First Summer Course on

# PRINCIPLES OF BIODIVERSITY CONSERVATION AND SUSTAINABLE DEVELOPMENT

(March - April, 1998)

Summary of Lectures delivered

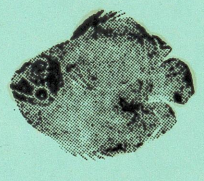
*by*

**Prof. R. J. Ranjit Daniels**

Compiled and Edited by

G. Anuradha & Jayshree Vencatesan

**1998**



**B. R. Barwale Chair in Biodiversity**

M. S. Swaminathan Research Foundation

Chennai 113

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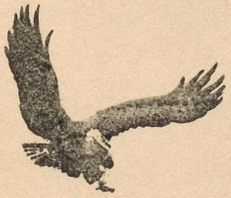

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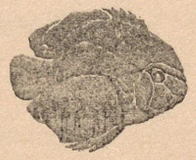

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## 0.0 Preamble

A growing emphasis on Conservation of Biodiversity in the context of Sustainable Development has necessiated the need to take this science across to a wide range of people; not only to create a greater awareness on the prevailing theories and practices, but also to initiate and inculcate a scientific interest on the issues.

Recognising this importance, the B R Barwale Chair in Biodiversity of M. S.Swaminathan Research Foundation offered the First summer course on the Prinicples of Biodiversity Conservation and Sustainable Development during the months of March-April, 1998.

The course attracted 40 participants representing students, teachers and other professionals. The course was offered through a series of lectures, discussions, video sessions and field visits which provided scope for interaction. The following document is a compilation of the major topics which were covered during the course.

## 0.1 Article 6 (a) of the United Nations Convention on Biological Diversity (CBD)

'... each Contracting Party shall, in accordance with its particular conditions and capabilities develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adopt for this purpose existing strategies, plans or programmes which shall reflect, inter alia, the measures set out in the Convention relevant to the Contracting Party concerned'.

## 0.2 Biodiversity in Developing Countries: Major issues, problems and unresolved questions

The summary for Policy Makers of the Global Biodiverstiy Assessment (GBA) states that the primary causes underlying the loss of biodiversity are demographic, economic, institutional and technological factors, including

- increasing demands for biological resources due to increasing population and economic development.

- failure of people to consider the long-term consequences of their actions, often due to a basic lack of knowledge.
- failure of people to appreciate the consequences of using inappropriate technology.
- failure of markets to recognise the true value of biodiversity.
- failure of economic markets to apply the global values of biodiversity at local level.
- institutional failure to regulate the use of biological resources resulting from the growth in urbanization, changes in property rights and shifting cultural attitudes.
- failure of government policies to address the over-use of biological resources and
- increasing human migration, travel and international trade.

**0.3 Facts and Figures**

- More than 3.5 billion years of evolution, involving speciation, migration, extinction and more recently, human influences, has determined the magnitude and present distribution of biodiversity.
- Recent estimates have put the total number of species between 13 and 14 million.
- Of these, 1.75 million have been scientifically described.
- Less studied organisms include bacteria, arthropods, fungi and nematodes.
- Those species living in marine environments and beneath the ground are especially poorly known.
- With the exception of a few groups of organisms, biodiversity is generally a tropical phenomenon.
- Unfortunately, however, the tropics have also been the most ravaged of geographical areas both due to developmental pressures within and that from outside.
- Models of species extinctions and predictions of loss of species in numbers when applied to tropical areas (forests in particular) suggest that in the next 25 years or so 2-25% of the various groups of organisms (especially plants and birds) will be wiped out.
- Such alarming facts have become common knowledge, at least amongst scientists.

# 1.0 Biodiversity

## 1.1 Definitions

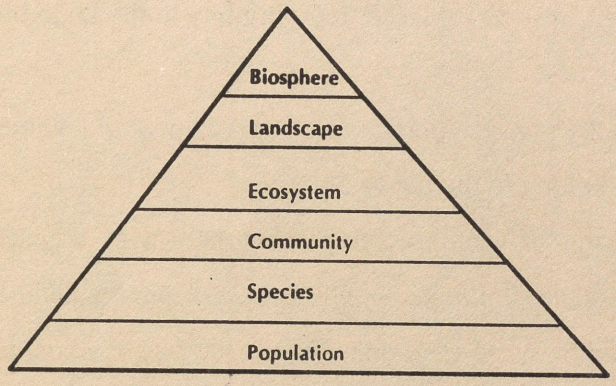
- Biological diversity is a term that refers to the variety in life amongst microorganisms, plants and animals. Biodiversity is nothing but the short-form of biological diversity.
- Agrobiodiversity is the component of biodiversity that is directly related to agriculture. It includes crop plants and their wild relatives, livestock and beneficial organisms such as pollinators, decomposers and predators which are normally associated with cultivated areas.
- Domesticated biodiversity includes all forms of life that have been tamed, captive bred, modified and multiplied by humans. Domesticated biodiversity includes cultivated plants, livestock (cattle, buffaloes, horses, pigs, sheep, goats, rabbits, chicken, turkeys, ducks, geese, quails), honey bees, silk worm and non-farm animals such as aquarium fishes, cage birds, rats, guinea pigs, cats and dogs.
- Endemic biodiversity refers to those forms of life that are exclusive to a given geographical area such as a landscape, nation, region or continent. For the sake of convenience, endemic biodiversity is often assessed within political boundaries. Islands are rich in endemic biodiversity.
- Introduced biodiversity is that of microorganisms, plants and animals that have been accidentally or deliberately transported by humans to landscapes, countries, regions or continents where they never occurred naturally. Disease causing organisms, weeds, insect pests and rats are good examples of introduced biodiversity.
- Microbial diversity refers to the variety in microorganisms such as viruses, bacteria, yeasts, amoebae and certain fungi.

## 1.2 Magnitude and distribution

- World-wide scientists have identified and described 1,750,000 species of microorganisms, plants and animals.
- It is however estimated that there can be between 10,000,000 and 30,000,000 species on earth. Conservative estimates put this figure around 13,600,000.
- Insects alone amount to 8,000,000 species. Insects, as we are aware, are important in the global agricultural economy.
- It is estimated that there can be 400,000 species of viruses, 400,000 species of bacteria and 1,500,000 species of fungi. Microorganisms, like insects, are important determinants of agricultural productivity.
- Of the estimated total of 266,000 species of living plants, 3000 are exploited as food by humans. However less than 20 of these constitute crops of major economic importance.
- The tropical regions are generally richer in biodiversity than the temperate and Arctic regions of the world. Tropical rainforests and coral reefs are the best sources of biodiversity.
- Identifying and inventorying biodiversity is a major task. It is estimated that there are between 20,000 and 30,000 biosystematists (those who identify, name and catalogue organisms) world-wide.
- During the past 25 years, 20,000 species have been identified and named per year.
- With the current strength of biosystematists, and the above rate of identification, it is estimated that it will take 535 years to discover all the biodiversity on earth!

