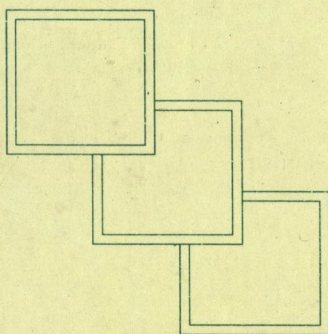


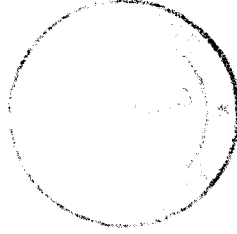
# Man and Environment



A. C. Mohapatra  
S. K. Barik  
C. S. Rao

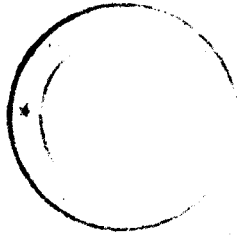
333.7095416  
MOH  
002899  
ICSSR

# Man and Environment



**Star Publishing House  
Shillong**

© Copyright authors. All rights reserved.  
1999 -- First Edition



333.7095416  
MOH

Price: INR 100.00  
US\$ 5.00



002899

*Published and distributed by*  
Mrs.K.Goel  
Star Publishing House  
Rynjah, Shillong – 793004  
INDIA

*Printed at*  
Archana Press  
Linkroad, Cuttack – 751012  
Orissa, INDIA  
First Edition: PB – 2000 copies

# CONTENTS

	Chapter titles	Page
	<i>Preface</i>	i-ii
<i>Chapter I:</i>	Conceptual background	1
<i>Chapter II:</i>	Relationships in nature and the interrelated nature of life on earth	17
<i>Chapter III:</i>	World population	29
<i>Chapter IV:</i>	Population in India	42
<i>Chapter V:</i>	Environmental consequences of human interventions	56
<i>Chapter VI:</i>	Environmental pollution	68
<i>Chapter VII:</i>	Vulnerability of the biosphere	86
<i>Chapter VIII:</i>	Environment and resource	95
<i>Chapter IX:</i>	Sustainable development and environmental movements	113
<i>Chapter X:</i>	Environmental problems in North East India	126

# Chapter I

## Conceptual Background

“The main challenges before humankind are three – to preserve peace, to eradicate poverty and to conserve the environment. The path that the world has until now traversed in the pursuit of technological mastery has imperilled peace and the environment and failed to provide prosperity and equality for all the peoples of the world. A major change is required in our outlook and our methods.”

-- **Rajiv Gandhi**, *former Prime Minister of India*  
*Foreword to **Our Common Future**,  
Report of the World Commission on  
Environment and Development, U.N.*

### Environment

For thousands of years man has wondered about the happenings in nature, his surroundings and purpose of his own and other life forms on earth. The explanations to such wonderment led him, curiously enough to both spiritualism and religion as well as to the rigour of science. However, the concern about environmental degradation and the predicament of a vulnerable earth is of recent origin, i.e. in the 1960s and 1970s. The tell-tale-signals of an impending environmental catastrophe led scientists, academics, political leaders to admit that they knew little about the intricacies of environmental relationships. (Though man has landed on moon in 1969!) Then they worked on policies and strategies to preserve and conserve the earth environment for all the living beings that this lonely planet only contains in the known universe.

### What is environment?

Environment is the *sum total of living and nonliving components, influences and events surrounding an organism*. In common sense parlance, environment means the surroundings. However, in size and spread it could differ widely from species to species. Therefore, what constitutes environment for man could be quite different for anaerobic bacteria. Moreover, the meaning of environment will widely differ in its connotation in the micro-scale or in the macro-scale. For example, the micro-environment of man could constitute his home, the food he takes or the air he breaths from the immediate surroundings, whereas the macro-environment would mean the general climatic conditions he lives in or the general rise in world temperature conditions that is likely to affect him etc. It is also to be noted that not all of nature is environment though all of environment is part of nature. Nature contains the sum total of all the elements of the universe and processes associated with their inter-connections. On the other hand, the references to environment arises in the context of earth, though some sources outside earth in many important ways influence the environment, like solar radiation, particles showers or the magnetosphere of the earth. The general context of environment used in this book is that of the human environment but also those elements that affect or are in turn

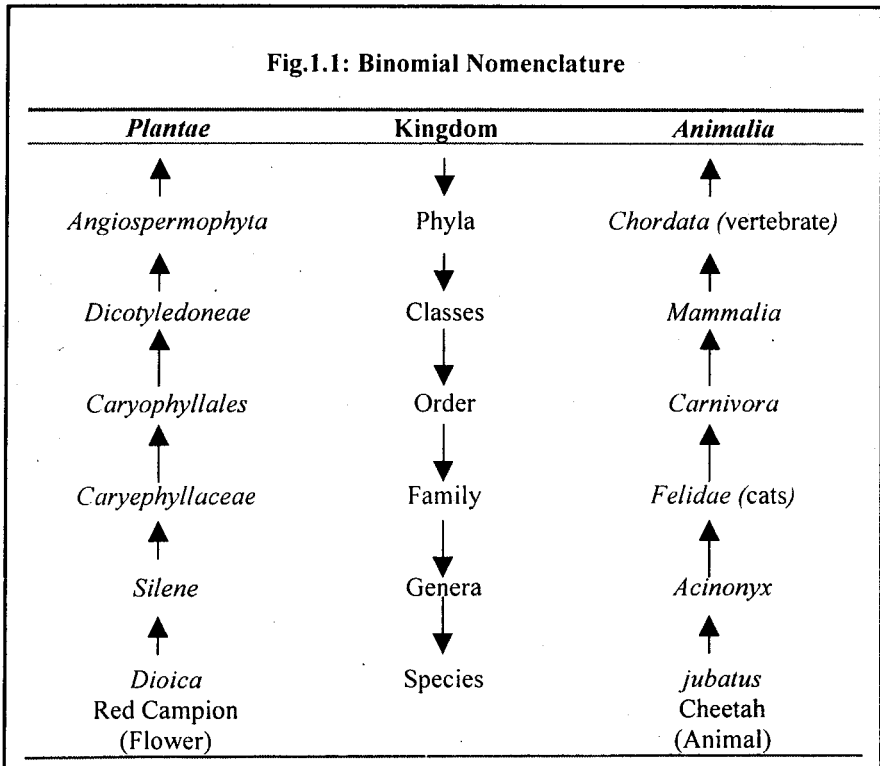
affected by human action, both living and the non-living. However, many principles and laws are common to both man and other living components of the environment.

