Biodiversity Impact Assessment and Management Plan

Safeguard Policies for Biodiversity

With

Biodiversity Checklist, Management and Monitoring Plan

BIA/ MP for BRO – Nampong to Vijaynagar Roads, Arunachal Pradesh State

BRO: Border Road Organization, July – 2019

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ABBREVIATIONS AND ACRONYMS

AADT	Annual Average Daily Traffic	**MOEF**	Ministry of Environment and Forests
AC	Asphaltic Concrete	**MORT & H**	Ministry of Road Transport & Highways
ADT	Average Daily Traffic	**BRO**	**Border Road Organisation**
BBD	Benkelman Beam Deflection	**MSA**	Million Standard Axles
BC	Bituminous Concrete	**MSL**	Mean Sea Level
BM	Bituminous Macadam	**NH**	National Highway
BOT	Build Operate Transfer	**NPV**	Net Present Value
BSNL	Bharat Sanchar Nigam Limited	**NSDP**	Net State Domestic Product
BT	Bituminous Track	**NTPC**	National Thermal Power Corporation
CBR	California Bearing Ratio	**O & M**	Operation & Maintenance
CD	Cross Drainage	**O – D**	Origin Destination
CGWB	Central Ground Water Board	**OFC**	Optical Fiber Cable
CMSA	Cumulative Million Standard Axles	**OMC**	Optimum Moisture Content
COI	Corridor of Impact	**PCC**	Plain Cement Concrete
CRRI	Central Road Research Institute (India)	**PCU**	Passenger Car Unit
CVPD	Commercial Vehicle Per Day	**PIU**	Project Implementation Unit
DBFOT	Design, Build, Finance, Operate & Transfer	**PPM**	Parts Per Million
DBM	Dense Bituminous Macadam	**PPP**	Public Private Partnership
DLC	Dry Lean Concrete	**PPR**	Preliminary Project Report
DTM	Digital Terrain Model	**PQ**	Pre – Qualification
EA	Environmental Assessment	**PQC**	Pavement Quality Control
EASL	Equivalent Standard Axle Load	**PWD**	Public Works Department
EIA	Environment Impact Assessment	**QAP**	Quality Assurance Plan
EIRR	Economic Internal Rate of Return	**QC**	Quality Control
FFR	Final Feasibility Report	**R & R**	Resettlement and Rehabilitation
FIRR	Financial Internal Rate of Return	**RAP**	Resettlement Action Plans
GAD	General Arrangement Drawing	**RCC**	Reinforced Cement Concrete
GDP	Gross Domestic Product	**RHS**	Right Hand Side
GOI	Government of India	**RL**	Reduced Level
GPS	Global Positioning System	**ROB/ RUB**	Road Over Bridge/ Road Under Bridge
GSB	Granular Sub – Base	**ROW**	Right of Way
GTS	Geodetic Triangulation Survey	**Rs.**	Rupees
Ha	Hectare	**SH**	State Highway
HDM – 4	Highway Design & Maintenance Model (Series – 4)	**SIA**	Social Impact Assessment
HDMQ	Highway Design and Maintenance Model with Congestion Analysis	**Sq. Km.**	Square Kilometer
HFL	High Flood Level	**TBM**	Temporary Bench Mark
IRC	Indian Road Congress	**Temp**	Temperature
IRR	Internal Rate of Return	**TOR**	Terms of Reference
Km	Kilometre	**TRL**	Transportation Research Laboratory
KMPH	Kilometre Per Hour	**UG**	Under Ground
LA	Land Acquisition	**VDF**	Vehicles Damage Factor
LT/ HT	Low Tension/ High Tension Electric Lines	**Veh.**	Vehicles
m	Meter	**VGF**	Viability Gap Funding
MDR	Major District Road	**WB**	World Bank
mm	Millimetre	**WBM**	Water Bound Macadam
Dia.	Diameter	**WMM**	Wet Mix Macadam
EPC	Engineering, Procurement, and Construction	**PPE**	Personal Protective Equipment
PPR	Peste – des Petits Ruminants	**GAD**	General Administration Department
LMI	Labour Market Information	**MSE**	Mean Squared Error
SARA	Saturates, Aromatics, Resins and Asphaltenes	**ACZ**	Agro – Climatic Zone
PET	Poly – Ethylene Tere – phthalate	**SEDP**	Sustainable Environmental Development
FRC	Fibre Reinforced Concrete	**PCM**	Public Consultation Method
PCM	Public Consultation Meeting	**FGD**	Focus Group Discussion
UTC	Universal Time Coordinated	**GPS**	Global Positioning System
DEM	Digital Elevation Model	**DTM**	Digital Terrain Model
FCW	Flush Cause Way	**CRRI**	Central Road Research Institute
CVPD	Commercial Vehicles Per Day	**ATTC**	Advanced Technical Training Centre
CCCT	Centre for Computers and Communication	**CRPF**	Central Reserve Police Force
NWL	Normal Water Level	**TAR**	Tibet Autonomous Region
CCP	CIVIL CONSTRUCTION PRACTICES	**NSSDA**	National Standard for Spatial Data Accuracy
GSD	Ground Sample Distance	**DGPS**	Differential Global Positioning System
NRSC	National Remote Sensing Centre	**GIS**	Geographical Information System
DEM	Digital Elevation Model	**RL**	Reduced Level

CHAPTER – 1: BIODIVERSITY IMPACT ASSESSMENT AND MANAGEMENT PLAN FOR ARUNACHAL PRADESH STATE

1. INTRODUCTION AND BACKGROUND OF THE PROJECT

"Arunachal Pradesh" is one of the 29 States of India. Located in North – East India it holds the most North – Eastern position among the other states in the North – East region of India. Arunachal Pradesh borders the states of Assam and Nagaland to the South, and shares international borders with Bhutan in the West, Burma in the East and China in the North. Itanagar is the capital of the state and Arunachal Pradesh is also known as the ***"Orchid State of India"*** or the ***"Paradise of the Botanists"***. Geographically, it is the largest among the North – East Indian states commonly known as the ***"Seven – Sister States"***. As in other parts of Northeast India, the people native to the state trace their origins from the Tibeto – Burman people. In recent times, large number of migrants from various parts of India and foreign lands has been affecting the state's population. In spite of being the second smallest as well as the least populated state of India, Arunachal Pradesh is a heaven for nature lovers, aspirators and inventors. Itanagar is the capital as well as the largest city of Arunachal Pradesh and is located at the height of 5,500 feet on the hills of Shivalik. The beautiful Kanchenjunga, which is the third tallest mountain of the world, can be viewed from Itanagar. The total area of Arunachal Pradesh is roughly 7,000 Square Kilometers with a total population of more than 6 lakhs.

"Arunachal Pradesh is a Land – Locked Indian State in the Himalayan Mountains". The state is bordered by Nepal to the West, China's Tibet Autonomous Region to the North and East, and Bhutan to the East. The Indian state of West Bengal lies to the South. With 6,07,688 inhabitants as of the 2011 census Arunachal Pradesh is the least populous state in India and the second – smallest state after Goa in total area, covering approximately 7,096 Km^2 (2,740 Square Mile). Arunachal Pradesh is nonetheless geographically diverse due to its location in the Himalayas; the climate ranges from subtropical to high alpine, and Kangchenjunga, the world's third – highest peak, is located on Arunachal Pradesh's border with Nepal. Arunachal Pradesh is a popular tourist destination, owing to its culture, scenery and biodiversity. It also has the only open land border between India and China. Arunachal Pradesh's capital and largest city is Itanagar. The consultancy services for carrying out preparation of **"BIODIVERSITY IMPACT ASSESSMENT AND MANAGEMENT PLAN"**/ Detailed Project Report (DPR) and bid documents to **"M/s L. N. Malviya Infra Projects Pvt. Ltd. Bhopal (MP)"**, for Survey, Investigation and Preparation of Detailed Project Report for improvement of Road and Bridges etc. for construction of High Altitude Hill Roads to Border Road Organization under Phase – I in the state of Arunachal Pradesh using **"Satellite Imagery"** and **"Geographical Information System" (GIS)**. The report brings out the project background, mobilization and staffing, approach and methodology relating to surveys/ investigations and detailed design. A broad conceptualization of the project essentially based on study of available data/ reports and a detailed reconnaissance survey has been provided. The report also makes proposals on issues requiring discussions with the **"Border Road Organisation" (BRO) by Ministry of Home Affairs, Department of Border Management, Government of India"** and decisions necessary for detailing of the project. **"Border Road Organisation (BRO)"** – **"PROJECT – UDAYAK"** in state of Arunachal Pradesh has been entrusted Technical Consultant for preparation of Feasibility Study (FS), Detailed Project Report (DPR) and Providing Pre – Construction Services for construction of **"Nampong to Vijaynagar Road from 30.000 Km to 213.000 Km (Approximately Length 183 Km)"** to NHDL specifications under **"752 – BRTF"** of **"PROJECT – UDAYAK"** in Arunachal Pradesh State. **"The Project Assignment/ Task for Letter No. LNM/ BRO/ UDAYAK/ 80955/ 160/ E8/ Dated – 17th July, 2018"**.

The report covers the following major aspects and prospects are as discussed below one by one:

- ***(i)*** *Project Background;*
- ***(ii)*** *Mobilization and Progress;*
- ***(iii)*** *Project Appreciation and Conceptualization;*
- ***(iv)*** *Proposed Approach and Methodology;*

Figure 1 (a): Arunachal Pradesh' Ethnicity and Cumulative Impact Assessment (CIA) Supporting Biodiversity along with Wealthy and Rich Varieties.

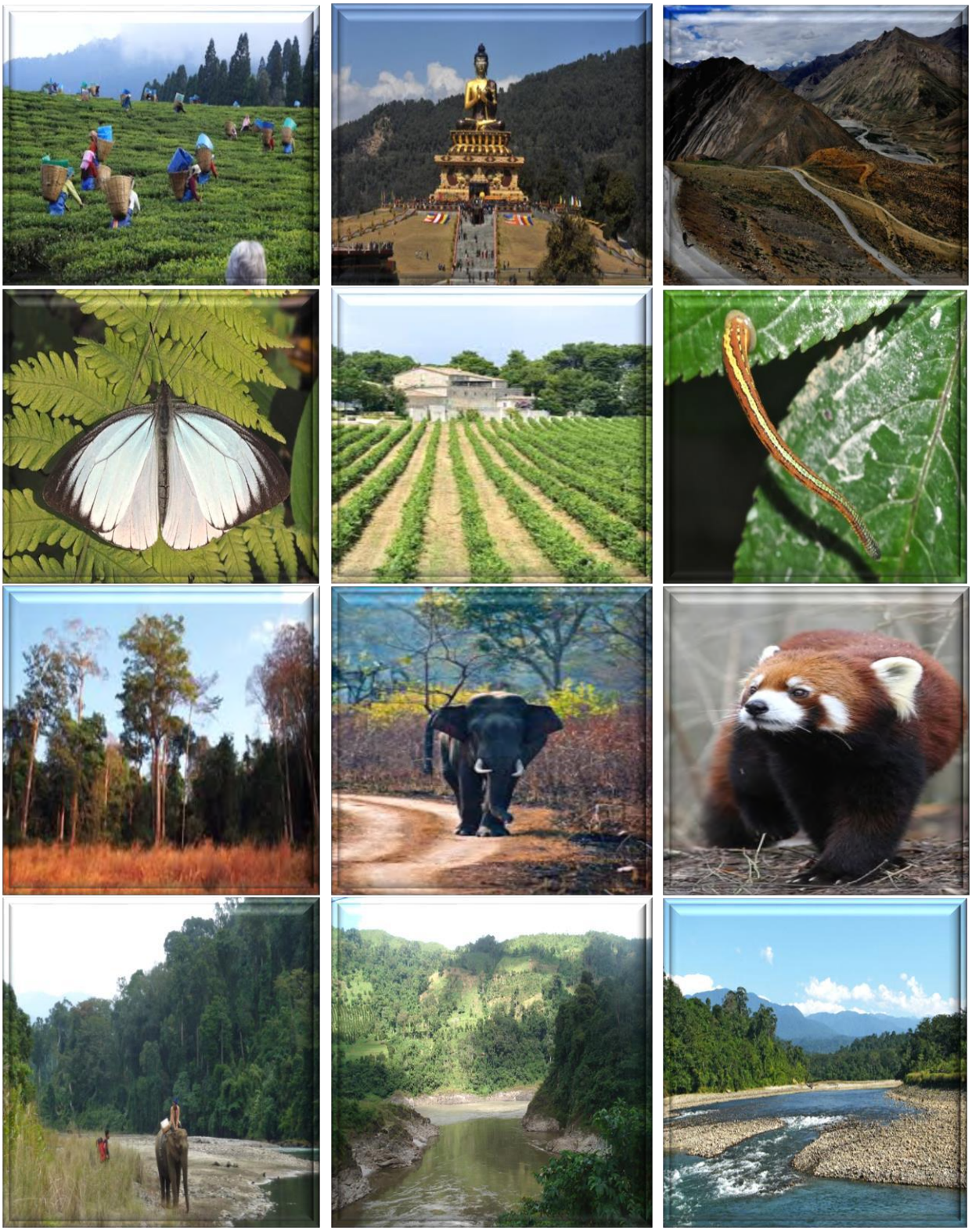


Figure 1 (b): Arunachal Pradesh' Civilization and Cumulative Impact Assessment (CIA) Supporting Biodiversity along with Wealthy and Rich Varieties.

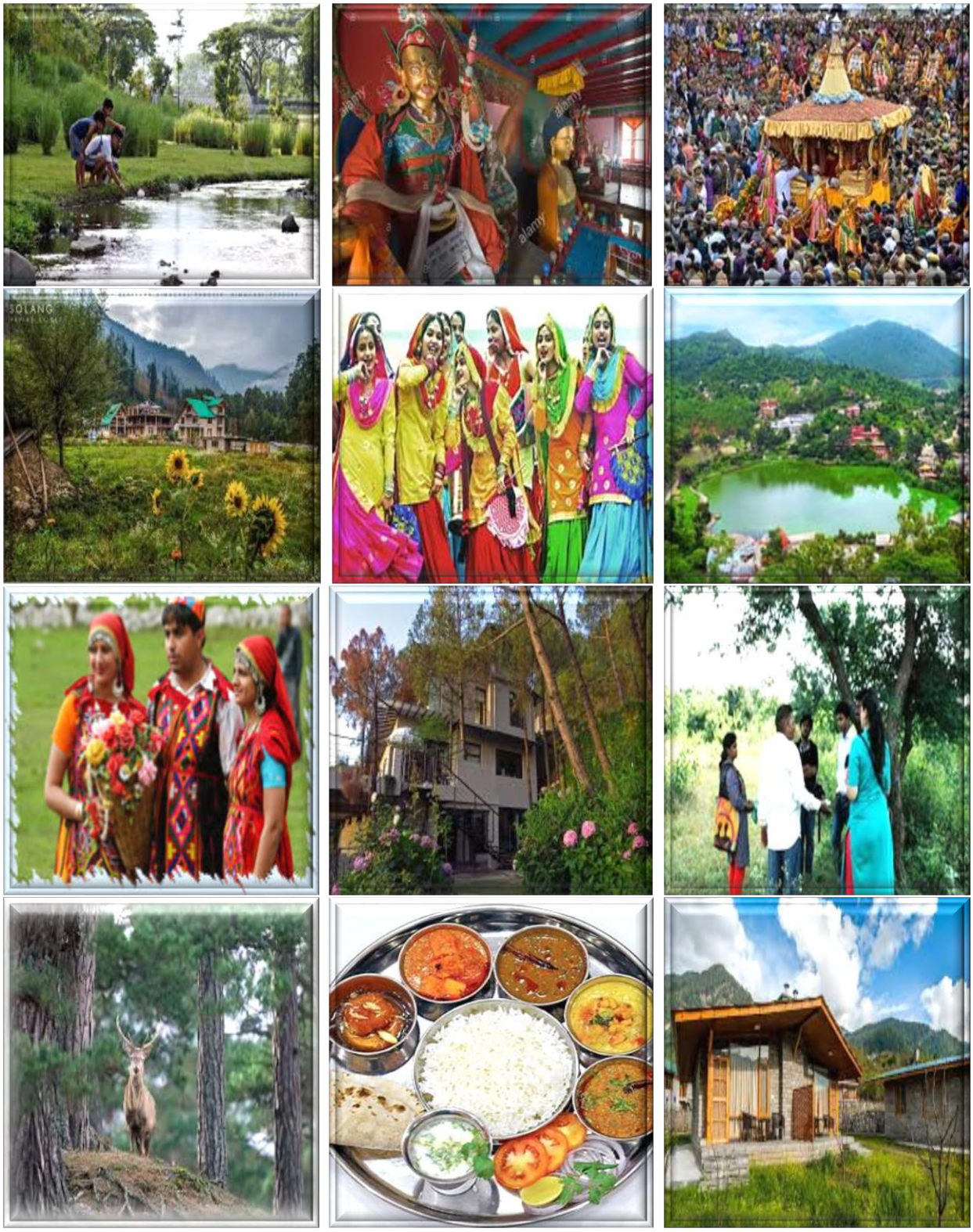


Figure 1 (c): Arunachal Pradesh' Food Culture and Cumulative Impact Assessment (CIA) Supporting Biodiversity along with Wealthy and Rich Varieties.

Socio – Economic Profile Index

The **"Economy of Arunachal Pradesh"** is mainly based on agricultural and animal husbandry. Approximately 11% of the total geographical area is under agriculture and agriculture is of the mixed type, which is still at the subsistence level rather than commercial level. The work force participation rate as per 1991 census is 40.44%. The female participation rate in Arunachal Pradesh is also much higher than the national average. This is an important aspect if the hill economy, as productivity is low and hence all the able – bodied people are employed in agriculture and other activities. Cultivators account for the greater majority of the people in the state and their percentage is 57.84%. Agricultural labourers as a whole constitute only 7.81% of the workers in the state. Households and other industries are negligible, but other worker (Tertiary Sector) at the state level represents a good percentage of population. The decreasing ratio of worker at the state level indicates the low level of economic diversification. The importance of agriculture can be judged by the high percentage of population approximately 65% engaged in it. Animal husbandry is an integral part of the house hold economy of the region and there are certain house hold industries also, which substantially adds to house hold incomes. The past one and half decade has witnessed a tremendous upward swing in various development programs giving a new thrust to the Arunachal Pradesh economy and **Arunachal Pradesh' Ethnicity, Civilization, Food Culture and Cumulative Impact Assessment (CIA) Supporting Biodiversity along with Wealthy and Rich Varieties** as shown above in the **Figures 1 (a)** to **(c)**.

The **"Projected Road"** is located in the district of **"East Siang"** and "**Upper Siang",** which in turn is located in the State of Arunachal Pradesh a **"Land of Seven Sisters"**. Population of Arunachal Pradesh is predominantly tribal; the main tribes include the Adi, Nyishi Apatani, Bugun, Galo, Hrusso, Koro, Meyor, Monpa and Tagin. Broadly the people divided into **"Three Cultural Groups"** on the basis of their socio – religious affinities. The **"First Group"** consists of the Monpas and Sherdukpens of Tawangand West Kameng Districts following the lama tradition of Mahayana Buddhism. The **"Second Group"** includes the Adis, Akas, Apatanis, Bangnis, Nishis, Mishmis, Mijis, Thongsas etc., who worship **Sun"** and **"Moon Gods"**. Their religious rituals largely coincide with phases of agricultural cycles. The **"Third Group"** comprises Noctes and Wanchos adjoining Nagaland in the Tirap District. These are hardy people known for their strictly structured village society in which hereditary system of village chief still has a vital role. The Noctes also practice elementary form of Vaishnavism. About 64% of the population is tribal and Arunachal Pradesh has the lowest average population density in India, at 17 per Square Kilometers. Papum Pare has highest population density, at 51 per Square Kilometers.

"Dibang Valley" has lowest density at, 1 per Square Kilometers and the preponderance of the population lives in the rural areas about 55% of Arunachal Pradesh population fall in the working age group. Another 40% fall in the 0 – 14 year age group and is expected to join the workforce in the coming 10 years. About 36% of Arunachal Pradesh working population is concentrated in Lohit, Papum Pare and Changlang Districts. **"Upper Siang"** has 3% population in the working age group. In 2001, Arunachal Pradesh had a total of 482,902 workers, of which 57.8% are cultivators as evaluated to national level aggregate of 31.7%. There were 37% other workers in Arunachal Pradesh. The category of **"Other Workers"** included government employees, teachers, factory and plantation workers, those occupied and busy in trade, commerce, business, transport, banking, mining, construction, political or social work, priests, entertainment artists, etc. Practically 35% of the main workers are concentrated in Changlang, Tirap and Lohit. **"Tawang"** and **"Upper Siang Districts"** have over 50% of total population as the operational and working population. ***"Ascertain and Discover" Everything a traveler should know about the "Hornbills" in "Sarawak", and why the state is also known as the "Land of Hornbills"***. Assam – 5,620 **"Karbi Anglong"** and **"Mora Dhansiri River"** area of Assam including **"Kaziranga National Park"** is home to largest number of wild elephants. The popular **"Elephant Festival"** is organizes in **"Kaziranga"** for the purpose of elephants conservation, largest elephant festivals in India. About 44% of the total population in Arunachal is working population and this process has increased wage employment opportunities and though most of the inhabitants are basically agriculture, they have diversified into tertiary jobs such as Government Services. The **Figure 2** is Showing the Index Map of Projected Road and **"Start/ End Point"** of **"Nampong to Vijaynagar Road"** near Changlai Village in **Figures 3 (a)** and **(b)**.

Figure 2: Index Map Showing Nampong to Vijaynagar Projected Road.

Start Point

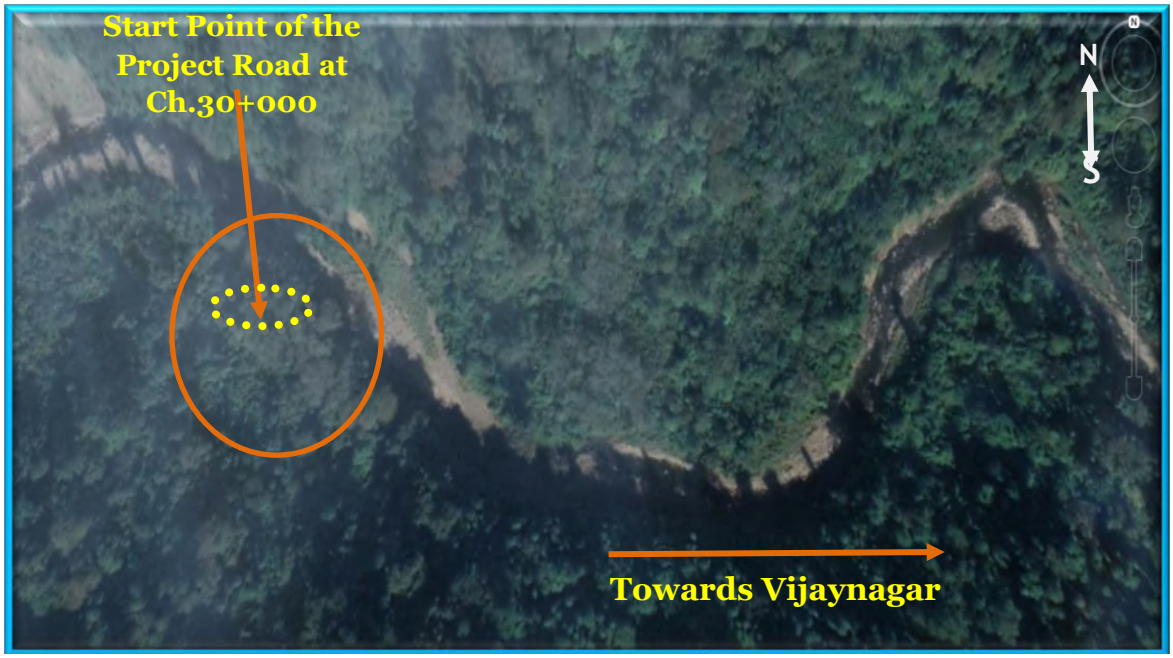


Figure 3 (a): Start Point near Changlai Village Chainage: 30+000 Km.

End Point

Figure 3 (b): End Point at Vijay Nagar Chainage: 213+000 Km.

Administrative Categorization and Draft Profile

The Department of **"Administrative Reforms"** is the coordinating agency of the **"Government of Arunachal Pradesh"** in the matters related to public grievances, reforms in administrations, framing of recruitment rules, career development, staff welfare, process re – engineering,

re – organizing and restructure of departments. The department is also concerned with the process of responsive people oriented modern administration. Allocation of business rules defines the work allotted for the department. Following are the work allocation as per business allocation rules and all policy matters relating to recruitment, promotions, service conditions, prescription of educational qualifications etc.

- *Preparation/ Revision of office Manuals;*
- *Devising new methods and procedures for improvement in the standard of administration;*
- *Studies in specific aspects of administration;*
- *Work studies for assessing requirement of staff in various departments;*
- *Quality control in offices;*
- *Clearance of proposals for environmental laws; rules and regulations (including biodiversity);*
- *Re – organization of departments/ office;*
- *Checks on delays;*
- *Chief Secretaries conferences;*
- *Secretaries meetings;*
- *Matters relating to office Inspection;*
- *Clearance of RRs/ Service Rules of all Departments and issue of general instructions on the subject;*
- *Collection and scrutiny of Monthly arrear statements;*
- *All matters relating to Public Service Commission (PSC);*
- *Matters relating to reservation in service inspect of SC/ ST;*
- *Matters relating to public grievances;*

"Arunachal Pradesh" is not a linguistic state and it is an ethnic state inhabited by colourful tribal people of diverse culture and lifestyle. All of them have their own unique culture and traditions. They also have customary laws and a time tested dispute resolution mechanism. The disputes in tribal societies are resolved by a system of administration of justice founded on customs and customary laws of each tribe by the **"Village Council"**. **"Administratively",** the State is divided into **"Seventeen Districts"** and Capital of the State is **"Itanagar"** in **"Papum Pare District"**. Itanagar is named after it a **"Fort"** meaning **"Fort of Bricks",** built in 14th century AD. ***"It is most gratifying to remember that the inhabitants of this tribal state have the spirit of democracy inherent in their traditional laws, which further strengthen by the five fundamental principles for "Administration" of "Tribal Areas"***.

Pandit Jawaharlal Nehru Amongst People in Arunachal Pradesh

There were unwritten rules for administration of tribal villages. However, the customs and traditions were almost compatible with the modern concepts of jurisprudence. The tribal councils in **"North East Frontier Agency" (NEFA)** were functioning on the lines of the system evolved for parliamentary democracy, which is in vogue now days. This is well illustrated in the utterances of the leaders of the councils Kebang/ Buliang/ Mela/ Abela of different communities in their traditional speeches, which they recite at the beginning of their meeting. ***"Villagers and brethren, let us strengthen our custom and our council, let us improve our relations, let us make the laws straight and equal for all, let our laws be uniform, let our customs be the same for all, let us be guided by the reason and see that justice is done and the compromise reached that is acceptable to both parties. We have come together for a council meeting and let us speak in one voice and decide our verdict…!!!"***. The council derived their authority from the expression of the will and power of the people. They had the support of both social and supernatural. Thus, the concept of parliamentary democracy is not new to the **"Tribal Society"**.

POLITICAL PROGRESSION

The history of the growth of political process in **"Arunachal Pradesh"** dates back to 1875 when the British – India Government started to define the administrative jurisdiction by drawing an **"Inner Line" (IL)** in relation to the frontier tribes inhabiting the **"North Frontier Tract" (NFT),** the area was kept outside the purview of regular laws of the country. Thereafter, the British followed the policy of gradual penetration to bring more areas under normal administration. By the year 1946, the **"North East Frontier Tracts" (NEFT)** were reorganized into four Frontier Tracts namely Sadiya, Lakhimpur, Tirap and Sela Sub Agency and Subansiri area and administrated by the Governor of Assam in his discretion. By virtue of the Indian Independence Act 1947, the Government of Assam assumed administrative jurisdiction over North East Frontier Tracts and the Governor of Assam was divested of his discretionary powers. The Government of Assam administered the North East Frontier Tracts during the period 15th August, 1947 to 26th January, 1950. After independence, a sub – committee headed by Gopinath Bordoloi was appointed by the Constituent Assembly of India to recommend the future pattern of administration of the **"North Eastern Frontier Areas" (NEFA)**. The Bordoloi Committee recommended that since the administration has been satisfactorily established over a sufficiently wide area, the Government of Assam should take over that area by the strength of a notification.

However, for various considerations, particularly problem of communication and defiance, Government of India decided to administer North East Frontier Tracts as **"Excluded Area"** through Governor of Assam as an agent to the President of India. In the year 1950, the plain portions of these tracts namely, **"Balipara Frontier Tract" (BFT), "Tirap Frontier Tract", "Abor Hill District"** and **"Mishimi Hills Districts"** were transferred to the Government of Assam. In 1951, the units of the tracts were reconstituted again and Tuensang Frontier Division was created which later merged with Nagaland. The remaining portion of the Tracts after the introduction of the **"North East Frontier" (Administration) Regulation, 1954** was designated as the **"North East Frontier Agency" (NEFA)**. Thereafter, the administration was brought under the Ministry of External Affairs and in August 1965, it was brought under the supervision and control of the Ministry of Home Affairs. It remained so, until the attainment of Union Territory status by **"Arunachal Pradesh"** in 1972.

It was only in 1975 that the virtue of the enactment of **"37th Constitutional Amendment Act 1975"** that the Pradesh Council was constituted as a separate Legislative Assembly and Lt. Governor was appointed as the head of the **"Union Territory"** of **"Arunachal Pradesh"**. The Pradesh Council became provisional Legislative Assembly having 23 members during 1975 to 1978. The first elected **"Legislative Assembly" (LA)** consisting of 33 members (30 elected members and 3 nominated

members) was formed on 4th March 1978, which lasted only for about 20 months. In November 1979, the Assembly was dissolved and President's Rule was imposed which continued till January 1980.

The Second General Election was held in January, 1980. The Third General Election for Legislative Assembly was held simultaneously with the **"General Election" (GE)** for the **"Eighth Lok Sabha"** in December, 1984 and the Assembly was constituted in January, 1986. There is one MP in the Rajya Sabha and two MPs in the Lok Sabha represent at the Union Government by people of Arunachal Pradesh. Arunachal Pradesh became full – fledged State with effect from 20th February, 1987. On the persistent demand of the people of the State, the total membership in the Legislative Assembly was raised to sixty during the General Election in 1990, and the First Legislative assembly of the State was constituted.

Physiographic Index

Arunachal Pradesh is the second – smallest Indian state and is geographically located at **"Latitude 28°57'52" N and Longitude 91°50'57" E"**. Landlocked in the Himalayan range, the state is bordered by Tibet on its North – East, Nepal on its west, Bhutan on its South – East and West Bengal on its South. The residents of Arunachal Pradesh experience two kinds of climate. The Northern part of the state experiences tundra type of climate, whereas, the Southern part observes sub – tropical climatic conditions. Because of the tundra type of climate, the Northern part of the state remains covered with snow for almost 4 months in a year, when the night temperature goes below the level of 0°C. The weather condition of the state is mainly divided into 5 seasons, which are depicted below:

- *Spring;*
- *Summer;*
- *Autumn;*
- *Monsoon;*
- *Winter.*

Arunachal Pradesh is subdivided into following units as Noteworthy and Remarkable Facts on Arunachal Pradesh State are shown in the **Table 1** with worth mentioning and incredible Index of Arunachal Pradesh State.

Table 1: Noteworthy and Remarkable Facts on Arunachal Pradesh State.

Facts on Arunachal Pradesh State	
Official Website	***www.arunachalpradesh.gov.in/***
Date of Formation	*Arunachal Pradesh was established as a state in 20th February, 1987 and was known as the **North East Frontier Agency (NEFA)** during British India and the Republic of India until 1972.*
Area	*83,743 Km²*
Density	*17 People/ Km²*
Total Population (2012)	*12.60 Lakhs OR 1,383,727 Approximately.*
Males Population (2011)	*713,912*
Females Population (2011)	*669,815*
Number of District	*29*
Capital	*Itanagar*

Rivers	*Brahmaputra, Lohit, Yarlung, Dibang, Kameng, Subansiri, Tirap and Dihing etc.*
Forests and National Park	*Around 5 national parks in Arunachal Pradesh. Namdapha National Park. Photo (cropped) by Travelling Slacker, Mouling National Park. Kane Wildlife Sanctuary. Mehao Wildlife Sanctuary. Daying Erring Memorial Wildlife Sanctuary etc.*
Languages	*Nyishi (208,337), Adi (193,379), Bengali (97,149), Nepali (94,919), Hindi (81,186), Monpa (55,428), Assamese (51,551), Wancho (48,544), Tangsa (34,231), Mishmi (33,522), Mishing (33,381), Nocte (32,591), and Others (64,711).*
Neighbours State	*Assam and Nagaland to the South and shares international borders with Bhutan in the West, Myanmar in the East and is separated from China in the North by the McMahon Line.*
State Animal	*Gayal (Official Animal) – Mithun – Bos Frontalis.*
State Bird	*Great Hornbill (Official Bird).*
State Tree	*Dipterocarpus Macrocarpus (Official Tree).*
State Flower	*Rhynchostylis Retusa (Official Flower); Orchidaceae is in the Major Group Angiosperms (Flowering Plants).*
Net State Domestic Product (2011)	*16,761*
Literacy Rate (2011)	*66.95%*
Females per 1,000 Males	*890*
Assembly Constituency	*30*
Parliamentary Constituency	*1 (This Constituency Covers the Entire Upper Siang, East Siang, Dibang Valley, Lower Dibang Valley, Lohit, Anjaw, Changlang and Tirap Districts).*

"ARUNACHAL PRADESH": It is situated in the North – Eastern part of India is 83,743 Square Kilometer in area and has long international border with Bhutan to the West (160 Km), China to the North and North – East (1,080 Km) and Myanmar to the East (440 Km). It stretches from snow – capped mountains in the North to the plains of Brahmaputra valley in the South. Arunachal is the largest state area wise in the North – Eastern region, even larger than Assam which is the most populous. It is a land of lush green forests, deep river valleys and beautiful plateaus. The land is mostly mountainous with Himalayan ranges along the Northern borders criss – crossed with mountain ranges running North – South. *"These divide the State into **"Five River Valleys":** the **"Kameng"**, the **"Subansiri"**, the **"Siang"**, the **"Lohit"** and the **"Tirap"**. All these rivers are fed by snows from the Himalayas and countless rivers and rivulets except Tirap which is fed by Patkai Range"*.

The mightiest of these rivers is **"Siang"**, called **"Tsangpo"** in **"Tibet"**, which becomes Brahmaputra after it is joined by the **"Dibang"** and the **"Lohit"** in the plains of **"Assam"**. High mountains and dense forests have prevented intercommunication between tribes living in different river valleys. Isolation imposed by geography has led different tribes with several dialects to live and flourish with their distinct identities. Nature has endowed the people with a deep sense of beauty which finds delightful expression in their songs, dances and crafts. The climate varies from hot and humid in the **"Shivalik Range"** with heavy rainfall. It becomes progressively cold as one move North wards to higher altitudes. Trees of great size, plentiful climbers and abundance of cane and bamboo make Arunachal evergreen. Tropical rain forests are to be found in the foothills and the hills in the East on the border with Myanmar. Northern most borders are covered with **"Alpine Forests"** and amidst the highly rugged terrain; there are green forests and plateaus.

Arunachal Pradesh is located between **26.28° N and 29.30° N Latitude** and **91.20° E and 97.30° E Longitude** and has an area of 83,743 Km^2 (32,333 Sq Mi). The topography rapidly rises to 7,000 m at its highest peak. Kangte, Nyegi Kangsang, the main Gorichen peak, and the Eastern Gorichen peak are some of the highest peaks in this region of the Himalayas. ***"Numerous river valleys dissect***

the precipitous terrain of Arunachal and some of the major rivers are Kameng, Subansiri, Siang, Dibang, Lohit and Noa – Dihing Rivers. Mountains until the Siang River are classified under the Eastern Himalayas mountain range". Between the Siang River and the Noa – Dihing River is classified as the Mishmi Hills that may be part of the Hengduan Shan, but the true extents of these mountains is unclear. South of the Noa – Dihing in Tirap and Longding districts, these mountains are part of the Patkai Range. The rivers are fed by an immense abundance of forest cover that absorbs moisture and transfers it to subsurface flows. Summer melt water from snow caps also contributes to the volume of water. Either or both Dong Basti and Vijaynagar basti in Arunachal Pradesh receives the first morning sun rays in the entire country, as the easternmost village of the country. The mountain ranges in Arunachal Pradesh are described as **"The Place Where Sun Rises"** in historical Indian texts and named the Aruna Mountains.

"EVOLUTION": Arunachal Pradesh became a full – fledged State on February 20th, 1987. Till 1972, it was known as the **"North – East Frontier Agency" (NEFA)**. It gained the Union Territory status on January 20th, 1972 and renamed as Arunachal Pradesh. On August 15th, 1975 an elected Legislative Assembly was constituted and the first Council of Ministers assumed office. The first general election to the Assembly was held in February 1978. Administratively, the State is divided into sixteen districts. Capital of the State is Itanagar in Papum Pare district. Itanagar is named after it a fort meaning fort of bricks, built in 14th Century AD. Arunachal Pradesh finds mention in the literature of **"Kalika Purana"** and **"Mahabharata"**. This place is the Prabhu Mountains of the Puranas. It was here that sage Parashuram atoned of his sin, sage Vyasa meditated, King Bhismaka founded his kingdom and **"Lord Krishna"** married his consort **"Rukmini"**. The widely scattered archaeological remains at different places in Arunachal Pradesh bear testimony to its cultural heritage.

Important Places of Interest

"BHISMAKNAGAR", in Dibang Valley was once a stronghold of Chutiyas (12th to 16th Century AD). Excavations of ruins of ancient fort have revealed the high standard of civilization that once prevailed there.

"MALINITHAN", near Likabali in West Siang district is a site of rich granite Sculptures belonging to 14th to 15th Century AD, the more important being Indra on Airavata, Surya on Chariot and the huge Nandi Bull. The temple dedicated to **"Goddess Durga"** at **"Malinithan"** is built on the classical tradition of Orissa. According to the local legend associated with the place, **"Lord Krishna"** carried away **"Rukmini"** the daughter of **"King Bhismaka"** on the eve of her marriage with Shishupal. **"Krishna"** and **"Rukmini"** were welcomed here by **"Parvati"** with garlands. Parvati thus acquired the name malini and the place **"Malinithan"**.

"PARASHURAM KUND", in the lower reaches of Lohit River is the legendary place where **"Sage Parashuram"** atoned of his sins. It is a place of pilgrimage and on **"Makara Sankranti"** day people in large numbers come to have a **"Holy Dip"** in the **"Kund"**.

Waterfalls

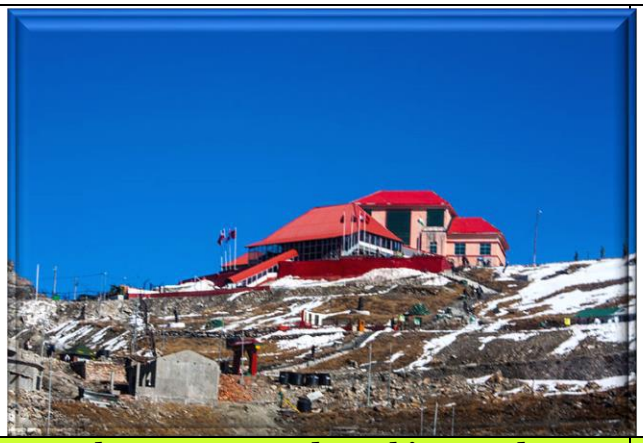
Arunachal Pradesh is primarily a land of sky scraping mountains and hills. The lush green vegetation on the mountain sides presents an **"Eye – Soothing View"** and this sight is made more panoramic by the waterfalls in Arunachal Pradesh. Mostly perennial in nature, waterfalls abound in Arunachal Pradesh, especially in the Northern region. The Dzongu area and the road between Lachung and Mangan are blessed with the maximum numbers of waterfalls in Arunachal Pradesh State. Most of the waterfalls of Arunachal Pradesh are snow fed and ultimately meets either Teesta or Rangeet River. The local inhabitants of Arunachal Pradesh consider some of the waterfalls to be sacred place. The waterfalls of Arunachal Pradesh are ideal sites for setting trekking base camps, since they fall from high altitudes and are perennial in nature; these waterfalls are also conducive for setting up hydro power projects. The important waterfalls in Arunachal Pradesh are:

- ***Kanchendzonga Waterfalls:*** *This is the largest waterfall in Arunachal Pradesh and it is located 15 Kilometre away from Pelling. Water splashes out from granite rocks in plumes of white in Kanchendzonga waterfalls. The sound produced in this voluminous and swift waterfall engulfs all surrounding noises.*
- ***Rimbi Waterfalls:*** *Flowing in the outskirts of Pelling, this waterfall forms an important sight scene to the tourists in Pelling.*
- ***Naga Waterfalls:*** *Along with Kabi Lungstok and Tashi Viewpoint, this waterfall is a popular tourist spot on way to Lachen from Itanagar.*
- ***Rukshyot Waterfalls:*** *Rukshyot waterfalls, in the outskirt of Bay Village and in close proximity to Lingzya monastic school, are the highest waterfall in Arunachal Pradesh State.*
- ***Bhim Nala Waterfalls:*** *Bhim Nala Waterfalls and the Twin Waterfalls are the other two waterfalls of Arunachal Pradesh en – route to Lachung.*

Demographic Infrastructure Index of the Project District/ State

Arunachal Pradesh roads are maintained by the **"Border Road Organisation" (BRO),** an offshoot of the Indian Army. The roads in Southern Arunachal Pradesh are in relatively good condition, landslides being less frequent in this region. The state government maintains 1,857 Kilometers (1,154 miles) of roadways that do not fall under the BRO's jurisdiction. Arunachal Pradesh receives most of its electricity from 19 hydroelectric power stations. Power is also obtained from the **"National Thermal Power Corporation" (NTPC)** and Power Grid Corporation of India. By 2006 the state had achieved 100% rural electrification. However, the voltage remains unstable and voltage stabilizers are needed. Per capita consumption of electricity in Arunachal Pradesh was approximately 182 kWh in 2006. The state government has promoted biogas and solar power for cooking, but these have received a poor response and are used mostly for lighting purposes. ***"In 2005, 73.2% of Arunachal Pradesh households were reported to have access to safe drinking water, and the state's large number of mountain streams assures a sufficient water supply"***.

On 8th December 2008, it was announced that Arunachal Pradesh had become the first state in India to achieve 100% sanitation coverage, becoming completely free of public defecation, thus attaining the status of ***"Nirmal State OR Swachh State",*** like Swachh Bharta Abhiyan/ Mission in India. ***"A clean India would be the best tribute India could pay to Mahatma Gandhi on his 150 birth anniversary in 2019," said Shri Narendra Modi as he launched the Swachh Bharat Mission at Rajpath in New Delhi.*** **Figure 4** shows **Nathu La Pass – Indo – China Border and Kirateshwar Mahadev Temple in Legship**.



Nathu La Pass – Indo – China Border.

Kirateshwar Mahadev Temple in Legship is Dedicated to Hindu God Shiva.

Figure 4: Nathu La Pass – Indo – China Border and Kirateshwar Mahadev Temple in Legship.

"Arunachal Pradesh" is helping tribal residents use **"Globally Significant Medicinal Plants"** for livelihood security through community management of forests. The State has a staggering 500 medicinal plant species, and more than half the forests come under the control of the indigenous people. At a presentation on indigenous and new approaches to natural resource management in the State, held on the sidelines of the Conference of the Parties to the Convention on Biological Diversity here tribal practitioners believed they had set up seven **"Medicinal Plant Conservation Areas" (MPCAs)** for **"Biodiversity Change"** in **"Tawang Area"**. According to tribal beliefs in Arunachal Pradesh, dense forests and big trees are looked upon as ancestral souls, and hornbill hunting is banned during the breeding season. The tiger is sacred as it is the **"Brother of Tani, the First Humans on Earth"**.

However, as a presentation by the **"INSPIRE Network"** for **"Environment"** made clear, large tracts of forest had been lost in Arunachal due to development of pastoral lands, agriculture expansion, shifting cultivation and demand for firewood and timber. INSPIRE is helping residents in **"Western Arunachal's Tawang – Kameng"** area form a large arboretum for Rhododendron arboreum, an evergreen tree with bright red or pink flowers that holds the soil against landslips **(Figure 5)**. Its flowers are used to produce squash under a plan partnered by the **"Indo – Tibetan Border Police" (ITBP)** and the **"Sir Ratan Tata Trust" (SRTT)**. Medicinal plants have come to the rescue of communities, and hence they vigorously guard against the removal of plant and animal species by outsiders. Hake – Tari, Salari, Laa and Wannu are examples of community forests, as elucidated by member – secretary of the **"Medicinal Plants Board of Arunachal Pradesh" (MPBAP)**.

Great – Hornbill – Bird

Dipterocarpus Macrocarpus Hollong Young Leaf – Plant

Wild – Bos – Frontalis – Upparabeeranahalli – Animal

Rhynchostylis – Retusa – Flower

Figure 5: Bird, Plant, Animal and Flower Preservation Organism as most Famous Species of Arunachal Pradesh State.

"Arunachal Pradesh" is attempting to show that community ownership can help produce incomes from biodiversity sustainably. There is strong support for conservation of fauna, too. The **"Nature Conservation Foundation" (NCF)** has been working in the area around the Pakke Tiger Reserve with the Nyishi tribal people, successfully persuading them against hunting hornbills for casqued, which form part of headgear. Fibreglass substitutes are accepted and tribal residents have participated in nest protection schemes, and local councils have seized guns from villages. An adoption scheme launched by **"Nature Conservation Foundation" (NCF)** for the hornbills has attracted 49 urban patrons, who paid between Rs. 1,000 and Rs. 1 – lakh to protect or preserve the bird's organism in the nesting sites. A dozen birds have fledged through this scheme and NCF researcher assumed that in the next phase an assessment of abundance of nesting sites and availability of some 45 fruit tree species favoured by hornbills would be carried out. A pictorial guide to significant medicinal plants of Arunachal Pradesh authored by Mr. D. Yonggam, with information about their use, was released here by **"Member of Legislative Assembly" (MLA)** Bamang Felix. Several tribal participants were present at the discussion wearing wood casqued headgear, demonstrating how hornbills could be spared in and around the Arunachal Pradesh especially in Tawang province.

Arunachal Pradesh is India's least populous state, with 6, 10,577 inhabitants according to the 2011 census. Arunachal Pradesh is also one of the least densely populated Indian states, with only 86 persons per Square Kilometers. However, it has a high population growth rate, averaging 12.36% between 2001 and 2011. The sex ratio is 889 females per 1,000 males, with a total of 3, 21,661 males and 2, 86,027 females recorded in 2011. With around 98,000 inhabitants as of 2011, the capital Itanagaris the most significant urban area in the mostly rural state; in 2005, the urban population in Arunachal Pradesh constituted around 11.06% of the total. In 2011, the average per capita income in Arunachal Pradesh stood at ₹ 81,159 (US $ 1,305) and languages of Arunachal Pradesh State are as given below in the **Table 2**.

Table 2: Conversation/ Speaking Percentage Languages of Arunachal Pradesh State.

Sr. No.	Languages	Conversation/ Speaking Percentage	Remarks
1.	Nepali	*62.6%*	Up to Mark
2.	Arunachal Pradeshese	*07.6%*	Low Level
3.	Hindi	*06.6%*	Medium and Low Level
4.	Lepcha	*06.5%*	Low Level
5.	Limbu	*06.3%*	Low Level
6.	Sherpa	*02.4%*	Very Low Level
7.	Other	*06.2%*	Low Level

Nepali is the lingua Franca of Arunachal Pradesh, while Arunachal Pradeshese (Bhutia) and Lepcha are spoken in certain areas. English is also spoken and understood in most of Arunachal Pradesh. Other languages include Dzongkha, Groma, Gurung, Limbu, Magar, Majhi, Majhwar, Nepal – Bhasa, Rai, Sherpa, Sunwar, Tamang, Thulung, Tibetan and Yakha. The major languages spoken as per census 2001 are Nepali (3, 38,606), Arunachal Pradeshese (41,825), Hindi (36,072), Lepcha (35,728), Limbu (34,292), Sherpa (13,922), Tamang (10,089) etc.

Ethnicity

The majority of Arunachal Pradesh residents are of Nepali ethnic origin. The native Arunachal Pradeshese consists of the Bhutias, who migrated from the Kham district of Tibet in the 14th century, and the Lepchas, who are believed to have migrated from the Far East. Tibetans reside mostly in the Northern and Eastern reaches of the state. Migrant resident communities include Biharis, Bengalis and Marwaris, who are prominent in commerce in South Arunachal Pradesh and Itanagar.

