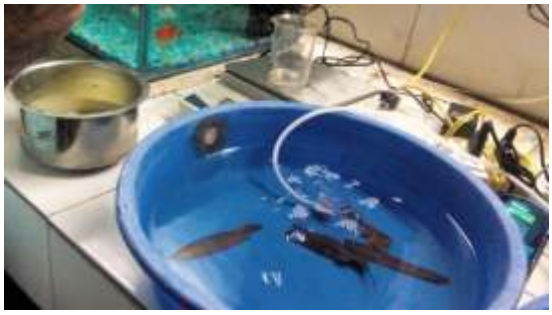

Fig. 5: Spawn of *Anabas testudineus*.

Fig. 6 : Rearing of *Anabas testudineus* spawn.

Table 1: Physico-chemical parameter of hatchery water at Raipur.

Sl. No.	Date	pH	Temperature (°C)	DO_2 (ppm)	Alkalinity (ppm)	Nitrite (ppm)	Nitrate (ppm)	Hatching hours
1	20.07. 2015	7.4	27.4	3.4	100	0.02	Nil	23.4
2	21.07.2015	7.2	27.8	3.8	120	0.01	0.01	-----
3	22.07.2015	7.6	28.2	3.6	110	0.01	0.01	-----
4	23.07.2015	7.4	27.2	4.0	130	0.02	Nil	24.0
5	24.07. 2015	7.2	28.2	3.8	110	0.03	0.01	-----
6	25.07.2015	7.5	27.8	4.2	110	0.02	0.01	-----
7	26.07. 20175	7.5	27.0	3.8	120	0.02	0.01	24-25
8	27.07. 2015	7.4	27.6	4.0	120	0.01	Nil	-----

Table 2: Details of Induced breeding experiments on *Anabas testudineus* at Raipur.

Sl. No.	Date	Weight of fishes (gm) body weight)		Dose of hormone (ml/100 g)		Number of fertilized eggs	Hatching (%)	Number of spawn	Fry
		Male	Female	Male	Female				
1	20.07.2015	32.0-32.5	42.0	0.02-0.02	0.06	4,800	90	4,320	1710
2	23.07.2015	32.0-36.0	38.0	0.02	0.05	2,600	80	2,080	1248
3	26.07.2015	33.0-42.0	39.2	0.03	0.04	3,200	90	2,880	1728
Total									4,686

above dose (Fig. 4). The injected brood fish sets comprising one female and two males (sex ratio 2:1) were released in cement cistern (Banerjee and Thakur, 1981). Breeding was observed in all the 3 sets of climbing perch but the latency period prolonged to 18-28 hours. Interestingly, A. testudineus given intramuscular (i.m.) injection of the hormonal drug also elicited successful spawning but the latency period was prolonged to 2-3 more hours. Fertilized eggs were transferred to fiber glass tub (size 3×2×1') with water depth 10" provided with aeration (Fig. 5). Hatching of fertilized eggs took place in cemented cistern by supplying oxygen through aerators (Fig. 6). Hatching of fertilized eggs took place in cemented cistern by supplying oxygen through aerators. Flowing water were stopped and spent brooders taken out with the help of hand net.

Results

Effects of ovatide administration on induced spawning of the climbing perch, *A. testudineus*, have been summarized in Table 2. In the present study, induced breeding was achieved successfully in all the three sets of *A. testudineus* without sacrifice of any male or female but the latency period prolonged to 18-28 hours (2 hours more in case of i.m. injection). The eggs (released in batches) were very minute and floating on the surface of water. The fertilized eggs were bright clear and transparent while unfertilized eggs appeared milky and opaque. The diameter of fertilized eggs ranged between 0.6-0.7 mm. Mookerjee & Mazumdar (1946), Banerjee & Prasad (1974), Khan & Mukhopadhyay (1975) and Zalina *et al.* (2012) also recorded diameter of fertilized eggs of the climbing perch between 0.7-

0.85 mm. Average fertilization rate was 90% under the hatchery conditions indicating successful natural spawning (without stripping) in A. testudineus. Fertilized eggs were transferred to fiber glass tub (size 3x2x1') with water depth 10" provided with aeration. Hatching of fertilized eggs took place in cemented cistern by supplying oxygen through aerators. Flowing water were stopped and spent brooders taken out with the help of hand net. Hatching took place in 18-22 h and the newly-hatched larvae measured 2.0-2.3 mm on day 1, 2.6-2.8 mm on day 2 and 3.0-3.6 mm on day 3. Air-breathing organ developed on day 10 and larvae measured 10.6-11.8 mm. Indoor rearing of the larvae was done on feed such as plankton, egg custard and chopped molluscan meat with water depth of 6-8". From the three sets of brooders, 10,600 hatchlings and ultimately 4,686 fry were produced.