**Elements of Environment**

Broadly environment contains two sets of components (elements). These are: (a) the biotic or living and (b) the abiotic or the non-living. The biotic environment contains all the living beings on this planet broadly classified into the plants and the animals. The living world is teeming with millions of varieties of plants and animal lives. Broadly the living world is divided into five kingdoms (by American Biologist Robert Whittaker, 1969). These are:

1. *Monera* (bacteria): 4000 species (both heterotrophs and autotrophs)
2. *Protista* (Protists): 40,000 species (divided into the plant like *algae* and the animal like *protozoa*)
3. *Fungi*: 100,000 species (including multi-cellular mushrooms and unicellular yeast)
4. *Plantae* (plants): 400,000 species
5. *Animalia* (animals): 1.3 million species divided into vertebrates that consists of only 3% of all animal species including the man and the invertebrates that accounts for the rest of the 97% of the animal kingdom.

The kingdom is a generic term at the apex of the hierarchy of the taxonomy (classification) and at the bottom is the species. This is illustrated in the box below:



The biotic components can also be classified, on the basis of the movement of energy within the living into the *producers* (the plant kingdom), the *consumers* (the animal kingdom: the *primary consumers* or the herbivores and the *secondary consumers* or carnivores) and the *residual consumers* or *decomposers* that belong largely to the other three kingdoms. (This is discussed in details in Chapter 2)

The abiotic elements are much more widespread in their incidence on the earth surface as compared to the biotic. They can be broadly classed within the spheres of their incidence, i.e. the atmosphere, the hydrosphere and the litho-sphere. *Biosphere* is at the interface of these three spheres, i.e. the sphere closer to the surface of earth that contains all life forms and provides resources and living conditions for life, like air, water, heat and nutrients. This would generally include the lower atmosphere (troposphere), the water bodies (both marine and freshwater) and the soils.

### (a) The Atmosphere

This is the gaseous envelope that surrounds the solid mass of the earth. It is a mixture of various gas molecules, water vapour, suspended particulate matters (SPM), aerosols, and ionised and transient gases like the Ozone. The gas envelope extends vertically from the surface of the earth to nearly 400-500 km and thins out to the outer space, beyond the pull of earth's gravitational pull. Since the atmosphere is a mixture of divergent materials, the heavier components settle close to the surface of the earth due to gravity, and thins out towards the outer periphery. An average sample of the atmosphere at the surface on the Equator contains 78 percent of Nitrogen (N<sub>2</sub>) and 20 percent of Oxygen (O<sub>2</sub>). This mixture and its right proportion is vital to all breathing (terrestrial) animals and plants. The balance 2 percent consists of water vapour (H<sub>2</sub>O), Carbon dioxide (CO<sub>2</sub>), Hydrogen (H), Argon, dust particles, hydro-carbons, Ozone (O<sub>3</sub>) etc.

**Table 1.1: Constitution of dry air in lower atmosphere**

Constituent gas	Percent by volume	Constituent gas	Percent by volume
Nitrogen (N <sub>2</sub> )	78.08	Ozone(O <sub>3</sub> )	0.00006
Oxygen(O <sub>2</sub> )	20.94	Hydrogen(H)	0.00005
Argon(Ar)	0.93	Krypton(Kr)	Trace
Carbon dioxide(CO <sub>2</sub> )	0.03	Xenon(X)	Trace
Neon (Ne)	0.0018	Methane (CH <sub>4</sub> )	Trace
Helium (He)	0.00005		

The gravitational pull of the earth ultimately creates a vertical layering of the atmosphere since the proportion of various gases change vertically depending on their molecular weights and abundance or scarcity. The radiant energy of the sun when passes through the transparent atmosphere and reaches the surface or when radiated back reacts with various gases in different ways and provides a thermal characteristic to the atmosphere. A part of the radiant energy is also trapped within the atmosphere by various gases. This becomes the prime energy source of all atmospheric phenomena, be they clouds or rain, snow or frost, typhoons or tropical storms, or it may be the continuous production and dissipation of Ozone in the upper atmosphere.

On the basis of characteristics of gases and density and thermal characteristics the atmosphere can be broadly divided into four layers: (a) the troposphere, (b) the stratosphere,

(c) the meso-sphere, and (d) the ionosphere. The vertical division of the atmosphere and its thermal characteristics is given in Dig.2.