Religion

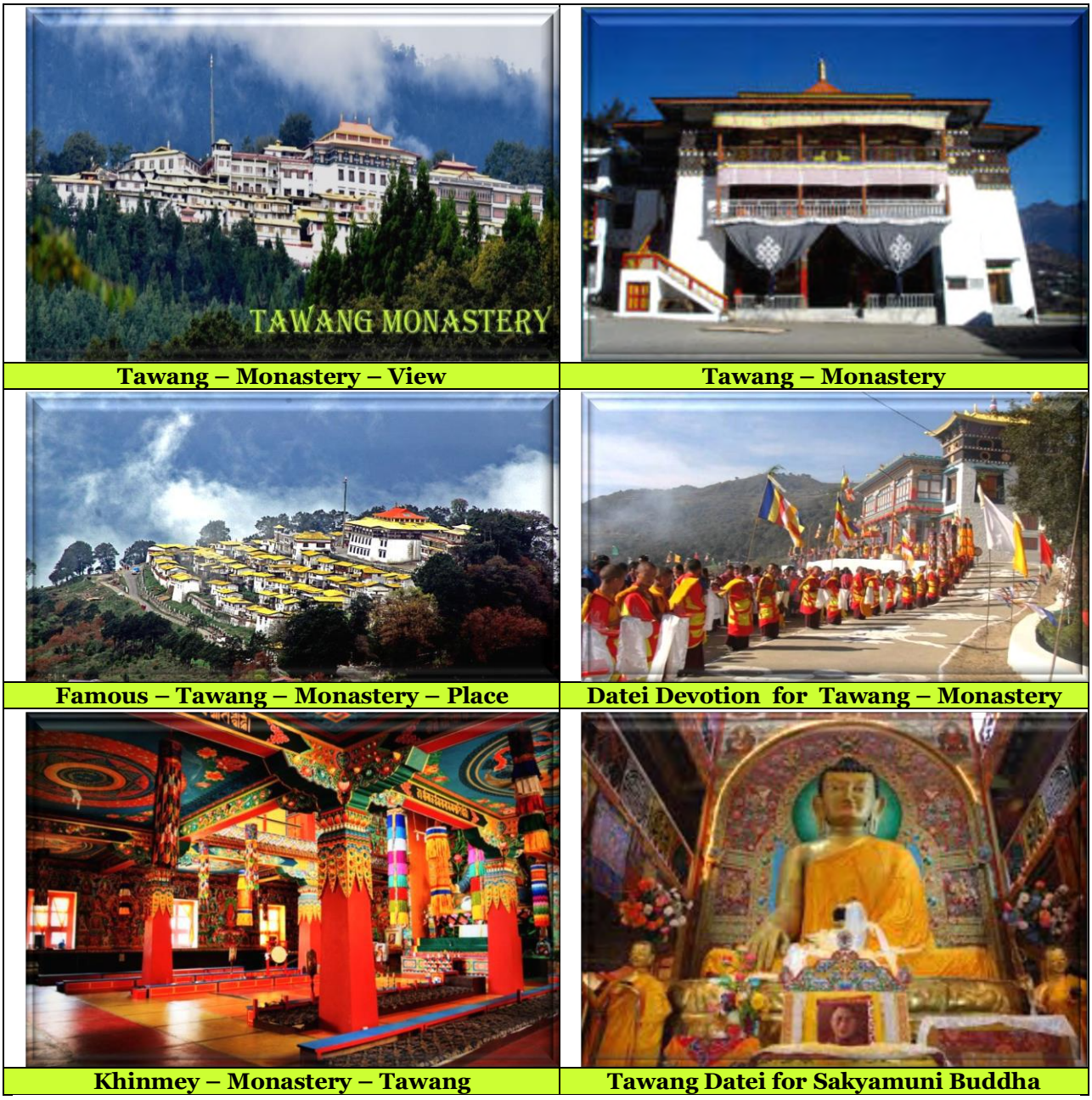
Hinduism is the state's major religion and is practiced mainly by ethnic Nepalis; an estimated 57.8% of the total populations are adherents of the religion. There exist many Hindu temples. Kirateshwar Mahadev Temple is very popular, since it consists of the Chardham altogether. Vajrayana Buddhism, which accounts for 27.3% of the population, is Arunachal Pradesh second – largest, yet most prominent religion. Prior to Arunachal Pradesh becoming a part of the Indian Union, Vajrayana Buddhism was the state religion under the Chogyal. Arunachal Pradesh has 75 Buddhist monasteries, the oldest dating back to the 1700s the public and visual aesthetics of Arunachal Pradesh are executed in shades of Vajrayana Buddhism and Buddhism plays a significant role in public life, even among Arunachal Pradesh majority Nepali Hindu population. The **Table 3** shows Religious Conviction Percentage in Arunachal Pradesh State.

Table 3: Religious Conviction Percentage in Arunachal Pradesh State.

Sr. No.	Religion	Religious Conviction Percentage	Remarks
1.	Hinduism	*57.8%*	Up to Mark
2.	Buddhism	*27.3%*	Low Level
3.	Christianity	*09.9%*	Low Level
4.	Islam	*01.4%*	Very Low Level
5.	Others	*03.7%*	Slightly Low Level

"Tawang Monastery" in **"Arunachal Pradesh"** is the largest monastery in India. It was founded by the Mera Lama Lodre Gyasto in accordance with the wishes of the 5th Dalai Lama, Nagwang Lobsang Gyatso. The monastery belongs to the Gelugpa School and has a religious association with Drepung Monastery in Lhasa. The monastery is at an elevation of about 3,300 meters (10,000 feet) in Tawang Town. It is three stories high and spread over an area of 140 Square Meter and enclosed by a 610 m long compound wall. Within the complex there are 65 residential buildings and 10 other structures having a capacity of about 700 monks. It is said to be one of the biggest Buddhist monasteries in the world outside of Lhasa, Tibet. Tawang Monastery is one of the largest monasteries of Mahayana sect in Asia. The monastery is also known in Tibetan as **"Galden Namgey Lhatse",** which translates to **"Celestial Paradise in a Clear Night"**. The library of the monastery has valuable old scriptures, mainly Kanjur and Tanjur, numbering 850 bundles. It also houses the three – storied Parkhang library: a collection of 400 – year – old Kangyur scriptures in addition to many other invaluable manuscripts. Other large collections include the Sutras, Tangym, Sungbhum, old books and other manuscripts, both handwritten and printed, many of them in gold. Dances and ceremonial celebrations are held in the courtyard, the most important of which is held on the night of **"Buddha Poornima"**.

The most fascinating part is the Dukhang or Assembly Hall — a three – storied building housing the temple and the 8.3 m (27 feet) high Golden Buddha. To the left of the altar on the Northern wall is a silver casket wrapped in silk containing the **"Thankas"** of **"Goddess Dri Devi (Palden Lhamo)",** the principal deity of the monastery. It was given to Merak Lama by the 5th Dalai Lama and has come to be known as the **"Ja – Droi – Ma",** which means it has the warmth of a bird, symbolizing that the Thanka is of a living type. Hinduism is the state's major religion and is practiced mainly by ethnic Nepalis; an estimated 57.8% of the total populations are adherents of the religion. There exist many Hindu temples. Kirateshwar Mahadev Temple is very popular, since it consists of the chardham altogether. Vajrayana Buddhism, which accounts for 27.3% of the population, is Arunachal Pradesh second – largest, yet most prominent religion. Prior to Arunachal Pradesh becoming a part of the Indian Union, Vajrayana Buddhism was the state religion under the Chogyal. Arunachal Pradesh has 75 Buddhist monasteries, the oldest dating back to the 1700s. The public and visual aesthetics of Arunachal Pradesh are executed in shades of Vajrayana Buddhism and Buddhism plays a significant role in public life, even among Arunachal Pradesh majority Nepali Hindu population. The **Figure 6** shows **Tawang Monastery is most Famous Religious Monuments**.



Tawang – Monastery – View	**Tawang – Monastery**
Famous – Tawang – Monastery – Place	**Datei Devotion for Tawang – Monastery**
Khinmey – Monastery – Tawang	**Tawang Datei for Sakyamuni Buddha**

Figure 6: Tawang Monastery is most Famous Religious Monuments.

Recorded history only became available in the **"Chutiya Chronicles"**. The Monpa and Sherdukpen do keep historical records of the existence of local chiefdoms in the Northwest as well. Northwestern parts of this area came under the control of the **"Monpa Kingdom of Monyul",** which flourished between 500 B.C. and 600 A.D. The remaining parts of the state, especially those bordering Myanmar, were under the control of the **"Chutiya Kings"**. However, most Arunachali tribes remained in practice largely autonomous up until Indian independence and the formalization of indigenous administration in 1947. Recent excavations of ruins of Hindu temples, such as the 14th century Malinithan at the foot of the Siang hills in West Siang, indicate they were built during the **"Chutiya Reign"**. Another notable heritage site, Bhismaknagar (built in 8th century), has led to suggestions that the **"Chutiya People"** had an advanced culture and administration in prehistoric times.

The third heritage site, the 400 – year – old **"Tawang Monastery"** in the extreme North – West of the state, provides some historical evidence of the Buddhist tribal people. The sixth Dalai Lama Tsangyang Gyatso was born in Tawang and Tawang Monastery, Tawang (built by Merak Lama Lodre Gyatso in 1680 – 1681). The Tibetan and British representatives at the conference agreed to the line, and Tawang and other areas ceded to the British Empire, since the British were not able to get an acceptance from China, Chinese considered the McMahon line invalid.

In 1938 the Survey of India published a detailed map showing Tawang as part of **"North – East Frontier Agency" (NEFA)**. In 1944 Britain established administrations in the area from Dirang Dzong in the West to Walong in the East. In recent years, China has occasionally made statements in conjunction with its claims on Tawang. India has rebutted these claims by the Chinese government and the Indian Prime Minister has informed the Chinese government that Tawang is an integral part of India. Later, in April 2017, a publicized visit to Tawang by the Dalai Lama (and an earlier visit by the US ambassador to India) was strongly objected to by China and is thought to have strained Indo – China relations. China has previously also objected to the Dalai Lama's visits to the area.

An uncertain but relatively large percentage of Arunachal population are nature worshippers (indigenous religions), and follow their own distinct traditional institutions like the Nyedar Namlo by the Nyishi, the Rangfrah by the Tangsa and Nocte, Medar Melo by the Apatani, the Kargu Gamgi by the Galo and Donyi – Polo Dere by the Adi under the umbrella of the indigenous religion the Donyi – Polo. A small number of Arunachali people have traditionally identified as Hindus, although the number may grow as animist traditions are absorbed into Hinduism. **"Tibetan Buddhism"** predominates in the districts of **"Tawang",** West Kameng, and isolated regions adjacent to **"Tibet"**. Theravada Buddhism is practiced by groups living near the Burmese border. Around 30% of the populations are followers of the Christian faith. Out of the 101 recognized tribes, only 17 have a **"Buddhist Majority" (Monpa, Khampti, Tawang Monpa, Momba, Singpho, Sherdukpen etc.)**. The remaining eight tribes are multi – faith, *i.e.,* they do not have a dominant religion (Nocte, Tangsa, Naga. etc.). Arunachal Pradesh has two highways: the 336 Km (209 Mi) National Highway 52, completed in 1998, which connects Jonai with Dirak, and another highway, which connects Tezpur in Assam with Tawang. **"Arunachal Pradesh State Transport Services" (or APSTS)** is the state – owned road transport corporation. ***"On 20th February, 2015 the first through train was run from New Delhi to Naharlagun, flagged off from the capital by the Indian Prime Minister, Narendra Modi. India plans to eventually extend the railway to Tawang, near the border with China"***. The state capital Itanagar was added to the Indian railway map on 12th April, 2014 via the newly built 20 Kilometer Harmuti – Naharlagun railway line, when a train from Dekargaon in Assam reached Naharlagun railway station, 10 Kilometers from the centre of Itanagar, a total distance of 181 Kilometers.

The **"Tawang War Memorial"** was built in memory of soldiers of the Indian Army who gave up their life in the 1962 Indo – Sino War. This is a fitting memorial for the greatest sacrifice anyone can offer. Located on a slope just before reaching the main town, the Tawang War Memorial is open to the public. Around 40 feet structure was built by the Indian Army and approximately Rs.15 lakhs were spent on constructing it. This stupa like structure was blessed by the Dalai Lama in 1997 and is called **"Namgyal Chortan"** by the locals. Led up by few steps, and surrounding the structure are walls of black granite. ***"The names of the 2,420 soldiers who laid down their lives in the Kameng sector during the 1964 war are inscribed on this granite plates. The memorial is surrounded by two rooms on each side; one room houses artifacts, maps, photographs and remains of the war and the other room is used for a sound and light show depicting the heroic deeds of the slain soldiers"***. The sound and light show room was usually closed, but the museum displays items used by the army during war, such as gun, bullets, helmet, mugs, pots etc. One can also learn more about the war from the newspaper clippings and maps marked with positions of both armies.

One black marble plaque reads, ***"In the memory of those brave soldiers who made supreme sacrifice defending the frontier of Mother Land during the 1962 Sino – Indo War"***. It was dedicated by Lt. General, HRS Kalkat, PVSM, AVSM; GOC IN – C Eastern Command on November 2nd, 1999. The structure signifies eternal spirit and was constructed in according with the local religious practices. The grey sky reflects the seriousness of the structure. This lovely memorial is a

testimony and a reminder of the ugliness of war. It is here to remind us that in a war no one wins and the **Figure 7** shows **Tawang War Memorial is the most Prominent and Renowned Place**.

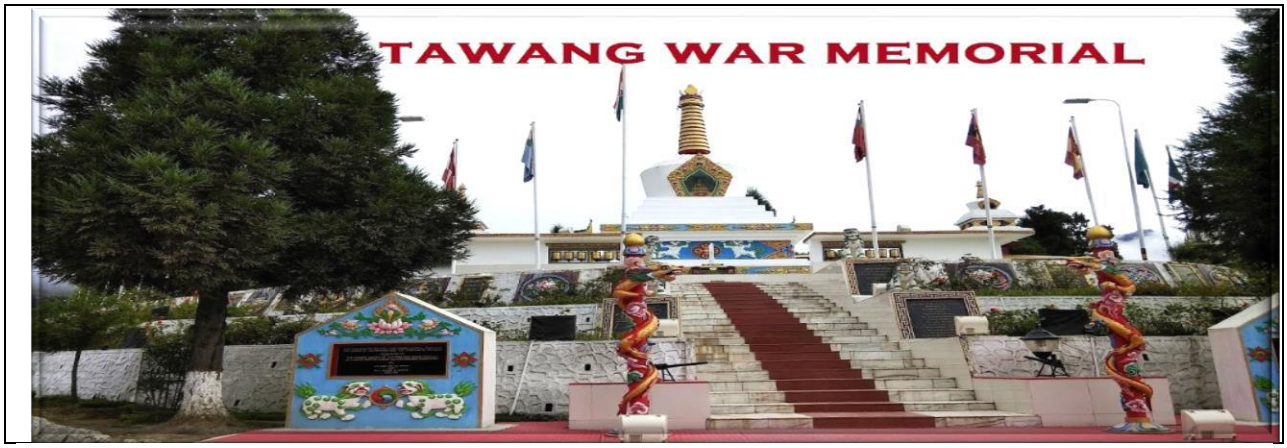
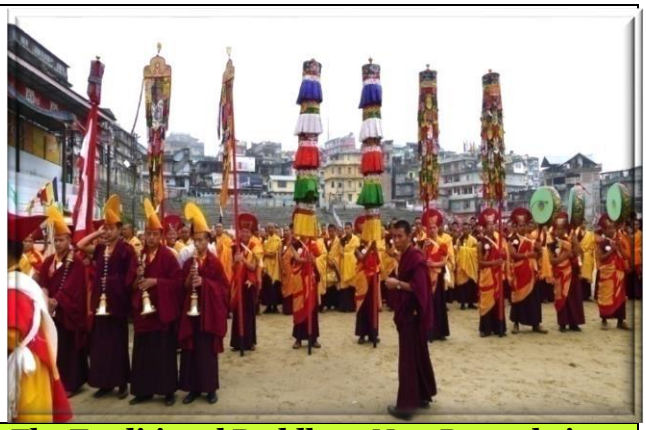


Figure 7: Tawang War Memorial most Prominent and Renowned Place.

Christians in Arunachal Pradesh are mostly descendants of Lepcha people who were converted by British missionaries in the late 19th century, and constitute around 10% of the population. As of 2014, the **"Evangelical Presbyterian Church of Arunachal Pradesh"** is the largest Christian denomination in Arunachal Pradesh. Other religious minorities include Muslims of Bihari ethnicity and Jains, who each account for roughly one per cent of the population. ***"The traditional religions of the native Arunachal Pradeshese account for much of the remainder of the population. Although tensions between the Lepchas and the Nepalese escalated during the merger of Arunachal Pradesh with India in the 1970s, there has never been any major degree of communal religious violence, unlike in other Indian states. The traditional religion of the Lepcha people is Mun, an animist practice which co – exists with Buddhism and Christianity"***.

Culture

The Traditional Gumpa Dance being performed in Lachung during the Buddhist Festival of Losar.



The Traditional Buddha – New Dance being Performed in Lachung during the Buddhist Festival of Losar.

Figure 8: Arunachal Pradesh's Traditional Gumpa Dance in Lachung during the Buddhist Festival of Losar.

Arunachal Pradesh Nepalese majority celebrate all major Hindu festivals, including Diwali and Dussera. Traditional local festivals, such as Maghe Sankranti and Bhimsen Puja, are also popular. The **Figure 8** shows **Traditional Gumpa Dance in Lachung during the Buddhist Festival of Losar**. The Losar, Loosong, Saga Dawa, Lhabab Duechen, Drupka Teshi and Bhumchu are among the Buddhist

festivals celebrated in Arunachal Pradesh. During the Losar (Tibetan New Year), most offices and educational institutions are closed for a week. Arunachal Pradeshese Muslims celebrate Eid ul – Fitr and Muharram. Christmas has also been promoted in Itanagar to attract tourists during the off – season. Western rock music and Indian pop have gained a wide following in Arunachal Pradesh. Indigenous Nepali Rock and Lepcha music are also popular. Arunachal Pradesh most popular sports are football and cricket, although hang gliding and river rafting have also grown popular as part of the tourism industry.

Cuisine

Noodle – based dishes such as Thukpa, Chow – Mein, Thanthuk, Fakthu, Gyathuk and Wonton are common in Arunachal Pradesh. Momos – steamed dump lings filled with vegetables, buffalo meat or pork and served with soup – are a popular snack. Beer, whiskey, rum and brandy are widely consumed in Arunachal Pradesh, as is Tongba, a millet – based alcoholic beverage, which is also popular in Nepal and Darjeeling. Arunachal Pradesh has the third – highest per capita alcoholism rate amongst all Indian states, behind Punjab and Haryana. The **Figure 9** shows **Arunachal Pradesh Traditional Noodle – based Dishes like Thukpa, Chow – Mein, Thanthuk, Fakthu, Gyathuk, Wonton and Momos**.

Noodle – based Dishes such as Thukpa, Chow – Mein, Thanthuk, Fakthu, Gyathuk and Wonton are Common in Arunachal Pradesh. Momos – Steamed Dump Lings filled with Vegetables, Buffalo Meat or Pork.

Figure 9: Arunachal Pradesh Traditional Noodle – based Dishes like Thukpa, Chow – Mein, Thanthuk, Fakthu, Gyathuk, Wonton and Momos.

Media

The Southern urban areas of **"Arunachal Pradesh"** have English, Nepali and Hindi daily newspapers. Nepali – language newspapers, as well as some English newspapers, are locally printed, whereas Hindi and English newspapers are printed in Siliguri. Important local dailies and weeklies include Hamro Xa – Xa – Prajashakti (Nepali Daily), Himalayan – Mirror (English Daily), the Samay – Dainik, Arunachal Pradesh – Express (English), Arunachal Pradesh – Now (English), **"Kanchanjunga – Times (Nepali Weekly)",** Pragya – Khabar (Nepali Weekly) and Himalibela. Furthermore, the state receives regional editions of national English newspapers such as The Statesman, The Telegraph, The Hindu and The Times of India. Himalaya Darpan, a Nepali Daily published in **"Siliguri",** is one of the leading Nepali Daily newspapers in the region. The Arunachal Pradesh Herald is an official weekly publication of the government. Online media covering Arunachal Pradesh **Figure 10** shows **Dro – dul Chorten Stupa and Buddha Park** include the Nepali newspaper Himgiri, the English news portal Haalkhabar and the literary magazine Tistarangit. ***"Avyakta, Bilokan, the Journal of Hill Research, Khaber Khagaj, Panda, and the Arunachal Pradesh Science Society Newsletter are among other registered publications"***.

Internet cafés are well established in the district capitals, but broadband connectivity is not widely available in the state or region. Satellite television channels through dish antennae are available in most homes in the state. ***"Channels served are largely the same as those available in the rest of India, although Nepali – language channels are also available. The main service providers include Dish TV, Doordarshan and Nayuma"***.

The Dro – dul Chorten Stupa. | **Buddha Park.**

Figure 10: Dro – dul Chorten Stupa and Buddha Park.

Education in Arunachal Pradesh

As per details from **"Census 2011, Arunachal Pradesh"** has population of 13.84 Lakhs, an increase from figure of 10.98 Lakh in 2001 census. Total population of Arunachal Pradesh as per 2011 census is 1,383,727 of which male and female are 713,912 and 669,815 respectively. In 2001, total population was 1,097,968 in which males were 579,941 while females were 518,027. The total population growth in this decade was 26.03% while in previous decade it was 26.21%. The population of Arunachal Pradesh forms 0.11% of India in 2011. In 2001, the figure was 0.11%.

Recently as per **"Arunachal Pradesh Census Data",** 68.27% houses are owned while 22.63% were rented. In all, 72.10% couples in Arunachal Pradesh lived in single family. In 2011, 53.03% of Uttar Pradesh population had access to Banking and Non-Banking Finance Corporation. Only 1.96% of Uttar Pradesh population had internet facility which is likely to improve in 2021 due to Jio. 7.92% of family in Uttar Pradesh owned car while 14.02% owned two wheelers and as per projection, population of **"Arunachal Pradesh"** in 2018 is 16.75 Lakhs. In few months we will also get details of election data for

Arunachal Pradesh. The largest institution is the Arunachal Pradesh **"Rajiv Gandhi"** University of Technological Sciences, which offers higher education in engineering, medicine and management. The **Figure 11** shows **Arunachal Pradesh Rajiv Gandhi University of Technological Sciences and Campus in Itanagar**. It also runs a host of distance education programs in diverse fields. There are two state-run polytechnic schools, the **"Advanced Technical Training Centre" (ATTC)** and the **"Centre for Computers and Communication Technology" (CCCT),** which offer diploma courses in various branches of engineering. ATTC is situated at Bardang, Singtam, and CCCT at Chisopani, Namchi. Arunachal Pradesh University began operating in 2008 at Yangang, which is situated about 28 Kilometers (17 miles) from Singtam. Many students, however, migrate to Siliguri, Kolkata, Bangalore and other Indian cities for their higher education.

Rajiv Gandhi University, Itanagar.

Rajiv Gandhi University Campus, Education Department.

Figure 11: Arunachal Pradesh Rajiv Gandhi University of Technological Sciences and Campus in Itanagar.

Pavement Condition

The existing road has CL – 9 specification from ***57+300 to 92+800 Km*** with bituminous surface, Carriageway width is 3.50 m to 3.75 m and condition of the pavement is varying from Poor to Very Poor along the road and condition of shoulders is also very poor The existing alignment passing through the mountainous steep terrain and the existing hill slope vary from 10° to 85°. The existing road has an intermediate lane configuration from ***"30.000 Km to 213.000 Km"*** total length of the road as per remote sensing and the total Sq. Km. Area as per 5 Km. buffer boundary is ***"83.743 Km²"*** and carriageway width 5.5 m bituminous surfaces and cement concrete surfaces and condition of the pavement is varying from poor to fair and having shoulder width of 1.0 m to 1.5 m on either side along the road and condition of shoulders is also poor and covered with vegetation. The entire project road traverses between hilly and mountainous terrains. All major utilities follow the road alignment as the project road connects to links ***"Siliguri (West Bengal) to Itanagar"*** and journey takes approximately ***"17 Hours and 7 minutes (720.00 Km) via NH – 27 and NH – 15"***. Arunachal Pradesh National Transport runs bus and truck services. Privately run bus, tourist taxi and jeep services operate throughout Arunachal Pradesh, and also connect it to Siliguri. A branch of the highway from Melli connects Western Arunachal Pradesh. Towns in Southern and Western Arunachal Pradesh are connected to the hill stations of Kalimpong and Darjeeling in Northern West Bengal. The state is furthermore connected to Tibet by the mountain pass of Nathu – La – Pass. ***"Arunachal Pradesh is located between 26.28° N and 29.30° N latitude and 91.20° E and 97.30° E longitude and has an area of 83.743 Km² (32,333 Sq. Mi.) and the topography rapidly rises to 7,000 m at its Highest Peak"***.

Climate

The climate of Arunachal Pradesh varies with elevation and the low altitude (100 to 1,500 m) areas have a Humid subtropical climate. High altitude and very high altitude areas (3,500 to 5,500 m) have a subtropical highland climate and alpine climate. Arunachal Pradesh receives 2,000 to 5,000 millimeters (79 to 197 in) of rainfall annually, 70 to 80% obtained between May and October. Project area experiences four seasons namely, Winter (Mid November to February), Spring (March to April), Monsoon (May to September) and a brief Autumn (October to Mid – November). The temperature varies from 35°C to 0°C at lower altitudes and ranges to below freezing at higher elevations. The mean annual temperature is 21°C. The annual precipitation ranges from a minimum of 1,400 mm to a maximum of 2,500 mm, 75% of which falls between April and October. The Park is also affected by seasonal floods in the Noa – Dihing River. There are some **"Hair – Pin Zone Portions"** within Proposed Alignment Option – 4 of Project Corridor which are given in below Pictures **Figures 12 (a)** to **(c)**.

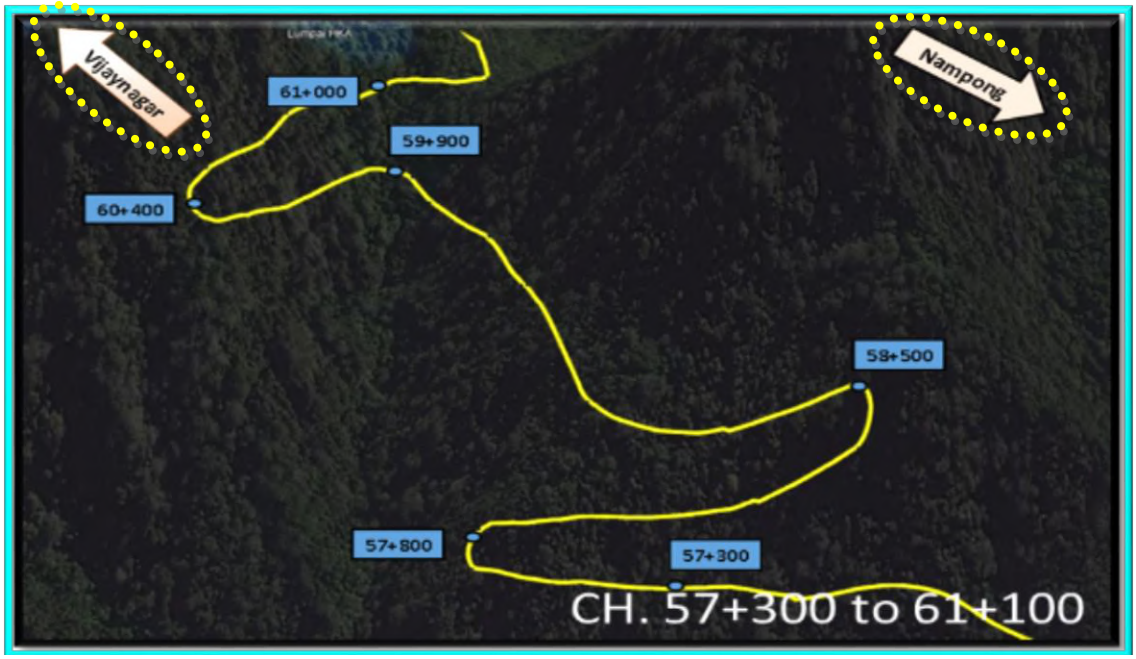


Figure 12 (a): "Hair Pin Zone Portions" in BRO – Nampong to Vijaynagar Roads, for Arunachal Pradesh (CH. 57+300 to 61+100).

Figure 12 (b): "Hair Pin Zone Portions" in BRO – Nampong to Vijaynagar Roads, for Arunachal Pradesh (CH. 77+100 to 78+600).

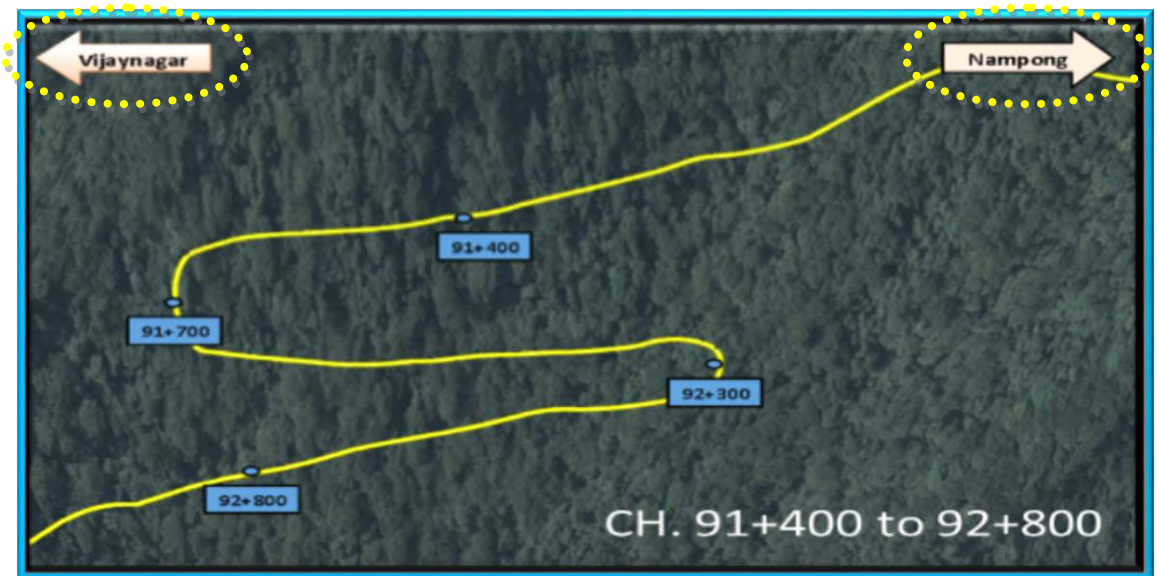


Figure 12 (c): "Hair Pin Zone Portions" in BRO – Nampong to Vijaynagar Roads, for Arunachal Pradesh (CH. 91+400 to 92+800).

2. ARUNACHAL PRADESH BACKGROUND

Introduction

In the North – East Region, Arunachal Pradesh with an area of 83,743 Square Kilometer is located in the Eastern Himalayas, and is particularly representative of all characteristics of the region. The Eastern Himalayas is one of the **18 "Biodiversity Hotspots"** in the world and is recognized as one of the major **"Bio – Geographic Zones"** of India. All the facts have contributed to consider the north eastern region of India – Arunachal Pradesh in particular as one of the eighteen **"Biodiversity Hotspots"** in the world. These communities depend on biodiversity for their sustenance and various daily needs; indigenous knowledge inherited through the ages in the sustainable use of biodiversity is unparalleled with any region of the country. In fact, our knowledge base on biodiversity of this little explored region is grossly inadequate and necessitates its detailed exploration, documentation and through understanding.

"It is important to maintain this Biodiversity, as it is essential component and a measure of the environment quality. Besides, the effects of decline in biological diversity hit hardest the indigenous people who are directly dependent on their natural environment and its products. There is an urgent need to discuss pertinent issues relating to conservation of the available Biodiversity and for formulating management plans to address these issues".

Biodiversity Conservation Initiatives in Arunachal Pradesh

In **Arunachal Pradesh** with the advent of scientific forestry in 1946, the effort of the state Forest Department has been to conserve the forests and wildlife, to maintain the ecological balance, and to promote sustained socio – economic development of the local people. An area of 9245.98 Square Kilometer representing diverse ecosystems and wildlife habitats spread over 7 districts of the state (covering about 11% of the geographical area of the state) has been brought under protected area network for protection, conservation and development of wildlife and biodiversity resources. The recorded forests occupy 61.5% of the total geographic area of the state covering some 51,540 Square Kilometer. Per capita forest area in the state is estimated to be about 6.0 hectares as against the average 0.1 hectares for the rest of the country. The predominantly tribal population of the state lives in close association with and depends largely on the forest resources. People in the hills mostly practice traditional **"Jhum"** cultivation which impacts upon forest conservation. Therefore forest management efforts seek to elicit the involvement and cooperation of the people while safeguarding their customary rights over the land.

Hitherto, forestry has been confined to reserved forests. But now with the growing emphasis on people's participation, forestry is gradually catching up as a land use practice even in the traditionally owned community lands under the schemes of social forestry and wasteland development. Since there is no land revenue regulation in the state, the legal status of forests outside Reserved Forests, Wildlife Sanctuaries and National Parks is not well defined. Forests of the state are legally classified and notified as reserved forests, protected forests, anchal and village forest reserves, national parks and wildlife sanctuaries under the relevant provisions of **"Assam Forest regulation 1891, Anchal and Village Forest Reserve Act 1978, 1981 and Wildlife Protection Act 1972"**. Un – surveyed forests where status of right and ownership is not settled are classified as **"Un – classed State Forests" (USF)**. The USF is a very ambiguous word and there is not much departmental control on it. The Reserved forests are scientifically managed. Most of them are covered under working plan and resource surveys. To replenish the dwindling resource, the department has been taking up various afforestation programmes. A large area of plantation has also been raised under various state and central schemes. The history of wildlife management is as old as that of forestry in the state. With the advent of scientific forestry in 1946, the **"State Forest Department"** had been making efforts to conserve wildlife and to maintain the ecological balance. Prior to 1972, when wildlife Protection Act came into force, the wildlife matters were dealt under the provision of **"Assam Forest Regulations"**. The main activities during the period were regulation of hunting, fishing, elephant capture, control of poaching, etc. With the adoption of **"Wildlife**

Protection Act in 1972", wildlife management underwent a radical change qualitatively. The state of Arunachal Pradesh is endowed with rich and unique **"Flora and Fauna"**. Wildlife sanctuaries and National Parks have since been constituted for wildlife conservation and management. Arunachal Pradesh is perhaps the only state in India which has four big cats viz. tiger, leopard, clouded leopard and snow leopards. Smaller cats are also found here.

3. MANAGEMENT PLANNING

"Management Planning" is an ongoing process and adaptive management is the key element. Good planning requires continuous monitoring and evaluation to test the effectiveness of the plan. Lessons learnt act as the feedback loop to review the appropriateness of management actions and policies and then used to either ***(a)*** make adjustments to the original plan to keep it on the right track; or ***(b)*** use the lessons to develop the next version of the plan.

Successful management planning will be characterized by these features:

It is a process, not an event *i.e.,* it does not end with the production of a plan, but continues through its implementation and beyond. It is concerned with the future: it identifies concerns and future alternative courses of action, and examines the evolving chains of causes and effects likely to result from current decisions. It provides a mechanism for thinking about threats and opportunities and other difficult issues, solving problems and promoting discussion between involved parties. It is systematic: most planning exercises work through a pre – determined sequence of steps that give structure to the process and encourage a logical approach. A systematic approach helps to ensure that decisions are based on knowledge and analysis of the subject and its context, and helps others to understand the rationale for proposed actions. It also involves value judgments. **"Management Planning"** can be thought of as a ***"Process which embraces the identification of what a protected area is and what it should become and how to maintain or attain that desired condition in the face of changing internal and external conditions"***.

It takes a **"Holistic"** view and the planning process can, if carried out openly and inclusively, take into consideration a very wide range of issues, views and opinions. When applied to a particular area, it should be able to include all processes and issues arising within it, as well as those arising outside its boundaries. How integrated or **"Holistic"** the process is will depend however, on how the process is carried out, who is involved and how the final decisions are made. It is a continuous process; it is never static; it must adjust to changing conditions and goals. Adopting a participatory approach to management planning by involving legitimate stakeholders in the management planning process, particularly local communities and indigenous peoples, is beneficial in a number of ways.

Participatory approach is to management planning involving stakeholders in the management process as forests are major repositories of biodiversity and provide essential goods and services for humanity. Biodiversity loss is a major threat to forest ecosystem and emerging as a great challenge to humanity. Estimation of biodiversity or biological richness of a region is a difficult task that is an impossible goal without technological inputs. The Northeast India, part of Indo – Burma biodiversity hotspot, is one of the still relatively undisturbed regions of the world harbouring almost 50% of the flowering plant of the Indian subcontinent. This region is economically less developed and forests are under tremendous pressure from the **"Anthropogenic Influences"** mainly due to the local **"Traditional Shifting (Jhum)"** cultivation practices. This article aims to bring an overview on current state of forest biodiversity and its conservation strategies in the Northeast India including traditional knowledge of conservation in this region. Further, the emphasis has been placed on various approaches of biodiversity characterization with the use of information technology like GIS to plan proper conservation and prioritization for sustaining the biodiversity of the region.

Forest biodiversity represents the variability of life in all its form and at all of its level of organization including structure, functioning and ecological processes. It can delineated into compositional diversity, structural diversity and the functional diversity that represents the whole gamut of diversity present within a forest. The distribution and magnitude of the biodiversity that exists today

has evolved over 3.5 billion years as a result of speciation, migration, extinction and recently human influences during the years. These processes mainly operated in natural vegetated areas and thus, the forest ecosystems has been the major repositories of biodiversity. ***"The adverse effects of human impacts on forest Biodiversity are increasing dramatically and threatening the foundation of sustainable development"***. Loss of biodiversity resources threatens our food supply chain, sources of wood, medicine and energy etc. and most precious ecosystem services. The need of the hour is conservation and sustainable use of biodiversity as an integral component of economic development.

The strength of biological diversity was at all – time high when the humans entered the industrial age with population of more than one billion; the natural resources then were abundant and freely available to sustain the humanity's needs and development. The increased multifarious human activities and overall negative indulgence with natural ecosystems and landscapes are destroying and changing magnitude of the earth's carrying capacity to support life. The major anthropogenic factors like changes in land use, atmospheric CO_2 concentration, nitrogen loading and acid rains, climate, and biotic exchanges (deliberate or accidental introduction of plant and animal species to an ecosystem) have been considered as leading drivers to cause deleterious effects on the biological diversity in the variety of ecosystems over the world. Further, these authors have considered land use change as an important driver of change in tropical regions either singly or in combination with other. The current rate of tropical forest loss and disturbances has resulted in 5% to 10% loss of all forest species in one decade during the last quarter century. Large – scale alteration of the landscapes for economic, industrial and infrastructure development and consequent habitat degradation, fragmentation and depletion are considered to be the prime causes of biodiversity loss in tropics. Therefore, there is an urgent need to conserve germ – plasm **"In – Situ"** before it is lost forever, because a large percentage of biological wealth and its importance are still unknown to us. Many important species are lost particularly from the tropical regions before they are being known to science.

The natural ecosystems are the repository of biodiversity and the tropical ecosystems have the largest share of the world's vascular plant species *i.e.,* 45% of the total as they provide a large number of species niches and thus distinctly prevail as the most complex ecosystems. India, the second most populous country in the world, is the eleventh mega – biodiversity center in the world and the third in Asia with its share of ~11% of the total plant resources. The floral wealth of India comprises more than 47,000 species including 43% vascular plants. Nearly 147 genera are endemic to India. The vast geographical expanse of the country has resulted in enormous ecological diversity, which is comparable to continental level diversity scales across the world. It has been the representation of which are having twelve bio – geographic provinces; five biomes and three bioregions. Natural forests and forest plantations together cover 21.02% of the geographical area in India. India, one of the twelve **"Vavilovian Centers of Origin"** and diversification of cultivated plants, is known as the **"Hindustan Centre of Origin of Crop Plants"**. About 320 species belonging to 116 genera and 48 families of wild relatives of crop plants are known to have been originated in India.

Biodiversity is intricately related to the plant community as it determines the biological diversity of the ecosystem and provide the basis for the living for the animals in the ecosystems. Plant community influences the ecosystem functioning essential for the survival of the species, and its heterogeneity is an important indicator for biodiversity assessment at landscape level. ***"Furthermore, plant species generally exists in association and any change in the species composition may lead to changes in the plant community resulting in changes to the native Biodiversity of the region because of the dependence of other animals, birds and microbes. The change in the Biodiversity is due to three basic ecological processes": (1)*** *invasion of exotic plants;* ***(2)*** *progressive succession as a part of the ecological process and* ***(3)*** *retrogressive succession due to natural and anthropogenic pressures on the ecosystems*. Assessment of the changes in the biodiversity or the state of the biodiversity is evident from the presence of indicator species and the distribution and the abundance of the keystone species.

The loss of species and changes in the local and global climate and their future consequences is the main concern for ecologist and environmentalist over the world. In recent decades much interest has

been focused on Earth's biodiversity after the realization of their importance for human society and the ever increasing pressure posed by humans on these systems. At present, biodiversity is accessed across the whole gamut of technological realms – right from molecular techniques, satellite technologies and computer based models of the climate. The ecologists are emphasizing the broader views of the planet Earth that includes the effect of life on earth, our role in influencing the species and ecosystem functioning, evolutionary changes in species and solutions to climate change effects on the earth. Broader views on all aspects of biodiversity and ecosystem functioning are being evaluated (in >38 countries) over the World through the **"Long Term Ecological Research" (LTER)** networks (with >600 sites) which is on the way of development in the country like India through the Ministry of Environment and Forest, Government of India.

The human population has started realizing the significance of biodiversity after the formulation of **"United Nations Convention on Biological Diversity" (UNCBD)** during the **"United Nations Conference on Environment and Development" (UNCED)** at Rio de Janeiro in June 1992, which was aimed to conserve biodiversity, promote sustainable use of its components, and encourage suitable sharing of the benefits arising from the utilization of genetic resources. The **"Convention on Biological Diversity" (CBD)** obliges signatory nations to undertake an inventory of their biodiversity to provide basic information about its distribution and abundance. India was one of the first signatory's nations to CBD. Natural ecosystems, the store houses of biodiversity, are being regulated by the variety of species present there, and thus certain threshold level of biodiversity is important for the proper functioning of the ecosystems below which they may not sustain their normal functioning. Biodiversity is the basis for ecosystem services and life support system for humans. Human societies derive many essential goods (*i.e.,* food, fodder, fuel, timber, pharmaceutics and energy) and services (*i.e.,* air and water, decomposition of wastes, recycling of carbon and nutrients, regulation of climate, regeneration of soil fertility, and maintenance of biodiversity) from natural ecosystems. This report study presents an overview on current state of forest biodiversity and its conservation strategies in the Northeast India including traditional knowledge of conservation in Northeast region in India. The study also discusses various approaches of biodiversity characterization and use of information technology mainly **"Geographical Information System" (GIS)** to plan proper conservation and prioritization strategies for sustaining biodiversity in Northeast India.

Biodiversity of Northeast India

"Northeast India" is composed of **"Eight States"** viz. Assam, Arunachal, Nagaland, Meghalaya, Manipur, Mizoram, Tripura and Sikkim **(Table 4)**. Geographically, this region occurs at the juxtaposition of Indo – Malaya, Indo – China, Indo – Myanmar and Indo – Bangladesh and joins the **"Foot – Hill of Himalayan Mountains"**. The immense variety of the climatic, edaphic and altitudinal variations in this region pay the way for a great range of ecological habitats for the Northeast India. Basically, the region represents sub – tropical belt that extends from the foothill of Himalaya in the West to Southeast China in the East. Besides, the Himalayan temperate and sub – alpine zone extends from Northern Pakistan and adjacent Afghanistan through Northeast India. Thus, this region is the geographic gateway for much of India's variety of the living organisms, and constituting rich variation in the **"Flora and Fauna"** and as a consequence the region identified as Indo – Burma hotspot that is one of the 35 Global biodiversity hotspots recognized. The eight states of Northeast India abode several endemic flora and fauna. Besides, the region has wide range of physiographic, cultural and economic diversity with certain inter and intra – state peculiarities. The region show wide topographical variations that vary from the flood plains of Assam to highest mountain peaks of Khanchanzonga (8,586 m) in Sikkim. The region is characterized by highest rainfall areas like Cherrapunji (which has recently shifted to Mawsynram about 50 Km apart from Cherrapunji) in Meghalaya. The states like Mizoram has highest percentage of forest cover with a characteristic of steep slopes.

Table 4: Forest Cover Change in North Eastern Region of India.

Sr. No.	State	Geographical Area (Km²)	Forest Cover (Km²) Assessment (2009)				Geographical Area (%)	Change compared to 2007 Assessment (Km²)
			Very Dense Forest	Moderately Dense Forest	Open Forest	Total Forest		
1.	Arunachal Pradesh	*83,743*	**20,868**	*31,519*	**15,023**	*67,410*	**80.5%**	*-74*
2.	Assam	*78,438*	**1,444**	*11,404*	**14,825**	*27,673*	**35.07%**	*-19*
3.	Manipur	*22,327*	**730**	*6,151*	**10,209**	*17,090*	**76.54%**	*-190*
4.	Meghalaya	*22,429*	**433**	*9,775*	**7,067**	*17,275*	**77.02%**	*-46*
5.	Mizoram	*21,081*	**134**	*6,086*	**12,897**	*19,117*	**90.68%**	*-66*
6.	Nagaland	*16,570*	**1,293**	*4,931*	**7,094**	*13,318*	**80.33%**	*-146*
7.	Sikkim	*7,096*	**500**	*2,161*	**698**	*3,359*	**47.34%**	*0*
8.	Tripura	*10,486*	**109**	*4,686*	**3,182**	*7,977*	**76.04%**	*-8*
	Total	***26,2170***	**25,511**	***76,713***	**70,995**	***1,73,219***	**66.07%**	**-------**

The Northeast India, having high rainfall and favourable climatic conditions, occupies 7.7% of India's total geographical area hosting 50% of the flowering plants (Calculated approximately 8,000 species), of which 2,526 species are endemic. The region is described as the **"Cradle of Flowering Plants"** because of its diversified angiosperm and many important cultivated plant species and some domesticated animals are originated from this region. The region is now experiencing severe alterations in land use and land cover type, due to **"Shifting Cultivation (locally known as Jhuming)"**, indiscriminate felling and illegal deforestation. These coupled with socio – economic changes have caused loss of natural habitats and complex assemblies of species. About 0.45 million families in the northeast region annually cultivate 10,000 Km² forests, whereas, the total area affected by Jhuming is believed to be 44,000 Km². With the phenomenal increase in the human population, the *Jhum Cycle* has been decreased (from 25 to 30 years earlier) to about 4 to 5 years and even less in some areas. This has accelerated the process of degradation of natural ecosystems. The highest change was recorded in Manipur followed by Nagaland, Arunachal Pradesh, and Mizoram and lowest in Sikkim with no change **(Table 4)**. Therefore, for maintaining pristine biodiversity these complex ecosystems need to be conserved **"In – Situ"**. Area is not only a storehouse of endemic flowering plants but also hosts the reptile, amphibian and butterflies as well as mammals. Collecting information about the biodiversity of the parts of the Eastern Himalayas, an Indian hot spot for biodiversity, is a challenging task.

The primitive flowering plants *e.g., Magnolia pealiana, M. qustavii, Myrica esculenta*; carnivorous plants like *Nepenthes khasiana, Lilium mackliniae* are of Convention on **"International Trade in Endangered Species" (ITES)** of **"Wild" "Flora and Fauna"**. This region originated some important gene pools of citrus, banana, mango and rice. Tropical forests found in Indo – Myanmar border area are dominated by *Dipterocarpus macrophyllus, D. turbinatus*; Shino – Japanese floristics elements, *e.g., Quercus* spp. *Schima wallichi*; Western China element like *Aneneonerupiwla, Magnolia campbelli*; Tibetan element like *Hippophae*; Siberian elements like *Potentilla, Pedicularis* etc.

Out of the India's 1,300 species there are orchid's **"Northeast Region Hosts"** to about 800 species. The listed threatened species includes *Paphiopedillium* spp., *Vanda* spp., *Renanthera imschootiana, Cymbidium* spp., *Thunia marshalliana* etc. Besides, there are many plants having great medicinal values like *Dendrobium nobile, D. denudens*, etc. Many species of *Rhododendron sabode*; edible plants like *Parkia roxburghii, Clerodendrum colebrookianum* and highly valued economic tree of *Aquilariam alacensis* are listed under the Wildlife Protection Act, 1972. *Hedychiums* of Zingiberaceae family are common in the region. Out of 136 bamboo species recorded in India about 64 species are found in Northeast region. The conifers of *Pinus keysia*; Gymnosperms of *Cycas pectinata* and *Gnetum gnemon* and broad – leaved Gymnosperms of *Podocarpus neirifolia* are present in the region. Of non – flowering plants like ferns, half of the total species recorded in the country are found in this region. Some

important ferns are *Dipteris wallichii, Asplenium nidus, Angiopteris evecta, Cythea gigantea* etc. and fern – allies like *Lycopodium* and *Sellaginella* are also diverse in the region. Among saprophytic plants *Ballanophora dioca, Aginitia indica, Manopar ahimalayana, Epipogium roseum, Euryale ferox* etc. are botanical curiosities of the region. Recently Singh reported changes in plant diversity including medicinal plants and soil nutrients during stand development in subtropical semi – evergreen forest of Mizoram. They reported that *Schima wallichii* was the dominant species in the degraded forest areas and less dominant in undisturbed areas. *Castanopsis tribuloides* was among the dominant species in the undisturbed and the moderately disturbed but this species was replaced by *Sterculia villosa* in the highly disturbed stand, and the shift in position of species and families from undisturbed to highly disturbed stands has been reported to be linked with degree of disturbance.

Socio – Economic and Environmental Issues in Northeast India

"Northeast Region" has highest forest cover (17.04 Mha) which is 66.81% of the total geographical area. The region comprising eight sister states as stated above and can be physio – graphically categorized into the **"Eastern Himalaya",** Northeast hills and the Brahmaputra and Barak valley plains. It is located at the confluence of the Indo – Chinese, Indo – Malayan and Afro – tropic bio – geographic realms. The region provides a great variability of habitats and harbour diverse biota with high level of endemism. Rich **"Flora and Fauna"** diversity with high degree of endemism in the region coupled with rapid changes due to development and resource exploitation has led to declaration of this region as one of the global biodiversity hotspot. Northeast region is part of both **"Himalaya"** and **"Indo – Burma" "Biodiversity Hotspots"**. North – East India harbours primary tropical to alpine forests in its almost undisturbed state due to variability in climate and topography and comparatively lesser disturbance in states like Arunachal Pradesh. The region is also rich in medicinal plants and several rare and endangered taxa.

The tribal population of the Northeast India constitutes about 30% of the total population and settled in hills with skewed manner. A majority of the tribes is having own forest land and they have marked as a private land with temporary boundary. Due to un – even distribution of tribe group or sub – tribe group, they are not able to avail basic government facilities such as sources of daily livelihood, food, school, medicine etc. In such condition the tribes totally depend on the forest resources for the livelihood and other necessary requirements. They adapted a unique socio – cultural aspect of this region which influences the forest cover is **"Shifting Cultivation"** or ***"Jhum"*** to earn revenue for sustaining the life. Shifting cultivation, is a traditional system of agriculture carried out without tilling the soil, is often cited as a reason for the loss of forest cover of the region. Shifting cultivation is the one of the major responsible driver of deforestation and degradation in Northeast India. According to **"Forest Survey of India" (FSI),** about 2 MHa area of Northeast India has been affected due to shifting cultivation. Most of the states of North – Eastern India, primary dense forest become degraded into secondary open forest or scrubland within few years, which leads to biodiversity loss primarily because of the practicing shifting agriculture.

On the basis of 2007 assessment, **"Forest Survey of India" (FSI)** has reported forest cover loss of 201 Km^2 in Nagaland between 2005 to 2007, followed by Arunachal Pradesh, Tripura and Assam losing 1,19,100 and 66 Km^2 respectively to ***"Jhum",*** fuel wood and timber extraction. The reason of the extended shifting cultivation in last three decades is the absence of effective land use policy. Present land use policy is based on totally traditional method which gives clear identity of land ownership to do anything for livelihood.

