CE6OE01(C)	ENVIRONMENTAL LAWS AND POLICY	OE – I	3-1-0	3 Credits

Prerequisites: Environmental Engineering

Detailed Syllabus:

MODULE	CONTENTS	Hrs
1.	Overview of environment, nature and eco system, Concept of laws and policies, Origin of environmental law,	14
2.	Introduction to environmental laws and policies, Environment and Governance, sustainable development and environment, understanding climate change, carbon crediting, carbon foot print etc.,	12
3.	Introduction to trade and environment. International environmental laws, Right to Environment as Human Right International Humanitarian Law and Environment, environment and conflicts management, Famous international protocols like Kyoto.	14

Ecology

What is ecology?

- *Ecology* (*Greek Oikos = home, habitat, logy = study*) was coined over a century ago.
- The word Ecosystem was first coined by British ecologist, A.G. Transley in 1935.

Definitions:

The interaction between biotic and abiotic components is known as Ecology.

• American plant pathologist Fedricks Clements (1916) " ***Ecology to be science of community*****"**

• Taylor (1936) "**Ecology as the science of the relations of all organisms to all their environments**".

• British ecologist Charls Elton (1927) "**Ecology *as scientific natural history concern with the sociology and economics of animals***".

•Woodbury (1955) " T***he science which investigated organisms in relation to their environment - and a philosophy in which world of life is interpreted in terms of natural process"***.

- Recently, some modern biologists have provided somewhat more boarder definitions of ecology:

- Southwick (1976) "***Ecology is the science of study of the relationship of living organisms with each other and their environment***
- American Ecologist Eugene P. Odum (1975) defined ecology as " ***The study of structural and function of ecosystem- or broadly the nature***".
- Odum (1963) **"The structure and function of Nature."**
- Stiling (2002) "***Ecology is the study of interactions among organisms and between organisms and their environment.***
- More simple term - an ecosystem can be defined as an "E***cological unit in which the biotic and abiotic interact with each other in terms of energy flow and material cycling***".

- Krebs (1972): *"Ecology is the scientific study of the processes regulating the distribution and abundance of organisms and the interactions among them, and the study of how these organisms in turn mediate the transport and transformation of energy and matter in the biosphere (i.e., the study of the design of ecosystem structure and function)."*

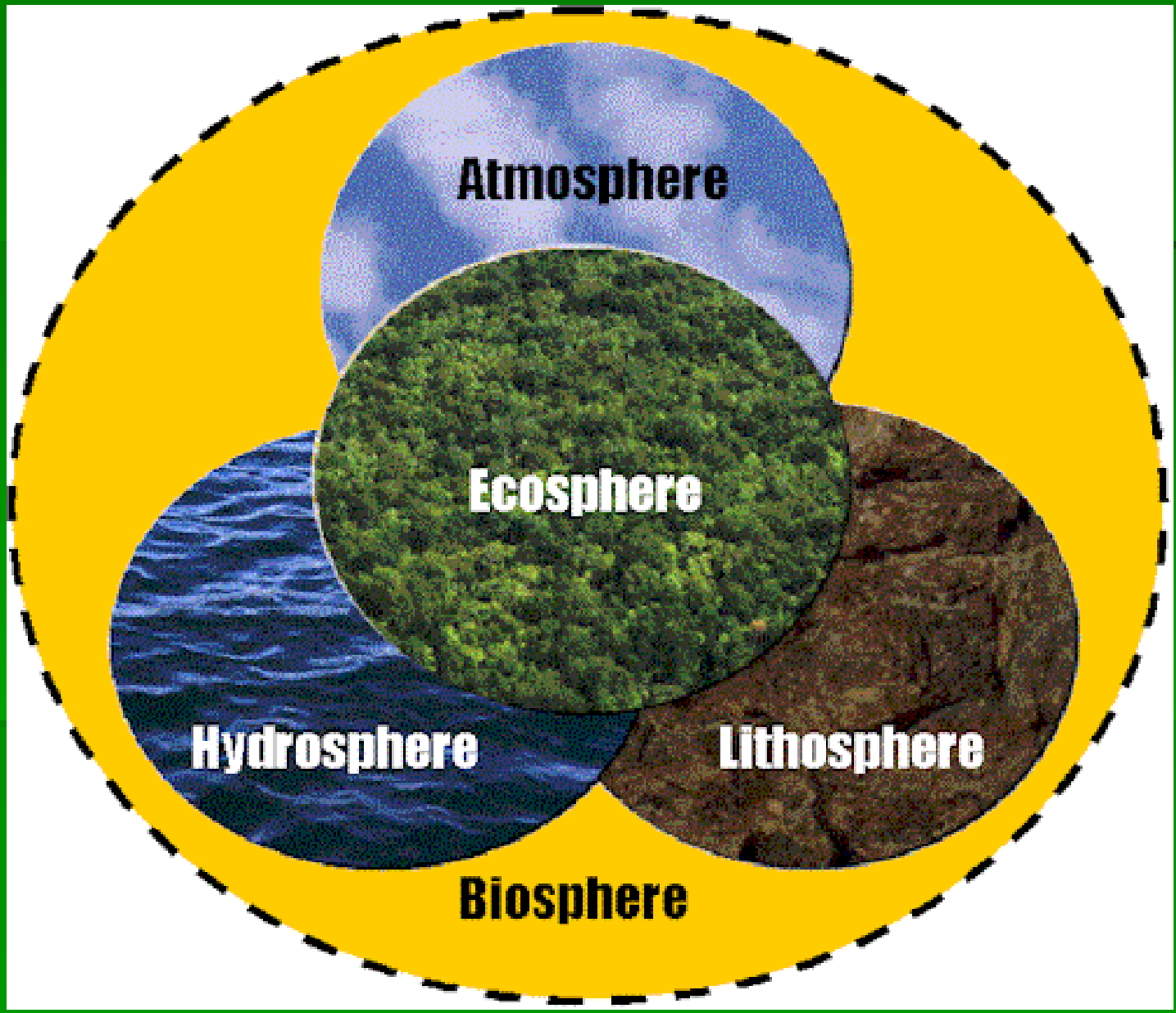
- The goal of ecology is to understand the principles of operation of natural systems and to predict their responses to change.

- *A contemporary definition of ecology is:*
- The scientific study of the distribution and abundance of organisms and the interactions that determine distribution and abundance.

The study of the interactions that take place among organisms and their environment

Biosphere

- The part of Earth that supports life
  - Top portion of Earth's crust
  - All the waters that cover Earth's surface
  - Atmosphere that surrounds Earth.


Atmosphere
Ecosphere
Hydrosphere
Lithosphere
Biosphere

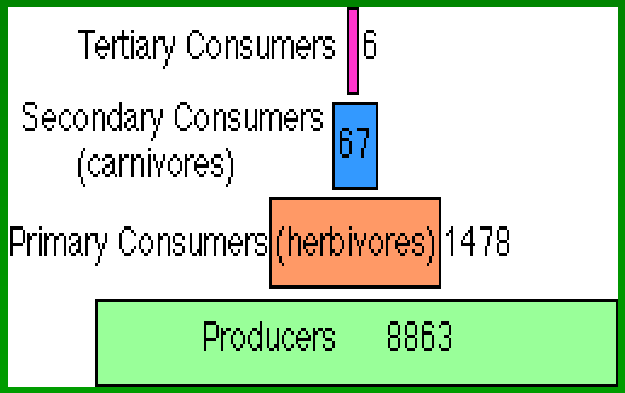
Ecosystem

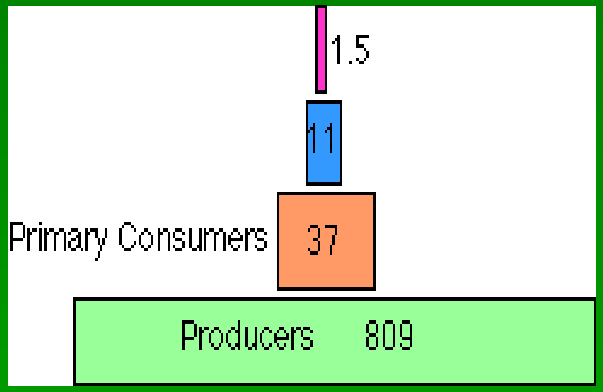
- All the organisms living in an area and the nonliving features of their environment

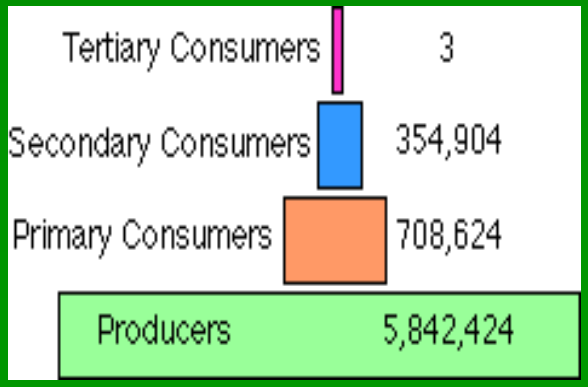
Biotic components

- The **autotrophs** (autotrpic = self-nourishing) which can produce their own food. These are green plants (with chlorophyll), blue green algae (BGA), and certain bacteria (chemosynthetic and photosynthetic).
- Since these organisms produce food for all the other organisms they are also known as **producer.**
- Algae of various types are producers of aquatic ecosystem. Terrestrial ecosystem have trees, shrubs, herbs, grasses, and mosses.
- Since heterotropic organisms depend on plants and other autotropic organisms like bacteria and algae for their nutrition, the amount of energy that the producers capture, sets the limitis on the availability of energy for the ecosystem.

