

# ENVIRONMENTAL AWARENESS AND WILDLIFE CONSERVATION

R.C. BASU  
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Thermal Plant

Acid Rain

Ash Dump

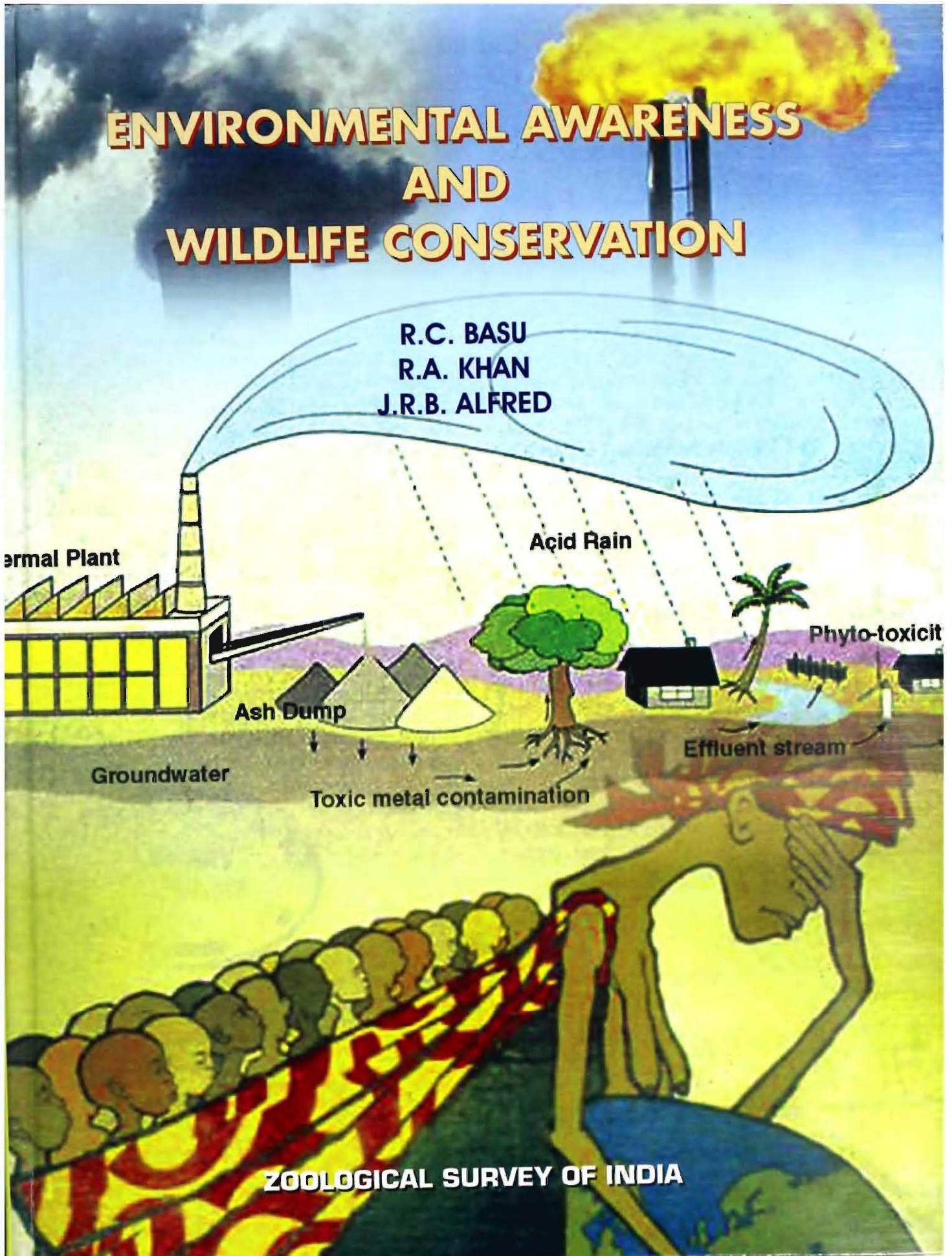
Phyto-toxicity

Groundwater

Effluent stream

Toxic metal contamination

ZOOLOGICAL SURVEY OF INDIA



# ENVIRONMENTAL AWARENESS AND WILDLIFE CONSERVATION

*Edited and compiled by*

**R.C. Basu  
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सत्यमेव जयते

**Zoological Survey of India  
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## PREFACE

Technically, the 'environment' entails everything around us. The modern society however, conceptualized the word to mean largely the natural environment - air, water, soil and living organisms. In a word, *nature*. Only a few Centuries ago, with billions fewer people on earth, protecting the natural world was not a crucial issue to the humanity. But the industrial revolution of 1800's transformed the traditional way of live and altered many societies. A major shift from agriculture to industry took its toll on the environment. As time passed and industry grew the natural resources were denuded and the pollution became severe, complex and widespread. This growing concern culminated in the first **Earth Day** in 1970. The event drew attention to the degraded environment and spurred scientists and governments to step up their efforts to reduce pollution and protect the natural world.

The tropical regions of the world are especially endowed with high level of biological resources and habitat heterogeneity. Many tropical ecosystems are however, fragile, being intricately balanced with the prevailing environment. The increasing rate of population over the years have been generating tremendous pressure on various ecosystems and overall environment of the region. It is perceived that the destruction of world's tropical rain forest will cause severe climate changes around the earth. The development oriented anthropogenic activities are leading to the degradation and alteration of environment at a massive scale, which in turn would contribute to the global change.

A plethora of environmental problems awaits sufficient understanding and appropriate ameliorative measures in our country. The environmental movement is not just about saving tigers, trees, tragopans or turtles- it is about saving life as we know it. Generation of sufficient information on key issues of environment was necessary to develop adequate understanding about the vulnerable facets of the ecosystems and to spread the understanding into the minds of the youths was imperative to boost up a movement. In order to enlighten and motivate young activists and students about various environmental problems and realistic approaches for their protection the "Leadership Course on Environmental Awareness and Wildlife Conservation" was organized first by the Zoological Survey of India in 1989, and this is organized as a biennial event as part of the institutional training programmes. There has been an effort for renewing the training curriculum in the pretext of newer visions and knowledge. About a thousand of persons has already participated in this course. There has been an increasing demands over the years for the content of the course from the participants and various academic sectors. So, we decided to bring out a volume, dedicated largely to the theme of the Leadership Course. Subsequently, a select group of authors (mainly faculty of the course) was invited to contribute to the present volume. These contributions have emphasized the key issues and challenges, physical properties of environment, ecosystem characteristics and

management, conservation and management of wildlife, conservation and management of mangrove and - marine ecosystems, terrestrial ecosystems and air pollution, use of biotechnology in combating pollutions, perspectives of biodiversity and human dimensions in their conservation, people's participation, tradition and wisdom in environmental protection and conservation of natural resources, available laws and legal remedies for environmental protection, etc.

We feel, we have been successful in assembling varied aspects that reflect our concerns for improvement of environment and conservation of natural resources. More important, many of the chapters/contributions will have significant impact and enduring values. We believe, this volume will serve as a source of information for the persons engaged in environmental management and movement, preservation of biological resources, and for the scientific community at large.

This work as virtually all scientific endeavours, could never have been successfully completed without the enthusiastic cooperation and support of numerous individuals and organizations. We thank the contributors for their efforts in trying to adhere to our editorial policies and schedules. Our thanks are also due to Dr. N.C. Nandi and Dr. T.K. Pal, Zoological Survey of India for various courtesies and to Mr. Rati Ram Verma, Publication Production Officer showed special interest in bringing out he book elegantly.

July, 2006  
Kolkata

**Editors**

# ENVIRONMENTAL AWARENESS AND WILDLIFE CONSERVATION

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## **FAUNAL RESOURCES AND THEIR SUSTAINABLE UTILISATION**

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### **INTRODUCTION**

It is notable that mankind has depended on bioresources for life support systems for many millennium. Bioresources have been defined as living entities, which include genetic resources, organisms, populations, with actual or potential use to mankind. Biological diversity refers to the variability of life in all forms, levels and combinations. It is an attribute of life. In the past, when human population density was low and people had only limited technologies for resource acquisition and environmental change, humans lived in close harmony with nature and the availability of existing, bioresources at all times. Increasing population and the development of technologies have resulted in the over-utilisation of bioresources and environmental destruction. As a consequence, human's life supporting system is inevitably deteriorated.

Biological Resources have been declared sovereign right of the country. The right could only change into economic power when major assessment of resource base could be made – that can lead to process of prospecting and product utilisation in a sustainable manner. Resource analysis is now at the heart of the political debate, at local, national or international level, and guided by the principles of sustainable development. The prominence given to biological resource is positive. It means that we are able to value nature and the environment; that we are better equipped to define the different options, the gains and the losses. These environmental considerations can be integrated into our policy and decision making in a wide social and economic context.

To meet these requirements, the following objectives are set in the context of resource analysis and sustainable utilisation *viz.*,

- (i) Biodiversity representatives in natural ecosystems and habitats.
- (ii) Biodiversity in landscapes where forestry, fisheries and grazing are dominant land uses.
- (iii) Threatened and Endangered population of wild species.

- (iv) Agriculture and other economically important species and wild relatives.
- (v) Species or habitats of significant social, cultural importance (e.g., Sacred groves).
- (vi) Habitats or ecosystems associated with the key evolutionary (e.g., "refugia") or biological processes (migratory habitats or corridors).

### **BIOLOGICAL DIVERSITY**

India is very rich in terms of biological diversity due to its unique biogeographical location, diversified climatic conditions and enormous ecodiversity and geodiversity. In fact, within only about 2% of World's total landmass, India harbours as much as 7% of the total animal species of the world. However, out of about 90 thousand animal species known from our country only few are so far been domesticated and improved through genetic modification for the benefit of mankind. World scenario in this aspect is no exception, where only small portions of biological resources are being used in a sustainable way.

The study on the biological diversity rests on the assessment, in terms of diversity, of species, of different areas, habitats or ecosystems. The criteria for assigning the priorities for conservation of biological diversity depends on the richness in a given area, the number of occurrences of a genotype, species or ecosystem (rarity), degree of separation of population, species or ecosystem from its comparable analog (distinctiveness), degree of occurrence (representation), imminent danger or harm (threat) and the presence or absence of key stone resources (function).

Genetic variation has improved agricultural productivity, and new biotechnological products that have stimulated economic prosperity. A deeper understanding of the structure and functioning of ecosystems has provided the scientific basis to improve humanity's ability to predict responses to environmental change and to restore damaged ecosystems, as well as to understand better the processes that must be maintained to ensure sustainable agro-ecosystems. Biodiversity knowledge has proven essential for effective decision-making in conservation and sustainable use of biotic resources.

We will not be able to define and evaluate concerns about the loss of biodiversity without due consideration of its importance to society. Studies of social systems at different scales and complexities will be needed to understand the scope and impact of biodiversity changes on societies themselves, as well as to develop utilisation patterns that are compatible with scientific information about the limits of sustainability. Human cultures are part of a country's heritage and count among its most important values. Traditional knowledge of indigenous and local communities must, therefore, be safeguarded, documented, and understood for insights into the options available for the sustainable utilisation of biodiversity.

At a time when the Earth's life-support system is being modified at an ever-increasing rate, the need for scientific information to mitigate the effects of these changes has never been more urgent. This is especially true for the country that house most of the Earth's

biodiversity but unfortunately possess only a small proportion of the necessary scientific expertise and technology. Well aware of the underlying difficulties and constraints, but also of its intrinsic responsibility for clarifying and harmonising scientific issues and for providing the relevant results to decision-makers of both developed and developing countries,

### FAUNAL DIVERSITY

India is known to have over 7% of the species of animals that the world holds and this percentage accounts nearly for 89,500 species, of which insects alone include 59,353 species. Inventories of mammals, birds, reptiles, amphibians and fish are fairly complete. Indeed, those groups that are known to occur in India have not received adequate attention, while some other invertebrates (like Nemertinea, Nematomorpha, Priapulida, Pogonophora and Pentastomida) are not known at all in India. Further studies will not only reveal many more species but also certainly enhance the quantity of endemic and threatened species.

**Table-1.** Estimated number of described species

Taxonomic group	No. of species		% in India
	World	India	
PROTISTA (Protozoa)	31250	2577	8.24
ANIMALIA			
Mesozoa	71	10	14.08
Porifera	4562	486	10.65
Cnidaria	9916	842	8.49
Ctenophora	100	12	12.00
Platyhelminthes	17500	1622	9.22
Nemertinea	600	-	-
Rotifera	2500	330	13.20
Gastrotricha	3000	100	3.33
Kinorhyncha	100	10	10.00
Nematoda	30000	2850	9.50
Nematomorpha	250	-	-
Acanthocephala	800	229	28.62
Sipuncula	145	35	24.14
Mollusca	66535	5070	7.62
Echiura	127	43	33.86
Annelida	12700	840	6.61
Onychophora	100	1	1.00

Table-1. *Contd.*

Taxonomic group	No. of species		% in India
	World	India	
<b>Arthropoda</b>	<b>987949</b>	<b>68389</b>	<b>6.90</b>
Crustacea	35534	2934	8.26
Insecta	867391	59353	6.83
Arachnida	73440	5818	7.90
Pycnogonida	600	16	2.67
Paupoda	360	-	-
Chilopoda	3000	100	3.33
Diplopoda	7500	162	2.16
Symphyla	120	4	3.33
Merostomata	4	2	50.00
Phoronida	11	3	27.27
Bryozoa (Ectoprocta)	4000	200	5.00
Entoprocta	60	10	16.66
Brachiopoda	300	3	1.00
Pogonophora	80	-	-
Priapulida	8	-	-
Pentastomida	70	-	-
Chaetognatha	111	30	27.02
Tardigrada	514	30	5.83
Echinodermata	6223	765	12.29
Hemichordata	120	12	10.00
<b>Chordata</b>	<b>48451</b>	<b>4952</b>	<b>10.22</b>
Protochordata	2106	119	5.65
Pisces	21723	2546	11.72
Amphibia	550	219	4.20
Reptilia	5817	456	7.84
Aves	9026	1232	13.66
Mammalia	4629	390	8.42
<b>Total (Animalia)</b>	<b>1196903</b>	<b>86874</b>	<b>7.25</b>
<b>Grand Total (Protista+ Animalia)</b>	<b>1228153</b>	<b>89451</b>	<b>7.28</b>

India has a great many scientific institutes and university departments interested in various aspects of biodiversity. A large number of scientists and technicians have been engaged in inventory, research, and monitoring. The general state of knowledge about the distribution and richness of the country's biological resources is therefore fairly good.

These faunal resources are located in the following ecosystems :

- ★ Forests
- ★ Mountains
- ★ Deserts
- ★ Grasslands
- ★ Freshwater
- ★ Marine
- ★ Wetlands
- ★ Estuaries & Backwaters
- ★ Islands

### ENDEMIC SPECIES

India has many endemic plant and animal species. Among plants, species endemism is estimated at 33% with approximately 140 endemic genera but no endemic families (Botanical Survey of India, 1983). Five locations have so far been recognised for India: the Agastyamalai Hills, Silent Valley and New Amarambalam Reserve and Periyar National Park (all in the Western Ghats), and the Eastern and Western Himalaya, with a large number of endemic plants. The Gangetic plains are generally poor in endemics, while the Andaman and Nicobar Islands contribute at least 220 species to the endemic flora of India (Botanical Survey of India, 1983).

The Indian fish fauna includes 2 endemic families viz., Parapsilorhynchidae (Hill stream fishes with one genus and three species) distributed in Western Ghats, Satpura Mountains and Bailadila range of Madhya Pradesh. The class Horaichthyidae includes a monotypic species *Horaichthyes setnai* distributed in the west coast of India. The fishes of India contains 223 endemic species representing 8.75% of the fishes known from India and 127 monotypic genera (13.10% of the Indian genera), the details are as shown in table below :

**Diversity of Endemic Fishes in India**

Order	Family	Genera	Species
Anguilliformes	Ophichthidae	1	1
Clupeiformes	Clupeidae	2	2
Cypriniformes	Cyprinidae	22	97
	Parapsilorhynchidae	1	3

Order	Family	Genera	Species
	Balitoridae	6	46
	Cobitidae	4	8
Siluriformes	Bagridae	5	10
	Siluridae	3	3
	Schilbeidae	6	6
	Sisoridae	7	21
	Clariidae	2	3
	Olyridae	1	1
Cyprinodontiformes	Hemiramphidae	2	2
	Horaichthyidae	1	1
	Synbranchidae	1	2
	Chandidae	1	1
	Nandidae	1	1
	Cichlidae	1	1
	Gobiidae	7	9
	Eleotrididae	1	1
	Mastacembelidae	1	1
	Chaudhuriidae	1	2
Tetraodontiformes	Tetraodontidae	1	1
<b>Total 6</b>	<b>23</b>	<b>78</b>	<b>223</b>

Of the 219 recorded species of Amphibians in India, 61.1 percent i.e., 134 species are endemic to the country, 6 genera are exclusively endemic to India (The genus *Indotyphlus* (Gymnophiana) and 5 genera belonging to Anura). The Western peninsula harbours highest number of endemic species (92) followed by North-east India (29), Andaman & Nicobar Islands have 5 species, north and Deccan plateau has 3 each. All the 20 species of Gymnophiana reported from India are endemic while among Anurans 114 species out of 198 (57.5%).

Reptiles were the dominant group of vertebrates during the mesozoic period, most of the orders of reptiles were established by the end of Triassic and some became extinct at that time. Of the 19 orders of Reptiles only 4 survive today (Crocodylia (Crocodiles & Alligators), Testudines (Turtles & Tortoises), Squamata (Lizards & Snakes) and Rhynchocephalia (Not distributed in India). Reptilian fauna has great affinity to the Oriental Region as well as a close relationship to the Indo-Chinese and Indo-Malayan Region. The diversity of Indian Reptilian fauna is shown :

About 176 species under 106 genera, 39 families and 11 orders are endemic to Indian Subcontinent including Pakistan, Nepal, Bhutan, Myanmar, Sri Lanka and Bangla Desh.

One genus *Ophrysia* and 50 species under 11 genera are exclusively endemic to India alone. There are 25 monotypic genera.

Only 176 bird species are endemic to India, with distributions concentrated in areas of high rainfall. They are located mainly in eastern India along the mountain chains where the monsoon shadow occurs, southwest India (the Western Ghats), and the Nicobar and Andaman Islands.

Out of 180 genera of Indian mammals, 61 genera are monotypic (see Table) and 105 are represented in India by a single species. Of these, 10 genera namely, *Scotozous* (Chiroptera), *Loris* (Primates), *Melursus* (Carnivora), *Antilope*, *Boselaphus*, *Tetracerus* and *Pantholops* (Artiodactyla), *Eupetaurus* and *Golunda* (Rodentia) and *Caprolagus* (Lagomorpha) are endemic to Indian subregion, and another 4 genera, namely *Anathana* (Scandentia) *Latidens* (Chiroptera) and *Biswamoyopterus*, and *Platacanthomys* (Rodentia) are endemic to the Indian Union. At specific level, 42 species (Insectivora-5, Scandentia-2, Chiroptera-10, Primates-3, Carnivora-4, Artiodactyla-1, Rodentia-17) are endemic of which 20 species to Western Ghats, 11 species to peninsular India, 4 species to northeastern India and the rest two to Western Himalaya. Endemism among mammals and birds is relatively low. Only 36 species of Indian mammal have a range that is confined entirely to within Indian territorial limits. Four endemic species of conservation significance occur in the Western Ghats. They are the Lion-tailed macaque *Macaca silenus*, Nilgiri leaf monkey *Trachypithecus johnii* (locally better known as Nilgiri langur *Presbytis johnii*), Brown palm civet *Paradoxurus jerdoni* and Nilgiri tahr, *Hemitragus hylocrius*.

#### List of mammalian species endemic to the Indian Union

Order	Species
<b>Andaman &amp; Nicobar Islands</b>	
Insectivora	<i>Crocidura jenkinsi</i> , <i>Crocidura andamanensis</i> , <i>Crocidura hispida</i> and <i>Crocidura nicobarica</i>
Chiroptera	<i>Pteropus faunulus</i> and <i>Rhinolophus cognatus</i>
Rodentia	<i>Rattus stoicus</i> , <i>Rattus palmarum</i> and <i>Rattus burrus</i>
Scandentia	<i>Tupaia nicobarica</i>
<b>Western Ghats</b>	
Chiroptera	<i>Latidens salimalii</i> , <i>Otomops wroughtoni</i> and <i>Hipposideros hypophyllus</i>
Insectivora	<i>Suncus day</i>
Primates	<i>Macaca silenus</i> and <i>Trachypithecus johnii</i> , <i>Macaca radiata</i>
Carnivora	<i>Paradoxurus jerdoni</i> and <i>Viverra civettina</i> , <i>Martes gwatkinri</i>
Artiodactyla	<i>Hemitragus hylocrius</i>
Rodentia	<i>Ratifa indica</i> , <i>Funambulus tristriatus</i> , <i>Platacanthomys lasiurus</i> , <i>Millardia kondana</i> , <i>Rattus ranjinae</i> , <i>Mus famulus</i> , <i>Mus platythrus</i> , <i>Cremnomys Elvira</i> and <i>Cremnomys cutchicus</i> .

Order	Species
<b>Peninsular India</b>	
Scandentia	<i>Suncus day, Anathana ellioti</i>
Primates	<i>Macaca radiata</i>
Chiroptera	<i>Hipposideros schistaceus, Rhinopoma mitratus</i>
Carnivora	<i>Martes gwatkinsii</i>
Rodentia	<i>Ratufa indica, Cremnomys cutchicus and Mus phillipsi</i>
<b>Western Himalaya</b>	
Chiroptera	<i>Murina grisea</i>
Rodentia	<i>Alticola montosa</i>
<b>Northeastern India</b>	
Chiroptera	<i>Eptesicus tatei</i>
Carnivora	<i>Herpestes palustris</i>
Rodentia	<i>Biswamoyopterus biswasi</i>

#### Estimated number & percentage of endemic species in India

Group	No. of species		Percentage
	Total	Endemic	
Protozoa			
Freeliving	1247	90	7.21
Parasitic	1330	550	41.33
Mesozoa	10	10	100.00
Porifera			
Freshwater	31	13	41.93
Cnidaria	842	*10	-
Platyhelminthes	1622	1160	71.88
Rotifera	330	23	7.00
Gastrotricha	100	64	64.00
Kinorhyncha	10	7	70.00
Nematoda	2850	*400	-
Acanthocephala	229	203	88.64
Mollusca			
Terrestrial	1487	498	33.50
Freshwater	183	77	41.80
Echiura	43	12	28.00
Annelida			

Group	No. of species		Percentage
	Total	Endemic	
Oligochaeta	473	368	77.80
Hirudinea	59	25	42.37
Arthropoda			
Crustacea	2934	501	17.07
Insecta	59353	20717	34.90
Arachnida	5818	2623	45.08
Phoronida	11	1	1.00
Bryozoa	4000	*12	-
Entoprocta	10	1	1
Chaetognatha	111	3	2.70
Chordata			
Pisces	2546	223	8.75
Amphibia	209	128	61.24
Reptilia	456	214	47.00
Aves	1232	176	14.28
Mammalia	390	36	9.23

\*Incomplete data and hence % not given

### THREATENED SPECIES

India contains 172 species of animal considered globally threatened by IUCN, or 2.9% of the world's total number of threatened species (Groombridge, 1993). These include 53 species of mammal, 69 birds, 23 reptiles and 3 amphibians. India contains globally important populations of some of Asia's rarest animals, such as the Bengal Fox, Asiatic Cheetah, Marbled Cat, Asiatic Lion, Indian Elephant, Asiatic Wild Ass, Indian Rhinoceros, Markhor, Gaur, Wild Asiatic Water Buffalo etc. Summary accounts for some of the globally threatened mammals found in India are given. The number of species in various taxa that are listed under the different categories of endangerment is shown below.

#### Globally Threatened Animals Occurring in India by Status Category

##### 1994 IUCN Red List Threat Category

Group	Endangered	Vulnerable	Rare	Intermediate	Insufficiently known	Total
Mammals	13	20	2	5	13	53
Birds	6	20	25	13	5	69
Reptiles	6	6	4	5	2	23

Group	Endangered	Vulnerable	Rare	Intermediate	Insufficiently known	Total
Amphibians	0	0	0	3	0	3
Fishes	0	0	2	0	0	2
<b>Total</b>	<b>26</b>	<b>45</b>	<b>49</b>	<b>28</b>	<b>24</b>	<b>172</b>

Source : Groombridge, B. (ed). 1993. *The 1994 IUCN Red List of Threatened Animals*. IUCN, Gland, Switzerland and Cambridge, UK. lvi + 286 pp.

The workshop held in 1982 indicated that as many as 3,000-4,000 higher plants may be under a degree of threat in India and published its findings in Red Data Books (Nayar and Sastry, 1987). Similarly, the Zoological Survey of India published an account of Threatened Animals of India in 1983, Status Survey of Endangered Species, the first being published in 1994 on Golden Langur, Phayre's leaf monkey and Hispid hare. In 1994, a Red Data Book was also published on vertebrates (Mammalia, Aves, Reptilia and Amphibia)

Recently (2001), eight species of sharks are included under the schedule -I of Wildlife Protection Act. Out of 219 species of amphibians known from India, 9 were considered as critically endangered, 42 endangered, 39 vulnerable, and 74 of lower risk category. Only 4 species, *Pedostibes kempfi* (Garo Hills Tree Toad), *P. tuberculatus* (Malabar Tree Toad), *Melanobatrachus indicus* (Malabar Black Narrow-mouthed Frog), *Tylototriton verrucosus* (Himalayan Salamander) are protected under Schedule- II of Indian Wildlife Protection Act of 1972 and frogs of the genus *Rana* under Schedule -IV of the Act. Among Reptiles, The IUCN list of threatened animals (1988) includes the Indian Python (*Python molurus*) as "Vulnerable" and Acellate cobra (*Naja oxiana*) as "Endangered" The protection offered by the Indian Wildlife Act of 1972 to pythons, egg eating snake, rat snake and Indian Cobra are significant conservation effort initiated by the government.

Among birds, three species (Pinkheaded Duck, Mountain Quail, and Forest Owlet) are suspected to be extinct. Jerdon's Courser which was considered to be extinct, is rediscovered. 24 species are rare, 31 species are critically endangered. It included 17 species as endangered from India. Bird life International in their Asian Red Data Book included 104 species from India which also containing those in the ICBP list. Bird Watchers' Guide to India enlisted 180 species for conservation. But the criterion is determined on the biological, zoogeographical, rate of exploitation, habitat loss and other factors of threats that are likely to inflict their survival potential, etc. separately or collectively for each species.

Of a total of 390 species of mammals reported from India, 175 species are threatened with extinction. But the degree of threat varies, and on that basis 75 species have been listed in Schedule I, 73 in Schedule II, 8 in Schedule III and 19 in Schedule IV of the Wildlife Protection Act (Appendix III). Of the 75 species in Schedule I, two species namely, the Hunting Leopard and the Lesser One-horned Rhinoceros are supposed to be extinct from India, and 32 species are highly endangered. These species are Lion-tailed Macaque,

Phayre's Leaf Monkey, Hoolock Gibbon, Chinese Pangolin, Malayan Sun Bear, Red Panda, Ratel, Malabar Civet, Desert Cat, Marbled, Marbled Cat, Pallas Cat, Golden Cat, Rusty-spotted Cat, Caracal, Indian Lion, Snow Leopard, Great one-horned Rhinoceros, Indian Wild Ass, Kiang, Pigmy Hog, Musk Deer, Thamin, Hangul, Swamp deer, Four-horned Antelope, Yak, Indian Buffalo, Himalayan Tahr, Markhor, Nilgiri Tahr, Hispid Hare, and Small Travancore Flying Squirrel (Agrawal *et al.* 1991). From Table, it is clear that practically all the species of mammals except insectivores, tree-shrews, bats and murid rodents are threatened, of course to a varying degree.

#### Number of Endangered Species of Mammals (order-wise) in India

Orders	No. of known species from India	No. of endangered species in Schedules			
		I	II	III	IV
Insectivora	28	–	–	–	1
Scandentia	3	–	–	–	–
Chiroptera	110	–	–	–	–
Primates	15	9	6	–	–
Carnivora	55	28+(1)	21+(4)	–	6+(1)
Artiodactyla	32	24	–	8	–
Perissodactyla	3	3	–	–	–
Cetacea	29	3	26	–	–
Sirenia	1	1	–	–	–
Proboscidea	1	1	–	–	–
Lagomorpha	10	1	–	–	9
Rodentia	101	2	16	–	2
Pholidota	2	2	–	–	–
<b>Total</b>	<b>390</b>	<b>75</b>	<b>73</b>	<b>8</b>	<b>19</b>

#### SUSTAINABLE UTILISATION

The "World Conservation Strategy" of 1980, emphasised three objectives of resources conservation, viz., i. maintenance of the essential ecological process and the life-support systems, ii. preservation of the genetic diversities, iii. Sustainable utilisation of the genes, species and the ecosystems. However, the strategy did not prescribe any social, political or organisational framework to realise these objectives. Norwegian Prime Minister. G.H. Burtland (Dec.1983), chairing the World Commission on Environment & Development of UN General Assembly made it clear that the existing pattern of development are not sustainable and the commission defined "Sustainable Development" as the development, which meets the needs and the aspirations of the present without compromising the ability of the future generations to meet their needs. From then onwards, the concept of

sustainable development has acquired a new dimension in terms of economic growth and environmental protection. It is this convention that gave the inter-generational equity, use and conservation of natural resources, environmental protection, precautionary principles, obligation and assistance to cooperate, eradication of poverty and financial assistance in the developing countries.

In 1987 that the definition of the phrase "Sustainable Development" was modified, and redefined as that which lasts and was durable and dynamic enough to meet the emerging needs of the people. It means taking the development processes in such a manner as to "preserve" or "conserve" the life-supporting systems and the resources-capital base of the Earth like air, water, soil, forests, fauna, flora, minerals, non-renewable resources, etc. It also means meeting the needs of the present generations without impairing the needs of the future generations. It is now defined as the " Social and structural economic transformation which optimises the social and economic benefits available in the present without jeopardising the likely potential for similar benefits in the future.

Ecologically the sustainable development is "using, conserving and enhancing the community resources so that the ecological processes, on which the life depends, are maintained and the total quality of life, now and in the future can be increased. Therefore the guiding principles of Sustainable development in the broad sense are :

- Respect and care for the community of life
- Improve the quality of human life
- Conserve the earth's vitality and diversity
- Conserve life support system
- Conserve biodiversity
- Ensure that the use of renewable resources are sustainable
- Minimise the depletion of non-renewable resources
- Enable communities to care for their own environments
- Provide a national framework for integrating the development and conservation

The manner in which the goals are achieved through are, i) emphasis on the basic role of natural ecological processes, bio-diversity and sustainable utilisation at all levels of decision making ii) identify conservation priorities with attainable goals iii) facilitate the actual implementation of sound conservation recommendations in the most effective way iv) promote establishment of protected area network, biosphere reserves, management plans and other conservation initiatives that will preserve the natural habitat v) promote a conservation consciousness within the public and community participation in conservation decisions vi) provide facilities for conservation education and community development programs vii) promote the wise use of natural resources and regulation of the trade in endangered species and other wild life products viii) Establish an efficient scientific information and decision support system that includes needs-driven research and conservation planning.

## I. POLICIES & PROGRAMMES FOR SUSTAINABLE UTILISATION

### a. Community based programme

The general perception of conservationists in the developing countries is that the wildlife conservation and protected areas were doomed unless local communities become an integral part of the conservation efforts (Haeckel, 1999), new strategies such as "Community Conservation" have evolved over the past several years in India, which intends to have the participation inclusive rather than exclusive. It is believed that the community conservation programme influence thinking and attitudes in the belief that this will lead to the changes in their behaviour.

An example can be cited of the entire process of conservation, development and sustainable utilisation as evidenced from selected sacred groves with community participation in many parts of the country.

Sacred groves are defined as the species rich habitats that were consecrated to a deity or spirit, where extraction of any living material is forbidden. These sacred groves serve as prey refugia, where prey populations could maintain a minimal population. Such sacred groves are investigated recently in Andhra Pradesh, Kerala, Karnataka, Madhya Pradesh, Bihar, and some Northeastern states. These areas are identified as the species rich area of the primary forests as in Western Ghats (Gadgil, 1993), or area with rare species (*Kunstleria keralensis*) Mohanan & Nair (1981), endemic frog (*Philaetus sanctisilvaticus*) as in Amarkantak, M.P. (Das & Chanda, 1997), sacred ponds having a refuge of the black turtle (*Chelonys nigricans*) in Chittagong, Bangladesh ( Reza Khan, 1980).