Forest based industries were encouraged for revenue without considering of **"Biodiversity Hotspots"** areas. The saw mills has increased five times from last two decades, which is also a responsible of clear cutting/ logging of primary forest of blue pine and tropical evergreen forest of Arunachal Pradesh, Tripura, Manipur and Assam. Encroachment in forest land is also responsible for degradation in forest area which is totally influenced by political issues. Several **"Biodiversity Hotspots"** areas across the border and in catchment area have been totally eliminated through illegal cutting by migrated populations from the neighboring country across the border area. Higher authorities reported depletion of 232.19 Km^2 areas between 1994 and 2001 in Sonitpur District, Assam due to clear

cutting of the forest for valuable timber extraction. Other senior authorities have also reported that *Taxus wallichiana* has been logged in illegal way for the medicinal values. Grazing, trampling and browsing through domestic cattle give the biotic pressure on the regenerated forest under present socio – economic condition. ***"The cattle entered in a Biodiversity rich area in foothills as well as in other part of forest, where they consume younger plantation which leads to degradation of forest"***. It happened in those areas where the local/ migrated people settled down in the vicinity of the forest and they release the cattle to graze anywhere in the forested area.

Biodiversity Distribution in Northeast India

According to recent studies the Northeast India, despite various anthropogenic pressures, has still stands one of the highest biodiversity ranking areas in the country. The region has some of the extensive tropical evergreen forests in India. Since the Northeast India is the confluence of three different geological origins, the resultant biodiversity has evolved from association of biota from three different bio geographic realms. The region has one of the least infrastructural developments in the South Asian region and has considerable forest cover. Geologically the region can be divided into the Himalayan Region, the Brahmaputra plains and the **"Garo"** and **"Khasi Hills"** in the South.

Using satellite remote sensing and other spatial databases, around 19 forest types have been identified in Northeast **(Figure 13)**. Among the dominant vegetation cover moist deciduous forest has the largest area (33,900 Km^2), followed by subtropical broadleaf forest (26,241 Km^2), Himalayan moist temperate (24,559 Km^2), and semi – evergreen forests (13,942 Km^2). Among the secondary vegetation, abandoned ***"Jhum"*** contributes 22,502 Km^2 in the entire North – East India. This region has some of the richest contiguous forest in the country. Arunachal Pradesh has contiguous forests of more than 20,868 Km^2 and harbours some of the richest biologically rich regions in the country.

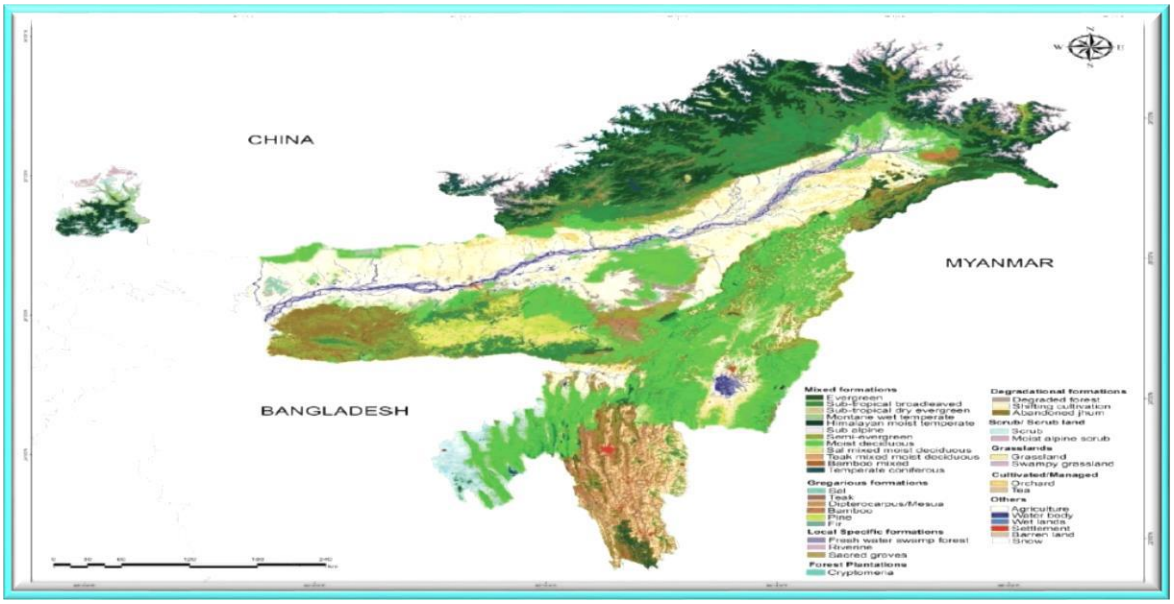


Figure 13: Vegetation Type and Land – Use Map of Northeast India.

Forests of Northeast India showed varied levels of fragmentation **(Figure 14)** and are mostly influenced by the prevailing socio – economic practices and customs. One of the most important causes of forest fragmentation in this region is shifting cultivation which is locally called ***"Jhum"***. In fact more than 50% of the forest fragmentation in Mizoram and Manipur is due to ***"Jhum"***. In this region the moist deciduous forests have the maximum area under high fragmentation followed by subtropical broadleaf and semi – evergreen forests. The ease of access is one of the major factors influencing the fragmentation in these forests. Furthermore, the soil of these forests has high nutrient content and hence the indigenous

people prefer these forests for practicing shifting cultivation. This practice is widespread in the region and causes significant loss to the health of forest and environment. Over the past century, fossil fuel combustion and agricultural activities have doubled the concentrations of reactive nitrogen (N) in the atmosphere that has resulted in significantly increased N deposition rates in industrialized regions of the world. Chronic N deposition has been reported to cause N saturation in natural ecosystems that accelerate nutrient leaching, soil acidification and forest decline. There is phenomenon of environmental nutrient loading, particularly N, and possible ecological implications of nutrient loads (N and P) in variety of natural and modified ecosystems in India. Biomass burning and vehicular exhaust have led to increase in the emissions of greenhouse gases (like CO_2, CO, CH_4, N_2O, NO_X) in the atmosphere and consequently N loadings in the primary and secondary forests of this region. The state of Mizoram has the highest forest cover (~89% of the total land area) and burnt area (736 Km^2) for shifting cultivation leading to largest **"Emissions"** of **"Green House Gases" (GHG)**.

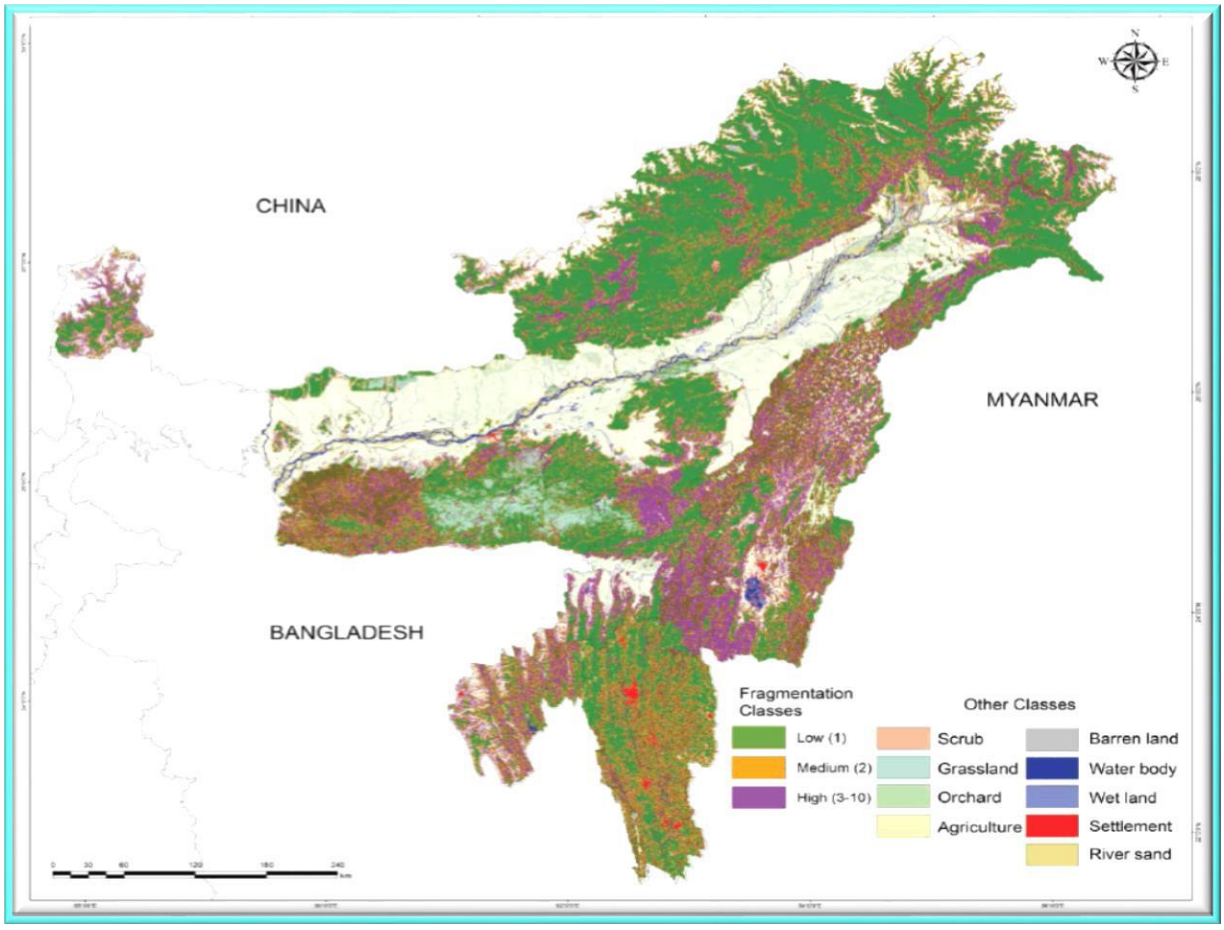


Figure 14: Disintegration Atlas of Northeast India.

The data on the biological richness in the Northeast India **(Figure 15)** showed the maximum area under high biological richness. The subtropical broadleaf forest had the highest area under very high biological richness **(Figure 16)** followed by semi – evergreen, evergreen and temperate coniferous forests.

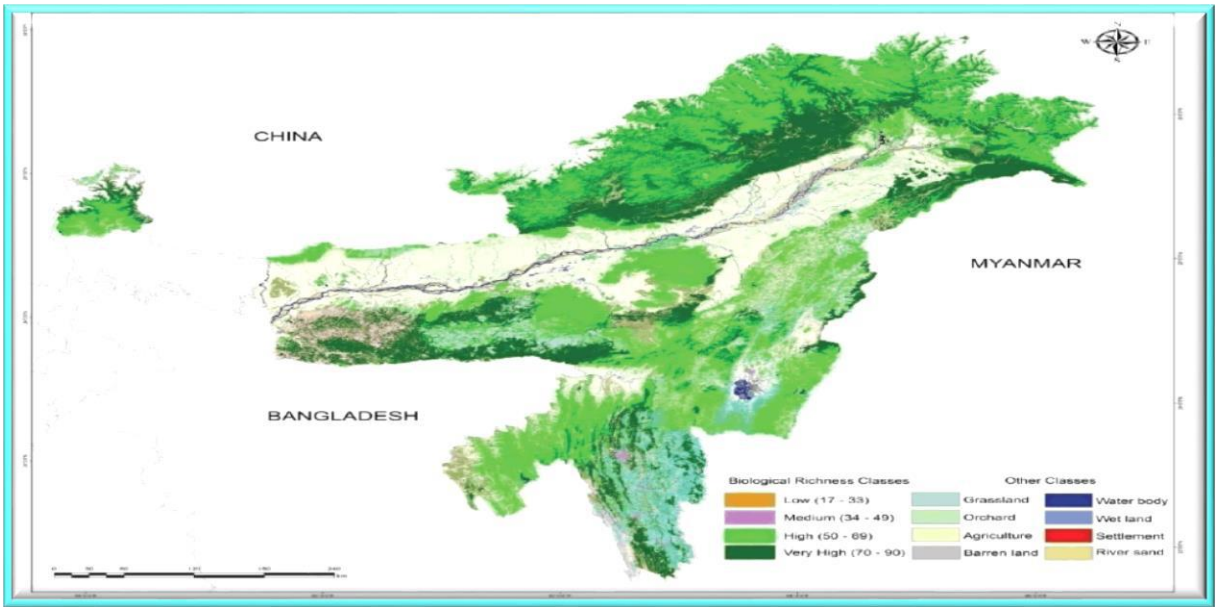


Figure 15: Biological Richness and Prosperity Atlas of Northeast India.

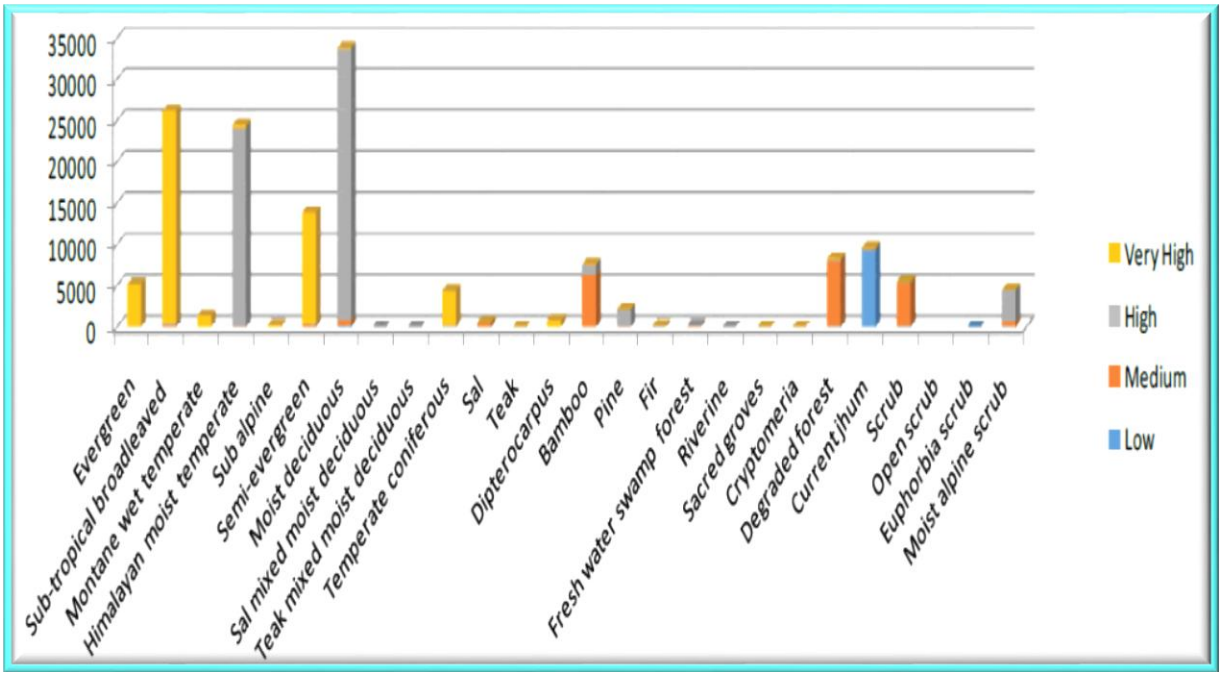


Figure 16: Vegetation Type – Wise Distribution of Biologically Wealthy Areas in Northeast India.

Biodiversity Conservation

Northeast India is biodiversity rich zone occurs in the Indo – Burma **"Biodiversity Hotspots"**. The region is experiencing high degree of anthropogenic pressure mainly because of age old shifting agriculture practice for livelihood of growing tribal population. In this system of agriculture, the piece of land is slashed and burned and the cultivated for one or two years then left abandoned for long time to

restore the fertility. In the meantime farmers move to other places for the continuation of the same practice. This practice is detrimental for the health of forest and the environment of the region. Recently, Government of Mizoram has launched a **"New Land Use Policy" (NLUP)** for farmers to replace the age old shifting cultivation. In this policy, the Government provides monitory financial support for the farmers to set up alternate source of income generation through dairy, piggery, poultry farms etc. for their livelihood.

India's national forest policy formulated in 1952 recommended 33% forest cover in the country which was revised in 1988 and emphasized the need to maintain two third forest cover in hills and mountains. Government of India has launched different programs from time to time for the **"In – Situ"** conservation of biodiversity through protected area networks. Through protected area network, the country has 96 national parks, 603 wildlife sanctuaries including 18 biosphere reserves which cover about 4.8% of the geographical area of the country. Establishing protected area network is ongoing process and thus more area will be covered in the future. **Table 5** includes a list of protected area networks (*i.e.,* biosphere reserves, national parks, and wildlife sanctuaries and tiger reserves) in different states of Northeast India. Most of the protected areas are having small size and are under the pressure because of the use and abuse of resources by the neighbouring human settlements. Another important conservation strategy by the community in India is sacred groves, which are protected to worship for their ancestral sprit and deities. Number of small and large sacred grooves has been reported to be as low as 5,000 to as high as 100,000 covering about 1% to 2% of the country's geographical area and forms the repository of rich **"Floral and Faunal"** biodiversity in this region.

Table 5: Protected Areas in North Eastern Region of India.

Sr. No.	State	Total Protected Area (Km^2)	Number of Biospheres	Number of National Parks	Number of Wildlife Sanctuary	Number of Tiger Reserves
1.	Arunachal Pradesh	*5,000*	1	*2*	11	*2*
2.	Assam	*3,010*	1	*5*	18	*3*
3.	Manipur	*2,500*	-------	*1*	1	-------
4.	Meghalaya	*3,500*	2	*2*	3	-------
5.	Mizoram	*2,200*	-------	*2*	8	*1*
6.	Nagaland	*2,250*	-------	*1*	3	-------
7.	Sikkim	*4,500*	1	*1*	7	-------
8.	Tripura	*1,600*	-------	*2*	4	-------
	Total	***24,560***	**5**	***16***	**55**	***6***

Thus systematic biodiversity conservation efforts would be required to conserve the biodiversity, with special attention in tropical regions. These efforts would require a critical monitoring and base line information in quantitative terms at each level of biodiversity organization, *i.e.,* from gene to species and from regional to the global scales. ***"A proper assessment in the form of concise numerical information showing intra – ecosystem and inter – ecosystem diversity will provide a base for modeling projected Biodiversity change and strategies for its conservation. Since Biodiversity is a multidimensional concept so it cannot be expressed through a single scalar quantity"***. It can better be represented if it covers the range of information like geographical (latitude and longitude), a biotic (temperature and precipitation), taxonomic variety (taxonomic information of the species) and life form variations (size or the biomass) to describe the diversity of ecosystems. It is a difficult task to record the compositional, structural and functional diversity of an ecosystem or a landscape. However, it is prerequisite to collect such information for the proper understanding of the global biodiversity assessment and better strategies for its conservation.

Using the database generated as part of the **"Biodiversity"** characterization at landscape level, it is possible to prioritize the biologically rich areas most vulnerable to loss or degradation. It is well known that patch sizes influence the rate of species loss. Identification of biologically rich areas which have relatively smaller patches can provide critical insights into the distribution of the biologically rich areas with respect to the disturbances and fragmentation. It can be safely assumed that the smaller patches have the highest risk of endemic species loss **(Table 6)**. On categorizing the patch sizes with landscape level biological richness in the Northeast India it was observed that most of the areas where the shifting cultivation is prevalent fall under high risk zone and should be put under highest priority for conservation practices. Further, improvement of conservation status of endemic species under threatened categories along with their abiotic conditions would be required by using critical site based information. For example, Adhikari has suggested improvement in conservation status of *Ilex khasiana* Purk, a critically endangered species endemic to **"Khasi Hills"** of Northeast India, through Maximum Entropy distribution model using 16 environmental parameters from 16 localities of **"Khasi Hill Range"**.

Table 6: Area Covered by Different Vegetation Types in North Eastern India.

Sr. No.	Vegetation Type	Area/ Region (Km²)	% of Area/ Region
1.	Evergreen Area/ Region	*5245.89*	2.11
2.	Sub – Tropical Broad Leaved	*26241.4*	10.54
3.	Montane Wet Temperate	*1423.82*	0.57
4.	Himalayan Moist Temperate	*24559.5*	9.86
5.	Sub Alpine Area/ Region	*246.06*	0.10
6.	Semi – Evergreen Area/ Region	*13942.53*	5.60
7.	Moist Deciduous Area/ Region	*33900.76*	13.61
8.	Sal Mixed Moist Deciduous	*0.01*	0.00
9.	Teak Mixed Moist Deciduous	*0.15*	0.00
10.	Temperate Coniferous	*4467.13*	1.79
11.	Sal Area	*513.96*	0.21
12.	Teak Area	*16.84*	0.01
13.	***Dipterocarpus***	*851.53*	0.34
14.	Bamboo Area/ Region	*7668.8*	3.08
15.	Pine Area/ Region	*2196.98*	0.88
16.	Fir Area/ Region	*141.59*	0.06
17.	Fresh Water Swamp Forest	*197.25*	0.08
18.	Riverine Area/ Region	*0.02*	0.00
19.	Sacred Groves	*25.46*	0.01
20.	***Cryptomeria***	*2.42*	0.00
21.	Degraded Forest	*8362.35*	3.36
22.	Current ***Jhum***	*9683.17*	3.89
23.	Scrub Area/ Region	*5518.45*	2.22
24.	Moist Alpine Scrub	*4551.7*	1.83
25.	Grassland Area/ Region	*5723.35*	2.30

Sr. No.	Vegetation Type	Area/ Region (Km²)	% of Area/ Region
26.	Riverine Grasslands	*147.09*	0.06
27.	Swampy Grassland	*409.72*	0.16
28.	Orchard Area/ Region	*5701.84*	2.29
29.	Tea Cultivation Area/ Region	*0.02*	0.00
30.	Agriculture Area/ Region	*45712.82*	18.35
31.	Abandoned *Jhum*	*22502.53*	9.03
32.	Barren Land	*913.13*	0.37
33.	River Bed	*4126.4*	1.66
34.	Water Body	*4503.18*	1.81
35.	Wet Lands	*288.88*	0.12
36.	Settlement Area/ Region	*660.73*	0.27
37.	Snow Area/ Region	*8535.96*	3.43
38.	Unclassified Area/ Region	*92.68*	0.04
	Total Area	***249076.1***	**100**

Climax and Recommendations

The speed of computation is rising due to the development of the tools and techniques of bio – informatics and geo – informatics for the management and analysis of biological data. The combination of several bioinformatics databases, software and visualization techniques of GIS may be helpful to identify biological trends and relationships. The integration of various data sources such as clinical, epidemiological, genomics and proteomics data will allow ***"Ecologists and the Environmentalists"*** to use contamination/ toxic effluence symptoms related to **Nampong to Vijaynagar Areas** to predict and choose better future medicines and medicinal plants. GBS can boost the discovery rate in bioinformatics, in large – scale comparative genomics. Intelligent **"Geographical Bioinformatics System" (GBS)** techniques can compute fast, exact and error – free results when utilized in existing bioinformatics system like monitoring, quantifying and predicting the impact of environment phenomena (type of weather changes, and emerging infectious diseases) on human – health. In public health, GIS can play a vital role to resolve issues that required spatial analysis and spatial attention. Hence, **Nampong to Vijaynagar Areas** specialists along with epidemiologists will now be able to predict disease outbreaks by looking at the scenario of **"Spatial Data" (GIS Data)** and bioinformatics data.

Presently, both GIS and bioinformatics tools should try to hybridize and develop a program for better representation of the genome at a higher level of organization, *i.e.,* chromosome and cellular **"Deoxyribonucleic Acid" (DNA)**. GIS tries to look at the DNA at the macro level whereas the bioinformatics software tries to look at the genome at the micro level. Future clinicians targeting for better medicine for any particular disease may be able to look at the changes of the genome of pathogen by collaborative **"Geo – Bioinfo – Softwares"**. Hence, future clinician may be able to prescribe appropriate drug to a patient rather than putting the patient in adverse situation which is caused by presently used medicines. Algorithms used for geographical information analysis by GIS software may be implicated in analysis of biological information; hence, specific tools might have to be designed for it as shown in **Figure 17**.

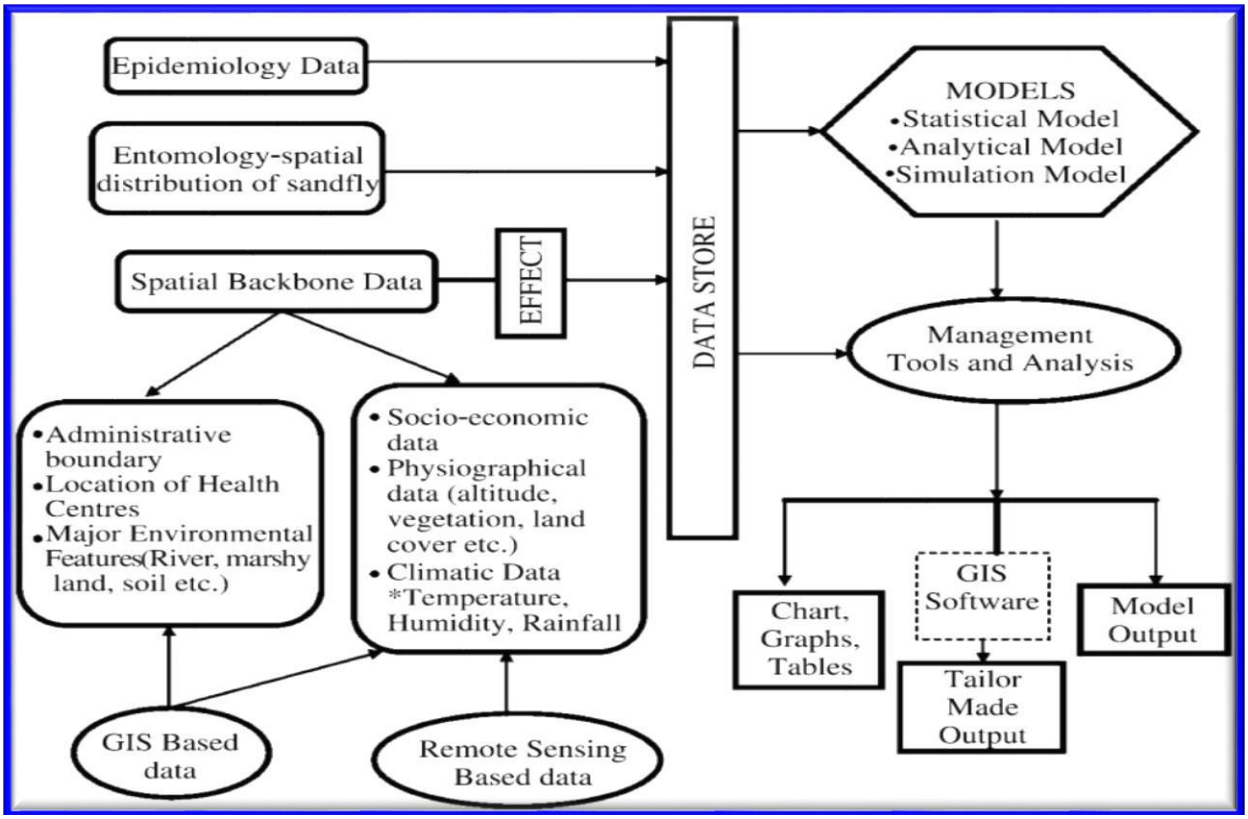


Figure 17: "Decision – Support – System/ Techniques" of Analysis Nampong to Vijaynagar Areas through Remote Sensing and GIS Technique.

India encompasses a variety of climatic conditions (like tropical, subtropical, temperate, alpine etc.) due to wide variations in temperature and precipitation. Climatic variations make the country rich in ***"Flora and Fauna"*** making it a ***"Mega Biodiversity Country"*** in the world. ***"Geographically, India has about 2.4% of the total land area of the world but it accounts for about 8% of the total number of species found over the world. Because of the rich biodiversity wealth of the country, critical "Biodiversity" assessment and its conservation strategies is important task ahead among the "Ecologists and the Environmentalists"***. In the past, the species diversity has been reported mainly on the basis of the data collected on number of species present within the ecosystem through phyto – sociological measurements that do not account for the biodiversity in total. To have complete information about the biodiversity of the region requires use of advance technological tools like **"Remote Sensing" (RS)** and **"Geographical Information System" (GIS)** in addition to the field data. Biological status of forests in a hotspot includes the basic information regarding the forest structure, species density, mean basal area, the diversity index, etc. ***"Moreover, parameters like the area under different forest covers, the ecologically and medicinally important trees/ plants, and their uses will help us to understand the threats on the local "Flora and Plants" can be made for "Biodiversity" conservation"***.

4. AREA BOUNDARIES AND ADMINISTRATIVE INFORMATION

Profile of Namdapha National Park

The Namdapha National Park in the Changlang district of Arunachal Pradesh is one of the relatively unexplored **"Protected Areas" (PAs)** harbouring rich plant diversity apart from its unique character as a **"Tiger Reserve" (TR)**. ***"Namdapha National Park (27°23'30" – 27°39'40" N to***

96°15'2" – 96°58'33" E) is located in the Changlang District of Arunachal Pradesh State in the Easternmost Corner of India". The total park area is 1,985 Square Kilometer, of which 177 Square Kilometer is buffer zone and remaining 1,808 Square Kilometer is the core zone. The park lies within the Indo – Myanmar global biodiversity hotspot at the junction of the Palaearctic and Malayan bio – geographic realms resulting in a highly diverse species assemblage. The area was originally **"Reserved Forest"** and was declared as Wildlife Sanctuary in 1972 under **"Assam Forest Regulation" (AFR)**. It was declared a **"National Park"** in 1983. In the same year, it was declared a **"Tiger Reserve"** under the Project Tiger scheme of Government of India. An area of 177 Square Kilometer of Reserved forest was added to the Tiger Reserve in 1986 (http://projecttiger.nic.in/namdapha.htm). Prior to constitution of Arunachal Pradesh, the entire Union Territory was known as **"North East Frontier Agency" (N.E.F.A.)**. A scheme for the creation of a National Park in N.E.F.A. was proposed in 1947. The area chosen for the purpose lies in the valley of the **"Diyan or Noa – Dihing River"** and its catchment area, whose elevation **"Above Mean Sea Level" (AMSL)** varies between 500 feet at the Miao Village to 15,020 feet at Daphabum. The scheme aimed at the establishment of the National Park for public recreation, research and study of wildlife in natural surroundings of an area of 802.9 Square Miles.

4.1 Elevation

"The Assessment of Biodiversity Impact for Nampong to Vijaynagar Road", "Digital Evaluation Model" (DEM) derived from the 40 m interval contour lines was used for analyzing the altitudinal variations in topography. The elevation ranges from a minimum of 260 m to a maximum 4,500 m as per the derived DEM. The park was classified into 5 categories.

Lowest elevation (260 m – 1,100 m) occurs in the Western, central, portion of Southern and South – Eastern part of the park. The highest elevation (3,600 m – 4,500 m) occurs in the extreme Northern part, the North – Eastern portion of the National Park and, also in the Eastern and South – Eastern part. The central and Southern part mostly falls in 1,200 m – 2,800 m and 2,900 m – 3,500 m altitude ranges. Higher elevation of 3,600 m – 4,500 m occurs in the Northern, Eastern and South – Eastern portions. Most part of the park lies in the range of 1,200 m – 2,000 m (39%) while least area falls in the highest elevation category of 3,600 m – 4,500 m, which is only 3% of the total area. Nearly 30% of the area falls within the 260 m – 1,100 m, the lowest elevation range **(Figure 18 and Table 7)**.

Table 7: Area within Different Elevation Zones in Namdapha National Park.

Sr. No.	Elevation/ Altitude (m)	Area/ Region (Sq. Km.)
1.	*260 – 1,100*	**587.28**
2.	*1,200 – 2,000*	**743.25**
3.	*2,100 – 2,800*	**354.41**
4.	*2,900 – 3,500*	**175.52**
5.	*3,600 – 4,500*	**59.99**

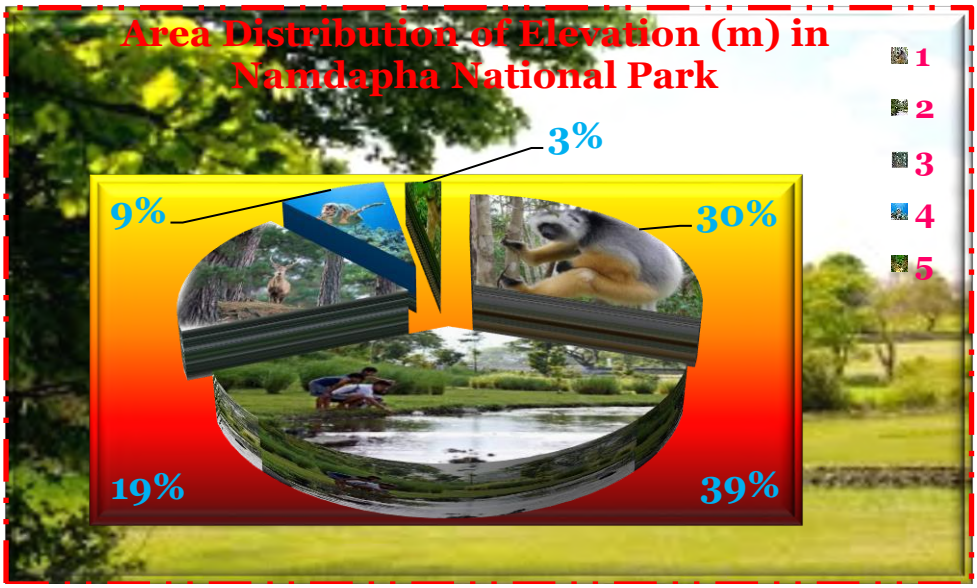


Figure 18: Graph showing Percentage of Area within the Elevation Zones in Namdapha National Park.

4.2 Slope

Data regarding slope was derived from **"Digital Evaluation Model" (DEM)** with 40 m interval using Arc **"Geographical Information System" (GIS)** 9.3 Software. The whole area was again divided into 5 categories on the basis of the derived slope **(Figure 12)** and the slope ranges from absolute flat areas of 0° slope to a maximum of 89°, very steep slopes. Most of the low lying areas with minimum slope occur in the Western and Southern part, while the steep and very steep slopes occur in the Northern, part of central and Eastern portion of **"Namdapha National Park"**. Most part of the park area lies within 11° – 20° and 21° – 30° slope, which is 27% each. Almost 15% of the area falls within the least slope category of 0° – 10°, which is approximately 280 Square Kilometer. Slope ranging from 41° to 89° covers 11% of the park area. Moderate slope (31° – 40°) occupies 20% of the national park **(Figure 19 and Table 8)**.

Table 8: Area Distribution within Slope Categories in Namdaph in Namdapha National Park.

Sr. No.	Slope/ Angle (Degrees)	Area/ Region (Sq. Km.)
1.	*0 – 10*	**280.35**
2.	*11 – 20*	**525.60**
3.	*21 – 30*	**516.98**
4.	*31 – 40*	**388.24**
5.	*41 – 89*	**2017.61**

Figure 19: Pie Chart Depicting Percentage Distribution of Area within Slope Categories.

4.3 Aspect

Aspect is the direction that a slope faces. It identifies the steepest down slope direction at a location on a surface. It can be thought of as slope direction or the compass direction a hill faces. Aspect as well as prospects is measured in counter clockwise in degrees from 000 (due North) to 360 (again due North, coming full circle). The value of each cell in an aspect grid indicates the direction in which the cell's slope faces. Flat slopes have no direction and are given a value of -1. Likewise slope, aspect was also derived from 40 m resolution **"Digital Evaluation Model" (DEM)** data and eight classes were extracted as Flat, North – East, East, South – East, South, South – West, West, North – West and North.

4.4 Climate

The park exhibits tropical climate having typical monsoon pattern with distinct rainy season. The region experiences four seasons namely, winter (mid November to February), spring (March to April), monsoon (May to September) and a brief autumn (October to mid November). Due to altitudinal variation, the climatic conditions area heterogeneous across the park. The temperature varies from 35°C to 0°C at lower altitudes and ranges to below freezing at higher elevations. The mean annual temperature is 21°C. The **"Annual Precipitation"** ranges from a minimum of 1,400 mm to a maximum of 2,500 mm, 75% of which falls between April and October. The Park is also affected by seasonal floods in the Noa – Dihing River. The water level rises very quickly if rain continues for 3 to 4 days flooding the river bank. During rainy season the water current is rapid. It carries dead logs, boulders and pebbles and deposits them on the bank which results into additional flood plains and new ecological succession sets in. At times the rainy season prolongs to 9 months in a year. Occasional off – season showers are also not uncommon and the **"Humidity Levels"** remain high throughout the year, it varies from a minimum of 47% to a maximum of 93%.

4.5 Demography

Several **"Indigenous Tribes"** and other communities reside in and around the park such as the Lisu, Miju Mishmi, Lama and Chakma communities. The Chakma and Miju Mishmi enter the park for fuel – wood, non timber forest produce collection, hunting and fishing. While their impact is restricted to the Western portion of the park, it is members of the Lisu tribe that reside along the Eastern fringe of the park

who access the interior and remote areas. A population of 3,988 (Census of India, 2001) reside beyond the South – Eastern park boundary in four villages of the Lisu tribe and nine villages of the Nepali community. Although some Lisu households existed within the park earlier, more Lisu families have migrated into the park since 1997, as their populations have grown and owing to a serious decline in cultivable land due to erosion by the river Noa – Dihing. Currently 65 such families reside in the park and practice settled rice cultivation in the river valley.

4.6 Flora

The altitudinal variation along with the heavy rainfall it receives has made Namdapha congenial for 1,000 plant species. The National Park's "Hornbill Birds" and harbours extensive *dipterocarp* forests, the Northern most lowland tropical rainforests in the world **(Figure 20)**. With increasing elevation, there is a transition in habitat from subtropical broad – leaved forests to subtropical pine forests, temperate broad – leaved forests, alpine meadows and perennial snow. Though primary forests cover most of the park, there are extensive bamboo and secondary forests. The "Floral and Faunal" composition is highly similar to the adjoining forests in Myanmar and other parts of South – East Asia.

Figure 20: National Park's "Hornbill Birds" and Harbours Extensive *Dipterocarp* Forests, the Northern most Lowland Tropical Rainforests in the World.

"Namdapha National Park" is the largest protected area in the **"Eastern Himalaya Biodiversity Hotspots"** and is located in Arunachal Pradesh in Northeast India. It is also the third largest national park in India in terms of area wise. It is located in the Eastern Himalayan sub – region and is recognized as one of the richest areas in biodiversity in India. The park harbours the Northern most lowland evergreen rainforests in the world at 27° N latitude. The area is also known for extensive **"*Dipterocarp* Forests"**.

Figure 21: First Time Recorded Species "White – Bellied Heron", A "Critically Endangered Bird".

Among the earlier approach and study on the birds of Namdapha was published in 1990. The park has about 425 bird species with many more to be recorded from work in the higher areas. There are five species of **"Hornbill Birds"** recorded from the area and several species of rare wren – babblers have been recorded in Namdapha. Other bird groups include laughing thrushes, parrotbills, fulvettas, shrike babblers and scimitar babblers. The Snowy throated Babbler is a rare species of Babbler found only in the Patkai and Mishmi hills and nearby areas in **"Northern Myanmar",** is found in **"Namdapha"**. Other rare, restricted range or globally endangered species include the Rufous – necked Hornbill, Green Cochoa, Purple Cochoa, Beautiful Nuthatch, Ward's Trogon, Ruddy Kingfisher, Blue – eared Kingfisher, White – tailed fish eagle, Eurasian Hobby, Pied Falconet, White – winged Wood Duck, Himalayan Wood – owl, Rufous – throated Hill – partridge, and White – cheeked hill partridge. Several leaf warblers and migrants such as Amur Falcon and several Thrushes can be seen here. The first mid – winter waterfowl census in Namdapha was conducted in 1994 when species such as the White – Bellied Heron; a **"Critically Endangered Bird"** was recorded for the first time as above shown in the **Figure 21**.

4.7 Fauna

"Arunachal Pradesh" is situated between 26, 028′ and 29, 030′ North latitudes and 97, 030′ and 97, 030′ East Longitudes covering an area of 83,743 Square Kilometer. Bio – geographically it is situated the **"Eastern Himalayan Province",** the richest bio – geographical province of the **"Himalayan Zone"**. The entire territory forms a complex hill system with varying elevations ranging from 50 m in the foot – hills and gradually ascending to about 7,000 m, traversed throughout by a number of rivers and rivulets by Sub Tropical Forest of Arunachal Pradesh. Rainfall varies from 1,000 mm in higher reaches to 5,750 mm in the foot – hill areas, spread over 8 to 9 months excepting the drier days in winter.

This diversity of topographical and climatic conditions has favoured the growth of luxuriant forests which are home to myriad plant and animal forms adding beauty to the landscape. ***"Living in this incredible cradle of nature are the colorful and vibrant tribes of Arunachal Pradesh for whom the forests and the wildlife are of special significance. Nature has been exceedingly kind and has endowed this beautiful State of Arunachal Pradesh with diverse forests and magnificent wildlife"***. The richness of life forms *i.e.,* the **"Floral and Faunal"** that occur in these forests presents a panorama of biological diversity with over 5,000 plants, about 85 terrestrial mammals, over 500 birds and a large number of butterflies, insects and reptiles. Such an unparalleled occurrence of life forms can be attributed to the peculiar location of the State which is at the junction of the Paleoarctic, Indo – Chinese, and Indo – Malayan bio – geographic regions, Biotic elements from all these regions occur in this state making it very rich in **"Floral and Faunal"** resources. There are 7 types of Pins and 635 types of Followers Sanctuaries in India and can get more information about **"Flora and Fauna"** of **"Arunachal Pradesh State" (Figure 22)**.

Figure 22: Biotic Elements in Rich in "Floral and Faunal" Resources and Forests Presents a Panorama of Biological Diversity.

"The vegetation of Arunachal Pradesh falls under four broad climatic categories and can be classified in five broad forest types with a sixth type of secondary forests.

These are Tropical Forests, Sub Tropical Forests, Pine Forests, Temperate Forests and Alpine Forests". In the degraded forests bamboos and other grasses are of common occurrence.

Rationale Model on Bio – Resources and Sustainable Development in Arunachal Pradesh

North – East India comprising of eight states namely Arunachal Pradesh, Assam, Manipur, Mizoram, Nagaland, Tripura and Sikkim which fall under two biodiversity hotspots of the world *i.e.,* Himalayan and Indo – Burma. The state of Arunachal Pradesh and Sikkim are under Eastern Himalayan **"Biodiversity Hotspots"** while the remaining six states viz. Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura are under Indo – Burma **"Biodiversity Hotspots"**. All the states of North – East India have their own characteristic biodiversity and unique bio – resources. Arunachal Pradesh with an area of 83,743 Square Kilometers, has the resources in abundance with the highest forest cover in the country and is least populated and it is a nature's laboratory unto it and has many endemic and vast areas are still unexplored. In Arunachal Pradesh that one can still hope to find new species and records hitherto to the world. An estimated number of 5,000 flowering plants, 600 orchids, 400 ferns, 48 gymnosperms and an equally high number of unexplored algae, fungi, lichens and bryophytes inhabit the diverse habitats that occur in at least six broad forest types of Arunachal Pradesh. The different habitat and ecosystem types of Arunachal Pradesh in particular described above are home to more than 100 species of mammal, 650 birds, 83 reptiles, 130 fishes and 7 non – human primates and innumerable species of insects and other life forms. This rich **"Flora and Fauna"** form rich genetic resources which are highly useful for the human population.

The diversity is directly related to the food, culture and way of life of 10.91 Lakhs (As per 2001 census) of more 25 indigenous ethnic communities (with more than 125 sub tribes) inhabiting the hills of the state with distinct diversity. These communities depend on biodiversity for their sustenance and various daily needs. Indigenous knowledge inherited through the ages in the sustainable use of biodiversity is unparalleled with any region of the country. *"In fact, our knowledge based on "Biodiversity" of little explored region is grossly inadequate and necessitates its detailed exploration, documentation, sustainable development through proper and scientific understanding"*. **"Modern Arunachal Pradesh"** is on the cross – roads of age – old tradition and modern development, but on what cost…!!! Should it be on biodiversity, culture, traditional knowledge that have evolved and sustained over a period of years through synthesis and churning of natural selection and adoption…? The developments taking place around the world, throughout the country including Arunachal Pradesh needs to have reorientation, as the result so far has been erosion of biodiversity, bio – resources gradually and steadily. In order to reverse the halt process of such erosion, irreparable loss, there is a need to have understanding on various aspects of bio – resources, its conservation and man's role and extent of interventions towards its **"Sustainable Development"**.

"Hence, it is important and calls of the time to develop, maintain the rich bio – resources, "Biodiversity" of Arunachal Pradesh, as it is an essential component and measure of the environment quality". Besides, the effects of decline in biological diversity would hit hardest the indigenous people who are directly dependent on their natural environment, if not scientifically studies, conserved and most importantly developed sustainably.

4.8 Mission

Development of Bio – Resources and their sustainable utilization is under process through biotechnological interventions for socio – economic growth in the Arunachal Pradesh in particular. Right kind of development, conservation and use of bio – resources requires a strong institutional setup and properly developed human capacity. In this regard there is a basic need of integrating science and society, which is possible through institutional setup and networking. In this regard, the proposal of setting up of a **"Bio – Resources Development Centre"** at **"Itanagar"** in **"Arunachal Pradesh"** should be vigorously persuaded with **"Arunachal Pradesh State Council for Science and Technology" (APSCST)** as the nodal agency to take lead in this direction.

4.9 Objectives

- ✓ *To set up state – of – art biotechnology research facilities at Arunachal Pradesh for work on sustainable development of bio – resources, using tools of modern biology;*
- ✓ *To study and document the unique biodiversity and bio – resources of Arunachal Pradesh;*
- ✓ *To undertake biotechnological interventions for sustainable development and utilization of bio – resources of Arunachal Pradesh;*
- ✓ *To generate technological packages for employment generation and economic progress of the state in particular;*
- ✓ *To undertake capacity building (human resource development) in bio – resources conservation, development and utilization; and*
- ✓ *To collaborate with other institutions/ organizations/ universities regionally/ nationally in further research pursuits in bio – resources.*

4.10 Areas of Focus

As a result of the recommendation made in this **"Final Report"** of the **"State Biodiversity Strategy"** and **"Action Plan for Initiating and Strengthening of Research and Development"** in Bio – resources, the following areas of focus on bio – resources development have been identified and which need immediate attention for **BRO – Nampong to Vijaynagar Regions**.

4.11 Medicinal Plant Resources

Arunachal Pradesh can be termed as nature's repository of medicinal plants. The people of this remote state with their indigenous skill and close association with plants have accumulated an envious treasure of knowledge related to the utilization of plants surrounding their settlements. This traditional knowledge of **"Medicinal Plant"** is becoming a potential source for the **"Pharmaceutical Industries"**. Collection of the raw plant materials in bulk for these industries has posed a great threat to this wild wealth and large numbers of such species have already become rare and threatened. A sustainable utilization of this wealth is urgently required.

4.12 Medicinal and Nutraceutical Value of Orchids for Commercialization

The use of orchids as medicine and nutraceutical has a very long history in Indian and Chinese Materia Medica. Many orchid species viz. *Dendrobium loddigesii, D. Plicatile, D. nobile, D. cumalati, D. moscatum, D. crepidatum, Sophronites coccinea, Bletilla striata,* etc. have been **"Chemically and Pharmacologically"** investigated for bioactive molecules since 1892 and many orchid alkaloids, terpenoids and phenolic compounds have been identified by European, Chinese, Japanese and Korean researchers. From the traditional knowledge of Arunachal Pradesh, some orchid species are known for their medicinal and nutraceutical values. Report indicated that very limited work has been done on the evaluation of medicinal and nutraceutical values of orchid species grown in India. Looking into the possibilities of identifying orchids with medicinal and nutraceutical values and availability of rich orchid diversity at Arunachal Pradesh, the following activities are proposed to be taken in the institute.

- ***(a)*** *Chemical prospecting of orchid species of Arunachal Pradesh for medicinal and nutraceutical values.*
- ***(b)*** *In – vitro mass multiplication protocol development of the identified orchid species for bio – mass production.*

4.13 Mountain and High Altitude Microbiology

Extremophiles *i.e.,* microorganisms living in very harsh natural conditions of mountain and high – altitude areas of Eastern Himalayas are not yet sufficiently understood for their potential utilization in sustainable development of State. Microorganisms living in natural cold conditions have attracted the attention of scientists for use in manufacturing of cold active enzymes for washing powder, textile industry and bioremediation processes. Japanese companies are very active in this research area. India too is a

player in this industrial biotechnology sector, which focuses on producing enzymes for textile and paper industries. ***"Arunachal Pradesh could become an organic state for producing the important cash crops viz. apple, large cardamom, kiwi, orange, ginger, pineapple etc. by utilizing useful bio – fertilizers and bio – pesticides/ bio – controlling agents in adequate quantities"***. Considering the above facts, researchable issues which need immediate attention are proposed as under:

(a) *Prospecting for cold tolerant industrially useful enzymes from extremophiles.*
(b) *Development of bio – fertilizers and bio – pesticides/ bio – control agents for quality crop production in the mountain areas.*

4.14 Aquatic Bio – Resources (Fish Genetics and Breeding)

India and its neighbouring countries in South – East Asia are home to rich genetic resources of freshwater fishes. They are widely distributed in inland water bodies and are highly favoured for commercial farming. The reasons for the popularity of carps in aquaculture include enormity of resources and good range of varieties for selection, relatively simple and well – tested culture techniques etc. apart from the fast growing exotic and Indian Major Carps, several minor carps are widely distributed in different freshwater bodies in the Indian region of the **"Indo – Burma", "Biodiversity Hotspots",** supporting commercially important capture and culture fisheries. Considering these facts, the present studies were proposed on priority species with the following objectives.

(a) *Collection and brood stock development of the selected commercially important indigenous fishes of Arunachal Pradesh.*
(b) *Population genetics study of the selected indigenous fishes of Arunachal Pradesh.*
(c) *To improve growth rate of selected indigenous fishes of Arunachal Pradesh through selective breeding.*
(d) *To develop package of practices for culture of selected indigenous fishes of Arunachal Pradesh.*

4.15 Insect Bio – Resources

Insects are the most diverse group of organisms on earth comprising approximately 7, 50,000 – 8, 40,000 described species. From time immemorial insect has been one of the most beneficial animal to the mankind. They provide valuable bio – resources for the welfare of human being like silk, honey, natural dyes, nutritious food items, therapeutic value, bio control agent etc. ***"Thus insects play a vital role in their own way in maintaining the quality of human's life. Therefore, it is proposed to take up exploring therapeutic, dyeing and nutritional value of insect bio – resources of Arunachal Pradesh for sustainable utilization with the following objectives"***.