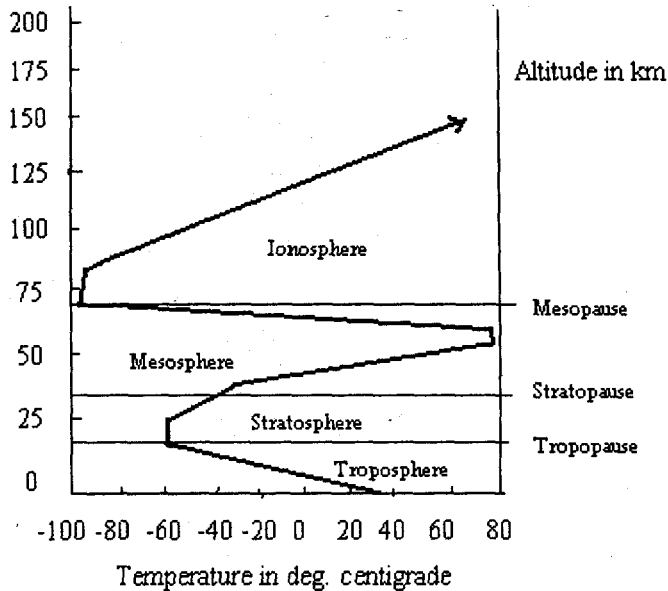
- (a) *Troposphere*: This is the heaviest and the closest (to the surface) layer of the atmosphere. It is a 10 to 16 km thick layer (higher closer to the equator and lower closer to the poles) that contains the air-mix that we are used to and most of the water vapour, CO<sub>2</sub> and other particulate matters and pollutants. Most of the weather phenomena are confined to this layer. It is segregated from its upper layer, the stratosphere by a narrow zone of discontinuity called the Tropopause.
- (b) *Stratosphere*: This is a 15 to 20 km thick layer, immediately above the troposphere. This is considerably thinner and contains oxygen in much lower quantity than required for normal breathing. This is differentiated because of its thermal gradient, which unlike the troposphere is either stable or increasing. Stratopause is narrow layer of discontinuity with the next upper layer, the meso-sphere (meso: middle).
- (c) *Mesosphere*: This layer is about 40-50 thick lying between 35 and 80 km, just above the stratosphere. This layer is considerably thinner, contains light and rare gases and the Ozone. Its temperature gradient is peculiar in the sense that from about 35 km it rises from -40°C to +80°C at 50 km height and thereafter slides to -60°C closer to the Mesopause the layer of discontinuity below the Ionosphere. The mesosphere filters most of the harmful radiation from the sun, like the ultraviolet radiation and particle showers that could otherwise result in debilitating effects on life on the surface of earth.
- (d) *Ionosphere*: This layer is extremely thin. It stretches from about 70-80 km from the surface towards the outer space. It is extremely hot and temperature constantly rises from -60°C to about +1000°C until it reaches the outer space. Between 400 km and 1000 km from the surface is often referred to as the Exosphere, which at that height can be of superheat of 5568°C – but it may not be felt since the air is so thin and little material is available to be heated up. Gases are no more found in molecular form but in ionised form – that's why Ionosphere. There is no presence of water or CO<sub>2</sub>, but air often contains space-dust that is continuously showered by passing meteorites and comets and gradually settles to the lower atmosphere.

*Lapse Rate*: The observed rate of decrease in temperature along the vertical gradient (in the troposphere and stratosphere) is called “the Lapse Rate”. Because of this rate, when one moves upward, it feels cooler as on a mountain height. This rate varies with height, latitudinal position and season. It is approximately 6.5°C/km on the equator. However, beyond 20-25 km height the temperature starts rising again till about 40-45 km, it starts falling to -95°C at 60-65km and then rises continuously till the periphery, towards the outer-space, where it dips again.

*Temperature Inversion*: In the lower atmosphere the general rule is temperature decline with height by the lapse rate. However, under special circumstances this could be reversed, which is called the inversion of temperature, i.e. while going it cold feel warmer. In the lower atmosphere this may occur during the winter months up to a level of 300 metres from the surface. They could be either radiation inversion or valley inversion. Under conditions of clear sky the ground radiation during the night could be high resulting in frosting. The air closer to the ground will be cooler than air 200-300 metres at height. If the day-time is sunny followed by evening clouds, the radiated heat during the night is trapped by the clouds, where it would

be warmer than the ground level. These are radiation inversions. In enclosed valley conditions, during the winter nights cooler (and heavier) mountain air descends to valley bottom and is capped by warmer air on the top. Due to temperature inversion in highly industrially polluted areas the smog (the CO<sub>2</sub>, Sulphur dioxide, soot and other particulate matter) hangs in the lower atmosphere – the normal convection currents (the upward movement of air) do not

**Fig.1.2: Atmospheric layers and thermal gradient**



work. This becomes a serious health hazard to the residents of the city and surrounding villages. The worst smog disaster was that of the 1953 London.

*The horizontal distribution of temperature:* The latitudinal distribution of the atmosphere results from the differential incidence of insolation and causes the planetary circulation (movement of zonal winds) and creates different climates and climatic regions of the globe. The angular momentum of the planet that creates seasons also adds colour to climates and the regions. The intensity and duration of insolation changes from equatorial to polar areas. Closer to the equator the earth receives solar radiation perpendicular (90°) to the surface, whereas away from the equator the inclination declines till the Arctic Circle or beyond where the sun is viewed at an acute angle on the horizon. On the other hand, on the equator the days and nights are of the same duration, though out the year – there is no other seasons in equatorial areas. On the other hand, away from the equator the duration of the day-light can vary widely depending on the season – the maximum in the summer and the minimum in the winter, till the polar areas where there is six months of day-light and six months of continuous darkness of winter nights.