The perception of conservation among the traditional folks living within the forests and other conservation area on the other hand needs no explanation. Having sustained the forests over centuries, they have evolved a 'low desire level' of lifestyle, which enables them to live in unique harmony with nature. Instead of being mere a watchmen of the forests, the traditional tribals realises and inherits the sensibilities regarding the conservation and sustenance of the biodiversity. Their style of construction of huts by utilising only deadwood and dry leaves and as a tradition they do not cut branches of live trees for any purpose including their fuel requirements. During the past century, the tribal had a migratory lifestyle like most forest beings moving from one location to the other within a specified area in order to help re generation of the forests. The medicinal plants which the tribals use are nature's gifts and after their movement was hampered, the tribals began to spread the seed around to have these plants available in more than one location. The conservation idioms of the tribal are also seen in their hunting practices. The Jenu Kurubas in Southern India never takes the honey completely from the honeycomb in order to ensure that the bees did not suffer and the production does not come to an abrupt end. Similarly, the tubers and other roots on which tribal sustain are never uprooted fully and is used ensuring that the mother plants survive and reproduce.

Community participation can also be seen in Kani Tribes in Kerala, which had the traditional knowledge on the seeds of the plant *Trichhopus zeylanicus*, a steroid free anti

fatigue and restorative drug developed by TBGRI, gets a royalty of 2% of the sales to the community.

#### **b. National Resource Protection Programme**

The aim is to promote the wise use of natural resources and regulation of the trade in endangered species and other wild life products. This is achieved through :

- **Wildlife (Protection) Act, 1972 & Wildlife (Protection) Amendment Act, 1991.**

Section (29) No person shall destroy, exploit or remove any wildlife from sanctuary or destroy or damage the habitat of any animal or deprive any wild animal of its habitat.

Section 35 (1) Declaration of National Parks including the marine protected areas

Section 39 deals with the ban on breeding, hunting, trophies, importing etc., in contravention of any provisions and vehicle, vessel, weapon, trap or tool for collection/committing an offence shall be the property of the state Govt.

- **Environmental Protection Act, 1986**

Section 3(1) Central Govt. has the power to take all such measures as it deems necessary or expedient for the purpose of protecting and improving the quality of the environment and preventing controlling and abating environmental pollution

- **Constitution of India**

Article 48–A : The state shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country

Article 51(g) : Impose a similar responsibility on every citizen to protect and improve the natural environment including forests, lakes and wildlife and to have compassion for living creatures

- **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)**

The Indian Government joined the convention on October, 1976, as a member of CITES, whose main goal is to monitor and stop commercial international trade in endangered species, maintain those species under international commercial exploitation, maintain ecological balance and assist countries enabling a sustainable use of species through international trade.

- inspection of imports and exports of fauna and flora at all International Airport and other airports, inspection of exemption farms, pet shops, zoos, and holders of permits to import, keep, or export wild animals and import or export protected plants
- to investigate the illegal trade in wildlife species
- Besides above, many national and international acts/treaties are being followed to maintain the natural balance in the ecosystem.

### c. Programme based on Conservation and Sustainable Utilisation of Biodiversity

#### i) Protected Area Network

Ministry of Environment & Forests, through various programmes assist and contribute to the development of a soundly based programme for the conservation and sustainable and equitable utilisation of biodiversity in the Protected Area management systems that will assure enduring ecological, economic and social benefits. The three-pronged approaches are :

1. Securing the integrity of nearly a total of 89 National Parks with an area of 37,648.57 km or 1.15% of the country's geographic area and 482 Wildlife Sanctuaries with an area of 115,351.77 km or 3.51 % have been established. This gives a total of 571 Protected Areas, with an area of 153,000.34 km or 4.66% of the country's geographic area, within the forest ecosystem to preserve, mainly through the preparation of management plans and also through provision of support for surveillance and monitoring activities
2. Institutionalise the basic biological inventory work that has been progressing satisfactorily for several years, giving emphasis to the efficient data collection, storage and analysis and innovative information management;
3. Bioprospecting - an activity concerned with the search for new forest or marine products and other natural faunal and floral resources or their products with market potential. Culture of species of biomedical importance like horseshoe crabs, beetles etc.

#### ii) Biosphere

A biosphere reserve is a specific type of conservation area, which accommodates and benefits both the natural environment and the communities living in and around it. This is possible because a biosphere reserve consists of three different but associated zones *viz.*, Core, Buffer and Transition. Core a most ecologically sensitive and pristine area where nature conservation is a priority and low-impact activities are allowed. Buffer a less ecologically sensitive but mostly natural area where recreation and sustainable utilisation of natural products can be accommodated and the Transition a less ecologically sensitive area where a great variety of land uses occur. All zones are interdependent and are managed and protected according to the definitions above. By linking conservation, development and the sustainable use of natural resources, a harmony and balance between nature and people can be achieved. Following are the list of biosphere reserves in India, wherein conservation and management action plans are initiated. Several new ones are being in the process of addition to the existing ones.

#### Biosphere Reserves in India

No.	Name	State	Area in Km <sup>2</sup>
1	Nilgiri	Karnataka, Kerala & Tamil Nadu	5520
2	Nanda Devi	Uttar Pradesh	5860.69
3	Nokrek (Tura Range)	Meghalaya	820

No.	Name	State	Area in Km <sup>2</sup>
4	Great Nicobar	Andaman & Nicobar Isl.	885
5	Gulf of Mannar	Tamil Nadu	10,500
6	Manas	Assam	2,837
7	Sunderbans	West Bengal	9,630
8	Simlipal	Orissa	4,374
9	Dibru – Saikowa	Assam	765
10	Dehang – Debang	Arunachal Pradesh	5,112
11	Kanchengdongza	Sikkim	2619,92
12	Pachamarhi	Madhya Pradesh	4,926.28

### c. Forests

Tropical regions house more than half of the world's bioresources. In the tropical forest, bioresources play an important role in accelerating economic development processes of the world. For example, almost half of all prescription drugs in industrialised nations were derived wholly or synthesised partially from natural sources. Some 85 percent of foods are derived from only 20 kinds of plants, two-thirds from corn, wheat and rice. There are at least 75,000 edible plants in existence and many of them have characteristics superior to the currently used plants.

Forest covers nearly 23.42% of the total geographic area of the country. The recorded forest area in the country is 7, 65,210 sq. km while the forest cover analysed by the satellite is 6, 39,900 sq. km covering nearly 19.47%. (ICFRE, 2002). Champion & Seth (1968) identify sixteen forest types. The contribution from forest is nearly 2.00% of the GDP mainly in the form of fuel, food, fodder, medicine, timber etc. Besides these the non wood forest products such as wild edible product, sal oil, mohua oil, and some other essential oils, gums, resins, turpentine, tans, dye, bamboo, fibers, grasses, beedi and tendu leaves, etc. In fact, over 50% of the revenue earned by the forest department comes from non-wooded forest produces.

Conservation of forests is through the Forest Act, which guarantees economically, ecologically, socially and culturally sustainable utilisation of the forests. It aims at promoting a rational use of forest resources. A key element of the Forest Act, with regard to safeguarding biodiversity, is defining certain habitats of special importance and giving guidelines as to how these habitats may be managed. Recently, Joint Protected Area Management an Act under Participatory Management Under Wildlife Act and silvicultural practices and co-operation between forest dwellers and forest authorities are added to the forest protection & Conservation.

Furthermore, the use of remote sensing for data gathering, allied to the introduction of Geographic Information System (GIS) as a powerful tool to process that data in conjunction with information collected using traditional field techniques permit the forest

managers to be a more effective component of that planning process. These tools, specifically aerial and satellite borne imagery permit the discrimination of different forest types as well as the multi-temporal appraisal of land cover/land use change and of the impacts of that change.

#### **d. Animal breeds**

The primary biological capital for livestock development, food security and sustainable rural development are the breeds of the few domesticated farm animal species important to food and agriculture production. The value of the vast majority of these animal genetic resources is poorly understood. Domestic species such as The pariah dog (*Canis familiaris*), domestic cat (*Felis catus*) ass (*Equus asinus* and *E. Cabalus*), pig (*Sus domesticus*), camel (*Camelus dromedarius*), cow (*Bos frontalis*) buffalo (*Bubalus bubalis*), sheep (*Ovis aries*) goat (*Capra hircus*), yak (*Bos grunniens*) and mithun are domesticated species which occur in India.

A broad range of specific information required for the country to develop cost-effective policies, plans and programmes for development and sustainable utilisation of domesticated species are :

- Genetic development of those livestock resources along with necessary safeguards, currently important to realising food security as well as other objectives,
- Maintaining, to meet possible future needs, those unique and are of little current interest to farmers.

#### **e. Fisheries**

The fisheries today are confronting problems such as over-exploitation, poor fishing gear selectivity; poor utilisation of potentially valuable by-products, etc. In addition, the harvesting, processing and distribution of seafood products are energy-intensive activities, emitting more pollutants than the corresponding processes for comparable agricultural food products. *Sustainable fisheries* means (a) maintaining the potential of fisheries resources to meet the reasonably foreseeable needs of future generations; (b) avoiding, remedying or mitigating any adverse effects of fishing on the aquatic environment. Utilisation means conserving, using, enhancing, and developing fisheries resources to enable people to provide for their social, economic and cultural well being. The basic objectives of sustainable fisheries are a) Sustainable exploitation of fish stocks–status and perspectives for improvement keeping in view the reproductive/stock regeneration capabilities b) Conservation of the environment c) Efficient utilisation of input factors (bio-mass, energy, capital and manpower) d) Food safety and quality e) Maximising output of limited catch quotas f) Integrated approaches to fisheries regulation f) Environmental impacts of fisheries technology g) Innovative approaches to technology development h) Innovations aimed at improving sustainability in the capture, processing and transportation of fish and fish products I) enhancement of fisheries both inland and marine by both intensive and extensive culture with proper environmental safeguard.

Besides above the up gradation of the Fishing Vessel Technology such as i) Need for technology change and fleet restructuration ii) Design methodology for sustainability iii) Energy efficiency and environmental impact iv) Innovations in fishing vessel design v) Gear and catch handling systems vi) Refrigeration systems for reduced environmental impact (ozone depletion and global warming) vii) Preservation and improved utilisation of catch viii) Monitoring and control of gear and vessel performance. The Fishing Gear Technology includes selective fishing gear, methods and selectivity; impact on nontargeted biomass; catch quality aspects of fishing gear and methods and lastly fishing gear technology for new species. In addition to the above, fish processing technology and distribution is to include technology for improved utilization, quality and food safety throughout the value chain, environmental impact of processing and distribution, and refrigeration systems for reduced environmental impact.

Ensuring ecologically sustainable fisheries in the coming years will require considerable and continuing effort by all stakeholders. Besides, cooperation and support of all stakeholders and working together to improve fisheries management will be able to continue to yield fish - and economic and social benefits - for the betterment of the community.

## **II. ECOSYSTEM APPROACH**

The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Application of the ecosystem approach will help to reach a balance of the three objectives of the Convention on Biological Diversity (CBD). These objectives are :

- Conservation of biological diversity,
- Sustainable use of its components, and
- Fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

Ecosystem approach is based on the recognition that conservation of species and species diversity cannot be considered without taking into consideration the essential processes, functions and interactions among organisms and their environment. It also recognises that humans, with their cultural diversity, are an integral component of ecosystems.

## **III. NATURAL RESOURCE USE & MANAGEMENT PROGRAMMES**

### **a. Natural Resources Inventorisation Programme**

Provides and develop the natural resource and biological bases, reference collections, gene banks, technologies and services required by Government in the execution of its regulatory, developmental and protection functions and in meeting its obligations in terms of national, international agreements and conventions. It also delivers related services to other public organisations and individuals through various departments of the Ministry of Environment & Forests for protecting the natural environment; Bureau of Fish Genetic

resources; Bureau of Animal Genetic Resources; Bureau of Plant Genetic Resources; Agricultural Institutes for soil, water, fisheries, aquaculture and agriculture; Universities and other Non Governmental Organisations.

### **b. Natural Resources Management**

The maintenance of the productive potential of agro-ecosystems and the integrity of natural eco-systems requires that sustainable integrated research-based use, management and conservation systems to be developed and implemented. The policies and programmes are achieved through a coordinated effort of various interdepartmental agencies of Government of India and State governments. These are :

- Inventories, benchmarks and databases of soil, climate and water
- Inventories and reference collections of flora, fauna and microbial organisms
- Criteria for the optimal use of natural resources for different purposes
- Distribution of areas, density and volumes of different classes of natural resources
- Early warning of impending threats to the integrity of the natural resource base and the human activities dependent thereon (Forecasting)
- Timely implementation of preventive and remedial measures (disaster management system)

### **c. Sustainable utilisation of Resources**

The potential of natural resources is to contribute to economic development and social improvement and can be realised if location-specific sustainable utilisation systems are in place, involving optimal combinations of resources, technology and products. This is achieved through sustainable production systems and conservation of natural resources. Natural ecosystems are important from the point of view of biological diversity, rural livelihood, ecotourism and require protection in order to remain sustainable. Further the Stabilisation of ecosystems by effective countering of the negative environmental impacts imposed by agriculture, aquaculture and other impacts. Protection of human health by food security, effective control of communicable diseases, and prevention of dangerous exotic organisms are the other means of sustainable utilisation. Such programmes can be achieved through:

- Development of Safari Park
- Ranching of some game animals
- Identification of agriculture and forests pests and propagation of species effective in control of pests (Biological Control)
- Culture of edible frogs, oysters, clams and other food animals

### **d. Natural resources information systems**

In order to utilise the natural resources by Government agencies, public entities, private organisations and individuals, natural resource information should be packaged for

multiple usage and disseminated by means of appropriate communication media, electronic networks, training programmes and extension systems. These includes a well informed support system of

- Trained and well informed manpower
- Land users, general public and government decision makers
- Government functions and programmes are supported by publications, electronic networks and expert systems
- Training courses for government regulatory and other purposes

#### e. Awareness programme

An awareness programme to dispel the misconception of Talisma and Faith healing by wild animals and their products is to be undertaken. Currently many wild animals and their parts are used for very undesirable and avoidable uses as in Table.

#### Unsustainable, undesirable and avoidable uses of wild animals and their products

#### MAMMALS

Animal	Body/organ	Part used as	Purpose	Remarks
Elephant	Molar teeth	Ivory	Statues, jewellery boxes, decorative items	There are many synthetic material now available which look exactly like ivory
Rhino	Tuff of hair on nose	Horn	Oriental medicine as an aphrodisiac	No scientific ground
Tiger & Leopards	Skin, bones claws teeth	Skin, bones, claws, teeth	Skin for making coats, bones for oriental medicine, teeth and claws as talisman and faith healing	Undesirable use as clothing as many better cloths is available. Parts used in faith healings have not proven curing capabilities
Fishing cat, marbled cat, Jungle cat, Golden cat, fox	Skin	- do	For making small coats, gloves	- do
Tibetan antelope or chiru	Furry skin	Shatoosh	For making expensive cloth	- do -

Animal	Body/organ	Part used as	Purpose	Remarks
Bear	Gall bladder	Bear bile	Oriental medicine	No proven ability to cure
Musk deer	Musk gland in abdomen male	Musk	Asian medicine	- do -
Monkeys, gibbon			Used in circus, street plays, biomedical researches, pets (as food in certain parts of the country)	All are avoidable
Slow loris, slender loris			Pet trade	do-
Pangolin	Scales		As talisman	-do -
<b>BIRDS</b>				
Rose winged parakeet, Alexandrine parakeet, blossom head parakeet, Red breasted parakeet, Red munia, Spotted munia, white-winged munia,			As pets	- do -
Hornbills, flamingos, Storks, Cranes, pheasants			Zoos	Minimum numbers, Should be kept with great care
Wild ducks, geese, assorted waterfowl, Jungle fowl, partridges, quails, pheasants, doves, pigeons			As food	Totally avoidable

Animal	Body/organ	Part used as	Purpose	Remarks
Owls			Witch craft and medicine	Unfounded
Peregrine falcon, shaheen falcon, Red headed marlin			falconary	Undesirable game
Swiflets			Nests used as food	totally avoidable
<b>REPTILES</b>				
Marine turtles		Flesh/ shell  Eggs, fat skin	Flesh as food Shell for pieces of arts like boxes, ear rings, bangles, cigarette holders, spectacle frame etc, and whole shell as decorative pieces. As food Belts, purses	This can be restricted to shells of dead animals  Avoidable Avoidable
Freshwater turtles		Flesh, eggs and fat	As food	- do -
Crocodiles	Skin	skin	Fashion accessories like hand bags, wallets, boots, belts	- do -
Monitor lizard, spiny tailed lizard, snakes	Skin, Whole animals/ other body parts	Skin Whole animals/ other body parts	-do- Traditional medicine, roadside shows, venom research	-do- snake venom should be extracted judiciously, other uses are undesirable uses in traditional medicines scientifically unfounded
<b>AMPHIBIA</b>				
Different species of <i>Rana</i>	Hind leg		For food as frozen frog legs	Farming desired
<b>BUTTERFLIES</b>				
Families Papilionidae, Danaidae, Lycacnidae			As collectors items, textile designing	Avoidable

#### IV. Initiatives of Sustainable Development

##### Conservation of biodiversity

Conservation is the planned management of natural resources, to retain the natural balance, diversity and evolutionary change in the environment (Lincoln *et al.*, 1982). It is a protective measure taken a) to prevent the loss of genetic diversity of a species, b) to save a species from becoming extinct, and c) to protect an ecosystem from damage so as to promote its sustained utilisation.

The aims and objectives of species conservation programmes are :

- (a) to promote conservation of biodiversity in defined habitats and geographical areas;
- (b) to promote *in situ* conservation and sustainable management of ecosystems, natural habitats and species populations;
- (c) to establish and formulate strategies for *ex situ* conservation for the components of biodiversity through an integrated scientific research;
- (d) to study the intrinsic and extrinsic factors causing the depletion of species/populations and to formulate and adopt scientifically oriented conservation strategies;
- (e) to identify Biodiversity Conservation Regions and 'hotspot' areas (that require urgent measures) in the country for concentrated research and protection;
- (f) to promote research in traditional and ethnic knowledge areas, utilisation of natural resources, and to encourage equitable sharing of benefits arising out of utilisation of such knowledge systems;
- (g) to promote research on wild relatives, land races and cultivars of cultivated species;
- (h) to maintain database systems on economically important groups of plant and animal species as a source information on them;
- (i) to evolve guidelines for the management of protected areas so as to enable the policy makers and managers to take effective measures to conserve biodiversity and species; and
- (j) to disseminate information on the importance of conservation and sustainable utilisation of biodiversity, through popular and scientific publications and other educational programmes.

Since the criteria and action plans differ very widely, often within the country, depending upon the needs of a specific situation, no uniform approach is practicable. Several programmes on Conservation has been initiated by Government of India *viz.*,

- Conservation and sustainable utilisation medicinal plants
- Involvement of Industries in the conservation and sustainable utilisation of biological diversity

- Conservation of coastal and marine biodiversity
- Environmental Information System (ENVIS)
- Setting up of National Bioresources Board
- Document by MoEF on “Conservation of Biological Diversity–An Approach” to disseminate and share the Indian experience on conservation and sustainable management of Biological diversity with International Community
- **Ex-situ conservation** : This is an important point of view in terms of conservation of genetic resources employed in the country. National Bureau of Plant genetic resources, Indian National Gene Bank are some of the methods of conservation of plant resources. Similarly, National Bureau of Animal Genetic Resources, National Bureau of Fish Genetic Resources are the institutes to collect the indigenous germplasm for maintenance, distribution and exchange of genetic material in the country. Establishment of Botanical and Zoological gardens is also a method for the conservation of Resources.

## **ANATOMY OF ENVIRONMENT AND BIODIVERSITY—AN EXPOSITION IN OUTLINE FOR ANIMATING ENVIRONMENTAL AWARENESS**

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### **INTRODUCTION**

ENVIRONMENT, ECOLOGY AND BIODIVERSITY are the buzz words of recent times. Nearly some decades back very few persons, excepting some conscientious environmentalists, farsighted philosophers, apprehensive futurologists and ardent humanists, bothered for environment. But as a result of mass scale ecodegradation which is threatening the very existence of man and biosphere, we have not only become concerned but also scared about undesirable changes in the quality of our environment. A small book entitled, "Silent Spring" written by Rachel Carson in 1962 did a big job by creating mass awareness at the global level about the vulnerability of environment caused by persistent pesticides. A decade after, the first UN Conference on the Human Environment was held in Stockholm in 1972 which brought global environmental issues into limelight. Subsequently, in 1992 United Nations Conference on Environment and Development (UNCED) was held at Rio, Brazil which gave a clarion call for the conservation of environment. Again in 2002 (26th August to 4th September) World Summit on Sustainable Development was held in Johannesburg, South Africa, to discuss environmental problems and the problems of development. However, let me now explain and interpret environment and ecology in an alternative perspective in my own humble way.

The UNCED document comprises following five separate agreements : (1) The Framework Convention on Climate Change, (2) The Convention on Biological Diversity, (3) The Rio Declaration, (4) The Forest Principle, (5) Agenda 21.

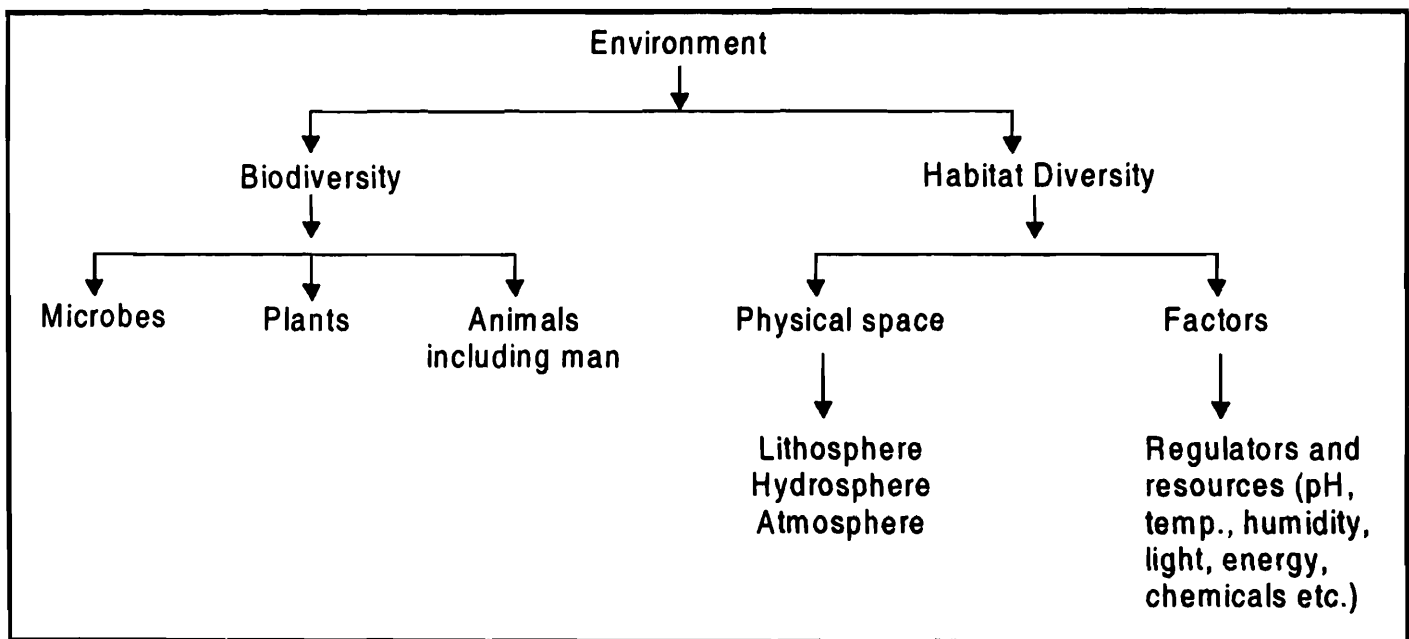
### **ANATOMY OF ENVIRONMENT**

**Environment Defined** (*Fr. environner-environ, around-virer, to turn round*) : Environment, according to common man's perception, means just surroundings—a nontechnical word,

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which does not communicate the depth and dimension of the term in a technical sense. Precisely speaking, an organism's environment consists of all those elements, factors and forces external to the organism that enter its reaction systems or otherwise directly affect its maintenance, growth, reproductive and other functions. From ecological standpoint, environment as hereby conceived, comprises two discrete and distinct components : (a) Habitat diversity (abiotic part) and (b) Biodiversity (the biotic part). Habitat diversity includes the physical space of all kinds (e.g. lithosphere, hydrosphere and atmosphere) and the factors (e.g. temperature, light, pH, humidity, energy, chemicals etc.) which regulate the ecosystem processes. Biodiversity encompasses all organisms from microbes to man.



### Biodiversity Defined

Biodiversity is one of the most important catchphrases of the third millennium. In 1980 Norse and McManus first defined "biological diversity" which essentially combines genetic diversity (the amount of genetic variability within species) and ecological diversity (the number of species in a community). However, it is now known that the abbreviated form "biodiversity" was probably coined by Walter G. Rosen in 1985 for the first planning meeting of the National Forum on Biodiversity held in Washington DC in 1986 (Heywood, 1995). The concept of biodiversity has attracted the apt attention of the scientists of different disciplines, environmentalists in particular, after the outstanding publication of Wilson and Peters (1988). The debate and discussion on biodiversity reached the climax during the Convention on Biological Diversity (CBD) at the United Nations Conference on Environment and Development (UNCED) held in June, 1992 at Rio de Janeiro, Brazil. The convention on biological diversity came into force on 29 December, 1993. The Convention was also duly conscious of the colossal loss of biodiversity on one hand, and on the other, realized the ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic values of biodiversity.

According to CBD Biological Diversity "means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and

the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems” The above narration of biodiversity seems to be complex and therefore needs simplification. Although there are quite a good number of definitions of biodiversity but in a very general way it may be interpreted as the totality of diverse kinds of biota including all conceivable varieties from micro to macro level. It is now evident that from etymological perspective biodiversity should obligatorily include only biota neither habitat, which is a nonliving entity, nor ecosystem.

In this context the term biosphere (or ecosphere) may be explained. Because along with biodiversity, biosphere has also now become a common vocabulary. Biosphere may be defined as the berth (in the sense of a place to live) on the planet earth where biota of various kinds occur and their life processes take place. Its total thickness is less than 10 miles.

**Ecology Defined :** Ecology is rapidly emerging as an exciting and indispensable discipline in recent years. Although ecology is as old as biology but for reasons unknown its progress has been tardy. Probably *Hanns Reiter* first combined the Greek words *oikos* meaning “home”, and *logos* “the study of” to form the term ecology in 1865 (Kormondy, 2000). A year later in 1866, Ernst Haeckel also used the term ecology. In 1870, Haeckel precisely defined ecology as stated below :

“By ecology we mean the body of knowledge concerning the economy of nature—the investigation of the total relations of the animal both to its inorganic and to its organic environment, including above all, its friendly and inimical relation with those animals and plants with which it comes directly or indirectly into contact - in a word, ecology is the study of all the complex interrelations referred to by Darwin as the conditions of the struggle for existence”

With the above self explanatory definition in the background, ecology started to grow steadily. In this context some more terms tangential to ecology may be mentioned. French zoologist Isidore Geoffroy St. Hilaire introduced the term ethology for the “study of the relations of the organisms within the family and society in the aggregate and in the community” St. George Jackson Mivart coined the term hexicology to depict the study of the relations existing between the organisms and their environment and also the relations among the organisms themselves. Sociology is also akin to ecology which according to Kendeigh (1975) encompasses the ecology and ethology of mankind. By their own merits both ethology and sociology are now developed as distinct disciplines.

Modern ecology by and large is a product of the last four decades. Ecology has now gained a rank of synthetic science, multidisciplinary in nature and boundless in its concern due to immense input from various areas of human knowledge. Although basically ecology is biological in its marrow but it has now become a social science, a basic component of liberal education for commoner to elite (Datta, 1990). Southwick (1976) made a very revealing statement that deserves due consideration. He states, “Rarely has an academic subject become such a major issue in the public consciousness as ecology in the late 1960s and early 1970s. Within a few years ecology progressed from a rather quiet and obscure

branch of biology to a subject of national and international concern. Education, business, politics, law, agriculture, engineering, medicine, public health and even international affairs were all affected by the sudden upsurge of ecological and environmental concern." In accordance with the above argument a comprehensive and a radical definition of ecology in keeping with the modern trends of the subject is the need of the time. Datta (1990) defined ecology as "a branch of science or rather a discipline of human knowledge dealing with the strategies of survival of man and biosphere in space and time." Interestingly, it may be noted that both 'economics' and 'ecology' are derived from the same Greek root '*oikos*' meaning home. According to E.P. Odum (1971) economics deals with financial housekeeping and ecology with environmental housekeeping. Furthermore, he also significantly mentioned following H.T. Odum (1971) that energy can be thought of as the "currency" of ecology as "money" in economics. Of course, it is well known that money circulates whereas the flow of energy is unidirectional.

**Ecosystem and Noosystem—Two Pragmatic Philosophical Concepts in Ecology :** An introspection of ecological knowledge explicitly reveals that ecological science has been lacking a unifying concept - a holistic approach to the problems of man and his environment. With the enunciation of ecosystem concept by Tansley (1935) ecologists became sufficiently enriched with a comprehensive outlook to explain and analyse all kinds of relationships between biotic and abiotic components of environment. It was realized that (a) both biotic and abiotic components are bound together in a system forming an orderly working totality through which energy cascades and matter cycles and (b) that the principles of cybernetics become applicable for the maintenance of the homeostasis or rather dynamic equilibrium of the ecosystem through the operation of positive and negative feedback mechanisms until some extraneous interference does not vitiate the natural range of limits of functioning of the ecosystem. Concomitant with the above concept, the application of 'Systems Analysis Procedure' becomes inevitable so as to delineate many intricate problems of ecosystem.

Ecosystem may now be formally defined as a conceptual scheme or an abstract doctrine where biotic and abiotic components of environment are linked interdependently demonstrating a system which facilitates the flow of energy and cycling of matter. Although, strictly speaking ecosystem is a hypothetical proposition but a particular ecosystem is a concrete one. Pond ecosystem, grassland ecosystem and forest ecosystem are few such examples. An actual ecosystem is a fundamental unit of study in ecology.

The term system also needs an explanation. System may be conceived as a set of different elements or components or compartments or units, or events or even phenomena joined in regular interaction or interdependence. Although enormous encouraging ecological studies have been done after the formulation of ecosystem concept but subsequently a serious weakness became obvious in it. The position of man and his ubiquitous role which should form the focal point of ecosystem, were either overlooked or ignored as if man is not a part of nature but apart from it. In order to obviate this critical drawback a new philosophical outlook termed 'Noosystem' concept has been propounded. According to Barrett (1985) 'Noosystem' concept is preferable to ecosystem

as a fundamental unit of study for integrating biological, physical and socioeconomic parameters within a framework of holism. He unambiguously emphasized that on one hand, ecologists very often study ecosystems with scant regards to human impacts in such a system and on the other, the decision makers very frequently make judgements that are not based on the prudent principles of ecology. Thus, ecologists remain oblivious to human role and the decision makers turn their back to ecological principles. As a result, after implementation of many developmental plans serious ecological backlashes occur inevitably causing unprecedented ecological crisis. In many instances it becomes too late to adopt compensatory or restorative measures and sometimes the backlashes are irreversible. The large scale developmental plans like the reversing of the natural flow or linking of the rivers, building of high dams etc. may bring short term gain but very often incur long term loss. The developmental plans should be such that these should bring greatest good for the greatest numbers for a longer time. Applied ecology could thus be an integrative paradigm for unifying basic sciences with social sciences and the noosystem concept advocates this maxim.

**Emergence of Environmental Science :** Recently Environmental Science is emanating as a compulsory course of study at various levels of our educational system. In this context following few questions may be posed: Is it altogether a new species of science? Or, is it a new name of old ecology? [Old wine in a new bottle! Or, both wine and bottle are new!] It is rather difficult to give the final verdict. Of course, Ecology and Environmental Science are not mutually exclusive and obviously have maximum contents in common. However, it is evident that Environmental Science virtually vivifies the message of Noosystem.