### 1.3 Biological Hierarchy

- Biodiversity is measured at different levels. Each level has a place in what is called the biological hierarchy.
- The biological hierarchy is often represented as a pyramid.




- Populations are made of individuals belonging to the same species. A population exists within a clearly defined geographical space.
- A species exists as many populations. Individual organisms belonging to such populations tend to be more similar to each other than to members of other species' populations. Amongst sexually reproducing organisms, populations that cannot breed with one another, are treated as belonging to different species.
- When more than one species coexist over a known period of time and geographical space, the assemblage is called a community.
- Species in a community interact with each other as well as the non-living components of their limited environment. The sum of all species and their interactions make an ecosystem.
- Depending on the number of species and types of interactions ecosystems vary from one another. Hence different ecosystems can be identified within larger geographical spaces as that of landscapes.
- A structurally distinct geographical space which is kilometres wide is called a landscape. Many landscapes together form the earth's biosphere.
- Biosphere is the limited zone of life on earth.

## 1.4 Taxic Hierarchy

- The science of providing standard names to organisms is called taxonomy. Such names, as a rule, are in Latin.
- A given organism is provided a scientific name based on its relationships to other known organisms. It is then placed appropriately in the taxic hierarchy. This process is called biosystematics.
- The taxic hierarchy places closely related species within a genus. Brinjal, Potato, Night Shade and such belong to the genus *Solanum*.
- The scientific name of each species has two parts viz., a generic name and a specific name. Thus brinjal is *Solanum melongena* and potato *Solanum tuberosum*. Generic names are shared by more than one species. No two species, within a genus however, can have the same specific name.
- Closely related genera (plural of genus) are placed within a family. The family of Palms viz., Arecaceae thus contains many distinct genera including Coconut (genus *Cocos*), arecanut (genus *Areca*), Sago (genus *Metroxylon*), rattan (genus *Calamus*) and others.
- The general system of placing plants and animals in the taxic hierarchy is illustrated below.

| | **Plant** | **Animal** |
|---|---|---|
| ↑ Kingdom | Plantae | Animalia |
| Phylum | Tracheophyta | Chordata |
| Class | Angiospermae | Mammalia |
| Order | Fabales | Primates |
| Family | Leguminosae | Hominidae |
| Genus | *Pisum* | *Homo* |
| Species | *Pisum sativum* (Pea) | *Homo sapiens* (Human) |

- The number of species that comprise each taxic level in the hierarchy increases as we follow the direction of the arrow in the illustration. All species of plants belong to the kingdom Plantae as do all animals to kingdom Animalia.

## 1.5 Biodiversity and Biotechnology

- Biotechnology, in its simplest sense, is the successful utilisation of living organisms and their life processes for improving the quality of human life and its environment.
- Agriculture, animal husbandry and human health have benefited considerably through biotechnology.
- Chemicals of microbial, plant and animal origins have been immensely used in improving the quality of human life all over the world.
- The inherent natural variation in living organisms has been the basis of all our domesticated and improved varieties of crops and livestock.
- Life on earth has sustained itself for millions of years by generating diversity. This diversity is passed down from one generation to the next. In other words, each generation inherits its biological diversity from its previous generation.
- Biological inheritance is made possible by small chemical units. These are called genes.
- Life on earth is an expression of billions of genes. Hence biodiversity is often referred to as the earth's genetic resources.
- Genes are the primary targets of modern biotechnology.
- Biotechnological tools enable the identification, isolation and manipulation of genes. The process, when applied to modify living organisms, is referred to as genetic engineering.
- It is widely hoped that genetic engineering can help combat pests and diseases and enhance future agricultural productivity.
- Biodiversity opens newer avenues for biotechnology.

## 2.0 Biological Communities - Keystone species, indicator species

- Species communities vary in structure over space and time.
- Communities are often characterised by single dominant or a set of 'key' species.
- Keystone species in a community are those whose presence influences the survival of several other species locally. Eg. Ficus, termites.
- The loss of keystone species is expected to have a greater impact on a community than the loss of several others in the community.
- Often the complex structure and function of communities are not readily understood. However, certain species 'indicate' trends of change in the community more conspicuously than the others. Such species are called indicator species - sometimes, bioindicators.

### 2.1 Bioindicator : Definitions

- Bioindicator is a living organism that expresses changes in appearance or behaviour in response to changes in some environmental influence.
- Biomonitor is a living organism whose number or geographical distribution is studied from time to time and compared against some standard or base line data. Measurable deviations in number or distribution is noted.
- The response of biomonitors is measured quantitatively where as that of a bioindicator is usually qualitative.
- Although by definition the two terms are different, in practice they are often used interchangeably.
- Whether an organism is a bioindicator or biomonitor, it is most efficient when it helps in detecting early stages of environmental disturbances. Scientists refer to this as an 'early warning system'.

## 2.2 Bioindicator : Characteristics

- A bioindicator should ideally show a prompt and accurate response to a specific environmental disturbance.
- It should reflect some aspect of ecosystem function.
- It should be a component in lower parts of food chains.
- It should be easily recognised and sampled in the field even by non-experts.
- It should be widely distributed and expected to be found in the area to be studied by virtue of its ecology.
- Bioindicators should include species that are characteristic of different scales of environmental disturbance.
- A bioindicator must be easy to identify in the field with minimal aid - often not more than a hand lens.

## 2.3 Bioindicators : Some basic considerations and limitations

- The choice of a bioindicator is determined by the geographical scale and magnitude of the disturbance and by the material and human resources available.
- A swallowtail butterfly may be sensitive to change at 50m X 50m scale. A tiger beetle can respond to disturbances at 1m X 1m scale. Microorganisms may be influenced by even smaller magnitudes of change.
- Hence general inferences that we draw from each organism needs to be treated cautiously.
- Confirmative tests are only possible when long term data on the ecology of the bioindicator and the specific environmental influence are available.
- The effect of the environmental influence - e.g. temperature, on the performance of the bioindicator should be known.
- The functional role of the bioindicator in the ecosystem should also be known.
- Most often, such information is lacking in the tropics.
- Species that are mobile or migratory are not ideal candidates.
- Species that are affected by competition from other members of their own species or those of other species are not ideal candidates.

- Species whose presence or absence in a given locality is affected by reasons other than landscape modifications or disturbances are not ideal candidates.
- Few tropical organisms would therefore qualify as bioindicators if the above considerations are strictly adhered to.