The differential temperature condition also creates the global pressure zones (or belts). Areas within  $10^{\circ}$  north and south of the equator are constantly heated though out the year resulting in warming of the resident air that moves vertically creating a regular zone of low-pressure, called the *equatorial low-pressure belt*. These air streams move to north and south tropical areas (tropics of Capricorn and Cancer— $23.5^{\circ}$  north and south latitudes) in the upper air currents and being cooled descend creating zones of high pressures – the *tropical high pressure belts*. On the ground level air blows from the tropical high-pressure zones to the equatorial low-pressure belt and also north- and southward to the temperate low pressure belts. The vertical round about movement of air is often called the Hadley's cell. Further to north and south of the tropical areas around  $40^{\circ}$  north and south latitudes lie the *temperate low-pressure areas*, which are often referred to as the *roaring forties* (particularly in the southern-hemisphere). Finally, farther to north and south, closer to the polar areas lie the *polar high-pressure belts* ( $60^{\circ}$  north and south). The pressure belts are extremely significant in terms of the energy (within the air) redistribution, climate regimes and precipitation depending on their coastal or continental locations.

### (b) Hydrosphere

The simplest of all natural compounds, water is the chief source of life on earth. Water that is found in oceans and seas, the inland waters in lakes and reservoirs, in flowing rivers and glaciers or in its frozen form in icecaps is part of the hydrosphere and contains life even in the deepest trenches on the ocean floor. Broadly earth's water can be divided into freshwater and saline or marine water. Such a division is ecologically valid since specific organisms have evolved in conditions of either freshwater or saline water. Freshwater bodies cover 2 percent of earth's surface and contains roughly  $125 \times 10^3 \text{ km}^3$  with lake Baikal of Russia containing as much as 20 percent of that ( $23 \times 10^3 \text{ km}^3$ ). Whereas Nile river at 6698 km is the longest, Amazon river (second longest with 6640 km) delivers  $643 \times 10^6 \text{ m}^3$  of water to the Atlantic Ocean every hour. The inland saline water bodies like the Caspian Sea contain  $104 \times 10^3 \text{ km}^3$  of water. The oceans cover 70 percent of the surface of earth with an average depth of 3750 m and salinity of 3.5%. The water volumes of the major oceanic bodies are given in Table 1.2.

**Table 1.2: Water in Major Oceans and Seas of the World**

Oceans/ Seas	Area ( $10^3 \text{ km}^2$ )	Average depth (m)	Water Vol. ( $10^3 \text{ km}^3$ )
Pacific Ocean	165250	4280	707600
Atlantic Ocean	82440	3930	324600
Indian Ocean	75440	3960	291000
Arctic Ocean	14090	1205	17000
South China Sea	3685	1060	3905
Caribbean Sea	2755	2490	9585
Mediterranean Sea	2515	1495	4250
Bering Sea	2270	1440	3300
Gulf of Mexico	1555	1640	2330

The marine water bodies are divided into several zones, like the littoral zone (coast), the continental-shelf, the continental slope, the ocean floor and the oceanic trenches (Mindanao being the deepest at 10,925 m: Philippines). The oceanic water also contains some 45 elements,

though not in great concentration, like Chlorine, Sodium, Magnesium, Sulphur, Calcium, Potassium and minor elements like bromine, carbon, strontium, nitrogen etc. There are also mineralised compound concentrations deposited on the ocean floor that are being assessed for commercial mining. Oceans are also the primary source of creation of all hydrocarbon deposits that are the prime mover of modern industries. There are also many shallow and deepwater oceanic oil exploration sites around the world including Bombay High (India), North Sea (U.K. and Norway), Gulf of Mexico (USA and Mexico) and many others.

### (c) The Lithosphere

Lithosphere consists of the crust materials of the earth – both of the continental masses as well as the ocean floors. The continental crust contains the soil as a living body that supports life as well as contains life (mostly the decomposers). The crust also contains a variety of rocks and minerals, like the limestone (for cement industry), slates, marbles and granites (housing materials), coal or petroleum deposits (fossil energy), minerals like iron ore, bauxite, tin, zinc, manganese, sulphur, precious metals like copper, silver and gold and a large number of other ingredients of modern industries.

However, soil is the most preponderant and is essential to life on earth – it is also one of the most environmentally vulnerable. Without soils plants cannot produce food (the primary producers) and therefore, would jeopardise the entire chain of life on earth. Soil constitutes the top few centimetres of the crust, usually a mixture of finer rock particles, minerals, a variety of plant nutrients, organic (decomposed) materials and a living body of life.

**Table 1.3: USDA Soil Classes**

Category	Derivation	Description
Alfisols	Aluminium (Al), Iron (Fe)	Soils with silicates of aluminium and iron in B horizon, low humus, well-defined horizons
Aridisols	Lat: <i>aridus</i> = dry	Desert soil, dry for long periods, low humus
Entisols	Lat: <i>ent</i> = recent	Young soil lacking in defined horizons, weakly developed, dominated by minerals (like on river banks)
Histosols	Grk: <i>histos</i> = tissue	Soils with abundant organic matter (peats, bogs, muck)
Inceptisols	Lat: <i>inceptum</i> = beginning	Moderately developed, horizons not well-defined, variable chemical properties found in humid climates
Mollisols	Lat: <i>mollis</i> = soft	Well developed with a dark A horizon, high alkalinity, surface soft (e.g. prairie soil)
Oxisols	Fr.: <i>oxyde</i> = oxide	Well-weathered tropical soils rich in iron oxides and rich in humus (e.g. lateritic soils)
Spodosols	Grk: <i>spodos</i> = wood ash	Humus rich A <sub>1</sub> horizon, A <sub>2</sub> ash-colour and B reddish-black ( <i>podisols</i> of New England)
Ultisols	Lat: <i>ultimu</i> = last	Old soils usually in warm and humid climates, well leached, low alkalinity (e.g. many hill areas of NE India)
Vertisols	Lat: <i>verto</i> = to turn	Clay soils with deep wide cracks in some parts of the year, dark in colour (e.g. alluvial flood plains)

Vertically the soil can be divided into 5 layers, which is called the soil profile. At the top is the "O" horizon that contains organic litter of leaves and debris. Below this lies the "A" hori-

zon – A<sub>1</sub> at the top is rich in humus and organic material (decomposed) and dark in colour, A<sub>2</sub> to its bottom is the zone of leaching of minerals that is easily available to plants. Below A lies the “B” horizon that is poor in organic material but contains accumulated released minerals from the bedrock. Horizon “C” is the weathered (softened) bedrock and “D” is the bedrock itself on which the soil is formed. It takes normally a few thousand years a few inches of soil to form. A Russian scientist, V.V. Dokuchaiev was the first soil scientist to produce a system of soil classification in 1900 (Three broad classes, *Zonal*, *Azonal* and *Trans-zonal* soils). He related soils with climatic regions and their locations. Currently however, the United States Department of Agriculture classification system is commonly used. The system is given in Table 1.2.