(a) *Survey, collection, preservation, identification and documentation of insect bio – resources having therapeutic, dyeing and nutritional properties based on traditional knowledge of the ethnic groups of Arunachal Pradesh;*
(b) *Traditional knowledge based specific chemical evaluation for therapeutic, dyeing and nutritional values for possible product development and value addition;*
(c) *Development of mass breeding technology for sustainable utilization of the potential insect species of therapeutic, dyeing and nutritional values.*

4.16 Bio – Resources Database and Bioinformatics

In **"Arunachal Pradesh"** an estimated number of 5,000 flowering plants, 600 orchids, 400 ferns, 48 gymnosperms and an equally high number of unexplored algae, fungi, lichens and bryophytes inhabit the diverse habitats that occur in at least six broad forest types of Arunachal Pradesh. The different habitat and ecosystem types of Arunachal Pradesh in particular described above are home to more than 100 species of mammal, 650 birds, 83 reptiles, 130 fishes and 7 non – human primates and innumerable species of insects and other life forms. Scientific documentation of this rich bio – resources

of the state is very much essential for safeguarding of the bio – resources through development of database of Arunachal Pradesh in this line. Development of the bio – resources database of the Arunachal Pradesh region of the **"Indo – Burma" "Biodiversity Hotspots"** will be developed with following objectives.

(i) *Development of computerized interactive and informative database of the bio – resources of Arunachal Pradesh hotspot region;*
(ii) *Development of separate database on priority areas of the proposed institute to provide maximum available information;*
(iii) *To develop an information base on the* ***"Bio – Resources and Biodiversity using Biotechnology System Network" (BTISNet)****;*
(iv) *To conduct training courses in the specialized areas to meet the special requirements of the manpower development;*
(v) *Development of website with all the information and activities of the Institute.*

4.17 Measures

"**Arunachal Pradesh**" which is resource rich state particularly in terms of bio – resources has to harness it for industrial and economic development along with its **"Sustainable Management and Utilization"**. The basis of any management plan has to be research and development. There is need to strengthen this sector. Hence, in this direction it is proposed to Department of Biotechnology, Government of India to peruse the proposal and extend support to establish the Centre for Bio resources and **"Sustainable Development Centre in Arunachal Pradesh" (SDCAP)** under the aegis of **"Arunachal Pradesh State Council for Science and Technology" (APSCST)** for initiating and pursuing research and developmental activities in the field of Biotechnology.

Because of many different vegetation zones, the park is home to a great diversity of mammal species the four big cat species occurred in the park: as snow leopards, clouded leopards, common leopards and tigers. Other large predators are dholes, wolves, and Asiatic black bears. Smaller carnivores include red panda, red fox, yellow – throated marten, Eurasian otter, Oriental small – clawed otter, spotted linsang, binturong, common palm civet, small Indian civet, large Indian civet, masked palm civet, marbled cat, fishing cat, Asiatic golden cat, and two species of mongoose. Large herbivores are represented by elephant's wild boar, forest musk deer, Indian muntjac, hog deer, sambar, gaur, common goral, mainland serow, takin and bharal. Seven species of non – human primates including Stump – tailed macaque and Slow Loris, Hoolock Gibbons, Capped Langurs, Assamese Macaques and Rhesus Macaques. ***"Arunachal Pradesh – has found with total number of 890 species and "Kameng Elephant Reserve" in the "Himalayan Foothills" of "Arunachal Pradesh" is established for wild elephants, there are 377 elephants in "Kameng" reserve along with clouded leopard, red panda and 4 species of hornbills"***. The Group of People is Crossing River as Expedition towards Namdapha National Park in the State of Arunachal Pradesh **(Figure 23)**.

Figure 23: Group of People Crossing River as Expedition towards Namdapha National Park in the State of Arunachal Pradesh.

Seven **"Land Use/ Land Cover" (LU/ LC)** classes were derived in this classification scheme, which are as follows:

(i) *Dense forest – all lands of forest cover having a canopy density of 40% and above;*
(ii) *Open forest – lands with forest cover having a canopy density between 10 – 40%;*
(iii) *Scrubland – degraded forested lands having canopy density less than 10%;*
(iv) *Non – forested area – land without any kind of forest cover. In this case the non forested areas derived are:*

(a) *River;*
(b) *River – Bed;*
(c) *Grassland; and*
(d) *Snow Cover.*

In order to investigate the species diversity and spatial distribution of vegetation as affected by slope aspect and slope position in the hilly region of Mount Taihang, North China, and eco – characteristics and abundance distribution of shrubs and herbs were studied at different geographical locations in 2008. Samples were collected along 32 transects at different slope positions (upper, medium and lower) of Southern and Northern slopes. Results show that vegetation mainly consists of communities with a limited number of species, and a total of 44 species (9 shrubs and 35 herbs) were recorded. Shrubs are widely distributed in Southern slopes while herbs are better distributed in Northern slopes. Southern slopes exhibit higher shrub species diversity while Northern slopes have higher herb species diversity. ***"In addition, lower positions host highest species diversity and richness, while hotter and drier mid – slopes support lowest species diversity and evenness. Due to the semi – arid climate and limited resources, only few species can adapt well to the thirsty/ dehydrated/ dissected local environmental conditions, and they have rather wider niches and occupy most available resources"***. The community structures are rather similar among the slope configurations, and all comprised of few common but most occasional species, with the former greatly exceeding the latter in the total number of individuals. ***"The results indicate that slope aspect and slope position have strong influence on plant diversity and spatial distribution, but little effect on plant assemblage. Soil available water capacity and solar radiation are the***

major factors influencing the plant diversity and distribution in the study area".

Sampling Methods and Data Analysis: In this report, species statistics are based on field observations. The vegetation survey was conducted using the transect method in August, 2008. About 32 belt transects were set systematically, including 16 transacts each in the Southern and Northern slopes. Also based on the characteristics of each mountain region, sample plots were set in three different slope positions (upper, middle and lower). This transects consists total of 96 sample plots (2 m × 2 m). The species category and presence, plant height and vegetation cover in each sampling plot were recorded. The elevation, slope direction and geomorphology of each sampling plot were also recorded.

A total of four indices are used to access species diversity of shrubs and herbs. For the diversity indices, the **"Shannon – Weiner" (H')** index is used which in effect measures both species number (richness) and equitability (evenness). Then for richness and evenness measures, the **"Margalef" (M_a)** and **"Pielou" (J)** indices are in turn. The Pielou index ranges from 0.0 to 1.0, with the maximum value representing a situation where all taxa have equal abundance. The degree of dominance of each species is measured using **"Simpson" (D)** index. The index gives the probability of any two variables drawn randomly from an infinity large community. These four indices are used because of the moderate sensitivity to sample size and preferential representation in describing species diversities among plant communities. Then on – way ANOVA analysis is used to determine the significance difference of species diversity indices among different topographic positions. The equations used in the calculations of the indices are as follows in **Equation (1)**:

$$\mathbf{H' = -\sum_{i=1}^{s}(Pi \ln Pi)\ (Pi = \frac{Ni}{Pi})} \qquad \textit{...Equation (1)}$$

$$\mathbf{M_a = \frac{(S-1)}{\ln N}}$$

$$\mathbf{J = (-\sum_{i=1}^{s} Pi \ln Pi)/ \ln S}$$

$$\mathbf{D = \sum_{i=1}^{s}(Pi)^2\ (Pi = \frac{Ni}{N})}$$

Where P_i is the relative importance value of species i, N_i is the number of individual species i in each slope Aspect (or Position), N is total number of all species in each slope Aspect (or position), S is the number of species recorded in each slope configurations.

5. BIODIVERSITY INDEX CALCULATION

The Biodiversity Index Calculation

"Diversity is defined as the measure of the number of different species in a biotic community". Generally speaking, diversity is high when there are many different species in a community and low when there are few or in a very small number.

- ✓ Comparing the diversity of two or more different biotic communities can give an idea of the comparative stability and health of those communities. Comparing and analyzing the results can be difficult if all you have to work with are lists of life forms from different sites.

- ✓ When scientists are faced with this problem, they often create an **"Index"**. An index is a scale by which your object of study can be rated, and then compared to other things of the same type. *A **"Biodiversity Index"** is a scale of the diversity of plant and animal species at your study site. Biodiversity is a widely used tool for estimating the complexity, stability, and thus **"General Health"** of an **"Ecosystem"**.*

- ✓ One example of an index is a report card. Performance on a test or assignment places a

student's work in a range (for example, 80 to 83%). That range is then translated into a ranking on a scale (B–). Put simply, an index turns complicated and difficult – to – compare data – like school assignments or lists of life forms – into numerical data which are easier to analyze.

The ideal way to measure diversity is to count every species in sight. However, this approach requires much time and considerable expertise in taxonomic classification. This worksheet describes how you can turn the data collected at the sampling plot into an index of biodiversity. You will calculate the biodiversity index using the data gathered at the study site. You can submit your ***"Biodiversity Index Value (BIV)"*** to the ***"Biodiversity Project"***.

Gathering Raw Data

During the trip to the study site, an abundance reporter was asked to record the number of individuals of each plant species growing within a particular space. Gather this data together in a chart like the one below. Each line in the chart represents one of the species observed and the number of individuals of that species **(Table 9)**.

Table 9: Number Observed within Species OR Kinds Categories in Namdaph in Namdapha National Park.

Sr. No.	Species OR Kinds	Number Observed
1.	***A – (Dendrobium nobile)*** *Type Category/ Class*	06
2.	***B – (Pinus keysia)*** *Type Category/ Class*	04
3.	***C – (Gnetum gnemon)*** *Type Category/ Class*	07
4.	***D – (Podocarpus neirifolia)*** *Type Category/ Class*	02
5.	***E – (Parkia roxburghii)*** *Type Category/ Class*	03
6.	***F – (Clerodendrum colebrookianum)*** *Type Category/ Class*	10
7.	***G – (Paphiopedillium spp.)*** *Type Category/ Class*	01
8.	***H – (Renanthera imschootiana)*** *Type Category/ Class*	07
	Total Number of 40 Individual Plants	40

Biodiversity Formula

The diversity formula is a mathematical formula that allows you to estimate the diversity in an entire sample – in this case, the quadrate. We make the assumption that the diversity found within the quadrate is representative of your study site as a whole projected place as shown in **Equation (2)**.

Biodiversity Index = −2.303 × Sum of pi log (pi) ***...Equation (2)***

Materials

The materials are used as Calculator that includes a log function Grid Paper etc.

Procedure

1. In the formula, p_i is the number of a particular kind of plant divided by the total number of plants observed. For instance, if you look at species B in the chart above, you will see that 4 were observed, and since there were a total number of 40 different individual plants in the sample, then 4/ 40 represents B's fraction of the total observed. You will see in the third column, under p_i, the result of 4/ 40 which is .1.

2. Complete the formula by multiplying the values in the third and fourth columns. In the case of species B, .1 × -1 = -0.100.

3. Using the calculator find the log of p_i. For example, the log of .1 is -1, which is recorded in the

fourth column.

4. Finally, to get a **"Diversity Value for the Whole Set of Data",** sum all the values in the fifth column and multiply this times the **"Magic Number" –2.303**. For our sample set, the sum of values in the fifth column is –0.829, multiplied by the **"Magic Number –2.303... Equals to 1.908"**. This is the biodiversity index value for this sample set. The higher the biodiversity index value, the more diverse the sample.

5. Enter the biodiversity index value for your sampling plot onto the **"Inventory Database Worksheet" (Table 10)**. Eventually you will submit all these data to the **"Global Lab Inventory Database" (GLID)** on the Web.

Table 10: Number Observed within Species OR Kinds Categories for P_i log (p_i) Value in Namdaph in Namdapha National Park.

Sr. No.	Species OR Kind	Number Observed	p_i	Log (p_i)	P_i log (p_i)
1.	***A – (Dendrobium nobile)*** *Type Category/ Class*	**06**	*0.150*	**-0.824**	*-0.124*
2.	***B – (Pinus keysia)*** *Type Category/ Class*	**04**	*0.100*	**-1.000**	*-0.100*
3.	***C – (Gnetum gnemon)*** *Type Category/ Class*	**07**	*0.175*	**-0.757**	*-0.132*
4.	***D – (Podocarpus neirifolia)*** *Type Category/ Class*	**02**	*0.050*	**-1.301**	*-0.065*
5.	***E – (Parkia roxburghii)*** *Type Category/ Class*	**03**	*0.075*	**-1.125**	*-0.084*
6.	***F – (Clerodendrum colebrookianum)*** *Type Category/ Class*	**10**	*0.250*	**-0.602**	*-0.151*
7.	***G – (Paphiopedillium spp.)*** *Type Category/ Class*	**01**	*0.025*	**-1.602**	*-0.040*
8.	***H – (Renanthera imschootiana)*** *Type Category/ Class*	**07**	*0.175*	**-0.757**	*-0.132*
	Sum	**40**	*1*		*-0.829*
	Diversity 1.908				

Sampling Methods and Data Analyses: In this study, species statistics are based on field observations. The vegetation survey was conducted using the transect method in August 2008. About 32 belt transects were set systematically, including 16 transects each in the Southern and Northern slopes. Also based on the characteristics of each mountain region, sample plots were set in three different slope positions (upper, middle and lower). Here transects are consisting of a total of 96 sample plots (2 m × 2 m) in the area/ place. The species category and presence, plant height and vegetation cover in each sampling plot were recorded. The elevation, slope direction and geomorphology of each sampling plot were also recorded **"Ten"** types of vegetation type were identified on the basis satellite image interpretation and field survey. The classes derived are as follows:

(i) *Alpine Forest;*
(ii) *Sub – Alpine;*
(iii) *Mixed Coniferous Forest;*
(iv) *Wet Temperate Forest;*
(v) *Sub – Tropical Pine;*
(vi) *Tropical Wet Evergreen;*
(vii) *Tropical Broad – Leafed Forest;*
(viii) *Bamboo;*
(ix) *Water; and*
(x) *River Bed.*

Area under each vegetation type is given in **Tables 11 and 12**.

Table 11: Area under Different Vegetation Type in Namdapha National Park.

Sr. No.	Classes/ Types	Area/ Region (Sq. Km.)
1.	*Alpine Forest*	86.50
2.	*Sub Alpine*	79.91
3.	*Mixed Coniferous Forest*	256.30
4.	*Wet Temperate Forest*	415.06
5.	*Sub Tropical Pine*	54.65
6.	*Tropical Wet Evergreen*	165.89
7.	*Tropical Broad – Leafed Forest*	730.79
8	*Bamboo Forest*	75.93
9.	*Water/ River*	18.13
10.	*River Bed/ Sand Bar*	31.35

Table 12: Different Vegetation Type in Namdapha National Park.

Sr. No.	Broad Forest Type	Altitudinal Range (m)	Important Species
1.	*Alpine and Sub – Alpine Forest*	3,000 – 5,500	*Rhododendron, Primula, Saussaurea, Saxifraga*
2.	*Mixed Coniferous Forest*	2,300 – 3,350	*Abies sp. Tsuga dumosa Wet*
3.	*Wet Temperate Forest*	1,800 – 2,750	*Quercus lamellose, Quercus sp. Castanopsis indica, Acer hookeri Sub*
4.	*Sub Tropical Pine*	1,000 – 1,800	*Pinus Roxburghii, Pinus wallichiana and Pinus merkusii*
5.	*Tropical Wet Evergreen*	Up to 900	*Phoeba paniculata, Actinodaphne obovata, Alnus nepalansis, Phoebe attenuata*
6.	*Tropical Broad – Leafed Forest*	Up to 900 – 1,900	*Bombax ceiba, Lagerstroemia parviflora, Terminalia berllirica, Sterculia villosa.*
7.	*Bamboo Forest*	-------	*Bambusa pallid, Schizostachyum polymorphum, Bambusa tulda, Dendrocalamus hamiltonii*

***(a)* Alpine and Sub – Alpine Forest:** The vegetation consists mainly of juniper, rhododendron, birch and larch. It has low scrub, dense evergreen forest consisting mainly of rhododendron and birch. Mosses and ferns cover the ground patches. This region receives very heavy snowfall.

***(b)* Mixed Coniferous Forest:** These forests are typically found on steep, rocky, north facing slopes. The most common trees are Abies spectabilis, Larix griffithii, Juniperus recurva, Juniperus indica, Betulia utilis, Acer spp., and Sorbus spp.

***(c)* Wet Temperate Forest:** It is found in the region receiving a minimum rainfall of 2,000 mm, the forests are because over time the original trees have been replaced by fast growing varieties such as the eucalyptus. Rhododendrons and a variety of ground flora can be found here.

***(d)* Sub – Tropical Pine:** Pine forests are usually found in the steep dry slopes. The trees predominantly found in these areas are the chir, oak, rhododendron and pine.

***(e)* Tropical Wet Evergreen:** It is characterized by tall, straight evergreen trees that have a buttressed trunk or root on three sides like a tripod that helps to keep a tree upright during a storm. These trees often rise to a great height before they open out like a cauliflower.

***(f)* Tropical Broad – Leaved Forest:** These wet forests consist mainly of evergreen trees with a sprinkling of deciduous here and there. There are oak, alder, chestnut, birch and cherry trees.

***(g)* Bamboo Forest:** Bamboos grow mostly in pure stands with very less of associated species. Normally bamboos appear in areas abandoned after shifting cultivation, where they colonize fast.

Wild Fauna

Ninety mammal species are reported from the park, including nine species of felids, two bear species, fifteen – vive rid and must lid species and seven primate species. Four species of mountain ungulates: *red goral* (Nemorhaedus baileyi), *serow* (Nemorhaedus sumatraensis), *takin* (Budorcas taxicolor) and *musk deer* (Moschus sp.) occur at higher elevations, while the *hog deer* (Axis porcinus) is restricted to the grassland habitat in the river valleys. The main species targeted by hunting are the Indian *munjtjac* (Muntiacus muntjak), *sambar* (Cervus unicolori), *wild pig* (Sus scrofa) and *gaur* (Bos frontalis). These four species are among the important prey of the tiger, *leopard* (Panthera pardus) and the *wild dog* (Cuon alpines), while primates and smaller mammals constitute important prey for the *clouded leopard* (Neofelis nebulosa). Nearly 90% of Namdapha remains unexplored. The park continues to record new species: even tigers, though extremely rare, could possibly bounce back, given the large area.

6. THREATS TO NAMDAPHA NATIONAL PARK

The existing threats to the National Park can be briefly summarized as follows:

***(i)* Human Influx –** In recent years, human migration caused by population increase has posed increasing threats to the biodiversity of forest zones all over the world. Although Namdapha is in a remote corner of the country, it could not escape from human interference. As has been mentioned earlier several ethnic human communities have been living in and around the park and are fully dependant on the resources of the national park for their day to day life. Besides the side – line settlements mentioned above, there are two unauthorized settlements in the core zone with 43 households and a population of 280.

The Chakmas, originally belong to the Chittagong Hill Tracts of Bangladesh, have settled down in different parts of the State as refugees (mainly in Changlang and Lohit districts) during 1964 – 65. Prior to the declaration of Namdapha as a national park and tiger reserve, the Chakmas were living in Haldibari, Zero camp and Farmbase (present buffer zone). After declaration as a national park in 1983, they were resettled outside the park boundary in the adjacent Anchal reserve forests. However they continue to use the park resources for their livelihood. Similarly there are other migrant communities dependent upon the forest resources. There are two Lisu (originally belong to Myanmar) settlements in the core zone of the park, damaging the virgin forest. About 170 Ha of forest land (in the core zone) has already been cleared within the last few years for agriculture (excluding Jhum) and settlement. Further, there is illegal felling of trees and collection of **"Non – Timber Forest Products" (NTFPs)**.

***(ii)* Extraction of Forest Products –** People depend on the park for timber, bamboo, roofing materials, medicinal plants and other NTFPs. Happy Valley, Haldibari and M.V. road side areas (in the buffer zone) have been identified as extraction zones in the park. It is estimated that about 975 tones of bamboos and posts, and 45.5 tones of wild vegetables and medicinal plants are harvested annually in the villages in and around the national park. This can be attributed to demographic pressure and easy accessibility to the forest as well as to the local market demand. Fuel – wood is the major source of energy in these areas, as no alternative energy sources like electricity and cooking gas are available. The consumption of firewood is higher during winter in comparison to summer for processing of agricultural products for their value – addition. Also, more firewood is required for warmth during winter season. Illegal felling and trafficking of trees have been noticed several times inside the park area although Supreme Court banned such activities in the North – Eastern states since December 1996. Extraction of these forest resources in such unsustainable manner, will ultimately affect the overall biodiversity of the park, in the long run.

***(iii)* Hunting and Poaching –** Hunting, illegal fishing and trapping of wild fauna like tiger, barking deer, leaf deer, sambhar, wild boar, bear, wildcat and a variety of birds by local inhabitants (Lisu, Chakma and Mishmi) for bush meat and hide, is a severe concern for the management of Namdapha.

Habitat destruction poses further threat to wildlife. Although the Wildlife (Protection) Act 1972, was extended to Arunachal Pradesh in May 1973, and prohibits picking, poaching and hunting of wild animals and plants, its enforcement is not to be of much use in this area. The great Indian *hornbill* (Buceros bicornis), is the State bird of Arunachal Pradesh, has played an important role in the traditional lifestyle and dressing habits of many tribes in the state. The tribal people use the beak of the bird as a headgear to be worn as a traditional knot on the forehead. Thus, the world's most colourful bird is heading towards extinction in the North – Eastern states of India. Moreover, there are ample game hunters around Namdapha who frequently hunt birds for fun and food. The Apatani tribe residing in higher elevations (Ziro) of Arunachal Pradesh now use artificial beaks of the hornbill, as reiterated by the **"WWF – India" (World Wide Fund for Nature – India)** in the state.

***(iv)* Buffer Zone –** The buffer zone concept of Namdapha nature reserve is somewhat different from the **"IUCN" (International Union of Conservation)** concept. The buffer area (177 Square Kilometers) is confined only to the North – West corner of the park. This area had human settlements earlier (Haldibari, Farmbase and Zero camp) and was later added to the park in 1986. Currently, in the buffer zone (demarcated by forest authorities), there is no human settlement, but the resettled communities frequently visit the zone for various forest produces. The South – Eastern periphery of the park was earlier considered as a core area and human interference was supposed to be negligible there. However, decadal increase of human population in the fringes of this reserve has compelled people to encroach the park area. Further, immigration from neighbouring Myanmar is also adding to demographic pressure over the natural resources in the park. Consequently this is disturbing the pristine forest vegetation and the resident wild fauna in the protected area. Thus, it is evident that the buffer – zone concept failed with respect to Namdapha National Park.

7 (A). ROLE OF GEOGRAPHIC INFORMATION SYSTEMS AND REMOTE SENSING

Effective management of protected area and conservation of biodiversity in general demands inventory, evaluation, planning and management at scales ranging from the local and regional to national, continental and global foundation. ***"Protected area mapping is an important aspect of protected area management and it serves as baseline for ecological modeling and future monitoring and assessment"***.

APPROACH

The main goal for management and conservation of **"Namdapha National Park"** is to maintain the scenic, ecological and biological characteristics of the ecosystem. The present management plan is an effort to apply the techniques of GIS and Remote Sensing to develop an effective Management Plan for Namdapha National Park. Use of geospatial tools would allow continuous monitoring and timely up – gradation of different components of the Management Plan. Following analysis was carried out as a part of the process to develop a detailed plan. These are:

(i) *To identify key species, important habitat areas which will assist in developing specific conservation action plans for biodiversity conservation;*

(ii) *To identify potential sites for location of watch towers and construction of water holes.*

7 (B). STATUS OF FORESTS AND BIODIVERSITY IN INDIA

"India is a Mega – Biodiversity Project" in the country and variety of physiographic and climatic conditions has attributed India with rich Biodiversity. Biogeographically, India is situated at the Tri – Junction of three realms, namely, Afro – Tropical, Indo – Malayan and Palaeo – Arctic Realms". Therefore, India has characteristic elements from each of them. This assemblage of three distinct realms probably is a fact, which is believed to partly account for its rich and unique biodiversity. India also represents three major biomes, viz.,

tropical humid forests, tropical dry forests/ deciduous forests and warm forests/ semi – arid desert. Based on available species data, India ranks tenth in the world and fourth in Asia in plant diversity and ranks seventh in the number of endemic species of higher vertebrates in the world **(MOEF, 1999 and 2001)**. The **"Wildlife Institute of India" (WII)** divides **"India into 10 Bio – Geographic Zones or Regions"**. ***"These are: Trans – Himalayan, Himalayan, Indian Desert, and Semi – Arid, Western Ghats, Deccan Peninsula, Gangetic Plain, North – East India, Islands and Coasts"*** **(Figure 24)**.

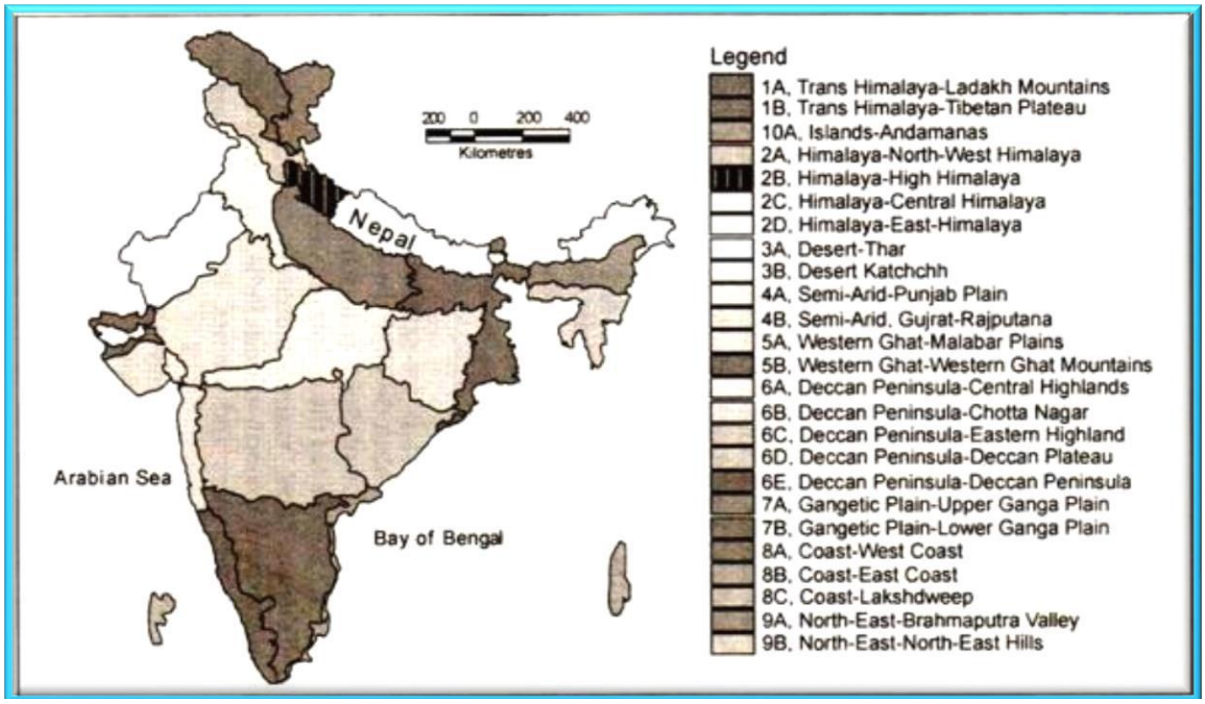


Figure 24: Bio – Geographic Zones of India.

In the year 2000 Arunachal Pradesh was covered with 63,093 Km^2 (24,360 Sq Mi) of tree cover (77% of its land area). Arunachal forests account for one – third of habitat area within the Himalayan biodiversity hot – spot. In 2013, 31,273 Km^2 (12,075 Sq Mi) of Arunachal forests were identified as part of a vast area of continuous forests (65,730 Km^2 or 25,380 Sq Mi, including forests in Myanmar, China and Bhutan) known as **"Intact Forest Landscapes" (IFL)**. It harbours over 5,000 plants, about 85 terrestrial mammals, over 500 birds and a large number of butterflies, insects and reptiles. At the lowest elevations, essentially at Arunachal Pradesh border with Assam are Brahmaputra Valley semi – evergreen forests. Much of the state, including the Himalayan foothills and the Patkai hills, are home to Eastern Himalayan broadleaf forests. Toward the Northern border with Tibet, with increasing elevation, come a mixture of Eastern and Northeastern Himalayan subalpine conifer forests followed by Eastern Himalayan alpine shrub and meadows and ultimately rock and ice on the highest peaks. It supports a large number of medicinal plants and within **"Ziro Valley"** of **"Lower Subansiri District"** 158 medicinal plants are being used by its inhabitants. The mountain slopes and hills are covered with alpine, temperate, and subtropical forests of dwarf rhododendron, oak, pine, maple and fir. The state has **"Mouling"** and **"Namdapha National Parks"**.

7.1: Trans – Himalayan

It is an extension of the Tibetan plateau, harboring high – altitude cold desert in Ladakh (Jammu & Kashmir) and Lahul Spiti (Himachal Pradesh). It comprises about 5.7% of the country's landmass.

7.2: Himalayan

The entire mountain chain, running from North – Western to North – Eastern India, comprises a diverse range of biotic provinces and biomes. It covers 7.2% of the country's landmass.

7.3: Desert

This is an extremely arid area, which is mainly in the West of the Aravalli hills range, comprising both the salty desert of Gujarat and the sand desert of Rajasthan. It covers about 6.9% of the country's landmass.

7.4: Semi – Arid

The zone lies between the desert and the Deccan plateau, including the Aravalli hills range. It covers 15.6% of the country's landmass.

7.5: Western Ghats

The hill ranges and plains running along the Western coastline, South of the Tapti River, cover an extremely diverse range of biotic provinces and biomes. It is extended on 5.8% of the country's area.

7.6: Deccan Peninsula

This is largest of the zones, covering much of the Southern and South – Central plateau with predominantly deciduous vegetation. About 4.3% of the country's landmass is under this province.

7.7: Gangetic Plain

This is defined by the Ganga river system. These plains are relatively homogenous in surface characteristics. It covers about 11% of the country's landmass.

7.8: North – East India

The plains and non – Himalayan hill ranges of North – Eastern India have wide variation of vegetation. This zone is one of the highly diverse regions in terms of species richness and endemism covering about 5.2% of the country's geographical area.

7.9: Islands

This includes Andaman and Nicobar Islands in the Bay of Bengal, with a highly diverse set of biomes comprising of 0.03% of the country's landmass.

7.10: Coasts

A large coastline distributed both to the West and East, with distinct differences between the two; Lakshadweep islands are included in this with the percentage area being negligible. India is one of the 12 identified mega – biodiversity centers of the world. It also harbours two of twenty – five identified biological diverse centers termed as **"Hot Spots"**; the Eastern Himalaya covering Indo – Burma region and Western Ghats in South India and Sri Lanka. **"Hot Spots"** are the areas that are extremely rich in species, have high degree of endemism and are under constant threat called **"Loss of Biodiversity"**. These areas are very rich in **"Flora and Fauna"** diversity.

7.11: Eastern Himalaya

Physio – graphically, the Eastern Himalaya forms a distinct floral region. The area comprises Nepal, Bhutan and neighbouring states of North – East India. Although all Eastern Himalayan forests lie North of tropic of cancer and some of them are at the altitude of 1,780 to 3,500 meters, they can be considered as tropical forests since they occur largely within the climatic tropics.

(i) This region is the meeting ground of Indo – Malayan and Indo – Chinese bio – geographic realms as well as the Himalayan and peninsular Indian elements, formed when the peninsula plates struck against the Asian plate.

(ii) Around 30% flora is endemic to India. Of these endemic species, 3,500 are found in this region. Many deep and isolated regions are exceptionally rich in endemic plant species. In Sikkim, 60% of plants species are endemic. In India's sector of the area, there are about 5,800 species of which about 2,000 (36%) are endemic.

(iii) In Nepal, there are 7,000 plant species, many of which overlap with India and Bhutan. Of these species about 500 are believed to be endemic. In Bhutan Himalaya about 15% of plant species are considered to be endemic to Eastern Himalaya.

7.12: Western Ghats:

Western Ghats extends parallel to the Western coasts in North – South direction. Average altitude ranges between 900 to 1,100 m and average width is 50 to 80 Km. About 40% of endemic species are found in a 17,000 Square Kilometers strip of forests along the seaward side of Western Ghats in Maharashtra, Karnataka, Tamil Nadu and Kerala. Forests tracts up to 500 m in elevation, comprising one – fifth of the entire forests expanse, are mostly evergreen while those in the 500 to 1,500 m range are semi – evergreen. There are two main centers of diversity, the **"Agastyamalai Hills"** and **"Silent Valley"**:

(i) About 62% of known amphibian species are endemic with the majority occurring in the Western Ghats. Nearly 50% of lizards of India are endemic with high degree of endemism in the Western Ghats.

(ii) There are currently seven national parks in Western Ghats with a total area of 2,073 Square Kilometers and 39 wildlife sanctuaries covering an area of about 13,862 Square Kilometers.

(iii) The status of management of wildlife sanctuaries in this part of India varies enormously. Nilgiri wildlife sanctuary, for example, has no human inhabitant, while the Paramikulam wildlife sanctuary in Kerala includes considerable area of commercial plantation with heavy resources exploitations.

India has a large network of protected areas that gives priority to conserve and protect the remaining **"Biodiversity Centers" (Natural Forests)**. Altogether, there are 14 biosphere reserves, out of them three are in the world network of biosphere reserve – Sunderban, Gulf of Mannar and Nilgiris. Also, there are about 100 national parks and about 500 wildlife sanctuaries. The forests in India range from tropical evergreen forests in Andaman and Nicobar Islands, Western Ghats and North – Eastern states to dry alpine scrub in high Himalaya. Between the two extremes, the country has **"Semi – Evergreen"** rain forests, deciduous monsoon forests, thorn forests, subtropical pine forests in lower mountain zone and temperate mountain forests. Western and Central India is characterized by dry and thorn forests **(Table 13)**.

Table 13: General Distribution of Forest Types in India.

Sr. No.	Forest Type	Area of Occurrences
1.	*Tropical Wet Evergreen Forests*	**North – East and South India, Andaman and Nicobar Island**
2.	*Tropical Semi – Evergreen Forests*	**South and East India**
3.	*Tropical Moist Deciduous Forests*	**Central and East India**
4.	*Tropical Dry Deciduous Forests*	**West and East India**
5.	*Tropical Thorn Forests*	**West and East India**
6.	*Tropical Dry Evergreen Forests*	**Central and South India**
7.	*Subtropical Broad – Leaved Forests*	**South India**
8.	*Subtropical Pin Forests*	**Sub – Himalayan Regions**
9.	*Subtropical Dry Evergreen Forests*	**North – East and South India**
10.	*Montane Wet Temperate Forests*	**Himalaya and Nilgiris**
11.	*Himalayan Moist Temperate Forests*	**Temperate Areas of Himalaya**
12.	*Sub – Alpine Forests*	**Himalaya Range**
13.	*Himalayan Dry Forest and Alpine Scrubs*	**Himalaya Range**
14.	*Littoral and Swap Forests*	**Along the Coasts**

North – Eastern states, viz., Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, parts of states to the western side of Western Ghats, coastal plains and islands, etc., have very rich forests and biodiversity. Each of these states has more than 70% area under forest cover. These regions are mainly having tropical evergreen forests. Some tribal and hill states, viz., Orissa, Chhattisgarh, Uttarakhand and Himachal Pradesh have also a large area under forest cover. On the other end, Punjab, Haryana, Uttar Pradesh, Bihar and Rajasthan, each having less than 10% of their geographical area under forest cover, are very poor in terms of forest cover **(Table 14)**.

Table 14: Special Distribution of Forests in India.

Sr. No.	States/ Union Territories	Forest Cover (Sq. Km.)	Percentage (%age)	Tree Cover (Sq. Km.)	Percentage (%age)	Forest and Tree Cover (%)
1.	**Andhra Pradesh**	*44,372*	**16.13**	*7,640*	**02.78**	*18.91*
2.	**Arunachal Pradesh**	*67,777*	**80.93**	*446*	**00.53**	*81.46*
3.	**Assam**	*27,645*	**35.24**	*1,484*	**01.89**	*37.13*
4.	**Bihar**	*5,579*	**05.92**	*2,522*	**02.68**	*08.60*
5.	**Chattisgarh**	*55,863*	**41.32**	*4,492*	**03.32**	*44.64*
6.	**Delhi**	*176*	**11.87**	*107*	**07.20**	*19.07*
7.	**Goa**	*2,164*	**58.45**	*268*	**07.24**	*65.69*
8.	**Gujarat**	*14,715*	**07.51**	*7,621*	**03.89**	*11.40*
9.	**Haryana**	*1,587*	**03.59**	*1,565*	**03.54**	*07.13*
10.	**Himachal Pradesh**	*14,369*	**25.81**	*709*	**01.27**	*27.08*
11.	**Jammu & Kashmir**	*21,273*	**09.57**	*5,633*	**02.53**	*12.10*
12.	**Jharkhand**	*22,591*	**28.34**	*3,080*	**03.86**	*32.20*
13.	**Karnataka**	*35,251*	**18.38**	*5,467*	**02.85**	*21.23*
14.	**Kerala**	*15,595*	**40.13**	*2,632*	**06.77**	*46.90*
15.	**Madhya Pradesh**	*76,013*	**24.66**	*6,267*	**02.03**	*26.69*
16.	**Maharashtra**	*47,476*	**15.43**	*8,978*	**02.92**	*18.35*
17.	**Manipur**	*17,086*	**76.53**	*142*	**00.63**	*77.16*
18.	**Meghalaya**	*16,988*	**75.74**	*405*	**01.80**	*77.54*
19.	**Mizoram**	*18,684*	**88.63**	*122*	**00.58**	*89.21*
20.	**Nagaland**	*13,719*	**82.75**	*238*	**01.43**	*84.18*
21.	**Orissa**	*48,374*	**31.07**	*4,589*	**02.95**	*34.02*

22.	**Punjab**	*1,558*	**03.09**	*1,823*	**03.62**	*06.71*
23.	**Rajasthan**	*15,850*	**04.63**	*8,379*	**02.45**	*07.08*
24.	**Sikkim**	*3,262*	**45.97**	*27*	**00.38**	*46.35*
25.	**Tamil Nada**	*23,044*	**17.72**	*5,621*	**04.32**	*22.04*
26.	**Tripura**	*8,155*	**77.77**	*134*	**01.28**	*79.05*
27.	**Uttar Pradesh**	*14,127*	**05.86**	*8,203*	**03.40**	*09.26*
28.	**Uttarakhand**	*24,442*	**45.70**	*658*	**01.23**	*46.93*
29.	**West Bengal**	*12,413*	**13.99**	*2,269*	**02.56**	*16.55*
30.	**Andaman and Nicobar**	*6,629*	**80.36**	*53*	**00.65**	*81.04*
31.	**Chandigarh**	*15*	**13.16**	*09*	**07.61**	*20.77*
32.	**Dadra and Nagar Haveli**	*221*	**45.01**	*28*	**05.66**	*50.67*
33.	**Daman and Diu**	*08*	**07.14**	*09*	**07.76**	*14.90*
34.	**Lakshadweep**	*25*	**78.13**	*04*	**13.33**	*91.46*
35.	**Pondicherry**	*42*	**08.75**	*42*	**08.66**	*17.41*
	Total	***6,77,088***	**20.60**	***91,663***	**02.79**	***23.39***

Geographical distribution of forest cover is depicted in **Figure 24**. It can be concluded from the figure that Eastern Himalaya, Western Himalaya, Western Ghats, islands have substantial area under forest cover. Eastern parts of Central Indian upland, *i.e.,* Orissa, Chattisgarh, Jharkhand, Eastern Madhya Pradesh, etc., are also characterized by dense forests. North – Western parts of the country, Indo – Gangetic plain and rain shadow parts of South India are very poor in terms of forest cover **(Figure 25)**.

Figure 25: Spatial Distribution of Forest in India.

The number of plant (flowering and non – flowering) species in India is estimated to be over

47,000 representing about 12% of world's flora. These are categorized in different taxonomic divisions including over 1,500 flowering plants. Estimates for lower plants are: 64 gymnosperms, 2,843 bryophytes, 1,012 pteridophytes, 1,940 lichens, 12,480 algae and 23,000 fungi. Some 5,150 species of flowering plants are endemic to the country. Among the endemic species, 2,532 species are found in Himalaya and adjoining areas followed by 1,782 species in peninsular India. About 1,500 endemic species are facing varying degrees of threat. In India, tropical forests harbour around 89,451 animal and 49,219 plant species. Forests are rich in **"Floral and Faunal"** diversity and are regarded as home of the biodiversity because most of the biodiversity occurs in the forests particularly tropical forests among terrestrial systems have a great number of species.

"COMPARISION OF TOP 10 COUNTRIES IN BIODIVERSITY WITH INDIA"

Discover the most diverse countries in the world. ***"The loss and degradation of Biodiversity negatively affects every level of the planet. Next Brazil; South Africa; Madagascar; Ecuador; Mexico; United States; China; Philippines; Australia Countries with more Biodiversity in the world"***. The loss and degradation of biodiversity negatively affects every level of the planet, especially the poor and vulnerable: women, children and indigenous people, therefore, biological diversity is indispensable for the well – being of mankind. America is the continent that has the most countries rich in biodiversity: Brazil, Colombia, Ecuador, Mexico, Peru, Venezuela and the United States. ***"For its part, in Asia, the countries with the greatest Biodiversity are China, Indonesia, India, Philippines and Malaysia. In Africa, Madagascar, Democratic Republic of Congo and South Africa and, lastly, Oceana has Australia and Papua New Guinea. These countries together are home to more than 70% of the planet's Biodiversity...!!!"*** And their territory is only 10% of the earth's surface. These 10 countries are together home to over 70% of the planet's **"Biodiversity Tweet"** the quantity and quality of forests, as well as living creatures, is the data analyzed for preparing this list of the Top 10 countries with the greatest biodiversity of 2014. ***"Sustainability is understood as the development that meets the present needs without compromising the capacities of future generations, ensuring the balance between economic growth, environmental care and social welfare"***. In sustainability for all we promote the awareness and diffusion of good practices that allow to combine economic and social development with the preservation of natural resources comparison including India.

Brazil: It is the country with the greatest biodiversity of **"Flora and Fauna"** on the planet. Brazil has the highest number of species of known mammals and freshwater fish, and more than 50,000 species of trees and bushes, it takes first place in plant diversity. Even so, the loss of tropical forest (due to uncontrolled agriculture and logging) is still on the rise.

South Africa: One of the most diverse countries in the world. It contains nearly 10% of all known species of birds, fish and plants registered in the world and 6% of mammal and reptile species. Poaching and deforestation are problems that this territory rich in biodiversity must face.

Madagascar: Approximately 70% of species that inhabit these islands are totally unique in the world. Its great richness of biodiversity goes from lemurs, mongoose, chameleons, bats, foxes...!!! Additionally, during the last decade 40 mammals, 69 amphibians, 61 reptiles, 42 invertebrates and 385 new plants were discovered within its territory. Even so, 75% of its forests have disappeared over the last few decades; therefore urgent measures must be taken to stop this phenomenon.

Ecuador: This country has more species of plants per area unit than any other country in South America. 18% of the total discovered birds in world, 1,655 birds, are found in Ecuador. The 382 mammal species that exist in this country comprise 7% of the 5,490 species registered in the world. It is, in summary, a rich tropical region, with wetlands, due to its privileged geographic location in the Neotropics, which makes it form part of this privileged list of biodiversity.

Mexico: Mexico is home to between 10 and 12% of the species of the planet. What is the reason for these fantastic data on biodiversity...? It is privileged geographical position, the variety of climates and its complex topography, which have favored a great variety of conditions. In addition, it is one of the

countries in the world with the greatest extension of coasts and has an exclusive sea, the **"Gulf of California",** which is the second largest reef in the world.

United States: In its vast extension, the USA has almost 400 National Parks among, which we find deserts, glaciers, forests, plains and canyons. According to the climate of each zone, the autochthonous vegetation and animal life, is characterized by the variety. Yosemite, Yellowstone, the **"Glacier Bay in Alaska",** Hawaii... is a paradise in terms of **"Biodiversity"**.

China: It is the third largest land area in the world. Its great diversity of landscapes and a great variety of natural resources are distributed in its mountains (which occupy 43% of the territory). It has 30,000 plants and 6,347 vertebrates, representing 10% and 14% of the animals and plants of the world. But, once again, between 15% and 20% of the plants are on the verge of extinction, affecting the survival of up to 40,000 biological species.

Philippines: The biodiversity of its mountains, its marine life, and its indigenous population... make the Philippines one of the paradises of biodiversity, with its more than 7,100 islands of great vegetable and animal wealth. Unfortunately, their forests suffer the constant exploitation of natural resources, so they must stay alert. The increasingly incessant scourge of typhoons due to climate change is also another factor that may end up destroying this pearl the planet.

Australia: The curious thing about Australia is that despite being mostly desert or, at least, semi – arid, it has a great diversity of habitats where tropical forests are also found. Its climates are very variable, but thanks to the isolation in time that it experiences from other continents, it obtains that of 85% of the flowering plants, 84% of the mammals, more than 45% of the birds, and 90% of the fish from temperate coastal areas (where the greatest biodiversity is concentrated) are endemic.

8. COMPONENTS OF MANAGEMENT PLAN

"To prepare a detailed Biodiversity conservation plan, information on administrative aspects, ecology, human activities including intrusions and land use patterns are essential". These would require compilation of available information and new studies which will help in formulation of the plan.

8.1: Identification of Important Habitat Types

Using habitat suitability mapping potential suitable habitats for tigers have been identified within Namdapha National Park. This will help in prioritizing areas for tiger conservation. The potential suitable habitats need better protection and conservation efforts so as to sustain viable tiger populations. The suitability map was classified into five levels of suitability. ***"For deriving the suitability map five parameters were used namely, vegetation type, vegetation density, elevation, slope and distance from anthropogenic disturbances"***. Thematic layers depicting each of the three factors were also generated. The set of input layers were run on Arc Map 9.3 using weighted sum spatial analyst. Input set of factors in the raster format were run using weighted sum approach. As such, the vector layers converted into raster format.

Higher the value greater is the suitability with respect to tiger habitats. Protection and restoration of these potential habitats shall go a long way in conserving the large mammal population. Similar suitability maps can be developed for other threatened species inhabiting the park area.

8.2: Identification Suitable Sites for Watch Towers and Water Holes

Using habitat suitability map and relief distribution maps, sites suited for location of watch towers and water holes. Watch towers are usually located at higher points within the protected areas so that a

larger area can be kept under observation at any point of time. Using **"Geographical Information System" (GIS)** we can find sites where watch towers should actually be located within the park area for better vigilance. The rivers flowing through the park area are seasonal with limited water flow during dry season. Hence, to cater to the needs of the inhabiting wildlife throughout the year water holes or water reservoir needs to be constructed within the park area.

Satellite data is in association with **"Geographical Information System" (GIS)** provide cost and time effective tool for **"Mapping"** and **"Formulation of Conservation and Management Plans"**. Over the past few years, the sustainable management of protected areas has gained more and more recognition within the relevant government sectors, yet due to the economic development pressure and high population growth, it is a challenge to turn policies into action. For a continuous and proper management, decision makers and policy makers need to be provided with useful and understandable information on all relevant factors. Using GIS and Remote Sensing it will be possible to map analyze data and attain information at any scale according to the management and conservation requirements.

Concluding Interpretation

Conservation of biological diversity through protected area networking in the less explored Eastern Himalayan zone is distant dream due to several constraints, viz. inadequate data on biodiversity potential, village – to – village and community – to – community variations in dialects and culture, site inaccessibility, natural disasters, ineffective legal enforcement mechanisms, and lack of adequate infrastructural facilities and of well trained, well equipped and motivated personnel. The age old practice of shifting agriculture has been one of the factors affecting the virgin forest cover in the region. Moreover, people are forest dependent and any external intervention or monitoring of biodiversity or natural resources without people's participation will not be successful, even if it is well intended. In order to effectively manage biodiversity, the communities should be consulted through a functional participatory mode of community mobilization.

Nevertheless for conservation purposes, **"Protected Areas"** needs meticulous monitoring that is rational and at the same time useful for management, rather than what is ideally required for in – depth studies of how community structure and species richness are affected by anthropogenic stress and changing environmental conditions. ***"There is an urgent need for environmental education and awareness regarding Biodiversity conservation amongst the local communities"***. Overall, the land use development schemes in and around the PAs should be oriented towards:

(a) *Environmental education to local people;*

(b) *Managing abandoned shifting agriculture lands or providing suitable alternatives to shifting cultivation through community consultation; and*

(c) *Strengthening linkage between people's institution and other government agencies for sustainable development.*

The project has been able to meet its intended objectives. Spatial database for all four **"Protected Areas"** have been created, which would be very valuable in both management and monitoring of resources and especially in revising and updating the management plans. The availability of spatial information at the **"Forest Range Level" (FRL)** is an important contribution of the project which would help in improving the efficacy of protected area management.

As part of the project activities the spatial database so developed would be provided to the forest officials in the respective PAs and it would be imperative upon the PA management to use as well as update the database periodically. The process of converting the outputs of the project into scientific research articles is also being done. These research credentials as and when published would serve as a valuable reference material for the scientific community and park mangers interested in the application of **"Remote Sensing"** and **"Geographical Information System" (GIS)** in protected area management and wildlife conservation. The capacity building of the involved researchers to conduct ecological surveys

and to build spatial databases using satellite data has also been a major achievement of this project. The project has demonstrated the utility of LISS – III satellite images in **"Land Use/ Land Cover" (LU/ LC)** and infrastructure mapping of inaccessible, rugged terrain.