**Deep Ecology :** In recent years many new ecoethical ideas are emerging and deep ecology is one such concept. The germ of the concept of deep ecology may be found in the writings of Nathaniel Shaler (1905) who emphasized the "need for the development of a new ethical relationship with the natural world that would protect the Earth and all its creatures, including man" The living creation is far from being man-centered and it is rather biocentric and is emphasized that man should refrain from "claiming gross superiority over the rest of the natural world"

However, the term deep ecology owes its origin from the writings of Norwegian philosopher, Arnie Naess (1972) who stated that shallow ecology is concerned with apparent environmental problems like pollution, soil erosion, cultural eutrophication, resource depletion etc. Deep ecology, on the other hand, deals with deeper roots of ecological problems and proclaims that the richness and diversity of all life on earth has intrinsic value and all life on earth have the exclusive right to exist regardless of its utility for human purposes. Naess also visualized a deeper concern of ecology with the structure and purposes of the society which is tangential to the "principles of diversity, complexity, autonomy, decentralization, symbiosis, egalitarianism and classlessness" Despite deep ecology emphasizes the protection, preservation and restoration of environment in its totality which is although a noble task of human kind but it fails to address the socio-economic and political problems of environment of the present day consumer society.

In my opinion obstinate anthropocentric attitude, ruthless egocentric behaviour and all-out oligarchic temperament of man are the root causes of present day ecological crisis. In addition to these, the exponential growth of human population coupled with over consumption of matter and energy by the developed countries is adding fuel to the fire. Therefore, a compatible synthesis of the ecoethical concepts which will establish the balance among preservation, population growth and utilization of natural resources in the sustainable manner, is the need of the time.

**Bioinformatics vis-a-vis Ecoinformatics** : Recent years have experienced an explosion of information in various fields of studies. Since biological information generated all over the world are so huge and since conventional file keeping is almost redundant, an altogether new discipline called "Bioinformatics" has been developed. Bioinformatics is interdisciplinary and spans over a range of subjects like biology, biophysics, biotechnology, biochemistry, computer science, information technology, molecular biology, mathematics and statistics. The principal purpose of bioinformatics is to deal with all the subjects of biological information like acquisition, processing, storage, distribution, analysis and interpretation. In keeping with the above contention, an altogether new term, Ecoinformatics has already been proposed to deal with the voluminous data generated in the field of ecology and environmental science (Datta, 2003). It is expected that ecoinformatics will develop in a big way to analyze and interpret ecological data in a meaningful manner as bioinformatics has done in biology in general.

### **WORLD CONSERVATION STRATEGY (IUCN, WWF AND UNEP)**

World conservation strategy includes three maxims: (i) Maintenance of essential ecological processes, (ii) Preservation of genetic diversity and (iii) Sustainable utilization of species and ecosystems.

From economic standpoint, environment is our asset or capital. Virtually environmental resources are economic resources which form the basis of economic growth and development. Solar energy, the driving force of our planetary ecosystem, is received from the sun. All other raw materials such as food, fodder, fuel, fossil fuel, minerals, medicines, oxygen, are obtained from environment. Not only for survival but also for our very existence we are totally dependent on congenial environment which maintains the life support system. Therefore, conservation of nature in its totality is our obligation for our own well being.

A succinct definition of conservation is proposed here :

Conservation may be defined as an enterprise or a concept or rather a philosophy which unequivocally aims to protect, preserve and perpetuate natural resources in a sustainable manner for the use and appreciation of the posterity.

**Epilogue** : It is now understood that man is totally dependent on environment not only for his survival but also for his continuance. In order to maintain the sustainability of clean environment I suggested the following set of ten golden rules which has already

been christened as New "Ten Commandments" (Datta, 1990). Ten Commandments are the ten laws which were given by God to Moses on Mt. Sinai.

1. Man's place and role in nature should be re-examined.
2. Man should refrain from making large scale transformation of environment without proper environmental impact analysis.
3. Man as a part of Earth Watch Programme should ensure that the fate of the "global commons" does not end in the "tragedy of the commons"
4. A balance between population growth and resource utilization should be established.
5. The gap between the rich and poor, between the developed and developing, as well as between the developed and underdeveloped countries should be narrowed.
6. Equitable distribution of resources to all for rightful use should be allowed and needful conservation of vital resources should be practised.
7. Essential ecological processes should be allowed to continue in time and space without any impediment.
8. Abuse and misuse of resources should be avoided and wastes should be recycled as far as practicable.
9. Man will have to develop a profound respect for nature.
10. Man should remain altruistic.

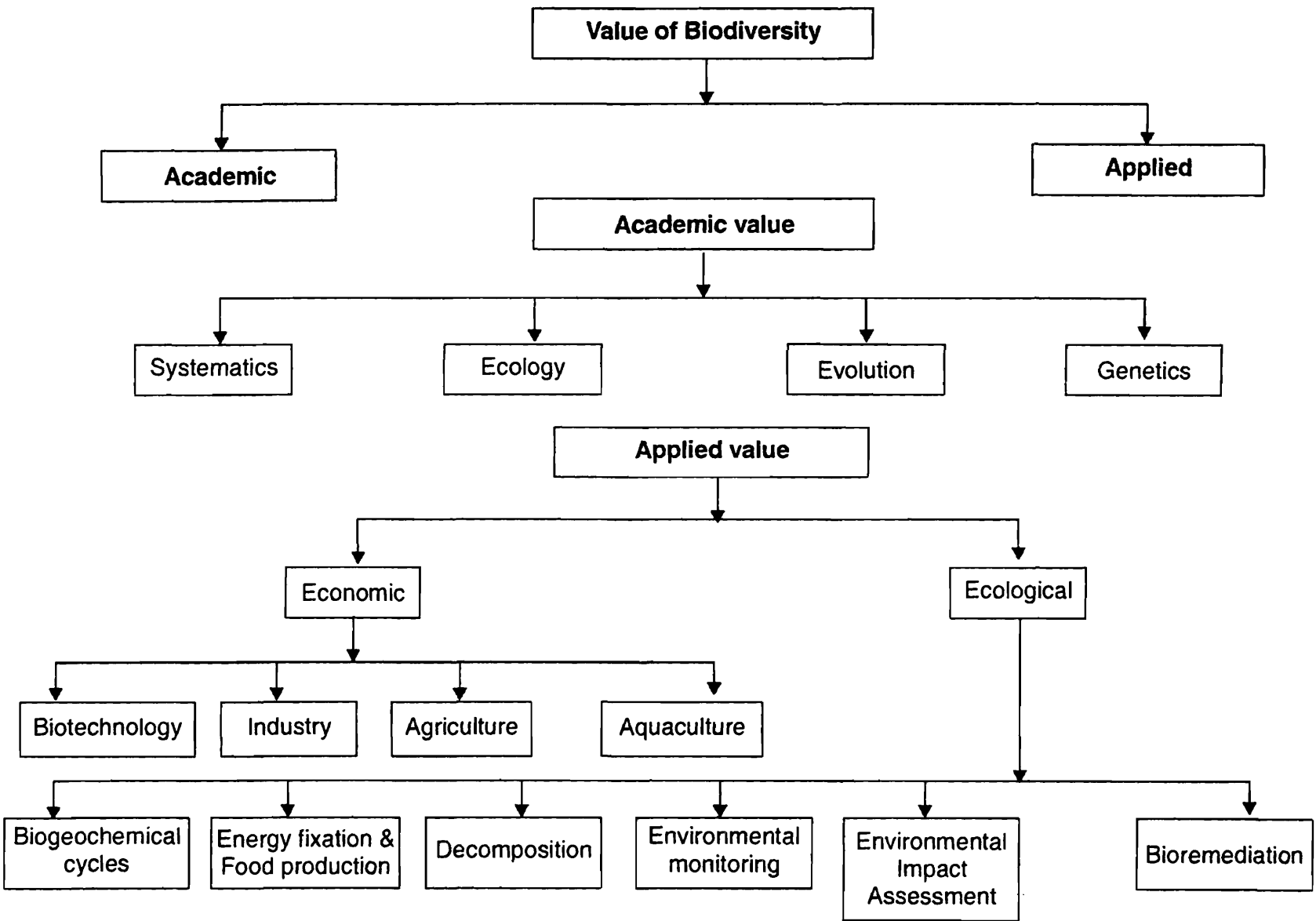
In recent years the question of maintenance of desirable quality of environment, conservation of natural resources and sustainable development have received priority over other issues of human society. In many national and international conclaves environmental issues have become an almost obligatory agenda of vibrant sociopolitical encounter. Colossal conflict of interests with regard to global warming, emission of green house gases, ozone layer depletion, loss of biodiversity, acid rain, overuse of plastic and other synthetic materials (which are non-biodegradable), discharge of hazardous wastes of all kinds is in constant succession.

### **Key to survival of man and biosphere**

However, in conclusion it may be said that excepting TIME nothing appears to be eternal. It is apprehended that not only the planet earth with its bounteous biodiversity but also the incandescent sun, which is supplying us essential energy to run the ecosystem dynamo, will not survive for aeon. But it may be presumed that if we accept the New "Ten Commandments" as outlined above in principle and if we religiously practise the same the doomsday of our civilization will be delayed at least for trillion years, if not more.

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**Appendix-2****Crux of The Convention on Biological Diversity**

(Source : Kalpavriksh, 1994)

1. Develop strategies for biodiversity conservation and sustainable use, and incorporate biodiversity issues into national plans, programmes and policies.
2. Identify and monitor important biodiversity components, and activities which have negative effects on them.
3. Establish protected areas and other means of conserving biodiversity in-situ (i.e. in natural habitats, and in the case of agricultural species, in areas where they have been developed). This includes action against any factors destroying biodiversity, restoration of habitats and species, and control of alien species.
4. Adopt measures for ex-situ conservation, i.e. outside natural habitats (e.g. gene banks).
5. Take measures to respect and protect the knowledge and skills of traditional communities, and to equitably share with them the benefits that accrue to larger society from the use of these knowledge and skills.
6. Adopt economic and social incentives for conservation.
7. Encourage relevant research, education, and training.
8. Incorporation of biodiversity concerns into environmental impact assessment procedures, with public participation.
9. Provide access to genetic resources, subject to the sovereign rights of each country over its biodiversity. Such access is to be on mutually agreed terms, with prior informed consent of the country providing it and with a commitment on the country taking it to share in the benefits of utilizing the resource thus provided.
10. Provide access to relevant technologies (including biotechnologies) on "fair and most favourable terms" This is subject to "effective protection of intellectual property rights" (IPRs), though such IPRs may not be imposed if they are against the Convention's objectives. Countries are also to facilitate transfer of technologies developed by the private sector.
11. Consider an international protocol on the safe transfer, handling, and use of genetically modified organisms resulting from biotechnology.
12. Contribute to a fund (applicable especially to "developed" countries) for use by "developing" countries for biodiversity conservation. Such a fund is to "operate within a democratic and transparent system of governance", and "function under the authority" of the Conference of Parties.
13. Ensure that the exercise of rights and obligations under other international treaties does not cause destruction to biodiversity.
14. Authorise the creation of a Scientific and Technical Advisory Committee, for the purposes of guiding the development of the Convention.
15. Agree to resolve international disputes on biodiversity in accordance with rules and procedures laid down in the Convention and its Annexes.

*Appendix-3*

**A Calendar of Events regarding Global Awareness  
about Environment (1948-2002)  
(Compiled by Prof. N.C. Datta)**

- 1948. UN Charter : International Union for the Protection of Nature (IUPN) established.
- 1956. Man's role in changing the face of the Earth. An international symposium held at Chicago, U.S.A.
- 1957. The IUPN becomes the International Union for the Conservation of Nature and Natural Resources (IUCN).
- 1958. Law of the Sea. The first UN Conference on the Law of the Sea (UNCLOS) approves the draft convention.
- 1959. Antarctic Treaty signed.
- 1961. Establishment of World Wildlife Fund (Worldwide Fund for Nature).
- 1962. 'Silent Spring' by Rachel Carson published.
- 1963. International council of Scientific Unions (ICSU) established the International Biological Program (IBP).
- 1966. IUCN Red Data Book first published.
- 1968. UNESCO 'Biosphere' conference.
- 1969. Friends of the Earth (FOE) founded.
- 1970. The US National Environmental Policy Act (NEPA) requires preparation of Environmental Impact Assessment (EIA).
- 1971. Man and the Biosphere Program (MAB) of UNESCO launched. Greenpeace International founded.
- 1972. UN Stockholm Conference on the Human Environment. Concept of a Global Environmental Monitoring System (GEMS) endorsed by the Stockholm Conference. United Nations Environmental Program (UNEP) established. 'Blueprint for Survival' sponsored by the Journal Ecologist. Limits to Growth published (Club of Rome Report).
- 1974. UNEP Regional Seas Program initiated.
- 1975. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).
- 1976. The Scientific Committee on Problems of Environment (SCOPE) reports to the International Council of Scientific Unions (ICSU) on global trends in the Biosphere most urgently requiring international and interdisciplinary scientific effort.

1979. UN Conference on Desertification. World Climate Conference Organized by the World Meteorological Organization recognizes the 'Greenhouse effect'
1980. World Conservation strategy (IUCN) launched. IUCN Conservation Monitoring Centre (now the World Conservation Centre) established. The global 2000 report forwarded to the US President Carter.
1982. UN Nairobi Conference held ten years after the Stockholm Conference. World Charter for Nature adopted by UN. The World Environment 1972-1982 published. The World Commission on Environment and Development (WCED) established.
1984. The Resourceful Earth. A response to Global 2000 is published.
1985. Vienna Convention for the protection of the ozone layer.
1987. 'Our Common Future' published (WCED). Montreal Protocol on substances that deplete the ozone layer.
1988. Oslo Conference on Sustainable Development—to get away from the tyranny of the immediate.
1989. The 'Green Summit' in Paris of G7 (Canada, USA, France, Italy, Japan, UK and West Germany). Urgent need to safeguard the environment is emphasized. IUCN published 'From Strategy to Action' a response to Our Common Future. Saving the Ozone Conference in London. Basle Treaty on International Transport and Disposal of Hazardous Wastes. Non-aligned Movement (NAM) conference at Belgrade. Proposal for Planet Protection Fund mooted. Langkawi (Kualalampur) declaration on environment. Hague declaration on ozone depletion and global warming.
1990. Tokyo Conference—a youth perspective on Sustainable Development. The role of economics and education.
1992. Rio Conference (UNCED) Major environmental issues discussed are : Deforestation, Biodiversity loss, Climate change, Marine and Coastal Zone, Law of the Atmosphere Ozone layer depletion and Agenda 21. The Agenda 21 is intended to set an international programme of action for achieving sustainable development in the 21st century.
1997. Kyoto Conference on global warming (Kyoto Protocol signed).
2002. World Summit on Sustainable Development (26th August to 4th September, 2002) Johannesburg, South Africa.

(Major events are mentioned)

## **BIOLOGICAL MONITORING FOR ASSESSMENT OF ENVIRONMENTAL IMPACT WITH SPECIAL REFERENCE TO FLORA AND FAUNA**

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### **INTRODUCTION**

Environmental Impact Assessment (EIA) is a formalized procedure for evaluation of impact of any developmental project on human welfare or local environment. The impact may be beneficial or harmful to mankind or other biological species. The impact may also be immediate or delayed kinds. EIA is imposed as a part of legal compulsion with respect to Environment (Protection) Act 1986 in India.

Understanding of baseline environmental condition with respect to physical, biological and socio-cultural environment in each proposed project site is highly essential. One has to evaluate the fact that how particular developmental project will affect the above environment. Biological monitoring is such environmental quality assessment part.

Biological monitoring (Ecological survey) is one of the prime activities in EIA process. It is very complex and needs several specialists to record data and also to interpret the same information. The study of forests, vegetation composition, faunal distribution, wildlife habitat evaluation, aquatic flora and faunal assessment, economic valuation of flora and fauna, assessment of endemic, endangered and rare flora and fauna etc. are need to be evaluated through intensive field visit.

### **BIOLOGICAL MONITORING**

In a conventional EIA activity the following ecological parameters were consider per routine monitoring purpose :

- Assessment of present status of forest/flora/fauna from the field survey and previous literature if any;
- Assessment of quantitative aspects of biological resources in terrestrial and aquatic habitats through field sampling and laboratory analysis;
- Identification of endemic, rare and endangered species of plants and animals;

- Assessment of wildlife habitat status including wildlife migration pattern;
- Assessment of aquatic ecology through field sampling and laboratory analysis;
- Analysis of impact of proposed project on ecology and biological components;
- Formulation of recommendation/mitigatory options with respect to protection and conservation measures.

Biological monitoring and survey techniques vary widely with respect to parameters which need to be investigated. The prime objectives of this programme are stated below :

1. Initially rapid qualitative assessment (checklist) is to be prepared, followed by population study of each species and food chain analysis.
2. There are cases when mapping of sensitive species distribution or biochemical monitoring may also be undertaken.

A number of biological variables and processes used in monitoring and surveillance of Environmental quality determination are given below :

#### **Variables**

- |   |   |
|---|---|
| ★ Biomass   | ★ Population density                            |
| ★ Area of cover or percentage Cover                   | ★ Relative abundance of predators and prey      |
| ★ Production  | ★ Tropic position                               |
| ★ Amount of dead material, litter                     | ★ Population age class distribution             |
| ★ Vegetation structure                                | ★ Diameter (of trees) at breast height          |
| ★ Lichenometric studies                               | ★ Birth, recruitment and death rates            |
| ★ Species lists (species composition)                 | ★ Size  |
| ★ Species richness                                    | ★ Growth rates                                  |
| ★ Species diversity                                   | ★ Reproductive state                            |
| ★ Species frequency                                   | ★ Number in reproductive condition              |
| ★ Proportion of all samples in which a species occurs | ★ Plants in flower                              |
| ★ Occurrence of indicator species                     | ★ Size of breeding colony                       |
| ★ Occurrence of rare species                          | ★ Chemical content of living and dead material. |
| ★ Phenology of selected species                       | ★ Soil structure and composition.               |
| ★ Spatial patterns of distribution                    |   |

In addition, in most of the projects where project site is located adjacent to the forest or sensitive location, the Wildlife habitat evaluation is one of the major aspects to be considered. There are four major criteria of Wildlife habitat evaluation :

- (a) Food availability
- (b) Corridor analysis
- (c) Threat evaluation
- (d) Grazing pressure

### **ECOLOGICAL IMPACT MONITORING (POST PROJECT)**

There are couple of situation where post project ecological monitoring is also essential. This monitoring programme have the following steps :

#### **A. Qualitative analysis**

- i. Listing of indicator species and their distribution mapping
- ii. Impact symptom analysis

#### **B. Quantitative analysis**

- i. Lesion or damage assessment

### **POLLUTION MANAGEMENT BY GREEN BELT (GB) DEVELOPMENT**

Green belt-development envisages the multiplicity of objectives encompassing the micro-level air pollutant abatement to enhancement of socio-economic value of the region. The prime objectives of GB is attenuation of air and noise pollution. It comes to the immediate resource during accidental release/exploitation minimizing the risk to quite a considerable level. GB can also serve as a measure for soil protection for erosion losses, enhance the aesthetic value and beautify the landscapes. GB also improve the soil quality of degraded landscape. Development of GB can help generate the employment avenues and thus involve the mass participation in environmental protection activity.

### **SPECIES CHOICE FOR GREENBELT**

A good number of plants were now screened out for their tolerance efficiency to various air pollutants. These plants can be used for green belt development.

**Table :** Resistant/tolerant plant species as a function of pollutants for green belt development. (after Rao, 1981 Ahammed *et al.*, 1991 and Bhattacharya, 1994).

Suspended particulate matter (SPM)	Sulphur dioxide (SO <sub>2</sub> )	Oxide of nitrogen (NO <sub>2</sub> )	Fluorides	Ozone (O <sub>3</sub> )	Hydrogen sulphide (H <sub>2</sub> S)	Perody acetyl nitrate (PAN)
Accianilotica	Abies grandis	Abies grandis	Ailanthusaltissima	Acer negunda	Carissa carandes	Acer negunda
Achyranthes aspera	Acacia nilotica	Acacia nilotica	Atlanthus excelsa	Acer platanoides	Malus pumila	Acer platanoides
Aegle mormelos	Acer soccharinum	Aegle mormelos	Althaea officinalis	Gladiolus sp.	Malva parviflora	Quercus palustris
Ailanthus excelsa	Acer platanoids	Albissia lebbek	Betula pendula	Quercus rubra	Prunus persica	Quercus rubra
Albizzia lebbek	Aegle marmelos	Ailanthus excelsa	Crdrus deodara		Prunus serortina	
Alstonia macrophylla	Ailanthus excelsa	Alstonia macrophylla	Diospyros vlriginlana			
Alstonia scholaris	Albizzia lebbek	Alstonia scholaris	Fraxinus velutins			
Alnus viridus	Alstonia macrophylla	Anthocephalus cadamba	Gleditschia tricanthos			
Amaranthus graecizans	Alstonia scholaris	Artocarpus heterophyllus	Juniperus sp.			
Artocarpus heterophylla	Anthocephalus cadamba	Azadirachta indica	Paulownia sp.			
Azadirachta indica	Artocarpus heterophyllus	Butea monosperma	Picea glauca			
Bougainuillea sp.	Azadirachta indica	Carissa carandes	Platanus accrifolia			
Braya purpurascens	Butea monosperma	Casuarina equisetifolia	Prunus cerasifera			
Butea frondosa	Casuarina equisetifolia	Citrus medica	Prunus serrata			
Calotropis procera	Citrus medica	Dalbergia sissoo	Pyrus communis			
Calotropis gigantea	Citus sinensis	Delonix regia	Sorbus acuparia			
Cossia sopheru	Delonix regia	Diospyros melanoxylon	Tilia americana			
Cossia siamea	Dalbergia sissoo	Emblica officinalis	Ulmus americana			
Casuarina equisetifolia	Diospyros melanoxylon	Eucalyptus citriodora				

Suspended particulate matter (SPM)	Sulphur dioxide (SO <sub>2</sub> )	Oxide of nitrogen (NO <sub>2</sub> )	Fluorides	Ozone (O <sub>3</sub> )	Hydrogen sulphide (H <sub>2</sub> S)	Perody acetyl nitrate (PAN)
Citrus medica	Emblica officinalis	Fagus orientalis				
Clerodendron infortunatum	Eucalyptus citriodora	Ficus benghalensis				
Contia obliqua	Eucalyptus globulus	Ficus infectoria				
Croton sparsiflorus	Ficus benghalensis	Ficus religiosa				
Dalbergia sissoo	Ficus infectoria	Holoptelia integrifolia				
Diospyros melanoxylon	Ficus religiosa	Lagerstroemia indica				
Eucalyptus citriodora	Largerstroemia indica	Leucaena macrophylla				
Eucalyptus citriodora	Largerstroemia flosreginae	Madhuca indica				
Ficus benghalensis	Leucaena macrophylla	Mimuspos elengi				

### ECORESTORATION OF DEGRADED AREA

Revegetation with suitable species in degraded areas provides unique opportunity for ecorestoration. The proper selection of species for such ecorestoration is also equally important. A species list for such activities is given below :

#### Species Choice Eco-restoration

Sl. No.	Local Name	Scientific Name	Criteria for selection of species
1.	Jarul	Lagerstroemia flos-reginae	Fast growing evergreen, medium size tree;
2.	Katbadam	Terminalia catappa	Evergreen tall tree
3.	Chatim	Alstonia scholaris	Evergreen tall tree with dense foliage;
4.	Kadam	Anthocephalos chinensis	Evergreen tall tree with large foliage;
5.	Am	Mangifera indica	Evergreen tall tree with dense foliage;
6.	Bandarlati	Cassia fistula	Evergreen medium size tree with large leaves;
7.	Gulmohor	Delonix regia	Deciduous medium size tree with spreading cnopy.

Sl. No.	Local Name	Scientific Name	Criteria for selection of species
8.	Karanj	Pongamia pinnata	Evergreen, medium size tree with dense foliage;
9.	Arjun	Terminalia arjuna	Evergreen tall trees with shiney leaves;
10.	Bahera	Terminalia belerica	Deciduous tall trees with coriaceous leaves;
11.	Palas	Butea superba	Deciduous medium size tree with coriaceous leaves
12.	Jamun	Sizygium cumini	Evergreen tall tree with large leaves;
13.	Kanchan	Bahunia acuminata	Deciduous medium size ornamental tree;
14.	Mehagini	Swetenia mahogini	Evergreen tall tree with compact leaves;
15.	Neem	Azadiracta indica	Semievergreen tree with shiney leaves;
16.	Bat	Ficus bengalensis Ficus religiosa	Semievergreen tree with spreading canopy & compact leaves;
17.	Asatha		Semievergreen trees with shiney leaves;
18.	Kanthal	Artocarpus integrifolia	Semievergreen tree with large leaves;
19.	Akasmoni	Accacia auriculiformis	Evergreen tree with compact leaves;
20.	Gamar	Gmelina arborea	Deciduous tree with hairy leaves;
21.	Putranjiba	Putranjiba roxburghii	Evergreen tree with shiney leaves.

### CONCLUSION

The proper understanding of flora and fauna of an area both in qualitative and quantitative terms is highly essential. This requires intensive field survey and subsequent analysis of recorded informations. There are several of species which are known as indicator species of a habitat. These species need to be examined carefully for impact prediction and evaluation purpose in near future.

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## **SOME ENVIRONMENTAL ISSUES–THEIR IMPACT, LOCALLY AND GLOBALLY**

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### **INTRODUCTION**

Impact of human activities on the environment has reached a global scale. Soil matrix and water bodies have become the sinks for chemical and radiation pollutants.

Pesticides and fungicides – some are mercury based – add considerably to the chemical contamination of soil and water systems. And, the widespread use of aerosols and chlorofluorocarbons has resulted in increased incidence of UV light on the surface of the earth by depleting the ozone layer. There are atmospheric changes which ultimately influences crop-production patterns.

There are several issues related to the environment of one part of the globe, which to begin with start as a local issue/s of that part, or the country, but ultimately becomes a global phenomenon. The following are some of these issues that have been discussed :

1. Ocean, Atmosphere, rainfall and agriculture.
2. Nuclear Power and consequences of utilisation.

1. Ocean and atmosphere interacts with each other. Changes in the sea-surface temperature influence the wind pattern and the general circulation of the atmosphere causing weather and climatic variability. Easterlies (easterly trade winds) blowing over the upwelled cold water of the Equatorial Pacific chill the air above it, making it too dense to rise high enough for water vapour to condense to form clouds and rain drops. As a result this strip of ocean stays conspicuously free of clouds during normal years and the rain in the equatorial belt is largely confined to the extreme western pacific, near Indonesia. But when the easterlies weaken and retreat eastward during early stage of El Nino event, upwelling slows and the ocean temperature rises, which leads to high evaporation rate and cloud formation, causing heavy rain near equator.

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What is El Niño – This is a Spanish term meaning "the Christ Child" originally used by the fishermen of Ecuador and Peru. It refers to a warm ocean current that typically appears around Christmas time and lasts for several months. El Niño is known to have direct impact on weather over about one quarter of the earth's surface as well as inter annual variability of climate and sea-level.

While trying to predict Indian Monsoon Sir Gilbert Walker – the Chief of the Weather Service in India during the 1920's – discovered a remarkable connection between barometer reading at stations on eastern and western sides of the Pacific; when pressure rises in the east, it usually falls on the west and vice versa. Walker termed this as 'Southern Oscillation' to denote the ups and downs in the east-west seesaw in Southern Pacific barometer. 'High Index' – (strongly tilted) state, pressure high on the eastern side of the Pacific and low on the western side. When seesaw in 'Low Index' state – easterly surface winds weaken. He also noticed that seasons with low-index conditions are often marked by drought in pressure seesaw and is linked to the rainfall in the tropics. In 1960, it was Prof. Jacob Bjerknes of the University of California who saw the connection between unusually warm surface temperatures and the weak easterlies and heavy rainfall that accompany low-index conditions. The conclusion was that the warm waters of El Niño and pressure seesaw of Walker's 'Southern Oscillation' are part and parcel of the same phenomenon, referred as ENSO.

There are four distinct phases : 1. precursor, 2. onset, 3. growth, and 4. decay (Fig. 1).

**Global consequences of El Niño :** Some important consequences are :

- a) Shift in tropical rainfall
- b) Effects on the wind pattern
- c) Effects on the Monsoon hence agriculture and crop production
- d) Causes Unseasonal weather changes
- e) Impacts on climate at Temperate latitudes

Many of the years when Monsoon has been weak and there has been, in India, widespread drought, has also been El Niño years.

Climatic effects in distant parts of the Globe and El Niño is now well established (Fig. 2.a,b).

Between two El Niño's the gap period situation is known as LA-NINA.

A marked ENSO event developed in 1982-1983. This has stimulated interest in finding out whether low frequency inter-annual oscillations also occur in other world oceans. Just as there is a Southern Oscillation (SO) represented by an alternating, pattern of high and low pressures between Darwin and Tahiti, there is evidence of a similar pattern, but with an opposite sign, in the equatorial sectors of the Atlantic Ocean.

Similar to the Southern Oscillation (SO), Sir Gilbert Walker suggested a North Atlantic Oscillation (NAO). It is a temporal function of the mean zonal winds across the Atlantic Ocean. They are caused by variations in the gradient of pressure between a subpolar low over Iceland and a belt of high pressure over the Atlantic. Walker and Biss suggested an index for the NAO that is measured by the difference in pressure between the Azores and Iceland. Bjerknes related the NAO to changes in Sea Surface Temperature (SST) over the northern and tropical sectors of the Atlantic. Reports have appeared in recent years to suggest that this climatic signal has an impact on winter weather conditions over Europe.

Opinion is still divided on a possible link between the SO and the NAO. Some have expressed the view that both the oscillations were strongly correlated to each other. On the other hand, Barnett suggests that the NAO is the result of internal dynamics of the atmosphere, and is not related to the SO. It appears that the low frequency oscillations of this nature are generated by the weakening and strengthening of the equatorial trade winds. These fluctuations cause changes in SST, which measures the oceanic thermal response to wind fluctuations. This, in turn, could provide the trigger for equatorial waves in the atmosphere.

The prediction of climatic changes requires models to simulate the coupled ocean-atmosphere system. In this context, the slower response of oceans makes it the memory of what goes on aloft, i.e., over the land and atmosphere. The time scale on which the oceans adjust to changes over land and the atmosphere vary from decades to centuries. The difficulties with which one has to contend are best seen in the irregular behaviour of ENSO events. What cause the sudden changes in its variability is not yet well understood.

### **Atmospheric Circulation**

Difference in solar heat between the tropic and the polar regions, between the oceans and the land, creates the circulation of the atmosphere : the whole process is in dynamic equilibrium.

About 4,50,000 cu. km. of water evaporates from the surface of the world ocean every year. 3,00,000 cu. km. precipitates back into the ocean, remaining 1,50,000 cu. km. precipitates over the continents and feeds the rivers.

Many of the coast lines are studded with mangrove vegetation in the different pockets of the globe – we have our Sunderbans. Apart from standing against the cyclonic storms and hurricanes the mangroves are known today for their various direct and indirect benefits.

\* Mangroves are salt tolerant woody plant communities with associated fauna that occupy the tropical tidal zone. They are productive ecosystems that receive nutrients and fresh water from land and export to the sea materials that are important to near-shore shell fish and finfish populations. Estuaries may be defined as localities where river-water is incorporated into the ocean by mixing with sea water. They also serve as protective nursery areas for many marine organisms. They are very vulnerable to human induced changes in salinity and to pollutants such as oil which coat breathing roots and mud sediments.