## CONCEPTS

### Ecology

Generally speaking, Ecology is the science that studies the relationships in nature, i.e. within the living organisms and between the living and the non-living components on earth. German biologist, Ernst Haeckel is credited with using the term first in 1866. In 1870 he stated,

“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 complex interrelations referred to by Darwin as the conditions of the struggle for existence.”

However, compared to its early definitions the ideas and objects of ecology has changed drastically. Initially the subject or the term was not very commonly used. But after the establishment of the British Ecological Society in 1913 and shortly thereafter the Ecological Society of America (1915), the subject was formally institutionalised. Charles Elton (1927) referred to ecology as “scientific natural history” concerned with the “sociology and economics of animals”. Earlier the famous American ecologist, Frederick Clements (1905) considered ecology as the “science of the community”. Victor Shelford (1937) another American ecologist regarded ecology as “that branch of general physiology which deals with organism as a whole, with its general life processes as distinguished from the more special physiology of organs.” German ecologist Karl Friederichs (1958) defined ecology simply as the “science of the environment”. The most accepted definition in contemporary ecology however, goes to Eugene P. Odum (1962), the American ecologist who considers ecology as “*the study of the structure and function of the ecosystem.*”

### Ecosystem

The ecosystem is the basic functional unit in ecology. An ecosystem or ecological system is a dynamic complex of plant, animal and micro-organism communities and their associated nonliving environment interacting as an ecological unit. The term was first used by the British ecologist, Arthur Tansley (1935) as follows:

“... the whole system (in the sense of physics) including not only the organism-complex but also the whole complex of physical factors forming what we call the environment of the biome – the habitat factors in the widest sense. Though the organism may claim our primary interest, when we are trying to think fundamentally, we cannot

separate them from their special environment, with which they form one physical system. It is the systems so formed which, from the point of view of ecologist, are the basic units of nature on the face of the earth.”

According to Odum (1971), *any unit that includes all the living organisms that function together in a given area, interacting with the physical environment so that a flow of energy leads to clearly defined biotic structures and cycling of materials between living and the nonliving parts is an ecosystem*. An ecosystem is a special universe, relatively independent in structure and function within the larger universe. It must contain two or more components surrounded by the environment with which it may or may not interact. Its relative uniqueness is what differentiates it from the neighbouring ones, certain homogeneity and heterogeneity in its environment that is consistent and coherent to certain life forms. It is no arbitrary unit of the environment. Ecosystems are real—like a pond, a field, a forest, an ocean or even an aquarium. There is a great diversity in ecosystems -- from the tiniest to the massive, of continental proportions. They could be terrestrial or freshwater or marine, a field or a laboratory.

### **Ecotone**

Ecotone is the transitional region between two neighbouring ecosystems, like a tropical deciduous forest ecosystem and a tropical savannah. These are extremely important from the point of view of ecological conservation because they contain maximum species diversity. Without conservation of the ecotones, conservation of the core region of the ecosystem is meaningless. Most conservationists agree on the ecotone being the cornerstone of any conservation strategy.

### **Biosphere**

As was mentioned earlier, biosphere is that part of the earth that contains and sustains life. It is delimited by parts of the atmosphere, lithosphere and the whole hydrosphere that is the source of life, a realm in close proximity to the surface of the planet. The idea of the biosphere is credited to Austrian geologist, Eduard Suess (1875) and was later popularised by Russian geochemist, Vladimir Vernadsky in 1920s. It is the sum total of all the biomes and ecosystems. Various living organisms derive the food, colonise and grow (propagate) in various segments (or units) of the biosphere called the ecosystems that biologically provides the most ideal conditions or to which they have adapted over millions of years of the evolutionary trail. The biosphere is dynamic and the dynamism is provided by the flow of energy that is mostly sourced from the sun, except in very specialised ecosystems like the deep oceanic geysers and volcanoes, where life is found without support of solar insolation.

### **Biota**

Biota is the sum total of all living organisms in a biome. In other words, it is the biotic community of the given biome. This could be extremely diverse as in the tropical rainforest biomes or fairly restricted as in the Tundras.

### **Biomes**

In the broadest sense there are two types of ecosystems-- the terrestrial and aquatic. Major terrestrial ecosystems occur at a regional or sub-continental scale and these are referred to as *biomes*. Biomes are ecosystems but they can also contain hundreds or even thousands of eco-

systems. Latitudinal location, climates, soils and the product—natural vegetation and wildlife constitute the biome and its characteristics. Climate has the most overriding significance in formation of a biome—in a general sense soil and natural vegetation are products of the climate, though other factors may influence them. Therefore, the global distribution of biomes follows the climate classes. Fig. 1.3 shows the connection between main climatic parameters—temperature and precipitation that influence biome distribution. Some of the major and lesser biomes are as follows:

**Major Biomes:** (1) *Tundra*: It means “marshy plains” that lies north of 60° North latitude. It constitutes 20% of the landmass of North America (Canada, Alaska and Greenland) and 15% of Europe-Asia (parts of Norway, Finland, Belaruss, and Russia). Arctic Tundra is characterised by the absence of trees, dwarf plant species, lichens and ferns, ground surface spongy and uneven due to continuous freezing and thawing and poorly drained. It is also called permafrost (permanently frozen) due to the soil from a few centimetres to a few metres being frozen though out the year preventing any root penetration.