Discussion

In spite of moderate growth, A. testudineus is esteemed for flavour and medicinal values of flesh and prolonged freshness out of water which call to extend and intensify production through cultural practices (Banerjee and Prasad, 1974; Zalina *et al.*, 2012; Chakraborty and Haque, 2014; Chakraborty, 2015). It has been recommended for culture in swamps, pens and even in carp ponds where advanced fingerlings (over 10 cm) are stocked (Alikunhi, 1957; Hora and Pillay, 1962; Banerjee and Prasad, 1974; Dehadrai and Kamal, 1993 and Tuan and Hau, 2012). With the success of induced spawning by hypophysation in carps for seed production (Chaudhuri and Alikunhi, 1957; Chaudhuri, 1960; Chaudhuri *et al.*, 1966; Varghese *et al.*, 1975; Bhowmick *et al.*, 1977; Chaudhuri and Singh, 1984; Mahanta *et al.*, 1998), this technique was also extended to induce spawning in other commercially important including air-breathing fishes for diversification and expansion of freshwater aquaculture in swampy, derelict and sewage water which were unsuitable for carp culture (Ramaswamy and Sundararaj, 1956, 1957; Devaraj *et al*, 1972; Khan, 1972; Khan and Mukhopadhyay, 1975; Zonneveld *et al.*, 1988; Kohli, 1989; Kohli and Vidyarthi, 1990; Tripathi, 1990; Rao and Janakiram, 1991; Thakur, 1991; Chondar, 1999)). With the discovery of GnRH-based drugs, induced breeding technique has been simplified and successfully employed for breeding and seed production of carps and other commercially important fishes (Peter *et al.*, 1988, 1993; Kouril *et al.*, 1986; Lee *et al.*, 1986; Nandeesha *et al.*, 1989, 1990; Alok *et al.*, 1993, 1997; Lin and Peter, 1996; Lakra *et al.*, 1996; Tharakan and Joy, 1996; Pandey *et al.*, 1998; Nayak *et al.*, 2000, 2001; Pandey and Singh, 2003; Pandey and Koteeswaran, 2004; Chaturvedi et al., 2015).

Observations on breeding and life-history (including larval development) of *A. testudineus* have been documented and induced breeding through hypophysation (pituitary gland extract) also reported (Mookerjee and Mazumdar, 1946; Khan,1972; Banerjee and Prasad, 1974; Khan and Mukhopadhyay, 1975; Mahmood, 2006; Akter et al., 2014; Sarkar et al., 2015) but survival of the larvae has been poor partly due to pronounced cannibalism (Khan and Mukhopadhyay, 1975; Zworykin, 2012). Banerjee and Prasad (1974) observed spawning in *A. testudineus* with single low dose (15-20 mg /kg body weight) of carp pituitary gland extract (PGE). Mass scale seed production of the climbing perch for commercial aquaculture is also hampered owing to low fecundity (Khan and Mukhpoadhyay, 1972; Banerjee and Prasad, 1974; Zalina et al., 2012). Induced spawning of *A. testudineus* using GnRH-based drugs has also been attempted during the recent years (Sarkar *et al.*, 2005, 2015; Bhatta-charyya and Homechaudhuri, 2009; Kumar *et al.*, 2010; Zalina *et al*, 2011, 2012; Loh and Ting, 2015; Singh *et al.*, 2015) with varying success. In the present study, ovatide in the dose of 0.06 ml/100 g body weight in females and @ 0.04 ml/100 g body weight in males induced successful spawning in A testudineus. Sarkar *et al.* (2005), Perera *et al.* (2013) and Singh *et al.* (2015) also achieved success with similar dose of GnRH-based drugs, however, Kumar *et al.* (2010) used ovaprim in the dose of 15 ml/kg body weight for successful induced spawning of the species in different seasons (February through August). In the present study, spawning took place in batches similar to those reported by other workers in *A. testudineus* (Mookerjee and Mazundar, 1946; Banerjee and Prasad, 1974; Kumar et al., 2010). Since water temperature and pH play pivotal role in induced spawning and larval rearing

of the climbing perch, it ranged between 27.4-28.20C and 7.2-7.6, respectively in the present study which were within the optimum range. Mookerjee and Mazundar (1946) and Zalina et al. (2012) also found 26-270C to be optimum temperature for induced spawning of the climbing perch. In the present study, air-breathing organ developed on day 10 when larvae measured 10.6-11.8 mm. Hughes et al. (1986) reported air-breathing in 13-14 days old hatchling. Average fertilization rate of 90% under the hatchery conditions found in the present study indicates successful natural spawning (without stripping) in the species. Indoor rearing of the larvae was done on feed such as plankton, egg custard and chopped molluscan meat with water depth of 6-8".

From the three sets of brooders, 10,600 hatchlings and 4,686 fry of A. testudineus were produced under agro-climatic conditions of Raipur (Chhattisgarh) Though A. testudineus has been kept under Data Deficient-ver 3.1 category of IUCN Red List of Threatened Species (Pal and Chaudhry, 2010), population of this species has declined drastically in some of its natural habitats and declared vulnerable in West Bengal (Mukherjee *et al.*, 2002) and endangered in Bangladesh (Rahman and Marimuthu, 2010; Chakraborty and Haque, 2014), the successful induced spawning of the climbing perch pave the way for rehabilitation of this species through conservation aquaculture (True et al, 1996; Anders, 1998).