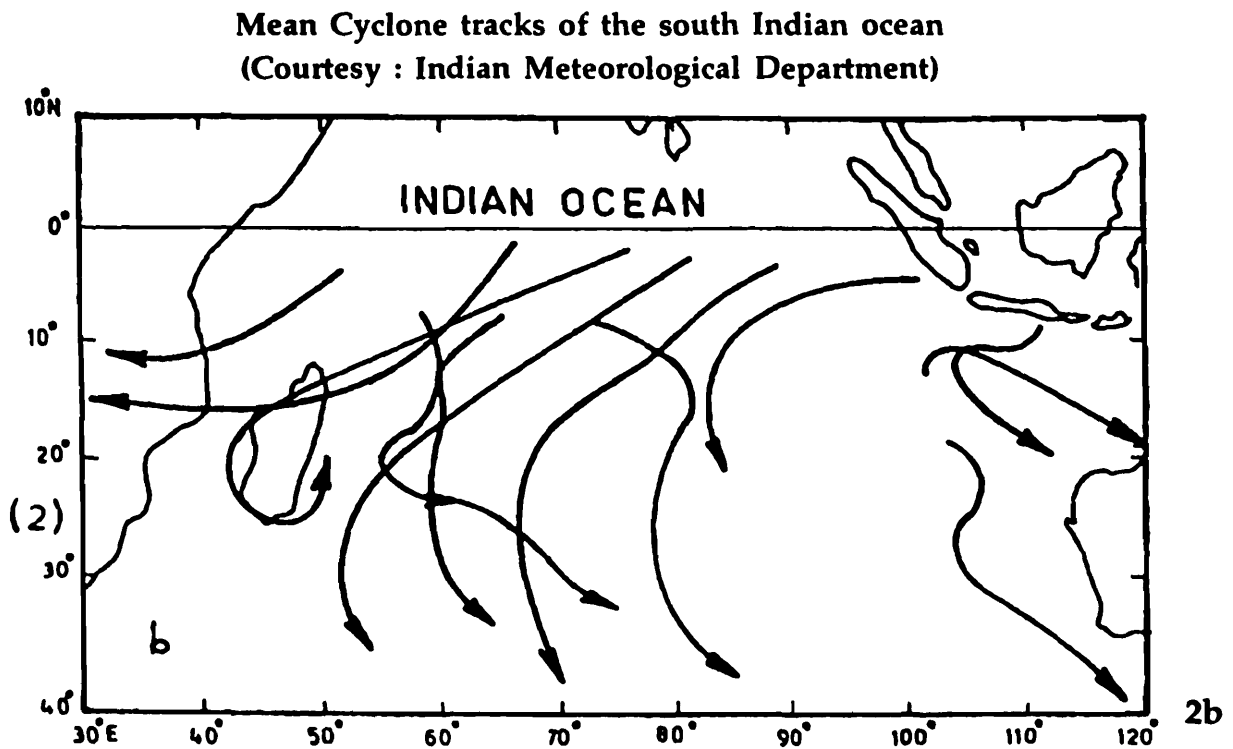
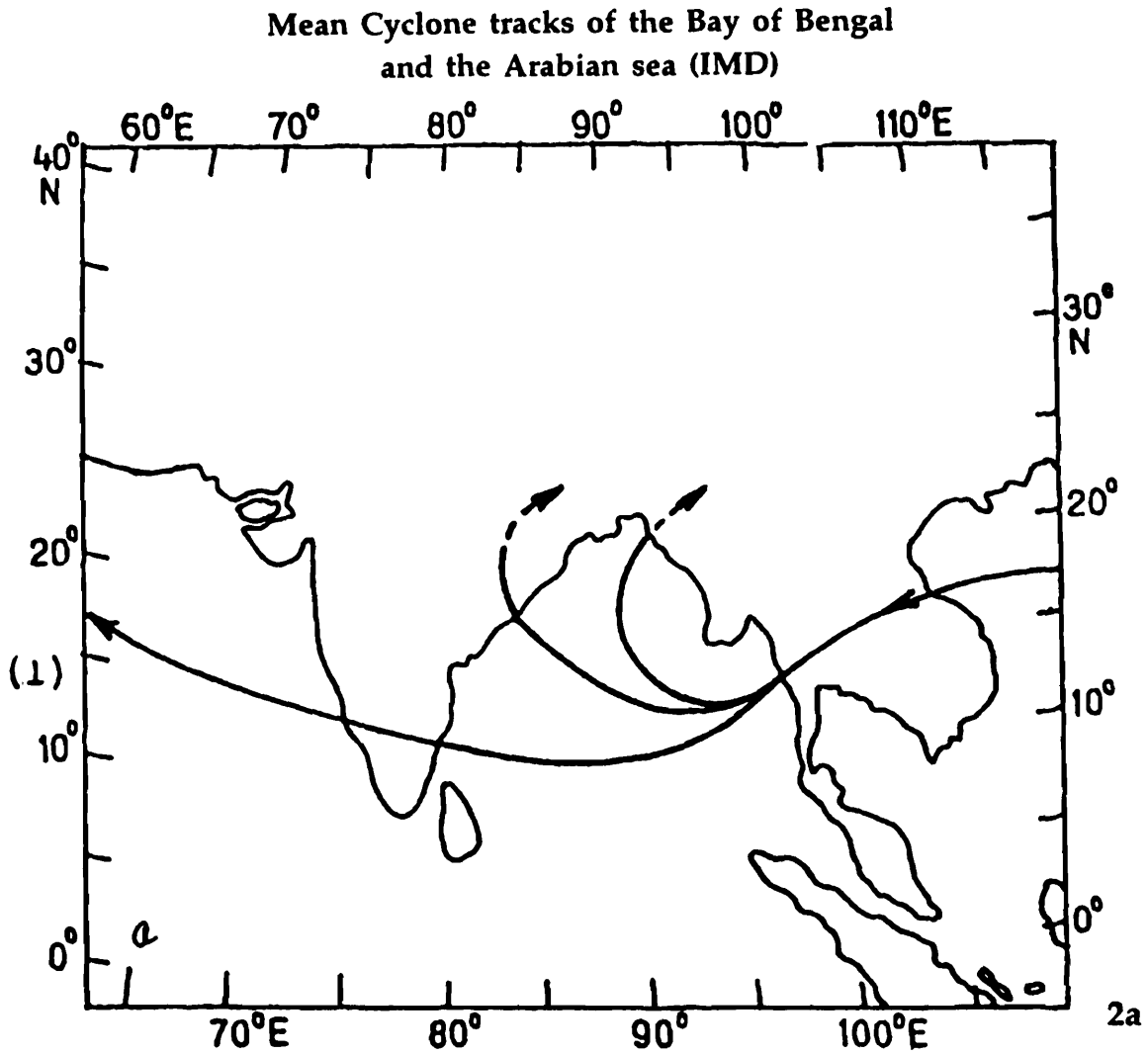


Fig-1 (a & b)

**Impacts of Sea-level rise :**

The major impacts are inundation, erosion, increased flooding and salt water intrusion. Areas that are now just over sea-level will be inundated.

A six-foot rise in sea level would flood about 20% of Bangladesh, and a similar portion of the Nile Delta in which almost all of Egypt's population resides.

The coastal wetlands would be vulnerable to a rise in sea level.

The rise also increases the salinity of ground and surface waters in coastal areas which again can cause important shifts in coastal ecosystems.

**Physical Hazards**

Physical hazards have two basic elements : geological and climatological. Western Environmental Scientists formulated two equations to explain the connection between disaster, hazard and vulnerability.

i.  $R = H + V$ , where  $R =$  risk of disaster  
 $H =$  hazard and  
 $V =$  vulnerability

ii.  $I = P \times A \times T$ , where  $I =$  impact (on environment)  
 $P =$  population  
 $A =$  affluence (consumerism)  
 and  $T =$  technology

**ENERGY**

Till 1980-s agriculture and industry together consumed about half of all the energy (in India) and the other half consumed for cooking and domestic use.

The trend at present is different, with commercial consumption increasing every year.

Our capacity to generate electricity through different methods were as follows :

- |   |   |                   |
|---|---|-------------------|
| 1. Nuclear capacity (thermal)             | – | 10,000-15,000 MW  |
| 2. Lignite                                | – | 6,570 MW          |
| 3. Major hydel capacity                   | – | 57,450 MW         |
| 4. Coal based capacity                    | – | 77,000-112,000 MW |
| 5. Small mini-micro hydel and few others. | – | 5,000 MW,         |

Apart from the last mentioned, all others listed above have significant negative impacts : Pollution in some form or the other.

### Alternative Energy

Power of Nuclear Reactor : If A is the number of nuclei undergoing fission then

$$A = nvNV$$

where  $n$  = average neutron density  
 $v$  = average speed, so that 'nv' is the average neutron flux  
 $N$  = no. of fissionable ( $U^{235}$ ) nuclei  
 $\sigma$  = cross section for fission  
 $V$  = volume of the reactor.

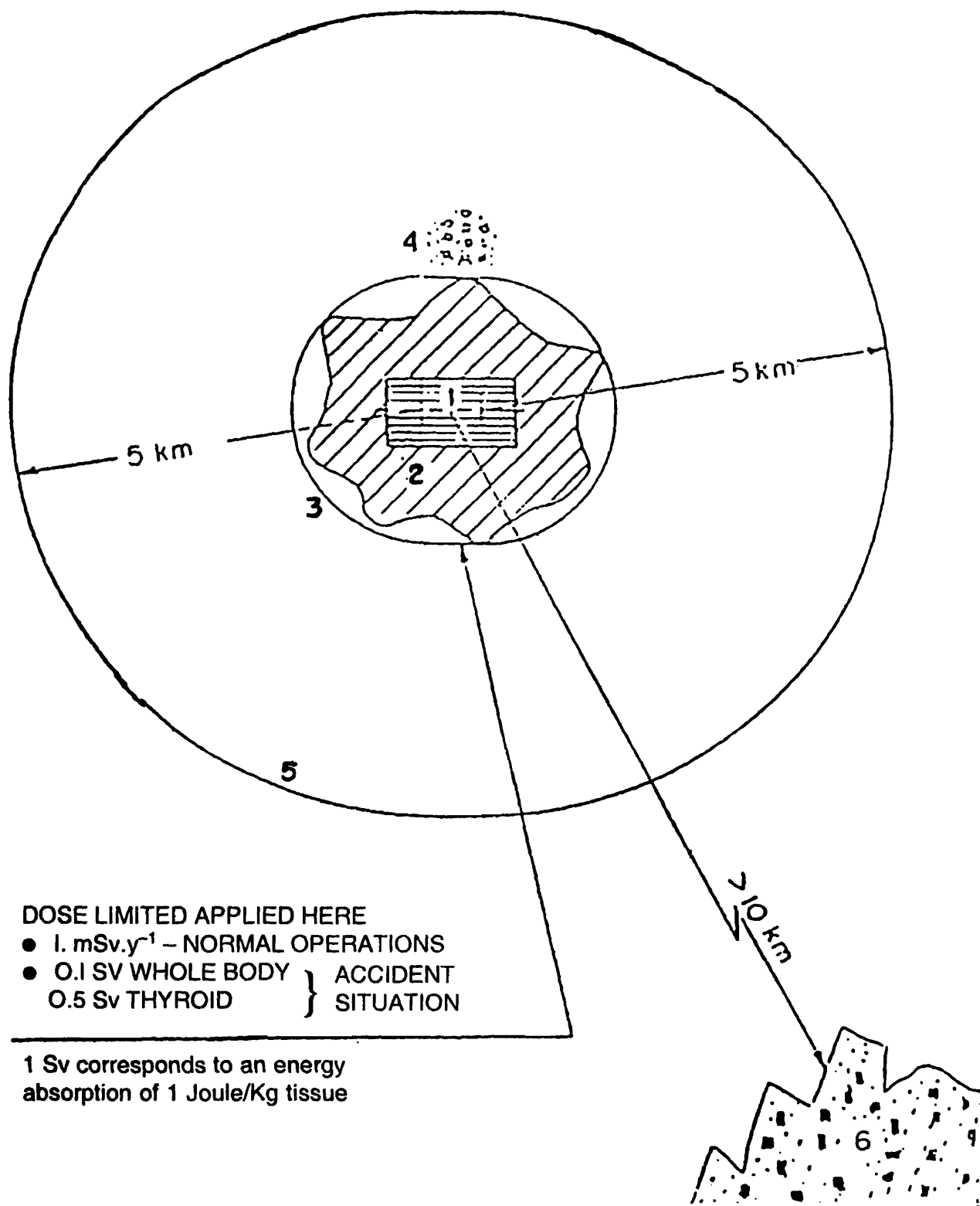
It is seen that  $3.1 \times 10^{10}$  fissions per sec. produce 1 Watt of power 'P'

$$\therefore P = \frac{n v N \sigma V}{3.1 \times 10^{10}} \text{ watts.}$$

### Solar energy : Fusion energy

Extremely high temperature, enormous pressure due to its (Sun's) bulk cause protons to fuse.

A. Site related factors	B. Plant related factors
<ul style="list-style-type: none"> <li>● Potential for earthquakes and related phenomena</li> <li>● Potential for extreme meteorological conditions such as –               <ul style="list-style-type: none"> <li>Cyclones, tornadoes, high winds</li> <li>Heavy rains and floods</li> </ul> </li> <li>● Potential for man-induced events               <ul style="list-style-type: none"> <li>Aircraft crashes</li> <li>Release of toxic, flammable and / or corrosive substances</li> <li>Explosives</li> <li>Mining activities and blasting</li> </ul> </li> <li>● Presently (2004) Seismic disturbances and Tsunami Disasters.</li> </ul>	<ul style="list-style-type: none"> <li>● Demographic characteristics               <ul style="list-style-type: none"> <li>Population density</li> <li>Dietary and other habits</li> </ul> </li> <li>● Individuals dose limits collectives doses</li> <li>● Doses during accidents</li> <li>● Dispersion characteristics               <ul style="list-style-type: none"> <li>Dispersion in air</li> <li>Dispersion in water costal/ inland/lakes/rivers.</li> </ul> </li> <li>● Hydrology</li> </ul>



- 1 – NUCLUEAR POWER STATION COMPLEX
- 2 – ISODOSE CURVE (SCHEMATIC)
- 3 – EXCLUSION AREA
- 4 – HUMA SETTLEMENT TO WHICH DOSE LIMITS SHOWN APPLY
- 5 – STERILIZED ZONE WHERE PROTECTIVE ACTIONS ARE ENFORCED
- 6 – POPULATION CENTRE (SCHEMATIC) ~ 10<sup>4</sup> PERSONS

Fig-2

## FACTORS CONSIDERED IN NUCLEAR POWER PLANT SITING

### Peaceful uses of Nuclear Energy

#### Production of Electricity

Nuclear Power Plants in 1986 produced 30% or more of the total electricity in 8 countries – and between 10 to 70% of electricity in altogether 19 countries. Total power produced by the end of the year was 273715 megawatts.

France–69.8%, Belgium–67%, Sweden–50%, Japan–24.7%, Spain–29.4%, Germany–29.4%, India–2.7%, Pakistan–1.8%.

#### Study on radio nuclides in Pacific

Using an array of sediment traps equipped with a satellite radio transmitter and set up to 2000 meters below the ocean's surface scientists belonging to IAEA tracked the seasonal movement of certain long-lived artificial radio nuclides in the Pacific Ocean to quantitatively assess their migration.

#### Accidents and Risk Management

The IAEA, WHO, UNEP (also UNIDO) jointly worked towards the assessment and management of risks associated with industrial developments : A number of major accidents over the last few years such as – Three Man Island and Chernobyl – have underlined the need.

#### Hazards

For whatsoever purposes nuclear energy is used – peaceful or otherwise – the physical and bio-environment can not get away with its hazards.

(i) Delayed effects of fall out, (ii) power reactor accidents,

(iii) radioactive by products, (iv) use of radiation and radioactive isotopes in technology and medical therapy and medicine. Radioactive waste disposal–bioconcentration–fish, algae.

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## **ENVIRONMENT AND DEVELOPMENT**

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### **INTRODUCTION**

There has been a phenomenal growth of Science and Technology during the last hundred years. When this article is being written space ships are going out of the solar system into the outer space to divulge its mysteries. In the world of micro new particles are being discovered and new theories are proposed to explain the structure of matter. New vistas have been opened in the field of life sciences. The discovery of transistor a few decades back has revolutionized communication. There has been an Information Revolution. Information is doubling every decade. But has man's wisdom increased? Doubting this the english poet T.S. Eliot wrote "Where is the wisdom we have lost in knowledge." In spite of the immense potentiality that science and technology offer to improve human condition a large part of humanity do not have access to food, water, health, education and shelter. George Tressel in his book "Information Education" writes "We are well into the technological era of thinking machines, designer genes, and a truly frightening ability to travel, communicate and annihilate each other." We not only see the annihilation of each other in different regions of the world but also of other life support systems and species.

The social environment in both third and the first world, second world having collapsed, is breaking apart, W.B. Yeats perhaps had the premonition at the beginning of the last century of the crumbling apart of the world when he wrote, "Things fall apart/The Centre cannot hold/Mere anarchy is loosed upon the world" This article would like to deal with the crisis that the social and the environmental world faces today and point towards the way this crisis can be faced and a sustainable world achieved.

### **THIRD WORLD**

We, in India are in the third world, In spite of all hullabaloo of a shining India and a high economic growth a large part of India is mired in poverty, malnutrition and illiteracy. 135 million people have no access to primary health, 226 million people are without safe drinking water and 640 million people lack basic sanitations. 50% of Indian children are malnourished. The middle class in India has grown from 5% to 15% since Independence.

The benefits of industrialization & manufacturing industries are being enjoyed mainly by the rich and the middle class. The large majority of Indians, who are poor, have no connection with the goods that are produced in the factories. According to 1987-88 NSS data, only 7.56% of Indian people at the top consume 71.2% of consumer durables. Whereas 56.64% at the bottom consumer only 6.8% of the same. Our country is gradually falling into a debt trap. In 1950, our foreign debt was only 89 paise per capita. In 2000, it became more than Rs. 5000 per capita. In 1970, foreign debt was only 0.35% of our national income. In 1995-96 it increased to 31.7%. A large part of our budget goes for debt servicing for which we again have to take loan.

The so-called development that has taken place after Independence has displaced millions of people from their hearth, home & livelihood who have not been properly rehabilitated. All the 3300 major dams that have been constructed since independence have displaced more than 30 million people of whom majority are tribals and dalits.

The third world as a whole faces severe social and environmental crisis. The rise in Gross Domestic Product (GDP) per capita from 1961-70 in the third world was on an average 3.3%. From 1986-90 it decreased to only 0.1%. Today 12 billion people have an income of only \$ 1 per day and 3 billion people earn only \$ 2 per day.

Every year the disparity between the rich and poor is increasing. The malady and strife that we observe in different parts of the world today is an expression of this deep cleavage that has taken place in society. The ratio of incomes of the richest and poorest countries has been growing steadfast. In 1920 it was 3 : 1; In 1950, 35 : 1 and in 2000-2001 it became 100 : 1. Only 225 billionaires in the world owns 47% of world's wealth which is equal to India's GDP. According to the Forbes magazine, the world's billionaires in 2004, only 587 individuals and families, own \$ 1.9 trillion. This is more than the GDP of the world's 135 poorest countries combined together. Forbes also informs that in 2004 there are 111 more billionaires added in the world. This fissured world is the cause for the strife in society that we witness today.

### **FIRST WORLD**

The first world of high income countries is in the deep crisis of over production and over accumulation of capital. The world manufacturing capacity, excluding China, is operating at 65%. The average annual growth rate of world's GDP declined from 4.9% between 1950 and 1973 to 3% between 1973 and 1992 and to only 2.7% between 1990 and 2002. For the third consecutive year till 2003 world's stock market continued their steep slide down reminding the slide of 1929-31 when the stock market crashed by 58.8%. In January 2000, the stock market crash wiped out world-wide \$ 12 trillion of which the share of USA was \$ 7 trillion.

In USA 11 million working people are out of job and, unemployment in USA is increasing by 6.2% every year. The situation reminds of 1930 crash. The National saving in USA plunged to an all-time low of 1.6% of GDP in the third quarter of 2002. This is less than one-third of 1990s average and one-ninth of the rate of 1960s & 1970s. Import-Export deficit of USA is \$ 500 billion. It is increasing at a rate of 10% every year.

United States is the acme of the developed world. I shall quote from a speech by Neil Postman, an American thinker, who delivered the key note address at the triennial World Congress of International Council of Museums in 1989 at Den Hague in Holland. Postman asked the audience, about 2500 museum experts from all over the world, what kind of museum should be set up in the world? Will those be copies of EPCOT Centre? EPCOT is a fantastic display of future science & technology in Florida, USA adjacent to Disney World. Postman said, "What can EPCOT teach us the Americans and inspire us to think. We have already organized our society to accommodate every possible technological innovation. We have deliriously, willingly, mindlessly ignored all consequences of our actions. And have, because technology requires it, turned our backs on religion, family, children and education. As a result of what we have done American Civilization is collapsing. Everyone knows this to be true but seems powerless in the face of it. Here is a partial account of our technological dream : By 1995, 85% of our children will live in own parent homes. In our large cities, fewer than 50% of the students graduate from high schools. This from the culture that invented the idea of education for the masses. And while the average American delights in watching 16000 hours of television by age eighteen and approximately one million television commercials by age twenty, one-fourth of our population - sixty million people - is illiterate. Every year, forty million people change residences and several million have no residences at all, living in the streets and subways. From 1950 to the present the incidence of violent crime has increased by 11000 percent. And two out of every ten Americans will spend some part of their lives in a mental institution. Our cities are choked with traffic; own water supply is poisoned with lead and medical debris; our rain is acid; our people consume more aspirin per capita than any other population in the world; our infant mortality rate is one of the highest in the Western world and our teenagers are frying their brains with drugs."

"It's a pity that the newly liberated countries of the third world, after the second world war, started copying the same paradigm of the Western model of development. Rabindranath Tagore and Gandhiji understood that the Western developmental model of industrialization will cause disaster. While visiting China in 1924 Tagore said in a lecture, "We have for over a century been dragged by the prosperous west behind its chariot, choked by the dust, deafened by the noise, humbled by our own helplessness, and overwhelmed by the speed. We agreed to acknowledge that this chariot drive was progress and that progress is civilization. If we ever ventured to ask 'progress for what and progress for whom' it was considered to be peculiarly and ridiculously oriental to entertain such doubts about the absoluteness of progress, of late a voice has come to us bidding us to take count of not only the scientific perfection of the chariot but also of the depth of ditches lying across its path." The fast moving western chariot that Tagore refers to is the technology and the ditches are the social and environmental degradation that are taking place. Gandhiji also understood that the unbridled industrialization may bring disaster. He wrote, "God forbid India should ever take to industrialization in the manner of the West. A tiny island kingdom is today keeping the whole world in chains. If an entire nation of 300 million took to similar kind of economic exploitation the whole world will be bare like locust." If today, India and China with about 2.15 billion population start consuming like an

American the natural resources then the world will become bare like locust in a few decades.

On October 5, 1945, when freedom was knocking at the door, Gandhiji wrote a letter to Jawaharlal Nehru giving his dream of future India that he charted out in his book "Hind Swaraj" written in 1907. Gandhiji wrote, "I am convinced that if India is to attain true freedom and through India the world also, then sooner or later the fact must be recognized that people will have to live in villages, not in towns, in huts, not in palaces. Crores of people will not be able to live in peace with each other in towns and palaces. They will have no recourse but to resort to both violence and untruth... While I admire modern science... (it) should be re clothed and refashioned aright... I am not envisaging our village life as it is today... My ideal village will contain intelligent human beings. They will not live in dirt and darkness as animals. Men and women will be free and able to hold their own against any one in the world' Jawaharlal replied to this letter on October 9 and wrote." It is many years ago since I read Hind Swaraj and I have only a vague picture in my mind. But even when I read it 20 or more years ago it seemed to me completely unreal... The world has completely changed since then, possibly in a wrong direction... you are right in saying that the world, or a large part of it, appears to be bent on committing suicide. That may be an inevitable development of an evil seed in civilisation that has grown." Knowing fully well that the western paradigm of an industrial society is like "Committing suicide" the reigning rich and middle class leadership of India planted "the evil seed" in India too and we witness the breaking a part of India with religions, casteist, ethnic and regional conflicts.

### **Historical background**

In the 15th and 16th centuries three important developments took place : Renaissance, Exploration and Discoveries and Scientific Revolution in Europe. Renaissance brought in a change in man's understanding about itself and the world. Exploration and discoveries led to the establishment of colonies in the rich tropical world. With colonization the loot started reaching Europe, specially England and a large market for goods manufactured in England. This gave birth to Industrial Revolution in Europe between the mid-18th and mid-19th centuries. The world started changing very fast. Life style of people of the western rich countries changed and consumption of world's natural resources gallopingly increased.

With the discoveries of scientific and philosophical knowledge of Greeks, Arabs and East from the 12th century onward Scientific Revolution started in Europe in the 15th century and matured in the 17th century. Galileo Galelei, Francis Bacon, Rene Descartes and Isaac Newton brought the modern world into being. Bacon and Descartes spoke of acquiring 'fruits of science' and the idea of becoming the master of nature. Descartes' method of breaking a phenomenon into simpler elements to understand nature and nature's process also gave birth to a Reductionist world view of reducing the property of the whole in particular. The communist philosopher Friedrich Engels wrote in the 19th century, "The analysis of Nature into its constituent parts were the fundamental conditions for the gigantic strides made in our knowledge of Nature during the last 400 years. But the

method of investigation also left us a legacy of the habit of observing natural objects and natural processes in their isolation, detached from the vast interconnection of thing" (Anti-Duhring). The cognitive future of reductionist epistemology is that it has created ecological instabilities which in turn threatens human survival.

As the nation states started emerging militarisation of each state started. The Bolshevik Revolution in 1917 in Russia gave birth to a new kind of egalitaria social order socialism. Competitions between the two world systems, capitalism and socialism, increased military competition and development of science and technology. A vibrant and demanding middle class came into existence. In India the great middle class population increased from 5% in 1947 to 15% by 2000 AD. A complete change of life style started in west and among the middle class rich people of the third world. The Soviet Union and Eastern Europe, the second world, wanted to beat USA in per capita production and collapsed by 1991.

Since the mid-20th century three trends were visible : i) Doubling of world's population, 95% of that growth in the third world; ii) Five fold increase of global economic output and; iii) Widening gap in the world distribution of income and resources. As recently as in 1950 the world manufactured  $\frac{1}{7}$ th of the goods that it produced in 2000 AD and extracted from earth  $\frac{1}{3}$ rd of minerals. If we take any parameter of development then 80% of everything is enjoyed by the first world : 90% of industry, 94% of registered patents and 100% of breakthrough know-how. Average consumption of power of High income countries per capita is 7250 kg of oil equivalent per year. Whereas a third world country like India uses only about 250 kg per capita per year. An average American or a Canadian uses 40 times more of commercial energy compared to an average third world population. USA with only 5.6% of world population consumes up to 40% of world's resources, most of them non-renewable.

### **A fissured world**

The disparity in the share of world income is appalling as shown in the table below

<b>Country</b>	<b>% of world population</b>	<b>% of world income</b>
India	16.1	1.14
43 least developed countries	58	4
24 high income countries	15.45	82.11

The Human Development Report of 2002 shows that the income of the richest 10% of US population (about 25 million) now equals that of the poorest 43% of world population.

The consumerist life style of first world population and the rich and middle class all over the world is increasing gallopingly. The newly built shopping plazas in Kolkata can compete with American or Bangkok ones where the rich and the great Indian middle class satisfy their gluttonous consumption.

In 1800 in the middle of Industrial Revolution when an American used to go to the market for shopping he could get a choice of only 300 items to buy in a shopping area of 150 sq. m. It today an American, living in a city of 1,00,000 population, goes to the market he gets a choice of 1 million items in a market space of 1.5 million sq. m. of space. This proliferation of goods produced by the industrial society is the root cause for the breaking down of society and environment.

When we look at the goods that is produced for the market we find that a large part of the name are inessential for satisfying the basic needs of humans. The table below gives a brief mapshot of much production :

Alcoholic drugs in Europe	–	\$ 105 billion (b)
Cigarettes in Europe	–	\$ 50 b
Narcotic drugs in the world	–	\$ 400 b
Military spending in the world	–	\$ 780 b
Pet food in Europe & USA	–	\$ 17 b
Business entertainment in Japan	–	\$ 35 b
Ice cream in Europe	–	\$ 4 b
Cosmetic in USA	–	\$ 8 b
Perfumes in USA & Europe	–	\$ 12 b
Total –		\$ 1411 billion

If we consider all such inessential items produced in the world then the total amount spent for such goods and the use of natural resources will be stupendous. An artificial scarcity conditioning of human mind is being created right from the childhood through the mass media. And for the production and distribution of all these goods we need mines, factories, land, energy, roads, transport and communication systems. All these use up natural resources.

### **ENVIRONMENTAL DEGRADATION**

The industrial society is today degrading the natural environment all over the world. All the five natural resources on which life sustains on earth are being jeopardized. The resources are : forest, land, water, biodiversity and air. Let us consider their situation one by one.

#### **FOREST AND LAND**

As I write a sentence four football field equivalent of forest vanish from the earth of which the major part is tropical forest. In Africa if 29 parts of tropical forest is cut one part is planted. In Asia it is 5 : 1 and the world average is 10 : 1. But the planted forest is not tropical forest. It is basically monoculture of quick growing trees. It has been estimated that it deforestation continues as it is then by 2030 all tropical forests of the world will

vanish. India had 3 times more forest 100 years back. Brazil has lost 95% of its once vast coastal rain forest. To supply timber to Germany alone the third world loses 0.2 million hectares (ha) of forest each year. For all these escalating deforestation forest is converted to savannah, savannah to steppe and steppe to desert. Each year the third world loses 6 million ha to wasteland. Every year 2.5 billion (bn) tons of top soil is eroded of which India's share is 6 bn tons. Due to soil erosion every year the world loses 20 million ha of cultivable land. So, desertification is growing. Sahara has engulfed during the last 50-60 years about 6.5 million sq. km. of land. So we see the plight of Sub-Saharan Africa in television.

### **WATER**

World will face a severe water crisis in this century. The growing population, the change in agricultural practices with HYV seeds, demands of industry and the consumerist life style of the rich are making heavy demands of water all over the world. The demand of water in the world is increasing at double the rate of population growth. A north American uses on an average 1300 gallons of water. 70% of that water is used in agriculture for irrigation of crops which require large amount of water. The water needed for producing 1 kg of sugar (2 to 3 tons of water) can produce 150-200 kg of millet. Americans eat 122 kg of beef per capita every year. To produce 1 pound of beef 5200 gallons of water is needed. Jeopardizing the food security of the world cash crop is being produced by rich farmers to make profit. The "Green Revolution" in India with the use of HYV seeds has accentuated the water problem. West Bengal is having serious problem of Arsenic poisoning of drinking water.

Water pollution has become a major problem all over the world. Major sources of water pollution are human activities, municipal, industrial and agricultural practices. All effluents of industries and sewage are dumped into wetlands and rivers. Thousands of toxic materials are in use today of which many are carcinogenic. In the third world typhoid, cholera, dysentery and infectious hepatitis are all water-borne diseases. Millions die of such diseases every year.

Oil spills, specially in estuaries, often make fishes unsuitable for human consumption. Extensive use of pesticides, herbicides and weedicides pollute water in wetlands, rivers and oceans. All these exterminates biodiversity of water and soil.

### **BIODIVERSITY**

When forests vanish, land and water get polluted and biodiversity vanish. Scientists have studied only about 1.4 to 1.5 million species. But nature can harbour 5 million to 50 million species. It means that scientists yet don't know much of biodiversity.

In 1980 biodiversity extinction rate was 1 species per day, in 1990 it became 1 species per hour. Background rate of extinction was 1 bird in 200 years and 1 mammal in 400 years. During the last 3 centuries 115 bird and 58 mammal species have become extinct.

India's genetic diversity of rice was phenomenal. It had more than 42,000 varieties of rice. West Bengal had 4,800 varieties of rice before 1965. HYV has eroded the diversity to such an extent that it is difficult to get more than 410 or so varieties as reported by Dr. Deval Dev of Centre for Interdisciplinary studies. Nearly 1,00,000 species are threatened with extinction each year.

### AIR

Two of the most important global problems that the world faces today are global warming due to green house gases (GHG) and Ozone layer depletion due to the release of ozone-depleting gases like chlorofluorocarbon (CFC) and halon compounds.

Due mostly to Carbon dioxide (CO<sub>2</sub>) released by power houses, automobiles and industries the heat from the sun reflected by the earth is trapped like a green house. Every year about 6.5 bn tons of CO<sub>2</sub> is released. Due to green house effect global warming and climate change is taking place. In the Earth Summit in Rio in 1992 different States signed the Climate change convention. Kyoto Protocol was signed in 1997. USA which releases the largest percentage of CO<sub>2</sub> did not sign the Kyoto Protocol. The Protocol decided that all industrial developed nations will reduce their CO<sub>2</sub> release 5% below the 1990 level between 2008 and 2012. It is observed that CO<sub>2</sub> release is constantly rising in USA & Japan since 1997. Though European Union is more or less stable. Chinese & Indian economy is developing at a fast rate. These two countries are not yet bound by Kyoto Protocol but fast becoming producer of large amounts of CO<sub>2</sub>.