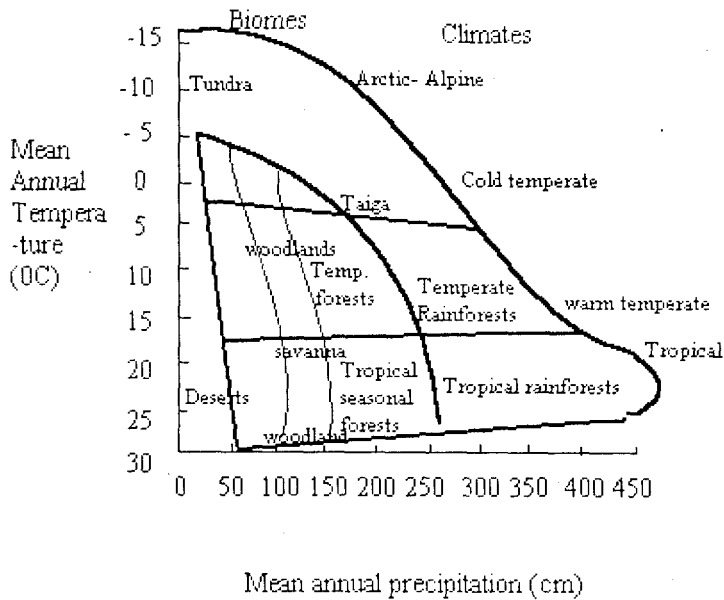
(2) *Taiga* (Boreal Coniferous forest): This moist-cool, transcontinental forests of the north-hemisphere literally means “the great north woods”. This generally lies between 45° to 60° north latitude. The climate is cool to cold and moist, particularly during the summers. The largest taiga forests occur in Russia (Siberia) but also in Canada, USA and the Nordic countries. The main trees are needled-leaf, coniferous species like white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), red pines (*Pinus resinosa*: USA), white pine (*Pinus strobus*), hemlock (*Tsuga canadensis*) etc.

(3) *Temperate biomes*: This region occurs between 35° to 50° north and south latitudes. The composition of temperate forests, the proportion of deciduous to evergreen trees, and the spacing and height of trees depend on the seasonal distribution of rainfall, the severity of winter, the nature of the soil etc. Temperate forest has a wide variation in natural vegetation or biomes.

- (a) Temperate deciduous forests: They occur in moderately humid, continental climates rainfall distributed through out the year but with severe winter – summers are warm. Broad-leaved deciduous trees like oaks, beeches and maples are common. Soil is rich in minerals and organic matter decomposition is slow due to severe winters.
- (b) Temperate evergreen forests: They occur in wide areas where conifers and broad-leaved evergreens dominate over the deciduous—particularly pines and spruce and firs.
- (c) Temperate rainforests: They occur in temperate regions but closer to the sea like the pacific coast of North America. Temperature is moderate with cool winter – rainfall well distributed around the year. The redwood Sequoia forests of California grow to the heights of 60 - 90 metres. Other areas include the New Zealand, Tasmania (Australia) and parts of southern Chile.
- (d) Temperate woodland: These woodlands are found in climates, too dry to support forests, but sufficient for some trees and grasses. The dominant tree may be conifers, evergreen flowering trees or deciduous. Pine, juniper, oaks are common.
- (e) Temperate shrub-land: They are best represented by the chaparral communities in the five Mediterranean climates of the world – coastal California and Chile, the Mediterranean coast, southern Australia and South Africa. Summer is warm and winter cool and moist. Most of the plants are within 1 to 5 metre height to economise on scarce water. These semi-arid biomes are often prone to forest fires.

- (f) Temperate grassland: These are known as prairie (North America), steppe (Asia), pampas (South America) and veldt (South Africa). Generally found in interior of continents, there is little moisture to support trees or woodlands.
- (g) Temperate desert: They occur in limited areas, largely in the Mongolian desert (including parts of western China, much of the Great Basin east of the Cascade and Sierra Nevada of western USA and the Kalahari of southern Africa. The vegetation is dominated by sagebrush (USA), some perennial grasses – animals mostly rabbits, mice and kangaroo rats (USA).

**Fig 1.3: Climates and Biomes**



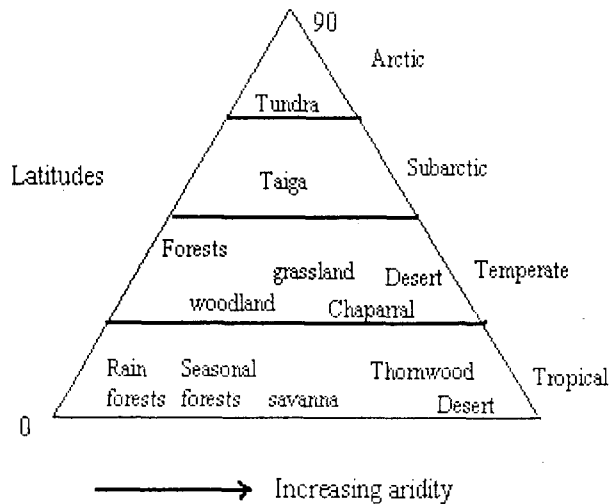
(4) *Tropical biomes*: These occur up to 30° north and south of the equator. They are warm throughout the year with hot summers. They are extremely varied and contain large species diversity.