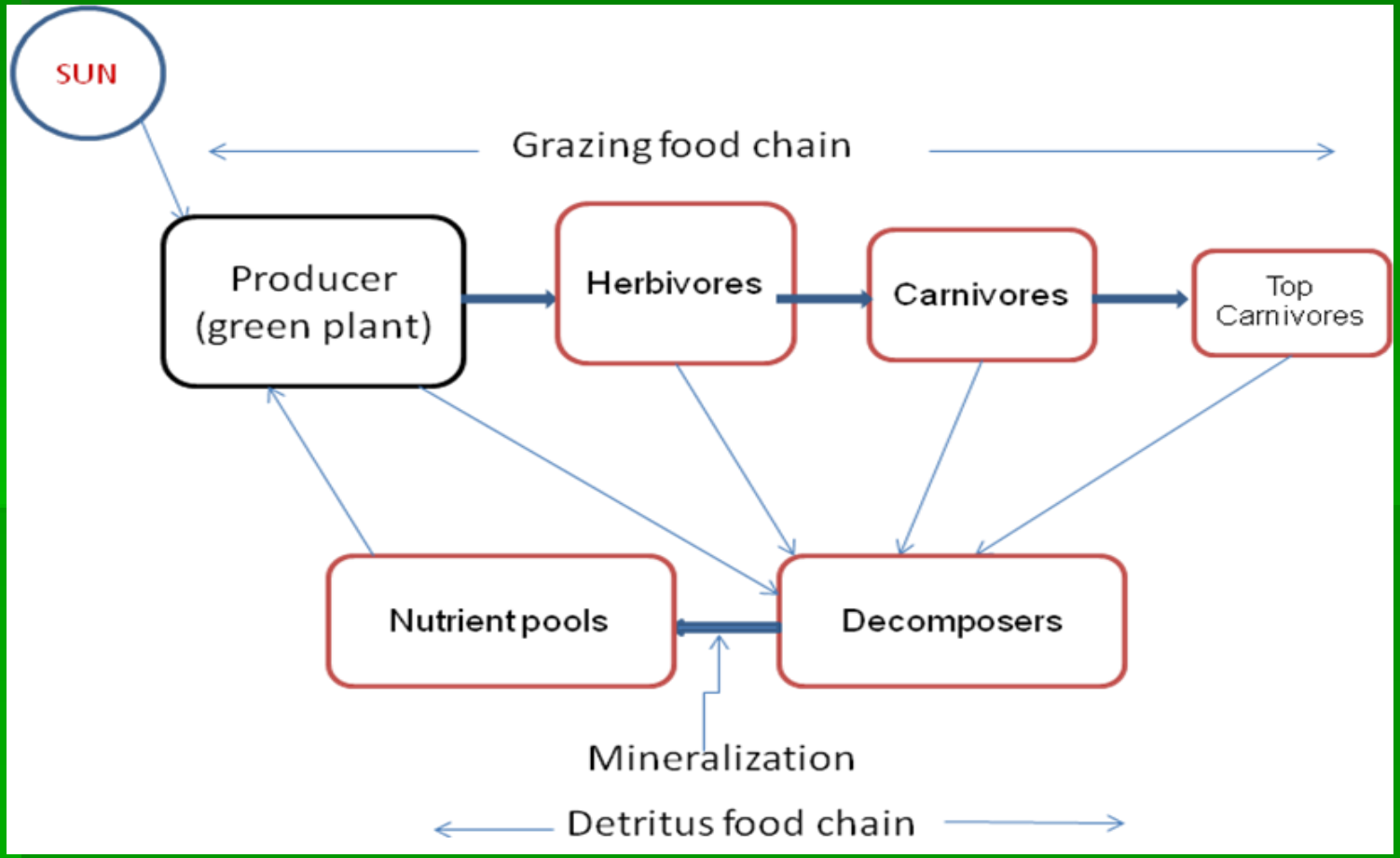
Ecological Pyramids







Balanced Ecosystem



Population

- All the organisms in an ecosystem that belong to the same species

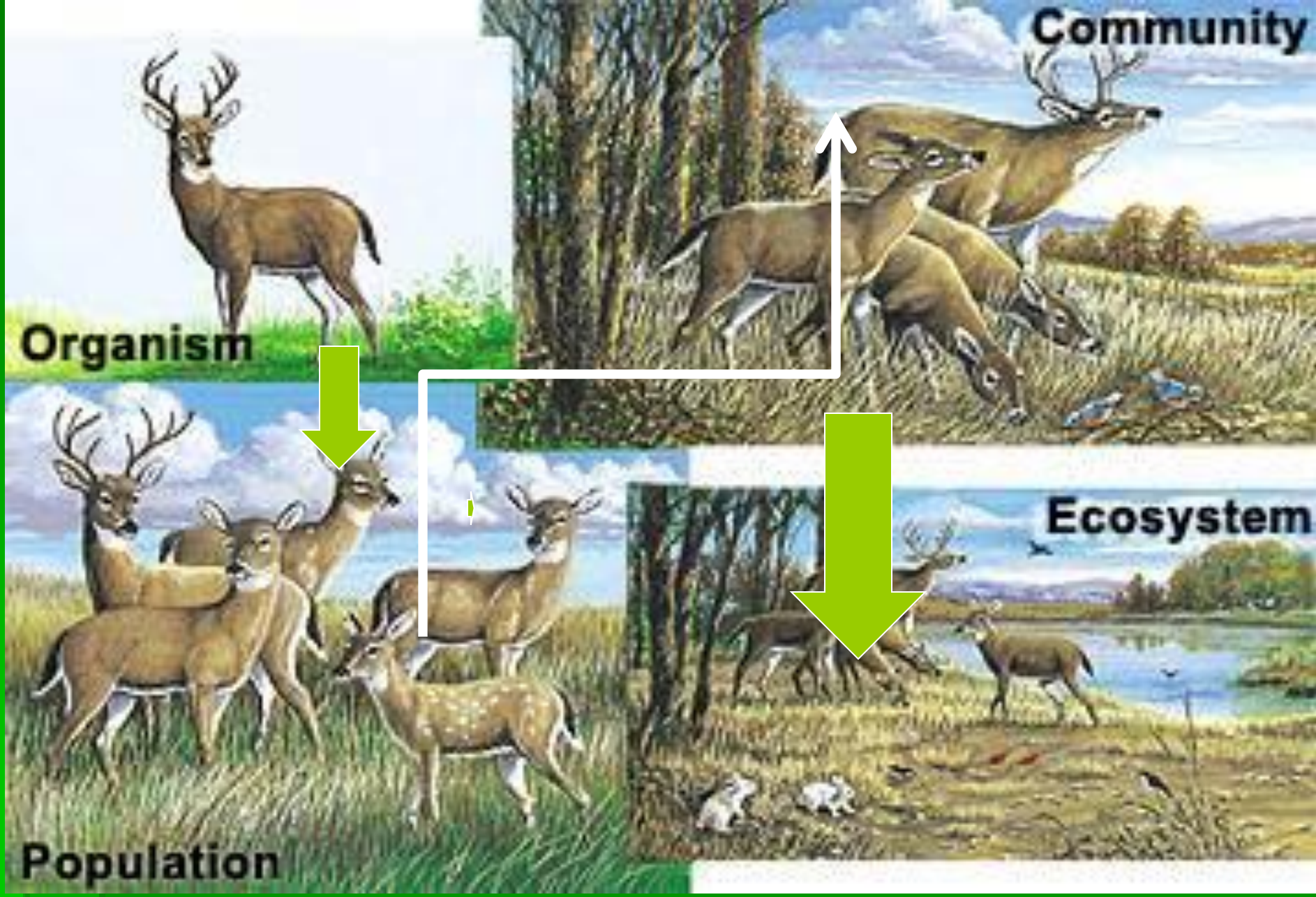
How to study ecology?

- *What kinds of experiments do ecologists perform?*

- Observations – Go into the field and see what's happening.
- Microcosms – Isolate a portion, limit factors, manipulate conditions.
- Mathematical models – Describe ecosystems interactions as equations.