Due to global warming all glaciers at the mid and higher latitudes are melting and receding every year by a few meters. Polar ice caps are breaking. Due to all these the sea level is rising. Many of the low lying areas on earth will go under water if things continue like this.

But the most grave problem that looms large over the world is the change of thermohaline circulation. The thermohaline circulation, that maintains a balance in global temperature, suddenly slowed down in the 1980s. This happened on earth 10800 years back when there was a natural catastrophe. A similar catastrophe awaits earth if global warming and climate change are not averted.

Ozone layer sustains life on the planet earth by absorbing the major part of ultraviolet (UV) radiation that comes from the sun. If UV-ray had reached earth in its original proportion then life on earth would not have evolved. CFC used for refrigeration, paint industry etc. and halon-based compounds are ozone-depleting chemicals. One chlorine molecule released in the atmosphere can break down 1,00,000 ozone molecules. Due to this the ozone layer is thinning down in higher latitudes. This is known as ozone hole. A depletion of 1% in stratospheric ozone is estimated to cause 3 to 15 million new cases of skin cancer called melanoma and 55,000 to 208 million cataract cases for white people born before 2075. Excessive UV exposure induce Vitamin D toxicity with symptoms of

kidney stones, abdominal and bone pains as calcium gets mobilized from the bone structure and excreted to kidneys. Two-third of 300 crops used by humans are vulnerable to UV radiation. In 1987, the Montreal Protocol pledged to reduce the CFC production to 50% by 2000 AD. Environment Protection Agency of USA estimates that if all CFC production and consumption stops totally by 2000 AD the effect will continue. Because the ozone hole effects mainly the counties of higher latitudes the developed countries have taken effective steps to find alternatives to CFC.

Acid rain is also a serious problem affecting soil, water and biodiversity. Different oxides of sulphur and nitrogen released by industries mix with water vapour to form sulphuric and nitric acids which fall on earth cause, devastation. Western American Industries release gases which cause acid rains in south-east Canada and north-east America. So, the industrialized countries are today shifting all polluting industries to the third world countries.

## WASTES

Modern industrial societies generate mountains of wastes some of which are extremely hazardous. Most liquid wastes ultimately find their way to water bodies, rivers and oceans. According to a 1992 estimate 2.3 bn gallons of municipal wastes and 4.9 bn gallons of industrial wastes are dumped in ocean coasts every year. Such wastes pollute water and land. Today, there are over 200 industrial chemicals and pesticides commonly found in the body tissues of 95% of Americans tested. DDT has been found in some quiet and remotest sea areas. One of the most dangerous hazardous wastes is the nuclear wastes that are generated by nuclear armament factories and nuclear power stations. Many of the nuclear power stations which were recited in 1950s have to be decommissioned. All such power stations are highly radioactive. All nuclear power plants generate radioactive plutonium 239 whose half life is 24,000 years. Scientists yet do not know what to do with such radioactive wastes and materials. If only ½ kg of Plutonium 239 is ground to powder and each human being on earth is asked to inhale a particle of it then the same can kill the whole human race. Many nuclear submarines are in the sea floor due to accidents. No one knows what may happen to such submarines due to conversion by sea water.

## ENVIRONMENTAL DEGRADATION COST

Environmental impact of the highly industrial countries are stupendous. A child in USA makes an environmental impact equal to two children born in Sweden, 35 children born in India and 140 children born in Chad, Rwanda, Bangladesh or Nepal. Modern developed societies externalises the environmental degradation cost. So, the technology seems very efficient. If all the social and environmental degradation costs were taken into account and mitigating actions taken then the electric power generated in nuclear power, hydell or thermal power plants may cost many times more than the present day one. Environmental degradation cost of India comes to about 7-9% of GDP as per a 1992 estimate by World Bank and Centre for Science and Environment, Delhi.

## ECOLOGICAL FOOTPRINT (EFP)

EFP is the total area of the planet that humans require for agriculture, grazing, timber, housing, production, marine housing and infrastructure together with the area required for sequestering CO<sub>2</sub> produced by burning coal, oil and other fossil fuels. EFP has already exceeded the regenerative capacity of earth since 1980s. EFP in 1999 was 2.3 ha per person which was 20% more than the biological capacity of earth that is about 1.9 ha per person. EFP for USA is 9.6 ha per person and that of Europe is 5 ha and of Asia and Africa only 1.4 ha per person in 1999. Hence, it is the rich industrialized societies with only about 25% of world's population that is causing the environmental degradation and not the populous third world.

There has been plethora of conferences, conventions and treaties to control environmental degradation. But it seems that it is a losing battle. No world conferences from Stockholm to Johannesberg speak of fundamental changes in the life style of rich few of the world that causes the social and environmental degradation. If the world has to be saved from an environmental catastrophe then the industrial first world and the rich of the third world have to reduce their consumption by 90% and the world as a whole by 50%.

We have to understand that the modern technological society has an enlargement problem. If there is a sudden enlargement of any organ in a human body then one has to go to surgeon for an emergency operation. Today's industrial society needs an emergency decision to halt the unbridled growth of consumer and technology.

Mankind has to strive for a new kind of society which Tagore and Gandhi have proposed. The objectives of such a society can be summarised as follows :

- A society with equity and justice, simple living and self-reliant with decentralization of economy and polity.
- Clean air and water and adequate housing.
- Relevant education for all.
- Gender equality.
- A harmonious relation between man and nature and between an individual and society.
- A developmental paradigm that will not jeopardize the life and livelihood of future generations.

There is a need to alter our epistemological understanding of the meaning of 'development' Development does not mean only economic development that satisfy only our consumerist lifestyle. True development will make possible the satisfaction of the immense potentiality of human mind that creates literature, science, poetry, arts etc. In these only we differ from any other living forms.

Such a sustainable society can't be achieved by itself. For this a world struggle and simultaneous constructive activity in various fields have to be undertaken. "Struggle and construction" should be the new slogan for achieving a sustainable society.

## **ENVIRONMENTAL IMPACT ASSESSMENT AND DEVELOPMENTAL PROJECTS**

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### **INTRODUCTION**

Earth is the only place in the universe known to sustain life. Unfortunately, the existence of the life system is in danger in recent times due to tremendous explosion of human species, a major component of living system, and their activities to satisfy the increasing need for development at the cost of life-supporting systems. Through the advent of industrial age and development of technology, there are marked changes in use of natural resources through exploitation of different ecosystems for various developmental projects, resulting rapid depletion of natural resources and adverse effect upon environment and its life-supporting system. There is always a conflict between development and environment, though these two are interdependent. But development is needed and thus developmental projects are unavoidable. To minimize the unwanted effects on environment caused by polluting and degrading developmental projects, environmental clearance from the competent authority has become mandatory before the construction phase of the project. The objectives of the environmental clearance are, i) optimal utilization of natural resources through improved technologies and management and ii) development and incorporation of suitable mitigating measures at the project formulation stage. The first and foremost task to get the environmental clearance is preparation of Environmental Impact Statement (EIS) and Environmental Management Plan (EMP) based on Environmental Impact Assessment.

Environmental Impact Assessment or 'EIA' for short is a formal study process used to predict the environmental consequences of a proposed major development project. An EIA concentrates on problems, conflicts or natural resource constraints that could affect the viability of a project. It also examines how the project might cause harm to people, their homeland or their livelihoods, or to other nearby developments.

The phrase 'Environmental Impact Assessment' comes from Sec. 102(2) of the National Environmental Policy Act (NEPA), 1969, USA.

### Aims and Objectives of EIA

- Meaningful mitigation of impacts on wildlife species and habitats of conservation significance.
- Additional information generated on the status and distribution of endangered species and habitats.
- Prevention and Control of Pollution.
- Conservation of Natural resources.
- Formulation of Environmental Management and Planning Strategies.

### IMPACT ASSESSMENT STUDIES IN INDIA

In India, Environmental Impact Assessment is now a compulsory task to the developer of any major developmental project. The genesis of EIA in India is shown in table 1.

**Table 1. Trends of EIA Studies in India**

<b>Phase</b>	<b>Trend and innovations</b>
1972 : Pre-EIA	National committee on Environment Planning and Coordination (NCEPC) was established in the Department of Science and Technology (DST) with 14 members.
1974-1979 : Constitutional provision for environmental protection	Environmental protection incorporated into constitution by the Forty Second Amendment Act in 1976. Fifth plan stressed close association of NCEPC with major industrial decision. A few programs under "Minimum Need Program" placed priority to minimize pollution and degradation.
1980-1985 : Recognition of Central Authority for environmental protection and conservation	A new mechanism of environmental protection included planning commission's approval of major projects and review report by the Department of Environment. Environmental appraisal and monitoring committees were set up to review impact statement by project proponents. A separate Department of Environment was established at the Center. Guidelines and checklists for EIA were developed for hydroelectric, mining, harbour, thermal and road/ rail projects. Environmental boards in all states and universities established for review and monitoring of all environmental matters.
1985-1990 : Initial phase of evolving EIA related procedures	The most significant central legislation Environmental (Protection) Act, 1986 came into force. The amendments to Air Act, 1987 and the Water Act, 1988 empowered enforcement agencies to close polluting industries. Environment (Protection) Rules were also amended.

Phase	Trend and innovations
1990 – : Present Methodological Refinement	EIA/EIS became mandatory for environmental clearance. Formalised EIA procedures developed in line with requirements by International Agencies. Research and data needs were prioritized for EIA. Emphasis on Environmental Management Plan and Disaster Management Plan laid in environmental appraisal. Progress in computer aided technological advancement.

The Ministry of Environment and Forests, Government of India issued a notification in 1994 and made EIA statutory for 29 sectors of developmental activities (Table 2)

**Table 2.** List of projects requiring environmental clearance from the central Government

<ol style="list-style-type: none"> <li>1. Nuclear Power and related projects such as Heavy Water Plants, Nuclear fuel complex, Rare Earths.</li> <li>2. River Valley projects including hydel power, major irrigation and their combination including flood control.</li> <li>3. Ports, Harbours, Airports (except minor ports and harbours).</li> <li>4. Petroleum Refineries including crude and product pipelines.</li> <li>5. Chemical fertilizers (Nitrogenous and Phosphatic other than single superphosphate).</li> <li>6. Pesticides (Technical).</li> <li>7. Petrochemical complexes (Both Olefinic and Aromatic) and Petrochemical intermediates such as DMT Caprolactum, LAB etc. and production of basic plastics such as LDPE, HDPE, PP, PVC.</li> <li>8. Bulk drugs and pharmaceuticals.</li> <li>9. Exploration for oil and gas and their production, transportation and storage.</li> <li>10. Synthetic Rubber.</li> <li>11. Asbestos and Asbestos products.</li> <li>12. Hydrocyanic acid and its derivatives.</li> <li>13. (a) Primary metallurgical industries (such as production of Iron and Steel, Aluminium, Copper, Zinc, Lead and Ferro Alloys). (b) Electric arc furnaces (Mini Steel Plants).</li> <li>14. Chlor-alkali industry.</li> <li>15. Integrated paint complex including manufacture of resins and basic raw materials required in the manufacture of paints.</li> <li>16. Viscose Staple fibre and filament yarn.</li> <li>17. Storage batteries integrated with manufacture of oxides of lead and lead antimony alloys.</li> </ol>
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18. All tourism projects between 200m – 500 meters of High Water Line and at locations with an elevation of more than 1000 meters with investment of more than Rs. 5 crores.
19. Thermal Power Plants.
20. Mining projects (major minerals) with leases more than 5 hectares.
21. Highway Projects.
22. Tared roads in Himalayan and/or Forest areas.
23. Distilleries.
24. Raw Skins and Hides.
25. Pulp, paper and newsprint.
26. Dyes.
27. Cement.
28. Foundries (individual).
29. Electroplating.

The 29 projects listed in Schedule-I of the EIA Notification can be broadly categorized under the following sectors :

- Industries
- Mining
- Thermal Power Plants
- Ports, Harbours and Airports
- Communication
- Atomic Energy
- Transport (Rail,Road, Highway)
- Tourism (including hotels, beach resorts).

### **EIA and Rio declaration on Environment and Development**

The Rio Convention on Biological Diversity in 1992 strongly emphasized the need of impact assessment and minimizing adverse effects of developmental projects. The Article-14 mentions that each contracting party shall:

- Introduce appropriate procedures requiring EIA of its proposed projects that are likely to have significant adverse effects on biological diversity.
- Introduce appropriate arrangements for consideration of adverse effects.
- Promote reciprocity, notification, exchange of information and consultation on activities.
- Promote national arrangement for emergency responses to activities or events.

## THE ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

### **EIA is a management tool**

The major development projects need economic analysis and engineering feasibility studies. Likewise, EIA is a management tool for officials and managers who must make important decisions about the project. EIS is considered to be equally important tool in designing a viable project.

It is observed that many of the major projects have encountered serious difficulties because of insufficient account has been taken of their relationship with the surrounding environment. Some projects have been found to be unsustainable because of resource depletion. Some of these have been abandoned because of public opposition, financially encumbered by unforeseen costs, held liable for damages to natural resources and has been the cause of disastrous accidents.

Considering the experiences, it is very risky to approve a major project without first taking into account its environmental consequences – and then siting and designing the project so as to minimize adverse impacts. It is, therefore necessary to ask the following questions about the project prior to its initiation :

- Can it operate safely, without serious risk of dangerous accidents or long-term health effects?
- Can the local environment cope with the additional waste and pollution it will produce?
- Will its proposed location conflict with nearby land uses?
- How will it affect local fisheries, farms or industry?
- Is there sufficient infrastructure such as roads and sewers to support it ?
- How much water, energy and other resources will it consume and are these in adequate supply?
- What human resources will it require or replace, and what social effects may this have on the community?
- What damage may it inadvertently cause to national assets such as virgin forest, tourism areas or historical and cultural sites?
- What impact may it cause on the ecology including flora and fauna?

### **Who are involved in the EIA process ?**

An EIA review is normally undertaken by those responsible for the development—the developer. Governments and international agencies are adopting regulations that legally require developers to undertake EIAs. In such cases, the EIA report may need to be submitted as part of the application to a permit-granting government department—the

'competent authority' But many developers, on their own initiative, are incorporating the EIA process into their routine project cycle.

Although the developer is usually responsible undertaking the EIA, the 'competent authority' also has a role to play :

- By providing general guidance, past EIA formats or examples to follow
- After the EIA is done, using its results to reach a decision on the project, and later ensuring that all the mitigation measures are implemented.

The concerns and points-of-view of all the various groups interested in and affected by the project should be taken into account throughout the EIA process. Each of these participants will have a different use for the results of the EIA :

- The Developer : Needs to know where to site a project and how to reduce adverse environmental impacts.
- The Investor : Needs to know how the impacts will affect the viability of the project, and what liabilities are incurred.
- The Competent Authority : Uses the EIA's results to decide on a response to the permit application.
- Other Government Authorities : Will want to know the implications of the project's adverse impacts for other projects they may wish to promote.
- The Regulator : Needs to know the extent of environmental impacts and whether they are acceptable.
- The Regional Planner : Needs to know how the impacts will interfere with adjacent developments and land uses.
- The Local Community or its representatives : Will need to know how the project's impacts will affect their quality of life.
- The Politician : Needs to know who is affected and in what way and what issues should be of concern.

Major activities and personnel involved in the EIA process are shown in table 3.

**Table-3.** Activities and types of personnel involved in the EIA process

<b>Major activities</b>	<b>Types of personnel involved (examples only)</b>
1. Deciding if a study is necessary	Senior officers in competent authority, project leader in developer organization and certain of their supporting staff.
2. Scoping of study	Project leaders in competent authority and developer organization (with support staff), environmental control agency specialists, representative of interest groups.

<b>Major activities</b>	<b>Types of personnel involved (examples only)</b>
3. Managing the study	Developer/consultancy/competent authority/ project leaders.
4. Preparing specialist technical contributions to the study	Technical specialists employed by Developer/consultancy/competent authority/other environmental control agencies (some of the work may be subcontracted to a number of different consulting groups).
5. Preparing the study report	Developer/consultancy/project leaders (with support assistance).
6. Reviewing the study report	Competent authority/project leader (with technical support assistance), members of review panel (if in existence).
7. Organizing the consultation and public participation process	Competent authority/ project leader (with support assistance), chairman of public inquiry.
8. Participating in the consultation process	Environmental control agency specialists, interest group representatives, general public.
9. Synthesizing the findings of the consultation process	Competent authority/ project leader, chairman of public inquiry.
10. Using the findings of the study and consultation process to reach a decision on the proposed action	Competent authority/ senior officers and elected representatives.
11. Monitoring and post-auditing the environmental consequences arising from project implementation	Technical specialists employed by developer, competent authority and other environmental control agencies; competent authority/ senior officers.

### **IMPORTANT PRINCIPLES IN MANAGING AN EIA**

#### *Principle 1*

##### **Focus on the main issues**

It is important that an Environmental Impact Assessment does not try to cover too many topics in too much detail. At an early stage, the scope of the EIA should be limited to only the most likely and most serious of the possible environmental impacts. The EIA's findings must be readily accessible and immediately useful to decision-makers and project planners.

*Principle 2***Involve the appropriate persons and groups**

Just as it is important not to waste time and effort on irrelevant issues, it is also important to be selective when involving people in the EIA process. Generally, three categories of participants are needed to carry out an EIA :

- Those appointed to manage and undertake the EIA process (usually a coordinator and staff of experts)
- Those who can contribute facts, ideas or concerns to the study, including scientists, economists, engineers, policy makers, and representatives of interested or affected groups.
- Those who have direct authority to permit control or alter the project that is the decision-makers—including for example the developer, aid agency or investors, competent authorities, regulators and politicians.

*Principle 3***Link information to decisions about the project**

An EIA should be organized so that it directly supports the many decisions that need to be taken about the proposed project. It should start early enough to provide information to improve basic designs, and should progress through the several stages of project planning in a typical sequence:

- When the developer and investors first broach the project concept, they consider likely environmental issues
- When the developer is looking for sites or routes, environmental considerations are used to aid the selection process
- When the developer and investors are assessing the project's feasibility an EIA is in progress, helping them to anticipate problems
- When engineers are creating the project design, the EIA identifies certain standards for the design to meet
- When a permit is requested, a completed EIA report is submitted, and also published for general comment
- When the developer implements the project, monitoring or other measures provided for in the EIA are undertaken.

*Principle 4***Present clear options for the mitigation of impacts and for sound environmental management**

To help decision-makers, the EIA must be designed so as to present clear choices on the planning and implementation of the project, and it should make clear the likely

results of each option. For instance, to mitigate adverse impacts, the EIA could propose:

- Pollution control technology or design features
- The reduction, treatment or disposal of wastes
- Compensation or concessions to affected groups

To enhance environmental compatibility, the EIA could suggest :

- Several alternative sites
- Changes to the project' design and operation
- Limitations to its initial size or growth.
- Separate programmes which contribute in a positive way to local resources or to the quality of the environment.

And to ensure that the implementation of an approved project is environmentally sound, the EIA may prescribe :

- Monitoring programmes or periodic impact reviews
- Contingency plans for regulatory action
- The involvement of the local community in later decisions.

#### *Principle 5*

##### **Provide information in a form useful to the decision-makers**

The objective of an EIA is to ensure that environmental problems are foreseen and addressed by decision-makers. To achieve this, decision-makers must fully understand the EIA's conclusions. Most decision-makers are unlikely to use information; no matter how important it is, unless it is presented in terms and formats immediately meaningful:

- Briefly present 'hard' facts and predictions about impacts, comment on the reliability of this information, and summarize the consequences of each of the proposed options.
- Write in the terminology and vocabulary that is used by the decision-makers and the community affected by the project
- Present the essential findings in a concise document, supported by separate background materials where necessary
- Make the document easy to use, providing visuals whenever possible.

##### **Before beginning the EIA**

Despite its usefulness in finding ways to make projects more successful, the full EIA process is not necessary for every kind of development project. For a major project, an EIA may use considerable resources and expertise. If a detailed EIA is not really needed, these resources can be put to better use elsewhere.

There are two 'tiers' of assessment which should be applied to the project before proceeding with a full EIA : *Screening* and *preliminary assessment*. Where these first tier of assessment are a regulatory requirement, the developer normally does the work and submits the results to the regulatory agency. The agency may then decide :

- There is nothing to be concerned about, or
- The evaluation should be processed to the next tier.

The advantage of a tier approach is that the extent of the inquiry expands with the advancing development of the project plans. 'Screening ' is appropriate when the project is only a rough concept. Later, when the project is under more general discussion, a 'preliminary assessment' can look deeper into possible sites and potential impacts. Then, just before the preliminary stages of feasibility and design work get underway, a full 'EIA study' can commence, so that it can influence the detailed decisions to come. This tier approach also ensures that impacts are examined at a very early stage in the project planning, and not later when sites or designs are already decided by other factors.

### SCREENING

Screening is the first and simplest tier of project evaluation. Screening helps to clear types of projects which in past experience are not likely to cause serious environmental problems. The exercise may take one of several forms :

- Measuring against simple criteria such as size or location
- Comprising the proposal with lists of project types rarely needing an EIA (e.g. schools) or definitely needing one (e.g. coal mines)
- Estimating general impacts (e.g. increased infrastructure needed) and comparing these impacts against set thresholds
- Doing complex analyses, but using readily available data.

### PRELIMINARY ASSESSMENT

If screening does not automatically clear a project, the developer may be asked to undertake a *Preliminary Assessment*. This involves sufficient research and expert advice to :

- Identify the project's key impacts on the local environment
- Generally describe and predict the extent of the impacts
- Briefly evaluate their importance to decision-makers.

The preliminary assessment can be used to assist early project planning.

## ORGANIZATION

If after reviewing a preliminary assessment the competent authority deems that a full EIA is needed, the next step for the project developer is the *Organization* of the EIA study. This entails :

- Commissioning and briefing an independent coordinator and expert study team (the disciplines that will be represented are decided after the 'scoping')
- Identifying the key decision-makers who will plan, finance, permit and control the proposed project, so as to characterize the audience for the EIA
- Researching laws and regulations that will affect these decisions
- Making contact with each of the various decision-makers
- Determining how and when the EIA's findings will be communicated.

## SCOPING

The first task of the EIA study team is '*Scoping*' the EIA. The aim of scoping is to ensure that the study addresses all the issues of importance to the decision-makers. First the study team's outlook is broadened – by discussion with the project developers, decision-makers, the regulatory agency, scientific institutions, local community leaders, and others – to include all the possible issues and concerns raised by these various groups. Then the study team selects primary impacts for the EIA to focus on, choosing on the basis of magnitude, geographical extent and significance to decision-makers, or because of special local sensitivities (*e.g.* soil erosion, the presence of an endangered species, or a nearby historical site).

### **Beginning of EIA study**

After '*scoping*', the EIA study itself begins. Simply put, the EIA study attempts to answer five questions

- (i) *What will happen as a result of the project?*
- (ii) *What will be the extent of the changes?*
- (iii) *Do the changes matter?*
- (iv) *What can be done about them?*
- (v) *How can decision-makers be informed of what needs to be done?*

After controls on the project's impacts are proposed in answer to question (iv), the study team may again ask: 'What will happen as a result of the (now revised) project?' Thus the EIA often becomes a cyclical process of asking and re-asking the first four questions, until decision-makers can be offered workable solutions.

## Identifications

The answer to the first question – ‘*What will happen as a result of the project?*’ – has already been partly addressed, but only in general terms: if a ‘preliminary assessment’ has been done, it will have broadly reviewed the project’s effects; also, ‘scoping’ will have focused the study on the most important issues for decision-makers. Taking these findings into account, the full EIA study now formally identifies those impacts which should be assessed in detail. This *Identification* phase of the study may use these or other methods:

- Compile a candidate list of key impacts—such as changes in air quality, noise levels, wildlife habitats, species diversity, landscape views, social and cultural systems, settlement patterns and employment levels – from other EIAs for similar projects. This should draw as many examples of similar projects as possible.
- Name all the project’s ‘sources’ of impacts (e.g. smoke emissions, water consumption, construction jobs) using checklists or questionnaires; then list possible ‘receptors’ in the environment (e.g. crops, communities using the same water for drinking, migrant laborers) by surveying the existing environmental and consulting with interested parties. Where the ‘sources’ may affect the ‘receptors’, a potential impact is suspected.
- Identify impacts themselves through the use of checklists, matrices, networks, overlays, models and simulations.

## Prediction

The next step, called *Prediction*, answers the EIA’s second question : *What will be the extent of the changes?* As far as is practicable, prediction scientifically characterizes the impact’s causes and effects, and its secondary and synergistic consequences for the environment and the local community. Prediction follows an impact within a single environmental parameter (e.g. a toxic liquid effluent) into its subsequent effects in many disciplines (e.g. reduced water quality, adverse impacts on fisheries, economic effects on fishing villages, and resulting socio-cultural changes). Prediction draws on physical, biological, socio-economic, and anthropological data and techniques. In quantifying impacts, it may employ mathematical models, photomontages, physical models, socio-cultural models, economic models, experiments or expert judgments.

To prevent unnecessary expense, the sophistication of the prediction methods used should be kept in proportion to the ‘scope’ of the EIA. For instance, a complex mathematical model of atmospheric dispersion should not be used if only a small amount of relatively harmless pollutant is emitted. Simpler models are available and are sufficient for the purpose. Also, it is unnecessary to undertake expensive analyses if they are not required by the decision-makers for whom the EIA is being done.

All prediction techniques, by their nature, involve some degree of uncertainty. So along with each attempt to quantify an impact, the study team should also quantify the prediction’s uncertainty in terms of probabilities or ‘margins of error’

It has been a shortcoming of many EIAs that social and cultural impacts are not given

the prominence they deserve in describing the extent of changes expected to result from a major development project. A consideration of socio-cultural impacts should be integrated.

### **Evaluation**

The third question addressed by the EIA – ‘**Do the changes matter?**’ – is answered in the next step. **Evaluation**, so called because it evaluates the predicted adverse impacts to determine whether they are significant enough to warrant mitigation. This judgment of significance can be based on one or more of the following :

- Comparison with laws, regulations or accepted standards
- Consultation with the relevant decision-makers
- Reference to pre-set criteria such as protected sites, features or species
- Consistency with government policy objectives
- Acceptability to the local community or the general public.

### **Mitigation**

If the answer to the third question is ‘Yes, the changes do matter’, then the EIA proceeds to answer the fourth question – ‘*What can be done about them?*’ In this phase, the study team formally analyses *Mitigation*. A wide range of measures are proposed to prevent, reduce, remedy or compensate for each of the adverse impacts ‘evaluated’ as significant. Possible mitigation measures include:

- Changing project sites, routes, processes, raw materials, operating methods, disposal routes or locations, timing, or engineering designs
- Introducing pollution controls, waste treatment, monitoring, phased implementation, landscaping, personnel training, special social services or public education
- Offering (as compensation) restoration of damaged resources, money to affected person, concessions on other issues, or off-site programmes to enhance some other aspect of the environment or quality of life for the community.

All mitigation measures cost something, and this cost must be quantified too.

These various measures are then compared, trade-offs between alternative measures are weighed, and the EIA study team proposes one or more ‘action plans’, usually combining a number of measures. The action plan may include technical control measures, an integrated management scheme (for a major project), monitoring, contingency plans, operating practices, project scheduling, or even joint-management (with affected groups). The study team should explicitly analyze the implications of adopting different alternatives, to help make the choices clearer for decision-makers. Several analytical techniques are available for this purpose :

- Cost/benefit analysis, in which all *quantifiable* factors are converted to monetary values, and actions are assessed for their effect on project costs and benefits.

- A simple matrix of environmental parameters versus mitigation measures, containing brief descriptions of the effects of each measure
- Pair wise comparisons, whereby the effects of an action are briefly compared with the effects of each of the alternative actions, one pair at a time.

It is the first and foremost duty of the investigator to provide a complete listing and description of mitigating measures which will minimize the adverse impact of the project on the biota. The suggested mitigation measures help the project authorities to monitor and mitigate the impacts on the biological components in the site.

These may be needed for taking mitigation measures for saving a particular species of plant or animal in the project site for saving a number of species through restoration of habitat. These needs depend upon the nature of the developmental projects and accordingly the mitigating measures are to be different to fit with the situation.

The most important mitigating measures to be considered for protection of biotic resources in the developmental sites are mentioned below:

- (i) During the construction phase and after the construction is over the wildlife habitats are to be restored
- (ii) Attempts are to be taken to retain the trees as far as possible
- (iii) The natural water sources are to be retained in original or modified state
- (iv) New wildlife habitats within the site area are to be developed
- (v) The threatened species of animals are to be translocated prior to the project activity is initiated. All or some of them are to be retranslocated after the construction phase is over
- (vi) Developmental projects fragment the wildlife habitat into patches. These patches are to be linked by construction of tunnels, over bridges, etc. for migration of wild animals
- (vii) Measures should be taken to remove the plant specimens of importance during preparation and construction phases and these are to be replanted in the site after completion of construction phase.
- (viii) Compensatory afforestation should be done.

### Documentation

The last step in the EIA process, which responds the last question – ‘How can decision-makers be informed of what needs to be done?’ – is the *Documentation* of the process and the conclusions. Recall that the purpose of an EIA is to ensure that potential problems are foreseen and addressed in the project’s design. The EIA can achieve its purpose only if its findings are well communicated to decision-makers.

Generally, to produce effective communications, one must identify the target audience or audiences, and then shape and style the publication to meet their specific needs. In documenting an EIA, this means identifying the key decision-makers, perceiving the questions they will be asking, and providing them with straightforward answers, formatted for easy interpretation in relation to their decision-making (e.g. tables, graphs, summary points). Successful EIA documentation is more readily produced if the audience and their needs are established at the start of the EIA, and then made to affect how the research is focused and reported.

So that decision-makers can look more deeply into particular issues, the EIA report should also include a record of the EIA process and the judgments made by the study team. An EIA report typically contains:

- An executive summary of the EIA findings
- A description of the proposed development project
- The major environmental and natural resource issues that needed clarification and elaboration
- The project's impacts on the environment (in comparison with a baseline environment as it would be without the project), and how these impacts were identified and predicted
- A discussion of options for mitigating adverse impacts and for shaping the project to suit its proposed environment, and an analysis of the trade-offs involved in choosing between alternative actions
- An overview of gaps or uncertainties in the information
- A summary of the EIA for the general public

All of these should be contained in a very concise, easy-to-read document, with cross references to background documentation, which is provided in an appendix. (The short document is sometimes called an 'Environmental Impact Statement', especially when it is submitted as part of a permit application).

### **Using the results**

Decisions based on the EIA are usually made by persons who have not been closely involved with the day-to-day progress of the EIA study. Their first consideration of the project may well be the moment they pick up and skim through the EIA report. The EIA will hopefully tell them all they need to know about 'what will happen as a result of the project', 'the extent of the changes', 'whether the changes matter', and 'what can be done about them' But the decision-makers themselves must also consider political realities when selecting a course of action. Only decision-makers are in a position to balance the project's needs and problems with the other needs and problems over which they have

jurisdiction. They must take into account not only the facts of the situation, but also people's perceptions:

If the project is accepted, perhaps with recommended modification, then the decision-maker may need to take two further actions:

- Prepare a plan for reducing conflicts about the project; this may include public participation in planning, public education, and actions to compensate affected groups
- Allocate institutional responsibilities for overseeing the developer's adherence to its environmental requirements, for incorporating environmental management into further planning, and for enforcing any restrictions or carrying out any monitoring.

Sometimes, the competent authority sends the EIA to a review panel for comment on its adequacy and quality, before reaching its decision. The decision-maker may call for further study to answer additional questions about the project. The decision-maker may also ask that an opportunity be provided for public review and involvement. The competent authority simply places copies of the report on public display, and invites the public to comment. The EIA team may then be asked to re-draft the EIA to take account of the comments made, before a decision is taken. In cases where the decision-maker chooses to reject the proposed project altogether; there should be an appeal process open to the project developers.

The EIA's usefulness does not end with the decision on a course of action about the project. It still has several further contributions to make to the project's success:

- If the project goes ahead with recommended changes, the EIA's findings should be used to help shape the project to suit the environment, by influencing engineering designs
- Decisions that need to be in the latter phases of project planning, such as precisely where to route supporting road or rail links, should be based on the EIA
- The EIA's precautions on environmental impacts can be part of the brief for tendering on contracts, and should be re-drafted as environmental safety guidance for workers.