(a) *Tropical rainforests*: They occur generally within 10° north and south of the equator in Central and South America, Central and Western Africa, South East Asia and north-east Australia and a large number of oceanic islands. About 25 percent of all tropical forests are the rainforests. They are the most ancient of all ecosystems (continuously over 60 million years). They hold considerable ecological significance due to their species diver-

sity and rare life forms, their influence on global climatic regime and their role in maintaining the global carbon balance. Annual rainfall exceeds 200 cm well distributed though out the year. The flora is highly diverse – 2.5 km<sup>2</sup> of area may contain 300 varieties of plants. Forest canopy could be 25 to 30 metres tall. Where the dense canopy is broken (along drainage channels), there is a multitude of creepers and foliage. It has four levels of vertical division of the ecosystem – (a) the floor (rich in detritus materials), (b) the bush and creeper above the floor, (c) the midlevel (of trees) and (d) the canopy which are colonised and utilised by specialised animal and plant lives.

- (b) Tropical deciduous forest biomes: They occur between 10 and 25 north and south latitudes, generally intervening between the rainforests and the tropical savannah. The climate is warm though out the year, but rainfall (annual average not exceeding 80 cm) is confined to a few months a year – winters are dry. Most of the Indian sub-continent, parts of Africa and South America, one can observe this type of climate-vegetation complexes.

**Fig.1.4: Biomes and latitudes**



- (c) *Tropical savannah*: These are grasslands with scattered, drought resistant trees not over 10 m in height. They are extensive in eastern Africa (Ethiopia, Kenya etc) and also found

in Australia, South America (*Llanos* in Venezuela) and Asia. The climate is characterised by seasonal summer rains (June through October) and winters are cool and dry. Annual rainfall does not exceed 130 cm. This biome is marked by the presence of the greatest number of grazing animals (mammals).

- (d) *Tropical deserts*: They are the most extensive of all deserts with annual rainfall less than 20 cm. They occur generally between 10 and 30 north/south latitudes in Asia, Africa and Australia. They also occur to the western parts of the continental mass, on the rain-shadows of wind systems. Prominent of such deserts are the Sahara desert, the Arabian desert, the *Thar Desert* of western Rajasthan State of India and adjacent areas of Sindh Province of Pakistan and western Australian desert. Extensive sand dunes and wind-eroded topography can be observed. Occasional thorn-bush, acacias and date palms are the main natural vegetation.

### Aquatic Ecosystems

All aquatic ecosystems can be divided into (i) freshwater and (ii) marine ecosystems. The freshwater bodies cover about 2 percent of the surface of earth.

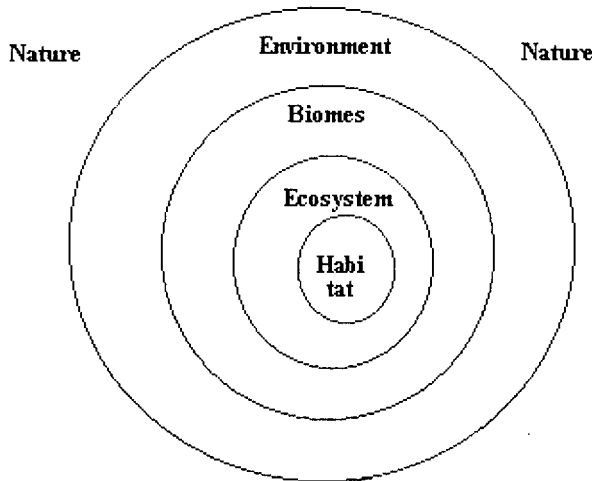
- (i) The freshwater ecosystem is divided further into the (a) the *lotic* ecosystems (running water i.e. stream, river etc.) and (b) the *lentic* ecosystems (still water i.e. lakes, ponds etc).
- (a) *Lotic ecosystems*: Freshwater streams (springs, rivulets, brooks and creeks) and rivers change in their size and volume from origin (upper reaches) to the destination—the sea or lake through a vertical descent. The valleys on the upper reaches are narrow and the flow of the river speedier. There is also less of sediment in the upper reaches. Organisms capable of holding on to the rocks and banks in the fast flowing river flourish, like the periphytons –blue green algae and many invertebrates, larvae of insects. Fishes like crayfish, trout and salmon love such an ecosystem. Lower reach of the river is rich in nutrients and a vast variety of aquatic life flourish.
- (b) *Lentic ecosystems*: These include confined waters of lakes, ponds, swamps and bogs etc. These have three zones: the coast (littoral), *limnetic* and the *profundal*. The littoral is around the shoreline and is colonised by water-loving plants, weeds, reeds and lilies. Amphibians like the frogs, crocodiles, snakes, snail etc flourish. The *limnetic* zone is of the open water to the depths of penetration of light. This zone contains *phytoplanktons* and a variety of *zooplanktons*. Swimming organisms like fish, amphibians and large number of insects flourish in such environment. The *profundal* is at the bottom with little light penetration. Main source of food comes from the detritus chain, since food is not produced here due to lack of solar light. Fishes like bass, catfish, pikes, freshwater eel etc are found.
- (ii) **The marine ecosystems**: Since the oceans and seas cover nearly 70 percent of the surface of earth, these are the most extensive and varied. They are essentially of two types, (a) marine (proper) and (b) the estuaries.
- (a) *Marine ecosystems*: Unlike the freshwater ecosystems, the marine ecosystem operates in an environment of a large number of soluble chemicals, called salts that accounts for an average of 3.5 percent of the oceanic body. On the other hand, the oceans and seas are in continuous motion, oceanic circulation, currents, up-welling waters, waves and tides – an extremely active medium. On the basis of distance from the shore, there are three distinct zones – (1) the *littoral* or *intertidal zone*, (2) the *neritic zone* and (3) the *pelagic zone*. The littoral zone is the narrow zone is the shoreline between the land and the sea. It is