Community

- All the populations in an ecosystem


Community
Organism
Ecosystem
Population

Habitat

- The place in which an organism lives
  - provides the kinds of food and shelter, the temperature, and the amount of moisture the organism needs to survive

Competition

- Food
- Space

Competition

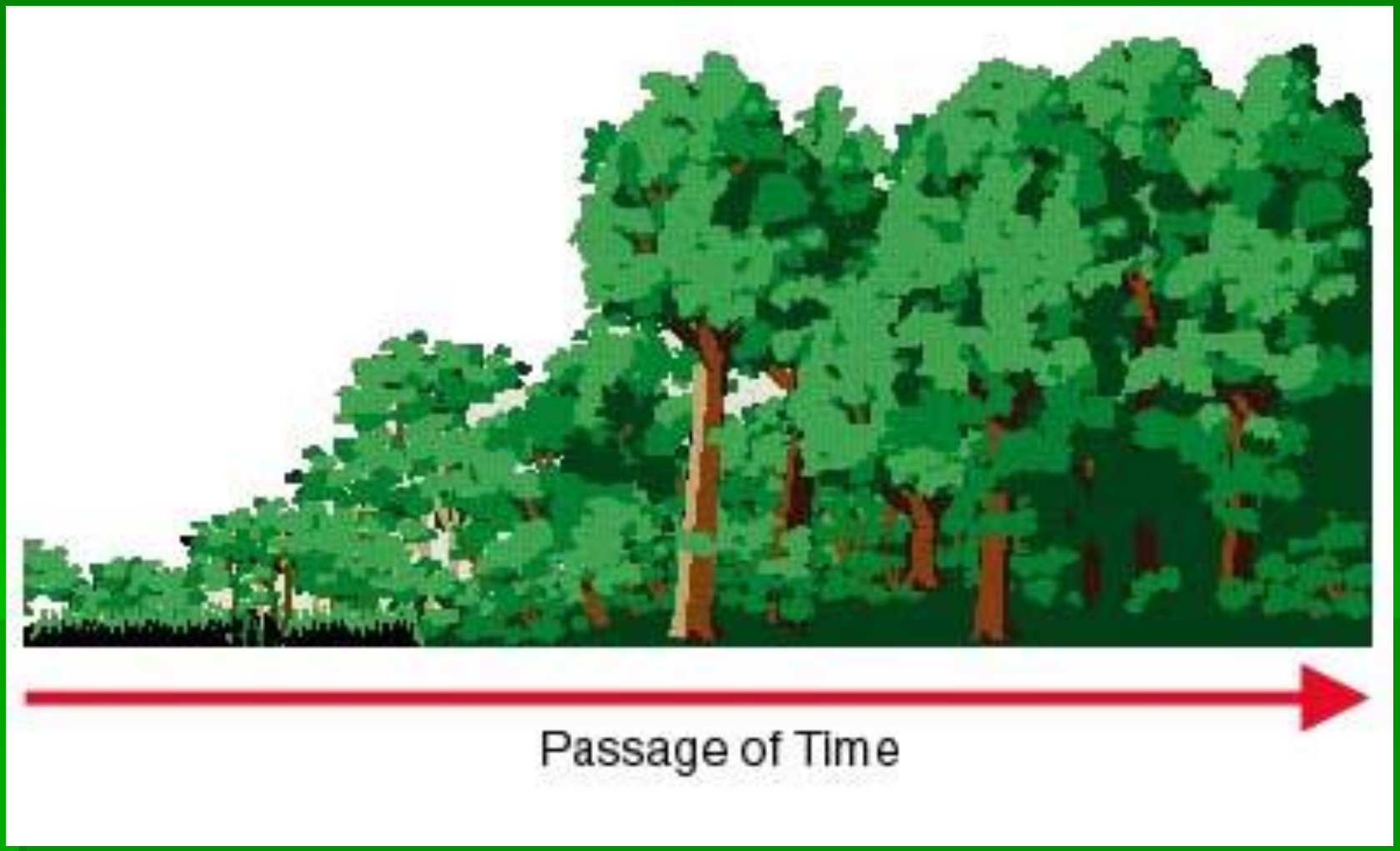
- Competition caused by population growth affects many organisms, including humans
- Limits population size

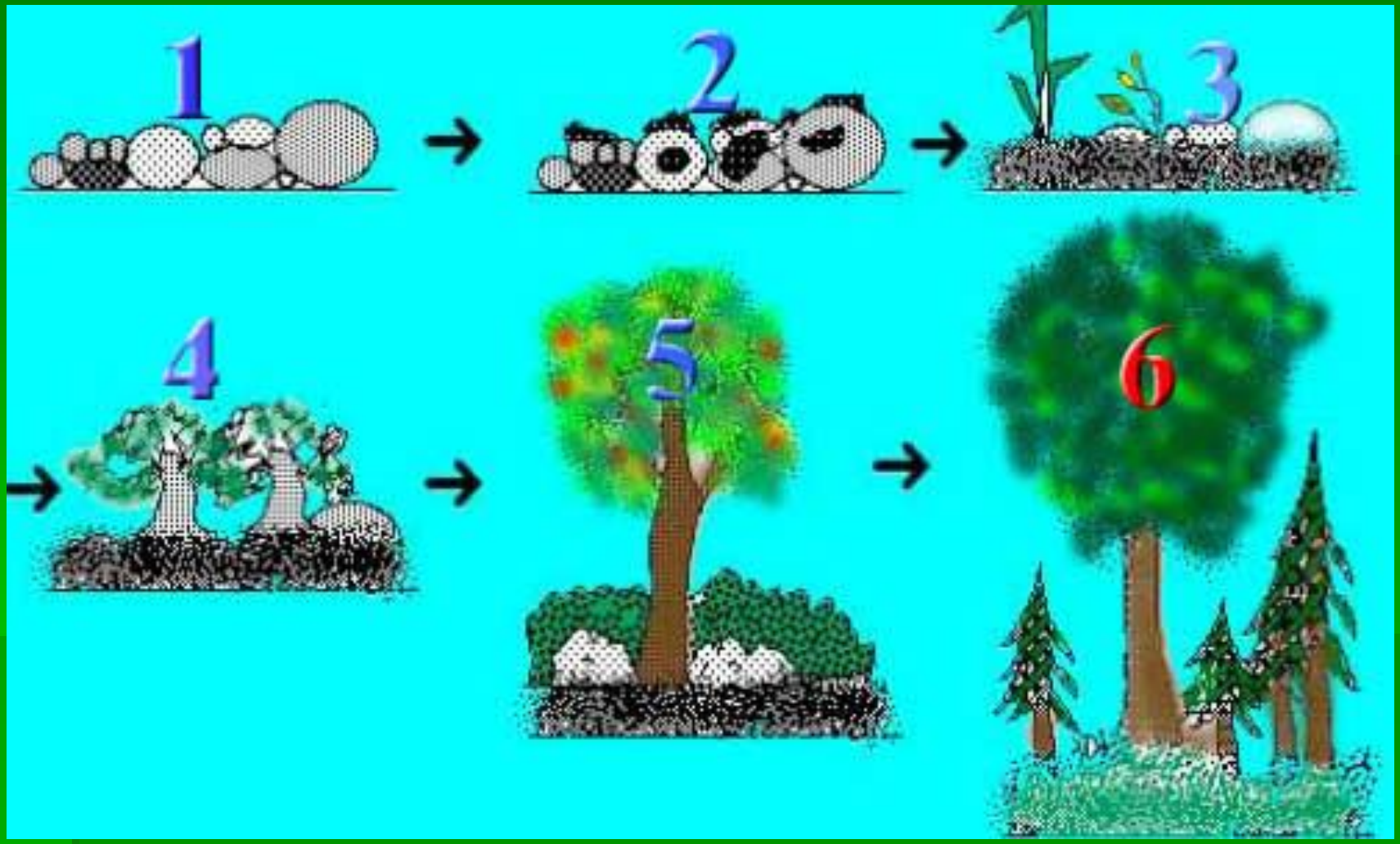
Limiting Factor

- Anything that restricts the number of individuals in a population.
- Includes living and nonliving features of the ecosystem

Succession

- Natural, gradual changes in the types of species that live in an area; can be primary or secondary.
  - Primary – begins in a place without soil
  - Secondary – where soil already exists


Passage of Time


1
2
3
4
5
6

Primary Succession

Secondary Succession

Pioneer species

- A group of organisms, such as lichens, found in the primary stage of succession and that begin an area's soil-building process

Climax community

- A community that has reached a stable stage of ecological succession

Biome

- Large geographic areas with similar climates and ecosystems

Biome

Large scale areas of similar vegetation and climatic characteristics.

A fundamental classification of biomes is:

1. Terrestrial (land) biomes
2. Aquatic biomes (including Freshwater biomes and Marine biomes).

- Climate is a major factor determining the distribution of terrestrial biomes.