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Response of French Marigold to varied spacing and Phosphate level on Sodic Soil

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Introduction

French marigold (*Tagetes patula* Linn.) is a popular flower crop, easily cultivated with wide adaptability to varying soil and climate conditions. It is a hardy, dwarf annual, forming a bushy plant. The flowers are small and compact, either single or double and their colour may be yellow, orange, golden yellow, primrose, mahogany, rusty red, tangerine or deep scarlet or a combination of these. The flowers are extensively used on religious and social function, while leaved and flowers have medicinal value. The present investigations were undertaken to explore the potential odf its cultivation on partially reclaimed sodic wastelands with suitable agri-horticultural practices.

Materials and Methods

The field experiments were conducted on partially reclaimed sodic soil of Banthra Research Station of CSIR-National Botanical Research Institute, Lucknow during the winter season. The soil of the experimental plot was clay-loam with 8.7 pH, 0.6 dS m-1 electrical conductivity, low organic matter and nitrogen along with poor physical properties. The experiment was conducted in Split Plot Design with two spacings (30×30cm and 45 × 45 cm) as main plot treatments and four phosphate levels (0,30,60 and 90 kg ha^{-1}) as sub-plot treatments with five replications. The seedlings were raised in nursery beds in October and transplanted in field at 30 days age, after basal application of farm yard manure at 25 tons ha-1 and nitrogen at 40 kg ha^{-1}. The crop was top-dressed with 40 kg N ha^{-1} after 45 days of transplanting. The size of sub plots was 2.7m × 1.8m and observations were recorded on plant height, number of primary and secondary branches, number of flowers, and their weight and per unit area field.

Results and Discussion

Proper spacing between rows and plants (optimum plant population) is required for better development and high flower yield of French marigold. Wider spacing of 45x45cm (49,382 plants ha-1) resulted in significantly more number of primary and secondary branches and higher number and yield of flowers per plant, as compared to 30x30cm spacing (1,11,111 plants ha-1). Plant height and flower weight also showed the same statistical magnitude. However, large plant population in closer spacing compensated for the lower per plant yield and produced significantly higher flower yield (98.8q ha-1) as compared to wider spacing. Different species of marigold have specific requirement of optimum plant population (spacing) in different soil and climatic conditions. The studies conducted on *T. erecta* also revealed significantly higher per plant yield at 40x30cm as reported by S. Sridhar *et.al* (2010) and Lakshmi *et al* (2014). Favourable conditions like availability of nutrients, sunlight and soil moisture to individual plant in wider spacing would have increased the flower yield.

Marigold responds to fertilization, but information on response to *T. patula* to fertilizer application, especially phosphorous in sodic soils is scanty. The findings of our experiment revealed that phosphate levels had significant effect on plant height, number of primary branches, flowers per plant and flower yield on per plant and unit area basis. Increasing phosphate level from 60 to 90 kg ha-1 did not cause significant improvement in plant height, number of flowers and yield per plant and unit area yield. Phosphate application at 60 kg ha-1 produced 44% more flowers as compared to control. The interaction effect of spacing and phosphate levels was significant for single flower weight only

Table 1: Effect of spacings and phosphate levels on growth and flower yield of *Tagetes patula*

Treatments	Plant ht. (cm)	No. of primary branches	No. of secondary branches	No. of flowers per plant	Flower weight (g)	Flower yield per plant (g)	Flower yield (q ha-1)
Spacings							
30 × 30 cm	24.8	8.0	94.5	43.8	1.047	44.2	98.8
45 × 45 cm	24.2	9.8	101.1	54.9	1.051	55.5	84.6
CD (5%)	NS	1.2	8.1	6.7	NS	2.8	12.8
Phosphate							
0 kg ha	22.2	8.4	91.0	41.9	0.980	41.7	74.2
30	23.7	9.0	98.6	45.1	1.005	45.8	83.6
60	25.3	8.6	95.1	53.4	1.048	55.3	107.1
90	9026.6	9.6	100.6	57.3	1.164	56.6	102.0
CD (5%)	1.6	0.8	NS	5.6	0.053	0.053	2.6
Interaction	NS	NS	NS	NS	NS	NS	NS

(Table-1). The effects of N, P and K have been studied on nutrient content and dry weight and it was noticed that on omitting P, both dry weight and P content were reduced.