Lastly, after the project is completed, a 'post audit' can be done to determine how close the EIA's predictions were to the project's real impacts. This forms a valuable record for others doing EIAs on similar projects in the future.

### **Resources needed for an EIA**

Certain minimum resources are needed to perform EIAs that can successfully shape major projects :

- **Qualified multi-disciplinary staff**, includes a skilled manager (to co-ordinate the activities, communicate with decision-makers, and motivate the study team), trained

specialists (in fields such as environmental science, rural and urban planning, economics, waste and pollution control, process engineering, landscape design, sociology and cultural anthropology), and a communications expert.

- **Technical guidelines, agreed with the competent authority**, for carrying out the various phases of the EIA process, especially screening, scoping, prediction, evaluation and mitigation.
- **Information about the environment** (especially relating to the impacts being considered after 'scoping') which can be sorted and evaluated.
- **Analytical capabilities** for doing field work, laboratory testing, library research, data processing, photomontage, surveys and predictive modeling.
- **Administrative resources** for the day-to-day running of the EIA process, including office staff, meeting rooms and support, communication facilities and records management.
- **Institutional arrangements**, including a formal procedure for consultation with the decision-makers and other interested groups, the authority to obtain the necessary information of the proposed project, and a formal process for integrating the EIA into decision-making about projects.
- **Review, monitoring and enforcement powers**, to ensure that accepted mitigation measures are included in the development.

## METHODOLOGIES FOR IDENTIFICATION OF IMPACT

The impact identification or assessment has been subject of a large number of proposed methods and techniques, which are often been called EIA techniques. The methods constitute useful aids in identification of impacts in a structured and systematic way.

The methods which were started in use in 1970's in USA and Canada involve a lot of tools to perform tasks within the EIA. These tools are impact checklists, impact matrices, map overlays, cause-condition-effect- networks and spatial impact assessment method (SIAM).

### Checklist method

The checklist method is a common, simple and inexpensive method. It is basically a method for summarizing environmental impacts in the sense that it starts with a list of potential impact areas. The most common checklists are listed below :

(a) *Simple checklists* – It lists the components or aspects, usually the environment that might be considered by the assessment, but no other assistance is provided to guide the impact identification process. In table 4 an example of a simple checklist is given.

Table 4. Typical project Check-list by Impact Area

Construction phase				Operation Phase		
Potential Impact Area	Adverse effect	No effect	Beneficial effect	Adverse effect	No effect	Beneficial effect
<b>A. Land Transformation and Construction</b> (a) Compaction and setting (b) Erosion (c) Ground Cover Deposition (sedimentation, precipitation) (d) Deposition (sedimentation, precipitation) (e) Stability (slides) (f) Stress-strain (earthquake) (g) Floods (h) Waste control (i) Drilling and blasting (j) Operational failure <b>B. Land Use</b> (a) Open space (b) Recreational (c) Agricultural (d) Residential (e) Commercial (f) Industrial <b>C. Water Resources</b> (a) Quality (b) Irrigation (c) Drainage (d) Groundwater <b>D. Air Quality</b> (a) Oxide (sulphur), carbon, nitrogen) (b) Particulate matter (c) Chemicals (d) Odors						

Construction phase				Operation Phase		
Potential Impact Area	Adverse effect	No effect	Beneficial effect	Adverse effect	No effect	Beneficial effect
(e) gases <b>E. Service System</b> (a) Schools (b) Police (c) Fire Production (d) Water and power systems (e) Sewerage system (f) Refuse disposal <b>F. Biological Conditions</b> (a) Wildlife (b) Trees, shrubs (c) Grass <b>G. Transportation System</b> (a) Automobile (b) Trucking (c) Safety (d) Movement <b>H. Noise and Vibration</b> (a) On-site (b) Off-site <b>I. Aesthetics</b> (a) Scenery (b) Structures <b>J. Community Structure</b> (a) Relocation (b) Mobility (c) Services (d) Recreation (e) Employment (h) Housing quality <b>K. Other (List as appropriate)</b>						

(b) *Descriptive checklists* – It provides additional assistance by indicating, for example, the specific variables to be measured to characterize each component.

(c) *Scaling checklists* – It helps to assess importance or significance of suspected impacts. Here the criteria are assigned with letters of numeric scales, to indicate the importance of impacts. The suspected impact can be estimated in broad terms and given a value to represent its significance.

(d) *Questionnaire checklists* – It is a form of scaling checklist but uses a series of questions and their answers elicit information about possible impacts and their likely importance. The following questions (after Shukla and Srivastava 1992) are used for assessment of impact on biota.

1. What are the possible negative impacts that might affect the biota of the area?
2. Which biotic habitats will be impacted?
3. Within each affected habitat, which species have biological significance?
4. Are individual specimens involved, and, if so, how they will be impacted?
  - i. Do they have historic value?
  - ii. Do they have aesthetic value?
  - iii. Do they have scientific or educational value?
  - iv. Do they have sport commercial value?
5. Will there be short term biotic impacts?
  - i. Which species will be displaced from the site?
    - a. Will they pose a problem to surrounding areas?
    - b. Will their displacement create ecological problems ?
  - ii. Which species will be destroyed on site and what will be the ecological consequences?
  - ii. Which species may invade the disturbed site from adjacent areas?
6. Will there be long-term biotic impacts?
  - i. What will be the effects of the loss of native plants and animals on the site and adjacent region?
  - ii. What problems may result from the encroachment of weedy species?
  - iii. To what extent diurnal and seasonal movement of animals will be disturbed?
  - iv. To what extent food and water supply to biotic community will be affected?
  - v. To what extent there will be loss of shelter, nesting Land breeding ground?
  - vi. What problem will result from the loss of fisheries?
  - vii. What will be consequences of noise-air-water pollution resulting from the project activities?

7. What are all possible impacts that might occur as a result of the project?

- i. Will beneficial species be enhanced?
- ii. Will the project reduce pressure on the adjoining forest?

### Matrices

Matrix methods basically incorporate a list of project activities or actions with a checklist of environmental conditions or characteristics that might be affected. The project activities are cross-tabulated with environmental components. Table 5 provides an illustrative example of the matrix method.

**Table 5.** Illustrative matrix Approach to Comparing Environmental impact of Actions on Existing Characteristics and Conditions of the environment

Proposed Action	Modification of Habitat	Alternative of Hydrology and drainage	Surface paving	Noise and vibration	Vibration	Cut and fill (land fill)	Erosion control	Land-scaping	Traffic circulation
Land Form	B	C	B	A	B	C	C	D	B
Water Recharge	A	B	B			B	A	D	
Climate	A				A				
Floods-stability	C	C	B			A	D		
Stress-Strain (Earthquake)	B	C			A	B	A		
Open Space	D		D	B	C			D	B
Residential	D				D				
Health & safety	D	B	B		B	B	A		C
Population									
Density	B			A	B				
Structures	B	B	B		B	B	A		B
Transportation	B	C	B	A	B	B	A	D	B,C

Legend : A = Insignificant low impact not injurious to land and environment

B = Measurable impact, but with proper planning and building is not injurious to land.

C = High impact on environment, but can be changed by taking proper precautionary measures

D = Impact on environment, but considered good

E = Impact that will be detrimental to environment

### Map Overlays

Map overlays may be used to identify geographic areas where the environmental load or the sensibility of the environment to a load is high. The maps of different properties and environmental loads are superimposed.

**Network diagrams**

Network methods are basically an attempt to recognize that a series of impacts may be triggered by a project action. This may be used to illustrate linkages and higher order effects in the system. This method provides a “roadmap” type of approach to the identification of second and third order effects.

**Spatial Impact Assessment Methodology (SIAM)**

Spatial Impact Assessment Methodology (SIAM) is based on the assumption that the importance of environmental impacts is dependent, among other things, on the spatial distribution of the effects and of the affected environment. This method depends on the evaluation of the spatial significance of impacts, using information generated within the EIA process, with the support of Geographical Information Systems (GIS). The information generated by the use of GIS in impact identification and prediction stages of EIA is used in the assessment of impact significance by the computation of set of impact indices.

**ENVIRONMENTAL IMPACT ASSESSMENT w.s.r. TO BIORESOURCES**

The bioresources are most important components of environment and requires a special attention in assessing the impact of development projects on environment. The bioresources in any ecosystem are unique in their diversity as well as complexity in their relationship with other abiotic components of the environment. These complexities poss special problem in assessing the impact of a project on them.

**Aspects to be considered**

While undertaking EIA studies w.s.r. to biota the following aspects are to be considered :

1. Whether there is any wildlife sanctuary near the site
2. Whether the project will be detrimental to wildlife
3. Whether the sites serve as the breeding and foraging site of any animal occurring there
4. Whether the site falls under any migratory route of any birds and mammals
5. Whether the site is a potential wildlife sanctuary
6. Afforestation and deforestation feasibility
7. Faunal and floral rehabilitation possibility
8. Whether the site supports economically viable plants and animals.

**Assessment of Impact of Developmental Projects on Bioresources**

Considering the complexity and variability of ecosystems and their recovery capabilities, the impact on the biotic components are categorized as direct and indirect and short term

and long term. Direct impacts destroy or displace plant or animals, whereas indirect impacts destroy or disrupt habitats, ecosystems or other physical and biological factors upon which a species depends. Short term impacts are those which cause immediate and direct environmental changes while developing the project, but minimized after the mitigation measures are adopted. Long term effects are resulted during operational phases of the project and difficult to minimize the impact. The nature of impacts on plants and animals in project area vary greatly depending upon the project activities. Some project activities and their impacts on biota are shown in Table 6.

**Table 6.** Typical impacts of some developmental activities on bioresources

<b>Activity</b>	<b>Types of impact</b>	<b>Adverse</b>	<b>Beneficial</b>
1. Agriculture	(a) Encourages a few species	+	+
	(b) Habitat destruction	+	-
	(c) Loss of native plants and animals	+	-
	(d) Increase in pest species	+	-
2. Dams and reservoirs	(a) Create shore line ecosystems	-	+
	(b) Potential increase in species type	+	+
	(c) Habitat destruction	+	-
	(d) Loss of native plants and animals	+	-
3. Power plant Construction and operation	(a) Alternation of breeding and feeding activities	+	-
	(b) Change in form of aquatic life due to heating of adjacent waters	+	-
	(c) Potential loss of wildlife	+	-
4. Roads, highways, railroads, airports	(a) Increase 'Edge effect'	-	+
	(b) Disturb corridors and natural movement	+	-
	(c) Increase 'Road Kills'	+	-
5. Communications and utility towers	(a) Create new roosting and resting sites for birds	-	+
	(b) Interfere with migration of birds	+	-
6. Gas and oil pipe lines	(a) Interfere with daily and seasonal animal migration	+	-
7. Industrial, commercial and residential development	(a) Increase pest species	+	-
	(b) Habitat destruction	+	-
	(c) Increase 'Edge effect'	-	+

The analysis of impacts as mentioned in Table 6 indicates that there are a number of negative impacts of development projects on wildlife as summarized below :

- Destruction of or disturbance in vegetation
- Reduction or fragmentation of wildlife habitat resulting death or displacement of wildlife
- Disruption or destruction of migration routes for wildlife
- Disruption or destruction of nesting, mating and other activities of wildlife
- Increase of "Road kills"
- Change in species composition and increase in pest species.

### METHODS FOR ASSESSMENT OF BIORESOURCES IN THE SITE

#### Assessment of physical features

The biological resources or biotic components present in the development project site are of great concern of assessment for an investigator. The living of plants and animals in a particular habitat depends upon the nature of the habitat mainly the physical features of the site, *viz.*, topography, rainfall, wind, light, soil type, etc. Thus, biotic assessment should first consider the physical features of the site and its surroundings. A summary of the physical features to be studied is given in table 7.

Table 7. Physical features of the proposed project site to be studied

Physical features	Description
A. Geography	<ul style="list-style-type: none"> <li>● Elevation off-and-on site</li> <li>● Drainage system</li> <li>● Presence of ocean, lake, river, pond, marsh.</li> </ul>
B. Geology and Soils	<ul style="list-style-type: none"> <li>● General geological important features</li> <li>● Major rock types</li> <li>● Soil physico-chemical features</li> </ul>
C. Climate	<ul style="list-style-type: none"> <li>● Average annual rainfall and snowfall</li> <li>● Average annual and seasonal changes in temperature</li> <li>● Wind characteristics.</li> </ul>
D. Others	<ul style="list-style-type: none"> <li>● Utility</li> <li>● Noise – source</li> <li>● Any other features of special interest</li> </ul>

#### Assessment of bioresources : Inventorization of fauna and flora :

Prior to the assessment of impact of development project on fauna and flora of the site, the detail lists of plants and animals are to be prepared on the basis of the existing

literature. If the literatures contain the information of recent intensive surveys then the lists prepared are sufficient to proceed further in the process of preliminary assessment of impacts. Further, to get the actual information on the present biotic resources, field survey is to be conducted in and around 25 sq.km. of the project site in different seasons of the year. During field survey the investigator should consider the aspects like ecological conditions of different ecosystems, their species composition, community structure, population structure and behavior mainly feeding, migration and breeding and other biological aspects. The specimens collected and/or observed in the field are to be identified by expert taxonomists and a list of the species from the area with special mention of species which are important from the conservation point of view and their legal status as per Wildlife (protection) Act, 1972 and consequent amendments is to be prepared.

### ● Quantitative analysis of bioresources

Estimation of population density of different species of plants and animals is the most important criteria for assessment of bioresources. There are a number of techniques for quantitative analysis of which few simple ones are briefly discussed below.

**Plants :** To begin with some sample plots of the size from 0.1m<sup>2</sup> to 100m<sup>2</sup> or more are selected at random or systematically. The number of specimens of one species in the area samples is counted and density is calculated by the following formula.

$$\text{Density} = \frac{\text{Number of specimens of one species}}{\text{Area sampled}}$$

$$\text{Relative density} = \frac{(\text{Density of a species})}{\text{Total density of all species)} \times 100$$

**Animals :** The dynamicity and variability in animals cause more problems in quantitative analysis of fauna. The methodology varies according to the habitats and behavior of animal groups. The following methods are usually followed:

- **Direct count :** In this method direct count of animals is made in the feeding grounds, resting sites, rutting and breeding grounds and in roosts. This method is generally followed in case of herding animals and flocking birds.
- **Sample plots :** The counting is done directly in the sample plots for sedentary or attached animals and burrowing species.
- **Count indices :** This method is applied for indexing of various species in an area which can be obtained by identifying and counting of animal signs like pug marks, faecal matters, scratch on ground or trees, calls or road side counts. This method helps to compare the quantitative and qualitative status of different species through the seasons, between sites or habitats. For counting the species which frequently cross the road or can be observed from the road the roadside count is very useful method. For example, a count was made at every 0.5 km interval for a distance of 5 km and the result was recorded as mentioned in the table below :

Km. from starting	Count of species1	Count species 2	Count of species 3
05	1	-	-
10	-	-	-
15	-	2	-
20	-	1	1
25	2	-	-
30	-	-	-
35	-	-	2
40	1	3	-
45	-	2	-
50	-	1	1
Total	4	9	4

Thus, the census index can be obtained by the following formula :

$$\text{Census index} = \frac{N}{\text{Km}}$$

Where N = Total number of individuals of a species observed

Km = Total distance travelled

**Catch – Mark – Recapture (C.M.R.) :** This is a most suitable method for estimation of population size of a species particularly for those which can be easily trapped or netted. First a portion of population in an area is captured and then released after marking each individual. Then after a fixed interval of time another sample is collected from the same area, the total number as well as marked specimens in the sample is made. The population size is then estimated by the following formula:

$$N = \frac{T}{t/n} \text{ or } \frac{nT}{t}$$

Where T = Number of originally marked specimens

t = Number of marked specimens recaptured

n = Total number of specimens in the second collection

N = Population size

### Estimation of valuation of bioresources

The developmental project, if implemented and continued to work, some biological resources are invariably be sacrificed. In such cases, to prepare the account of loss and profit estimation of valuation of biological resources is an important task of the investigator. In doing the job the following three main approaches are used.

i) **Consumptive-use valuation :** It involves assessment of valuation of resources like firewood, fodder, game, meat; etc. that are consumed directly, without passing through the market.

ii) **Productive-use valuation** : It involves assessment of valuation of resources like timber, medicinal plants, fish, meat, ivory, etc. which are commercially harvested and marketed.

iii) **Non-consumptive-use valuation** : It involves estimation of valuation of ecosystem functions, such as photosynthesis, soil formation, watershed protection, animal shelter, food, etc.

Finally all data on biotic resources in the study area collected both from primary and secondary sources are assessed in a flow chart fashion (after Shukla and Srivastava 1992) as mentioned below:

1. What is the existing vegetation?
  - i. Weeds
  - ii. Ornamental plants
  - iii. Grassland
  - iv. Shrub
  - v. Forest
  - vi. Other vegetation.
2. Are there any unique vegetative features?
  - i. Rare or endangered species
  - ii. Species with high visual, historic or aesthetic value
  - iii. Plants associated with particular habitat such as stream, acid soil, shade, etc.
  - iv. Threats posed by individual plant species or vegetation (for example, poisonous, fire potential, disease, etc.)
  - v. Wild varieties of domestic stocks
  - vi. Plants of medicinal importance
  - vii. Schedule species.
3. Should any plant or communities be retained or preserved? Answers to questions 1 and 2 will lead to the answer of this question.
  - i. Should specimens of a species be saved?
  - ii. Should a representative plant community be saved?
  - iii. Should a particular natural habitat be saved?
4. What is the existing animal life?
  - i. Mammals
  - ii. Birds
  - iii. Reptiles and Amphibians

- iv. Fish
  - v. Insects and other Arthropods
  - vi. Other animals.
5. Are there any unique faunal features?
- i. Critical, Endangered, Vulnerable, Rare species
  - ii. Species of high visual, historic or aesthetic value
  - iii. Schedule I species
  - iv. Migratory species
  - v. Indicator species
  - vi. Threats posed by animal species (for example, poisonous species, disease carrier, crop depredating species, etc.).
6. What natural habitats are present?
- i. Are any of the habitats suitable for threatened or economically important species?
  - ii. Are any of the habitats important for wildlife productivity (for example, sports of fish, tourism, educational, commercial, etc.).
7. Does the area serves as a corridor for migratory species ?
8. Does the area serves as only breeding ground for a species occurring in the region?
9. What is the approximate valuation of the biological resources of the area?
10. What are the population estimates of the species of conservational importance?
11. What type of natural habitats will be destroyed by the project?
- i. Forest
  - ii. Grassland
  - iii. Wetland
  - iv. Rock
  - v. Desert
12. What are the sonic problems of the area in relation to wildlife? This factor is to be analyzed in respect of present construction and operational stages.

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## **LAW AND ENVIRONMENT**

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### **INTRODUCTION**

The word 'environment' is derived from an French word 'environ' meaning 'encircle' Earth's environment is a rich heritage handed over to us by previous generations.

With the pattern of rapid economic growth during the last few decades, the utilisation of natural resources has increased exponentially to a point where the livelihood of physical constraints has suddenly become evident. Consequently, there is a growing number of increasingly urgent environmental problems to be tackled. Needless to mention that by consuming, polluting or wasting natural resources like energy, raw materials, genetic resources, and air-water-land and natural vegetation we have failed to realise that they have a definite capacity for regeneration and therefore, we have been unconsciously living beyond our means.

During the period between fifties and sixties people all over the world became more concerned about the quality of their environment.

Well-known environmental tragedies, like the cases of mercury poisoning in Minamata (Japan), severe smoke pollution episodes in London and the massive oil spill caused by the Terrey Canyon accident reinforced in people's mind, the sense that the quality of air, water and a wide range of other natural resources was being seriously degraded. The intensity of danger from chemicals can be gauged from the extent of havoc caused by the accident in a pesticide factory at Bhopal on December, 1984 which killed over 3000 people, blinded several thousands and affected over 1,50,000 people.

### **BACKGROUND OF ENVIRONMENTAL LAWS**

Law is born out of social, economic and political causes. The first law for protecting nature was implemented in India during British Rule. The year was 1905 and the whole of Bengal was caught up in the tide of the revolutionary movement following the partition of Bengal.

Amidst the storm, inconspicuous for the moment, was born in Calcutta, the Bengal

Smoke Nuisance Act, its purpose being mainly to preserve the dazzling whiteness of Victoria Memorial. The British had come to our country to rule, not to serve. Hence in matters regarding the preservation of balance in nature in India they bore neither concern nor responsibility. Their thoughts remained limited within the borders of their own profits. Following the end of the British Rule India plunged into a series of troubles - communal riots, the partition, external wars causing conflicts and disintegration, problems which glaringly and prominently stares us into the face even today. Hence India has not been able to pay proper attention to matters relating to environment. The Five Year Plans were implemented with a view to the economic development of the country. The Second Five Year Plan designed for industrial development paid no attention to the harmful consequences that nature would have to face with the growth of industry. Hence the plans remained unconcerned about protecting nature. This implies a lack of a sense of responsibility about protecting the environment and there was no awareness of the necessity of preserving it until the beginning of the seventies when a law for the protecting of the environment was passed.

The United Nations Conference on the Human Environment, held at Stockholm, Sweden, in June 1972, was the first comprehensive international attempt to articulate the interrelationship between the quality of environment, a growing world population, and the world economic growth needed to sustain it. The conference recongnized the need for specific national and international actions to ensure that economic growth is planned in full appreciation of the long term value of environmental protection and natural resources conservation.

Since 1974, number of acts were enacted for the protection of environment and also there are other acts which can enforce for the protection of environment by the different enforcing authorities i.e. Police Authority, Local Authority, District Administration, Chief Inspector of Factories, Fisheries Dept., etc. Department of Environment and W.B. Pollution Control Board are now the main enforcing authorities to protect the environment exercising its power under the provisions of Warter (Prevention & Control of Pollution) Act, 1974, Air (Prevention & Control of Pollution) Act, 1981 and Environment (Protection) Act, 1986 and Rules made thereunder.

### **RESPONSIBILITIES OF THE STATE POLLUTION CONTROL BOARD**

- to plan a comprehensive programme for the prevention, control or abatement of pollution from different sources;
- to advise the State Government on any matter concerning the prevention, control or abatement of pollution;
- to collect and disseminate information relating to pollution and the prevention, control or abatement there of;
- to encourage, conduct and participate in investigations and research relating to environment;
- to inspect sewage or trade effluents and pollution control system of the industries

and local bodies in connection with the grant of consent as required under the environmental Acts;

- to lay down, modify or annual discharged standards for the sewage and trade effluent and gaseous substances;
- to evolve economical and reliable methods of treatment of sewage, trade effluents and gaseous substances;
- to evolve methods of utilisation of sewage and suitable trade effluents in Agriculture;
- to evolve efficient methods of disposal of sewage, trade effluent and hazardous waste;
- \*● to issue regulatory order in form of closure, disconnection of electricity or any other order in accordance with law against the recalcitrant units in respect of environmental pollution;

### **POLLUTION CONTROL LAWS PRESENTLY EXECUTED BY THE STATE POLLUTION CONTROL BOARD**

#### **1. Water (Prevention & Control of Pollution) Act, 1974**

*Intention of the Act* : The main intention of the Act to control water pollution in the stream, well or in land as defined under the Act.

- i) Constitution of the State Board (Sec. 4)
- ii) Terms and conditions of service of members (Sec. 5)
- iii) Functions of the State Board (Sec. 17)
- iv) No industrial unit can establish or operate (Sec. 25)
- v) Refusal or withdrawal of the consent (Sec. 27)
- vi) Power to give direction to the industries including closure and disconnection of electricity and water line (Sec. 33A)
- vii) Penalty for contravention of section 25 (Sec. 44)
- viii) Power of State Govt. to make rules (Sec. 64)

#### **2. Water (Prevention & Control of Pollution) Cess Act, 1977**

*Intention of the Act* : The main intention of the Act to augment the resources of the State Board.

- i) Local bodies and specified industry are liable to pay cess (Sec. 3)
- ii) Assessment of Cess (Sec. 6)
- iii) Interest payment for delay in payment of cess (Sec. 10)
- iv) Penalty proceedings against non payment of cess (Sec. 11)
- v) Power to file complaint case against defaulting units (Sec. 14)

### 3. Air (Prevention & Control of Pollution) Act, 1981

**Intention of the Act :** The main intention of the Act is to control air pollution generated from the industries. Under this Act, State Board is also entrusted to fix up standard for automobile emission.

- i) No industrial unit can establish or operate without consent (Sec. 21)
- ii) Power to give direction including closure and disconnection of electricity and water line (Sec. 31A)
- iii) Penalty for contravention of the provisions of the Act (Sec. 39)
- iv) Power of the State Govt. to make rules (Sec. 54).

### 4. The Environment (Protection) Act, 1986

**Intention of the Act :** The main intention of the Act is to control environmental hazards in different aspects and for this reasons, a number of rules have been notified for the purpose of controlling pollution from different sources.

- i) Power of the Central Govt. (Sec. 3)
- ii) Appointment of Officers by the Central Govt. (Sec. 4)
- iii) Power to give direction of closure, disconnection of electricity and water line (Sec. 5)
- iv) Penalty for contravention of the provisions of the Act (Sec. 15)
- v) Power to make rules (Sec. 25)

### 5. Hazardous Waste (Management & Handling) Rules, 1989

**Intention of the Rule :** The main intention of the Rule is to look after the storage, treatment and disposal of hazardous wastes in order to control the indiscriminate dumping of hazardous waste generated from the different industries.

- i) Grant of authorization for handling hazardous wastes (Rule 5)
- ii) Inventory of Disposal Site (Rule 8)
- iii) License for import of Hazardous Waste (Rule 11)

### 6. Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989

**Intention of the Rule :** The main intention of the Rule is to control the import of hazardous Chemicals which are not permitted to import under this Rule.

- i) Notification of major accidents (Rule. 5)
- ii) Notification of sites (Rule 7)
- iii) Permission for Import Hazardous Chemicals (Rule 18).

**7. Public Liability Insurance Act, 1991**

**Intention of the Act :** The main intention of this Act is to offer compensation to the people who have become affected due to environmental accident, living outside the factory.

- i) Liability of the Industry (Rule 4)
- ii) Penalty for contravention of Section 4 (Rule 14)

**8. Bio-Medical Waste (Management & Handling) Rules, 1998**

**Intention of the Rule :** The main intention of the Rule is to look after the storage, treatment and disposal of Bio Medical Waste in environmentally safe manner of Bio-Medical Waste generated by different health care establishments like Hospitals, Nursing Homes and Pathological Clinics.

- i) Duty of the Health Care Unit (Rule 4)
- ii) Authorization of the Health Care Units (Rule 8)

**9. Recycled Plastics Manufacture and Usage Rules, 1999**

**Intention of the Rule :** The main intention of the Rule is to put some restrictions on the use of plastic carry bags.

- i) Prescribed Authority to implement the Rule (Rule 3)
- ii) Prohibition of usage of carry bags (Rule 4)
- iii) Condition of Manufacture of carry bags (Rule 5)

**10. Environment (Protection) (Second Amendment) Rules, 1999 regarding standard of fire works.**

**Intention of the Rule :** The main intention of the Rule is to fix up the standard of fire works.

- i) Noise standard of fire works (Rule 89)

**11. Noise Pollution (Regulation and Control) Rules, 2000**

**Intention of the Rule :** The intention of the Rule to control noise pollution from microphones.

- i) Responsibility as to enforcement of Noise Pollution Control Measures (Rule 4)
- ii) Restriction of use of loud speakers (Rule 5).

**12. The Municipal Solid Wastes (Management & Handling) Rules, 2000**

**Intention of the Rule :** The main intention of the Rule to dispose the Municipal Solid Waste in a scientific manner.

- i) Responsibility of the Municipal Authority (Rule 4)
- ii) Responsibility of the Central Pollution Control Board and State Board (Rule 6).

**RESPONSIBILITY OF THE OTHER ENFORCING AUTHORITIES FOR  
CONTROLLING POLLUTION IN DIFFERENT ASPECTS OF LIFE.**

Classified Sections	Enforcing Authorities
<p><b>a. Water Pollution</b></p> <p>Indian Penal Coade, 1860. Sec. 269, 277, 430 to 432.</p> <p>Criminal Procedure Code (as amended in 1973) Sec. 133, 143, 144</p> <p>The Police Act, 1861. (Act V of 1861) Sec. 34(8)</p> <p>Factories Act, 1948 Sec. 11, 12, 18, 19, 42, 89</p> <p>West Bengal Municipal Act, 1993 Sec. 257, 333, 339, 340, 349, 354, 358, 361</p> <p>Calcutta Municipal Corpn. Act, 1993. Sec. 290, 294, 298, 303, 309, 336, 470, 496, 502, 503, 509.</p> <p>Calcutta Metropolitan (Water &amp; Sanitation Authority) Act, 1966. Sec. 46, 47, 49, 50, 52, 53, 55, 57, 58, 59, 63, 64, 65, 67, 68, 70.</p> <p>West Bengal Inland Fisheries Act, 1984. Sec. 3, 4, 5, 6, 8(1).</p> <p>The West Bengal Panchayat Act, 1973 Sec. 26, 27, 28, 29.</p> <p>Howrah Improvement Act, 1956. Sec. 33(1), 42(1) &amp; (3), (b), (c), (e), 64(1), (4).</p> <p>Howrah Municipal Corpn. Act, 1980 Sec. 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 145, 146, 148, 149, 150, 152, 153, 154, 155, 157, 158, 185, 212(1).</p>	<p>Police Authority</p> <p>District Magistrate, Executive Magistrates.</p> <p>Police Authority</p> <p>Factory Directorate</p> <p>Municipal Authority</p> <p>Calcutta Municipal Corpn.</p> <p>Local Authority</p> <p>Fishery Dept.</p> <p>Panchayat</p> <p>Howrah Municipal Corpn.</p> <p>Howrah Municipal Corpn.</p>

Classified Sections	Enforcing Authorities
<p><b>b. Air Pollution</b></p> <p>Indian Penal Code, 1860 Sec. 269, 278, 290.</p> <p>Criminal Procedure Code, 1973 Sec. 133(1) (c), 143, 144.</p> <p>Motor Vehicles Act, 1988. Sec. 190</p> <p>Factories Act, 1948 Sec. 12, 14, 16, 36, 37, 87, 89</p> <p>The West Bengal Motor Vehicles Rules, 1989. Sec. 258.</p> <p>Central Motor Vehicles Rules, 1989 Sec. 115, 116</p> <p>The Police Act, 1861 Sec. 34(3) &amp; (5)</p> <p>Howrah Municipal Corpn. Act, 1980. Sec. 191</p> <p>The Explosives Act, 1884 Sec. 6, 6A.</p>	<p>Police Authority</p> <p>District Magistrate, Executive Magistrate.</p> <p>Transport Dept.</p> <p>Factory Directorate.</p> <p>Transport Department.</p> <p>Transport Department.</p> <p>Police Authority</p> <p>Howrah Municipality</p> <p>District Magistrate, Calcutta Police Explosive Dept.</p>
<p><b>c. Noise Pollution</b></p> <p>Statutory guideline of Hon'ble High Court, Calcutta, in respect of use of microphone and fire works.</p> <p>Calcutta Police Act, 1866. Sec. 43C, 43D.</p> <p>Calcutta Suburban Police Act. Sec. 39A, 39c.</p> <p>The Police (West Bengal Amendment) Act, 1963. Sec. 34A.</p> <p>Motor Vehicles Act, 1988. Sec. 190.</p> <p>The West Bengal Motor Vehicles Rules, 1989. Sec. 258, 294</p>	<p>W.B. Pollution Control Board and Police Authority.</p> <p>Calcutta Police</p> <p>Calcutta Police</p> <p>Police Authority</p> <p>Transport Dept.</p> <p>Transport Dept.</p>

Classified Sections	Enforcing Authorities
Howrah Municipal Corpn. Act, 1980 Sec. 193	Howrah Municipal Corpn.
The Explosives Act, 1884 Sec. 6, 6A.	District Magistrate Calcutta Police Explosive Dept.
<b>d. Environmental Pollution (*)</b>	
Indian Penal Code, 1860 Sec. 268, 290, 425.	Police Authority
Criminal Procedure Code (as amended in 1973). Sec. 133, 143, 144.	District Magistrate Executive Magistrate
Police Act, 1861. Sec. 34	Police Authority
Factories Act, 1948. Sec. 42, 87, 89, 90	Factory Directorate
West Bengal Municipal Act, 1993 Sec. 202, 270, 272, 278, 282, 283, 330, 331, 333, 343, 347, 349, 355, 356, 357, 361, 362.	Municipal Authority
Calcutta Municipal Corpn. Act, 1980. Sec. 299, 332, 336, 338, 407, 419, 479, 493, 517.	Calcutta Municipal Corpn.
Calcutta Metropolitan Planning Area (Use & Development of Land) Control Act, 1965. Sec. 1, 2, 4, 5	C.M.D.A. & Local Authority
West Bengal Town & Country (Planning & Development) Act, 1979 Sec. 44, 45, 46, 52, 53, 54, 55	C.M.D.A. & Local Authority
West Bengal Marine Fishing Regulation Act, 1993. Sec. 3, 4, 6(1), 8, 15, 16	Fishery Dept.
West Bengal Inland Fisheries (Amendment) Act, 1993. Sec. 17A.	Fishery Dept.
West Bengal Govt. Township Act, 1975 Sec. 4A, 4C, 4D, 4E.	C.M.D.A. & Local Authority
West Bengal Panchayat Act, 1973 Sec. 19, 21, 23, 25, 114, 117, 157, 158.	Panchayat
Howrah Improvement Act, 1956 Sec. 33(2), 42, 64(5)	Howrah Municipal Corpn.