Here we group biomes into six major types:


Freshwater

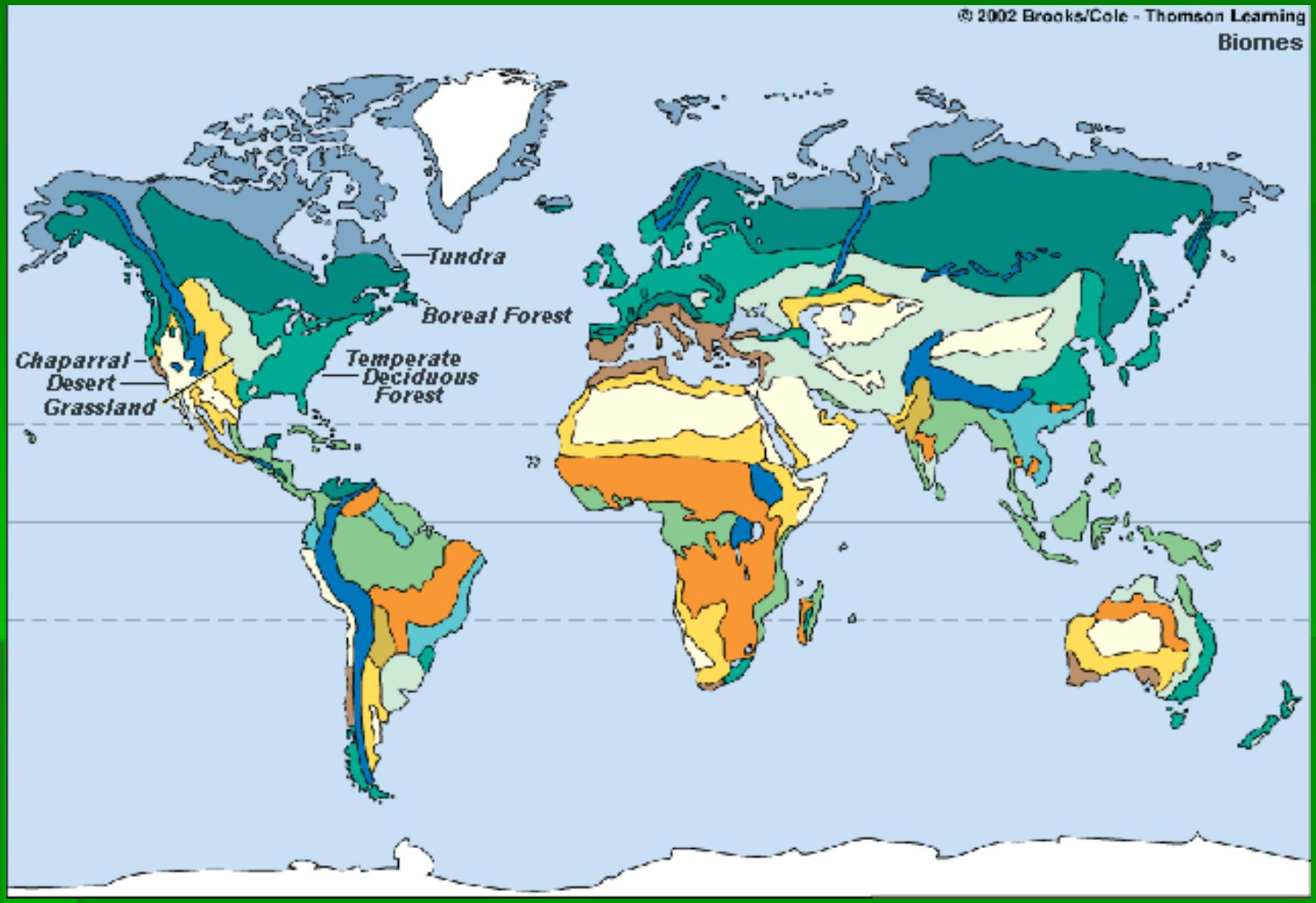

Marine


Desert


Forest


Grassland


Tundra


© 2002 Brooks/Cole - Thomson Learning
Biomes
Tundra
Boreal Forest
Chaparral
Desert
Grassland
Temperate
Deciduous
Forest

Different types of Biomes - Includes

1) Tundra
2) Taiga
3) Desert
4) Temperate deciduous forest
5) Temperate rain forest
6) Tropical rain forest, and grassland

Lecture No. 2:

ECOSYSTEM – INERTIA AND RESILIENCE

Components of Ecosystem

- Biotic components:
  - Autotrophs & heterotrophs.
- Abiotic components:
  - (a). Inorganic (C, N, CO2), which involves in the material cycling.
  - (b). Organic compound (protein, carbohydrates, lipids, humic substances) links biotic and abiotic components.
  - (c). Climatic regime

Functional aspects of ecosystem

- Food chain
- Diversity pattern in timed space
- Nutrients (biogeochemical cycles)
- Development and evolution
- Control (self-regulation)

Types of Ecosystem

- Two types:

(i) Natural - a pond, a river on estuary, - an ocean, a forest and so on

(ii) Man-made or Artificial - an aquarium, a dam, cropland, or garden, a city and so on..

TYPES OF SYSTEM

- **There are two types of systems that are of ecological interest - *open & cybernetic*.**
- ***Open System:*** Depends on an outside environment to provide inputs and accept outputs. [Example- Radio is an open system. It receives input energy from outside, acts upon it; transmit the sound near to the outside]
- Ecosystem too, in an ***open system*** it received energy from outside source (*sun*), fixes and utilizes it, and ultimately *dissipater heats to space*.
- ***Cybernetic system*** is also an open system, has some short of *feedback system* to make it self-regulating. To function such a manner, the cybernetic system, has an *ideal state* or *set points* around which it operator

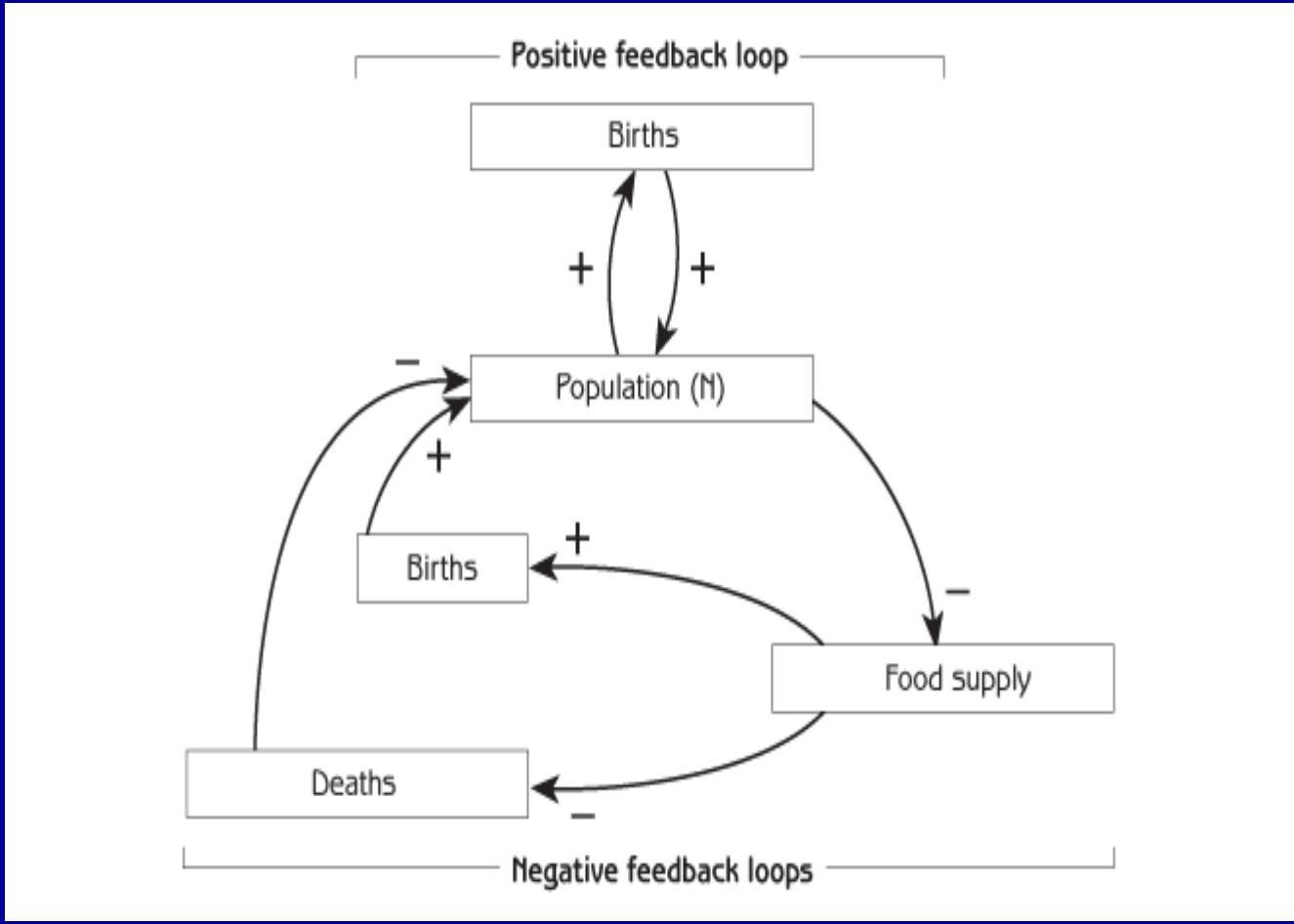
Homeostasis of Ecosystem

Ecosystem is capable of self-maintaining and self-regulating as are their components and organisms.

Homeostatic (Homeo = same; stasis = standing) is the term generally apply to the tendency for Biological system to resist change and to remain in a state of equilibrium.