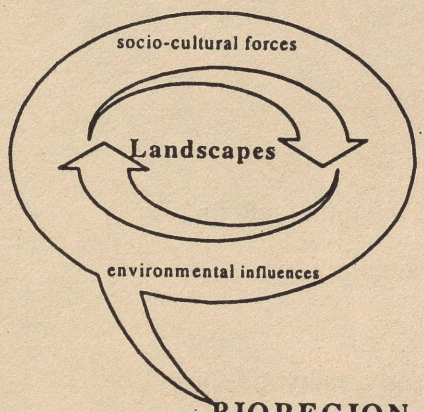
## 3.0 Ecosystems

- When living communities of organisms interact amongst themselves and their surrounding non-living environment, an ecosystem is created.
- Ecosystems have both structural and functional dimensions and hence are often complex.
- Although vital to the overall functioning of the biosphere, individual ecosystems are hard to delimit as it is difficult to identify where exactly an ecological interaction starts and ends.
- For practical reasons, with the exception of certain discrete geographical elements as that of high altitude lakes or oceanic islands, ecologists often treat different habitat types or broade vegetation types as distinct ecosystems.
- When two distinct habitat types exist side by side in a larger landscape the zone of contact is considered an 'ecotone'.
- Ecotones are transitional habitats, often rich in biodiversity, but subject to what ecologists consider as 'edge effects'.
- Edge effects are external influences on a habitat often expressed in the form of invading organisms (eg., weeds and predators) or wind, rainfall and temperature.
- Habitat fragmentation leads to reduction in size of individual patches which tend to further suffer the effects of increasing edge.
- Examples of ecosystems can be of little freshwater swamps in rainforests, mangroves, islands, mountains, etc.
- However, since these are not really discrete geographical elements, but only components of an ecological continuum, it is more appropriate to study ecosystems within the framework of 'Landscape Ecology'.

- Landscape ecology is the science of studying large geographical areas within which many ecosystems, including human dominated, exist and interact.
- Landscape ecology is also the science of managing fragmented and human modified habitats including

| | |
|---|---|
| Corridors | Woodlots/Orchards |
| Fallows/Wastelands | Afforestation |
| Rainwater catchment | Parks/Gardens |
| Institute Campus | Etc. |

- Landscapes are hence dynamic spatial systems within the biosphere, the boundaries of which are drawn and modified by the constant impacts of humans.




**BIOREGION**
**Basis for policy formulation**
**Local level**
↓
**National level**
↓
**International level**

- Landscapes shaped and impacted by socio-cultural forces are treated as bioregions.
- Bioregions are often the basic units for biodiversity conservation policy formulation.

## 4.0 Managing Population and Communities

### 4.1 Key issues of concern

- International co-operation in the conservation and use of biodiversity.
- Well defined national policies, legislations and strategies for conservation and use of biodiversity.
- Well-informed and active participation of the local human communities and indigenous peoples in the conservation action and,
- Practical systems of recognising and rewarding the knowledge of these people and equitably sharing the benefits derived from such knowledge.

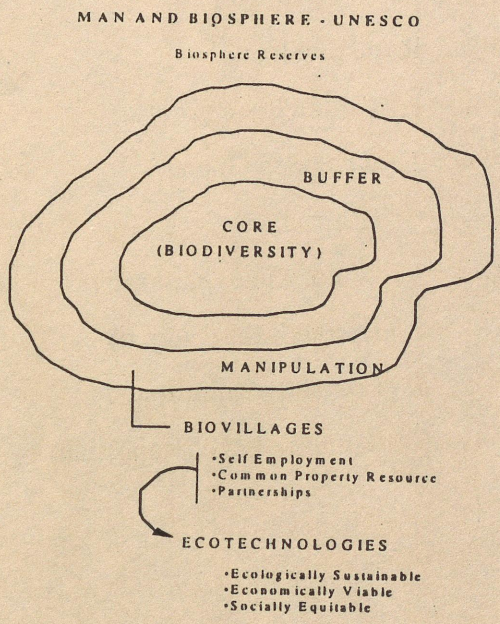
### 4.2 India - a megadiversity country

- > 500 Protected Areas (Pas)
  accounting for a mere 3 - 4% of the total land area
- > 95% of the land outside the PA system

### 4.3 Areas of Natural Biodiversity adversely affected

- Unsustainable agricultural practices
- Urbanisation.

## 4.4 The System of Protected Areas




### 4.4.1 UNESCO's Man and Biosphere (MAB) - Seville Strategy - 1995

**Goals:** To ...

1. Improve the conservation of biodiversity through the use of bioshpere reserves.
2. Make biosphere reserves demonstration areas for Joint Management and for the Integration of Sustainable use and conservation of natural resources.
3. Improve research, education, training and monitoring activities in biosphere reserves and
4. Reinforce activities necessary for the good functioning of the biosphere reserves network.

### 4.4.2 Indian Man and Biosphere Programme and Protected Areas of International Importance

**Biosphere Reserves**

1. Nilgiris (TN, Kerala, Karnataka)
2. Nokrek (Meghalaya)
3. Nandadevi (UP)
4. Sunderbans (WB)
5. Simipal (Orissa)
6. Gulf of Mannar (TN)
7. Great Nicobar (A & N)
8. Manas (Assam)
9. Dibru Saikova Duar (Assam)

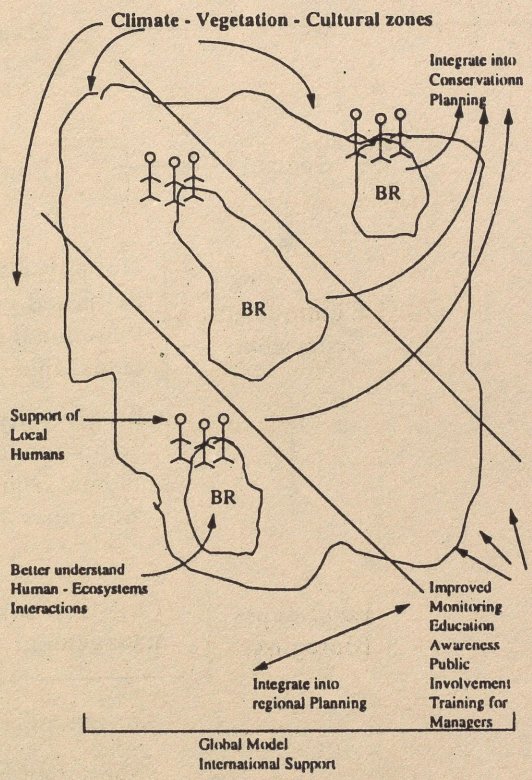
**Ramsar Sites**

1. Chilka Lake (Orissa)
2. Keoladeo Ghana (Rajasthan)
3. Wular Lake (Kashmir)
4. Harike Lake (Punjab)
5. Loktak (Manipur)
6. Sambhar Lake (Rajasthan)