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A Preliminary Analysis of Angiospermic Flora of Sonbhadra District, Uttar Pradesh

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Introduction

The information of the floristic alignment of a plant community is an essential to know the overall structure and function of any environment. A forest is a large area of land covered with tree, herbs, shrubs or other woody vegetation and known to be critically important habitats in terms of the biological diversity. About 400000 species are estimated from throughout the world, of which 46000 species have been reported from India, which constitute about 11 % of total world floral wealth. In angiosperm alone, India has more than 19000 species from throughout the country, but there is still about 30 % land area is yet to be explored and floral wealth present there awaiting exploration, identification and scientific research (Sanjappa, 2008). Brummit *et al.* (2001) have also very rightly said that we have not so far completed the cataloguing of half of the higher plants found on the Earth. In view of this, the unexplored and underexplored areas with high percentage of plant diversity need to be studied further. The present study provides a preliminary analysis of higher plants of Sonbhadra district of Uttar Pradesh as it has very rich plant diversity and is not yet properly explored to know the plant wealth of the area.

Sonbhadra district is located between 24°41'23"N and 23°03'55"E with an area of 6788 sq. km at elevation of 285 feet from the sea level. Total Forest area in the district is reported to be about 3,782.86 sq. km, which accounts for about 56% of total land area (Anonymous, 2011). The district is situated in the extreme south east of the state in the Vindhyan region. It is bounded by Mirzapur district to the north west, Chandauli district to the north, Kaimur, Rohtas district of Bihar state to the north east, Garhwa district of Jharkhand state to the east, Koriya and Surguja districts of Chhattisgarh state in the south and Singrauli district of Madhya Pradesh in the west (Map 1). Sonbhadra has a relatively tropical climate with high variation between summer and winter temperatures. The average temperature is 32°C-42°C in the summer and 2°C-15°C in the winter. The entire area of the district is uneven and dominated by tropical dry deciduous forests.

Although, the area has very rich plant diversity, but it has not been properly assessed after its separation from Mirzapur district. Only a few scattered information are available on the plants of the area in the work of Bhattacharyya (1963, 1964) and Srivastava (1955). In recent time, only Kushwaha *et al.* (2016) have published a brief taxonomic account of family Cucurbitaceae of the area. Except these works, the other works (Singh *et al* , 2002; Singh *et al.*, 2010; Chaudhary, 2010; Singh *et al.*, 2012; Singh & Dubey, 2012; Mishra *et al.*, 2012) available from the area is chiefly pertaining to the ethnobotany or study on medicinal plants. So, it is the first report of the plant diversity occurring in Sonbhadra district.

During last three years (2012–2015), entire area was thoroughly explored in different seasons to study the vegetation and collect the plant materials for taxonomic study. Besides, the specimens collected previously by different organizations and persons and housed at BSA, BSD, DD and LWG were also examined to know plant diversity of the region. All our collections have been deposited at LWG for future record and reference after following proper procedures, out lined by Lawrence (1951) and Jain & Rao (1977).

Result and Discussion

So far, more than 2000 specimens have been examined in the present study, which have resulted about 747 species under 114 families of higher plants from the study area. As usual, the dicots with 586 species dominate the area over monocots which contain about 161 species only (Figure 2, 3). The area

Figure 1: Map of Sonbhdra district.