The set points in living system is not fixed, rather organisms have a limited range of tolerance, called ***homeostasis plateau.***

Negative & Positive feedback



The dynamic property of ecosystem is explained by two terms:

Inertia property (resistance to change)

&

Resilience properties (a return time to a stable state following a disturbance)

Ecosystem Inertia and Resilience

- Ecosystem in a dynamic and self-regulating system.
- In nature there is always a disturbance and according to the nature and magnitude of disturbance, ecosystem responding its own may and changes according.
- Earlier literature, the ***dynamic properties of ecosystems*** in response to disturbance were referred to as ***stability properties.***

Inertia *(Persistence)- Resistance to Change*

- The resistance of an ecosystem so change under stress is form inertia or referred simply as "**resistance" or "resistance stability**".
- Inertia (or persistence) implies that the living system is able to resist external fluctuations.
- **Inertia, persistence:** Ability of a living system to survive moderate disturbances
- For example –
  - ✓ Force needed to stretch a coil a given distance; or
  - ✓ Amount of oil that must accumulate over a given area in a given time period to cause ecosystem to damage.
  - ✓ or How much (energy) disturbance is needed to cause the ball to more ?

Resilience Property of Ecosystem

- The rate and manner of recovery of an following disturbance is called ***resilience.***
- Resilience is the tendency of a system to return to a previous state after a perturbation.
- Resilience properties refer to ways in which a disturbed system responds.
- There are four components of resilience:

(i) Elasticity
(ii) Amplitude
(iii) Hysteresis &
(iv) Malleability

Elasticity and Amplitude are measures of Resilience.

1. Elasticity Property

- The time required to restore to its initial steady state, i.e., rate of recovery.

Elasticity is the speed with which a system returns.

- For example –
  - (a) Time require to spring back to its initial stage after stretching a given distance

  or

  - (b) How first ball returns to its original stage?

2. Amplitude

The zone of deformation from which the system will still return to its original stage.

Amplitude is a measure of how far a system can be moved from the previous state and still return.

For example:

(a) Maximum amount of oil that accumulates in area such that damage sustained can fully be repaired.

OR

(b) In case of spring, distance beyond which coil cannot be stretched without being permanently deformed.

3. Hysteresis

The extent to which the path of restoration is exactly reversal of path of degradation.

For example:

Is there any differences in paths of alteration and recovery.

4.0 **Malleability**

- ✓ Degree to which stable state (old viz. new) established after disturbance differs from the original steady state.

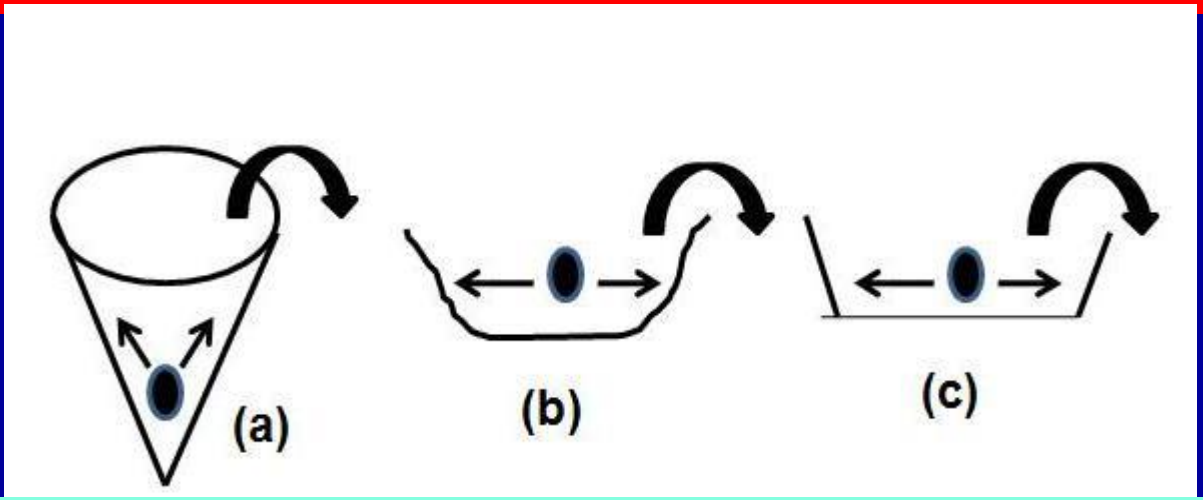
- ✓ How closely do the species composition and equitability of new climax resembles the old.

Resistance & Resilience

- Resistance is the term describing an ecosystem's ability to maintain its structural and functional attributes in the face of stress and disturbances.

- Resilience is the ability of an ecosystem to regain structural and functional attributes that have suffered harm from stress or disturbance

Inertia and resilience analogized to a ball in a cup



Inertia: a > b > c
How much disturbance is needed to cause the ball to move?

Elasticity: a > b > c
How fast will the ball return to its original position? [Time]

Amplitude c > a > b [Threshold of disturbance]
How much disturbance is needed to cause the ball to roll out of the cup?

Hysteresis: a = b < c
Will the ball roll back by the same route it took when initially displaced?

Malleability: b > a > c: How far away will the ball land when displaced from the cup with a given force of disturbance?

INERTIA AND RESILIENCE: Example -2

- G**rasslands** have low species diversity and low inertia (they burn easily and are not resistant to change…), but these are very resilient.

Why?

- Because a lot of nutrients are stored below ground in root systems. So after fire sweeps through, they can bounce back quickly (high resilience)

Lecture 3: Fragile / Sensitive Ecosystem & Hot spot

Introduction

- All ecosystems develop a set of specialized and integrated structural and functional properties, which are in delicate balance.
- An upset in ecological balance may result in fragility of the system.
- In a stable ecosystem, all the system variables may return to the initial equilibrium, if the disturbance is minor

Resilience ??

- Resilience is the capacity to absorb a given degree of disturbance without complete disruption of structural and functional integrity of the ecosystem.
- For example, an ecosystem with high biomass can absorb a small disturbance, such as drought, to a better extent than a low biomass.
- Resilience is the quality of the system which determines the rate with which the variables return towards normalcy following a disturbance.

Parameters for determining ecological fragility

- It is difficult to lay down a set of uniform parameters for determining ecological fragility.

1) The same parameters may not define fragility in all ecosystems, e.g, soil depth is a more crucial factor for a mountain watershed but it is not at all important for an alluvial flatland.

2) The fragility of an ecosystem very much depends on the nature of disturbance and developmental activities taking place or likely to take place in that region.

2.0 Fragile / Sensitive Ecosystem

- “***An area whose ecological balance is prone to be easily disturbed may be considered as fragile area***”.

- Some of the ecosystems, which are fragile/ sensitive and more susceptible to disturbance than others are discussed:

1.0 Ecosystem with unique properties

- Areas which have developed through a long span of evolution with less disturbances and are characterized by uniqueness of species composition, e.g.,

  (i) wilderness (natural isolating barriers relatively free from human interference);

  (ii) specialized environments like a deep marine ecosystem surrounding the coral reefs, estuaries, costal belt and islands.

2.0 Ecosystem with intrinsically low resilience properties

- These types of ecosystem have poor rate of recovery towards normalcy following a disturbance. Such areas have –

  (i) harsh climate,

  (ii) slow recovery rate,

  (iii) steepness of slopes,

  (iv) low productivity rate,

  (v) lack of higher plant life,

  (vi) low nutrients and

  (vii) poor humus content in the soil. e.g, **alpine and desert ecosystem**.

3.0 Ecosystem with high species richness and biological diversity

- Tropical moist forests belong to this category.
- Because of the species richness and rich genetic resources, these are subjected to continuous exploitation.
- Consequently, these ecosystems in various parts of the country are now threatened which could eventually lead to mass extinction of the species.
- Among such ecosystem, particularly ***threatened are those areas having diversity of species but with less number of individual species.***

4.0 Ecosystems susceptible to species loss

- These ecosystems are habitats which serve as shelter for very rare and extinct species.
- Even a very low order disturbance may lead to their complete extinction.
- Hence, those ecosystem are treated as highly **fragile**.

5.0 Ecosystem linking two or more protected ecosystem

- These are habitats and corridors which allow gene flow from one ecosystem to other, e.g,

  (i) Corridor used by wild buffalo for migration from Sitanadi to Udaipur,

  (ii) Elephant migration route from Kuldiha to Simplipal in Orissa.

- Delinking or destruction of such areas may stop natural gene flow from one system to the other resulting in extinction of species and thus making the ecosystems more fragile.

6.0 Ecosystem with aquifers and water recharge areas of mountain springs

Topographical features of mountainous region are specially responsible in which any major modification or abrupt change may alter:

- the drainage pattern,
- moisture retention capacity of soil,
- accumulation and melting of snow,
- growth of glaciers, rainfall, waterfall/springs, velocity of stream(s) causing irreversible change in ecosystem properties and
- alteration in ground water movement, e.g. *Oak forest in Himalaya*.