9. BIODIVERSITY MANAGEMENT IMPLICATIONS PROFILE

From the present study it can be said that the four **"Protected Areas"** taken into consideration are ecologically very important owing to the wildlife inhabiting these areas. The following are the major management implications:

(i) *Moderate spatial resolution and multispectral nature of IRS – P6: LISS – III satellite data is very useful in forest types and density mapping;*

(ii) *The time for the satellite data acquisition for vegetation mapping should be carefully chosen so as to capture maximum variations amongst forest types. November, December and January months are the best time for satellite data acquisition since vegetation is in the peak of its biomass and cloud free data can also be obtained;*

(iii) ***"Land Use/ Land Cover" (LU/ LC)** mapping exercise should be repeated at every five year interval to monitor changes in landscape;*

(iv) *Data on forest inventory should be collected at five year interval to monitor changes in floristic;*

(v) *Proper records should be maintained with respect to wildlife population in the **"Protected Areas"** and should be used for subsequent monitoring of their populations;*

(vi) *The maps generated in this study could be employed in monitoring and management of the PAs and key wildlife habitats;*

(vii) *Presence of human habitations tends to lower habitat suitability for key species and therefore appropriate village relocation programmes should be planned and implemented;*

(viii) *Ecological separation amongst wild population is mediated by canopy densities which has implications for habitat management.*

(ix) *Controlled burning has positive influence on wild population abundance and distribution, hence need to be practiced but with due caution;*

(x) *Intensive training of all frontline staff with regard to use of **"Global Positioning System" (GPS)** and recording of information on to datasheet is highly desirable to ensure more rigorous and scientific approach to the population estimation exercise.*

The neglect of ecological knowledge is often a limiting factor in the application of statistical modeling in ecology and conservation planning and therefore an amalgamation of ecological theory and modern statistical modeling is needed. This study has a direct application to the conservation of wildlife implicitly. The present study will also serve as a primary input for planning management interventions for sustaining the phyto – diversity of the diverse forest cover present in the area of study. In order to achieve the more dynamic and specific species distribution models, modelers, bio – geographers, community ecologists, population biologists and eco – physiologists need to work synergistically. ***"It is expected that the results of this research will be linked with the results of other Biodiversity research both globally and locally and will be used to improve conservation and management plans in near future"***.

Management Goals

The **"Management Goals"** of the **"Tiger Reserve"** are to protect and Conserve the unique Biological diversity of the **"Namdapha Tiger Reserve",** for the values listed in this study. The management initiative aims to protect not only the flagship species *i.e.,* Tiger but all the biological elements, which are the integral part of the **"Namdapha Ecosystem"**. In this landscape each and every element is essential and integral because missing of a single link will break the chain. The management objectives are summarized as follow:

(i) *In situ conservation of the unique biodiversity;*
(ii) *To sustain a viable population of Tiger, the flagship species; and*
(iii) *To act as source population for the sink population of the surrounding forest areas.*

10. A NOVEL REVISION ON RELIABILITY – BASED DESIGN OPTIMIZATION FOR BIODIVERSITY

The consideration of biodiversity and **"Ecosystem Services" (ES)** in impact assessment are providing a critical analysis of some of the latest research and practices in this field. And to support researchers and practitioners are in the conceptual development and operational implementation of biodiversity and ES – inclusive impact assessment process. Biodiversity and ecological analysis to **"Individual Species" (*e.g.*, Iconic, Endangered or Protected Species)** and sites already designated for natural conservation, concluding that the majority of EIA did not discuss impacts on the different levels at which biodiversity occurs.

Meanwhile the Convention on Biological Diversity endorsed and popularized a broader definition of ***"Biodiversity", seen as "The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part; this includes diversity within species, between species and of ecosystem"***.

More comprehensive approaches to address biodiversity in impact assessment were developed in the years that followed. For example, identified important principles are to ensure that biodiversity considerations are appropriately addressed in EIA and SEA, respectively. **"Decision – Support – System/ Techniques"** have advanced the treatment of uncertainty factors in **"Biodiversity Impact Assessment" (BIA)**. The foundations for landscape and regional level analysis of biodiversity in SEA applied innovative modeling tools to predict and assess impacts on biodiversity of projects plans. Even though all these studies demonstrates a more systematic understanding of biodiversity and its complexity, they look at biodiversity from a nature conservation perspective, with limited (or only indirect) consideration of human development and well – being. The economics of **"Ecosystem"** and **"Biodiversity"** comes under **"Intergovernmental Platform"** and the proposed integrative impact framework that include the effects of development on ES and human well – being, along with more traditional biodiversity conservation issues. Biodiversity and ES information can be mainstreamed in different impact assessment types to improve their salience and effectiveness. **"Biodiversity"** and **"Ecosystem Services" (ES)** are within existing impact assessment types, rather than via separate stand – alone processes and innovative conceptual frameworks, and practical methodologies, to strengthen the consideration of **"Biodiversity"** and **"Ecosystem Services" (ES)** in different type of impact assessment.

Biodiversity and ecosystem services and their quantification introduce the state of the art of the different impact indicator proposals addressing biodiversity loss and change in **"Ecosystem Services" (ES)** in the frame of **"Life Cycle Assessment" (LCA)**. The review focuses on the effects of land use and land change as the key drivers of biodiversity loss. Finally, the main challenges in the quest for good and harmonized indicators to account properly for biodiversity in terms of ES in LCA and the impact of urbanization on biodiversity and the capacity of urban green areas to provide ES. And a description of the role of biodiversity and ES is provided the framework for a landscape approach in biodiversity assessment

and for presenting the practical examples. Three different case studies in urban planning from the region are presented and discussed, together with tools to predict and assess biodiversity impacts at a landscape level and to plan and manage urban green areas. To assess the impact of agricultural and forest management on **"Biodiversity"** and **"Ecosystem Services" (ES)** for **"Agricultural"** and **"Forest Land"** management practices play a key role in affecting biodiversity shifts and sustaining natural capacities to provide a multitude of ES. Positive and negative impacts are identified, acknowledging that the nature of such impacts is influenced by political and socio – economic factors that characterize the areas in which the biodiversity occurs. The findings of the review are used to identify key issues that should be addressed in **"Biodiversity Impact Assessment" (BIA)** of any planned development interventions, if the subsequent implications for poverty are to be taken into account.

To explore biodiversity offsets in the context of impact assessment processes, particularly examine the role of offset in achieving **"No Net Loss"** or **"Net Gain"** of biodiversity when the development takes place. Challenges to effective offset design and responses to challenges are to be discussed as quantitatively estimate impacts on services, consistently construct mitigation replacement ratios and identify and design potential ES offsets. Climate change is also expected to be an increasingly important source of impact on biodiversity and **"Ecosystem Services" (ES)**. In other words, **"Ecosystem Services" (ES)** provision depends not just on how much of a particular ecosystem is present, or the level of biodiversity or ecosystem functions within it, but also where that ecosystem is located on the landscape and critically, where relative to people who have the potential to benefit from its functions. The concept of **"Service – Heads"** provides a practical way to account for this spatial aspects of **"Ecosystem Services" (ES)** provision. **"Service – Heads"** are defined as those area that provide specific **"Ecosystem Services" (ES)** to a specific beneficiary, which may be an individual, a group of people, a government or a corporation etc. **"Service – Heads"** link the places on the landscape where ES are supplied to the people and places to which the benefits of those services occur. They make it possible to identify who will be affected by impacts to the environment from development and which ecosystem services will be affected. With this information, impacts between alternative project designs then can be directly compared or mitigation activities can be designed to return benefits back to the same people who lost services with development.

A comprehensive, integrated framework for biodiversity and ES mitigation has been proposed as summaries in key impact assessment steps and **"Biodiversity Impact Assessment" (BIA)** efforts have traditionally focused on project – scale assessments, but recent calls have emphasized the need to expand to a landscape scale approach that allows for consideration of cumulative impacts and international consideration of efficient and effective siting and offset design. **"Service – Heads"** boundaries can be delineated for any prioritized service and related beneficiaries, just as boundaries for biodiversity can be peroxide by ranges, occurrences, densities, numbers and interactions of species and habitats. Ultimately, the spatial extent needed to capture both biodiversity (and associated ecological processes), and **"Service – Heads"** (and associated beneficiaries) of all services targeted. As in **"Biodiversity Impact Assessment" (BIA),** a subset of ES should be chosen that reasonably represents the full set of services relevant to the system. Unlike **"Umbrella Species"** in the biodiversity context that have consistent ability to reflect trends in other associated species, ES relationships often vary from place to place. This means that a service that might be a good surrogate for other service in one place is not guaranteed to play that role well in another. For example, water quality regulation and carbon sequestration were positively correlated (and so good proxies for each other) in North – Eastern part of India, but held the opposite relationship in Argentina prioritization of the components to be assessed. This engagement of stakeholders and the ultimate use of the output by decision – makers, require methods to rationalize and communicate complex information, including the communication of uncertainty.

Modeling and mapping approaches are effective analysis and communication tools that enable important areas for ES provision to be identified and potentially prioritized for protection. They also assists in identifying possible trade – offs between areas of high intensities of human activities and services provision. The main limitations though are the information requirements in terms of habitat maps, understanding of the relationships between marine habitats and ES provisions, and how human pressure may reduce service flows. Despite this and compared to other pressures, effectively managed

ecotourism can be positive activity in regard to the conservation of biodiversity. However, problems, even with the supposed begin character of ecotourism, such as risk of human – carried disease transmission to target species, are apparent. Most of the great apes in Africa reside in protected areas, but even in these places there can be problems of hunting and poaching for food and traditional medicines. This has been identified as a problem and reported on poor management effectiveness in many of the world's protected areas. These problems occur at various scales such as landscape – level impacts such as pollution, agriculture encroachment, invasion of pest species, illegal logging and inadequate resources to manage a particular park or other type of protected area.

At the same time the future of great ape conservation beyond existing protected area network (which are potential ecotourism resources) due to deforestation is especially problematic, where there is a combination of existing agriculture, rapid human population growth, a lack of enforcement controls on illegal logging (either due to corruption or inadequate park management effectiveness) and planned industrial agricultural projects with potential loss of important ecotourism resources and wildlife connectivity. There is a major problem when there are dominant government policies that emphasize agriculture, mining and timber rather than wild – life based ecotourism...!!! If there is no specific reason for tourist to visit areas that have high biodiversity, governments will not easily be convinced to protect them especially in the absence of financial incentives. In this regard, **"Environmental and Social Impact Assessment" (E/ SIA)** especially needs to be considered in the context of places which are high in biodiversity, that have no ecotourism. For example, almost a decade ago areas that remained unrecognized and not properly protected or designed as protected areas are lost opportunities for positive impact ecotourism development. However, this additional ecotourism potential is also dependent on constructive political views and social stability.

Most of the river basins support both high levels of biodiversity and a large human population dependent upon fisheries or agriculture maintained by free – flowing river floodplain processes. The potential impacts of dams on biodiversity expands on the typology of cumulative impacts as it applies to dams and how these are distinguishable based on contextual, spatial and temporal dimensions of impacts and multiplicity of drivers of change. Impacts in nature are not experienced sequentially, from one dam to another. It is also almost impossible to unscramble the impacts from those of individual or multiple projects or from those resulting from other indirect perturbations in a landscape. Anticipating impacts is therefore not synonymous with accurately predicting the nature and magnitude of impacts from several projects having multiple sources and complex pathways, seen together on ecosystems and biodiversity. Addressing cumulative impacts or effects of large development projects is therefore increasingly gaining importance. Such effects refer to ***"The net result of environmental impact from a number of projects and activities"***. These impacts can also be explained as spatially or temporally accumulated changes in the environment resulting from the perturbations originating from one or more resources sectors and activities over time and space.

This sheds light on some of the issues that should be addressed in **"Biodiversity Impact Assessment" (BIA)** of any planned development interventions if the subsequent implications for poverty are to be taken into account. Specifically, there is a need to upgrade **Nampong to Vijaynagar Regions**:

- *Unpack **"Biodiversity"**, and clarify which are the most important components of biodiversity for poor people (e.g., the availability of some key species; the availability of a particular type of resource such as bush meat or firewood). This would help to steer the scoping stage of impact assessment towards the issues that matter the most to the poor people.*

- *The people with different income levels or different degree of dependency from given biodiversity resource or service (due to livelihood systems, culture, lifestyle, etc.) **(UNEP, 2014)**. In this way, clear predictions of winners and losers associated with planned interventions can be produced and used to inform decision – making, but also to enhance public engagement, which is central to impact assessment processes.*

- *Understand the way in which poor people extract values from biodiversity, so as to predict the effects on these processes that the planned interventions is likely to cause, for example, in terms of reducing the quality or quantity of a given resource or generating biodiversity **"Dis – Services"**. This would provide much more context – specifies information on which to base possible alternative strategies that minimize negative interferences and/ or enhance positive ones. In this way, impact assessment could be used not only in a reactive way to assess the effects of proposals, but also in a more proactive way, to improve the design and implementation of such proposals.*

11. BIODIVERSITY OFFSETS FOR "NO NET LOSS" THROUGH "BIODIVERSITY IMPCT ASSESSMENT (BIA)"

Simply stated, biodiversity offsets are intended to balance loss of biodiversity due to development with commensurate gain. Loss of biodiversity is escalating and climate change is likely to accelerate that loss. The current rate of species extinction is estimated to be 100 – 1,000 times more that would be expected to occur naturally. This is an issue of deep concern, not only because biodiversity has intrinsic value, but also because it underpins a wide range of **"Ecosystem Services" (ES)** on which humans depend. If current rates of loss continue, the capacity of ecosystems to provide for the needs of present and future generations is uncertain. It is against this background that interest in biodiversity offsets has strengthened. Environmental policies and regulations in developed countries have increasingly incorporated **"No Net Loss" (NNL)** and preferably **"Net Gain" (NG)** concepts. **"Impact Assessment" (IA)** is seen as a key implementation mechanism, because it is endorsed by several international conventions as a tool for mainstreaming biodiversity into planning and decision – making, is widely promoted as a tool for **"Corporate Social Responsibility" (CSR)** and is seen by financial institutions as a key tool to manage environmental and social risks of the developments in which they invest. One of its advantages is that it assigns liability to developers to compensate for environmental damage, according to the **"Polluter Pays Principle" (PPP),** as in Europe, for example residual losses of biodiversity are accepted in many IA systems, provided that reasonable efforts are made to avoid or minimize impacts. This approach is one of the main reasons why addition of an offset step to the mitigation hierarchy is considered necessary if there is genuine intent to achieve NNL/ NG.

Recognizing the role that offsets could play in strengthening IA through the mitigation hierarchy, more than 60 countries have adopted, or are developing, policies or laws requiring compensation or offsets biodiversity loss with gains may be insurmountable, and that offsets might **"Perversely Yield Worse Biodiversity Outcomes" (PYWBO)** than weakly enforced prohibitions. Biodiversity offsets are as part of the initial project **"Go"** or **"Not Go"** decision may be lead to authorization of projects that are inappropriate, because of the severity of their biodiversity impacts. The rest of the study explores the issues associated with incorporating biodiversity offsets in IA in line with good practice principles and standards. It then goes on to consider some of the aspects that need future consideration to allay fears that use of offsets might reduce the effectiveness of IA and accelerate loss of biodiversity due to development. Biodiversity offsets are measurable conservation outcomes resulting from actions designing to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken. The goal of offsets is to achieve NNL/ NG of biodiversity on the ground with respect to species composition, habitat structure, ecosystem function and people's use and cultural values associated with biodiversity.

12. BIODNIVERSITY OFFSET PRINCIPLES' IDIOLOGY/ PHILOSOPHY/ MORALITY

1. ***Adherence to the mitigation hierarchy:*** A biodiversity offset is a commitment to compensate for significant residual adverse impacts on biodiversity identified after appropriate avoidance, minimization and on – site rehabilitation measures have been taken according to the mitigation hierarchy.

2. ***Limits to what can be offset:*** There are situations where residual impacts cannot be fully

compensated for by a biodiversity offset because of the exposure or vulnerability of the biodiversity affected.

3. ***Landscape context:*** A biodiversity offset should be designed and implemented in a landscape context to achieve the expected measurable conservation outcomes taking into account available information on the full range of biological, social and cultural values of biodiversity and supporting an ecosystem approach.

4. ***No net loss:*** A biodiversity offset should be designed and implemented to achieve ***"In – Situ",*** measurable conservation outcomes that can reasonably be expected to result in no net loss and preferably a net gain of biodiversity.

5. ***Additional conservation outcomes:*** A biodiversity offset should achieve conservation outcomes above and beyond results that would have occurred if the offset had not taken place. Offset design and implementation should avoid displacing activities harmful to biodiversity to other locations.

6. ***Stakeholder's participation:*** In areas affected by the project and by the ***"Biodiversity offsets, the effective participation of stockholders should be ensured in decision – making about biodiversity offsets, including their evaluation, selection, design, implementation and monitoring"***.

7. ***Equity:*** A biodiversity offset should be designed and implemented in an equitable manner, which means the sharing among stakeholders of the rights and responsibilities, risk and rewards associated with a project and offset in a fair and balanced way, respecting legal and customary arrangements. Special consideration should be given to respecting both internationally and nationally recognized rights of indigenous people and local communities.

8. ***Long – term outcomes:*** The design and implementation of a biodiversity offset should be based on an adaptive management approach, incorporating monitoring and evaluation, with the objective of securing outcomes that last at least as long as the project's impacts and preferably in perpetuity.

9. ***Transparency:*** The design and implementation of a biodiversity offset, and communication of its results to the public, should be undertaken in a transparent and timely manner.

10. ***Science and traditional knowledge:*** The design and implementation of a biodiversity offset should be a documented process informed by sound science, including an appropriate consideration of traditional knowledge.

Assessing and evaluating impacts on biodiversity, applying the mitigation hierarchy and engaging a diverse range of stakeholders to understand their issues and values. In practice, addressing offsets effectively within IA dependents on many factors. Offsets may require longer lead times, more detailed or different data, different specialist skills, and/ or a wider special scope than is typically provided. To extent to which offset studies are completed within the IA process prior to authorization of a project is likely to be case and context specific, but should at least be sufficient to give assurance the **"Non – Offset able"** impacts on biodiversity would be avoided, that an offset could and would be successfully implemented, and that adequate financial provision for implementation has been made.

13. SCOPING AND BASELINE OF BIODIVERSITY ASSESSMENTS AND IMPACTS

Early identification of critical biodiversity, its sensitivity to impacts and, the likely ability to offset any residual impacts, is crucial. This enables the appropriateness and acceptability of offsets to be considered when there is still time to review alternatives, which is essential if there is any possibility that

impacts might be difficult or impossible to offset. The potential need for offsets should be considered at the scoping stage, especially if IA is being undertaken for proposals in biodiversity – rich or – sensitive environments such as in a **"Biodiversity Hot – Spots"** and centre of endemism in the Northern Cape, South Africa. In this way, the necessary information can be obtained without duplication of efforts or delay and adequate financial provision for the implementation of offset can be built into project budgets. As well as supporting rigorous assessment, evaluation and mitigation of impacts, identifying the intrinsic, use and cultural values of biodiversity during the early screening and scoping phases of IA, through stakeholder engagement and gathering of baseline information, provides a sound basis for deciding whether avoidance is appropriate.

"Impact Assessment" (IA) processes typically accommodate specialist studies to assess impacts on biodiversity and recommend mitigation, but may fall short of providing measures of residual negative impacts that could form the basis for detailed offset design and planning and budgeting for offset implementation. ***"To provide this information, it may be necessary to expand the scope of baseline studies, for example, to include information at the species, community and ecosystem level, and potential offset locations. As indicated in principles, a landscape – scale perspective is needed to understand the threats and pressures affecting "Biodiversity" and how these may be exacerbated by a development proposal"***.

14. CASE STUDY: "BIODIVERSITY HOTSPOTS" IN INDIA, ARUNACHAL PARADES STATE

The **"Arunachal Pradesh"** is one is of the world's **"Ecological Hotspots"** presenting a vast range of species and ecosystem diversity in the **"Eastern Himalayas"**. It is also considered as one of the eighteen **"Biodiversity Hotspots"** in the world. It is estimated over 5,000 species of flowering plants occur in the territory (of both – vascular and non – vascular origin). Out of which, 238 are endemic to the state. The vegetation/ forest are classified under 6 major categories *i.e.,* tropical, subtropical, temperate, subalpine and alpine vegetation, secondary forest and aquatic vegetation; each comprising subtypes primarily based on altitude and climate change. The state is rich in agro biodiversity and has been a centre of origin for a number of crop plant species. Orchids are often associated as the **"Jewels of Arunachal Pradesh"**. ***"The state houses 500 species out of 1,000 species, which are estimated to occur in India. It's the nature's repository of medicine plants. Out of 16 primates in the world, 7 are found in Arunachal Pradesh. The state has amazingly rich avifauna with over 650 bird species. The state is unique in having traditional rights of various tribes over land, water and forest within their jurisdiction. Each tribe as a community exercise control over the natural resources within their surrounding inhabited traditionally by them and sustainable use the resources for shelter, cultivation, food and other day to day multifarious uses"***.

Problems Resulting in Biodiversity Loss:

- ✓ *Deforestation;*
- ✓ *Jhum Cultivation;*
- ✓ *Tea Plantation;*
- ✓ *Timber Felling;*
- ✓ *Forest Fire;*
- ✓ *Hunting;*
- ✓ *Soil Erosion;*
- ✓ *Encroachment Problem; and*
- ✓ *Urbanization.*

A zinc mining company plans to expand its mine in the semi – desert **"Bush – Man – Land"** part of the **"Succulent Karoo Global", "Biodiversity Hotspots";** also a center of endemism. This region is home to unique succulent flora and is a national priority area for protected area expansion. A botanist identified and mapped sensitive areas on the mining site, comprising communities of plant

species of concern and important ecological corridors across the landscape has been introduced through some regions of the Arunachal Pradesh in India. The features had already been identified as **"Critical Biodiversity Areas"** in all over India through region and state wise in Arunachal Parades for **Nampong to Vijaynagar Road, BRO (PROJECT – UDAYAK) – Road**.

15. ASSESSING AND EVALUATING IMPACTS ON BIODIVERSITY

Assessing impacts typically involves analysis of their nature, magnitude/ severity, extent and duration. The severity of impact as being its intensity at a defined (usually spatial) scale; its extent as the proportion of the population/ range of a given biodiversity feature (inversely related to the viability of the reminder of that feature) and its durations the time period for which impact can be expected to continue. Evaluating impacts involves a judgment of the impact's significance that is, whether the impacts are acceptable to stakeholders, requires mitigation and/ or compensation, or is unacceptable. Significance lies at IA; it is not the same thing as **"Impact Magnitude",** which is the prerogative of scientists and technical experts and more amenable to objective and quantitative procedures. ***"Significance" takes into account the values that affected communities attach to "Biodiversity and broad societal values expressed through laws or policy related to environmental and Biodiversity conservation priorities and strategies"***. Essential elements in assessing and evaluating impacts on the intrinsic value of biodiversity for **Nampong to Vijaynagar Road** which includes as depicted below:

- ✓ *The conservation or threat status of affected ecosystems, habitats and species at different spatial scales;*

- ✓ ***Measuring losses and gains:*** **"Ideally all biodiversity losses addressed through offsets should be reversible"**. A good offset will account for loss and gain of biodiversity at all levels of biological organization, as well as the role of changes in structure, composition and function of biodiversity in influencing provision of ES to different stakeholders. A good metric should thus capture the type, amount and condition of the key biodiversity components that are being lost and gained and should take into account the underlying ecological processes/ function that sustain these components. Since it is generally impossible to measure every form of biodiversity, **"Surrogate"** or **"Proxies**" are often used to represents key biodiversity components.

- ✓ *A wide range of metrics has been developed over the last 40 years and the most use some measurement of habitat area as a basic proxy unit for calculating biodiversity losses and the conservation gain that must be achieved. Others use a combination of area and* ***"Condition"*** *or* ***"Quality"*** *of habitat. Area alone is not an adequate metric; such proxy measures of biodiversity need to be scaled against changes in the components of conservation concern (e.g., presence of a particular species); doubling of habitat area is not likely to lead to a doubling in species.*

- ✓ A number of complementary measures may be used to account for distinct biodiversity components and functions (*e.g.,* rare species, wetland functions); one method uses a **"Biodiversity Distinctiveness"** score as a levels of landscape connectivity are designed to make an explicit contribution to national conservation and sustainable use objectives, or determine **"Ecosystem and Species Credits"** at prospective offset sites. Populations, or other indicators of species diversity and abundance, may be measurable in some cases. Alternatively, the availability of suitable habitat and its capacity to support viable populations can serve as a proxy.

- ✓ *There is increasing interest in the use of these types of metric to quantify biodiversity impacts in IA so that losses and gains can be tracked throughout the mitigation hierarchy. This approach underpins* ***"Biodiversity Strategy",*** *for example and its stated intention to demonstrate a net positive impact on biodiversity.*

- ✓ Restorations have numerous limitations and found little support that ecological restoration leads to a NNL/ NG. Many expectations of restoration are not supported by evidence; the promise of full restoration may increase the chance that damage to biodiversity is permitted. However, increased use of offsets within **"Impact Assessment" (IA)** may improve understanding of actions needed for successful restoration and raise awareness of the need to plan the resources needed earlier in the process.

- ✓ *Uncertainties associated with restoration favour the use of habitat bank for offsets and these banks constitute areas in which **"Biodiversity Gain" (BG)** have already been achieved through **"Habitat Creation, Restoration and/ or Protection"**, to be converted into credits. Credits can be sold to developers to meet their offset obligations. Habitat banks can demonstrate that the requisite biodiversity gains have been secured before development begins. In some cases, companies may establish their own habitat to meet anticipated offset requirements.*

- ✓ Where there is real, immanent or projected loss of biodiversity, its protection can generate **"Gains"** for **"Biodiversity"**: the difference between background rates of loss **"Without"** and **"With"** protection of biodiversity in an area constitutes these gains. The offset type is appropriate where background rates of biodiversity loss are high and relatively large intact areas can be protected from transformation, as in Madagascar, and/ or in areas where restoration is not considered to be achievable.

- ✓ *In some countries financial compensation to a dedicated offsets fund may be an option instead of **"In – Situ"** measures. For relatively common biodiversity, predetermined checklists could be used to calculate debits, which could be compensated through an in lieu fee. However, there is a risk that offsets might become functionally and spatially disconnected from the impact and/ or funds may be diverted away from conservation.*

- ✓ Offsets must deliver benefits to those communities whose use and culture values attached to biodiversity are affected by development; the **"Biodiversity Offset" (BO)** should provide acceptable substitute values to those lost. Although separate offset for intrinsic, use and cultural values are feasible, it is preferable to prioritize offsets near impacted areas that could deliver the biological and socio – economic outcomes needed and widen the areas of search as necessary.

- ✓ *Involvement of local communities in offset implementation may also be sought and their willingness to participate needs to be explored. **"This is an aspect of offset design that has been relatively neglected and requires close collaboration between social and Biodiversity practitioners. The "Impact Assessment" (IA) process needs to be designed to foster this collaboration. When selecting offset sites, consideration must be given to possible "Leakage" that occurs when an offset displaces pressure on Biodiversity (e.g., deforestation or poaching) to another areas. Instead of remedying project residual negative impacts, therefore, an offset may simply shift a threat to another location, thwarting NNL/ NG"**.*

- ✓ The use of offsets in **"Impact Assessment" (IA)** fundamentally poses the problem of balancing certain biodiversity loss with uncertain gains. Drawing on numerous sources, the following challenges in designing a biodiversity offset can be identified, which must be addressed to make IA an effective tool for NNL/ NG:

    - *Using suitable metrics;*
    - *Dealing with **"Non – Offset able"** impacts;*
    - *Ensuring equivalence of losses and gains;*
    - *Ensuring **"Additional/ Supplementary"** and reliable baseline; and*
    - *Integrating ES in offset design.*

- ✓ The quantification of biodiversity losses and gains poses significant challenges, because of the inherent complexity of biodiversity and the variety of ways, in which it can be measured. Different methods for calculating the required offset activities results in divergent outcomes for biodiversity; ***"The method used to quantify losses and gains strongly influences the Biodiversity outcomes of offsetting, implying that offsets generated using different methodologies are not transferrable between jurisdictions"***.

- ✓ *More specificity in the choice of metrics might be more conductive to achieving NNL/ NG, but it also makes offsets less likely to be implemented and may complicate the use of trading with mitigation banks. Using additional metrics results in additional complications and expanse and beyond some point will not justifiably reduces uncertainty in quantifying biodiversity further.*

- ✓ The use of crude metrics, poor biodiversity surrogates and over – simplified metrics also fails to account for significant environmental and social welfare values across the space, type and time. These shortcomings, together with the frequent failure of restoration as a core offset mechanism and time lag effects between offsets and impacts on threatened biodiversity, means that there is a high risk of losing biodiversity in each exchange and failing to achieve NNL/ NG.

- ✓ ***"Biodiversity offsets are not appropriate for "Critical" or "Non – Substitutable" Biodiversity assets which cannot be replaced using known techniques or within reasonable time frames"***. *"Some things, such as critical habitat for listed threatened species are not tradable". Major financial institutions* ***(e.g., World Bank, 2004)*** *recognize the principle that, due to the high value of some* ***Biodiversity*** *resources, there are – effectively –* ***"No Go Zones"*** *for new extractive industry investments. The challenges lie in determining where those limits lie. Factors that indicate a high risk that impact would be* ***"Non – offset able"*** *comprise:*

    - *A high proportion and condition of biodiversity (population, species or ecosystem) to be residually impacted;*
    - *A high level of exceptionality or uniqueness of features and sites (e.g., habitats for highly specialized or uniquely adapted species, restricted in distribution, relatively immobile and/ or slow to regenerate affected biodiversity) and probable scarcity of suitable offset options in the landscape; and*
    - *A high vulnerability of affected biodiversity (highly threatened ecosystems/ species), especially where the cause of decline is unknown, or not track – table.*

- ✓ ***Time Lags:*** Development of results in immediate biodiversity losses and protection offsets may not be immediate and positive management actions take time to mature and grown – up. A time lag is expected between the creation of habitat and inhabitation by the target species, as some resources may only become available in later succession stages. These delays may have significant consequences for biodiversity conservation, and even if biodiversity levels were eventually restored, the ES lost in the interim could necessitate additional compensation.

- ✓ *There may be uncertainties in predicting negative impacts on biodiversity due, amongst others, to the quality of available data and/ or inherent uncertainty regarding ecosystem dynamics. The effectiveness of measures proposed to avoid, minimize or repair impacts may be unpredictable or overly optimize, resulting in uncertainty about – or underestimate of – residual negative impacts.*

- ✓ Understanding the socio – economic and cultural context is crucial for understanding the affected biodiversity when designing and implementing offsets. Do local communities rely on the biodiversity of the region for their subsistence, livelihoods, health or safety from natural

hazards…??? Do they hold certain biodiversity features as culturally or spiritually significant…???

- ✓ ***Offsets targeting ES exist, but may not be leveled as such:*** *For example, where quantity trading credits and fisheries compensation. Depending on their timing and location, biodiversity offsets may be sufficient to provide compensation to affected parties for impacted ES. In other situations, particular services may need to be offset separately; water purification and provision of fuel wood are common examples. Economic valuation and financial compensation (e.g., impacts on forest livelihoods) and measures of loss and gain of ES over time (e.g., months of lost access to potable water left only 0.8% at present condition not only in India, but facing problem all around the world) are metrics most commonly used to measure ES.*

- ✓ Multipliers sometimes referred to as **"Mitigation Ratios**" or **"Offset Ratios",** are applied to increase the size of an offset, and/ or the number and type of offset activities, in order to be confident of achieving NNL/ NG. They may be used to address uncertainties and/ or risks associated with the success of restoration; **"Out of Kind"** or **"Trading Up"** exchanges; or location differences between the impact and offset sites (*e.g.,* in or out of a specified watershed mission). They may be designed to ensure that conservation goals or targets would be met and/ or that conservation of highly **"Threatened Biodiversity",** components would be assured.

- ✓ *Multipliers are also used to address risk associated with time lags; size of the offset is increased proportional to the risk of delays in achieving the offsets. Use of multipliers has limitations and* ***"[U]ncertainty multiplier system are at best complicated and unworkable in the eyes of proponents and are at worst token and not commensurate with the inherent uncertainty about restoration success"****. The uncertainties associated with restoration are large; the multipliers are likely to be unworkably large, and far exceed what is currently applied in practice. Despite using large (up to 19 – fold increases in pond habitat) multipliers to account for time lags between habitat creation for, and habitation by, a threatened frog species. Time discounting, where future gains are valued in present – time units, is advocated on the grounds that it is unfair to compensate for a guaranteed immediate loss with a hypothetical and less certain future gain. Although this multiplier makes sense in terms of equity, the use of time discounting may do nothing to address the fact that delays in providing an offset can lead to critical shortages in ecological resources over time, no matter how large the offset. These critical shortages or* ***"Ecological Bottlenecks",*** *could make is impossible to achieve offset gains comparable to losses from development.*

- ✓ Not only in India, but in some other countries (*e.g.,* South Africa) ratios are used as a mechanism to promote preservation of highly valued ecosystems and/ or to ensure that biodiversity targets would be met; ratios of up to 20: 01 for highly **"Threatened Biodiversity",** are required. In Colombia requiring higher offset ratios (up to 10: 01) for ecosystems with few remaining patches relative to their historic distribution, experiencing a high rate of loss over the past six years, and/ or with a large, intact proportion of their historic distribution remaining, is deemed appropriate.

This study presents a general approach for probabilistic constraint evaluation in the **"Reliability – Based Design Optimization" (RBDO)** for construction of roads. Different perspectives of the general approach are consistent in prescribing the probabilistic constraint, where the conventional **"Reliability Index Approach" (RIA)** and the proposed **"Performance Measure Approach" (PMA)** are identified as two special cases. PMA is shown to be inherently robust and more efficient in evaluating inactive probabilistic constraints, while RIA is more efficient for violated probabilistic constraints. Moreover, RBDO often yields a higher rate of convergence by using PMA, while RIA yields singularity in some cases. And this methodology may be applicable for roads development technology to know the capability/ potential with estimation and judgment of road sustainability. This model has been

developed to make the roads with working capability and reliability for long time after construction of roads. This model has been represented by less traffic pressure according to weather or climate variations while road construction works. Early specialist input enabled the review of layout plans for the mine and changes in the siting of waste dumps and the tailing dam, as well as roads and mining methodology, to avoid or prevent, and minimize potentially significant impacts.

The availability of regional spatial data of significant habitats and species provided the basis for a well – informed evaluation of biodiversity impacts in a regional context and the identification of optimal, contiguous offset sites that contribute to securing critical habitat in this region as conventional **"Reliability Index Approach" (RIA)** and the proposed **"Performance Measure Approach" (PMA)**. This study observation addresses the questions raised by the use of nanotechnology that may influence biodiversity. There are various definitions of biodiversity, and this occurrence will use that of the United Nations **"Convention on Biological Diversity" (CBD)** which is, ***"The expression or approach Biodiversity is 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 a part; this includes diversity within species and of ecosystems"***. There can be variations within genes, species and ecosystems.

16. MECHANISM OF NANO – PARTICLES – MICROORGANISM INTERACTION AND IMPACT ON BIODIVERSITY

Nano – structured materials are in the frontline of the present scientific research because of their multifunctional properties that leads their applications from optics to electronic, from mechanical engineering to medical science and technology. However increased levels of nano – materials in the environment drastically affect the lifestyle activity of the microorganism of the environment. This also changes the biodiversity of the system. This mini review discusses about effect of nano – particles on the **"Biodiversity"** of **"Soil"** and **"Water Microorganism Community" (WMC)** as reported by the researchers. Also the mechanism of nano – particle – microorganism interaction and functionality has been discussed.

"Nano – Particles" (NPs) dissolved in water and soil is directly absorbed by several microorganisms and plants. Once the NPs come into the cell wall of the microorganism, they immediately penetrate it if the size of the NPs is ~50 nm. Once the NPs penetrate the cell wall, it affects the conductivity of the cytoplasm of the cell. The size of the NPs plays most important role in this surface interaction process. As the size reduces, more number of atoms is exposed to the surface hence more atoms can interact with the bacterial cells. The anti – microbial are the effect of ZnO – NPs on S. Aureus, S. Marcescens, Neisseria. Gonorrohea, P. Mirabilis, Klebsiella, Streptococcus Mutans, Vibrio Cholerae, E. Coli, C. Freundii and on Fungi like A. Nidulans, A. Flavus. A Spergillus Niger and R. Stolonifer are reported in the literature by the researchers. Silver NPs are found to be very toxic to several bacteria. Hence the use of Ag – NPs is growing day – by – day in various medicinal applications. However there are some bacteria which are silver – resists. They precipitate the silver in metal form or some insoluble form. It is also experimentally demonstrated that several microorganisms like water fleas, earthworms, fishes absorbs nano – particles during their food intake and a low level of accumulation is observed in several organs. Sometimes the NPs enter into the blood and muscles of the organism. This affects the organs to work in normal way. Thus the function of the cell is disrupted. Several methods such as disk diffusion, broth dilution, agar dilution and the microtiter plate – based method have been reported in the literature to investigate the antibacterial activity of NPs in vitro.

However, there are some other indirect methods also like bacterial metabolism – induced change in conductivity, and flow cytometry. The basic mechanism of antibacterial activity of NPs is the toxicity of the materials. But the exact mechanism of toxicity and antibacterial activity is yet not well established. There are several mechanism reported by the researcher behind the antibacterial activity of NPs. The antibacterial activity of ZnO – NPs depend on the particle size and particle concentration. It was also found that the encapsulation of the NPs by **"Poly Ethylene Glycol" (PEG)** or **"Poly Vinyl Pyrolidone" (PVP)** does not affect the antibacterial activity of ZnO – NPs significantly. They showed

that the antibacterial activity was originated due to destruction of cell membrane of bacteria upon direct interaction with the NPs. Other causes may be Zn^{2+} ion liberation and reactive oxygen species. These antibacterial/ microbial effects of NPs lead a potential problem to the biodiversity. Researchers are trying to synthesize NPs in green route and enzyme route so that the synthesized NPs are less hazardous. So these **"Nano – Particles" (NPs**) have weaker effect on the **"Soil – Water – Air Microbes"**. However, still it is a big challenge to save the **"Soil", "Water Microorganism"** and to preserve the **"Biodiversity"** in **Nampong to Vijaynagar Road,** in the **"State of Arunachal Pradesh"**.

17. BIODIVERSITY CONSERVATION AND AGRICULTURAL SUSTAINABILITY: TOWARDS A NEW PARADIGM OF "CO – AGRICULTURE" LANDSCAPES

The **"Millennium Ecosystem Assessment" (MEA)** documented the dominant impacts of agriculture on terrestrial land and freshwater use, and the critical importance of agricultural landscapes in providing products for human sustenance, supporting wild species biodiversity and maintaining ecosystem services. Yet global demand for associated agricultural products is projected to rise at least 50% over the next two decades. The need to reconcile agricultural production and production – dependent rural livelihoods with healthy ecosystems has prompted widespread innovation to coordinate landscape and policy action. However, the dominant national and global institutions – for policy, business, conservation, agriculture and research – have been shaped largely by **"Mental Models"** that assume and require segregated approaches.

This study will discuss a new paradigm, **"Eco – Agriculture"**: integrated conservation – agriculture landscapes in which biodiversity conservation is an explicit objective of agriculture and rural development, and the latter are explicitly considered in shaping conservation strategies. The rationale for scaled – up action to promote eco – agriculture landscapes, and define the approach. The current state of eco – agriculture knowledge and practice, in relation to agricultural technology, landscape management, financial viability, and supportive policies and investments with strategic actions required to mobilize eco – agriculture initiatives on a scale that would have a meaningful impact on global challenges for agricultural production and ecosystem management.

18. THE CHALLENGE OF MANAGING BIODIVERSITY "HOT SPOTS" AND AGRICULTURAL "HUMAN FOOTPRINT" LANDSCAPES IN THE TWENTY – FIRST CENTURY

"Current trends suggest that, during the twenty – first century, a continuing and growing demand for agricultural and wild products and ecosystem services will require farmers, agricultural planners and conservationists to reconsider the relationship between production agriculture and conservation of Biodiversity".

(a) The Current Ecological Footprint of Agriculture

Nearly one – third of terrestrial lands have agricultural crops or planted pastures as a dominant land use (accounting for at least 30% of total area), thus having a profound ecological effect on the whole landscape. Another 10 – 20% of land is under extensive livestock grazing; and approximately 1 – 5% of food is produced in natural forests. The **"Human Footprint"** analysis estimated that 80 – 90% of lands habitable by humans are affected by some form of productive activity. More than 1.1 billion people, most agriculture – dependent, now live within the **"World's 25 Biodiversity", "Hot Spots",** areas described by ecologists as the most threatened species – rich regions on Earth.

Both extensive lower – yield and intensive higher – yields agricultural systems have profound ecological effects. Millions of hectares of forests and natural vegetation have been cleared for agricultural use and for harvesting timber and wood fuels, and empirical evidence suggests that intensification rarely results in saving **"Land for Nature"**. Half the world's wetlands have already been converted; California

alone has lost 91% of its wetlands. ***"Overuse and mismanagement of pesticides poison water and soil, while nitrogen and phosphorus inputs and livestock wastes have become major pollutants of surface water, aquifers, and coastal wetlands and outlets".*** Between 1890 and 1990, the total amount of biologically available nitrogen created by human activities increased nine – fold, and human activity now produces more nitrogen than all natural processes combined. Agrochemical nutrient pollution from the US farm belt is the principal cause of the biological **"Dead Zone"** in the **"Gulf of Mexico"** 1,500 Km away and similar impacts are felt in the **"Baltic Sea"** and along the coasts of China and India. Environmental impacts of livestock are extensive.

Some introduced agricultural crops, livestock, trees and fishes have become invasive species, spreading beyond their planned range and displacing native species. Concerns about genetically modified crop varieties include their potential to become invasive species or to hybridize with wild relatives, leading to the loss of biodiversity. Agriculture fragments as the landscape, breaking formerly contiguous wild species populations into smaller units that are more vulnerable to extirpation. Farmers generally have sought to eliminate wild species from their lands in order to reduce the negative effects of pests, predators and weeds. However, these practices often harm beneficial wild species like pollinators, insect – eating birds and other species that prey on agricultural pests. These threats posed by agriculture to conservation have been a key motivator for conservationists to develop protected areas where agricultural activity is officially excluded or seriously circumscribed. Nonetheless, the MA calculated that more than 45% of 100,000 **"Protected Areas" (PAs)** had more than 30% of their land area under crops. In light of political and economic realities, many recently designated PAs in several African countries explicitly permit biodiversity – friendly agriculture, usually in areas considered category V or VI in the IUCN. It changed its name to the **"International Union for Conservation of Nature and Natural Resources" (IUCN)** in 1956 and was also known as the **"World Conservation Union" (WCN)** from 1990 to 2008. The IUCN is the world's oldest global environmental organization and its headquarters are in Gland, Switzerland.

(b) Meeting Increased Demand for Agricultural Products in Ecologically Sensitive Areas

Human population is expected to grow from a little over 6 billion today to over 8 billion by 2030, an increase of approximately one – third, with another 2 – 4 billion added in the subsequent 50 years. But food demand is expected to grow even faster, as a result of growing urbanization and rising incomes, and if hunger is reduced among 800 million people currently undernourished. More land will surely be required to grow crops, even more so if bio – fuels become a greater contributor to energy needs. In Africa alone, land in cereal production is expected to increase from 102.9 MHa in 1997 to 135.3 MHa in 2025. Global consumption of livestock products is predicted to rise from 303 million metric tons in 1993 to 654 million tons in 2020. Predict that feeding a population of 9 billion using current methods could result in converting another 1 billion hectares of natural habitat to agricultural production, primarily in the developing world, together with a doubling or tripling of nitrogen and phosphorous inputs, a two – fold increase in water consumption and a three – fold increase in pesticide use. ***"A serious limiting factor is expected to be water, as 70% of the freshwater used by people is already devoted to agriculture".*** Scenarios prepared by the MA thus suggest that agricultural production in the future will have to focus more explicitly on ecologically sensitive management systems. Below are four major reasons why meeting increased demand for agricultural products will often require eco – agriculture systems.

(i) Most of the Increased Food Production will be Grown domestically and increasingly in more "Marginal" or "Fragile" Lands

An estimated 90% of food products consumed in most countries will be produced by those countries. Total export levels increased sharply between 1961 and 2000, but agricultural exports still accounted for only approximately 10% of production. This pattern seems unlikely to change over the next few decades, even though continuing globalization of agriculture will influence product mix and prices. A reduction in developed world subsidies could further spur export agriculture in the developing world. Changes will depend not only on productivity and quality, but also on shifts in relative transport costs for

international shipping and internal overland transport, and the distances between major population centers, ports and agricultural regions. Large and growing interior populations in large countries will continue to be fed mainly by local and national producers. The declining rate of growth in yields in places like Punjab in India, the US Midwest and the Mekong Delta indicates that most new production may not come from the areas of highest current grain productivity, and some areas are already experiencing declining yields or productivity of inputs. ***"While yields may increase somewhat in these places, through greater input use, plant breeding, biotechnology and improved irrigation efficiency, marginal costs are likely to be high, as are the environmental costs"***.

Moreover, **"Lower – Productivity Lands" (Dry Lands, Hillsides and Rainforests)** now account for more than two – thirds of total agricultural land in developing countries. Because current yields are relatively low, technologies already existing can double or even triple yields, with adequate investment, market developments and attention to good ecosystem husbandry. Extensive grain monocultures are not likely to be sustainable in such areas, calling for more diversified land use approaches. Though the bulk of new production will come mainly from existing croplands, the most promising areas with significant new land for agriculture are in places like the forest and savannah zones of Brazil and Mozambique, which are the main remaining large reservoirs of natural habitat. ***"These habitats will be seriously damaged by highly simplified, high external – input production systems, but an eco – agriculture approach could significantly reduce the damage"***.

(ii) Wild Products Continue to be Important for Local Food Supply and Livelihoods

People in low – income developing countries and sub – regions will continue to rely on harvesting wild species. Wild greens, spices and flavourings enhance local diets, and many tree fruits and root crops serve to assuage **"Pre – Harvest Hunger"** or provide **"Famine Foods"** when crops or the economy fails. Frogs, rodents, snails, edible insects and other small creatures have long been an important part of the rural diet in virtually all parts of the world. Bush – meat is the principal source of animal protein in humid West Africa and other forest regions, and efforts to replace these with domestic livestock have been disappointing. Fisheries are the main animal protein source of the poor worldwide. In Africa and many parts of Asia, more than 80% of medicines still come from wild sources. Gathered wood fuel remains the main fuel for hundreds of millions of people, while forests and savannahs provide critical inputs for farming in the form of fodder, soil nutrients, fencing, etc. Achieving food security therefore will require the conservation and preservation of the ecosystems providing these foods and other products' output.

(iii) Agricultural Systems and Climate Change Risk – Extreme Weather Events

As per the data about the **"Weather Extremes"** in **"India (during years 2014 – 2017)"**, over 5,800 people and 10,000 cattle died due to **"Extreme Weather Events"** like cold wave, heat waves stroke, melting of glaciers and see level rise up to year 2050, heavy rainfall resulting in floods, hailstorm, lightning and cyclonic storms etc. Of these, at least 3,650 were due to heat waves and cold waves alone. Strategic planning for agricultural development has begun to focus on adaptation of systems to climate change, anticipating rising temperatures and more extreme weather events. These ecosystems are now at risk *i.e.,* climatic condition risk as a result of human developmental activities. **"Climate Change"** and habitat destruction are two of the greatest threats to **"Global Biodiversity"**. **"Global Climate Change"** along with continued habitat loss and fragmentation is now being recognized as a **"Major Threat/ Warning"** to **"Future Biodiversity"**. A diversity of species increases the ability of ecosystems to do things like hold soils together, maintain soil fertility, deliver clean water to streams and rivers, cycle nutrients, pollinate plants (including crops), and buffer against pests and diseases – these are sometimes called **"Ecosystem Functions"** or **"Ecosystem Services"**. A loss of species could reduce this ability, particularly if environmental conditions are changing rapidly at the same time. *The **"Melting of Glaciers"** because of global warming has left the scientific community worried. The **"Glaciers"** in Himalayas are **"Melting"** at a very rapid rate which has major **"Implications"** for water supply in the Northern part of the **"Indian"** subcontinent (Pachauri, 2007). It supports a large number of **"Glaciers"**, lakes, rivers, **"Flora and Fauna"** due to its variable climate. The present study discusses the various causes responsible for **"Melting"** and **"Shrinkage"** of **"Glaciers"**, decreasing water flow in the major rivers, increasing pressure of extinction of the*

ecological wealth of the country.

It is possible that as the climate changes and as species are eliminated from an area we will see a change in some ecosystem functions; this could mean more land degradation, changes in agricultural productivity and a reduction in the quality of water delivered to human populations. ***"This ascending or rise in sever extreme temperature and weather event/ climate "Natural Events/ Features/ Resources" or proceeding may cause high reduction in crops yields' production...!!! and on the same way will influence coral reefs along the coastal areas whole around the world. It is an assumption that the coral reefs and water scarcity may occur up to the years 2050 and 2030 respectively...!!!"***. In Indian organizations and the US Department of Agriculture of **"International Rice Research Institute" (IRRI)** have both concluded that with each 1°C increase in temperature during the growing season, the yields of rice, wheat and maize drop by 10%. Cash crops such as coffee and tea, requiring cooler environments, will also be affected, forcing farmers of these crops to move higher up the hills, clearing new lands as they climb. Montane forests important for biodiversity are likely to come under increasing threat. Effective responses to climate change will require changing varieties and modified management of soils and water, and new strategies for pest management as species of wild pests, their natural predators, and their life cycles change in response to climates. Increasing landscape and farm – scale diversity are likely to be an important response for risk reduction.

(iv) Agricultural Sustainability will require Investment in Ecosystem Management

Meeting food needs and economic demand for agricultural products will be constrained by widespread resource degradation that is already either reducing supply or increasing costs of production. Up to 50% of the globe's agricultural land and 60% of ecosystem services are now affected by some degree of degradation, with agricultural land use the chief cause of land degradation. Half the world's rivers are seriously depleted and polluted and 60% of the world's 227 largest rivers have been significantly fragmented by large dams, many built to supply irrigation water. Estimates are that 20% of irrigated land suffers from secondary salinization and water logging, induced by the build – up of salts in irrigation water. The food system will also have to address, or adapt to, the collapse in harvests of wild game and wild fisheries in many regions around the world, due to overexploitation and habitat loss or pollution. Considerable investments will be required to rehabilitate degraded resources and ecosystems upon which food supplies, particularly of the rural poor, dependent.