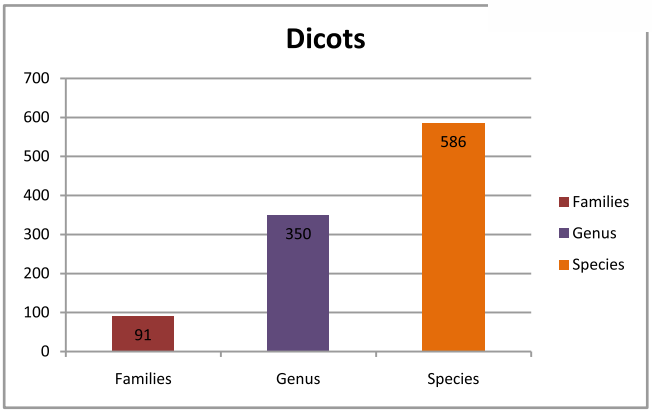

Figure 2: Dicot species with family and genus

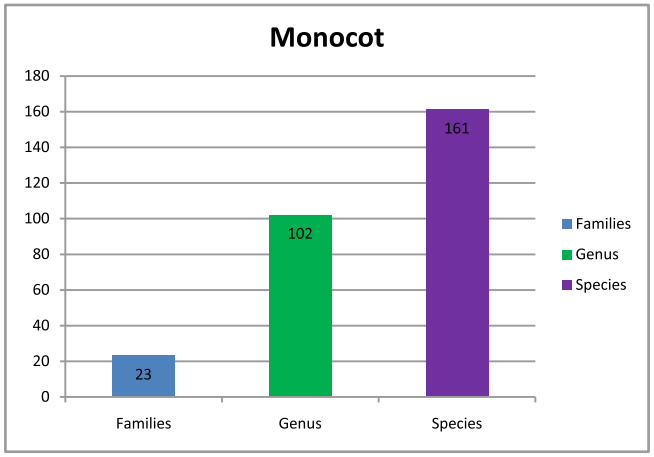

Figure 3: Monocot species with family and genus

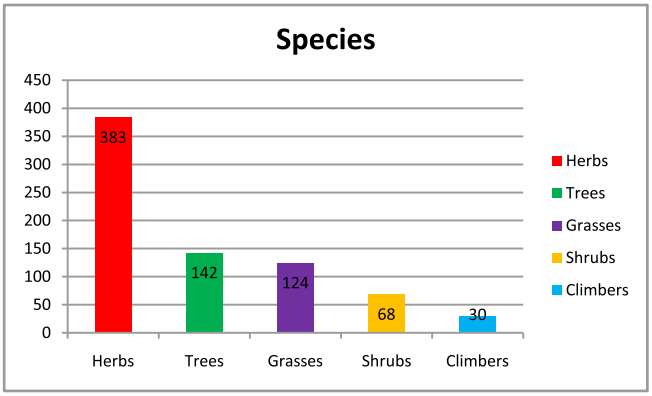

Figure 4: Distribution of species among different groups of plant.

contains more herbs (383 species) followed by trees (142 species), shrubs (68 species), climber and creepers (30 species). The. 124 species also belong to grasses (Figure 4).

Some of the dominant species under different categories of plant found in the study area are as follows:

Trees: *Anogeissus latifolia* (Roxb. ex DC.) Wall. ex Guillem. & Perr., *Soymida febrifuga* (Roxb.) *A. Juss.*, *Bombax ceiba* L., *Bridelia retusa* (L.) A.Juss., *Terminalia arjuna* (Roxb. ex DC.) Wight & Arn., *Bauhinia racemosa* Lam., *Diospyros melanoxylon* Roxb., *Syzygium cumini* (L.) Skeels., *Lagerstroemia parviflora* Roxb., *Miliusa tomentosa* (Roxb.) Sinclair, *Haldina cordifolia* (Roxb.) *Ridsdale, Nyctanthes arbortristis* L. *Cassia fistula* L., *Albbizia* spp., *Ziziphus nummularia* (Burm.f.) Wight & Arn., *Briedelia retusa, Hardwickia binata* Roxb., *Terminalia alata* Roth, *Butea monosperma* (Lam.) Taub., *Shorea robusta* Gaertn., *Acacia catechu* (L.f.) Willd. Etc.

Shrubs: *Adhatoda zeylanica* Medik., *Barleria prionitis* L., *Calotropis procera* (Aiton) Dryand. *Rauvolfia tetraphylla* L., *Opuntia cochenillifera* (L.) Mill., *Clerodendrum infortunatum* L., *Croton bonplandianus* Baill., *Capparis zeylanica* L.,

Figure 5 : Habit of plants. A: *Bombax ceiba* L. B: *Bridelia retusa* (L.) A. Juss. C:

Jatropha gossypiifolia L., *Argemone mexicana* L., *Arundo donax* L., *Ricinus communis* L., *Sagittaria sagittifolia* L., *Crotalaria albida* Roth., *Indigofera tinctoria* L., *Lawsonia inermis* L., *Hibiscus cannabinus* L.

Herbs: *Acanthospermum hispidum* DC., *Acmella calva* (DC.) Jansen, *Blumea laciniata* (Wall. ex Roxb.) DC., *Gnaphalium indicum* L., *Tagetes erecta* L., *Chenopodium murale* L., *Elephantopus scaber* L., *Eichhornia crassipes* (Mart.) Solms., *Uraria picta* (Jacq.) DC., *Tephrosia pumila* (Lam.) Pers., *Evolvulus alsinoides* L., *Crotalaria prostrata* Willd., *Hyptis suaveolens* (L.) Poit., *Bidens biternata* (Lour.) Merr. & Sherff.

Climbers: *Ampelocissus latifolia* (Roxb.) Planch., *Cryptolepis dubia* (Burm.f.) M.R. *Almeida*, and *Mucuna pruriens* (L.) DC.

Grasses: *Cyperus compressus* L., *Cyperus rotundus* L. *Fimbristylis dichotoma* (L.)Vahl., *Fimbristylis tetragona* R.Br., *Eleocharis quinqueflora* (Hartmann) O. Schwarz., *Kyllinga brevifolia* Rottb., *Schoenoplectiella erecta* (Poir.) Lye., *Scirpus supinus* L., *Scleria levis* Retz. (Figure 5).

The entire area is very rich in plant diversity of typical Vindhyan region, but it faces sever anthropogenic pressure from all sides. The previous reports reveal that the area also contains large number of medicinal plants used by different tribal and local people. *Hardwickia binata* Roxb., an endemic species to India, is one of the dominant constituents of the flora of the region. Since, the area has many important plant species, the whole area should be conserved for the protection of biodiversity available there.

Terminalia arjuna (Roxb. ex DC.) Wight & Arn., D: *Hardwickia binata* Roxb., E: *Acacia catechu* (L.f.) Willd. F: *Syzygium cumini* (L.) Skeels. G: *Solanum surattense* Burm. f. H: *Croton bonplandianus* Baill. I: *Clerodendrum phlomidis* L.f. J: *Eichhornia crassipes* (Mart.) Solms. K: *Acmella calva* (DC.) Jansen. L: *Argemone mexicana* L. M: *Sagittaria sagittifolia* L., N: *Eleocharis quinqueflora* (Hartmann) O.Schwarz. O: *Cyperus rotundus* L.