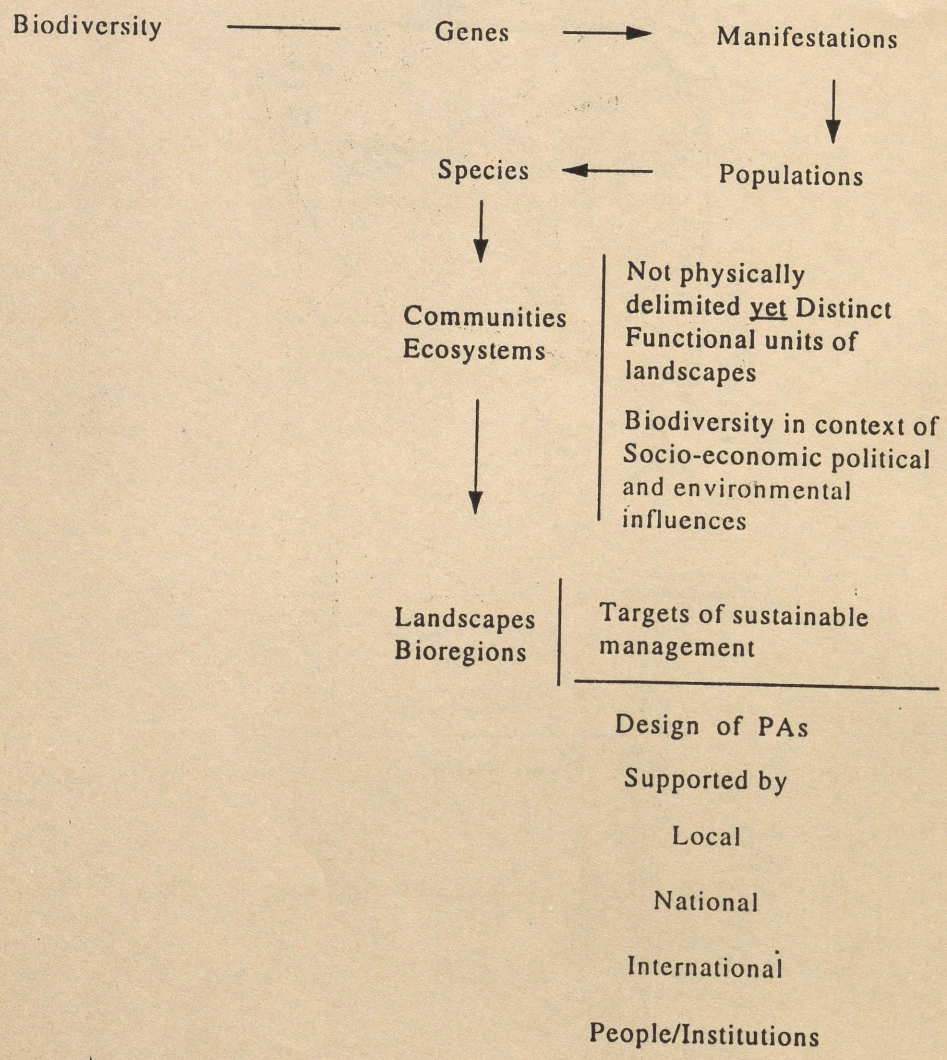
**World Heritage Sites**

1. Kaziranga (Assam)
2. Keoladeo Ghana (Rajasthan)
3. Manas (Assam)
4. Nandadevi (UP)
5. Sunderban (WB)

## 4.5 Integrating Biosphere Reserves (BR) into regional conservation planning



## 4.6 Summary


Biodiversity
Genes
Manifestations
Species
Populations
Communities
Ecosystems
Not physically delimited yet Distinct Functional units of landscapes
Biodiversity in context of Socio-economic political and environmental influences
Landscapes
Bioregions
Targets of sustainable management
Design of PAs
Supported by
Local
National
International
People/Institutions

## 5.0 Human Ecosystem Interactions

### 5.1 The 'Biophilia Concept'

- Utilitarian - the physical benefits derived from nature as a fundamental basis for human sustenance.
- Naturalistic - satisfication or a sense of fascination, wonder and awe derived from an intimate experience of nature's diversity and complexity - involves an intense curiosity and urge for exploration of the natural world.
- Ecologistic-Scientific - inquiry, study, a recognition of organisational structure.
- Aesthetic - the physical beauty of nature-larger, charismatic and megavertebrate species than the obscure.
- Symbolic - a means of communication and thought.
- Humanistic - deep emotional attachment to individual elements of natute-'love' for nature-companion animals-humanization of animals.
- Moralistic - strong feelings of affinity, ethical responsibility, and even reverence for the natural world- eg. sacred groves.
- Dominionistic - desire to master the natural world-hunter and his knowledge of the prey-development of skills.
- Negativistic - sentiments of fear, aversion, and antipathy towards various aspects of the natural world.

(Source: Kellert and Wilson, 1993).

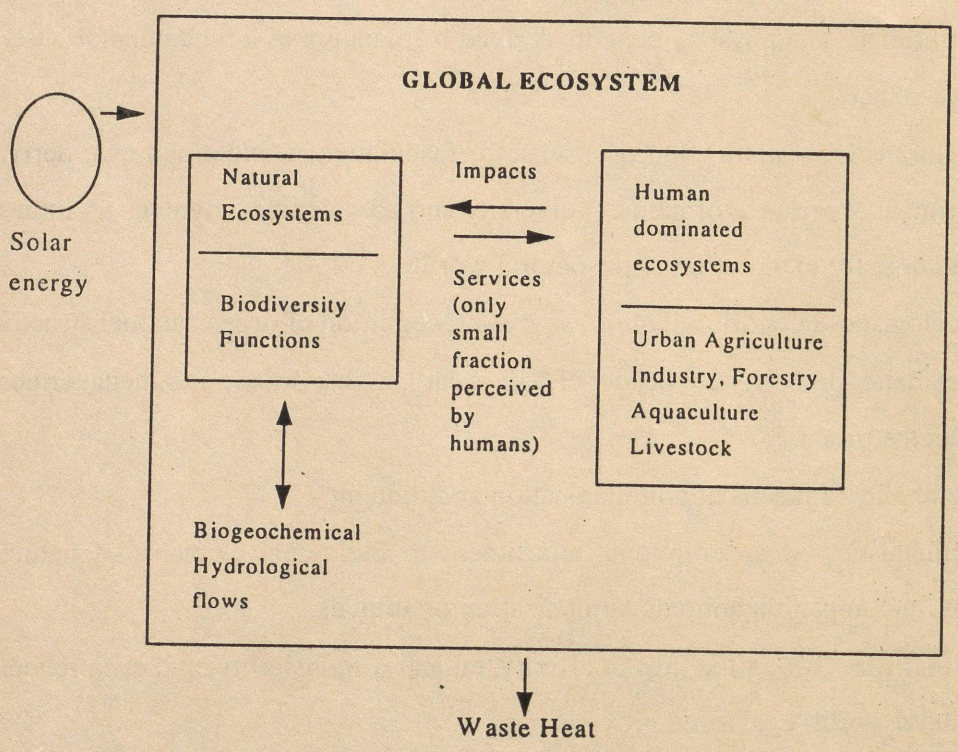
### 5.2 The Approach

Study the perceptions of people of diverse nature - hunters, birders, farmers, age groups, gender, socio-economic status and place of residence.