constantly affected by waves and tides and subjected to intense light, moisture and temperature conditions. Main organisms are the sessile organisms (algae, barnacles and starfish) and a variety of borrowing and amphibians, like crabs, dollars, mud-flippers, clams, worms and *crustacea* etc. Corals bordering the islands are also included within this zone. The *neritic zone* is confined to the continental-shelf (up to 100 fathoms, 200 m). This covers about 7.5 percent of the oceans. Extensive *algal* communities flourish. This zone has high biological productivity and is rich in species diversity. The pelagic zone is the open sea that accounts for about 90 percent of all ocean surfaces. Larger vertebrates, fish and whales inhabit the open seas, so also variety of *phyto-* and *zooplanktons*, particularly on the warmer surface layer of water. Depending on the penetration of sun light the marine ecosystem can be divided into the *photic* (zone of light penetration, 200 m maximum) and the *aphotic*—the deep water without light. This division is significant from the point of productivity of the ecosystem. The photic zone contains the producers and all oceanic primary production takes place here. The aphotic contains the specifically the decomposers (ocean floor) and there the consumers, fish and other organisms are found in both the zones. The *benthic zone* is the oceanic floor beyond the continental shelf (deepwater slopes and floors). This abounds in heterotrophic animals that are anchored to the muddy ooze of the floor like sea lilies, sea fans, sponges and brachiopods. Snails and clam embed in the mud, while sea urchins, starfish and sea cucumber move on its surface.

- (b) *Estuaries*: Estuaries are formed on river mouths where the freshwater carried by the river meets the saline water of the sea. The river also carries rich nutrients, silt and minerals. Though in a transitional zone (like an *ecotone*), location of estuaries form part of the marine ecosystem. They are the most varied of most ecosystems, both in plant and animal life. Mangroves are very specific to warm water estuaries that abound in profundity of life. *Sunderbans* of the Ganga-Brahmaputra (part of Bangladesh and State of West Bengal of India) estuary is a good example of such an ecosystem. Many of the mangrove-estuarine ecosystems are threatened due to human settlement encroachments and interference, and need strong conservation interventions.

### Habitat

The concept of habitat is closely linked with that of the ecosystem. Habitat is a place where a given organism dwells. The biotic community along with its habitat is called an ecosystem. Thus, habitat is a subset of the ecosystem. The ecosystem provides conditions for both habitat as well as resources. In a general way, all the landmasses of the earth is a habitat for man – it has the ability to modify and live anywhere. A catfish in a pond lives at the bottom but uses the entire pond for resources, being a carnivore. The pond bottom is the habitat and the pond is the ecosystem. Most life forms however live in their own natural habitats except man. Man has, by his own ingenuity, been able to create his/her own built habitat (towns, cities, villages etc.) at least from times of the Neolithic period, when the mud/stone houses were first built. In a general way Fig. 1.5 provides the relationships between nature, environment, ecosystems and habitat that are intermeshed and provide conditions of living for all organisms.

**Fig.1.5: Environment, Ecosystem and Habitat**

### **Man – Nature Interdependence**

Man is the only part of the living nature that has the ability to influence and change the environment. Some of the changes can be beneficial, others deleterious to himself and other living creatures. Some changes are reversible—others irreversible, i.e. once the change has been introduced to the ecosystem it cannot be undone anymore. Therefore, man has to worry about those changes that are both harmful and irreversible. On the other hand, while seeking resources from the environment man introduces these changes. This does not necessarily happen when other living beings seek resource from their environment. This is largely because all living beings source their resources directly, with their bodies and limbs – except man, who constantly through ingenuity uses tools and technologies external to himself. This enhances his ability many times over – an ability to conquer nature.

Thus, when man interacts with the environment by introducing alterations the environment changes. But such changes also bring about change in man and his civilisation. When man discovered the coal a source of energy or for that matter petroleum, such changes brought about changes in man and his social organisation. Initially coal became the prime mover of the Industrial Revolution, later oil – the latter especially brought about the automobile revolution that is now considered necessary for the modern man. When man discovered the gun powder in the middle ages (China), the whole societal organisations of the earlier periods collapsed in no time – the thick walled fortifications in Europe, Central Asia and Middle East fell like houses of cards. There was a complete churning of societies, their rulers and the search for a new set of rules (for peace and stability) continued.

However, the discoveries of external energy in form of coal, petroleum and electricity (now, nuclear) and the technologies to deploy them enhanced human abilities beyond anything imagined earlier. More and more of energy use made man able to exploit resources from the environment in far greater quantity, in far greater speed. There is where lies the problem and predicament of the contemporary civilisation. The changes are far too great, far too sudden and far reaching enough for the environment to take care of on its own. The in-

dustries that belch out carbon dioxide or sulphur dioxide are of such magnitude that the environment cannot clean it up—it accumulates in the atmosphere and results in the green house effects and global warming. A whole chain of changes is initiated. Not only that many of such changes are irreversible but also the fact that man as yet has no clear idea of what lies at the end of the chain. For hundreds of years man only interacted with the environment and modified or altered it. It is only in recent times that he is trying to comprehend the end game of such wanton interference in the web of life – that too when some of the negative effects of such changes became too apparent. Can this be stopped – quite unlikely. Once used to the comforts of modern life, it is unlikely that man will become a recluse and relinquish all his material and technological achievements. Man will and shall continue to interact and influence the environment – but perhaps, in a wiser way – with some success and some failures by continuously defining the acceptable level of such changes – now, and in future.