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Integrated Effects of Climate Change and Pollution on the Ganges River Biodiversity

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Introduction

In its fifth assessment report, IPCC has drawn the attention of the world by projecting the increase in average global temperature by 1.5-4.5°C (IPCC, 2014). According to this assessment, the globally averaged combined land and ocean temperature shows a warming of 0.89 (0.69 to 1.08) °C over the period 1901–2012; with the rate of warming at 0.05 (−0.05 to +0.15) °C per decade over the past 15 years (1998–2012). This report postulates that with increase in warming; the freshwater-related risks of climate change is likely to increase significantly where each degree of warming is projected to decrease renewable water resources by at least 20%. These trends may exacerbate the problems of raw water quality due to of increase in temperature, sediment, nutrient and pollutant loadings due to heavy rainfall; reduced dilution of pollutants during droughts, and unmanageable treatment facilities during floods (Sun *et al*, 2012).

Under diverse processes of climate change; the rivers are in unsafe state as due to their unique properties of turbulence and mixing, rivers respond to changes in atmospheric conditions quite easily and thus becoming warmer (Durance and Ormerod, 2009). It is now well established that increase of temperature influences physical, chemical and biological properties of aquatic ecosystems imparting undesirable impacts on the water quality causing changes in planktons and in turn affecting the animal-plant structures at the higher trophic levels (Arain, 2011). Temperature increase may alter pollution degradation, ambient partitioning of pollutants and solvent depletion in river waters (Meyer and Wania, 2008). Together with increased salinity this is able to enhance the toxicity of pollutants in aquatic biota by changing biotransformation mechanisms of contaminants impairing homeostasis and affecting physiological responses, reproduction, and development of aquatic organisms (Noyes *et al.*, 2009). These complex interactions between climate change and contaminants are dangerous for vulnerable species having low physiological tolerance range (Noyes *et al*, 2009).

The Ganges basin is the part of the combined Ganga-Brahmputra-Meghna basin spread across China, Nepal, India and Bangladesh (Figure 1). Out of the total drainage basin area roughly 80%, is located in India covering around one-fourth of the country's total geographical area and thus is biggest river basin of India. It has much complicated hydrology with peak discharge between 70000 m^3/s to 180 m^3/s; highly seasonal stream flow with average dry season to monsoon discharge ratio of 1:6, causing both drought and flood in this river basin. Together associated with population explosion and indiscriminate urban-industrial growth along this river basin, massive fluxes of nutrients and other contaminants are being added day by day. Consequently it is witnessing huge concerns for its increasing pollution levels and associated ecological crisis. Increased temperature and irregular rainfall patterns over this basin in recent decades has stimulated climate change stressors causing threat of ecological as well socio-economical crisis to it (Tripathi and Singh; 2013). So it is imperative to view the status of pollution and other ecological problems associated with this river in the context of regional climatic change and weather variations to understand the complex relations among pollution problems and climatic stressors acting in this river basin.

Interrelation of climate change and pollution in Ganges basin

From India, sporadic reports are available about the climatic impacts on water systems, and

Figure 1: Ganges basin map (source: Google)

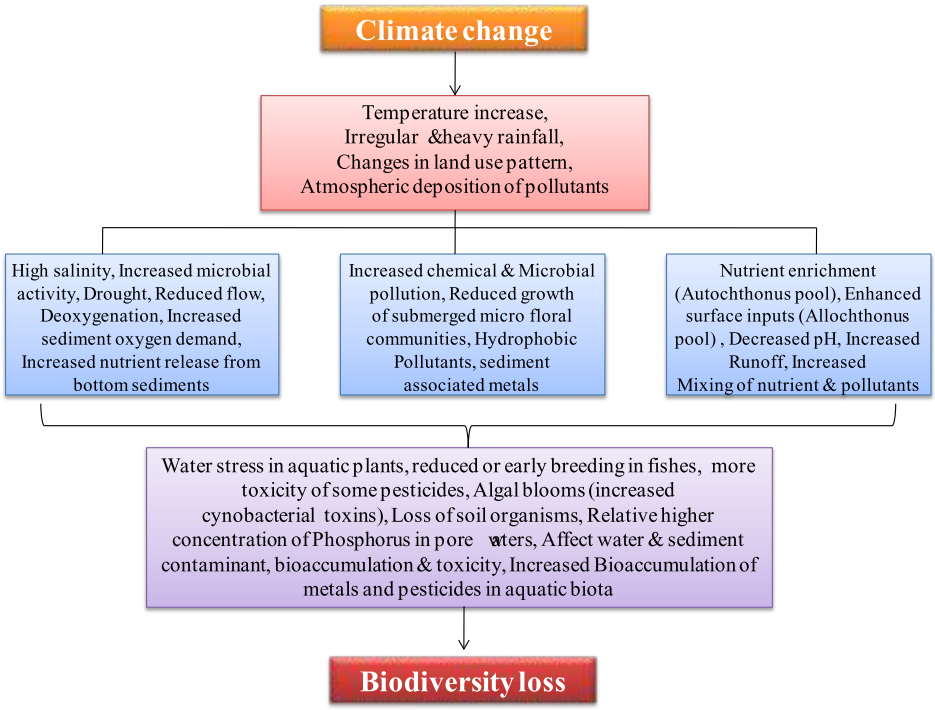

Figure 2: An overview of the climate change interaction with pollution problems and their combined impacts.