**First law of human altruism: "never ask people to do anything they consider contrary to their best interests'**

(Source: Kellert and Wilson, 1993).

## 5.3 Human - Ecosystem Interaction Modelled




The goods and services flowing from natural ecosystems are greatly undervalued by society.

Human disruptions of natural ecosystems are difficult or impossible to reverse on any time scale of relevance to society.

If current trends continue, humanity will dramatically alter or destroy virtually all of Earth's remaining ecosystems in a few decades.

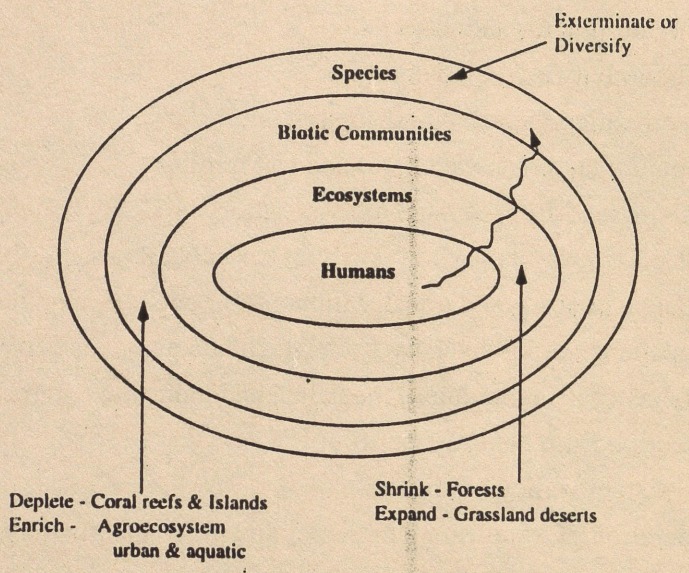
(Source: Daily, 1997).

## 5.4 Ecosystem Services

- Purification of air and water.
- Mitigation of floods and droughts.
- Detoxification and decomposition of wastes.
- Generation and renewal of soil and soil fertility.
- Pollination of crops and natural vegetation.
- Control of vast majority of potential agricultural pests.
- Dispersal of seeds and translocation of nutrients.
- Maintenance of biodiversity from which humanity has derived key elements of its agricultural, medicinal and industrial enterprise.
- Protection from the sun's harmful UV rays.
- Partial stabilization of climate.
- Moderation of temperature extremes and the force of winds and waves.
- Support diverse human cultures.
- Providing aesthetic beauty and intellectual stimulation.

(Source: Daily, 1997).

## 5.5 Impact on Biodiversity




**Diversification** is effected by selection and breeding below the level of species. Eg. in India there are 50,000 varieties of rice bred traditionally. Globally some 1400 breeds of livestock have been developed.

**Species extinctions** by man started 50,000 - 15,000 YBP. During the last 400 years 486 species of animals and 654 species of plants have been exterminated!

## 5.6 Human forces driving changes in Biological Diversity (Species - Ecosystems)

| Before 1500 AD | 1500-1800 AD | Since 1800 AD |
|---|---|---|
| • Fire | • Exploration | • Improved transporation |
| • Hunting | • Discoveries | • Multinational companies |
| • Gathering | • European colonization | • Irrigation/ hydropower |
| • Domestication | • Globalization of trade | • High input chemical agriculture |
| • Agriculture | • Revolution in food (tea, coffee) | • Mechanised fishery and forestry |
| • Trade | • Introduction of exotic species | • World wars |
| • Offshore traffic | • Large-scale emigrations | • Tropical deforestation |
| • Building empires | | • Afforestation of arid land with exotics |
| • Wars | | • Increased urbanisation |
| • Invasions | | • International markets |
| • Market economies | | • Genetically engineered organisms |

(Source: ?).

## 5.7 Human influences

Direct:

- Exploitation of wild living resources.
- Expansion of agriculture, forestry and aquaculture.
- Habitat loss and fragmentation.
- Negative effects of introduced species.
- Pollution of soil, water and atmosphere.
- Global climate change.

Indirect:

- Changes in human social organisation.
- Growth of human population.
- Changes in natural resource consumption patterns.
- Increased global trade.
- Economic systems and policy failures.
- Inequity in ownership management and flow of benefits from both use and conservation of biological resources.

(Source: ?).

## 5.8 Human Inference and Ecosystem Dynamics

- Ecological succession affected by fire, grazing and agriculture.
- Nutrient recycling interfered by soil and water denundation and pollution.
- Speciation affected by habitat fragmentation and reduced population size leading to inbreeding.
- Community organisation disrupted by changing the structure from complex to simple.

# 6.0 Agroecosystems

## 6.1 Agrobiodiversity

- All plants that are directly used as food for humans and livestock. Such plants can be either indigenous or exotic.
- Farm plants that are put to non-food uses such as fuel, fertiliser, fibre, construction and decorative purposes.
- Medicinal plants that are used daily for treating common ailments of both humans and their livestock.
- Weeds that have considerable impact on farmers' economy.
- Livestock - domesticated mammals, birds and fishes that are raised on farms.
- Organisms that adversely affect crops and livestock. E.g. herbivores, seed predators and parasites.
- Beneficial organisms including those which pollinate plants and disperse seeds.
- Organisms that function as vectors in spreading crop and livestock diseases.
- Organisms that naturally control populations of agricultural pests. These are called biocontrol agents.
- Lesser known on-farm biocontrol agents such as cats, mongoose, snakes, lizards, birds and amphibians.
- Soil fungi and bacteria that associate themselves with crop plants and help them grow and yield better. Such association is called symbiosis.
- Earthworms and termites that are important in the processing of surface soil.
- Insects that produce honey, lac and silk that are culturable.
- Wild relatives of plants (to a lesser extent animals) that can be domesticated or used for breeding purposes in future improvement of agriculture.