Classified Sections	Enforcing Authorities
<p>The Explosives Act, 1884. Sec. 6, 6A.</p> <p>Howrah Municipal Corpn. Act, 1980 Sec. 160 - 167, 170 - 173, 177, 179, 180, 185, 186 -193, 195 - 197, 200 - 208, 210, 211, 212, 214.</p>	<p>District Magistrate, Calcutta Police Explosive Dept.</p> <p>Howrah Municipal</p>

This covers pollution matters related to Area/Slum/Road/Other Development items of Local bodies.

### CONCLUSION

The proper implementation of law depends on a disciplined administration, active judicial system and social consciousness. Mere enactment of laws does not suffice to serve their purpose. What is needed simultaneously is a mass consciousness regarding the necessity and use of law. Legally the 'Sati' system was abolished long ago. Yet even today widows are burnt alive on cremation pyres in the name of 'Sati'... Administration stands a silent witness. Rejoicing in the resurival of Sati, its supporters distribute sweets amongst themselves. Similarly, laws passed for the protection of the environment will never be properly implemented until the masses become conscious of the necessity of protecting nature. However the responsibility of creating such a consciousness by national efforts and legal compulsion remains absolutely essential. In the present times quite a few important decisions have been taken by the Indian Judicial system. The highest seat of Judgement in India, the Supreme Court in deciding a case has stated that every man has the basic claim to a healthy, pollution-free environment in which he can live.

In our country, correct implementation of laws for the prevention of pollution coupled with a social movement alone can give the next generation a pollution free society. The only other path points to an unknown, uncertain darkness which equals death in its monstrosity.

In summing up, brings us back to square one. The responsibility is ours, the power and means are in our hands, the world is ours and its all upto us either to face perils or to boldly assert survival for the human race echoing the familiar song :

Live on, the Earth !

And you, earthfold, take this into your head :

We shall have not another Earth

If this one were dead.

Of a thousand planets no loved one like it

Of a thousand planets none so green and so sweet

So live on, the Earth !

Live on !

**SUGGESTED READINGS**

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Biswajit Mukherjee and Nandini Chakraborty. *Law & Environment*

Biswajit Mukherjee and Dr. Nandini Chakraborty. *Ignored Environment*.

## CONCEPT AND BIODIVERSITY IN INDIAN ECOSYSTEMS

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### CONCEPT

The term ecosystem comprises of two words –“eco” and “system” “Eco” means environment which includes the whole complex of physical factors that embrace the organism (biotic) complex. On the other had, a “system” is defined as a set (collection) of interdependent subsystems or components which function as a unit within a definable boundary.

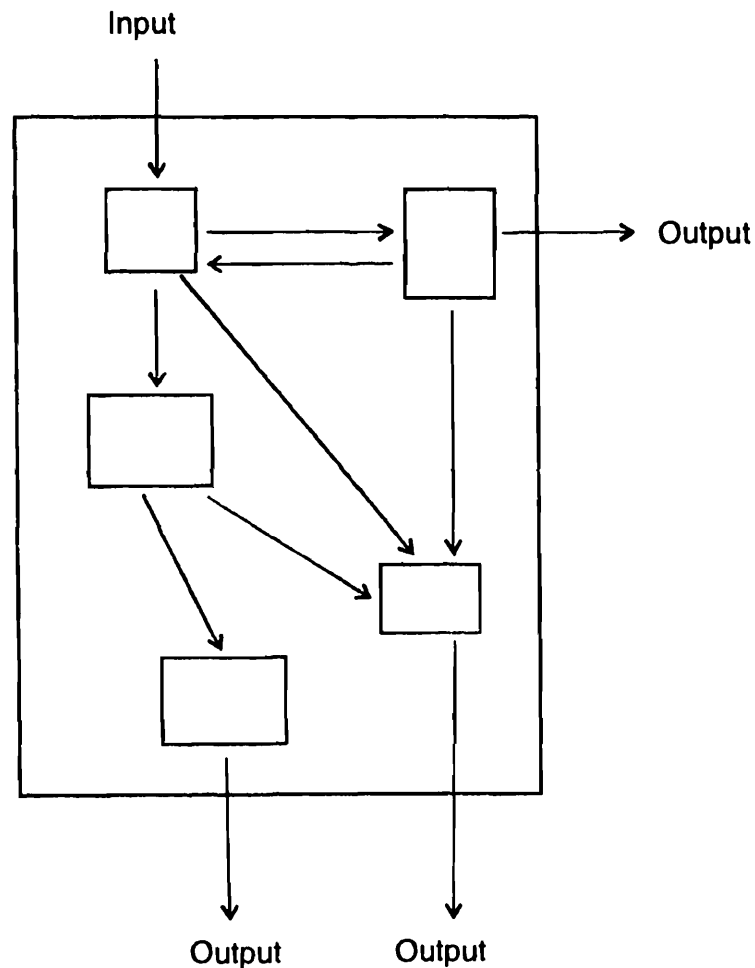


Fig. 1. Diagrammatic representation of a system (□ =sybsystem)

Every system requires some inputs from outside the system to generate some outputs through the interaction of its components. If these outputs are not shared with its surroundings, that is, if there is no exchange of any energy or matter with its surroundings then it is a close system. But, an open system depends upon outside inputs and provides outputs to its surroundings (Fig. 1.)

In this context, an ecosystem or ecological system is always an open system, schematic diagram of which is presented in Fig. 2.

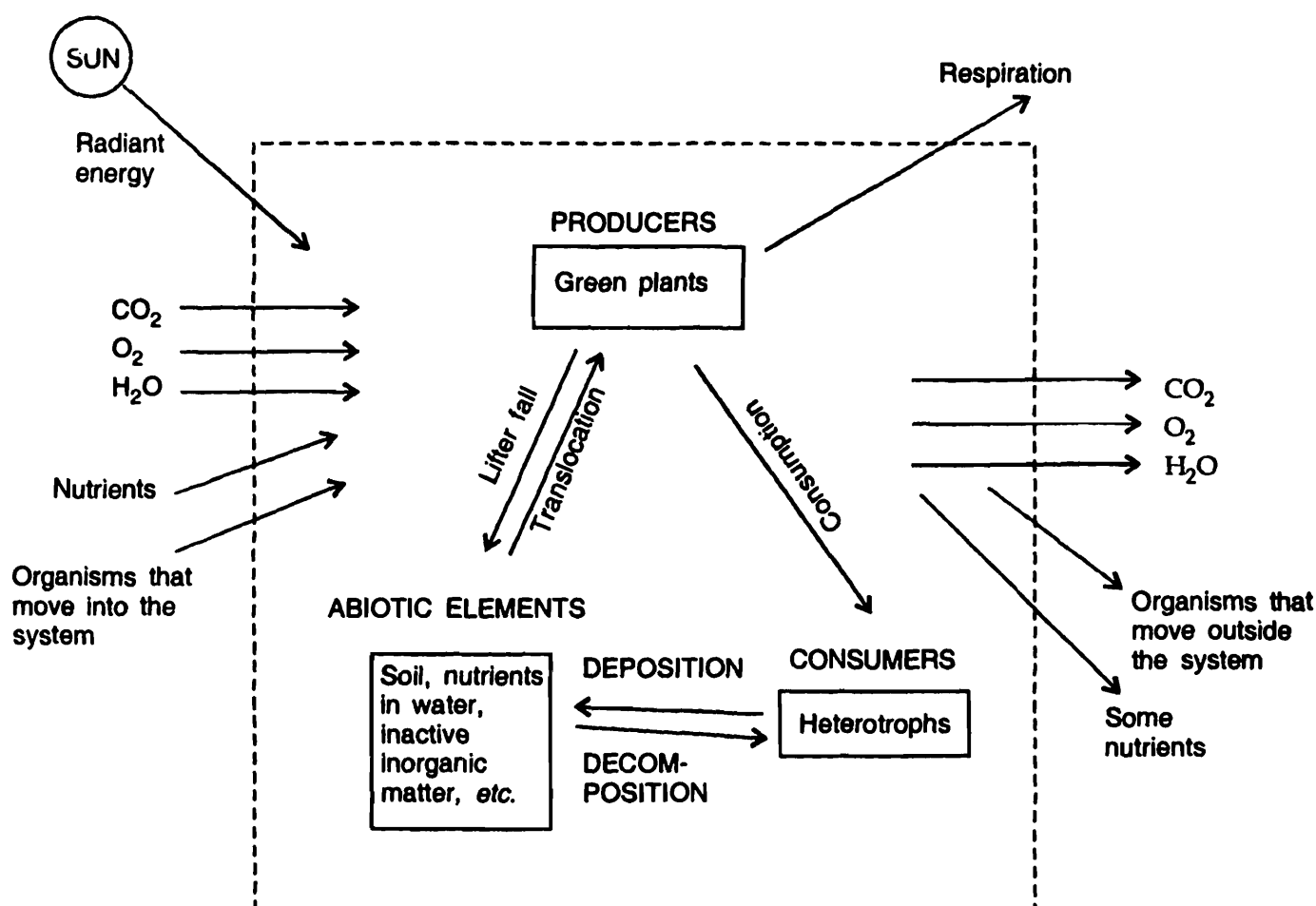


Fig. 2. Schematic diagram of an ecosystem

In ecology an ecosystem is defined as a dynamic complex of plants, animals and microorganism communities and their nonliving environment, interacting as a functional unit in a given area. The inputs of this system are abiotic or nonliving comprising of energy (heat and sunlight), inorganic materials, nutrients, CO<sub>2</sub>, O<sub>2</sub>, CO, etc, and sometimes biotic when some organisms move or are introduced into the system.

Components of the ecosystem are both abiotic and biotic. Abiotic components include :

- i) Inorganic substances (C, N, CO<sub>2</sub>, H<sub>2</sub>O, etc.) involved in a material cycle;

- ii) Organic compounds (proteins, carbohydrates) and
- iii) Climatic regime (temperature, moisture).

Biotic components of the ecosystem comprise :

- i) **Autotrophs or producers** : They fix energy of the sun and manufacture food from simple inorganic matter, *e.g.* green plants.
- ii) **Heterotrophs** : They utilise food stored by autotrophs, rearrange it and finally decompose the complex material into simple inorganic matter again. Heterotrophs are categorised under :
  - **Consumers** which largely feed on living organisms and
  - **Decomposers** which break down dead organic matter into simple inorganic substances.

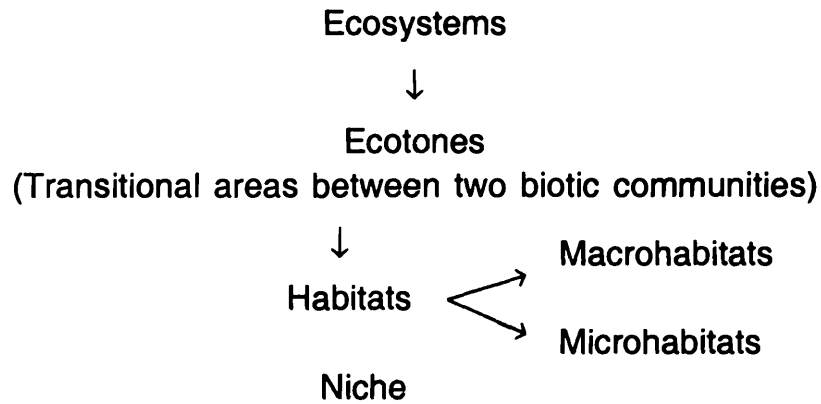
Ecosystems are usually demarcated on the basis of natural habitat classification, based on physical characteristics and general appearance like, forests, grasslands, deserts, *etc.* These are also classified on the basis of geographical and geological features like, mountains, deserts, *etc.* In natural environment there is no discrete and discontinuous unit. Therefore, in reality there is usually no generally accepted boundary to delimit one ecosystem from the other. There is rarely any sharp ecotone between forests and grasslands and there may be several wetlands within the forests. That is why, an ecosystem may be as small as a pond or as large as a biogeographic region or even still larger as terrestrial and aquatic ecosystems. For this reason, in biodiversity analysis ecosystems are considered at three levels, *viz.*, biogeographic regions, biotic provinces and biomes.

Each of the biogeographic regions embraces major continental land mass and each is separated from the other such region by oceans, mountain ranges or deserts. There are six biogeographic regions in this biosphere, *viz.*, Nearctic, Neotropical, Palaeartic, Ethiopian, Oriental and Australian.

The biotic provinces include major biogeographic habitats. India embraces three Biogeographic regions, *viz.*, Oriental, Palaeartic and Ethiopian and, includes 10 Biogeographic zones and 26 Biotic Provinces (*vide* Alfred, Das and Sanyal, 1998). For example, North-West Himalayas, West Himalayas, Central Himalayas and East Himalayas are Biotic Provinces within the Biogeographic zone Himalayan Biomes, on the other hand, are the major landscape features characterised by dominant life forms, chiefly plants. Such groupings are found within each biotic province. Examples of such biomes in India are alpine, subalpine, temperate, conifer forests, *etc.* within the West Himalaya or the East Himalaya.

## ECOSYSTEM DIVERSITY

Every ecosystem includes diversified habitats. More diverse are the habitats, more biodiversity rich is the ecosystems.

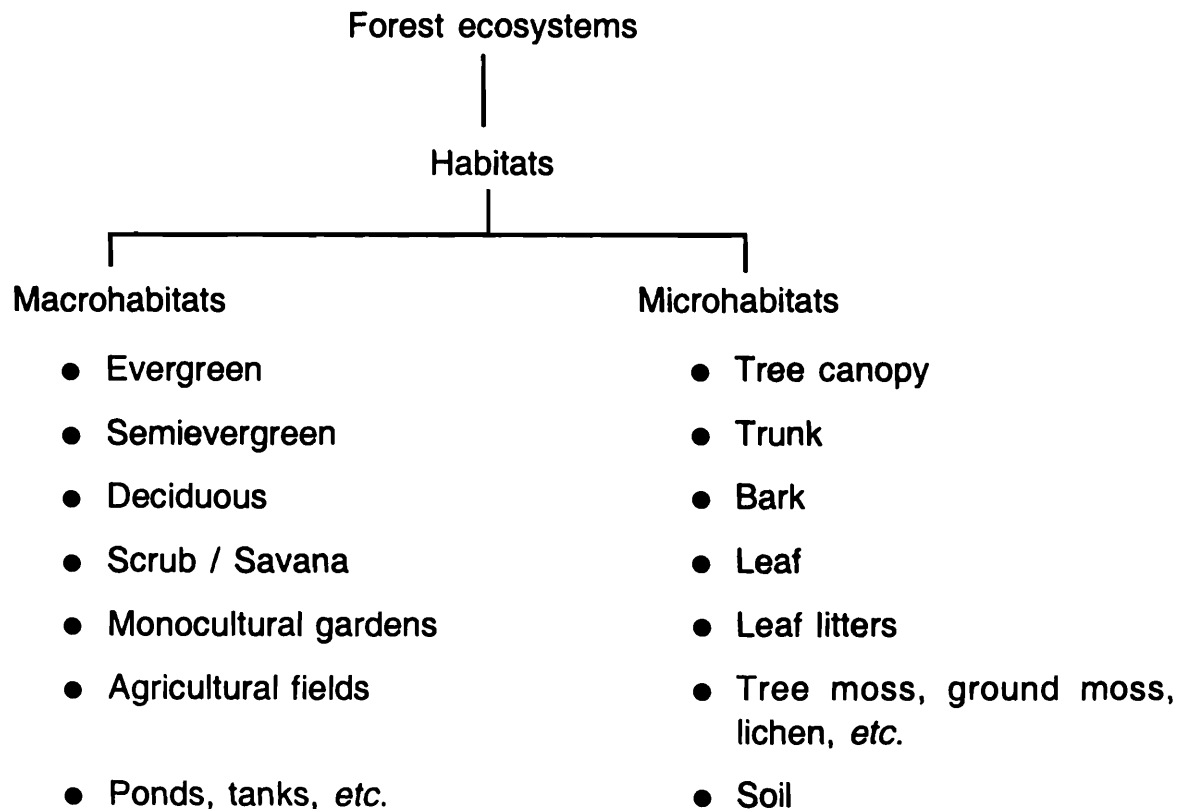


(Environmental complex that satisfies an organism or population in natural condition)

Habitats are environmental complex that satisfies life opportunities of an organism or population in natural condition. On the other hand, niche is the combination of different habitat factors that provide life opportunity for each species. It has been ascertained through several ecological studies that closely related species may occupy similar habitats but usually have different requirements. Such differences may be in foraging behavior, food selection, habitat preference, breeding behaviour, nesting place, *etc.* That is why, more than one species can not occupy same niche. That means, each species has its own niche.

### HABITAT DIVERSITY

In each ecosystem there are large number of macrohabitats and microhabitats. For example, in the Indian Forest ecosystem habitat diversity are broadly as follows



Such diversities are also prevalent in other Indian ecosystems as discussed later.

## BIODIVERSITY IN INDIAN ECOSYSTEMS

Based on major natural habitats Indian ecosystems are classified as :

- Forests
- Grasslands
- Deserts
- Wetlands
- Mangroves
- Coral reefs
- Marine

Based on geographical and geological features Indian ecosystems are demarcated as :

- Mountains
- Islands

Biodiversity of these ecosystems are presented in brief as follows under separate heads.

### FOREST ECOSYSTEM

It is the tree or bush dominated ecosystem which covers about 23.4 percent of the total geographic area of India. But, as analysed by the satellite imagery, forests occupy only 19.47 percent of the total geographic area of the country (ICFRE, 2000)., Sixteen important forest types are identified in India under four major groups as in Table 1.

Table 1. Indian forests

Major groups	Types	Characteristics
1. Tropical (Very hot and winter less)	1. Wet evergreen	Dense tall forests, entirely or mostly evergreen, mean annual rainfall 250 cm.
	2. Semi-evergreen	Evergreen predominates, deciduous species mostly dominant, annual rainfall 200-250 cm.
	3. Moist deciduous	Dominants mostly deciduous, top canopy rarely dense, mean annual rainfall 100-200 cm.
	4. Littoral and swamp	Mainly evergreen of varying density and height; always grow on wet sites; excepting littoral forests all others are subject to immersion and water logged situation.
	5. Dry deciduous	Entirely or almost deciduous, top canopy broken, trees usually 8-20 m high, canes and palms absent, annual rainfall around 100 cm.

Major groups	Types	Characteristics
	6. Thorn forests	Deciduous low thorny trees and with broken canopy, trees under 10 m height, grass generally absent, mean annual rainfall below 50 cm.
	7. Dry evergreen	Hard-leaved evergreen trees predominate, mixture of spiny and shrubby species, plenty of rainfall but with longer dry period.
2. Subtropical (Hot with a cool winter)	8. Broad-leaved hill forests	Broad-leaved largely evergreen forests of South Indian hills without conifers; also in slopes of the Eastern Himalaya.
	9. Pine forests	Pine association predominates, chiefly occur in the Western and the Eastern Himalaya and, in North-East India between 1000-2500 m altitude.
	10. Dry evergreen	Low xerophytic forests and scrubs; occur in foot hills of Himalaya.
3. Temperate (Warm summer with a pronounced winter)	11. Montane wet temperate	Evergreen forests without conifers, confined to South Indian Hills and the Eastern Himalaya above 1500 m altitude; rainfall above 150 cm.
	12. Himalayan moist temperate	Evergreen forests mainly of oaks and conifers, mixed variously with deciduous dicotyledonous species; occur above 1500 m altitude, annual rainfall 100-150 cm.
	13. Himalayan dry temperate forests	Open coniferous forests with sparse xerophytic undergrowth, dominated by Rhododendron, oaks and conifers; rainfall below 100 cm.
Subalpine and Alpine (Short summer and long winter)	14. Subalpine	Stunted deciduous or evergreen forests, usually in close formation with or without conifers; occur in 4500-6000 m altitude in the Himalaya.
	15. Moist alpine	Low but often dense scrubs, occur above 3000 m in the Himalaya.
	16. Dry alpine scrub	Xerophytic scrubs in open formation, occur in the Western Himalaya.

According to the Satellite Imagery, Indian forests are classified as (i) dense forests (crown density 40%+), (ii) open forests (crown density 10-40%), (iii) scrub area (> 10% crown density) and (iv) non-forest area (including tea garden)

Temperature, rainfall, altitude and various geomorphological features influence the vegetation type so also the animal biodiversity. Moreover, forests provide innumerable macro and microhabitats for varieties and variabilities of faunal components. As a result, forests become the store house of rich animal biodiversity. Forest animals include large mammals like elephant, tiger, rhinoceros, *etc.*, as well as very small mammals, birds, reptiles, amphibians, fishes (in forest wetlands), insects and other arthropods and annelids. In addition to these, innumerable macro and microfauna of diversified taxonomic groups are found on the forest floor and in the forest soil.

### GRASSLAND ECOSYSTEM

In natural grasslands perennial grasses are the dominant species with few or no shrubs and no trees. These are known as steppes, prairies and savannah in various parts of the globe. In India this ecosystem covers about 3.9% of its terrestrial area.

Based on the distribution of dominant genera of perennial grasses five grassland types are recognised in this country. These are (i) *Sehima – Dicanthium* type, (ii) *Dicanthium – Cenchrus – Lasiurus* type, (iii) *Phragmites – Saccharum – Imperata* type, (iv) *Themeda – Arundinella* type and (v) Temperate – Alpine type.

Indian grasslands exhibit considerable diversity ranging from semi-arid pastures in the Deccan peninsula, rolling shola grasslands in the hill tops of the Western Ghats, high altitude alpine pastures in the Himalaya and the water-logged grassland in Terai belt.

Large number of herbivore species are found in this ecosystems. It includes small sized mites and insects as well as the largest land mammal, the elephant. Common grassland mammalian species are Deer, Hare, Rats and Mice. In addition to these, several other mammals, *viz.*, Nilgiri Tahr, Gaur, Rhinoceros, Mouse, Deer, Sambar, wild Boar, *etc.*, also take shelter in grasslands. For haunting these herbivores various carnivorous mammals including Tiger and Fishing cats are also found in this habit. Among birds Munia, Streaked Baya, Grass Warbler, Partridge, *etc.* are common in grasslands.

### DESERT ECOSYSTEM

Deserts are arid lands with low rainfall. This ecosystem is characterised by an expanse of sands, rocks, salt or ice which are largely barren except for very sparse or seasonal vegetation cover. The vegetation includes mostly the thorny scrub and variety of grasses. Indian sand and salt desert cover about 2% of the total land area of this country.

Indian deserts are classified into three distinct types :

1. Sand desert : Thar desert in Western Rajagthan and its neighbouring areas in Gujarat, Punjab and Hariyana.
2. Salt desert : In Kutch of Gujarat.
3. High altitude Cold desert : In Jammu & Kashmir (Ladak and Kargil), Himachal Pradegh (Spiti, Lingti and Pooh tehsil), Uttaranchal and Sikkim (small snow covered areas).

### Sand desert

Indian sand desert possesses (i) plains with sand dune, (ii) plains with hills, (iii) hilly region and (iv) fresh and saline lakes and, marshes. Its macrohabitats are :

- *Sandy* : having thick deposit of older alluvial sand, sand dunes and flat sandy soil.
- *Rocky* : Rock plateau turned into pene-plains of arid waste land.
- *Aquatic* : Perennial lakes, ponds, marshes, etc.
- *Ruderal* : Village complexes depending on water and foliage for live stock.

Vegetation of sandy Thar desert is quite sparse and mainly of the thorn forest type, primarily comprising of *Capparis decidua*, *Calotropis procera*, *Prosopis cineraria*, *Acacia senegal*, etc. *Citrullus* and *Cucumis* are the creepers commonly found in sandy plains. The grassland of the Thar is of *Lasiurus - Cenchrus - Dichanthium* type.

Desert offers harsh habitats, having a wide range of temperature from freezing point in winter to about 50°C in summer. Even then 4509 animal species, comprising of 619 species of vertebrates and 3890 species of invertebrates have been recorded from the Thar. Some of the endangered animals of this region are Panther, Jungle Cat, Desert Fox, Wolf, Jackal, Hyena, Ratel, Black Buck, Chinkara, Pangolin, Great Indian Bustard, Sand Grouse, White Browed Bushchat, etc.

### Salt desert

The salt desert of the Rann of Kutch is characterised by its salinity caused by seasonal ingress of sea. It harbours a typical salt-marsh salt-bush plant community. The natural vegetation of Kutch is scrubby and some of the dominant species are *Euphorbia mivula*, *Acacia nilotica*, *Prosopis cineraria*, *Zizyphus* spp. About 27 species of mangroves which are of scrubby type have been reported from the Gulf of Kutch area. Important mangrove species of this region are *Avecennia* spp., *Rhizophora mucronata*, *Ceriops tagal*, etc.

The special feature of the Rann of Kutch is the presence of many elevated islands called "bets" where a wide variety of plants, specially grasses are found to grow. Number of desert living rodents like *Gerbillus* sp., *Tartermia* sp., and *Meriones* sp. inhabit these bets. It is needed to mention here that the saline-desert-marshy region of the Rann of Kutch is the only habitat of the rare Wild Ass, *Equus hemionys khur* and the only nesting and breeding ground of the Asian Lesser Flamingo in India. Several endangered mammals like Desert Cat, Caracal, Wolf, Chinkara and Indian Pangolin are also distributed in this region.

### High altitude cold desert

The snow-capped region of the high altitude of the Himalaya constitute the cold desert. This region is also known as the Trans-Himalaya and displays major characteristics of a desert in having :

- Considerably low rainfall (about 10 cm annually);

- Dry environment;
- Arid land, largely barren and characterised by desolate rocky and sandy areas as well as vast expanse of snow;
- Vegetation sparse and shrubby, either cushion shaped (*e.g.*, *Carangana* sp., *Acantholium* sp., *etc.*) or mat forming (*e.g.*, *Hippophae* sp., *Carex* sp., *etc.*) to withstand blizzards.

In cold desert there are several very large natural backish water lakes, *e.g.*, Pangong Tso, Tso Morai and Tso Kar which provide suitable habitats for diverse birds, fishes and other aquatic biota. Mammals of this region is very rich and of Palaearctic origin. The Wild Sheep and Goats include 4 species, *viz.*, Asiatic Ibex, Bharal, Nayan and Shapu. Other ungulates include Tibetan Wild Ass or Kiang, Wild Yak, Tibetan Gazelle, Tibetan Antelope, *etc.* Rodents are also very rich represented by Marmots, High Mountain Vole, Flying Squirrels, Hamsters, Pikas, Cape Hare, Wolly Hare, *etc.* As predators of these herbivores many carnivales, like Snow Leopard, Tibetan Wolf, Red Fox, Himalayan Lynx, Weasels, Brown Bear, *etc.*, are also found in this region.

## WETLANDS

Wetlands are the transitional areas between dry terrestrial and permanent aquatic lands where water table is usually at or near the surface or the land is covered by shallow water.

As per an estimate of the Ministry of Environment & Forests, Government of India. wetlands of this country cover about 4.1 million hectare (excluding paddy fields and mangroves). Out of this 1.5 million ha are natural and 2.6 ha man made.

Wetlands are broadly classified as freshwater and saltwater wetlands defined by salinity. The freshwater wetlands include standing water habitats like ponds, tanks, lakes and reservoirs as well as running water habitats like rivers, streams, canals and drainage channels. The brackishwater wetlands include estuaries, lagoons, backishwater lakes, backwaters and brackishwater impoundments.

Indian wetlands may be classified as follows :

### Saltwater

- |               |   |  |
|---------------|---|--|
| 1. Marine     | — | <div style="display: inline-block; border-left: 1px solid black; border-bottom: 1px solid black; width: 20px; height: 20px; margin-right: 5px;"></div> <div style="display: inline-block; vertical-align: middle;"> <p style="margin: 0;">Subtidal</p> <p style="margin: 0;">Intertidal</p> </div> |
| 2. Estuarine  | — | <div style="display: inline-block; border-left: 1px solid black; border-bottom: 1px solid black; width: 20px; height: 20px; margin-right: 5px;"></div> <div style="display: inline-block; vertical-align: middle;"> <p style="margin: 0;">Subtidal</p> <p style="margin: 0;">Intertidal</p> </div> |
| 3. Lagoons    |   |  |
| 4. Salt lakes |   |  |

**Freshwater**

- |    |            |   |   |  |           |  |           |  |          |
|----|------------|---|---|--|-----------|--|-----------|--|----------|
| 5. | Riverine   | — | <table border="0"> <tr> <td style="border-left: 1px solid black; border-top: 1px solid black; border-bottom: 1px solid black; width: 10px;"></td> <td style="padding-left: 5px;">Perennial</td> </tr> <tr> <td style="border-left: 1px solid black; border-bottom: 1px solid black; width: 10px;"></td> <td style="padding-left: 5px;">Temporary</td> </tr> </table>  |  | Perennial |  | Temporary |  |          |
|    | Perennial  |   |   |  |           |  |           |  |          |
|    | Temporary  |   |   |  |           |  |           |  |          |
| 6. | Lacustrine | — | Permanent   |  |           |  |           |  |          |
| 7. | Palustrine | — | <table border="0"> <tr> <td style="border-left: 1px solid black; border-top: 1px solid black; border-bottom: 1px solid black; width: 10px;"></td> <td style="padding-left: 5px;">Seasonal</td> </tr> <tr> <td style="border-left: 1px solid black; border-bottom: 1px solid black; width: 10px;"></td> <td style="padding-left: 5px;">Emergent</td> </tr> <tr> <td style="border-left: 1px solid black; width: 10px;"></td> <td style="padding-left: 5px;">Forested</td> </tr> </table> |  | Seasonal  |  | Emergent  |  | Forested |
|    | Seasonal   |   |   |  |           |  |           |  |          |
|    | Emergent   |   |   |  |           |  |           |  |          |
|    | Forested   |   |   |  |           |  |           |  |          |

**Man made**

8. Aquaculture / Mariculture
9. Agriculture
10. Salt exploitation (Salt pans)
11. Urban / Industrial (Excavations, Mining pools)
12. Water storage areas (Reservoirs, Hydrodams)

As per IUCN (1989) various wetland habitats of the world include 22 wetland types, of which India possesses the following 10 types.

- Tanks, reservoirs and other water bodies of the Deccan peninsula;
- Backwater and estuaries of west coast of the peninsula;
- Saline expanses of Rajasthan and Gujarat;
- Freshwater lakes and reservoirs from Gujarat, Rajasthan and Madhya Pradesh;
- Deltaic wetlands, lagoons and salt swamps of east coast;
- Marshes, jheels, Terrai swamps and Chaur lands of the Gangetic plains;
- Flood plains of the Brahmaputra and the marshes and swamps in the hills of North-east India;
- Lakes and rivers of the mountain regions of Jammu & Kashmir, Uttaranchal and Himachal Pradesh;
- Wetlands of the islands of the Bay of Bengal and the Arabian sea (primarily mangrove association and coral reefs);
- Coastal brackishwater wetlands in West Bengal, Andhra Pradesh, Tamil Nadu and Kerala.