most of them are limited to assessing temperature and rainfall analysis over a time period and effects on the species distribution in river (Nautiyal *et al*, 2013; Tripathi and Singh, 2013). There are evidences about a marked change and shift in weather patterns over Indo Gangetic region which can be noticed by increasing mean annual maximum and minimum temperature and decline in total monsoonal rainfall (Tripathi and Singh, 2013). Few studies have taken into account the impact of climate change on river hydrology and hydro-geochemical dynamics of Ganges basin (Gosain *et*

A: *Glossogobius giuris* (courtesy: Randall J.E.)

B: *Xenentodon cancila* (courtesy: Enrico Richter)

C: *Cyprinus carpio* (courtesy: Google)

D: *Aristichthys nobilis* (courtesy: Google)

Figure 3: Some examples of the Ganges fishes affected due to change in climate in this region (A-B) and alien fish species which are being found in the Ganges river basin (C-D).

al, 2006). Various simulation studies on extreme temperature over Gangetic basin show considerable seasonal and spatial variations due to warming with increasing numbers of warm nights/days as compared to cold ones (Cluis and Laberge, 2001).

Variety of pollutants arising out and getting transformed due to climate change and are causing danger to Gangetic ecosystem (Raha *et al,* 2012). Erosional features, salinity increase and more sedimentation in this river system are now prominent (Manna *et al*, 2013). Future changes in temperature and precipitation scheme in the Ganges river basin, may also increase the extreme events in the basin leading to more pollution load (Whitehead *et al*, 2015; Figure 2). Atmospheric nutrient loading in Ganges river basin is also big problems which also pollute the water along with anthropogenic pollution sources but model projections and scenario developments to estimate future effects are clearly lacking (Pandey *et al*, 2015). Distribution and transport of carbon, nitrogen, phosphorus and silicon in Ganges basin is linked to climatic aberrations and their interactions are complex (Singh *et al*., 2007). Arsenic and fluoride concentration and salinity increase in Ganges river basin in recent decades are also some important problems which have some linkages with changing temperature regimes of this basin (Raha *et al*., 2012). Since arsenic and fluoride is mainly derived from weathering which is directly affected by changes in pH, temperature and solubility product of chemical, the variation in climate would have interrelations with leaching of theses in water (Wetzel and Likens, 2000). It is predicted that the increase in temperature and decrease in precipitation can reduce groundwater recharge by 50%, raising salinity of soils and waters in catchments (Cañedo-Argüelles *et al*, 2013). Increased monsoon flow and flux also affect the concentration and dispersion pattern of metal pollutants in sediments of Ganges Rivers (Mittal *et al*, 2014; Figure 2). Most monsoonal discharge has also been notified to add the elevated levels of some radioactive elements such as Ba, Ra and Sr in Ganges river basin basically due to increased chemical weathering in Himalayas region and subsequent changes during transportation and deposition process which would be somewhere indirectly

linked with changing climate in this region (Singh *et al*, 2010).

Integrated effects of climate change and pollution on biodiversity of Ganges system

Under the influence of climate change, the organic matter and nutrients load in the river interact with many environmental factors changing the physiological properties of the water and thus affects its biota (Mittal *et al*, 2014). The Ganges river basin is witnessing the alteration in fish population dynamics, diversity and community structures for which climate change induced sedimentation and species invasion are thought to be the major cause (Sarkar *et al*, 2012). Invasion of alien fish species in the Ganga River is a threat which is related to changes in food chain and biotic communities which are the results of climate and pollution induces changes in the river (Singh *et al*, 2013; Figure 3). Downstream sediment transport by the river under increased flood conditions has caused much danger to fish biodiversity in this basin (Sarkar *et al.*, 2012). The increased temperature and related change in pollutant behaviour affect biodiversity spatial patterns in structure and distribution of benthic diatoms, macro invertebrates and ichthyofauna in Ganges (Nautiyal *et al*, 2013). An investigation reports 0.99°C increase in minimum water temperature in the upper stretch of river Ganges and 0-1.4°C increase in aquaculture waters of some Gangetic plains impacting breeding in native fishes and increasing the assemblages of non native fishes in polluted upstream (Das *et al,* 2013). The changes in thermal stratification in water columns may also impact the prey-predator relationship of this river causing manifold damages (Vass *et al*, 2009, Manna *et al*, 2013). An impact of climate change on breeding is evident in the advancement and extension of the breeding period of Indian major corps (Vass *et al*, 2009). Under the influence of climate change, a geographic shift of warm water fish species Glossogobius giuris and Xenentodon cancila (Figure 3) to the colder stretch of the river Ganga is a characteristic example. The predator prey ratio in the middle stretch in the river Ganga has also declined in the last three decades. The shift in minimum air temperature coupled with increase in post monsoonal rainfall is clearly evident in this basin which has impacted the warm water fish migration and spawning in great deal (Sinha and Khan, 2001).