### 6.2 Biodiversity in Rainfed Farming

- Rainfed areas are subject to considerable seasonal variations.
- Seasonally rainfed landscapes are normally dry during most part of the year.
- The rainfall received amounts to very little.
- Such landscapes are considered dry.
- Rainfed farming pertains to agriculture in dry landscapes wherein irrigation is minimal or nil.
- Many plants 'go to sleep' in the form of dormant seeds or rhizomes underground.
- A number of invertebrates and vertebrates are well adapted to subterranean lives during dry seasons emerging only after the rains.
- Species of amphibians, reptiles and some small mammals demonstrate seasonal habits.
- Breeding of birds and fish coincide with the rains.
- Biodiversity comes to real life only after rains in the rainfed areas.
- Crop damages by pest and diseases are also significant at this time.

### 6.3 Developing country aquaculture systems: Environmental impacts (EI)

| | System | EI |
|---|---|---|
| | **Extensive - No Feed/Fertilizer** | |
| 1) | Seaweed culture | Pristine reef and rough weather losses. Market competition and social problems (a). |
| 2) | Coastal bivalue culture | Public Health Risk (a - as above). |
| 3) | Coastal fish pond (Mullet, Milk fish, Tilapia, shrimp) | Ecosystem destruction (mangroves). Unsustainable against high population growth. |
| 4) | Pen and cage culture in eutrophic waters and/or on bottom | Exclusion of tradtional fisheries navigational hazarads (a - as above). |
| | **Semi-Intensive Some Feed/Fertilizer** | |
| 1) | Fresh and brackish water ponds (shrimp and prawns; carps, catfish, milk fish, | Freshwater Health risk to workers from water borne |

| | | |
|---|---|---|
| | mullets, tilapias) | diseases.<br>Brackish water<br>salinization/acidification of soil/aquifer (a - as above). |
| 2) | Integrated Agriculture/Aquaculture (rice/fish; livestock + poultry/fish; vegetables/fish; etc) | Risks as in freshwater.<br>Consumer resistance to excreta-fed fish (b).<br>Accumulation of toxic substances from livestock feed - heavy metals, pesticides. |
| 3) | Sewage/fish culture latrine wastes as pond inputs | Health risks to workers/consumers. |
| | Fish cages in waste water channels | b - as above |
| 4) | Cage and pen culture, especially in eutrophic waters or on rich benthos (carps, catfish, milkfish, tilapas) | As in extensive cage/pen systems. |
| | **Intensive: High Feed/Fertilizer** | |
| 1) | Freshwater brackish water and marine ponds (shrimp and prawns); carnivorous fish (grouper, snake heads) | Effluent drainage high in BOD and suspended solids (a - as above). |
| 2) | Freshwater, brackish water and marine cage/pen culture - carnivores, omnivores | build up of feed waste and faeces below cages (a - as above). |
| 3) | Others; raceways, silos, tanks | Effluents with high BOD and suspended soilds. |

(Source: *Sustainable aquaculture* (ed) Bardach, J.E. (1997) John Wiley and Sons, New York pp 251).

## 7.0 Managing Marine Ecosystems

Large Marine Ecosystems (LMEs) are regions of ocean space encompassing near coastal areas from river basins and estuaries on out to the seaward boundary of continental shelves and seaward margins of coastal current systems. They are relatively large regions on the order of 200,000 sq.kms or larger, characterised by distinct bathymetry, hydrography, productivity and trophically dependant populations (IOC/UNESCO; also the map).

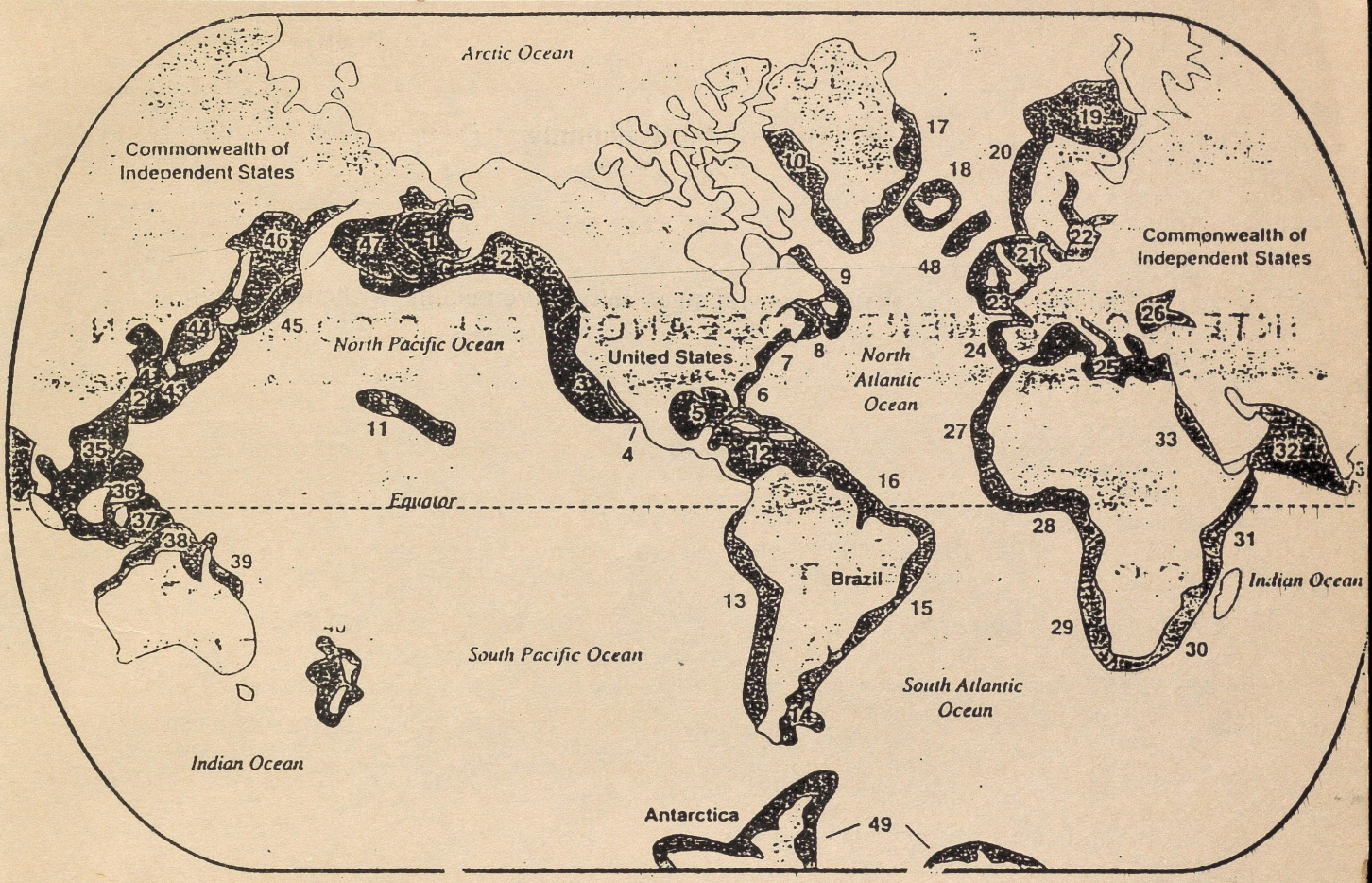
Nearly 95% of the usable annual global biomass yield of fish and other marine resources is produced in the 49 LMEs within an adjacent to the boundaries of the EEZs of coastal nations.