7.0 Areas with active geological faults and seismic hazards

Desert Ecosystem – A Fragile Ecosystem

Factors contributing are:

- Low precipitation,
- High diurnal temperature variations,
- Very less litter or no vegetation,
- Scarcity of water

Factors	Processes	Consequences
1. Climate change	Establishment of aridity & droughts	Dust storms, soil erosion, depletion of crop yields, degradation of vegetation, nomadism, livestock migration
2. Pressure of increasing human population	(i) Cultivation of marginal lands, (ii) Increase in irrigation cropping, (iii) Exploitation of woody biomass	(i) Decline in crop productivity, soil erosion, loss of soil fertility (ii) Water logging, salinity problems, over exploitation of ground water, introduction of new weeds and pests (iii) Degradation of wood-lot, suppression of natural regeneration, diminution of wildlife
3. Pressure of increasing livestock population	Overgrazing	Degradation of vegetation resource, diminishing livestock production, livestock migration and inducement of nomadism

Critical indicators of desertic fragility

(I) **Physical:** degree of salinity and alkalinity/depth and quality of ground water/effective soil depth/dust storms, sand storms and dust collection/presence of soil crusts and amount of soil organic matter/change in water flow and sediment flow in water course/area covered by turbidity/change of weather and climate/movement of sand and piling of sandy hummocks/drying of wells.

- **(II) Biological and agricultural:** Vegetation (canopy cover and above ground biomass distribution and frequency of key species)/animals (key species, population of domestic species, herd compositions, production, abundance and frequency of the activities of species leading to soil erosion and degradation)/yield of harvest (trend of low production).

Himalayan Ecosystem – A fragile Ecosystem

They are fragile because of:

- Weak geological formation,
- Arrested succession,
- Nutrient deficient soils,
- Shrinking water bodies, Glaciers,
- Seismic zones,
- Landslide zones &
- Watershed ecosystem

Examples Of Environmentally Fragile Ecosystem In India

- **Coral reefs** of Lakshadweep, Andaman & Nicober islands.
- Stretches of estuarine zones with mangroves, e.g. northern Andaman and Nicobar, Sundarbans (W.B), Bhitazkanika (Orrisa), Coringa (A.P), Mahanadi Delta (Orrisa), Pichavaram (T.N), Kumbarjua canal, Mandovi and Zuari rivers (Goa), Godavari delta (A.P), Gulf of Kutch (Gujrat), Coondapur (Karnataka), Achra/Ratnagiri (Maharashtra), Vembanad (Kerala), Point Calimare (T.N), Krishna estuary (A.P), etc.
- Doon valley

Examples Of Environmentally Fragile Ecosystem In India (Cont'd)

- Silent valley
- Alpine;s of Laddakh and Tonglu – Sandakphu of Sikkim Himalayas.
- Neorakhola in Eastern Himlayas
- Khasaijerain hills of Cheerapunjee
- **Core areas of bio-sphere reserves,** e.g. Nilgiri (TN, Karnataka &Kerala), Gulf of Mannaz (TN), Little run of Kutch (Gujrat), Kanha (M.P), Thar Desert (Raj), Nanda Devi & Uttarkhand (UP), Sunderbans (WB), Manas & Kaziranga (Assam), Namdapha (A.P), Nokrek/Tuza Range (Meghalaya). North islands of Andamans and great Nicobar island (A&N). etc.

Examples Of Environmentally Fragile Ecosystem In India (Cont'd)

- **Ecotones/ corrodors**: e.g. corridor used by wild buffalo for migration:
- From Sitanodi to Udaipur, elephant migration route from Kuldiha to Simlipal (Orrisa) and from Madumalal to Bilgiri Ramaswamy Temple. Wildlife sanctuary via Sujjalkuttal and Barbetta in Karnataka and T.N., natural areas linking protected regions within each major biome, ecotonal forests, e.g. tropical freshwater swamp forest, tidal forests, low mangrove forests, etc.

BIODIVERSITY HOTSPOT

- A **biodiversity hotspot** is a biogeographic region with a significant reservoir of biodiversity that is under threat from humans.
- The concept of biodiversity hotspots was originated by **Norman Myers** in two articles in "*The Environmentalist*" (1988 & 1990), revised after thorough analysis by Myers and others in "**Hotspots**:
- Earth's Biologically Richest and Most Endangered Terrestrial Eco-regions".
- major criteria for designating an area as hotspot are:
  - richness in endemic species, and
  - impact by human activities.
-

Criteria for Hotspots

- To qualify as a biodiversity hotspot on Myers (2000) edition of the hotspot-map, a region must meet **two strict criteria**:
- It must contain at least 0.5% or 1,500 species of **vascular plants** as **endemics**, and
- It has to have lost at least 70% of its primary vegetation.
- Around the world, at least 25 areas qualify under this definition, with nine others possible candidates.
- These sites support nearly 60% of the world's plant, bird, mammal, reptile, and amphibian species, with a very high share of endemic species.

Hotspots in India

- India is part of two hotspots-
- *Indo-Burma* (earlier Eastern Himalayas) and
- *Western Ghats and Sri Lanka .*
- Of late, conservationists named nine new **'Biodiversity Hotspots'**, making the total to **34**, which also include the *Himalayas .*

Biodiversity

What is Biodiversity?

- Biological diversity is the variety and variability among living organisms and the ecological complexes in which they occur.
- Biodiversity is the variety of life, including variation among genes, species and functional traits.
- It is often measured as:
  - Richness is a measure of the number of unique life forms;
  - Evenness is a measure of the equitability among life forms; and
  - Heterogeneity is the dissimilarity among life forms.

Biodiversity?

- **Year 1992**
- In 1992, India was one of 188 countries that ratified the Convention on Biological Diversity (CBD) at the Rio Earth Summit entered into force on 29 December 1993.

- The convention recognizes that ecosystems, species and genes are used for the benefit of humans.

The official definition of Biodiversity

"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"

(Convention on Biological Diversity, 1992).

Convention has three main goals

1. Conservation of biological diversity (or biodiversity);
2. Sustainable use of its components; and
3. Fair and equitable sharing of benefits arising from genetic resources

Biodiversity is the totality of

- Genetic diversity
- Species Diversity
- Ecosystem Diversity

Genetic diversity

- It refers to the variation of genes within species.
- This covers distinct populations of the same species (such as the thousands of traditional rice varieties in India)

  or

- genetic variation within a populations

Species diversity

- refers to the variety of species within region.
- different kinds of organisms, relationships among species.

Ecosystem diversity

- - Different habitats, niches, species interactions

A Brief History

- 1990s : several international initiatives were focused on the more specific question of how the diversity of life forms impacts upon ecosystems.
- The Scientific Committee on Problems of the Environment
- (SCOPE) reviews the state of knowledge on biodiversity and ecosystem functioning (BEF).
- Biodiversity and ecosystem services (BES) built on the idea that ecosystems provide essential benefits to humanity.
- 1992: Earth Summit

2005: Millennium Ecosystem Assessment (MEA)

- BEF research describes how genetic, species and functional diversity of organisms control basic ecological processes (functions) in ecosystems ?

- In contrast, BES works at the landscape scale and often focused on how major habitat modifications influenced 'provisioning' and 'regulating' services of ecosystems.

Conference of Parties (COP)?

1. The CBD governing body is the Conference of the Parties (COP), consisting of all governments (and regional economic integration organizations) that have ratified the treaty.
2. The CBD Secretariat, based in Montreal, it operates under the UNEP (United Nations Environment Programme).
3. The year 2010 was declared as the International Year of Biodiversity.
4. The 10th COP was held in 2010 in Nagoya (Japan).
5. The Nagoya Protocol was adopted on 22 December 2010 and the UN declared the period
6. from 2011 to 2020 as the UN-Decade on Biodiversity (CBD 2010)

Conference of Parties (COP) - 11

- The 11th COP meet was held in Hyderabad, India (1-19 October, 2012).
- The 12th COP (COP 12) meet will be held in South Korea in 2014.

Aichi Target 15?

- Develop a new work in support of achieving Aichi Target 15 which calls for the restoration of 15% of degraded lands.
- CBD and UN climate change initiatives including Reducing Emissions from Deforestation and Forest Degradation (REDD+).

What is TEEB?

- UNEP's Economics of Ecosystems and Biodiversity (TEEB) Initiative also presented a series of practical guides for governments at COP 11 for integrating the economic, social and cultural value of ecosystems into national biodiversity plans.