(c) Meeting Increased Demand for Ecosystem Services

"Conservation" of **"Wild Biodiversity" (Genes, Species and Ecosystems)** is considered by many to be an ethical imperative suggestion by the surviving people whole around the world. At the same also time, conservation supports **"Ecosystem Services"** – ecological processes and functions that sustain and improve human well – being. Ecosystem services can be divided into four categories: ***(i)*** *provisioning services*, or ecosystems that provide food, timber, medicines and other useful products, ***(ii)*** *regulating services* such as flood control and climate stabilization, ***(iii)*** *supporting services* such as pollination, soil formation and water purification, and ***(iv)*** *cultural services*, which are aesthetic, spiritual or recreational assets that provide both intangible benefits and tangible ones such as ecotourism attractions. **"Provisioning"** historically has been seen as the highest priority service provided by agricultural landscapes. But it is now recognized that even the **"Bread Baskets"** and **"Rice Bowls"** of the world also provide other ecosystem services, such as water supply and quality, or pest and disease control, which are also important. The conservation community is moving towards an **"Ecosystem Approach"** to conserving biodiversity, in light of the dependence of protected areas on a supportive matrix of land and water use, and creation of **"Biological Corridors (Convention on Biological Diversity, 2000)"**. The international community has set a goal of having at least 10% of every habitat type under effective protection by 2025. This strategy, if successful, will protect many species and ecological communities, but some estimates suggest that more than half of all species exist principally outside **"Protected Areas" (PAs),** mostly in agricultural landscapes. For example, conservation of wetlands within agricultural landscapes is critical for wild bird populations. Such species will be conserved only through initiatives by and with farmers. The concept of agriculture as ecological **"Sacrifice"** areas is

no longer valid in many regions, because agricultural lands both perform many ecosystem services and provide essential habitat to many species.

(i) Agricultural Landscapes Provide Critical Watershed Functions

Many of the world's most important watersheds are densely populated and under predominantly agricultural use, and most of the rest are in agricultural land use mosaics where crop, livestock and forest production influence hydrological systems. In such regions, agriculture can be managed to maintain critical watershed functions, such as maintaining water quality, regulating water flow, recharging underground aquifers, mitigating flood risks, moderating sediment flows, and sustaining freshwater species and ecosystems. This has led to the concept of **"Green Water"**: that terrestrial land, soil and vegetation management has critical roles in the **"Hydrological Cycle"**. Effective management of green water encompasses the choice of water – conserving crop mixtures, soil and water management (including irrigation), maintenance of soils to facilitate rainfall infiltration, vegetation barriers to slow movement of water down slopes, year – round soil vegetative cover and maintenance of natural vegetation in riparian areas, wetlands and other strategic areas of the watershed. Well – managed agricultural landscapes can also provide protection against extreme **"Natural Events/ Features/ Resources"**. With increased water scarcity and more frequent extreme weather events predicted in coming decades, the capacity of agricultural systems to sustain watershed functions is likely to be a priority consideration in agricultural investment and management.

(ii) Agricultural Landscapes Maintain "Green Space", Recreational Opportunities, Healthy Habitats and Aesthetic Beauty in Human Settlements

With accelerating urbanization worldwide, the loss of natural habitats and natural features has become a central concern for planners and residents, as well as farmers operating in urban areas. Agriculture can protect green spaces for aesthetic and recreation values, and help to finance the maintenance of green space for wildlife habitat and ecosystem services. Overall positive outcomes for human habitat and aesthetics require adequate management of crop and livestock wastes, air pollution (smoke, dust and odours) and polluting run – off.

Eco – Agriculture: The challenges described earlier are unlikely to be met by the solutions of industrial agriculture, the original green revolution, sustainable agriculture and natural resource management (with its primary focus on sustaining the resources underpinning production), or even the eco – technology approach of with its focus on the farmer's field, although all of these have major elements to contribute. Approaches to biodiversity conservation also need to move beyond the wild biodiversity focus of strictly protected areas and the modest goals of integrated conservation and development projects. We argue that eco – agriculture a fully integrated approach to agriculture, conservation and rural livelihoods, within a landscape or ecosystem context – is needed in many regions.

(a) Eco – Agriculture Landscapes

Eco – agriculture explicitly recognizes the economic and ecological relationships and mutual interdependence among agriculture, biodiversity and ecosystem services in **BRO – Nampong to Vijaynagar Roads,** for Arunachal Pradesh **(Figure 26)**. Eco – agriculture landscapes are mosaics of areas in natural/ native habitat and areas under agricultural production. Effective eco – agriculture systems rely on maximizing the ecological, economic and social synergies among them and minimizing the conflicts.

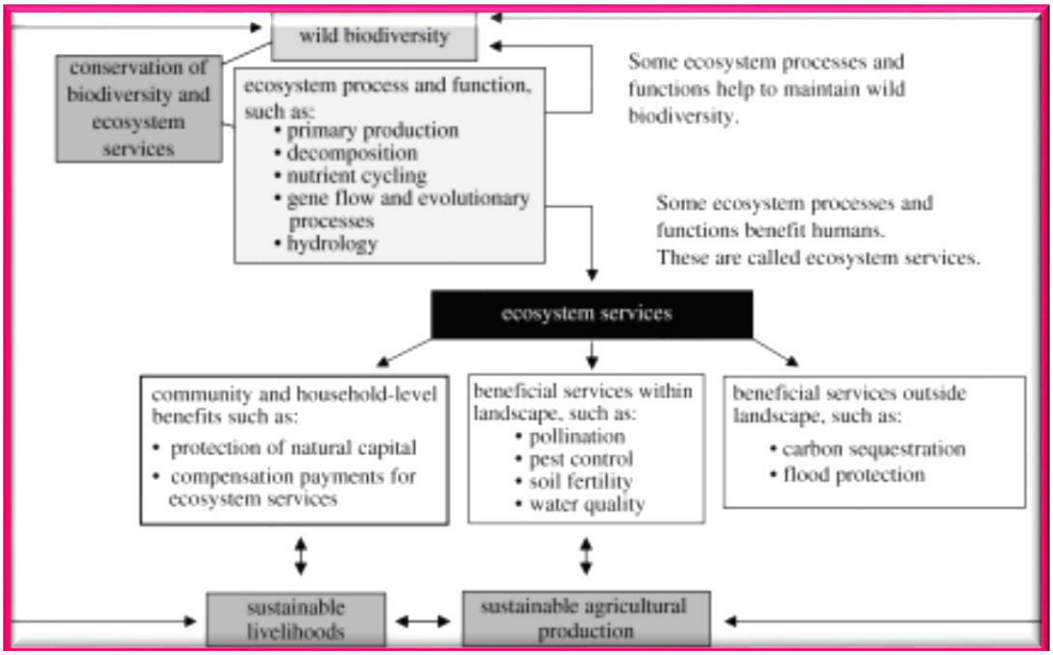


Figure 26: Ecosystem Services in BRO – Nampong to Vijaynagar Roads, for Arunachal Pradesh.

Ecosystem services are a key to the synergies between conservation, sustainable agricultural production and sustainable livelihoods. ***"The term "Landscape" itself is functionally defined, depending upon the spatial units needed or actually managed by the group of stakeholders working together to achieve Biodiversity, production and livelihood goals"***. Eco – agriculture landscapes are land use mosaics with:

(a) ***"Natural Areas"*** *(with high habitat quality and niches to ensure critical elements for habitat or ecosystem services that cannot be provided in areas under production), which are also managed to benefit agricultural livelihoods either through positive synergies with production or other livelihood benefits;*

(b) ***"Agricultural Production Areas"*** *(productive, profitable and meeting food security, market and livelihood needs), which are also configured and managed to provide a* ***"Matrix"*** *with benign or positive ecological qualities for wild biodiversity and ecosystem services; and*

(c) ***"Institutional Mechanisms"*** *to coordinate initiatives to achieve production, conservation and livelihood objectives at landscape, farm and community scales, by exploiting synergies and managing trade – offs among them.*

"The concept of eco – agriculture further recognizes that agriculture – dependent rural communities are critical (and sometimes the principal) stewards of Biodiversity and ecosystem services. While protected natural areas are essential in eco – agriculture landscapes to ensure critical habitat for vulnerable species, maintain water sources and provide cultural resource, these resources often may be owned or managed by local communities and farmers".

(d) Biodiversity and Ecosystem Services in Eco – Agriculture Landscapes

"Conservation of Biodiversity in eco – agriculture landscapes embraces all three

elements of agricultural Biodiversity defined by the Convention on Biological Diversity: genetic diversity of domesticated crops, animals, fish and trees; diversity of wild species on which agricultural production depends (such as wild pollinators, soil micro – organisms and predators of agricultural pests); and diversity of wild species and ecological communities that use agricultural landscapes as their habitat. The concept of Biodiversity serves enough to answer functional claim and show that Biodiversity, understood as "The Variety of Life Species Existing in Natural System", does have useful roles to play in systematizing understanding".

The concept of biodiversity has been scientifically and politically influential, it faces fundamental philosophical problems. In light of these problems defends an eliminative view, arguing that we should do away with the concept of biodiversity altogether and the concept of biodiversity has two parts. First objection is on conceptual, scientific grounds, and is that the concept is multi – dimensional in a way that limits its usefulness. As noted above, it is widely recognized that there are many different components of biological diversity. In considering the heterogeneity or homogeneity of an ecosystem, we may be interested in any number of features, including genetic and phenotypic variation; diversity between species; diversity with respect to functional roles in the ecosystem (*e.g.,* primary producers, herbivores, carnivores; canopy dwellers, ground feeders etc.); and variation in the composition or network structures of whole communities. Diversity, then, can be measured along innumerable different dimensions. Moreover, these different dimensions may vary independently of one another. A community might have many species, but low genetic variation. It might have many species in small numbers, but be dominated by just a few, and thus be relatively homogeneous in behaviour and structure. ***"Given that there are many dimensions by which ecosystems can be compared, and along which they may be more or less heterogeneous, no single measure is likely to capture the overall diversity of a community and Biodiversity is a fundamentally multidimensional concept"***.

If the different dimensions of biodiversity do not reliably vary with one another, then we are better off appealing just to the specific aspect of diversity that is relevant for a given explanatory purpose, and doing away with the overarching concept. ***"Against pluralists, who hold that Biodiversity consists of distinct but correlated properties of natural systems, argue that the supposed correlations between these properties are not tight enough to warrant treating and measuring them as a bundle"***. The overarching concept is redundant, if each time the term is used, the speaker in fact mean something more specific, the content of which is evident from explanatory context; and if there is no way to measure biodiversity as a whole. In one context, the important feature may be herbivore diversity; in another it might be variation in lifecycles amongst grassland insects. If the many dimensions of interest are distinct and vary independently, then little may be gained by employing the concept of biodiversity. Instead the focus in each case should be on whichever dimensions are explanatorily relevant.

The second objection is on normative grounds observes that biodiversity is often used in practice as a catchall for the value of living organisms in natural environments. As Maier puts it, many conservationists subscribe to the **"Biodiversity Project",** according to which biodiversity is meant to capture the core of what is valuable about the natural world. However, this inclusive use of the term is problematic. For reasons that have been explored thoughtfully by others much of what value about the natural world and living communities is not well – captured either by the broad concept of diversity, or by any of the individual measures commonly used to represent it. Conclusion is that conservation biologists should not seek to preserve biodiversity, which suggests is an unhelpful placeholder. Instead, conservationists should aim directly for preserving what he calls **"Biological Value"**. One does not define biological value, but seems to mean something like the value associated with the biosphere, ecosystems, or communities of living things.

One response would be to claim that this argument assumes too strong a standard for biological kinds. For instance, on the **"Homeostatic Cluster Properties" (HCP)** conception of natural kinds, there may be *no* properties that all instances of a kind share, but if the important properties tend on the whole to cluster together, and if a mechanistic explanation can be given for this clustering (such as species boundaries), then there might be a biological kind. One strategy therefore, would be to seek to show that

the dimensions of diversity do tend to be reasonably strongly clustered, and that there are underlying mechanisms for this clustering. Theoretically it might be possible to show that systems with high diversity of species tend to also have higher phenotypic diversity, genetic diversity, and morphological diversity (colours, shapes, sizes, behaviours, body plans and so on...!!!) than systems with low diversity of species. Even though these dimensions are not tightly correlated, and can come apart (so that a system might have high species diversity, but low morphological diversity, for instance). They might nevertheless tend to be sufficiently correlated for biodiversity to qualify under the **"Homeostatic Cluster Property" (HCP)** conception of biological kinds. A different strategy might be to emphasize that the property of biodiversity is a natural kind that can be multiply realized. It does not matter that the associated properties do not tightly cover; different biota can be bio – diverse in different ways, while sharing a common property of high heterogeneity. The challenge for this strategy is to show that systems that are bio – diverse in different ways really do share something important in common, which means that the multiply – realizable property of diversity is a natural kind and not just a conventional description.

"Although wild Biodiversity and ecosystem services are closely linked, they are not synonymous. A landscape with relatively intact wild Biodiversity is likely to provide a full complement of ecosystem services". However, many ecosystem services can also be provided by non – native species, or by combinations of native and non – native species in heavily managed settings such as permanent farms. The implication is that even where wild biodiversity has been significantly reduced to make way for food and fiber production, high levels of ecosystem services can often still be provided through intentional land management practices. ***"On the other hand, managing an eco – agriculture landscape for ecosystem services does not automatically ensure that wild Biodiversity will be protected adequately. Thus, wild Biodiversity and ecosystem services both require explicit consideration in eco – agriculture systems"***.

(e) Eco – Agriculture Approaches

Broadly, eco – agriculture landscapes rely on six basic strategies of resource management, three focused on the agricultural part of the landscape and three on the surrounding matrix. In production areas, farmers sustainably increase agricultural output and reduce costs in ways that enhance the habitat quality and ecosystem services:

a. *Minimize agricultural wastes and pollution;*
b. *Manage resources in ways that conserve water, soils, and wild "Flora and Fauna"; and*
c. *Use crop, grass and tree combinations to mimic the ecological structure and function of natural habitats.*

Farmers or other conservation managers protect and expand natural areas in ways that also provide benefits for adjacent farmers and communities:

a. *Minimize or reverse conversion of natural areas;*
b. *Protect and expand larger patches of high – quality natural habitat; and*
c. *Develop effective ecological networks and corridors.*

The relative area and spatial configuration of agricultural and natural components (and other elements, such as physical infrastructure and human settlements) are key landscape design issues. The conservation of wild species that are highly sensitive to habitat disturbance – as are some of those most endangered or rare globally – requires large well – connected patches of natural habitat. But many wild species, including many that are threatened and endangered, can coexist in compatibly managed agricultural landscapes, even in high – yielding systems.

Numerous approaches to agriculture, conservation and rural development contribute components, management practices and planning frameworks that can be applied in eco – agriculture landscapes. The outcomes of planning and negotiations among the multiple stakeholders in any particular landscape will take diverse forms depending on the context of local cultures and philosophies of land management. Eco – agriculture landscapes with documented joint benefits for agricultural production,

biodiversity conservation and rural livelihoods include these three examples as given below:

(i) Kalinga Province, The Philippines

For centuries, the Kalinga indigenous people of The Philippines have supported local livelihoods and conserved mountain biodiversity through integrated landscape management. Communities manage their watersheds to ensure a continual supply of water to communal irrigation systems, and in recent years over 150 Ha of integrated rice terraces (including fish and vegetable production) have been rehabilitated. Indigenous forests are managed for sustainable harvest of wild animals for protein, leading to an 81% rate of intact forest in Kalinga Province.

(ii) Trans – Boundary Co – Management in Costa Rica and Panama

The Gandoca – Manzanillo National Wildlife Refuge on Costa Rica's Caribbean coast connects with Panama's San Pondsak National Wildlife Refuge. This 10,000Ha refuge is co – managed by local communities, **"Non – Governmental Organizations" (NGOs)** and government agencies. Small farm agro – ecosystems are integral to regional biodiversity conservation. Over 300 farmers hold secure land titles in the refuge's buffer zone. A regional small farmers' cooperative (Smallholder Association of Talamanca) supports over 1,500 small farmers to become Central America's largest volume organic producer and exporter, generating 15 to 60% increases in small – farmer revenue. Conservation – based carbon offset schemes are being developed to provide additional revenue for stewardship – focused farming.

(iii) Community Dry Land Restoration in Rajasthan, India

For most of the past century, drought and environmental degradation severely impaired the livelihood security of local communities within **"Rajasthan's Arvari River Basin"**. Twenty years ago, the Tarun Bharat Sangh, a voluntary organization based in Jaipur, India, initiated a community – led watershed restoration programme. The programme reinstated **"Johads",** a traditional indigenous technology for water harvesting. Johads are simple concave mud barriers, built across small, uphill river tributaries to collect water. As the water drains through the catchment area, Johads encourage groundwater recharge and improve hillside forest growth, while providing water for irrigation, wildlife, livestock and domestic use. Over 5,000 Johads now serve over 1,000 villages in the region, and are coordinated by village councils. Landscape changes include restoration of the Arvari River, which had not flowed since the 1940s, and the return of native bird populations.

(f) Where Eco – Agriculture Approaches Are Needed

Eco – agriculture approaches may be relevant to some extent in all agricultural landscapes, in light of their focus on improving landscape performance vis – á – vis **"Three Goals (Agricultural Production, Biodiversity Conservation and Livelihoods)"**. Synergies may be most apparent, and trade – offs least difficult, in areas with less productive agricultural lands (so that the opportunity costs of protecting or restoring habitats are lower), and in heterogeneous areas where farms are already interspersed with hills, forests and abandoned farms. Nonetheless, the need to reconcile increased agricultural productivity and livelihoods with effective conservation of biodiversity and ecosystem services may be most critical in agriculture – dominated landscapes. Eco – agriculture approaches offer opportunities for integrated action, at a lower overall cost, to achieve **"Millennium Development Goals" (MDG)** for poverty, hunger, water, and sanitation and environmental sustainability. Eco – agriculture also provides a strategy for implementing national commitments to multilateral environmental conventions, including the **"Convention on Biological Diversity" (CBD),** the **"Framework Convention on Climate Change" (FCCC), "Ramsar Convention on Wetlands of International Importance"** and the **"Convention to Combat Desertification" (CCD)**.

But it is important to consider the situations under which integrated versus segregated land use is likely to be especially advantageous, and the scale at which integration is desirable. For example, where most biodiversity is likely to be lost in the transition from pristine to extensive systems or if key species

are very sensitive to fragmentation, and then segregated systems might be indicated at a coarse grain. But where the transition from extensive to intensive agriculture will result in greater biodiversity loss, then integrated low – intensity agriculture finely interspersed with natural areas may be most desirable. Real costs are associated with the cross – segment/ division/ zone planning and coordination and technical innovations needed to achieve impacts at a landscape scale. These must be considered in prioritizing private, public and civic eco – agriculture investments. Top priorities would be considered as:

a. *Agricultural landscapes located in or around critical habitat areas for wild species of local, national or international importance (e.g., landscapes in the highly threatened habitats of the Atlantic Forest of Brazil, now dominated by farming);*

b. *Degraded agricultural landscapes where restored ecosystem services will be essential to achieve both agricultural and biodiversity benefits (such as the dry land farming and pastoral regions of West Africa);*

c. *Agricultural landscapes that must also function to provide critical ecosystem services (such as the densely populated landscapes of Europe and Java); and*

d. *Peri – urban agricultural systems, where careful management is required to protect ecological, wildlife and human health;*

e. *No assessment has been done of the geographical scale and location of such priority areas for eco – agriculture development strategies (as distinct from agriculture – or conservation – led development), but undertaking such analyses is a critical step to guide policy action.*

19. THE STATE OF "ECO – AGRICULTURE" AND "ECO – BIODIVERSITY" KNOWLEDGE AND PRACTICE

Little effort has been devoted to explicitly pursuing agricultural development and biodiversity conservation objectives jointly at a landscape scale, so experience is poorly documented and the science is immature and poorly synthesized across disciplines. Removing major barriers to the widespread development of eco – agriculture landscapes requires answering questions like the following.

- *How can agricultural production systems contribute to conserving biodiversity while maintaining or increasing productivity?*
- *How can agricultural and natural areas be jointly managed to produce adequate ecosystem services, including wildlife habitat, at a landscape scale?*
- *How can eco – agriculture approaches become more financially viable for farmers and other stakeholders?*
- *How can communities, institutions and governments mobilize and develop the institutions and policies needed for eco – agriculture landscapes?*

The current state of knowledge on these four questions is considered as depicted below:

(a) Production Systems that Support Biologically Diverse Eco – Agriculture Landscapes

Since the 1960s, the **"Improved Seed – Fertilizer – Pesticide (Irrigation)"** paradigm has characterized both industrial agriculture in developed countries and the **"Original Green Revolution" (OGR)** in developing countries. This production model involved **"Short – Term, Plot – Level Production"** of a small number of crops, generally in monoculture stands (to increase efficiency in use of external inputs and mechanization, maximize the flow of natural resources to harvestable products). Wild **"Flora and Fauna"** were considered direct competitors for resources or harvested products, and thus eliminated, while water was diverted from wetlands and natural habitats for irrigation.

More ecologically benign production systems were retained in many traditional systems that for ecological, cultural or economic reasons were not effectively incorporated into the industrial model. Such systems sought to build on, rather than replace, natural ecosystems. Different modern approaches have focused on different aspects of ecological synergy, arising from differences in discipline, philosophy, problem focus or geographical conditions. Agro – ecology, perm culture, conservation agriculture, agro – forestry, organic agriculture and sustainable agriculture have focused principally on maintaining the resource base for production, through managing nutrient cycles, protecting pollinators and beneficial micro – organisms, maintaining healthy soils and conserving water. They sought to reduce the **"Ecological Footprint"** of farmed areas and the damage to wild species from toxics, soil disturbance and water pollution, but most focused on farm – scale action, rather than coordinating efforts among farmers and others to achieve demonstrable biodiversity benefits at a landscape scale.

To protect wild **"Flora and Fauna",** eco – agriculture landscapes must provide protection of nesting areas from disturbance, diverse perennial cover for protection from predators, adequate access to clean water throughout the year, territorial access between dispersed population groups to ensure provide minimum viable populations genetically and demographically, all – season access to food from diverse sources, viable populations of predators and prey, healthy populations of other species with which they are interdependent (such as their pollinators), and biologically active soils. Many of these functions can be provided by healthy patches and networks of natural habitat, but production areas also play a critical role. ***"To achieve these Biodiversity attributes in production areas, agricultural and conservation innovators are pursuing strategies such as minimizing agricultural pollution of natural habitats, managing conventional cropping systems in ways that enhance habitat quality and designing farming systems to mimic the structure and function of Natural Ecosystems"***. A key challenge for farmers is to do so in ways that also maintain or increase agricultural output, reduce overall production costs or enhance the market value of their products in order to meet their broader livelihood needs while conserving biodiversity.

(i) Minimizing Agricultural Pollution of Natural Habitats

Reducing agrochemical use and livestock wastes in high – input production systems can greatly benefit wildlife. For example, high – nutrient or toxic run – off into waterways (a problem for both natural and synthetic forms of nitrogen) can dramatically reduce aquatic biodiversity. Major advances have been made in methods to reduce and improve the efficiency of fertilizer use, through better timing and methods of application. Agricultural pesticides may also kill non – target insects and weeds that constitute the food base for insect – and grain – eating species. Integrated pest management systems have effectively used varietal crop mixes, pest monitoring and management practices to reduce the need for pesticides. Cellular and molecular biology have been used to tailor pesticides to affect only specific pests. New ecological and biochemical research techniques are revealing an unexpected sophistication of host – pest relations that could revolutionize agricultural pest control in the future meta – review of farmer experience found gains in both productivity and biodiversity from reduced chemical use in developing counties. For example, the System of Rice Intensification mobilizes biological interactions in plant – soil systems, rather than external inputs, to raise yields significantly while reducing costs. Meanwhile, new whole – farm planning approaches minimize run – off of agrochemical and livestock waste into aquatic systems by improving storage systems, managing fields to improve infiltration and reduce run – off and establishing buffer zones to filter pollutants before they enter into the streams.

(ii) Managing Production Systems to Enhance Habitat Quality

Farmers and conservationists have modified management of soil, water, fire and vegetation to transform crop fields into useful habitat for species, or to enhance their value as **"Corridors"** connecting natural habitat areas in the landscape. Appraise 79 studies where investigators quantified biodiversity (usually species richness) associated with 18 specific agricultural practices. The strategy most often correlated with the conservation of wild biodiversity was the maintenance of adjacent hedgerows, windbreaks or woodlots; 18 studies documented positive correlations with eight taxa. Organic agriculture was correlated with an increase in seven taxa in eight studies. Shaded tropical crop production (especially coffee and cacao) had higher species richness of three higher taxa by eight different studies. Research has

also found that many of these practices provide additional benefits to farmers, such as useful by – products, reduced risk of crop loss during droughts, diversified food and income sources and reduced vulnerability to environmental risks. For example, following the October 1998, Hurricane Mitch (the worst natural disaster to strike Central America in 200 years), researchers found that farms using agro – ecological practices suffered 58% less damage in Honduras, 70% less in Nicaragua and 99% less in Guatemala than those using conventional farming methods.

Impacts of conservation practices may be species specific. For example, cotton is an inhospitable habitat for many songbirds, particularly due to very high levels of pesticide use in conventional systems. But approaches such as conservation tillage and strip cover cropping reduce the ecological impact of cotton fields. Examined the effects of clover strip cover cropping with conservation tillage versus conventionally grown cotton with either conventional or conservation tillage on avian and arthropod species composition and field use in Georgia, USA. Strip cover fields had higher bird densities and biomass and higher relative abundance of arthropods than either conservation tillage or conventional fields. During migration and breeding periods, total bird densities on strip cover fields were 2 to 6 and 7 to 20 times greater than on conservation and conventional fields, respectively. Although the clover treatment attracted the highest avian and arthropod densities, conservation fields still provided more wildlife and agronomic benefits than conventional management. The reduction of inputs possible with the clover system allows farmers to reduce costs associated with conventional cotton production. Transgenic cotton has been developed to significantly reduce the need for pesticides, with observed benefits for biodiversity.

"The organic farming industry has only recently begun to develop standards that explicitly address conservation of wild Biodiversity. But found that a wide range of taxa, including birds, mammals, invertebrates and arable flora can benefit from organic management through increases in abundance and/ or species richness. Management practices, such as prohibition or reduced use of chemical pesticides and inorganic fertilizers, protection of non – cropped habitats, and preservation of mixed farming, are particularly beneficial for farmland Wildlife". Though yields from organic systems are still often lower than those in conventional systems, the gap is narrowing and research is accumulating that shows how agricultural production systems primarily or exclusively dependent on organic inputs can produce superior agronomic and economic results. Carefully targeted management practices applied to relatively small areas of cropped or non – cropped habitats within conventional agriculture may also provide valuable biodiversity benefits found that wild species richness generally increased with landscape heterogeneity on a farm scale and habitat type had a major effect on species richness for most groups, with most species found in pastures and leys (lands temporarily sown with grass). The level of motivation of the farmer to maintain biodiversity on the farmstead was more predictive of biodiversity outcomes than specific practices.

(iii) Modifying Farming Systems to Mimic Natural Ecosystems

From a wild biodiversity conservation perspective, the ideal agricultural production systems for eco – agriculture landscapes mimic the structure and function of natural ecosystems. In humid and sub – humid forest ecosystems, farms would mimic forests, with productive tree crops, shade – loving understory crops and agro – forestry mixtures; in grassland ecosystems, production systems would rely more on perennial grains and grasses and economically useful shrubs and dry land tree species. Annual crops would be cultivated in such systems, but as intercrops or monoculture plots interspersed in mosaics of perennial production and natural habitat areas. Domesticated crop and livestock species diversity would be encouraged at a landscape scale and intra – species genetic diversity would be conserved **"In – Situ"** at least at an ecosystem scale, to ensure system resilience and ecological diversity.

Multi – story agro – forest systems, tree fallows and complex home gardens are especially rich in wild biodiversity. For example, found that canopy height, tree, epiphyte, liana and bird species diversity, vegetation structural complexity, percent ground cover by leaf litter and soil calcium, nitrate nitrogen and organic matter levels in top – soils were all significantly greater in shaded than in sun – grown farms, while air and soil temperatures, weed diversity and percent ground cover by weeds were significantly greater in sun farms. Recent research in Central America has identified poly – culture combinations and

management systems that significantly improve the productivity of coffee, cocoa, banana, timber and other commercial tree products in these complex systems.

New and improved perennial crops can substitute for products now provided by annuals, such as fruits, leafy vegetables, spices and vegetable oils. Perennial crops can be more resilient and involve less soil and ecosystem disturbance than annual crops, and provide much greater habitat value, especially if grown in mixtures and mosaics. Breeding efforts are also underway to perennials annual grains and to mimic ecosystem functions of natural grasslands; in some cases, yields are becoming competitive with conventional varieties. This is a significant research opportunity and increased demand for livestock products in turn raises demand for animal feed, including for higher – quality pastures, fodder or inputs for concentrates. While historically low grain prices have meant that corn and soy have been dominant feed – stocks during the past few decades, alternatives abound, including perennial grass, shrub and tree species that can be grown more sustainably in marginal lands, as industrial processes adapt. Moreover, the future of industrial – type intensive, grain – fed livestock production is uncertain in the face of emerging zootoxic infectious diseases and associated pollution, opening more economic opportunity for substitutes from rotational grazing and even pastoral systems. Crops for bio – fuels are poised to become one of the fastest – growing segments of agricultural production, and although short – term investments have favoured annual crop sources in the developed world (as a way to absorb subsidy – driven surpluses), grasses, shrubs and tree sources may be more economic and sustainable options once the technical challenges of processing cellulosic sources are overcome.

(iv) Major Gaps

The development of agricultural practices and systems that explicitly support wild biodiversity is in its infancy. Highlight numerous critical knowledge gaps, especially knowledge about the link between diversity and ecosystem function, and the relationships between below – and above – ground biodiversity. Methods being used to assess biodiversity impacts are inadequate and generally fail to evaluate the impact on regional or global diversity or to interpret the significance of an individual member of a species found at a particular site. Researchers still find it difficult to link plot – based analysis with landscape – scale impacts. Even where successful biodiversity and production outcomes are well documented, the underlying biological or ecological mechanisms may be poorly understood. The potential contributions and threats of genetically modified organisms to biodiversity in eco – agriculture landscapes have not been explored. Little of the existing crop breeding research in general has been considered within an eco – agriculture framework. Rather, most have focused on addressing problems at the **"End – of – Pipe"** to offset existing problems rather than rethinking the ecological management system, or even considering potential trade – offs of risks and benefits.

More systematically assess the impact of different resource management options on specific components of biodiversity the function, structure and composition of communities/ ecosystems, populations/ species, genetic diversity and option space. Then, where eco – agriculture systems are successful in increasing populations of wild species, new methods for managing them may be needed to minimize conflicts. The major gap is the miniscule level of international and national public investment in research documenting and evaluating existing eco – agriculture production systems or in pursuing agricultural and conservation research to improve biodiversity – supporting and financially viable production systems.

(b) Managing Eco – Agriculture Landscapes for Both Production and Conservation

The eco – agriculture approach encompasses both **"Biodiversity – Friendly",** agricultural production systems and practices and their management in mosaics with natural areas and other landscape features to meet conservation, livelihood and production goals. One premise of eco – agriculture is that ecosystem services can come from both production and conservation areas, especially if they are coordinated and managed for that purpose. Improved tools, greater demand for landscape – scale action and reassessment of long – sustained traditional agro – ecosystems, have led to substantial

progress over the past two decades in laying out the basic parameters for biophysical management of eco – agriculture landscapes, if not location – specific guidance. Social and institutional aspects of landscape management are addressed in the study.

(i) New Tools for Landscape Assessment

Despite the importance of agricultural landscapes for biodiversity conservation, only a small fraction of published conservation biology studies has been undertaken in agricultural landscapes, so developing a baseline for assessing change is difficult. Most studies of the biodiversity impacts of particular agricultural practices and even the work of biodiversity – oriented groups like the **"Rainforest Alliance" (RA)** have focused on farm – level indicators. Meanwhile, a review of basic biodiversity research found very little empirical data on the contributions of wild species and natural ecosystem conditions to agricultural productivity. Landscape ecology has provided us with the analytical language and tools to systematically examine the interactions between farmed and unfarmed areas. The science of **"Countryside Biogeography"** has recently begun to work on biodiversity patterns in complex landscape mosaics, which shows how different land use elements and configurations support different wild species. Sophisticated landscape modeling and remote sensing tools are becoming available.

(ii) Maintaining Natural Habitats for Terrestrial Species in Agricultural Landscapes

A common goal in eco – agriculture landscapes is to conserve a broad range of terrestrial species native to the area. This includes species that are relatively resilient to habitat fragmentation and agricultural land use, as well as species that are rare or locally or globally threatened, and those that require larger extensions of minimally disturbed habitat. The prospects for achieving this in agricultural landscapes depends on the degree of fragmentation and functional connectivity of natural areas, the habitat quality of those areas, the habitat quality of the productive matrix and the behaviour of farmers. Efforts to maintain natural habitats in farming areas are longstanding, principally through diverse types of agricultural set – aside schemes. Based on a Meta – Analysis of 127 published studies, found that land withdrawn from conventional production of crops unequivocally enhances biodiversity in North America and Europe. The number of species of birds, insects, spiders and plants is 1 to 1.5 standard deviation units higher on set – aside land, and population densities increase by 0.5 to 1 standard deviation units. Set – aside land may be especially beneficial for desirable taxa because North American bird species that have suffered population declines reacted most positively to set – aside agricultural land. Larger and older plots protect more species with higher densities, and set – aside land is more effective in countries with less – intensive agricultural practices and higher fractions of land removed from production. For many commercial crop monocultures, leaving field margins uncultivated for habitat protection does not reduce total yields, as inputs were applied more economically on the rest.

However, landscape – scale interventions specifically designed to protect habitats for biodiversity (that include but coordinate and go beyond farm – and plot – specific interventions) are much more effective. A recent review of evidence from North America on how much habitat is **"Enough"** in agricultural landscapes concluded that strategies need to consider habitat needs within the landscape history and context. Adequate habitat patch size and connectivity must be maintained, but **"Adequate"** must be considered in relation to matrix influence and patch condition (sinks and ecological traps, patch location and configuration, edge effects and boundary zones). Smaller patches of natural habitat may be sufficient if adjacent agricultural patches are ecologically managed.

Based on studies from Central America, conclude that landscape connectivity between large patches of forest can be effectively maintained through retention of tree cover on the farm, such as live fences, windbreaks, and hedges in grazing lands and agricultural fields and describe effective approaches for forest landscape restoration in mixed use mosaics.

(iii) Protecting Habitats for Freshwater Aquatic Biodiversity

Protection or establishment of native vegetation buffers along streams, rivers and riparian systems is critical for biodiversity conservation. Data from the region or area suggest a minimum buffer

width of 25 m to provide nutrient and pollutant removal, 30 m to provide temperature and micro – climate regulation and sediment removal, a minimum of 50 m to provide detrimental input and bank stabilization and over 100 m to provide for wildlife habitat functions. Wetlands should be protected and the critical function zone of wetlands should be maintained in natural vegetation. The latest guideline in North America is that at least 10% of a watershed and 6% of any sub – watershed should comprise wetlands. ***"Biodiversity conservation emphasizes the importance of re – establishing hydrological connectivity and natural patterns for aquatic ecosystems"***. Based on literature review and field experiments, conclude that watershed functions in agricultural landscapes can be effectively provided through strategic spatial configuration of perennial natural vegetation and planted vegetation, with maintenance of continuous soil cover enhancing infiltration.

Maintaining seasonal flood pulse dynamics in floodplains involves restoring floodplains and protecting them from developments that disconnect rivers through levees and water level management. If floodplains must be used for agriculture, ecologists recommend using agro – forestry and other approaches compatible with natural cycles rather than monocultures requiring annual ploughing and fertilization. This study presents an example of river floodplain poly – culture in the Tisza River Basin in Hungary that exploits flooding as an engine of biodiversity. Natural floodplains, unconstrained by hydro – engineering infrastructure, sustained a diversity of habitats and the elevation structure in the landscape. They further maintained hydraulic connections that sustain nursery and migratory functions, stored water during times of drought and distributed and mixed fallen fruit in novel combinations that stimulated agro – biodiversity and the cultivation of hundreds of varieties of fruits and nuts, as well as fisheries.

(iv) Optimizing Agriculture – Natural Habitat Interactions in Landscape Mosaics

Biologically diverse agricultural systems and landscapes can contribute to control of pests and diseases, provide new economic species and buffer environmental changes and challenges investigated the role of tropical forest remnants as sources of pollinators for surrounding coffee crops in Costa Rica, observing bee activity and pollen deposition rates at coffee flowers, including 10 species of native bees and the introduced honeybee, *Apis mellifera*. Bee species richness, overall visitation rate and pollen deposition rate were all significantly higher in sites within approximately 100 m of forest fragments than in sites farther away. The vast majority of pollination in coffee plantations more than 100 m from a forest was introduced by the honeybee. Forest fragments near coffee plantations increased both the amount and stability of pollination services by reducing dependence on a single introduced species. In the study it is found similar results for pollinators of watermelon fields near and far from natural woodlands in India and as well as in California.

(v) Major Gaps

The past two decades have revolutionized the potential for landscape – scale assessment and scientific understanding of the ecological functioning of diverse types of agricultural landscapes. A framework for considering key management guidelines and broad parameters is now in place, but empirical or even ecological modeling evidence needed for managing eco – agriculture landscapes (*e.g.,* size and shape of natural areas required to sustain ecological functions, impacts on agricultural productivity of natural vegetation and species) is lacking. Agreed methods do not yet exist for integrated monitoring of livelihood, biodiversity and agricultural outcomes at a landscape scale, although this challenge is being taken up. Rigorous understanding of the potential benefits and costs for agriculture of associated wild **"Flora and Fauna",** and key ecosystem services, is lacking.

Agriculture specialist highlights numerous practices to manage irrigation water in ways that also support biodiversity. But these are not widely implemented, because they are not part of the institutions, incentive structures and education related to irrigation. Little of the new science has been shared with farmers or even with agronomists and other specialized agricultural scientists and technicians. The science is often missing that informs real – life innovations that local people can make to modify **"Ecological Impacts of Biodiversity Management",** activities. Technical assistance services for farmers rarely address landscape management issues. Lack of rigorous data and analysis about eco – agriculture impacts and potentials is a key constraint to increased investment in and policy support for

eco – agriculture. The complexity of eco – agriculture landscapes and management, multiple objectives and lack of information on interactions have made it difficult for project or community managers to document outcomes effectively or to compare results across sites and international collaborative research on tropical forest margins is rare.

(c) Achieving Financial Viability of Eco – Agriculture Landscapes

Investing and engaging in eco – agriculture systems will require that all key elements – farm production, nature conservation and associated institutions for collective landscape management – be adequately financed. If eco – agriculture systems are to be widely adopted around the world, then incomes (defined to include not only cash but also other livelihood components) for farmers in those systems need to be at least as high, or higher, than in less **"Biodiversity – Friendly",** production systems, and other non – monetary benefits will be key. Market – based innovations could provide many opportunities for scaling up eco – agriculture.

(i) Making Eco – Agriculture Systems more Profitable for Farmers and Investors

Contrary to common assumptions, farmers and their communities often have strong economic and social rationales for supporting biodiversity conservation: to reduce production costs, raise or stabilize yields; improve product quality; protect their right to farm/ herd/ harvest wild products in and around protected areas; comply cost – effectively with environmental regulations; conserve biodiversity and ecosystem services critical to their own livelihoods; access product markets that require **"Biodiversity – Friendly",** production systems; earn payments for ecosystem services; or conserve species and landscapes of special cultural, spiritual or aesthetic significance to them. Many eco – agriculture systems are, in fact, more profitable or less risky than alternatives. The study presents 28 examples that clearly demonstrated positive economic benefits and another five cases had a neutral impact on incomes (despite major benefits for wild biodiversity). Farm incomes had doubled or tripled in eco – agriculture landscapes not only in India, but with irrigated rice in The Philippines, dairy systems in Brazil and the US, and improved fallow systems in Africa.

Investment needs to be targeted to produce the research and management breakthroughs that will enable farmers to raise output and/ or reduce their costs while protecting and enhancing biodiversity. Community non – monetary benefits from use and non – use values of biodiversity, including inputs for farming and processing, medicines and cultural values are also important with documents financial and economic contributions of ecosystem services and biodiversity to poverty reduction and vice versa. Communities are organizing themselves regionally to improve market linkages, reduce marketing costs and connect directly with buyers. Communities need to understand and meet the quality and time demands of interested buyers and to enter into and fully respect commercial contracts. They also need technical assistance to improve product quality and manage commercial contracts, and gain access to harvest finance and credit for post – harvest product processing and handling facilities/ technologies. Development of innovations at all points in the marketing chain can reduce costs for trading, storage, transport, bulking, grading, etc. and thus improve returns from marketing products from poly – cultures and multi – product landscapes.

(ii) Develop Product Markets that Reward Ecosystem Stewardship

New market niches are beginning to develop for agricultural products that are certified to be **"Green"**. Producers or products are certified by independent third parties to have positive or neutral effects on biodiversity, based on criteria such as reduced agrochemical pollution, protection of natural areas, and use of production practices that do not interfere with key natural processes or species lifecycles and participation in the development of landscape – scale wildlife corridors. A 2005 review by Eco – agriculture Partners found more than 70 such **"Green Certification Systems",** ranging from **"Salmon – Friendly"** certification of farms protecting critical stream habitats to **"Conservation Beef"** to Rainforest Alliance – certified commodities. The **"Sustainable Agriculture Initiative Platform" (SAIP)** and the **"Sustainable Food Lab" (SFL)** are working with suppliers to enhance sustainability, including some elements of biodiversity.

New markets are also developing for products based on sustainable harvest of wild species, or on the domestication of wild species such as extracts, spices, medicinal, construction materials and fruits. The use of marketing labels for agricultural products coming from particular geographical regions, originally focused on quality, culture and taste, is being adopted for products labeled as supporting conservation of high – biodiversity – value landscapes. ***"Demand is growing as the food industry becomes more sensitive to reputation issues around environment and advocates promote new institutional procurement policies, although consumers remain motivated more by human health – related issues"***. Concerns about bio – terrorism and health, combined with low – cost monitoring technologies, could enable farm – to – consumer farm product tracking to become more common in high – and middle – income countries, reducing the relative costs of managing value chains for eco – certified products.

(iii) Reward Farmers and Farming Communities for Ecosystem Services

A major potential driver for eco – agriculture landscapes is payments to farmers or herders/ ranchers and their communities for conserving biodiversity important to outsiders, and for conserving other ecosystem services using management practices that also conserve biodiversity. Such compensation currently takes various forms, including payments for access to species or habitats (*e.g.,* research permits; hunting, fishing or gathering permits for wild species; or ecotourism); payments for biodiversity conservation management (*e.g.,* conservation easements, land leases, conservation concessions or management contracts); tradable rights under **"Cap – and – Trade"** regulations (*e.g.,* wetland mitigation credits, tradable development rights and biodiversity offset credits) and support for biodiversity – conserving businesses (*e.g.,* business investments or eco – labeling of **"Green Products"**. An estimated $6,000 million is spent worldwide on land trusts and conservation easements, a third in developing countries, with a large proportion in farm and ranchlands. Direct conservation and biodiversity payments for **"Flora and Fauna",** by governments amount to at least $3,000 million, most in the US, Europe and China. Roughly, 20% of the farmland in the EU is under some form of agri – environment scheme to counteract the negative impacts of modern agriculture on the environment, at a cost of approximately US$1.5 billion (approximately 4% of the EU expenditure on the **"Common Agricultural Policy"**).

In the US, approximately US$45 million is spent on regulatory offsets for biodiversity, including conservation banking, and such programmes have been initiated in Australia and France. New models are emerging for payments by private sector companies, utilities and municipalities for ecosystem services essential to businesses, and to reduce ecological risks. For example, at least $20 million in voluntary biodiversity offsets have been documented, half in developing countries. Thus, the size of payments is already considerable, although their effectiveness in achieving biodiversity objectives and in supporting **"Biodiversity – Friendly",** production systems at landscape scale is quite mixed. The potential future contribution of these new payments and markets to financing eco – agriculture landscapes will depend on the **"Rules of the Game"** and institutions that are currently being developed.

(iv) Major Gaps

New mechanisms have arisen over the past decade to **"Reward"** and **"Finance" "Biodiversity – Conservation"** and **"Biodiversity – Friendly", "Agriculture",** but most of these are modest in scale or modestly effective at landscape scale. Little research has been done on the structures and institutions in product market chains that facilitate biologically diverse production. Nor has any systematic assessment been done of overall agricultural investment and finance and how it might be shaped to better support biodiversity. Certification processes for agricultural products (and wild products sustainably harvested) can be expanded, streamlined, and designed for landscape – scale impact, enable low – income people to participate. Still, most demand in developing countries is for domestic markets and seeking lowest – cost supply, so it is crucial to focus on reducing costs across the market value chain (not only at the level of the producer). More explicit attention is needed to mobilize payments for ecosystem services to support eco – agriculture landscapes. Finance through carbon emission offsets is the greatest unexploited opportunity, but further technical research is needed to lower costs of organizing landscape – scale action and monitoring performance. The trade – offs and synergies among different

ecosystem services for different production and conservation strategies need to be more fully understood and addressed.

(d) Mobilizing Eco – Agriculture: from Community Action to Global Impacts

Eco – agriculture landscape innovators often identify their major constraint to be institutional barriers rather than technical or even financial ones. Key institutional challenges include inadequate community – level organizations for eco – agriculture action, landscape – scale planning, policies at various levels and mechanisms to achieve equitable outcomes in eco – agriculture landscapes.

(i) Organization of Communities for Eco – Agriculture

A core feature of eco – agriculture landscapes is the role of resident local farming or pastoral communities as key stewards, decision makers and managers of biodiversity. Public agencies may operate forests and protected areas, but their viability and sustainability depend on the matrix of private land uses in the landscape. Economic and social incentives can motivate collective action of local communities. Hundreds of community – based organizations have been documented to mobilize or engage in landscape – scale eco – agriculture initiatives. The institutions leading these initiatives are **"Hybrids"** fusing conventional farmer cooperatives, rural development committees and community – based conservation organizations. In The Philippines, for example, local farmer – based on **"Land Care Groups" (LCG)** are linked with conservation organizations, municipal governments and research organizations to re – vegetate hillsides, conserve biodiversity in populated **"Protection Areas" (PAs)** and improve water quality. An important implication is the central role of communities in biodiversity conservation, especially outside PAs. Conservation organizations need to embrace and reorient their role explicitly to support local community stewardship in ways that respect and realistically address the central role of agriculture and livelihoods in planning and implementation methodologies.

(ii) Landscape – Scale Planning and Governance

To achieve objectives at the landscape scale requires a process of collective action to support producers and coordinate action among key stakeholders in the landscape, often across sectors with a historical legacy of distrust. Development or adaptation of institutions for engagement, coordination and governance of eco – agriculture become the critical challenges. Scaling up and sustaining eco – agriculture landscapes that involve multiple stakeholders requires a process, and usually an institution, that will enable multi – stakeholder assessment, planning, implementation and monitoring for adaptive management. Currently, eco – agriculture initiatives take numerous forms, mobilized by community organizations, public agencies, NGOs or national/ international projects. Methodologies that have been developed to assist the planning and governance process include landscape **"Visioning"** and **"Scenario – Building"** processes, participatory landscape modeling, community biodiversity assessments and guidelines for **"Adaptive Collaborative Management" (ACM)**. Multi – stakeholder trust – building processes and negotiation platforms are being adapted to the specific context of agriculture – biodiversity conflict situations. Diversity of approaches is expected and desirable, but more systematic and comparative evaluation of effectiveness in achieving sustainable processes and outcomes is lacking.

(iii) Policies that Support Eco – Agriculture Landscapes

Eco – agriculture innovators around the world highlight the need for a more supportive policy environment for eco – agriculture, or simply the removal of major policy barriers. Core policy needs, at local, national and international scales are: ***(i)*** compatibility and coordination of agricultural development and biodiversity conservation policies, ***(ii)*** environmental legislation that embraces the potentials and rights of farming communities as conservators of biodiversity, and ***(iii)*** the removal of public subsidies for agricultural systems and investments that harm biodiversity.

Consumers, policy makers and investors are beginning to focus on the link between agriculture

and conservation, and responding with new demands on the agricultural system, through systems of voluntary certification, industry standards and government regulation. Ecosystem/ landscape – scale programmes and projects are being initiated by government agencies and NGOs, often in multi – stakeholder partnerships, and financed through public budgets (*e.g.,* in India and China) and international development loans. Initiatives to achieve these policy objectives include the Central America Presidents' joint commitment to promote environmental friendly agriculture, the removal of agricultural subsidies in Australia, and the recommendations from Communities to the Millennium Summit. New political coalitions are being formed to promote integrated cross – subdivision policies, bringing in voices and sectors not traditionally involved in either agricultural or conservation policy, such as municipal governments (in the context of political decentralization), urban consumer groups, international financial organizations concerned with screening investments for environmental sustainability, parts of the food industry, **"Public Health Advocates"** and **"Good Governance"** movements seeking to reduce wasteful spending on subsidies.

At the international policy level, eco – agriculture strategies are being integrated into the work programmes of the relevant international conventions. For example, the **"Convention on Biological Diversity" (CBD)** has adopted a new biodiversity goal of 30% of agricultural areas under **"Biodiversity – Friendly",** management by 2010, and will focus on agriculture in meetings during 2008, as will the Commission on Sustainable Development. Rules developing under the **"World Trade Organization" (WTO)** will need to be carefully scrutinized to ensure that they do not disadvantage producers in eco – agriculture landscapes. Some countries, notably Australia, Brazil and India, have adopted legislation that explicitly recognizes the rights of indigenous and other local communities to manage and conserve forests and natural habitats. The Convention on Biological Diversity and other international bodies are beginning to focus on opportunities for community – led conservation, although many elements of the conservation community are still uncomfortable directly addressing and supporting agricultural development. Policy changes can enhance the financial viability of eco – agriculture by removing government subsidies and fiscal incentives for biodiversity – harming production systems, in particular subsidies for agrochemical inputs and water, rules for commodity payment support that limit crop rotations, subsidies that favour annual crops over perennials, and intensive livestock production systems over grazing systems, and tax incentives for vegetation clearing.

(iv) Achieving Social Equity

Efforts to maintain or promote eco – agriculture landscapes are often instigated, complicated or impeded by the serious social inequities characterizing rural regions in many parts of the world. Indigenous communities are documenting their effective eco – agriculture systems in their efforts to reclaim land rights from the state. Corporate agribusinesses are seeking to promote eco – agriculture to ensure their **"Social License to Operate"**. Eco – agriculture strategies that coordinate the use and management of landscape resources can help resolve resource disputes between farmers and pastoralists. Community groups and advocates for the poor are promoting eco – agriculture policies as a way to protect and restore biodiversity and ecosystem services important to the poor.