### 7.1 Inter-tidal, Mangrove, Coral Reef & Near Shore Zones

| Species | World | India | A & N Islands |
|---|---|---|---|
| Echinoderms[1] | 6000 | 765 | 359 |
| Holothurians | 1150 | 160 | 88 |
| Marine Molluscans[2] | 31000 | 3200 | - |

1 & 2 Two diverse phyla of major importance

- human consumption as food, trinkets and producers of chemicals (including toxins)
- ecosystem function
- biomonitoring




# WORLD MAP OF LARGE MARINE ECOSYSTEMS

1. Eastern Bering Sea
2. Gulf of Alaska
3. California Current
4. Gulf of California
5. Gulf of Mexico
6. Southeast U.S. Continental Shelf
7. Northeast U.S. Continental Shelf
8. Scotian Shelf
9. Newfoundland Shelf
10. West Greenland Shelf
11. Insular Pacific-Hawaiian
12. Caribbean Sea
13. Humbold Current
14. Patagonian Shelf
15. Brazil Current
16. Northeast Brazil Shelf
17. East Greenland Shelf
18. Iceland Shelf
19. Barents Sea
20. Norwegian Shelf
21. North Sea
22. Baltic Sea
23. Celtic-Biscay Shelf
24. Iberian Coastal
25. Mediterranean Sea
26. Black Sea
27. Canary Current
28. Guinea Current
29. Benguela Current
30. Agulhas Current
31. Somali Coastal Current
32. Arabian Sea
33. Red Sea
34. Bay of Bengal
35. South China Sea
36. Sulu-Celebes Seas
37. Indonesian Seas
38. Northern Australian Shelf
39. Great Barrier Reef
40. New Zealand Shelf
41. East China Sea
42. Yellow Sea
43. Kuroshio Current
44. Sea of Japan
45. Oyashio Current
46. Sea of Okhotsk
47. West Bering Sea
48. Faroe Plateau
49. Antarctic

### 7.1.1 Estuaries, Sand Banks and Mangroves : as habitats

- Migratory birds
- Sea turtles
- Other endangered Indian vertebrates viz., tiger, saltwater crocodile, python, king cobra, water monitor, etc.
- Fish
- Molluscs
- Crustaceans

### 7.1.2 Coral Reefs : diversity

| | |
|---|---|
| Indo-Pacific | 700 species |
| India | 200 species |
| A & N Islands | 135 species |
| Lakshadweep Islands | 105 species |
| Gulf of Mannar | 94 species |
| Gulf of Kutch | 37 species |

**Value:**

| | | |
|---|---|---|
| Ecosystem services | - | productivity |
| | | habitat |
| Scientific Interest | - | diversity |
| | | stability |
| | | complexity |
| Aesthetics | - | tourism |

## 7.2 Productivity

### 7.2.1 Coral reefs : extent and productivity

| | |
|---|---|
| $6 \times 10^5$ km$^2$ | Global |
| = 0.17 % | World Ocean Area |
| 54 % in Asia | Mediterranean and Indian Ocean |
| 25 % in Pacific | |

| | |
|---|---|
| Harvest of food fish | = 20 T/Y/km$^2$ |
| | = 12 million T/Yr |
| | = 12-19 % of Global fish |

| | |
|---|---|
| Recommended Sustainable level | 4-6 T/Y/km$^2$ |
| | = 2.4 million T/Yr - |
| | 3.6 million T/Yr |

### 7.2.3 Sustainable harvest of marine fish in general

Best estimates 62 - 87 million T/Yr

= What we harvested in mid 1980s

| Annual | 1979-81 | 1989-91 | Potential (million Tons) |
|---|---|---|---|
| World | 60.4 | 76.11 | 68.82 - 96.23 |
| Indian Oc. | 3.89 | 5.93 | 5.31 - 8.01 |

### 7.3 Impacting Factors: To be monitored

- Pollution at continental margins eutrophication from high N & P.
- Toxins in untreated sewage discharge affecting wetland nursery areas.
- Over fishing causing biomass flips - dominant component of fish communities declines rapidly - affecting marine birds, mammals and zooplankton.
- Climate and natural environmental changes as driving forces of variability in fish population levels.

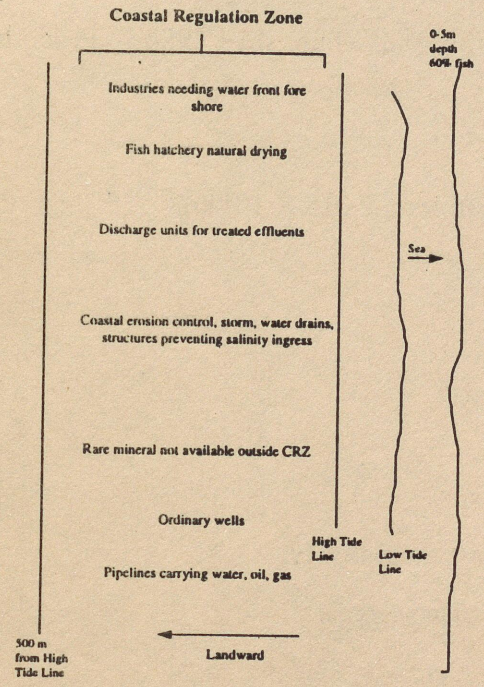
### 7.4 Other Health Indices

- Zooplankton - composition, biomass
- Water column structure
- Photosynthetically Active Radiation (PAR)
- Transparency
- Chlorophyll - $\alpha$
- NO2 and NO3
- Primary production
- Pollution
- Marine mammal biomass
- Seabird community structure
- Seabird counts
- Finfish composition - biomass
- Domoic acid
- Saxitoxin
- Paraly'ic Shell fish Poisoning (PSP)

## 7.5 Problems of Managing LMEs for sustainability

- Inter-State/Govt co-operation
- Unsuccessful predictions of fish yield - 75 years of 20th century biological oceanographers' predictions based on food chain studies - are open to disagreement
- Influence on fish stocks - competitors, predators and prey, environmental interactions, fisheries, habitat change, pollution.
- Lack of concerted study of health indices - diversity, stability, yields, production, resilience

## 7.6 Coastal Regulation Zone and permitted development activities



### 7.6.1 Classification of Coastal Regulation Zone (CRZ)

CRZ - I - Ecologically sensitive and important - Protected Areas, wildlife habitats, coral reefs, fish breeding habitat and area between low tide line and high tide line. No Hotels/Beach Resorts allowed here.