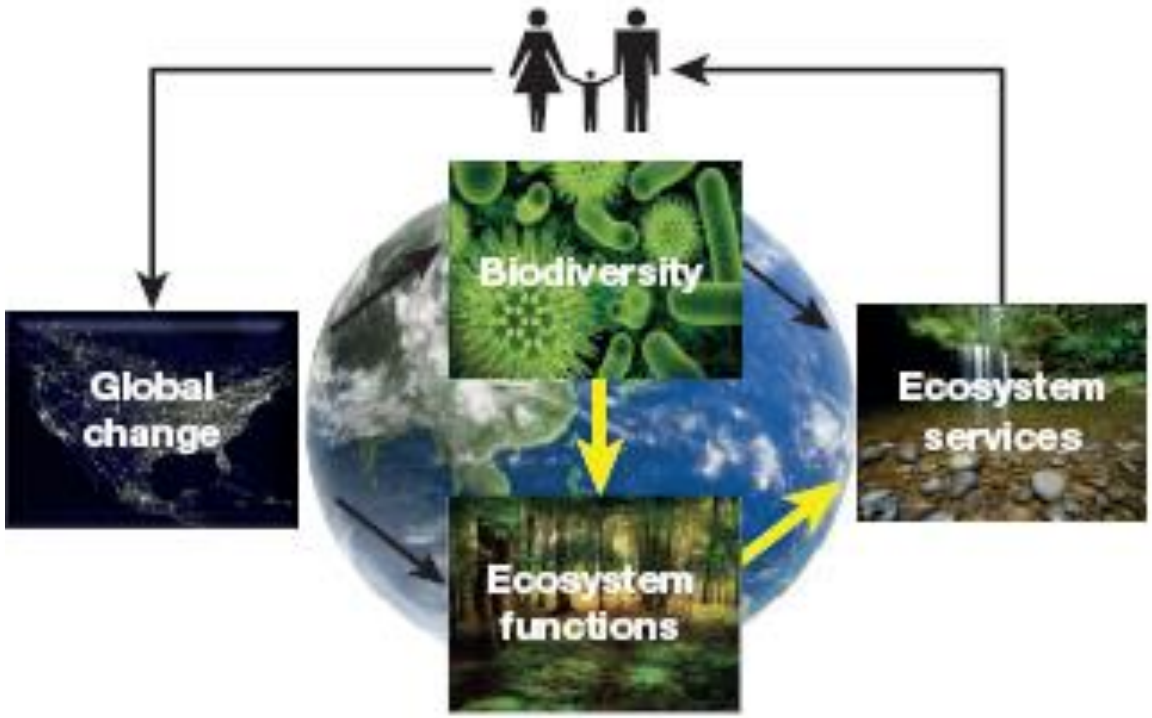
Ecosystem functions

- Ecosystem functions are ecological processes that control The fluxes of energy, nutrients and organic matter through an environment.
- Examples include:
- Primary production, which is the process by which plants use sunlight to convert inorganic matter into new biological tissue;
- Nutrient cycling, which is the process by which biologically essential nutrients are captured, released and then recaptured; and
- Decomposition, which is the process by which organic waste, such as dead plants and animals, is broken down and recycled.

Ecosystem services

- Ecosystem services are the suite of benefits that ecosystems provide to humanity.
- There are two types of ecosystem services: —
  - Provisioning and
  - Regulating.
- Provisioning services involve the production of renewable resources (for example, food, wood, fresh water).
- Regulating services are those that lessen environmental change (for example, climate regulation, pest/disease control).

Influence of Biodiversity in EF & ES



Benefits of Biodiversity

- Ecosystem functions
- Ecosystem services
  - Cleaning water,
  - Cleaning air,
  - Habitat & breeding areas for wildlife, …
- Aesthetic and cultural benefits

- **Rainforest are among the most biodiverse Ecosystem in the World**
- India is one of the 12 world hotspots for Biodiversity

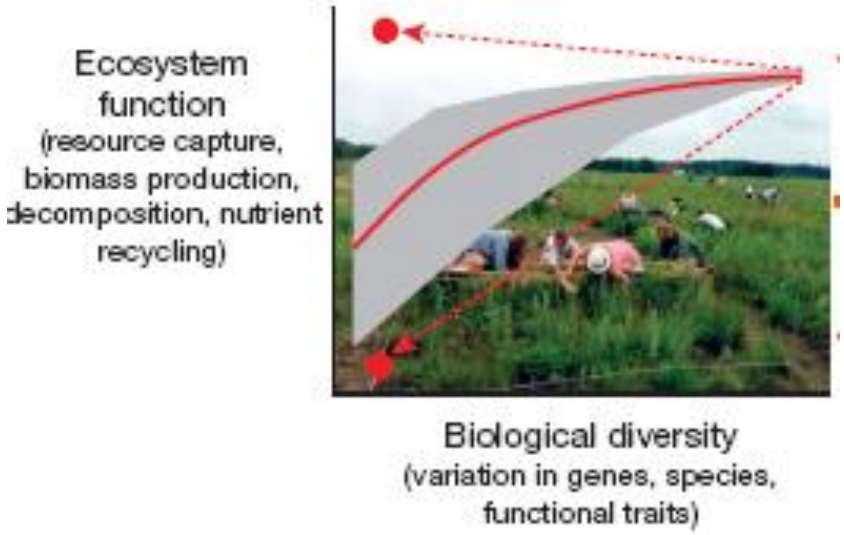
Is Loss of Biodiversity has an Impact on the functioning of Ecosystem?

1. Biodiversity loss reduces the efficiency by which ecological communities capture biologically essential resources, produce biomass, decompose and recycle biologically essential nutrients.

- i.e., Plant litter diversity enhances decomposition and recycling of elements after organisms die.

2.0 Biodiversity increases the stability of ecosystem functions through time

- that total resource capture and biomass production are generally more stable in more diverse communities.



3.0 Ecosystem change accelerates as Biodiversity loss increases

4.0 Diverse communities are more productive

- ✓ Because diverse ecosystem contain key species that have a large influence on productivity, and differences in functional traits among organisms increase total resource capture.

5.0 Loss of diversity across trophic levels has the potential to influence ecosystem functions even more strongly than diversity loss within trophic levels.

6.0 Functional traits of organisms have large impacts on the magnitude of ecosystem functions.

20 years of research on BES

- Biodiversity per se either directly influences or is strongly correlated with certain **provisioning and regulating services**.

Provisioning Services

1. Intraspecific genetic diversity increases the yield of commercial crops;
2. Tree species diversity enhances production of wood in plantations;
3. Plant species diversity in grasslands enhances the production of fodder; and
4. Increasing diversity of fish is associated with greater stability of fisheries yields.

regulating processes and services

1. Increasing plant biodiversity increases resistance to invasion by exotic plants;
2. Plant pathogens, such as fungal and viral infections, are less prevalent in more diverse plant communities;
3. Plant species diversity increases aboveground carbon sequestration through enhanced biomass production;and
4. Nutrient mineralization and soil organic matter increase with plant richness.

Biodiversity loss

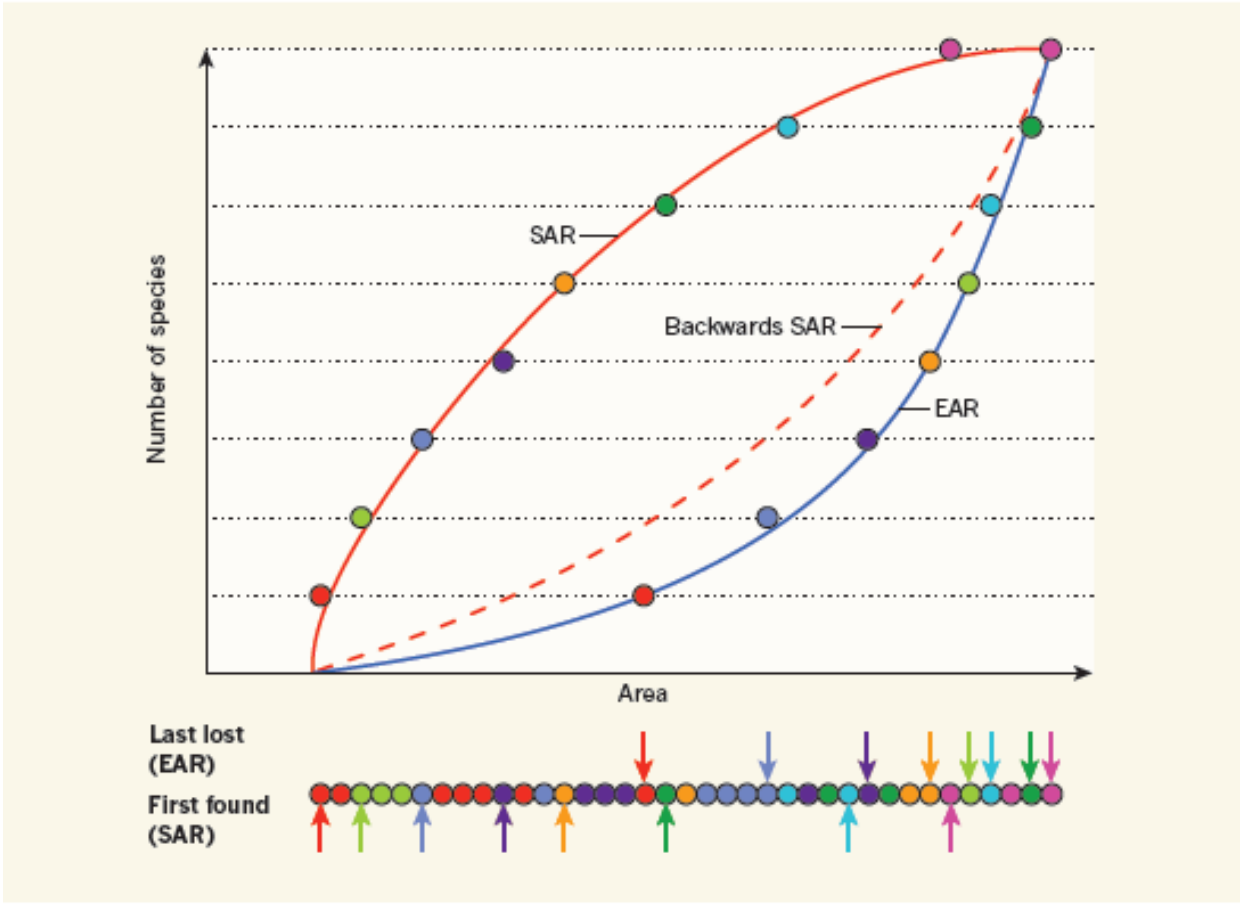
1. The accumulation of biodiversity on earth reflects the difference between the rates of speciation and extinction.
2. The background natural extinction rate estimated from fossil data was 10^{-7} species/ species/year, which has now increased up to 1000 to 10,000 times and according to some, as much as 120,000 times .
3. The current rate of species extinctions on Earth is 100 to 1,000 times greater than the natural rate and is accelerating (May *et al, 1995).*
4. It trends continues, within 240 yr earth may face sixth mass extinction?