Eco – agriculture approaches can create more **"Space"** for equitable outcomes by identifying synergies between local livelihood benefits and benefits for agricultural economies and biodiversity, and by justifying stronger rights for poor producers over **"Natural Resources"**. But eco – agriculture systems are both context specific and the result of negotiations among diverse actors. To achieve equitable outcomes will require that poor and disenfranchised groups within the landscape organize themselves for political strength, that they join coalitions with other stakeholders, and that they be supported strategically in their negotiations with more powerful groups.

(v) Major Gaps

While this survey of eco – agriculture innovators reports numerous promising institutional models – at community, landscape and policy levels – the conditions under which such innovations are most likely to emerge, or can be successfully applied, are poorly understood. Effective cross – subdivision political coalitions have seldom arisen to advocate for reconciling conflicting agriculture and

environmental policies. Eco – agriculture strategies are not well integrated into public investment plans, including the **"Poverty Reduction Strategies" (PRS)** of low – income countries and donor strategies designed to support the **"Millennium Development Goals" (MDGs)**. Rural farming communities are largely unrepresented at most international environmental policy forums, and environmental interests generally are absent from farming organizations. Local organizations find it difficult to access the specialized knowledge generated by others and are poorly integrated into ecosystem or watershed planning and policy processes at local, national or international levels. Few conservation organizations have staff with agricultural expertise. Most international and national policy and legal frameworks separate action on agricultural productivity, ecosystem management and rural livelihoods, and policy – making institutions reflect this separation. Most policy makers are unfamiliar with the opportunities for eco – agriculture, or of alternative policies and laws that would enable eco – agriculture activities and outcomes. Mainstreaming eco – agriculture will require that strategically important institutions – responsible for policy, research, and markets – modify how they do business to embrace eco – agriculture vision and strategies.

20. ACHIEVING "ECO – AGRICULTURE AND BIODIVERSITY" AT A GLOBALLY MEANINGFUL SCALE

"This practical and sensible review found many examples of apparently successful approaches linking Biodiversity conservation with sustainable agriculture. On the other hand, the current knowledge base and institutional arrangements are clearly inadequate to meet the objectives noted above across diverse ecosystems and production systems". To enable eco – agriculture landscape approaches to expand to a globally significant scale will require at least ***"Three Elements: New Knowledge, Institutional Capacity, and an Enabling Policy and Market Environment"***.

(a) Produce and Share Knowledge for Eco – Agriculture

The challenge of shaping agricultural landscapes to meet joint production, conservation and livelihood goals will require a dramatic scaling up and refocusing of research, in national research systems, the center supported by the **"Consultative Group"** for **"International Agricultural Research" (IAR),** centers of conservation science, national academies of science, and universities. Priorities are to understand the interaction and dynamics of conservation and production areas; to develop production systems (including improved varieties of more diverse domesticated species) that explicitly meet biodiversity objectives and mimic natural ecosystems; and to make more elements of farming systems ecologically sustainable, including industrial processing, packaging, transport, etc. Eco – agriculture systems that appear to be successful need to be fully documented, both in terms of landscape – scale outcomes and specific interventions. Mapping of spatial overlays between important agricultural areas (in terms of national product supply or local livelihoods) and important biodiversity will be essential.

(b) Build Capacity for Eco – Agriculture

Knowledge innovation systems need to be reshaped to provide services to rural resource stewards, and to accelerate exchange of practical knowledge among them and across sectors. Rural communities must be acknowledged as key stewards of **"Biodiversity Conservation",** and professional conservation organizations, public agencies and others need to reorient their activities to reflect this reality and provide services to community – based organizations, as well as to other stakeholder groups. Conservation organizations need to fully embrace farming partners, develop agricultural expertise and aggressively advocate for sustainable agriculture investment in coordination with conservation strategies.

(c) Promote Markets and Policies that Support Eco – Agriculture

Technical and local organizational opportunities and initiatives for eco – agriculture are unlikely to be successful unless major policy barriers are removed, and supportive policies developed. To advocate

for this agenda, beneficiaries of ecosystem services provided by agricultural landscapes, new economic actors in the product value chain and advocates for reinvigorated rural development need to form new political coalitions. In North America, Europe, Japan, Australia and many developing countries, shifting of government funds from agricultural commodity subsidies to payments for ecosystem services (including carbon emission offsets) in eco – agriculture landscapes could provide initial funding to build institutions and farmer capacity for eco – agriculture. Eco – agriculture offers cost – effective approaches for national investment strategies to achieve the **"Millennium Development Goals" (MDGs)**. Strategic changes in the food industry, institutional procurement, eco – certification of agricultural products and financial investors' oversight of agricultural investments can be mobilized to shift financial incentives towards eco – agriculture. At the international policy level, opportunities exist to integrate eco – agriculture strategies into the work programmes of the international environmental conventions, and to ensure that rules of the **"World Trade Organization" (WTO)** support eco – agriculture landscapes.

21 (A). CONCLUSIONS; RECOMMONDATIONS AND REMARKS

"The transformation of agricultural production actions from one of the greatest threats to global Biodiversity and ecosystem services to a major contributor to ecosystem integrity is unquestionably a key challenge of the twenty – first century. Many elements of eco – agriculture landscapes could also help to achieve the critical goals of agricultural sustainability, resilience of food systems and adaptation to climate change". To realize these potentials, the agricultural and biodiversity conservation research and policy communities will need to re – evaluate and coordinate their priorities and strategies for **Nampong to Vijaynagar Road,** in the **State of Arunachal Pradesh**.

Regenerative Design: Responding to Biodiversity Loss and Climate Change Simultaneously

"There is a synergistic relationship between the climate and ecosystems, additional strategies to address the causes and impacts of climate change may be found by reducing the loss of Biodiversity and working to restore the health of ecosystems" as shown in the **Figures 27 (a)** to **(d)**. This would at the same time restore or create ecosystem services and add to resilience. ***Many current Biodiversity loss and climate change mitigation and adaptation strategies can be described as*** **"Sustainable"**. While this is an improvement on design that does not consider environmental impacts at all, **"Sustainable"** design nevertheless tends to result in negative environmental impact. Sustainable design seeks to minimize pollution rather than achieving clean air, soil and water; it minimizes energy use, rather than using energy from non – damaging renewable sources; it minimizes waste rather than eliminating it altogether by creating **"Positive Cycles of Resource" (PCR)** use; and so on...!!! Within this paradigm, the built environment continues to degrade the ecosystems and climate humans are dependent upon for well – being, wealth, and basic survival. Currently, most urban environments are built in such a way that the outcome is detrimental to climate, ecosystems, and ultimately therefore to people, rather than nearing even approximate **"Sustainable"**.

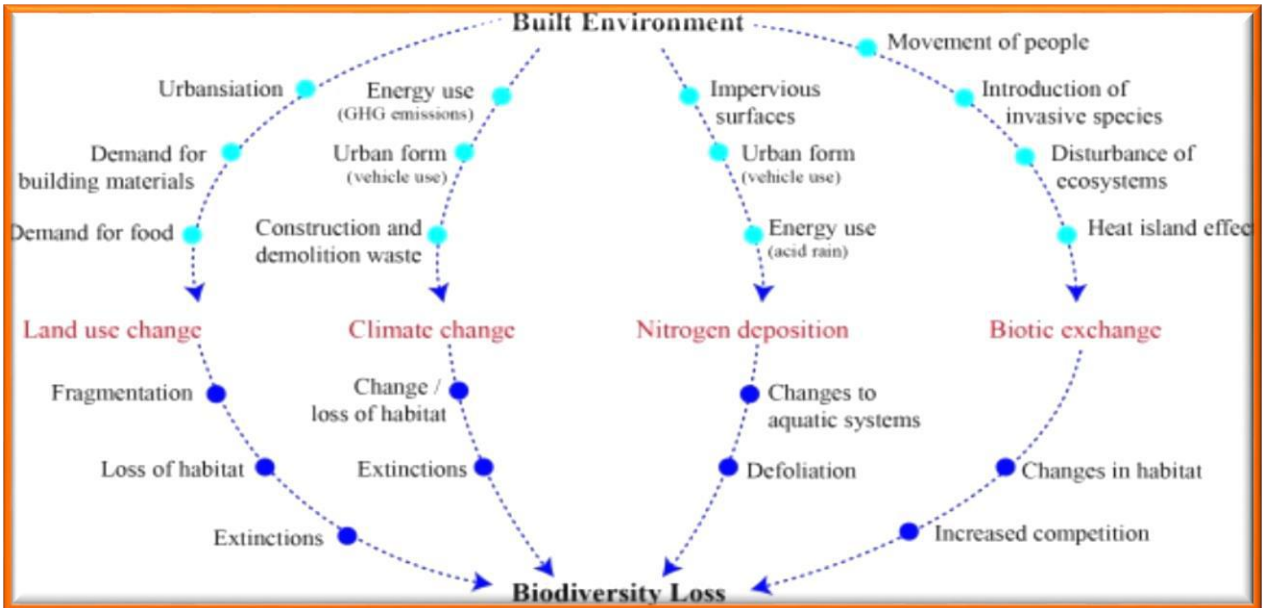


Figure 27 (a): Built Environment Drivers of Biodiversity Loss.

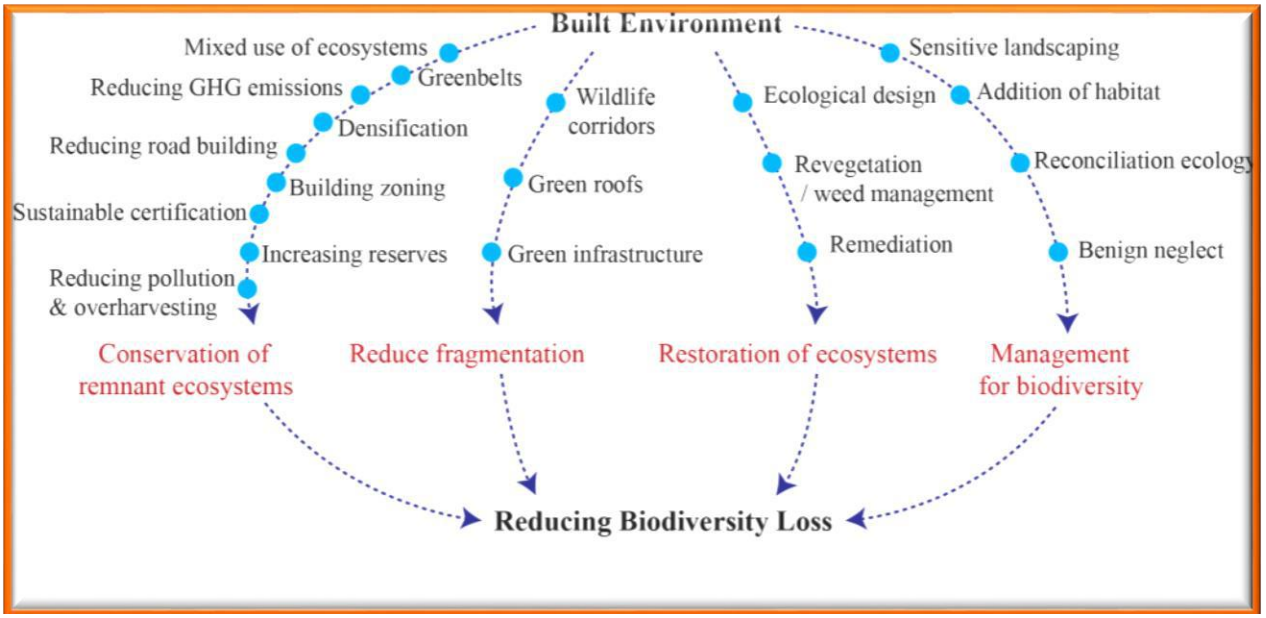


Figure 27 (b): Built Environment Responses to Biodiversity Loss.

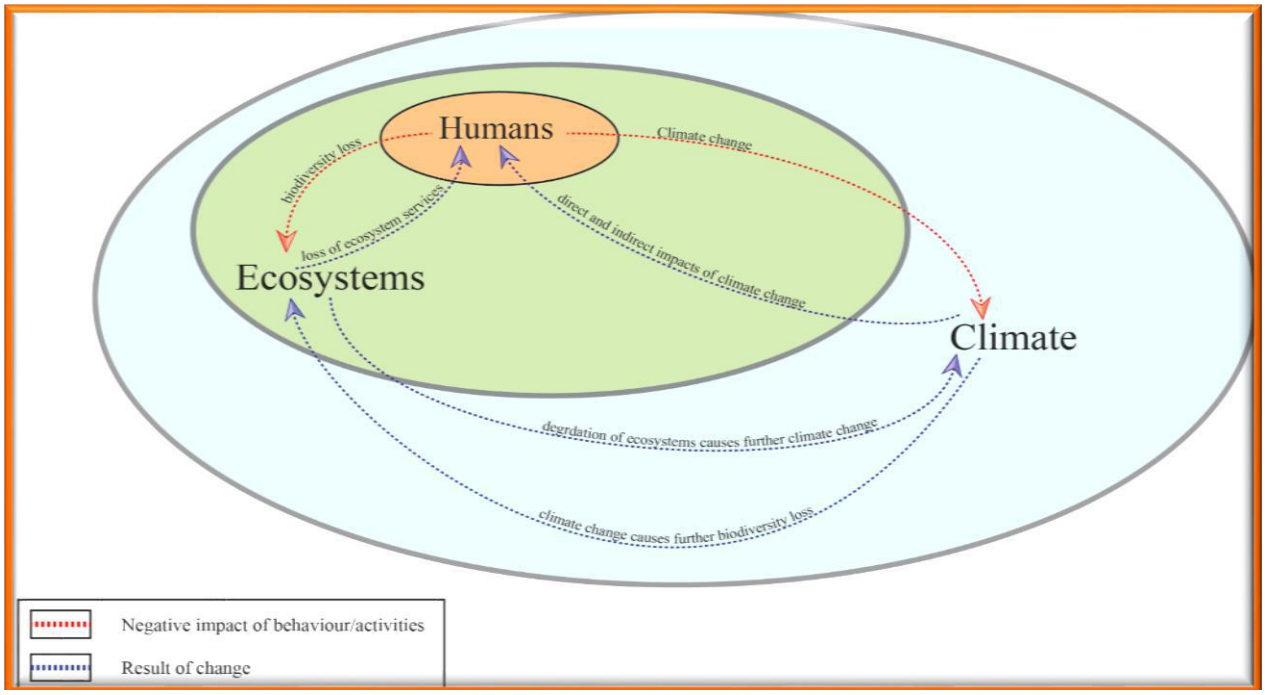


Figure 27 (c): Relationship between Humans, Ecosystems and Climate.

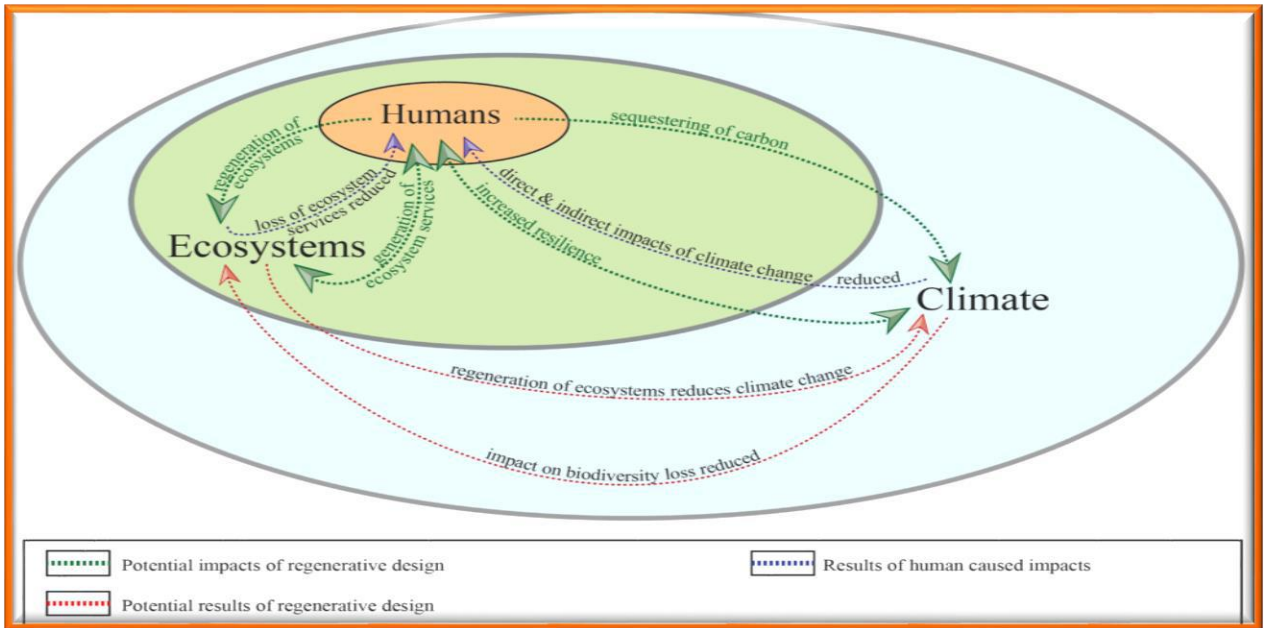


Figure 27 (d): Potential Impact of Regenerative Design.

Biosphere Verses Biodiversity: Protection of the Environment, the Biosphere and Biodiversity Ecosphere

"This revision concludes with an outlook on the future of the environment, the biosphere, and Biodiversity. The spotlight in this episode will fall on the challenge of

protecting the environment, the biosphere, and Biodiversity. In particular, an overview will be given of the conceptual, philosophical, and ethical challenges related to defining exactly what should be protected regarding the natural environment, the biosphere, and Biodiversity and what the arguments are to justify why this should be done. The crux/ core roots of this discussion will be devoted to different kinds of values that have been used to justify protection, as well as the different implications of these values have for conservation management, not only in setting its goals but also in determining its applicable/ pertinent tools and methods. Some of the discussion will also focus on the drivers behind Biodiversity loss, destruction of the biosphere, and the environmental crisis and what if anything could be done about them".

Biosphere is the region of the earth where life exists and includes a global girdle extending from about 10,000 m **"Below Mean Sea Level" (BMSL)** to 6,000 m **"Above Mean Sea Level" (AMSL)**. Thus, the biosphere covers the entire realm of living organisms and their interactions with the other segments of the environment, namely the lithosphere, the hydrosphere, the atmosphere and the **"Biodiversity Ecosphere"**. All the living things require energy and materials. In the biosphere, energy is received from the sound and the interior of the Earth, the received energy is then used and given of as materials are recycled. The idea of a biosphere was first suggested by and Austrian geologist Edward Sues, nearly a century ago. At that time, it was an insignificant concept. Today, the study of biosphere, has not only become necessary, but also is of the almost importance. Some authors consider biosphere as one of the segments of the environment, but it is not so. The biosphere, infect, is a thin shell that encapsulates the earth, which includes all life as well as lower atmosphere and the oceans, rivers, lakes, soils, and solid sediments that actively interchange materials with life. It is within the biosphere that all the life forms of earth, including man, live. The life sustaining resources viz. air, water and food are withdrawn from the biosphere and cycled through the biosphere only. The waste products in gaseous, liquid and solid – waste forms too are discharged into the biosphere and thus providing substances to all living organisms. This distinguishing feature of the biosphere is that it supports life. According to an estimate, the biosphere contains more than 3.5 lakhs species of plants including fungi algae, mosses and higher forms of plants and more than 11 million species of animals. The biosphere supplies all the essential requisites of life – namely, light, air, water, heat, food and living space for all these species for creation of **"Natural Biodiversity"** on the **"Earth"**.

The biosphere includes most of the hydrosphere and parts of the lower atmosphere and upper lithosphere. It reaches from the deepest ocean floor, 20 Km below sea level, to the top of the highest mountains. If the **"Earth"** were an apple, the biosphere would be no thicker than the apple's skin. The realm of ecology is to understand the interaction in this thin, life supporting global skin or membranes of air, water, soil and organisms. **"Biosphere Reserves"** cover a spread – out in an area of **"Biodiversity"** where **"Flora and Fauna"** are sheltered/ protected and privileged. ***"These spheres interact to influence such diverse elements as ocean salinity, Biodiversity, and landscape. For instance, the pedo – sphere is part of the lithosphere made of soil and dirt. The lithosphere also interacts with the atmosphere, hydrosphere, and cryo – sphere to influence temperature differences on "Earth"***. The biosphere is the portions of the **"Earth"** in which living (biotic) organisms exists and interact with one another and their non – living (a – biotic) environment **Figures 28** and **29**.

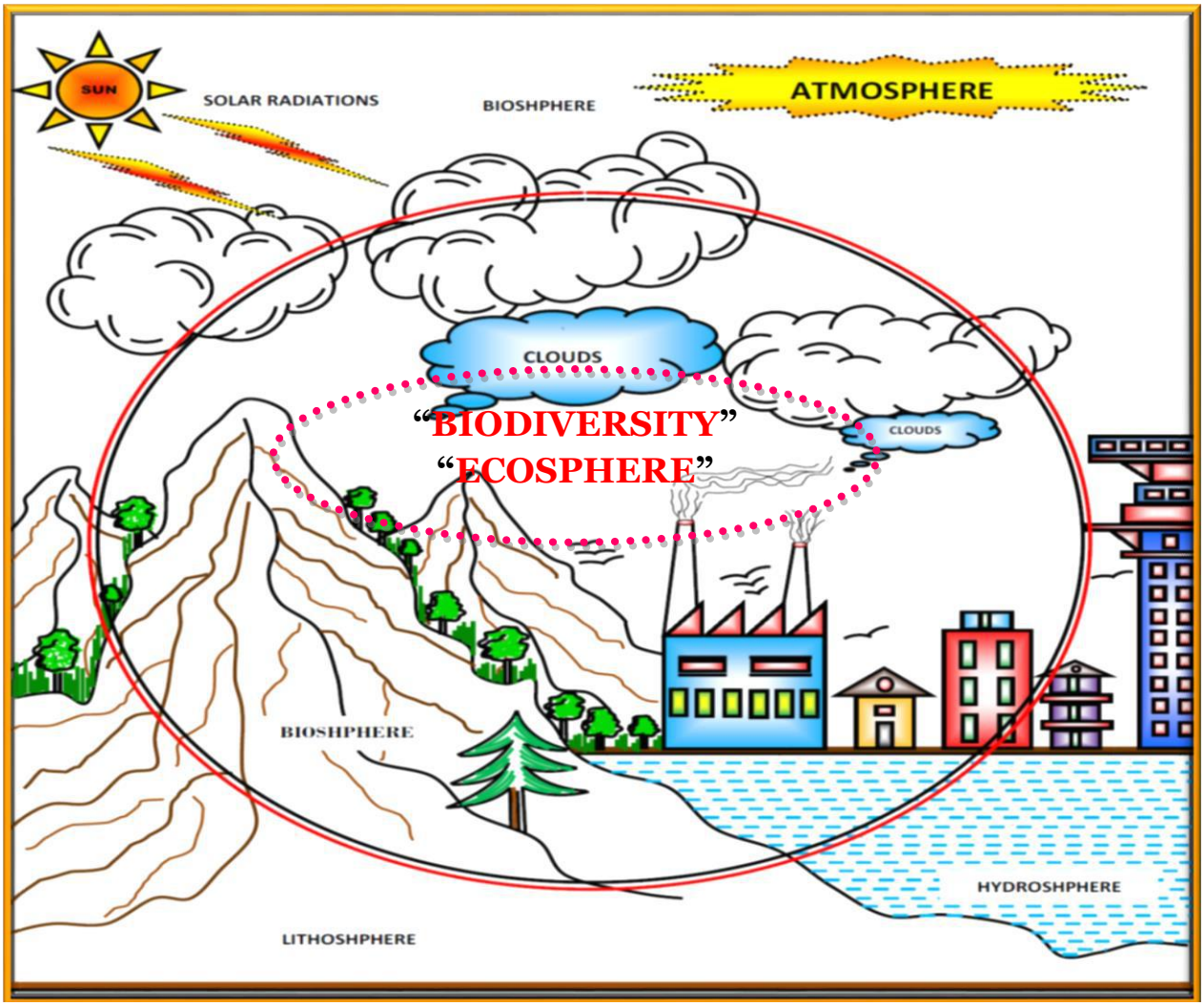


Figure 28: Genuine Illustration of Biosphere Verses Biodiversity Ecosphere.

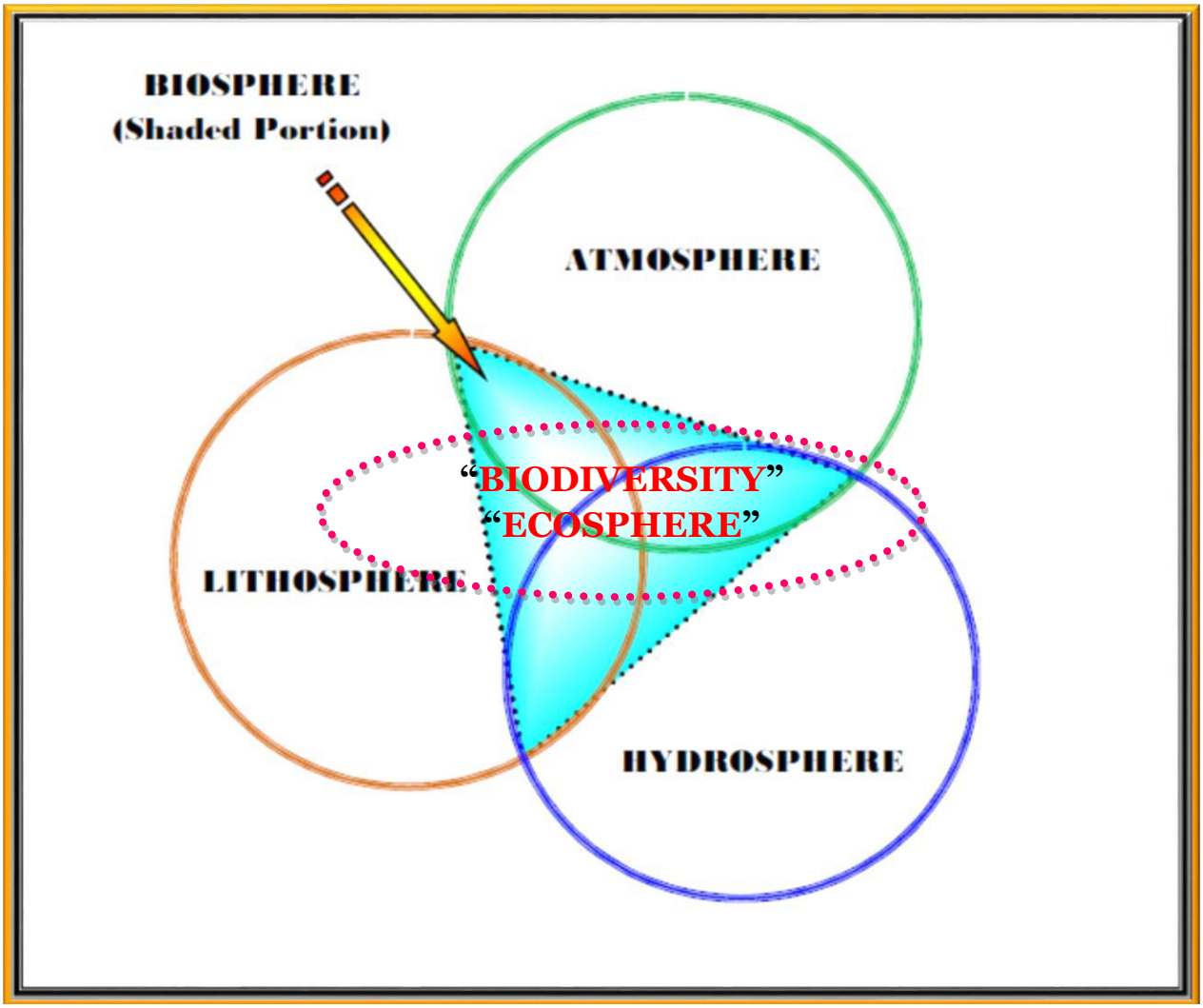


Figure 29: Relationship between Atmosphere, Hydrosphere, Lithosphere, Biosphere and Biodiversity Ecosphere.

21 (B). BIODIVERSITY MITIGATION HIERARCHY MEASURES

The **"Mitigation Hierarchy"** is a tool that guides users towards limiting as far as possible the negative impacts on biodiversity from development projects. It emphasizes best – practice of avoiding and minimizing any negative impacts, and then restoring sites no longer used by a project, before finally considering offsetting residual impacts.

The **"Mitigation Hierarchy"** is crucial for all development projects aiming to achieve no overall negative impact on biodiversity or on balance a net gain (also referred to a **"No Net Loss"** and the **"Net Positive Approach"**). It is based on a series of essential, sequential steps that must be taken throughout the project's life cycle in order to limit any negative impacts on biodiversity.

"The Biodiversity Consultancy's" (TBC) recently wrote a cross – sector guide for implementing the Mitigation Hierarchy on behalf of **"Cross – Sector Biodiversity Initiative" (CSBI)**. It provides practical guidance, innovative approaches and examples to support operationalising the mitigation hierarchy effectively. The publication is aimed at environmental professionals working in, or with, extractive industries and financial institutions, who are responsible for overseeing the application of the **"Mitigation Measures Hierarchy"** to **"Biodiversity Conservation",** while balancing conservation needs with development priorities (**Figures 30** and **31)** at all levels of biological organization… may be considered for **BRO – Nampong to Vijaynagar Regions…!!!**

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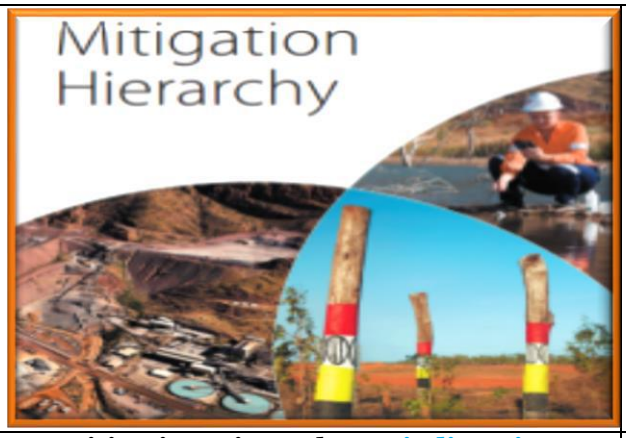
<tr><td> 
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<tr><td>Mitigation Hierarchy – Biodiversity</td><td>Biodiversity and Ecosystem Services – Built – up Area</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Biodiversity – Offsets</td><td>No Net Loss of – Biodiversity</td></tr>
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Figure 30: Practical Guidance, Innovative Approaches, Cross – Sector Guide for Implementing the Biodiversity Mitigation Hierarchy.

Sequential Steps of Measuring the Biodiversity Mitigation Hierarchy

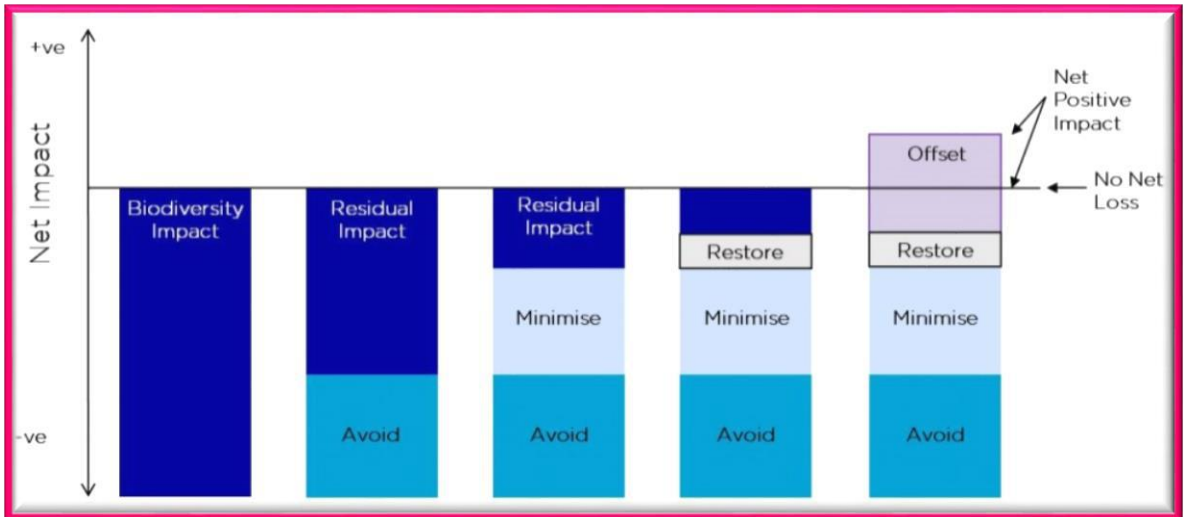

Figure 31: Sequential Steps on Net Positive and Negative Impact in Biodiversity Mitigation Hierarchy.

1. Avoidance: The first step of the mitigation hierarchy comprises measures taken to avoid creating impacts from the outset, such as careful spatial or temporal placement of infrastructure or disturbance. For example, placement of roads outside of rare habitats or key species' breeding grounds, or timing of seismic operations when aggregations of whales are not present. Avoidance is often the easiest, cheapest and most effective way of reducing potential negative impacts, but it requires biodiversity to be considered in the early stages of a project.

2. Minimization: Measures taken to reduce the duration, intensity and/ or extent of impacts that cannot be completely avoided. Effective minimization can eliminate some negative impacts. Examples include such measures as reducing noise and pollution, designing power lines to reduce the likelihood of bird electrocutions, or building wildlife crossings on roads.

3. Rehabilitation/ Restoration: Measures taken to improve degraded or removed ecosystems following exposure to impacts that cannot be completely avoided or minimized. Restoration tries to return an area to the original ecosystem that occurred before impacts, whereas rehabilitation only aims to restore basic ecological functions and/ or ecosystem services (*e.g.,* through planting trees to stabilize bare soil). Rehabilitation and restoration are frequently needed towards the end of a project's life – cycle, but may be possible in some areas during operation (*e.g.,* after temporary borrow pits have fulfilled their use). Collectively **"Avoidance, Minimization"** and **"Rehabilitation/ Restoration"** serve to reduce, as far as possible, the residual impacts that a project has on biodiversity. Typically, however, even after their effective application, additional steps will be required to achieve no overall negative impact or a net gain for biodiversity.

4. Offset: Measures taken to compensate for any residual, adverse impacts after full implementation of the previous three steps of the mitigation hierarchy. Biodiversity offsets are of two main types: **"Restoration Offsets"** which aim to rehabilitate or restore degraded habitat, and **"Averted Loss Offsets"** which aim to reduce or stop biodiversity loss (*e.g.,* future habitat degradation) in areas where this is predicted. Offsets are often complex and expensive, so attention to earlier steps in the mitigation hierarchy is usually preferable. **Figure 32** is Coastal Area's Positive and Negative Impact in Mitigation Hierarchy.

Figure 32: River/ Coastal Area's Positive and Negative Impact in Mitigation Hierarchy.

Supporting Conservation Actions: measures taken which have positive – but difficult to quantify – effects on biodiversity. These qualitative outcomes do not fit easily into the mitigation hierarchy, but may provide crucial support to mitigation actions. For example, awareness activities may encourage changes in government policy that are necessary for implementation of novel mitigation, research on threatened species may be essential to designing effective minimization measures, or capacity building might be necessary for local stakeholders to engage with biodiversity offset implementation.

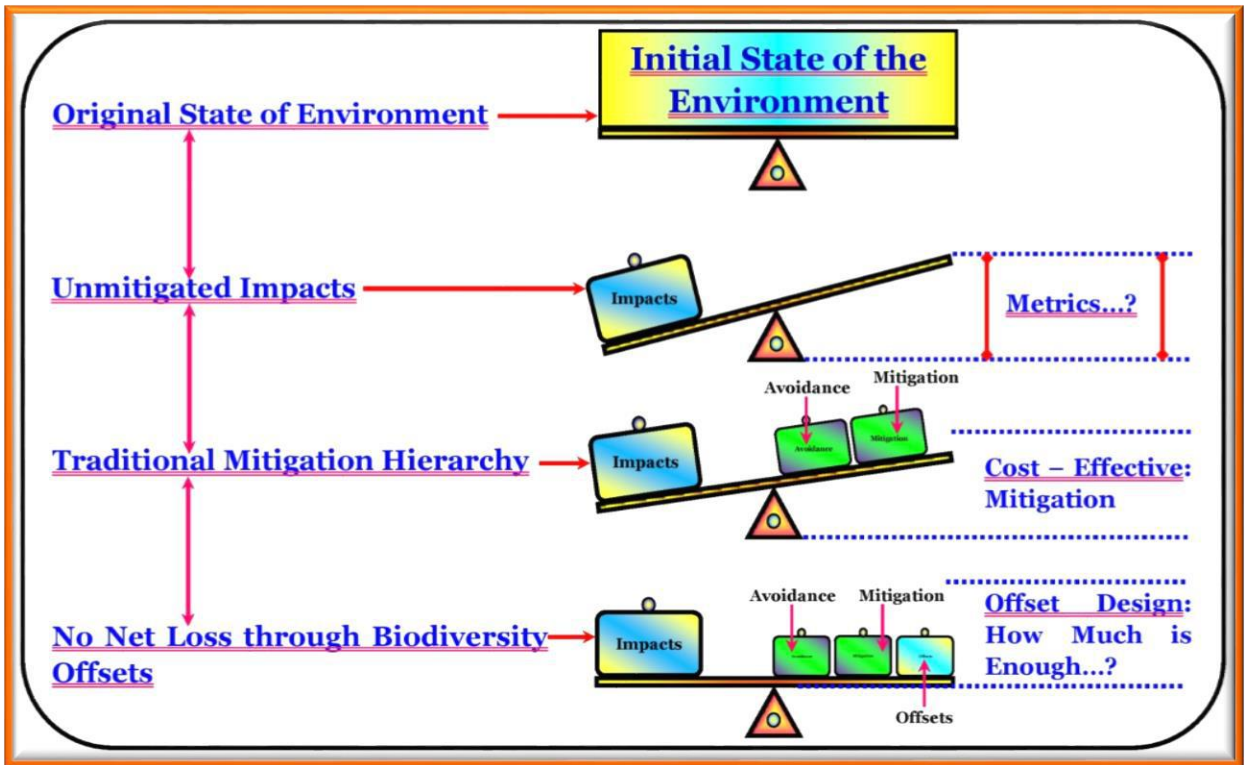

Figure 33: Biodiversity Accounting and Offset Design Methods in Mitigation Hierarchy.

22. COMPRISION AND ELUCIDATION OF OTHER STATES/ REGIONS "BIODIVERSITY"/ WILDLIFE IMPACT ASSESSMENT ("B"/ WIA)

INTRODUCTION

"Biodiversity", also called **"Biological Diversity",** the variety of life found in a place on Earth or, often, the total variety of life on Earth. A common measure of this variety, called species richness, is the count of species in an area. Colombia and Kenya, for example, each have more than 1,000 breeding species of birds, whereas the forests of Great Britain and of Eastern North America are home to fewer than 200. A coral reef off Northern Australia may have 500 species of fish, while the rocky shoreline of Japan may be home to only 100 species. Such numbers capture some of the differences between places – the tropics, for example, have more biodiversity than temperate regions – but raw species count is not the only measure of diversity. ***"Furthermore, Biodiversity encompasses the genetic variety within each species and the variety of ecosystems that species create"***.

Although examining counts of species is perhaps the most common method used to compare the biodiversity of various places, in practice biodiversity is weighted differently for different species, the reason being that some species are deemed more valuable or more interesting than others. One way this **"Value"** or **"Interest"** is assessed is by examining the diversity that exists above the species level, in the genera, families, orders, classes, and phyla to which species belong. For example, the count of animal species that live on land is much higher than the count of those that live in the oceans, because there are huge numbers of terrestrial insect species; insects comprise many orders and families, and they constitute the largest class of arthropods, which themselves constitute the largest animal phylum. In contrast, there are fewer animal phyla in terrestrial environments than in the oceans. No animal phylum is restricted to the land, but *brachiopods* (lamp shell), *pogonophorans* (beard worm), and other animal phyla occur exclusively or predominantly in marine habitats. Some species have no close relatives and exist alone in their genus, whereas others occur in genera made up of hundreds of species. Given this, one can ask whether it is a species belonging to the former or latter category that is more important. On one hand, a taxonomically distinct species – the only one in its genus or family, for example – may be more likely to be distinct bio – chemically and so be a valuable source for medicines simply because there is nothing else quite like it. ***"On the other hand, although the only species in a genus carries more genetic novelty, a species belonging to a large genus might possess something of the evolutionary vitality that has led its genus to be so diverse in Arunachal Pradesh State"***.

A second way to weight species biodiversity is to recognize the unique biodiversity of those environments that contain few species but unusual ones. Dramatic examples come from extreme environments such as the summits of active **"Antarctic Volcanoes"** (*e.g.,* Mt. Erebus [Ross Island] and Mt. Melbourne in the Ross Sea Region), **"Hot Springs"** (*e.g.,* Yellowstone National Park in the Western United States), or **"Deep – Sea Hydrothermal Vents"** (Marine Ecosystem: Organisms of the Deep – Sea Vents). The numbers of species found in these places may be smaller than almost anywhere else, yet the species are quite distinctive. One such species is the bacterium *Thermus aquaticus*, found in the hot springs of Yellowstone. From this organism was isolated *Taq Polymerase,* a **"Heat – Resistant Enzyme Crucial"** for a DNA – amplification technique widely used in **"Research and Medical Diagnostics"** (Polymerase Chain Reaction).

Facts Matter: More generally, areas differ in the **"Biodiversity of Species"** found only there and species having relatively small ranges are called **"Endemic Species"**. On remote oceanic islands, almost all the native species are endemic. The Hawaiian Islands, for example, have about 1,000 plant species, a small number compared with those at the same latitude in continental Central America. Almost all the Hawaiian species, however, are found only there, whereas the species on continents may be much more widespread. ***"Endemic species are much more vulnerable to human activity than are more widely distributed species, because it is easier to destroy all habitats in a small geographic range than in a large one"***.

"In addition to diversity among species, the concept of Biodiversity includes the genetic diversity within species. One example is our own species, for we differ in a wide variety of characteristics that are partly or wholly genetically determined, including height, weight, skin and eye colour, behavioral traits, and resistance to various diseases". Likewise, genetic variety within a plant species may include the differences in individual plants that confer resistance to different diseases. For plants that are domesticated, such as rice, these differences may be of considerable economic importance, for they are the source of new disease – resistant domestic varieties. The idea of biodiversity also encompasses the range of ecological communities that species form. ***"A common approach to quantifying this type of diversity is to record the variety of ecological communities and area may contain"***. It is generally accepted that an area having, say, both forests and prairies is more diverse than one with forests alone, because each of these assemblages is expected to house different species. This conclusion, however, is indirect – *i.e.,* it is likely based on differences in vegetation structure or appearance rather than directly on lists of species.

Forest and prairie are just two of a plethora of names applied to ecological assemblages defined in a variety of ways, methods, and terms, and many ideas exist regarding what constitutes an assemblage. Technical terms that imply different degrees to which assemblages can be divided spatially include association, habitat, ecosystem, biome, and life zone, eco – region, landscape, or biotype. ***"There is also no agreement on the boundaries of assemblages – say, where the forest biome ends and the prairie biome begins. Nonetheless, especially when these approaches are applied globally, as with the eco – regions used by the World Wide Fund for Nature (World Wildlife Fund, WWF), they provide a useful guide to Biodiversity patterns"***.

The catalog of **"Earth's Biodiversity"** is very incomplete and about 1.9 million species have scientific names. Estimates of the total number of living species cluster around 10 million, which means that most species have not been discovered and described. (These estimates omit bacteria because of the practical problems in defining bacterial species.) Simply counting species must be, at best, an incomplete measure of biodiversity, for most species cannot be counted within a reasonable time. At the present rate of describing new species, it will take about 1,000 years to complete the catalog of scientific names. Of the approximately 1.9 million species now described, perhaps two – thirds are known from only one location and many from examining only one individual or a limited number of individuals, so knowledge of the genetic variation within species are even more constrained. From just a few well – studied species, it is clear that genetic variability can be substantial and that it differs in extent between species. ***"(The loss of Biodiversity as a result of human activity and various methods aimed at preventing this loss are discussed in the fraction conservation)"***.

To assist in the daunting challenge of protecting species, a number of biologically rich but threatened regions containing high numbers of endemic species have been identified and mapped. Such **"Hot Spots"** of biodiversity have been described to assist governments and non – governmental organizations in the development of conservation priorities. The United Nations named 2010 as the **"International Year of Biodiversity" (IYB)** – a yearlong celebration intended to raise public awareness about the importance of biodiversity and to reinforce conservation efforts. ***"Many of the fraction conservation goals promoted by the IYB have resurfaced periodically in later United Nations awareness campaigns – such as the International Year of Forests (2011), the International Year of Soil (2015), and the International Year of Sustainable Tourism for Development (2017)"***.

Community Ecology: Biodiversity and the Stability of Communities

As species adapt to one another and to their communities, they form niches and guilds. The development of more complex structures allows a greater number of species to coexist with one another. The increase in species richness and complexity…!!!

Bio – Geographic Region: Components of Species Diversity – Species Richness and Relative Abundance

Species diversity is determined not only by the number of species within a biological community – i.e., species richness – but also by the relative abundance of individuals in that community. Species abundance is the number of individuals per species, and relative…!!!

Ordovician Period: Diversification of Life

During the Ordovician Period, life diversified to an unprecedented degree, undergoing a fourfold increase in the number of genera. This unique period, known as the Ordovician radiation, unfolded over tens of millions of years and produced organisms that would dominate marine ecosystems…!!!

"Biodiversity Conservation" and "Mitigation Measures Hierarchy"

*Biological diversity, or **"Biodiversity"**, is the variety of life either in a particular place or on the entire **"Planet Earth"**, including its **"Biodiversity Ecosphere"**, ecosystems, species, populations, and genes. **"Biodiversity Conservation"** and **"Mitigation Measures Hierarchy"** thus seeks to protect life's variety with Positive and Negative Impact as revealed above in **Figures 28** to **33 (Page Numbers 106** to **110)** at all levels of biological organization… in all probability will be considered for **BRO – Nampong to Vijaynagar Regions…!!!***

Community Ecology

*The number of interacting species in these communities and the complexity of their relationships exemplify what is meant by the term **"Biodiversity"**. Structures arise within communities as species interact, and food chains, food webs, guilds, and other interactive webs are created. These relationships change over evolutionary time as species…!!!*

"The Bio – Diversity (Bio – D) Research Forum will be an international online database of ongoing research aimed to "Decrease Human Effect" on "Biodiversity" and reduce the "Rate of Biodiversity Loss". The **"Bio – D"** forum construction and maintenance will be sponsored by the **"International Committee on Biodiversity" (ICB)** and will invite country representatives and specialists all over the world to solve the problems facing biodiversity in an efficient and economically profitable way. Companies, universities and freelance engineers, entrepreneurs and scientists will be able to apply and collaborate on making projects come to life with sponsorship from forum members and the ICB. The projects posted on this forum may either be brand new ideas that require funding and manpower to get off the ground or ideas that are already developed and need further adjustment and development.

Benefits of System

- ✓ *Ability to Apply for ICB Grants and Ask for ICB Sponsorship;*
- ✓ *Ability to Network with Greatest Minds of the World, get Expert Opinions;*
- ✓ *Ability to Obtain Extra Funding through Invited Venture Capital Companies, Private Businesses Interested in Projects, and other Grants that will be Posted through the Forum;*
- ✓ *Ability to Receive Annual International Committee Sponsored Awards, Promoting the Company Image;*
- ✓ *Access to International Committee Sponsored Advertisement;*
- ✓ *Access to a Database of Ongoing New Research, being a Part of the Future before it Happens;*
- ✓ *Ability to Join Brand New Research Projects and Profit from their Development (if applicable);*

- ✓ *Ability to Either Buy or Trade Shares of Projects to Split the Risk in their Development (if applicable);*
- ✓ *Power to Influence Future Movements in Technological Development;*
- ✓ *Greater Positive Attention from Press and News Channels, Promotion by International Committee Hired Publicists;*
- ✓ *Positive Influence of **"Biodiversity; Agricultural and Wild Life Impact Assessment Aspects/ Prospects"** will Result in Greater Abundance of Natural Resources Available to Companies/ Organizations;*
- ✓ *Access to Trained Work – Force and Ability to Recruit/ Involve Registered Students with a Skill and Interest in the Fields of Company Research.*

Wildlife Legislation: Subject related to wildlife and its conservation in India draws strength from **"Directive Principles of State Policy"** under the Constitution of India, which states that ***"The State shall Endeavour to Protect and Improve the Environment and to Safeguard the Forests and Wildlife of the Country"***. The Constitution specifying fundamental duties of the citizens of India, states that ***"It shall be the duty of every citizen of India to protect and improve the natural environment including agriculture, forests, lakes, rivers, and Wildlife and to have compassion for living creatures"***. The primary law governing matters related to wildlife in the country is the Wildlife (Protection) Act, 1972. The state of **"Arunachal Pradesh"** has adopted this Act and its subsequent amendments as the prime legislation to manage and guide wildlife related matters in the state including **"Jammu and Kashmir, Leh and Ladakh"** regions.

Among the 19 species of reptiles recorded, 8 species falls under the various Indian Wildlife Protection Act (1972). Of the 368 species of bird species documented from the study area, 11 birds fall under category of the Indian Wildlife Protection Act (1972) and among the 64 mammals recorded, 55 species falls under various schedules of **"Indian Wildlife (Protection) Act, 1972"**. Of the total 55 species, 22 species falls under Wildlife Protection Act. Out of the total 527 faunal species of different taxonomic groups recorded, one species of amphibian, 5 species of reptiles, 32 species of birds and 29 species of mammals are listed for Arunachal Pradesh State.

Importance of the Area from Biodiversity/ Wildlife Point of Views:

- ❖ ***Operation Phase: Impacts on Biodiversity/ Wildlife Movement;***
- ❖ ***Proximity to the Site of Use;***
- ❖ ***Sensitivity of Forests in the Nearby Areas;***
- ❖ ***Biodiversity/ Wildlife, if Any, in the Nearby Area;***
- ❖ ***Proximity from Habitations;***
- ❖ ***Predominant Wind Direction;***
- ❖ ***Natural Slope and Drainage.***

Since observations of fauna and wildlife take long time, primary surveys were limited to field visits and direct and indirect sightings of animals. The presence of wildlife was also confirmed from the local inhabitants depending on the animal sightings and the frequency of their visits in the catchment area. In addition to these, secondary sources mainly literature was referred for preparing checklists and other analysis in the study of animals and wildlife in the region. In addition the State has 32 wildlife sanctuaries and two National Parks. The State is a treasure house, both for plants as well as wildlife. The Bajoli Holi H.E. Project is located in the vicinity of Dhauladhar Wildlife Sanctuary which comprises mainly the upper catchment of Ravi River. However no part of the project falls within Dhauladhar Wildlife Sanctuary and nearest boundary is more 11 Km from the project components.