Ganges River biodiversity facing threats due to rise in water. Temperatures and temperature is an important influencing factor controlling the occurrence of different phytoplankton (Singh, 1993). Variability in pre and post monsoonal flow has been an important factor to assess the pollution variance in these river systems. Several water quality parameters such as turbidity, transparency, DO, pH, free CO2, specific conductivity, salinity, hardness, silicate silica remarkably affect the distribution of biotic communities and are related with the change in the climate of the region (Mall *et al*, 2006). Furthermore, the impact of increasing water temperature and their role in augmenting the pollutant behaviour and their effects on flagship animals of Ganges such as ghariyal, dolphin and turtles are still not established which warrants serious scientific studies. Apart from these studies on the impact of temperature induced changes on the ecology and behaviour of bacteriophages in this river system is also needed. This requires elaborative studies to identify different groups of phages and their role in microbial pollution abatement and the changes under climatic variables and pollutants.

Future approach

Pollution problems in river Ganges are now being viewed with broader aspects and with various dimensions of the climate change. However, there is a huge need to establish various interactive experimental evidences by intriguing climate variables and pollutant interactions to understand pollutant dispersion and transformation and their effects in water, sediments and biota. In view of these facts the river basin management authority should acquire adequate baseline information on water flows and related water quality disturbances interacting with climate change to develop comprehensive scenarios of the likely impacts of climate change in this river basin. Strong management actions should be employed to restore the ecosystem functioning of Ganges River in conjugation with scientific research outputs establishing climate interactions with pollutions. To reduce the

effects of climate change and related pollution problems, making augment water availability in the basin by rainwater collection, water conservation and water abstraction affected optimum flow determination in various segments of the Ganges river is urgently needed.

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- ❖ फ्लू गैस की मॉनिटरिंग CEMS तकनीक द्वारा की जाती है।
- ❖ फ्लाई ऐश का उपयोग ऐश ब्रिक्स बनाने में किया जाता है, जिससे भवन निर्माण कार्य हो रहा है।
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Fax : **05446 – 278596, 277164**
e-mail : **hindalco.rsg.@adityabirla.com**
GRAM : **Renupower- Renukoot**

U.P.Forest Corporation

Uttar Pradesh Forest Corporation, headquartered at Lucknow, was conceived as an agent of change in the field of Forest Management. Main purpose was to eliminate the forest contractors and play an important role in forest devolepment. Corporation fulfilled its duties faithfully and introduced scientific extraction of forest produce as per the specified management principles laid down in the Working Plans.

Mechanised Logging Operation

Timber Sale Depot. Kursi Road, Lucknow

CORPORATION VISION

- We aspire to establish U.P. Forest Corporation as the most efficient, innovative and citizen friendly organization in the country for preservation, supervision and development of Forests as well as for providing value added forest produce to common man.
- We aim to use cutting edge modern techniques in human resource management, communication, production and marketing of Forest produce in an efficient and transparent way.

To keep pace with the modern technique and making the system transparent, corporation has started E-Auction of Timber,Tendupatta,Bamboo & medicinal herbs etc successfully.

Uttar Pradesh possesses the highest number of Sarus Crane in the world.

HELP PROTECT AND HAND OVER THIS BEAUTIFUL STATE BIRD TO OUR NEXT GENERATIONS.

SARUS PROTECTION SOCIETY

CHIEF WILDLIFE WARDEN, U.P.

17, Rana Pratap Marg, Lucknow

Telephone: 0522-2206584

Website: sarusprotectionsociety.org

Grasim Industries Limited

ADITYA BIRLA
GRASIM

INTERTEK OHSAS 18001:2007 | INTERTEK ISO 9001:2008 | INTERTEK ISO 14001:2004

We manufacture chemicals

Chemicals

- **Caustic Soda (Lye & Flakes)**
- **Liquid Chlorine**
- **Hydrochloric Acid (30%)**
- **Stable Bleaching Powder**
- **Aluminium Chloride**
- **Poly Aluminium Chloride**
- **Chlorinated Paraffin**
- **Hydrogen Gas**
- **Nitrogen Gas**

and power is our lifeline

- **In an eco-friendly way we utilize coal for generating 50 MW.**

Chemical Division Renukoot

P.O. Renukoot, Distt.Sonbhadra,
Uttar Pradesh – 231 217
Tel : +91 5446-252044,252055,252075
Fax :+91 5446-252088
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Registered Office

Birlagram, Nagda
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