Indian wetlands support a significant proportion of the total diversity of organisms, representing almost all taxonomic groups. The floral elements of Indian wetlands are dominated by algae in open water where as macrophytes (higher plants) dominate the

littoral region in freshwater wetlands. So far as macrophytes are concerned, 690 species of Angiosperms and 87 species of Pteridophytes are reported from the wetlands of this country (Alfred and Nandi, 2001).

Almost all the faunal groups from Protozoa to Mammalia are found in Indian wetlands. Some animals reside permanently and others temporarily in wetlands for food, shelter and/or nesting. There are some animals like Kingfishers which live on land and depend on wetlands for their food. There are still others, like Reed Warblers which are associated with wetlands and stay or roost on marshes and/or reeds. All the three categories, *i.e.*, aquatic, wetland dependent and wetland associated fauna of Indian wetlands represent 17,853 species under 25 phyla, comprising 19.9 percent of the total faunal biodiversity of this country (Alfred and Nandi, 2000).

### MANGROVE ECOSYSTEM

Mangroves represent a characteristic littoral ecosystem, dominated by some specially adapted salt-tolerant plant community which grow at land-sea interphase and border the sheltered sea coasts and estuaries of tropical and subtropical regions of the world.

The mangrove forests comprise of a diverse composition of trees and shrubs. These plant community exhibits unique adaptation to survive in the habitats which are periodically inundated by salt water from the seas and estuaries and freshwater from the rivers and adjacent terrestrial areas. These plants are well adapted to encounter higher salinity, oppressive heat, tidal extremes and, water logged and saline soils, for which they have developed breathing roots or pneumatophores, supporting stilt roots and knee roots, succulent leaves with water storage tissue and viviparous germination.

Indian mangroves are distributed along the east and west coasts and, Andaman & Nicobar islands. In the East coast they occur in the Sundarban in West Bengal, Mahanadi delta in Orissa, Coringa, Godavari and Krishna deltas in Andhra Pradesh and, Cauvery delta and Thanjavur in Tamil Nadu. In the West coast they are found in the Gulf of Kutch, Gulf of Khambat, Saurashtra and, Narmada and Tapti estuaries of Gujarat; Malvan, Devgad and Vijaydurg in Maharashtra; Mandovi-Zuari estuary in Goa; Coondapur, Hannover and Malpe in Karnataka and Vembanad, Quilon, Trivandrum, Kozhikode and Kottayam in Kerala.

Indian mangroves occupy about 6740 sq km (Govt. of India Status Report 1987). But, according to FSI Remote Sensing data (1998) Indian mangroves cover 4827 sq km. The largest stretch of mangroves in the country lies in the Sundarbans covering about 4200 sq km and those in Andaman & Nicobar account for about 1200 sq km.

Considering their locations Indian mangroves may be deltaic, estuarine, backwater estuarine, coastal and insular. As mangrove ecosystem is located between the land and the sea it includes several distinct habitats in terrestrial, intertidal and aquatic environs as follows :

- Mangrove dominated forests;

- Litter laden forest floor;
- Tidal flats (muddy, sandy, rocky and coralline)
- Contiguous water courses (rivers, tidal creeks and channels, backwaters, neritic inlets and bays).

These habitats are demarcated horizontally. Several habitats are also demarcated vertically in mangroves by Berry (1963), following which several habitats can be identified in Indian mangroves as shown below.

- Tree canopy;
- Higher part of mangroves;
- Lower part of mangroves including roots;
- Forest floor in the supralittoral zone;
- Dead trees and stumps;
- Mudflat/sandy mudflat in intertidal zone;
- Temporary pools;
- Bank of river channels;
- Creeks and bays;

These macrohabitats comprise of diversified microhabitats which support rich and taxonomically diverse microbial, floral and faunal components making this ecosystem a reservoir of rich and unique gene pool.

The dominant mangrove species in India include *Avicennia marina*, *Avicennia officinalis*, *Bruguiera gymnorhiza*, *Bruguiera cylindrica*, *Rhizophora mucronata*, *Ceriops tagal*, *Heritiera littoralis*, *Xylocarpus granatum*, *Acanthus ilicifolius*, *Cerbera manghas*, *Sonneratia alba* and several others.

Animal communities associated with mangroves include both aquatic and terrestrial fauna. The aquatic fauna of mangroves consists marine and estuarine zooplanktons, benthic communities and nektonic forms mainly fishes. The terrestrial animals of this ecosystem comprises of mammals, birds, reptiles, insects, spiders, mites, etc.

Animals of mangrove include resident fauna which live entirely on mangrove ecosystem and the transient fauna which enter mangroves for food, refuge and transit and also to use mangroves as breeding ground and nursery bed. But, they live elsewhere during the remaining period of their life cycle.

Resident fauna are mostly benthic and comprise of

- Infauna which burrow and penetrate the substratum, e.g., polychaetes, wood-boring animals, mud-burrowing bivalves, gobiid fishes, etc.
- Epifauna which move over the substratum, e.g., gastropods, sessile bivalves like oysters and *Modiolus*, some crustaceans like barnacles.

Transient fauna include terrestrial elements as mentioned above and enter mangrove from the adjacent forested and nonforested areas. They also include diverse marina fauna which encroach mangroves from the adjacent estuaries, creeks, bays, coral reefs and rocky flats. Maximum number of animal species (1434) representing 20 phyla have been reported from the Sundarbans. In the mangroves of Andaman & Nicobar and Tamil Nadu 914 and 801 animal species respectively have been reported so far (Das, 2001). Dominant mangrove fauna comprise of polychaetes, gastropods, crabs and fishes amongst aquatic elements. Dominant terrestrial mangrove fauna are birds among vertebrates and insects among invertebrates. There are some terrestrial faunal components which are reported as mangrove specialists, e.g., Black - Capped Kingfisher (*Halcyon pileata*), Brown-winged King fisher (*Halcyon amauroptera*) and Mangrove Whistler (*Pachycephala grisola*).

### CORAL REEFS

The Coral reef is the most biologically diverse ecosystem on the earth. A single reef may be the home of 200 species of corals, 300 species of fishes and between 10,000 to 100,000 species of invertebrates (Cesar, 2000). It is also one of the most productive ecosystems that provides food and services to the millions of people in the coastal areas around the globe.

Coral reefs are tropical, shallow water ecosystem mostly restricted to the area between 30° N and 30° S latitudes. The basic units of reef growth are the coral polyps and the associated symbiotic algae and flagellates that live in the coral tissues.

Coral reefs are primarily of three types

- *Fringing reefs* : These are the most common type of coral reefs and grow along the edges of the continents and around the islands close to the shore but, sometimes separated from it by a shallow lagoon.
- *Barrier reefs* : These develop as fringing reefs that have become partially submerged and separated from the mainland or island by a wide deep lagoon.
- *Atolls* : These are circular reefs enclosing la goon and arise from deep sea platforms, such as, submerged volcanic sea mounts.

Besides these, there are also a few minor reef types, e.g., Platform reef, Patch reef, Reef flat, Coral pinnacle, Coralline shelf, Coralline heads and live Coral platforms.

In India, the reefs are distributed along the east and west coasts at restricted places and, around Andaman & Nicobar islands and Lakshadweep. In the East coast coral reefs are found in Palk Bay and Gulf of Mannar and in the West coast in Gulf of Kutch. There are also some scattered patches of corals in the intertidal areas and occasionally in subtidal depths along the West coast at Ratnagiri, Malvan and Rede Port.

All the major types of Coral reefs are found in India :

- (i) *Fringing reefs* in Palk Bay, Gulf of Mannar and Andaman & Nicobar islands.

(ii) *Barrier reefs* in Andaman & Nicobar islands.

(iii) *Atolls* in Lakshadweep.

Besides these, there platform reefs are found along the Gulf of Kutch and patchy reefs near Ratnagiri and Malvan Coasts.

As many as 208 species of hard corals have been reported so far from India (Venkatraman *et al.*, 2004). Among these, *Acropora* or Staghorn corals are most dominant followed by *Montipora*. Besides these, hard corals belonging to *Pocillopora*, *Pavona*, *Fungia*, *Favia*, *Favites*, *Porites* and *Goniopora* are also diverse in Indian coral reefs in number of species.

Coral reefs of Andaman and Nicobar islands are the richest in number of species (154 species) of hard corals amongst Indian coral reefs, followed by those of Lakshadweep (93 species), Gulf of Mannar (83 species) and Gulf of Kutch (37 species). Moreover 134 species of alcyonarian or soft corals also occur in Indian coral reefs.

The Coral reefs provide shelter and nourishment to innumerable diverse marine fauna as mentioned earlier. In Indian coral reefs, as in the globe, fishes are the most dominant faunal components amongst vertebrates. A few species of reptiles and mammals are also found in Indian coral reefs. Coral reef associated mammals are dolphins, whales and dugongs and those of reptiles belong to sea snakes, turtles and crocodiles. Amongst invertebrates sponges, molluscs, crustaceans and echinoderms constitute the major faunal components of reef associated fauna in India.

## MARINE ECOSYSTEM

Marine ecosystem includes sea and oceans with highly diverse coastal and open sea habitats. These habitats range from tidal flats of varying nature and shallow coral reefs to the dark ocean floors, soft sediments, thousand meters below the water surface.

Marine habitats of Indian may be broadly demarcated as

- Sea coasts
- Continental shelf area, *i.e.*, sea bed and submarine area extending from the coast up to 200 m depth. The total shelf area is divisible into :
  - i) Inshore (up to 50 m depth) and
  - ii) Out shore or off shore (between 50 m and 200 m depth)
- Open sea up to the Exclusive Economic Zone (EEZ). EEZ is an area beyond and adjacent to territorial waters with a limit of 200 nautical miles from the base line.

### Sea Coasts

India possesses a long coast line of about 8000 km along the east and west coasts and around Indian islands, *viz.*, Andaman and Nicobar in the Bay of Bengal and Lakshadweep

in the Arabian sea. Indian sea coasts are of varied nature, *viz.*, sandy, rocky, muddy, shingle and coralline. These coasts are indented with several rivers, forming estuaries at their confluence with the sea. The coast lands also include several habitats like intertidal, salt marsh, shingle above the High Tide Level (HTL), boulders/rocks above HTL, strandline vegetation, sand dune, maritime cliff and slope, coastal lagoon, backwater, *etc.*, which provide suitable microhabitats to host rich and diverse faunal components.

Rocky and coralline beaches support large number and diverse varieties of animals which include molluscs, barnacles, crabs, shrimps, sea-urchins, sea-cucumbers, brittle stars, *etc.*

Sandy beaches differ greatly in their animal content. There may be practically no fauna in the most wave-beaten sandy beaches whereas a very densely packed fauna may occur in such sandy beaches where there are perfect shelters from wave action. Sand being very unstable, usually tube forming polychaetes and bivalves with long siphon, (*e.g.*, *Tellina cardium* and *Macra*) and crabs are found in sandy beach. Varieties of brachyuran crabs, more particularly Ghost crab (*Ocepode* sp.) and Fiddler crabs (*Uca* spp.) are commonly found there.

In the muddy shore some tube forming polychaetes like *Eurythoe*, *Eunice* and molluscs like cerithids, stenothyrids and nassarids are found. Some gobiid fishes also live in muddy beach, forming burrows.

### **Continental shelf area**

In India average width of shelf varies in different coasts. For example, average width of shelf along the Andhra coast is about 32 km and that in Maharashtra coast is about 175 km. In shelf area there are several coastal wetlands like coral reefs, mangroves, estuaries and lagoons. These habitats host large number and varieties of plant and animal species.

The floral component of the marine ecosystem primarily includes sea grasses and sea weeds. In the infra-tidal and midtidal zones in the gulf, bays, backwaters, lagoons and sheltered localities of sea of the country about 120 species of sea grasses have been recorded. The sea weed communities prefer somewhat flat and rocky coastal wetlands.

The marine fauna of this country is very rich and varied. Out of 32 animal phyla, 20 are represented in marine ecosystem of India, with 12,372 species (Ramakrishna and Veakatrāman, 2001). Amongst these, fishes represent highest species diversity (1800 species) while in invertebrates highest species diversity is shown by mollusca (3370 species), followed by crustacea (2430 species), Cnidaria (790 species), enchinoderms (765 species) and sponges (500 species) in number of species.

## **ISLAND ECOSYSTEM**

India encompasses two different island groups, namely, Andaman and Nicobar islands, lying in the Bay of Bengal and the Lakshadweep in the Arabian sea. From geological point of view both the island groups are oceanic.

**Andaman and Nicobar islands :** These islands consist of an arcuate chain of more than 500 islands, islets and rocky out crops running north to south in the Bay of Bengal, extending over 800 km. Two volcanic islands, Barren and Narcondam are located within the Andaman group. Andaman and Nicobar groups occupy a total land area of 8293 sq km, of which 6340 sq km belong to the Andaman group and the remaining 1953 sq km belong to Nicobars. These islands usually have undulating terrain with spur hills and intervening valleys. There are few flat islands also like Car Nicobar and Trinket.

The coast line in these islands measure about 1962 km. It is very wavy, indented with large number of bays, lagoons and serpentine creeks. At several places tidal creeks penetrate far inside the land and form outlets for freshwater streams.

These islands are adorned with three natural ecosystems, *viz.*, forests, mangroves and coral reefs.

**Forests :** According to Champion and Seth (1968), 7 major natural forests types are recognised. These are : Giant evergreen, Andaman tropical evergreen, Southern hill-top evergreen, Andaman semi-evergreen, Andaman moist deciduous, Littoral and tidal swamp. There are also few more forest types, such as, cane brakes, bamboo brakes, *etc.* The dominant trees in these islands include *Dipterocarpus* spp, *Artocarpus* spp, *Terminalia* spp., *Albizia* spp., *Amoora wallichii*, *Sterculia campanulata*, *Pterocarpus dalbargiodes*, *etc.* Andaman & Nicobar forests have a profuse growth of epiphytic vegetation comprising mainly ferns and orchids.

**Mangroves :** Mangroves usually occur along the tidal creeks, sheltered bays and sea inlets, covering about 1200 sq km. The mangrove area of these islands is the second highest amongst Indian mangles, just after Sundarban. Among mangroove species *Rhizophora mucronata* and *Rhizophora apiculata* occupy the most sea-ward fringe forming thick clusters. In tidal creeks *Bruguiera gymnorrhiza* and *B. parviflora* are abundant. *Avicennia officinalis*, *Ceriops tagal*, *Kandelia candel*, *Xylocarpus granatum*, *Lumnitzera racemosa*, *Excoecaria agallocha*, *Aegiceras corniculatum* and *Acanthus ilicifolius* occur in tidal swamps. Towards the land side of mangrove swamp *Heritiera littoralis*, *Cynometra iripa*, *Scyphiphora hydrophyllacea* and *Brownlowia tersa* are found to grow. These mangroves occur either in luxuriant formation or in patches along the bays, tidal creeks and sea inlets.

**Coral reef :** There are luxurious coral formations in the marine waters around these islands. Coral have grown in the form of fringing reef on the eastern side whereas they constitute barrier reef on the western side of these islands.

Reef edges of Andaman islands contain mostly the stony corals of the genera *Acropora*, *Pocillopora*, *Favia* and *Porites*. There are also alcyonarian corals like *Sacrophytum*, *Lobophytum*, *Sclerophytum*, *etc.*, and gorgonids like *Isis*, *Melitha* and *Chalcogorgia* occurring in shallow water and reef edges. Most common reef building corals of Nicobar Islands are *Porites*, *Favia*, *Fungia*, *Acropora*, *Pocillopora*, *Heliopora* and *Montipora*.

Most abundant reef building corals are *Acropora* which form an almost continuous carpet of corals along the coast line of many of the islands. Other branching corals of the

Islands like *Psammocora*, *Pocillopora* and *Montipora*. The coral reefs of these islands sustain large number and varieties of marine animals, of which crabs, molluscs, echinoderms and fishes are very frequently seen.

Undulating topography, with mountains of variable height, tropical climate and abundant rainfall (about 3000 mm annually) in these islands offer suitable habitats for supporting rich diversity of plant species. As many as 2395 species of flora comprising of 2200 species of angiosperms, 130 species of pteridophytes and 65 species of lichens, mosses and hepatics have been reported from the islands. Little more than 10% of these flora are endemic.

Animals of these islands can broadly be divided into two categories. The inland animals inhabit land and freshwater and the marine ones occupy the coral reefs, mangroves and other marine habitats around these islands. A total of 6697 animal species are known so far from these islands. Out of these, 2919 species are reported from land and freshwater and 3778 species from marine environment (Das, 2001). Available data on island biota show that faunal endemism amongst terrestrial animal is significantly high, constituting about 26.3 per cent of the total faunal species of these islands. Amongst mammals, Crab-eating Macaque, Wild Pig, Palm Civet, all the Spiny Shrews (*Crodura*) and the Tree Shrews (*Tupaia*) are endemic. Birds of these islands are significant not only due to their higher percentage of endemism (40.2%) but also for their restricted distribution in these islands. For example, Narcondam Hornbill is found only in Narcondam island. Two subspecies of Megapode occur in these islands. One subspecies, the North Nicobar Megapode is restricted to the Nicobar group, lying north to Sombero channel (except Car Nicobar and Chaura). The other subspecies, South Nicobar Megapode is distributed only in Little Nicobar and Great Nicobar, lying south of Sombero channel. The species richness of these islands presented here is of the pre-tsunami period. As there has been some change in topography and vegetation of these islands during the Tsunami of December, 26, 2004, the species richness of these islands is expected to vary, the estimation of which is yet to be done.

**Lakshadweep** : This archipelago comprises 36 islands, including 12 atolls, 3 reefs and 5 submerged banks, occupying a total land area of only 32 km. But, with lagoons it occupies a vast area of about 4200 sq km.

The islands are flat, rising only 3-5 m above the sea level and enclosed within coral reefs. There is no natural forests, hillocks, bay, creeks, estuary, river, lake or freshwater tank. The lagoons are saucer-shaped shallow water depressions having 1 sq km to 150 sq km in area and 2-15 fathoms in depth.

Due to identical topography and uniform climate, vegetation of these islands is not diverse. Natural vegetation mostly comprises of herbaceous and shrubby bushes. All the islands are almost covered with coconut grooves excepting rocky Pitti islet. About 350 species of vascular plants comprising around 300 species of angiosperms and 50 species of ferns, lichens and mosses have been reported from these islands. Little more than 100 species of marine algae and sea-weeds have also been recorded from atolls.

As many as 1758 animal species have been recorded from these islands. Out of these only 172 species are terrestrial and the remaining 1586 species are marine. Terrestrial vertebrates comprises of 3 species of mammals, 73 species of birds, 8 species of reptiles and 2 species of amphibia. The invertebrates known so far from these islands are exclusively insects (83 species), excepting 2 species of earth worms.

Amongst marine fauna maximum number of species belong to fishes (741), followed by mollusca (424), corals (78) and echinoderms (72). There are several other marine faunal components of Lakshadweep with lesser number of species. There is no endemic plants in Lakshadweep. The land fauna is mostly exotic. Only two species of earth worms are endemic in this archipelago.

It is now well established that islands represent a fragile and biogeographically significant ecosystem. These are also recognised as the living laboratories on earth for demonstrating the process of organic evolution and speciation since Darwin era. The same is also evidenced in the Indian Bay islands as they not only host large percentage of endemic species of both flora and fauna but also display significant racial endemism amongst these island biota.

### **MONTENE ECOSYSTEM**

The mountainous zone of this country, the Himalaya constitutes one of the youngest mountain systems of the globe. It forms a gigantic physical barrier between the high plateau of Tibet and the Central Asia and, the Indian plains. The Himalaya spreads over a distance of about 2500 km in west-northwest to east-southeast direction extending from the River Indus in the west to the River Brahmaputra in the east. Geographically the Himalayan ranges are divided into the Eastern or the Assam Himalaya, the Central or the Nepal Himalaya, the Kumaon or the Western Himalaya and the North-West or the Punjab Himalaya. According to this division the Central India is outside the Indian territory.

The Himalaya encompasses considerably diverse habitats which may be broadly categorised as below.

- Perpetual snow-covered area in very high altitude
- Pastures (between snow line and tree line)
- All 4 major types of forests (tropical, temperate, subalpine and alpine)
- Vast stretches of grasslands
- Rich and diverse foliage cover
- Varied types of wetlands (*e.g.*, bogs, marshes, fresh and backishwater lakes, streams rivers, *etc.*)
- Special habitats (caves, cliffs, overhangs, crevices, *etc.*)
- Agroland and human habitation.

In addition, there are some significant physical and biogeographic factors which are also responsible for considerably rich biodiversity in this regions. These factors are :

- Geographic location at the confluence of Palaearctic and Oriental regions.
- Climatic variation (from near subtropical, tropical, temperate to near arctic)
- Considerable variation in rainfall (from the rain-shadow zone to abundant rain fall)
- Altitudinal variation (from about 550 m to 7700 m)
- Also possible path of faunal migration.

As a matter of fact, gorge of the River Sutlej in Himachal Pradesh forms biogeographical transition zone between Oriental fauna and, Ethiopian and Mediterranean fauna. The oriental fauna are generally restricted to the east of this river while Ethiopian and Mediterranean fauna are usually found west to this rivers although there are infiltration of these faunal elements on either side. Further, the timber line in the Himalaya also forms such transition zone. Because, above the timber line faunal elements are mainly Palaearctic and below it mainly Oriental and some are Ethiopian and Mediterranean as stated above.

The Himalayan ranges are the richest in the floristic diversity in the country. Out of about 17000 plant species found in India about 8000 species present in this region, out of which 3169 species are endemic. The largest flowering plant family in the Himalaya is Orchidaceae (750 species), followed by Asteraceae (734 species), Poaceae (517 species) and Leguminosae (507) in number of species.

Faunal elements of the Himalaya are not only diverse but also include Palearctic, Oriental, Ethiopian and Mediterranean elements as stated earlier. From the Himalaya 521 species of birds have been recorded. Other vertebrates of this region are also well documented. From the Eastern Himalaya 187 spp. of fishes, 80 spp. of Amphibia, 103 spp. of reptiles and 172 spp. of mammals, from the Western Himalaya 124 spp. of fishes, 19 spp. of Amphibia, 69 spp. of reptiles and about 100 spp. of mammals and from the North-West Himalaya 81 species of fishes, 17 spp. of Amphibia, 44 spp. of reptiles and 77 spp. of mammals have been reported so far. Amongst these, a large number of species are estimated as threatened, a detailed list of which is available in Alfred, *et. al.* (2001) and Khanna and Arun Kumar (2001).

Mention is to be made here that domesticated animal diversity is also very rich in the Himalaya, more particularly in the Trans-Himalaya. This region serves as a store house of several breeds of sheep, goats, yaks, ponies, horses and camels.

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**Fig. 1.** Indira Gandhi Wild Life Sanctuary–Evergreen Forests  
(Courtesy : P. S. Sivaprasad)



**Fig.2.** Indian Elephants–*Elephas maximus* in the grassland habitat of Corbett National Park, Uttarakhand (Courtesy : H. Nandi)



**Fig.3.** Characteristic flora in Thar desert

**Fig.4.** A shallow freshwater wetland of West Bengal infested with different macrophytic communities



**Fig.5.** A wetland ecosystem in Cauvery Delta (Courtesy : P. T. Cherian, Z.S.I.)



Fig.6. *Rhizophora mucronata* in-Mangrove Forest, Picavaram

Fig.7. Diversity of coral species in the reef slope of Chidiatappu, Andaman



Fig. 8. Rocky Coast, Mahabalipuram, Tamil Nadu



**Fig. 9.** Katchal Island, Nicobar



**Fig. 10.** A view of mountain ecosystem in Western Himalaya

## **FAUNAL AND FLORAL RESOURCES IN INDIA AND THEIR CONSERVATION STRATEGY**

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### **INTRODUCTION**

Plants and animals of the forests are the results of billions years of infinitely gradual evolution, which in the Indian sub-continent was abundantly expressed in terms of scenic splendour and variety of life-forms at the turn of the twenty-first century.

India is exceptionally rich in biodiversity with 6.5% of the world's fauna and 7% of the flora within its domain and has been included as one of the 12 countries identified as megacentres of biodiversity. In India, occurrence of such large number species of plants and animals with their innumerable varieties is mainly the result of variability of climate along with the variability of soil, water, geology and physiography of the sub-continent. The forests of India constitute an area about 21% of the total land surface of the country. In the world classification of forests the major part of the Indian vegetation is classified as monsoon and dry forests, thorn brush and savanna. The western part of Rajasthan is semi-desert and desert.

On the basis of plant distribution India is divided into a number of botanical regions. Though a casual survey would suggest that the Himalayan plants are distinct from those of other parts of India, actually a number of those plants are found in other parts as well. Some of the trees from the hill districts of Bihar, Orissa and the Western Ghats are directly related to Himalayan species, though there are isolated from the latter by hundreds of miles. The same phenomenon has been reported for many animal species as well.

While climate is the major factor in determining forest type along with their characteristic plants and animal species, geology is also of prime importance. In addition, in an ancient country like India much of the original forest has been destroyed or modified by the activities of man and his livestock. On the basis of all these factors the forests of India can be classified into four major types – tropical, subtropical, temperate and alpine. Only in Himalayas all of those types can be found relatively close to one another in India. The four major types reflect mainly conditions of temperature. Available water is a second factor that applies in each of these types, subdividing them into smaller units. Thus under

the heading tropical forests are found wet evergreen, semi-evergreen, moist deciduous and dry deciduous types. The same would apply to the subtropical, temperate and alpine forests of India.

Soil conditions further modify each of those forest conditions. The forests growing on immature or newly formed soils are often called edaphic forests. In India the edaphic tropical forests include beach forests, mangrove forests, or tidal forests, fresh water swamp forests plus river edge forests. In India the most widespread forests are being the tropical dry deciduous and tropical thorn forests

### **DEPTH AND DIMENSION OF BIODIVERSITY IN INDIA**

As referred earlier that India has been included as one of the 12 countries identified as Megacentres of biodiversity. In fact, all the world's major ecosystems are represented in India's 10 biogeographic zones and 25 biotic provinces exemplifying its exceptionally rich diversity of fauna and flora (Basu, 2004). The 10 biogeographic zones are : (1) Trans-Himalayan, (2) Himalayan, (3) Indian Desert, (4) Semi-arid region, (5) Western Ghats, (6) Decan Peninsula, (7) Gangetic plain, (8) North-East India, (9) Coastal region, and (10) Island. All the Indian flora and fauna have been distributed in three distinct Biomes which are : (i) Tropical Humid Forests, (ii) Tropical Dry Deciduous Forests, (iii) Hot Deserts and Semi-deserts. These zones and Biomes serve as the habitat of 45,000 plant species of which 15,000 are flowering plants; the others are 64 species of gymnosperms, 2,843 bryophytes, 1,012 pteridophytes, 12,480 algae, 23,000 fungi and 1,940 species of lichens (Basu, 2004).

Over 81,000 animal species have been estimated to be present which include over 5,000 species mollusks, 57,000 insects; the vertebrates consists of 372 species of mammals (of which about 63% are in Assam), 1228 of birds, 204 of amphibians, 428 species of reptiles, and 2,546 fish species (Basu, 2004). The microbial biodiversity is not known but possibly very high.

An estimated 33% of the flowering plants are endemic (native to a particular region) and the North-East, North-Western and Eastern Himalayas and the Western Ghats are areas of high endemism (The Western Ghats are specially rich in amphibians and reptiles), over 200 species of plants in the Andaman and Nicobar islands are endemic to the region. The faunal endemism is also very high - 62% in amphibians, 32% in reptiles, 14% of birds and 3.5% of mammals are endemic to this on.

### **BIODIVERSITY IS UNDER SERIOUS THREATS IN INDIA**

Due to ever increasing pressure of human population the extensive modification of forests by man through mass-scale encroachment, logging (including over exploitation of forest resources), grazing and poaching has greatly accelerated the reduction of forests' area in India along with the declining of frequency and diversity of plants and animal species of forests' ecosystem. About 100 years ago India had 1.6 million sq. km of forests, almost 90% of which has been destroyed and reduced to only about 0.165 million sq. km..

After the independence, within 30 years, in between 1951 to 1981, over 2.5 million hectare of forested land has been vanished, 0.5 million hectare of which has been encroached by river valley projects and rests are vanished under expansion of cultivation and urbanization. The most alarming situation may be indicated by the fact that every year a significant parentage of forested area is being lost. Between 1981–1990 the average rate of forest loss was 1.4% per annum in India. In Asia it was 1.2%. World average was 0.9%. At the end of this century, if this rate is maintained, obviously there would be no forests left outside the reserve and protected forests

A prominent adverse effect of depletion of forested area has been reflected with increasing magnitude on the frequency and diversity of flora and fauna of this sub-continent. Of the 15,000 species of flowering plants, 1,500 species, i.e., 10% of the total, have been found as endangered ones. Faunal situation in this respect is more perilous, Of the 372 species of mammals, 81 species are endangered ones. Among the mammals, of the 19 species of primate, 13 species have been enlisted as endangered ones; of 36 species of carnivora, 28 species are endangered ones, of 9 species of deer – 5 species are endangered ones. Among 1228 species of birds- 101 species are endangered ones. 15 species of reptiles, 3 species of amphibians and 2 fish species are also enlisted as endangered ones.

### CONSERVATION STRATEGY

India has ratified all the main international conservation conventions: the Convention on International Trade in Endangered Species of Flora and Fauna (CITES); the Convention on Wetlands of International Importance (the Ramsar Convention); the Convention on Migratory Species of Wild Animals and the International Convention for the Regulation of Whaling. In 1983 the historic National Wildlife Action Plan was adopted with the full backing of all the States and Union Territories, thus implementing the resolutions passed at the World Parks Congress in Bali and at the UN General Assembly on the World Charter for Nature. Finally, India now has no fewer than 52 National Parks and 223 wildlife reserves of various kinds. Though such record is commendable, but overall conditions of those Parks, wildlife reserves, including closed and open Indian forests, are not very healthy and sound and that necessitates a thorough review and strengthening of the current conservation strategy, which may be modified to reach the ultimate goal.

The current conservation strategy has been built up to achieve the following objectives :

#### **A. To reduce the mounting pressure on the forests and wildlife.**

The implementation is related to the controlling of human population of the country as a whole, as well as population of human and livestock around the fringes of the forests, wildlife reserves, national parks, etc.

Enactment of laws which prohibit trading of skins, bones, tasks, horns, etc.

Large scale marketing of bio-gas plants, solar cookers and other simple equipments, which would reduce the using of fuel wood.

**B. To check the loss**

The implementation is related to the checking of illegal logging, poaching, sweeping of forest floor, erosion of soils, over exploitation of forests' produce and wildlife :

**C. To regenerate resources of forests and wildlife**

Implementation is related to the afforestation and social forestry programme, large scale production of propagules by stemtip culture, somatic embryo culture and introduction of new breeds, creation of new sanctuaries and reserve forests for conservation of endangered animal and plant species.

**D. To manage the forests and wild life scientifically**

Implementation is related to the proper management of forests ecosystem, maintenance of healthy ratio of producers to consumers, making arrangement for food, water and health care of plants and animals, controlling noise pollution in the habitat within permissible limit. Keeping detail record of every aspects of the wild habitat

People participation is also obligatory in conservation of wildlife.

The grass-root support for environmental reform concerning the conservation of plants and animals species may be revealed from the success of the Chipko movement. Conservation is a continuous process and the people of the habitat play a prime role in this process. If people of the habitat are aware of the real value of plants and animals and their role related to their own existence, it would be easier to get their active involvement and support in the conservation process.

The present author developed a new system (Das, 1980 a, b, c,) to estimate the real value of a tree. This system considers at a number of factors, such as the production of oxygen, organic substances, recycling of water, controlling of soil erosion, air pollution, sheltering of other species, etc. and the real value of a tree may be revealed when costs of those work and productions would be added. This system is universal and may be applicable to other natural resources of the environment as well. This system has been recognized in different countries round the world (Beckham, 1992) and has been given a special name : *Social Accounting and Corporate Social Reporting*. This system may throw some light upon the environmental benefit and social value of a natural object. In this context, it appears quite relevant to discuss the system in some detail that would enlighten the people who are dealing with conservation of natural resources, specially that of plants and wildlife.

In our society, the determination of the value of any object is awfully arbitrary. Some times it loosely follows the rule of demand and supply, some times the assessment is made on the basis of cost benefit ratio. But in many cases there is hardly any such rule or a standard yard-stick. Quite often we remain totally blind, particularly with regard to the value of natural resources and the value of a tree is one of them.