All the medicinal plants and other commercial plants found in the higher elevation of these areas are collected by locals and sold to petty buyers who usually trade these plants to Amritsar. Local people also consume a few wild food plants such as *Rumex hastatus* (Amloda) as *Chutney and Chenopodium album* (Kasrod), *Fagopyrum racemosum* (Phafru) as vegetables. Zizyphus hydsurica locally called Ber is frequently cultivated in this region. The great variety of ecological conditions thus prevailing allows this

landmass to support a great diversity of wild life, including hot desert forms like the wild ass and cold desert forms like the Tibetan antelope, animals of open scrubland like the black buck and of grassy swamps like the rhinoceros, animals of deciduous forest like the Gaur and of tropical rain forest like the lion – tailed macaque.

Many areas have been declared as National Parks and Wildlife Sanctuaries for the conservation of wildlife which should really be seen as tools for the development that respect both **"Nature and People",** capable of meeting the needs to today's need without sacrificing the potential for tomorrow. About 4.70% (4.76% as on July 2004, by National Wildlife Database) of the total geographical area is covered under protected area network in the country. In India, there are 92 National Parks, 492 Wildlife Sanctuaries and 13 Biosphere Reserves and 2 Conservation Reserves. A small State like Arunachal, which has only 1.7% of the geographical area of the country, has contributed a remarkable 4.5% of the net increase in the forest cover of the country. In addition the State has 32 wildlife sanctuaries and two National Parks. The state has a varied topography; climate and forest cover which has resulted in making the state a very rich repository of wild **"Flora and Fauna"**. The rugged terrain and clearly distinct agro climatic/ physiographic zones in the state harbour area specific animals and plants. The lower reaches of the state are rich in populations of Sambar deer, Barking deer, Wild boar, Goral and Leopard amongst the mammals and Cheer and White Crested Kaleej, among the pheasants beside the Western Tragopan which has been bred in captivity for the first time in the world in Arunachal Pradesh.

Habitat destruction aided by developmental activities, encroachment over forestland, over grazing, soil erosion, poaching and floods have caused extensive damage to wildlife and natural resources. The main of degradation and depletion of forests and wildlife are the human activity in one side and on the other side population explosion, over exploitation of forest resources, urbanization, unscientific management, encroachment of forestland, illicit felling, lack of regeneration and large of livestock graze in the forested areas. Ever growing human and cattle population is having harmful impact on our precious wildlife population. Realizing this grave danger, the Government of Arunachal Pradesh has taken the lead in this direction to take safe guard and to save its wilderness, wild animals and their habitat along valuable forests. Although there is total ban on hunting of wild animals since 1972 and strictly followed from 1982 in Arunachal Pradesh but there is no denying of the fact that wildlife habitat is Hydro Power Pvt. Ltd. EIA Report RS Enviro – link Technologies Pvt. Ltd. shrinking rapidly which causing conflicts between wild animals and the human beings? The common leopard are turning into man – eater and Himalayan Black bear turning into regular raider of the crop field and mauled humans. The areas where sampling and transects were analyzed for wildlife surveys are as follows **(Table 15)**:

Table 15: Sampling and Transects Locations/ Areas.

Sr. No.	Location/ Area/ Region		Latitude and Longitude
1.	*Down Stream of Power House*	:	***32°21'14" N and 76°31'38.3" E***
2.	*Power House*	:	***32°20'20.1" N and 76°32'25.1" E***
3.	*Down Stream of Dam Site*	:	-------
4.	*Dam Site*	:	***32°16'49" N and 76°40'10.9" E***
5.	*Submergence Area*	:	-------
6.	*Catchment Area*	:	-------

The wild life of this area mainly consists of birds and entomo – fauna which are encountered frequently. Avian fauna includes Rock bunting, Eurasian blackbird, Plumbeous water redstart, etc. and Indian cabbage white, blue banded bee, common hawker etc. represent entomo – fauna. The Forest Working Plans or Management plans of the Forest Divisions falling in the project area for wildlife of the area. The villagers of the study area practice hunting. As a tradition they used to hunt for wild animals in and around Dhauladhar Wildlife Sanctuary **(Table 16)**:

Table 16: Species of Large Mammals Hunted for Various Purposes in the Study Area.

Sr. No.	Common Name		Scientific Name
1.	*Himalayan tahr (V)*	:	**Hemitragus jemlahicus**
2.	*Musk deer (L)*	:	**Moschus chrysogaster**
3.	*Himalayan monal*	:	**Lophophorus impejanus**
4.	*Goral (L)*	:	**Nemorhaedus goral**
5.	*Barking deer*	:	**Muntiacus muntjak**
6.	*Himalayan brown bear*	:	**Ursus arctos**
7.	*Indian wildboar*	:	**Sus scrofa**
8.	*Leopard*	:	**Panthera pardus**
9.	*Himalayan black bear (V)*	:	**Selenarctos thibetanus**
10.	*Indian porcupine*	:	**Hystrix indica**
11.	*Himalayan langur*	:	**Presbytis entellus**
12.	*Serow (V)*	:	**Capricornis sumatraensis**

Dhauladhar Wildlife Sanctuary is the nearest sanctuary in the vicinity of the project area. The Dhauladhar Wildlife Sanctuary is contiguous to Manali, Kugti, Tundah and Nagru Wildlife Sanctuaries which form a unique bio – geographic location (Western, North – Western and Trans Himalayan Ranges). This area is very important from ecological, geo – morphological and geographical point of view and qualifies to be declared as World Heritage site under UNESCO's recognition. Due to wide range of variation in altitude and habitat variety of animals are found in the Dhauladhar Wildlife Sanctuary and so far no detailed survey has been done to assess the status of different wild animals found in the Dhauladhar Wildlife Sanctuary. A systematic documentation of wild animals and their distribution at present is lacking.

A rich fauna still persists in Himalaya, although this region has suffered heavily from deforestation and destruction of wildlife. Dhauladhar Wildlife Sanctuary the fauna is predominantly Indo – Malayan with Palaearctic elements such as Hangul or Kashmir stag restricted to West. Other notable Himalayan forms include Snow leopard and clouded leopard, both threatened with extinction, the Brown bear, The Himalayan black bear, the Himalayan tahr and Goral, etc. In addition to impact on biodiversity and wildlife of the region, most of the construction activities will have some impact on water and air quality and will also generate noise. Other impacts will be the noise generated during aggregate acquisition through explosive and crushing, which could affect wildlife in the area, dust produced during the crushing operation to get the aggregates to the appropriate size and transport of the aggregates, and transport of materials. Management of such impacts with operation control and appropriate pollution control equipment is essential to minimize their effect on surrounding environment including local population and wildlife and same is discussed in **"Environmental Management Plan" (EMP)**.

Impact on Terrestrial Fauna

(a) Disturbance to Wildlife

During the construction period, large number of machinery and construction workers shall be mobilized, which may create disturbance to wildlife population in the vicinity of project area. The operation of various equipments will generate significant noise, especially during blasting, which will have adverse impact on fauna of the area. However no major wildlife population is found in the immediate vicinity of these sites due to encroachment and habitations in the influence zone. Only stray incidents of wildlife are reported from these areas. However the area has a good bird and butterflies population.

(b) Impacts on Migratory Routes

The faunal species observed in the project area are not migratory in nature. The proposed submergence area is not the migratory route of wild animals. The construction of the proposed Project will form a reservoir of about 16.5 Ha, which is also not reported to be on the migratory route of any major faunal species.

(c) Impact on Aquatic Ecology

The physic – chemical and biological water quality of Ravi River in the project area is very good. The dissolved oxygen is high in the river. The reason for good quality can be ascribed to high water discharge, low temperature and absence of any industrial activity. Fecal contamination is below detectable limits. Major sources of construction related impacts on water quality will be from erosion of the disturbed area required for the construction activities (construction sites, concrete batch plants, material storage areas, vehicle maintenance areas, disposal areas), from waste water discharge from the construction labour camps and from contaminated water (oil, grease, petro chemicals, cement and chemicals) resulting from various construction activities. The primary impact will be the potential for introducing sediments and pollutants to the adjacent river body during the period of construction, thereby affecting aquatic habitats, fishes and water source for residents and wildlife downstream of the construction areas.

(d) Impacts due to Ground Vibrations

The explosive energy generated during blasting sets up a seismic wave within the surface, which may affect the structures and cause discomfort to human population. When an explosive charge is fired in a hole, stress waves traverse in various directions, causing the rock particles to oscillate. Blasting also generates ground vibrations and instantaneous noise. Various measures have been recommended to minimize the adverse impacts due to blasting:

- *Proper design of blast hole to be developed;*
- *Use of noiseless trunk delays to minimize the noise due to air blast;*
- *Use of non – electric system of blasting for true bottom – hole initiation;*
- *Use of muffling mats to arrest the dust and fly rock.*

Noise in and around the construction site will likely affect the wildlife and residents in the nearby areas. Wildlife in the area will likely to move away from the noise and eventually return to the area when construction is complete. However, there is no major wildlife observed in and around the construction site and hence this may not be a significant issue.

(e) Indirect and Cumulative Impacts on Natural Resources

The improved year round access to the whole project area from new and upgraded roads will enable people to settle in the area. Use of the improved access will enable movement from one area to another. This translates into the development of roadside villages, and a potential increased pressure on the natural resources in the vicinity of the roads. The increased pressure will include uncontrolled logging, hunting, and fishing, wildlife and non – timber forest product collection, livestock husbandry, the shifting cultivation in forest areas and forest fires. These impacts are expected during the economic development of the river basin, and are expected to be managed by the basin level catchment area treatment plan, and the proposed **"Environmental Master Plan" (EMP)** for the state.

(f) Minimum Environmental Flow Requirement

The state government has declared its policy regarding ensuring minimum flow of water as per the policy; the projects shall ensure minimum flow of 15% water immediately downstream of the diversion structure of the project throughout the year. For the purpose of determination of minimum discharge, the average discharge in the lean months *i.e.,* from December to February shall be considered. The developer is committed to provide this minimum discharge at all times on account of ecology and environment and to address issues concerning riparian rights, drinking water, health, aquatic life, wildlife, fisheries, silt and even to honor the sensitive religious issues like cremation and other religious rites, etc. on the river banks.

(g) Terrestrial Fauna

During project operation phase, the accessibility to the area will improve due to construction of roads, which in turn may increase human interferences leading to marginal adverse impacts on the terrestrial ecosystem. Since significant wildlife population is not found in the region, no major adverse impacts are anticipated on this account. Without discordant interactions between people and wildlife, there would be no need for wildlife conservation programs. According to ecologist Puja Batra, successful wildlife conservation must put a significant focus on the people and communities involved in these conflicts. The local government, local and international NGOs, research groups, and educational groups have worked both independently and in union to improve and protect the well – being of the wildlife as well as the people who live among them in the high – altitude cold mountain desert of Ladakh. To accomplish this goal, these organizations have implemented programs to prevent or control human wildlife conflicts. In Ladakh, the most prevalent of these conflicts are livestock depredation by large carnivores such as snow leopards and wolves and competition between domestic herders and ungulates (wild goats and sheep) for grazing land. Ecologically, healthy predator populations control wild prey populations, thus reducing the strain on grazing lands. Similarly, healthy wild prey populations provide adequate food to predators, reducing the need for predators to attack domestic livestock. Unfortunately, such laws of interconnectedness do not always dictate the actions and reactions of local peoples.

Thus, villagers have been known to kill predators or chase away wild ungulates to resolve this conflict, which in turn increases the severity of these situations. Because it lies at the top of the food chain, the status of a top predator of a region indicates the condition of its entire ecosystem. Because the snow leopard generally recognized as Ladakh's top predator, also falls on the **"International Union for Conservation of Nature and Natural Resources" (IUCN) "Red List of Endangered Species",** wildlife conservation efforts in Ladakh have placed a significant focus on this species. The goal of such efforts has been to change local peoples' perceptions of the snow leopard through education, income supplementation, and depredation prevention measures. More specifically, organizations have worked to establish formal home stay networks, systems where tourists pay to eat and sleep in the homes of local families along trekking routes as a supplementary form of income to villagers. They have also provided wildlife education to children in schools, built predator – proof livestock corrals in areas of high depredation, and helped local communities organize and establish other business systems that garner income from the presence of tourists. Thus, these organizations have addressed the most basic rules of successful wildlife conservation as they aim to resolve human – wildlife conflicts, particularly those with Ladakh's top predator, through involvement of the local communities.

THE SNOW LEOPARD AND OTHER WILDLIFE IN LADAKH

Legislation Human – Wildlife conflicts can hardly be classified as new phenomena. Whenever human and wildlife populations coexist, potential for conflict arises. In Ladakh, the changes that brought such conflict into the spotlight began with national and local government legislation. The **"Indian Wildlife (Protection) Act of 1972",** revised in 2002, acted as the first nationwide legislation on wildlife protection in India. It classified **"Animal"** as including mammals, birds, reptiles, and amphibians, their young, and where relevant, their eggs. It defined **"Wildlife"** as any animals or vegetation that comprises part of a habitat. It defined and protected sanctuaries and national parks, and prohibited poaching and dealing in wildlife except in cases where licensed. Finally, it classified wildlife into six schedules, and afforded highest protection to the mammals, birds, and reptiles that fall under this act. The **"Jammu and Kashmir Wildlife (Protection) Act of 1978"** (revised in 2002) takes the place of the Indian Wildlife Protection Act of 1972 (revised in 2002) in the state of Jammu and Kashmir (J&K), in which lies Ladakh. Like the nationwide act, this J&K act classifies wildlife into schedules, with endangered species listed under act receiving full protection from any sort of trapping, injuring, or killing. In 1982 the Department of Wildlife Protection officially separated from the Forestry Department under which they previously stood. From 1982 until 1989, there was a Conservator of Forests, but no Wildlife Warden. In April 1989, the first **"Wildlife Warden, T. Norboo",** was appointed in Leh District. In 2002, the **"J&K Wildlife (Protection) Act of 1978"** was amended, the major amendment being a ban on all hunting and shooting and thus a complete cease of issuance of hunting permits and licenses. Previous to this 2002 revision, an interested party could acquire a permit to hunt animals but as of the

2002 amendment, all schedules are closed for hunting in Jammu and Kashmir. Now, under both acts, any person caught dealing, poaching, trapping, or killing any animal in J&K or the rest of India can be sentenced to up to seven years imprisonment and fined up to 25,000 Indian rupees. Such legislation and the mentality of conservation that drove its implementation have led to publicity in the name of wildlife protection in Ladakh.

Wildlife Postings in Leh District

Visible evidence of concern for wildlife awareness is apparent to the visitor almost upon arrival in Leh. On the drive from the airport to the main bazaar, and in fact past the airport on the road out of town, the army has posted pictures of a variety of animal and plant species native to Ladakh, each labeled with the animal's English name. Displayed wildlife include the Tibetan brown bear, the snow leopard, the Himalayan marmot, the blue sheep, the Ladakh urial, the argali, the red fox, the Tibetan Wolf, the Brahmini Duck, the Asiatic Ibex, the apricot flower, and a number of other plants and animals specific to this Trans – Himalayan region. The Sky Cyber Café, an Internet Café on the main bazaar, has photographs of ibex, red fox, snow leopard, and the mountains and lakes that migratory birds inhabit hanging on the walls above its computers, courtesy of the Wildlife Protection Division of Kargil district, along with a framed poster on climate change and a number of **"Conserve Wildlife Today for a Better Tomorrow"** stickers on its door. The walls of the Budshah Inn Restaurant on Fort Road are lined with posters of wildlife and landscape, their titles including **"Wild Mammals of Ladakh", "Ladakh High – Altitude Wetlands," "Floral Diversity of Ladakh,"** and **"Birds of Ladakh"**. On the road from Leh West toward Likir, the army has also drawn a picture of a black – necked crane in the sand with the words **"Conserve Wildlife"** crafted below. Earlier on this road, the **"Department of Wildlife Protection of the Jammu and Kashmir Government" (DWP – J&K)** has posted a billboard picturing a snow leopard with the words **"Ladakh Pride, Save It...!!!"** while on the road to Manali this department has also funded a billboard promoting general wildlife conservation. One trekking agency has chosen as its name **"Snow Leopard Trails" (SLT)**. Stickers from this agency can be found around Leh as well as on the windows of houses in semi – remote villages such as Hemis Shukpachen and Ulley. While trekking in Hemis National Park, hikers will see green blocks painted on cliff sides along the trail with the words **"Protect Wildlife"** painted inside in white. Trekking agencies, NGOs, the army, and the DWP – J&K all seek to portray and promote positive images of native **"Flora and Fauna"** in Ladakh, the illusive snow leopard acting as the movement's unspoken figurehead.

Snow Leopards and Their Prey

The snow leopard (unica unica), known in Ladakhi as Schan, stands approximately 60 cm high at the shoulder, and its length including tail ranges from 180 to 210 cm. While a smaller member of the family of large cats, this animal acts as a top predator in Ladakh. ***"Its natural prey can vary widely and includes Blue Sheep, Argali, Ibex, Urial, Marmot, Hare, Pika, and Waterfowl"***. Wildlife Warden of Leh District of the DWP – J&K further noted that in many of these cases, none of the meat is ever eaten. In two or three informal conversations, villagers explained that after such a mass killing, the snow leopard can even become drunk off the large amounts of blood consumed. This blood – drunken state, they said, allowed the snow leopard to be caught or even killed in times past.

The Ecological Connection

While some of the beliefs expressed here may exceed the realities of the snow leopard's resourcefulness, the actual financial losses and livestock fatalities brought about by successful hunting attempts of the snow leopard have certainly led to detrimental retribution killings like those found in Zanskar. From an ecological perspective, these retribution killings cause as much damage to the population of the snow leopard as they do to the wellbeing of the villagers that have participated in them. As the top predator of its ecosystem, the status of the snow leopard affects the balance of wildlife populations all the way down the food chain. As snow leopard populations decrease, the ungulate species it preys upon will over breed, creating increased competition for grazing lands. For the rural village, such ungulate overpopulation reduces the grasses and shrubs available for domestic livestock grazing. With

less foliage to be had, the amount of livestock that these areas can support also reduces. Wild and domestic animals that do graze on these lands will dig for roots in the absence of above – ground grasses, destroying what little vegetation still exists. Additionally, both wild and domestic animals will turn to crops as a source of food, further degrading the potential income for the villager. The conditions that drive a snow leopard to prey on domestic livestock result from ecological imbalances as well. Long – term effects of legal and illegal hunting of prey species, competition with an increasing domestic livestock population for grazing land, and, in some areas, deaths of wild prey due to diseases transmitted from livestock have reduced natural prey populations in many snow leopard regions, including those found in Ladakh. In the absence of sufficient numbers of its natural prey, snow leopards resort to domestic livestock predation, again creating human wildlife conflicts. At times it can occur simultaneously that grass levels prove insufficient to feed ungulate populations, and that ungulate populations prove insufficient to support snow leopard populations. Increasing numbers of livestock can cause such a situation when a domestic herd overgrazes the vegetation of a given area.

In response to such destructive interactions, interested NGOs along with the DWP – J&K began projects to help villagers prevent instances of depredation and financially recover if such attacks were to occur. These projects included plans to promote more positive local perceptions toward wildlife and wildlife conservation, a goal that, if achieved, could help sustain healthy wildlife populations in the future. These programs can be categorized into four different areas: livestock reimbursement, education, conflict control programs, and home – stay programs that have led to local association formation. Human – Wildlife conflicts by initiating a livestock reimbursement program began around 1997. However, within two years the program was drawing 60% of the department's annual budget, putting a great deal of strain on the department, despite the fact that reimbursement rates accounted for less than a fourth of an animal's actual value. An investigation of school texts shows that the books, written in English, teach Ladakhi wildlife in third and fourth class, with fifth class material extending to wildlife found in areas of J&K other than Ladakh. The third class book makes abundant use of pictures and simple sentences, while the amount and complexity of text increases with class level. The material specifically related to animals in the Environmental Studies Workbook for Class – III, published/ printed in 2003, teaches basic features of animals.

In 2006, the SLC – IT began its own wildlife education series, the **"Snow Leopard Conservation Education Programmes",** produced with the assistance of Sujatha Padmanabhan and an educational organization called Kalpavriksh. The SLC – IT runs this program in both public and private schools. Over the course of six to eight full – day sessions, the program teaches students in fourth through eighth class about biodiversity, mammals of Ladakh, birds of Ladakh, reptiles and insects of Ladakh, plants of Ladakh, how this **"Flora and Fauna"** has adapted to this region, the web of life, the food chain, **"Flora and Fauna"** outside of Ladakh, characteristics of and threats to the snow leopard, what constitutes a predator – proof corral pen, and how increased livestock numbers create grazing pressure. They plan to add educational sections next year that will discuss effects of the army's presence on the environment, issues surrounding domestic animals such as dogs and cats, and the intricacies of sustainable wildlife tourism. Educational tools used in the program include lectures in Ladakhi, quizzes in simple English, wildlife games, art projects, and color display posters, drawings on the board, informal discussion, and films. The program also allows students to plan a town improvement project for the year after the program. Past projects have included trash clean – up and recycling or the repair and whitewashing of stupas. The program also includes a trip in the summer to a region of Ladakh ecologically different than the students' home region. Finally at the end of the series, instructors encourage students to relate information acquired to friends and family.

Therefore, materials currently used in government schools programs derive from **"Snow Leopard Conservancy – India Trust" (SLC – IT)** in Leh, the original work of these five diverse organizations and so provide a solid foundation for wildlife education in Ladakhi schools. The J&K BOSE books and the Snow Leopard Conservation Education Programme in no way represent the entirety of educational efforts currently put forth in Ladakh, but rather the basis of wildlife education for preadolescent school children. For example, the DWP – J&K recently began a two to three day hands – on program to educate college students on the biodiversity of Hemis National Park. They have also run programs with the army and separately for tour operators to spread knowledge about wildlife and

conservation etiquette, and a Tranquilization and Rescue Training Workshop for DWP – J&K staff regarding proper tranquilization and capture techniques. The association with **"The Mountain Institute" (TMI)** and the **"Ladakh Ecological Development Group" (LEDeG)** ran a **"Livestock Predation Control Workshop" (LPCW)** in **"Markha Village"** to address the high rates of depredation found in the area. Thus, while most of these educational programs began within the past two to five years, they have provided wildlife conservation education to a diverse group of people living and working in Ladakh.

According to Jigmet Takpa, Conservator of Forests – Ladakh, Wildlife of the DWP – J&K, the initial motivation for this hospitality was not monetary, but rather a result of the cultural disposition of the Ladakhi people to house a traveler. Thus, in his view, it is due to the pre – existent culture of the people of Ladakh that formalized home – stays work in this region. In addition to providing food and housing to a traveler, this experience immerses a guest in Ladakhi culture by simply looking out the window in the evening and morning, an individual can observe animals coming from and going to pasture, cows and dozes getting milked, donkeys and horses carrying their daily loads, and wildlife traveling across the landscape. Through this experience, foreigners learn about the finer points of Ladakhi culture and participate in cultural exchange while inadvertently benefiting local people and wildlife alike. The program, now named Himalayan Home – Stays, aimed to foster more positive perceptions of sharing territory with snow leopards and other wildlife in local communities around Ladakh, while simultaneously bringing benefits to these communities. The program introduced guides to basic wildlife conservation concepts, educated them about Ladakh's protected areas, overviewed the **"Flora and Fauna"** of **"Hemis National Park" (HNP),** provided education about group safety guidelines, and gave basic instruction on how to manage a group of tourists. Through such a connection, an opportunity is created to garner local pride for the park and to generate a desire to protect the land and its wildlife.

As a complement to the efforts of the Home – Stay programs, the DWP – J&K and independently the **"Snow Leopard Conservancy – India Trust" (SLC – IT)** in Leh, began a number of conflict control programs to prevent detrimental interactions between villagers and wildlife. These initiatives sought to address predator entry into poorly constructed corral pens, general livestock depredation, the passing of diseases from livestock to wildlife, and incidences of wild herbivores eating villagers' crops. The DWP – J&K recently began programs to inoculate livestock and provide chain link fencing to villagers. Livestock inoculation provides protection to these domestic animals, a benefit to villagers, while also preventing the possibility of domestic diseases spreading to wildlife. After speaking with Ladakhis of various ages, backgrounds, realms of work, and regional origins, observed that rhetoric regarding Ladakhi knowledge of interest in wildlife and wildlife conservation varies widely; it was unclear whether actual perspectives differ as such. Ladakhis have never really had a love for wildlife, and evidenced this by stating that has been seen few, if any, prayers, poems, or pieces of literature about wildlife in Ladakhi texts. The **"Landscape Model of Conservation" (LMC),** in this model, the establishment of national parks acts to identify an area where a high density of often rare wildlife exists, but in no way do these parks limit the conservation area.

METHODOLOGY

In preparation of this research has been reviewed multiple articles concerning general predator conservation, general snow leopard conservation and wildlife conservation in Ladakh. This research methods during the month included interviews with urban and rural Ladakhis and conservation experts. Some interviews were conducted in English while others were held in Ladakhi with the use of a translator. Wildlife Warden, Leh – Ladakh provided substantial and detailed information regarding the Department of Wildlife Protection's recent conservation programs, along with several pictures of the snow leopard from Nemo that would not have otherwise been attainable. Jigmet Takpa, Conservator of Forests, Wildlife, and Ladakh enthusiastically explained broader wildlife philosophies and goals of the department. Ashwini Upadhyay of the **"Wildlife Institute of India" (WII)** shed light on the wildlife education research discussed here and further provided advice about pursuing a career in **"Wildlife Conservation Methodologies" (WCM)**.

Wildlife OR Biodiversity Conservation Needs and Method to Conserve the Biological Diversity

Biodiversity is the biological diversity, which includes the variety of the whole species present on earth. It includes different animals, plants, micro – organisms and their genes, water ecosystems, terrestrial, and marine ecosystems in which they all are present. Biodiversity is necessary for our existence as well as valuable in its own right. This is because it provides the fundamental building blocks for the many goods and services, which provides a healthy environment to lead our life. ***"Biodiversity include fundamental things to our health like fresh water clean air and food products, as well as the many other products such as timber and fiber. Biodiversity also includes various other important things and services such as cultural, recreational, and spiritual nourishment that play an important role in maintaining our personal life as well as social life. So, it is an important task for all of us to take care of our Biodiversity and we should try to maintain it".*** Over the last 200 years most of the countries have suffered the largest documented decline in biodiversity of any continent. Despite efforts to manage threats and pressures to biodiversity in Leh – Ladakh, it is still in decline. And the main threats to biodiversity are as given below:

- *Degradation, Fragmentation and Loss of Habitat;*
- *Spreading of Invasive Species;*
- *Unsustainable Use of Natural Resources;*
- *Change of Climate;*
- *Inappropriate Fire Regimes; and*
- *Changes within Aquatic Environment and Water Flows.*

Human should conserve biodiversity because of its benefit for example services and biological resources, which are essential to live life on earth. However, it also provides spiritual benefits as well as social and ecological benefits to the surrounding people and wildlife sanctuaries.

Biological Resources

"A biological resource means any product that is harvested from nature is the part of biological resources. These resources come under several categories such as medicine, food, wood products, fibers etc." For example under one category *i.e.,* Food more than 7,000 species of plants are involved, although we dependent mainly on only 12 major crops for food. For Medicinal field human population is dependent on plants and it is true that in the developed country, many of our medicines are produced by chemicals in pharmaceutical companies, but the original formulas come from plants. For example, aspirin is comes from willows, opiate which is a pain relievers is derived from poppies and quinine, which is used for the treatment of malaria produced by the Cinchona Tree. Fibers which is used for Ropes, Clothing, Webbing, Netting, Sacking, and other materials are obtained by plants mainly for example Cotton Plants, *Flax Plants* (Linen), *Corchorus Plants* (Jute), Bamboo, Palms and *Agave Plants* (Sisal) **(Figure 34)**.

Figure 34: The Tensile Strength of the Silk Produce by Spider Provided a Way to Engineer to form a Synthetic Fabric. (This is a Large Female Argiope Trifasciata Spider has a Male Suitor).

Ecosystem Services

"Ecosystem" services means ecological processes provided by the **"Nature"** to support human life and for example Pollination, Decomposition of Waste, Water Purification, Renewal of Soil Fertility and Moderation of Floods. Ecosystem processes are often overlooked, and are not generally valued as part of the economy until they cease to function. When economic value is assigned to these services, it becomes very high. For example, insect pollinators help to produce many commercially important fruits such as almonds, melons, blueberries and apples etc. The global economic value of pollination services performed by insects has been valued at $217 billion per year. Similarly in other ecosystem service water purification just involves filtering of rain water by soil and by microbes that can break down nutrients and contaminants and reduce metal ions, slowing their spread into the environment. Wetland and riparian plants absorb nitrogen and trap sediments that decrease water quality. But human construction and development will disrupt natural environments as well all activity and services related to this environment. ***"So finally we have to dependent on artificial man made services like for filtration we used different – different types of water filters and purifiers. For these artificial services we need to pay more attention, while the natural ecosystem services are at free of cost whole around the world on global basis"***.

Social and Spiritual Benefits

Most of the time in human history, **"Conservation**" means protecting **"Nature"** for the **"Spiritual Gifts"** and it provides, and protecting sacred places in the local/ regional/ state level landscape. The **"Biodiversity"** effects on cultural development can be shown by heterogeneity of the world's mythology, folk dances and folk art, which contribute to the richness of literature and global arts. In different landscapes, different cultures are present which influenced our language, diet, occupation and various types of activity. Uniqueness of each habitat is presented by their animals and plants that is why each country and state has their flagship animals as well as plants. Even during traveling, motivation of the peoples is to see biological diversity, different cultural and landscape. Ecotourism is travel with the aim to view, support and sustain the local/ regional scale cultures and its **"Natural Ecosystem"**. Support from ecotourism can be very helpful to reduce habitat destruction as well as to preserve endangered wildlife species globally.

Biodiversity Conservation Methods

IN – SITU AND EX – SITU BIODIVERSITY CONSERVATION METHODS

"In – Situ Conservation" means the conservation of species within their natural habitats, this way of **"Conserving Biodiversity"** is the most appropriate method for biodiversity conservation. In this strategy you have to find out the area with high biodiversity means the area in which number of plants and animals are present. After that this high **"Biodiversity Area"** should be covered in the form of **"Natural Park/ Sanctuary/ Biosphere Reserve"** etc. In this way biodiversity can be conserved in their natural habitat from human activities **(Figure 35)**.

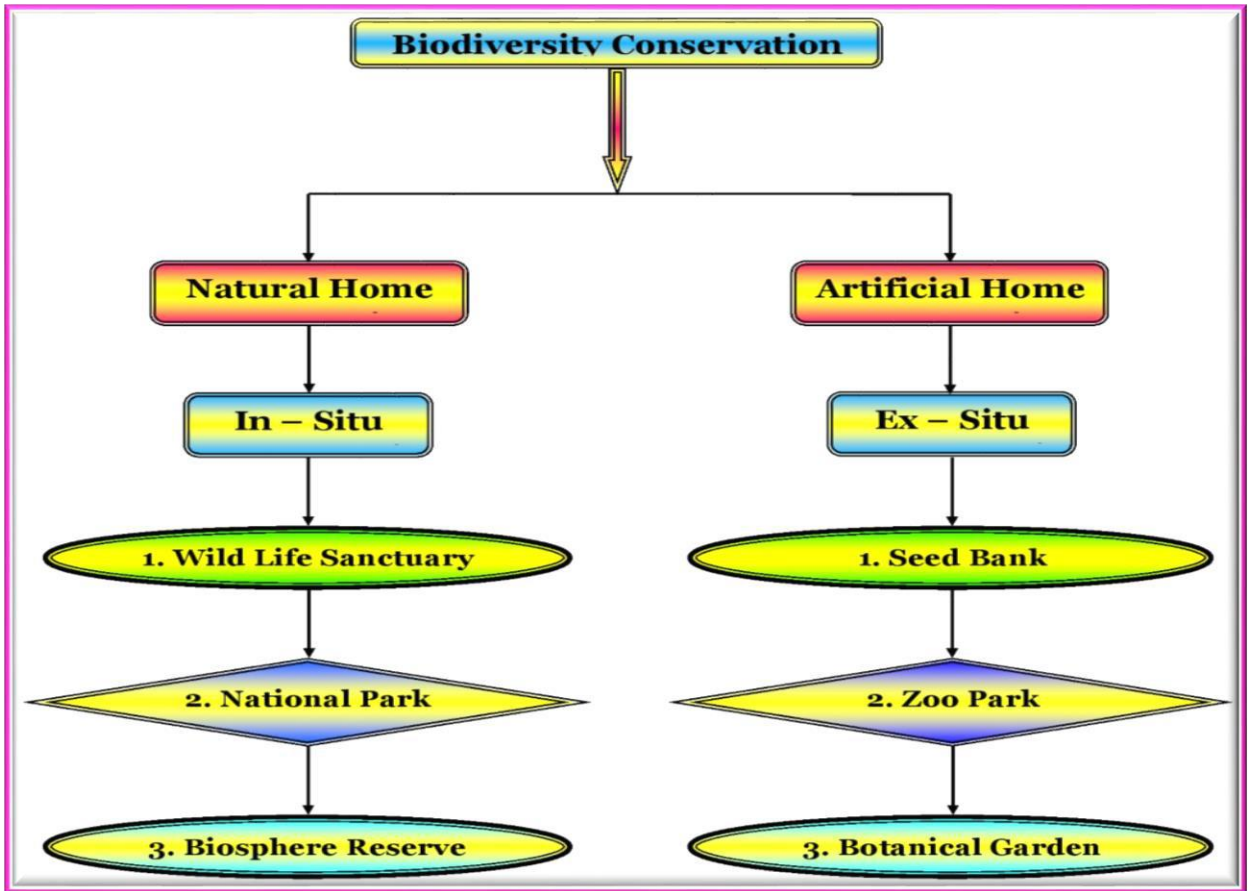

Figure 35: Biodiversity Conservation Method.

EX – SITU BIODIVERSITY CONSERVATION METHODS

"Ex – Situ Conservation" involves the conservation of biological diversity outside of their natural habitats. This involves conservation of genetic resources, as well as wild and cultivated or species, and draws on a diverse body of techniques and facilities. Ex – Situ Biodiversity conservation can be done as following:

- *By forming Gene banks: In this store seeds, sperm and ova at extremely low temperature and humidity;*

- *It is very helpful to save large variety of species of plants and animals in a very small space. e.g., sperm and ova banks, seed banks;*
- *Forming Zoo and botanical garden: for research purpose and to increase public awareness collecting living organisms for aquaria, zoos and botanic gardens;*
- *Collections of In – vitro plant tissue and microbial culture; and*
- *Captive breeding of animals and artificial propagation of plants, with possible reintroduction into the wild.*

"**Ex – Situ**" biodiversity conservation strategy also plays an important role in recovery programmes for endangered species. The **"Kew Seed Bank" (KSB)** in England has 1.5% of the world's flora – about 4,000 species – on deposit. In agriculture, **"Ex – Situ Conservation"** measures maintain domesticated plants which cannot survive in nature unaided. It provides good platform for research opportunities on the components of biological diversity. Some of the institutions also play a major role in public education and in increasing awareness among public by bringing members of the public into contact with plants and animals they may not normally come in contact with. It is estimated over 600 million people visit zoos every year worldwide.

INTRODUCTION OF WILDLIFE: JAMMU – KASHMIR AND LEH – LADAKH

Jigmet Takpa IFS, Conservator of Forest (Wildlife) Ladakh: The unique ecosystem of Ladakh has supported the vast diversity of wildlife. We constitute a hub of wildlife which includes that of Central Asia, Indian Subcontinent and the entire wildlife of Tibetan plateau. We have different wildlife species which includes Blue Sheep, Nayan, Ladakh Urial (Shapo), Ibex, Tibetan Antelope, Tibetan Wild Ass, Tibetan Gazelle (Gowa) and much more. Ladakh is also one of the major habitants of snow leopard and can be known as the **"Snow Leopard Capital" (SLC)** of the world. We have lynx, Tibetan Wolf Fox, and many other carnivores' animals. Apart from the wildlife, we are very rich in varieties of migratory birds.

Ladakh – Trans – Himalayan **"Bio – Diversity**" is very fragile and is in danger of extinction which needs to be protected and preserved for the better tomorrow. Wildlife conservation has become a matter of concern, not only for the departments but for everyone. A large number of livestock rearing has severely affected the wildlife. There are some wild animals which also depend on pasture land, but due to a large number of live – stocks they are unable to sustain themselves and survival becomes hard for them. Livestock rearing should not be given up, but can be reduced when people have options for another source of income. The department has been carrying up many conservation projects to increase the number in the wildlife population. There have been giving and constructing predator proof cattle pen or corral to the livestock reamers in the far flung areas to reduce the conflict, saving livestock from the carnivores attack. From the local point of view the level of conservation has progressed over the time *e.g.,* Snow Leopards can be spotted in almost every village, which attracts tourists during the winter season. This becomes a reason to save wildlife. Snow leopard which was considered as the biggest predator is now the biggest asset for the people of Ladakh.

If talk about **"Poaching"** it is not a new practice and hunting was carried from a very long time. Earlier, locals use to hunt wildlife to save their livestock as well as for their consumption need. There was no law for the conservation of the wildlife. There was a time when the Maharajas of Jammu created hunting reserve also known as a game reserve, in which only their guest or selected others could hunt. It was in 1972, the law was introduced and in the year 2002, it was amended strictly in the state. It is pertinent to mention here that Army and Para – Military forces have become a major threat to the wildlife. Their units are settled in the most fragile areas of the border which is rich in pastures, water and makes the hotspot for wildlife. Their settlements, therefore, disturb the eco – system.

The end number of dogs which breeds near their camps and units is another threat to the wildlife. Giving an example on the menace of dogs, **"Tibetan Antelope"** or **"Chiru"** is a species found in the Changchenmo Valley situated at China border in Changthang region. This species was hardly seen and

when asked, it came into light that the dog chases them away. But right across the border, Chirus are seen in end number. Thus, the dog menace has created a huge havoc in the population of wild animals as well the migratory birds. Wildlife crimes will be reduced if locals cooperate along with the concerned department. It is very important to save wildlife for the sustainable development of Ladakh **(Figure 36)**.

CHANGTHANG WILDLIFE SANCTUARY – JAMMU & KASHMIR; LEH – LADAKH

Figure 36: Changthang Wildlife Sanctuary in Jammu & Kashmir; Leh – Ladakh.

Changthang Wildlife Sanctuary in Ladakh is fascinating in a lot of ways and spreads over an enormous area of approximately 1,600 Sq. Km., as its home to an incredible variety of **"Flora and Fauna"**. As such, a visit to this sanctuary promises not just incredible opportunities for viewing the wildlife, but also exploring the amazing landscape of this place. Visiting the **"Changthang Wildlife Sanctuary" (CWS)** can be a rewarding experience.

Some Facts about Changthang Wildlife Sanctuary

"Changthang Wildlife Sanctuary" (CWS) is located in the Ladakhi Changthang plateau in the Leh district of Jammu and Kashmir. It covers an area of almost 1,600 Sq. Km., and is home to the highest altitude water lakes, namely, Tso – Moriri (which also happens to be the highest lake on earth), Pangong – Tso and Tso – Kar. Another interesting place to check out visit to Changthang Wildlife Sanctuary is the Korzok Village, which is also considered to be the world's highest village. One of the attractions of Korzok Village is the Korzok Monastery.

"Fauna and Flora" of Changthang Wildlife Sanctuary

Fauna

Apart from its location and the spectacular landscape that **"Changthang Wildlife Sanctuary" (CWS)** is renowned for, it's also home to an incredible variety of wildlife. The major attraction however, is the snow leopard. It's interesting to know that Changthang Wildlife Sanctuary is one of the few places in India which is the home of the Kiang or Tibetan Wild Ass along with the Dark – Necked Crane. Apart from the snow leopard, the other rare animals found here are Tibetan Wolf, Wild Yak, Bharal, Brown Bear and the Mormot, which seems to be present everywhere. Changthang Wildlife Sanctuary also boats a wide variety of avifauna. Around 44 types of water birds and seasonal species of migratory birds are also found here.

Flora

"Changthang Wildlife Sanctuary" (CWS) is home to almost 200 species of wild plants that grow in the higher pastures and are food for the animals inside the sanctuary. If rarely come across vegetation in this sanctuary, however, certain rare and endangered plant species with medicinal properties are found here.

Best Time to Visit "Changthang Wildlife Sanctuary" (CWS)

The best time to visit Changthang Wildlife Sanctuary is between the months of May and December. This is because the weather is best during these months.

Nearby Attractions to "Changthang Wildlife Sanctuary" (CWS)

Apart from Changthang Wildlife Sanctuary, there are **other attractions** which should be checking out to **make trip to Ladakh** a memorable one. Here are some nearby attractions to Changthang Wildlife Sanctuary.

Pangong Lake

Pangong Lake is one of the most captivating sites which ever come across in Ladakh. Extending to almost 150 Km, one side of it lies in India and the other side in China. Camping near the **Pangong Lake** is one of the most interesting activities to do in Ladakh.

Khardung – La Pass

Khardung – La Pass is one of the highest motor – able roads in the world, and crossing the pass is an adventure in itself. Situated at an altitude of almost 18,380 feet, **Khardung – La Pass** provides some of the most magnificent sights, which will ever come across.

Shanti Stupa

Shanti Stupa is a symbol of the predominant Buddhist influence in the region and is a major landmark in the city. **Shanti Stupa**, which is a white – domed chorten, stands as a strong contrast against the azure skies. The relics of Lord Buddha are preserved at its base.

Solution

- *Strict law enforcement against the violators;*
- *Awareness is very important to understand the importance of wildlife as well as biodiversity for the sustainable development of Ladakh;*
- *Working together with every responsibility to maintain ecological balance.*

Dr. Pankaj Chandan – Team Leader, Western Himalayas Landscape, and WWF – India: Ladakh has a very special place as far as the wildlife of the region is concerned. Some of unique assemblages of wildlife species exist here. The existence of a large number of medicinal plants in this region makes it a significant place for floral diversity as well. This is the only place within Indian limits where species like Black – Necked Crane and Bar – headed Goose Breed. In addition to this, many other species of birds also use the wetlands of Ladakh as their breeding and feeding grounds. ***"Ladakh has the best population of Snow Leopard and the existence of Saker Falcon, Upland Buzzard, Himalayan Otters; Tibetan Antelope make this region true Wildlife Hotspots"***.

Role of WWF in Ladakh

WWF – India also motivated twenty schools from Ladakh to form **"Freshwater Conservation"** groups to take up various activities to spread the message. WWF – India's slogan **"Consume**

Wisely…!!!, Conserve Widely…!!!" was the theme for an exhibition put up by various environmental organizations and the school children in Ladakh. These activities are part of the **"Education and Awareness"** component of WWF – India **"Conservation of High Altitude Wetlands of Ladakh"** project. Ladakh's high – altitude wetlands are unique. Nestled in the Trans Himalayan ranges of Eastern and North Eastern Ladakh between 4,000 and 5,000 m, these wetlands are facing the growing impacts of tourism, which adds significantly to the pressure on adjoining grasslands, leading to pollution, wildlife disturbance, change in local lifestyles, and loss of cultural heritage. However, good prospects exist for conservation action if implemented urgently with the support of local communities. *"For more information: Archana Chatterjee Coordinator (Wetland Habitats), Freshwater and Wetlands Conservation Programme, WWF – India (E – mail: Achatterjee@wwfindia.net)".*

Leh, India – Appeals for freshwater conservation and filled the air of Leh, Ladakh, when 2,000 school children chanted slogans at a rally organized by WWF – India and the **"Indo – Tibet Border Police" (ITBP)** to raise awareness on the importance of freshwater for **"People and Nature"** in this high –altitude cold area. The rally was addressed and flagged off by India's Deputy Prime Minister, Mr. L.K. Advani, enthusing and motivating the children to be role models and to spread the message of water conservation. The rally was held on 31st May to mark the International year of Freshwater 2003, and was preceded by a host of related activities in schools and ITBP camps. ITBP has a sizeable presence in Ladakh and their camps are located near important wetlands. WWF – India's Leh Field Office conducted education and awareness activities in ITBP camps near important wetlands to introduce them to the fragile nature of the ecosystem, its **"Biodiversity",** and the role the ITBP personnel can play in safeguarding it. Specifically, ITBP help has been sought to post their personnel at important nesting sites of endangered birds such as the black – necked crane during their critical incubation period (between May to July).

WWF through its education, outreach, and conservation research programmes is trying to protect the unique biodiversity of Ladakh in collaboration with various key stakeholders mainly the Department of Wildlife Protection. From time to time WWF does organize capacity building programmes through its various nature conservation initiatives. Another important role which WWF plays in Ladakh is through the production of **"Education and Awareness"** materials in the form of posters, booklets, and research papers.

There is need to conserve wildlife because it owe to our future generation. Moreover, this is a unique heritage and we must make efforts at all levels to protect it. In an area of Ladakh, the conservation of wildlife is linked to the economy and livelihoods of this region. As a large number of tourists come to Ladakh to see wildlife of this region, so it is very essential for us to protect this wildlife to ensure sustenance to our livelihoods and to our economy. ***"Also, healthy populations of wildlife are a clear indicator of a healthy environment so to ensure a healthy environment and to maintain ecological balance all efforts need to be made to conserve wildlife. It is very simple to understand, poaching can disturb the delicate ecological balance in the region"***. The decline in prey base will lead to the decline in predator population as well. Therefore in addition to immediate measures for the protection of predators more, long – term measures need to be taken to protect the prey base of these species.

All the protected areas of Ladakh are being managed by Department of Wildlife Protection, Government of Jammu & Kashmir and WWF plays the role of facilitators of various conservation initiatives in this region. The authority to take action against the violators of the rule is with the department of Wildlife Protection. Ladakh is a very vast area and a huge effort is required to regularly keep a watch on wildlife crime related cases so more and more efforts should be focused towards building the capacity of the enforcement agencies. At the same time, regular **"Education and Awareness"** activities are for all the stakeholders; about the importance of wildlife of Ladakh needs to be carried out in all parts of Ladakh. Moreover, a focused study on wildlife crime relates an issue in Ladakh needs to be conducted and only then this question can be answered with proper facts and figures. Through strict law enforcement, regular education and outreach programmes can tackle the issue of crime against wildlife. ***"Every case of wildlife crime needs to be dealt with strictly and guilty must be punished under the law. Everyone needs to realize that wildlife is our common heritage and must***

work together to protect this heritage". Also, there is a need to understand that in a region like Ladakh with very limited livelihood options, wildlife of this region offers tremendous opportunity to sustain an economy of this region through various ecotourism initiatives of this region. Therefore for sustainable development of Ladakh wildlife protection is must.

CONCLUSIONS AND SOLUTIONS

The story of the Nemo snow leopard brings into clear focus the fact that Human – Wildlife conflicts have not and will not be completely solved in Ladakh. On the contrary, a growing human population and a modernizing world will probably lead to increased conflict with wildlife. This will, in turn amplify the challenges faced by government parties such as the DWP – J&K and NGOs such as the **"Snow Leopard Conservancy – India Trust" (SLC – IT)**. Wildlife conservation projects in this high altitude desert have sought to create programs that respect the needs of local people while continuing to work for the protection of a rare and diverse **"Biodiversity/ Wildlife – Ecological – Environmental Impact Assessment" (B/ W – E – EIA)** in the district. As a result, according to Jigmet Takpa, once – dwindling wildlife populations have begun to flourish again over the past ten years. Through the implementation of community education, income – producing home – stays, and conflict control programs, the organizations working on behalf of Ladakh's wildlife have encountered successes in changing the ways of local people react to wildlife conflicts. Whether such reactions resulted from more positive views toward wildlife conservation or simply from adherence to advocated policy was less clear/ comprehensive. It also remains to be seen whether the home – stay systems can be sustained in the long term, as they are supported by outside economic forces and the preferences of a mostly non – Ladakhi demographic. For the moment, however, these districts – wide conservation systems and the philosophies that drove their creation are decreasing instances of the human – wildlife conflicts inherent to Ladakh. Finally, examining mentalities toward wildlife conservation in Leh District, a largely Buddhist area, in comparison to Kargil District, a largely Muslim area, could provide useful information regarding religious connections to wildlife conservation activities/ tricks/ actions.

- *Regular education and outreach programme on the important issues of wildlife as well as biodiversity sanctuaries and activities;*
- *Focused study on the biodiversity and wildlife crime in Ladakh;*
- *Regular monitoring program as per area/ region/ state wise;*
- *More awareness on the conservation of biodiversity as well as wildlife sanctuaries and activities.*

Ladakh hosts a wide range of wildlife populations, which concerned parties have struggled to conserve in light of wildlife conflicts with humans. Most conservation programs have focused on managing villager conflicts with the region's top predator, the snow leopard, because the health of a top predator's population indicates and thus determines the health of other **"Flora and Fauna"** in its habitat. Programs have also recognized the struggles of villagers, who often suffer losses of livestock due to the presence of local predators. As a result, villagers have been known to kill the responsible animals as acts of retribution or prevention. In this study research and examined these conservation programs and analyzed them in comparison to Ladakhi perspectives toward wildlife and wildlife conservation, with a particular focus on snow leopards. ***"Programs fall into four categories: livestock reimbursement, education in schools, home – stay programs, and other conflict control programs. The Department of "Biodiversity" and "Wildlife" Protection of the "Arunachal Pradesh", Jammu and Kashmir Government, Leh District and the "Snow Leopard Conservancy – India Trust" (SLC – IT) spearheaded most of the programs discussed in this study (Figures 37 and 38). Results showed mostly neutral or positive reactions to human – Wildlife conflicts are to be reduced, but still existent occurrences of livestock predation"***.

Figure 37: BOTHER… SAFEGUARD; PROTECT; CONSERVE AND PRESERVE OUR PLANET EARTH'S NATURAL – MOTHER… (ECO – NATURAL – GREEN – "BIODIVERSITY ECOSPHERE" AND ENVIRONMENT)…!!!

Figure 38: Prospects/ Scope/ Implementation of "Nampong to Vijaynagar Area", Transparent Skeleton – Flowers in Rainy Season, Diphylleia Grayi Rare – Plants Species as a Part of Biodiversity.

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