CRZ - II - Built areas within municipal limits with drainage, roads, etc.

CRZ - III - Less developed, within municipal limits or suburban/rural.

CRZ - IV - Islands.

**7.7 Some facts and figures for India** (Qasim and Khureishy, 1986 - Proc. Indian Academy of Sciences (Ani/Pl. Sci.) Supplement)

EEZ - Exclusive Economic Zone - 200 Nautical miles = $2.015 \times 10^6$ km$^2$

Coast = 6000 km

- 170 million (25%) People live in coasts
- Add 3.9 km$^3$ sewage/yr.
- Industrial and solid wastes
  0.39 km$^3$ $33 \times 10^6$ m$^3$/Annum
- 20,000 + 31,000 T of pesticides and detergents respectively.
- 513 million tons oil transported through Arabian sea/year.
- Spillage 2.1 million tons: + harbour activities, etc.

### 7.8 Islands and Ecotourism

"A characteristic of tourism activities is that they often misuse the natural and cultural environment by overusing the former and neglecting the latter, while in fact both these resources constitute the 'raw materials' for tourism development" ---------UNESCO -1994 (Island Agenda)

## 8.0 Sustainability in practice

### 8.1 Six fundamental causes of biodiversity loss

1. The unsustainably high rate of human population growth and natural resource consumption.
2. The steadily narrowing spectrum of traded products from agriculture, forestry and fisheries.
3. Economic systems and policies that fail to value the environment and its resources.
4. Inequity in ownership, management and flow of benefits from both the use and conservation of biological resources.
5. Deficiencies in knowledge and its application.
6. Legal and institutional systems that promote unsustainable exploitation.

### 8.2 Mechanisms for the loss of biodiversity

- Habitat loss and fragmentation.
- Introduced species.
- Over-exploitation of plant and animal species.
- Pollution of soil, water and atmosphere.
- Global climate change.
- Industrial agriculture and forestry.

### 8.3 Sustainable use of biodiversity and future development

1992 - Rio Earth Summit - United Nations - "Convention on Biological Diversity" (CBD)

The Contracting Parties,

- Conscious of the intrinsic value of Biological Diversity (BD) and of the ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic value of BD and its components.
- Conscious also of the importance of BD for evolution and for maintaining life sustaining systems of the biosphere.

- Affirming that the conservation of Biological Diversity is a common concern of human kind.
- Reaffirming that states have sovereign rights over their own Biological resources.
- Reaffirming also that states are responsible for conserving their Biological Diversity and for using their biological resources in a sustainable manner. (Source: Preamble CBD).

## 8.4 AGENDA 21

Chapter 2: International co-operation to accelerate sustainable development in developing countries and related policies.

International economy to provide supportive international climate for achieving environment and development goals by

- promoting sustainable development through trade liberalisation
- making trade and environment mutually supporting
- encouraging macro economic policies conducive to environment and development.

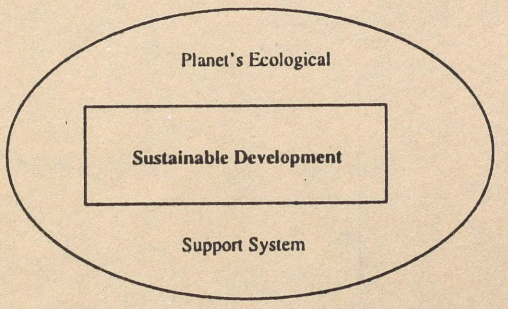
## 8.5 The Crux of the Problem

Let us draw our attentions to 2 issues which I feel are the most relevant to developing countries. These are

- failure of people to consider the long-term consequences of their actions, often due to a basic lack of knowledge and
- failure of people to appreciate the consequences of using inappropriate technology.
- The above statements can only be partly true, if at all, in the context of developing countries.
- Knowledge and action are not necessarily positively linked.
- Action is driven by need.
- Experience in India and other neighbouring developing countries have clearly pointed to the fact that when people are not able to meet their immediate/daily needs, they choose not to think of the future consequences of their present action.

- Here lies the major issue.

## 8.6 Biodiversity Conservation and Sustainable Development



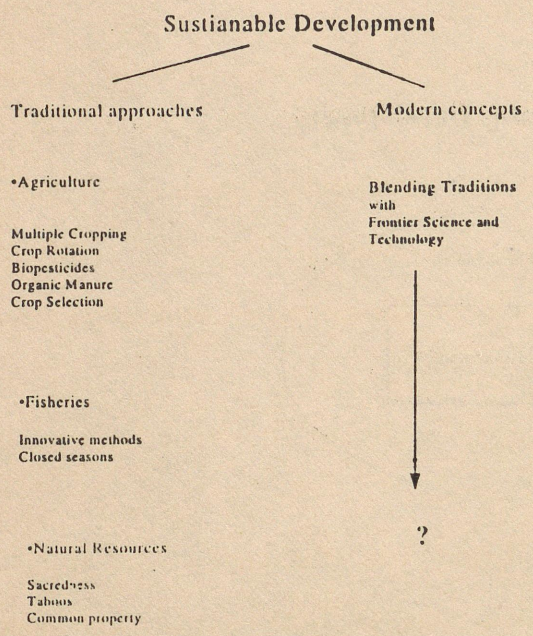

Ecological Sustainability - assessing and ensuring that the scale of human activities within the biosphere is Ecologically Sustainable.

Distributional Fairness/Equity - Distributing resources and property rights fairly, both within the current generation of humans and between this and future generations and also between humans and other species.

The issue of ensuring food and livelihood security of indigenous and local human communities in developing countries confronts us with both scientific and sociological questions. The following questions should really be of concern to us.

- What is the role of biodiversity in ecosystem functioning and in sustainable food production?
- What value do we place on biodiversity that could offer economically viable returns to the local peoples?
- How do we ensure a fair and continuous sharing of benefits?
- How do we balance biodiversity loss against sustainable development?
- How do we assess the gender dimensions in linking biodiversity with food security and sustainable development?

## 8.7 What does the future hold?




## 9.0 Major International Treaties/Conventions relating to Biodiversity

| | | |
|---|---|---|
| **CITES** - | Convention on International Trade of Endangered SPP - | 1973 |
| **RAMSAR** - | Wetlands of International Importance - | 1971 |
| **UNESCO's** - | Convention on World Heritage Sites - | 1972 |
| UNESCO's - | Man and Biosphere Programme - | 1970 |
| UN Convention on Law of the Sea - | | 1982 |
| UN Convention on Environment and Development - | | 1992 |
| Framework Convention on Climate Change - | | 1992 |
| UN Agenda 21 - | | 1992. |

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