Has the Earth's sixth mass extinction already arrived? Ref: Nature, Vol 471, p.51-57 (2011)

1. Of the 4 billion species estimated to have evolved on the Earth over the last 3.5 billion years, some 99% are gone.
2. These are the 'Big Five' mass extinctions (two are technically 'mass depletions').
3. Biodiversity loss in 21st Century could rank the major driver of ecosystem change.
4. Previous mass extinction were driven by global change in climate and in atmospheric chemistry, bolide impacts (Meteorites) and volcanism.
5. This time, species extinction is due to interaction & competition for resources with other species-human.

- Various studies predicted that loss of habitat causes 20-50% extinction of all species.
- **How to determine?**
- The species–area relationship (SAR), has been assumed that, by working backwards along the SAR, one can estimate the number of species that would be lost to extinction if a larger area were reduced by habitat loss.

Estimating species extinctions due to habitat loss



Contrast between use of the backwards species–area relationship (SAR), traditionally used to predict extinctions, and the true endemics–area relationship (EAR) that correctly estimates extinctions with increasing area lost

Biodiversity - Latest

Lecture 5:
Measurement of Biodiversity

Ecozone and Endemic species

- Large areas of the earth's surface where plants and animals developed in relative isolation over long periods of time, and separated from one another by barriers like oceans, broad deserts or mountain ranges that prevent migration of animals is called **ecozone.**
- Unique species of a particular area are called **endemic species**

Species richness

- The simplest measurement of species diversity is to count the number of species in an area.
- *In such count, we should include only residential species, no accidental or temporary immigrants be consider.*
- First and oldest concept of species diversity is species richness (d) - relates between
  - number of species (S) and
  - number of individuals of each species (N).

- Following species richness indices are used:
  1. Margalef's index (D_{Mg}): (S-1)/Ln N
  2. Menhinik index (D_{Mn}) = $S/(\sqrt{N})$
  3. General index: S/1000.

Species richness-

Drawback: does not take species abundance into account.

EXAMPLE 1: Imagine two hypothetical communities A & B, both with 100 individuals.

	Number of individuals of species 1	Number of individuals of species 2
Community A	99	1
Community B	50	50

✓Both communities A & B are equal in species richness, but B has a higher equitability or evenness.

✓To measure diversity, one must incorporate both abundance & species richness in measures of species diversity

- By applying three richness indices, both communities A and B show equal in species richness, but B has a higher equitability or evenness of the species richness:
  - d1 = (2-1)/ loge100 = 1/4:605 = 0:217;
  - d2 = 2/ √100 = 2/10 = 0.2;
  - d3 = 20:
- Therefore, during the measurement of species diversity, both abundance (i.e., evenness of distribution of species) and species richness has to be considered.

Types of Biodiversity indices

There are many indices, but we can divide them into two broad categories:

1. ***DOMINANCE INDICES*** – Dominance indices are weighted towards the abundance of the commonest species.

   (a) Berger & Parker index (1970) and

   (b) Simpson's index (Simpson, 1949);

2. ***INFORMATION- STATISTIC INDICES*** –

   a) Shannon index (1949) and

   b) Brillouin index (1962)

Berger–Parker Index (D_{BP})

$$(D_{BP}) = (N_{max})/ N$$

- N_{max} = total number of individuals in the most common species;
- N = total number of individuals in the community.

Date sets for Berger-parker index

Species	Community 1	Community 2
a	10	5
b	10	5
c	10	5
d	10	5
e	10	5
f	10	5
g	10	5
h	10	5
i	10	5
Total number of individuals	100	100
Total number of species	10	10

- $\mathbf{D_{BP}}$ for Com1= 10/100 = 0.1
- $\mathbf{D_{BP}}$ Com2 = 55/100 = 0.55
- To express greater diversity with a numerically greater value, we usually use a reciprocal form of the index.
- $\mathbf{D_{BP}}$ = 1/D, so that more diverse community actually have a higher index of diversity. In this case,
- For Com1, D_{BP} **= 1/0.1 = 10** &
- Com2 $\mathbf{D_{BP}}$ **= 1/0.55 = 1.82**.
- A huge advantage of the Berger-Parker index over the others is that it is very easy to compute.

Simpson's index (Ds) (Simpson, 1949) - **- a dominant index**

- Which gives the probability that any two individuals drawn at random from an infinitely large community will belong to different species.

Simpson's index (Ds)

- For infinite sample the index is:

  $C = \sum (ni/N)^2$

- For finite samples (i.e., which only a portion of the community has been measured), the form is: $C = \sum (ni\ (n-1)/\ N\ (N-1)$
- **Ds = 1-C (Gini 1912) or**
- **Ds = 1/C (Williams, 1964).**
- Where;

  pi = ni/N;

  ni = total number of individuals in each species;

  N= total number of individuals in all species;

  S= total number of species.

Simpson's index (Ds)

Tree species	Number of individuals
A	100
B	50
C	30
D	20
E	1
Total (N)	201

C = (100x99)/(200x201) + (50x49)/(200x201) + ((30x29)/(200x201) + (20x19)/(200x201) + (1x0)/(200x201) = 0.338;

Ds = 1/D = 1/0.338 = **2.96.**

Ds= 1-c = 1- 0.338 = **0.662.**

Disadvantage of Simpson's index

- The disadvantage of Simpson's index is that it is heavy weighted towards the most abundant species, as are all dominance indices. Thus addition of many rare species of trees with one individual will fail to change the index value.
- As a result, Simpson's index is of limited value in conservation biology if an area has many species with just one individual.

Shannon index (H)

1. The widely used Shannon index (H) is one of the best indices which is reasonable independent of sample size and also normally distributed (Odum 1971).
2. The greater the value of H, the higher is the diversity.
3. The value of H can be more than 1.
4. Higher diversity value occurs when the number of species and the evenness component are large (**low dominance**).

Shannon index (H)

- $H = - \sum p_i \ln p_i$

Where,

pi = ni/N and

'ln' denotes the natural logarithms.

- For community – 1: P[0.99 (loge 0.99) + 0.01 (loge 0.01)] = 0.056.
- For community – 2: P[0.5 (loge 0.5) + 0.5 (loge 0.5)] = 0.69.
- The second plant community is much more diverse than the first community. The higher the value of H, the greater the diversity.

Calculation of Shannon index

Name of species	Number of individuals (ni)	pi = (ni/N)	Ln pi	Pi ln pi
a	100	0.4975	-.6981	-.3473
b	50	0.2487	-1.3912	-0.3460
c	30	0.1495	-1.9021	-0.2844
d	20	0.0995	-2.3075	-0.2296
e	1	0.00497	-5.3033	-0.0263
				-1.2336

- ✓ Note that rare species with one individual contributes some value to the Shannon index, so if an area has many rare species, their contributions would be accumulated.

- ✓ Values of Shannon index for real communities are often found to fall between 1.5 and 3.5.

Could these two indices be comparable?

Answer is - yes.

Indices	Community -1	Community -2
Simpson index (Ds)	0.0198	0.50
Shannon index (H)	0.056	0.69
For comparison ($H/\ln_e S$)	$0.056/ \ln_e 2 = 0.0808$	$0.96/ \ln_e 2 = 0.995$

For comparison, Shannon index value (H) is divided with $\ln_e$ of total S (species).

Shannon Equitability Index (E_H) or Evenness Index

- For any information–statistic index, the maximum diversity of a community is found when all species are equally abundant.

- We can compare a community actual diversity, (Hs) to the maximum possible diversity (Hmax), by using a measure called evenness:

Evenness Index

- Evenness (E_H) = H/LnS
- Evenness (E_H) = 1.2336/ ln 5 [Shannon value)

  = 1.2336/ 1.6094

  = 0.621

- Evenness (E_H) = 2.30/ln 10

  = 2.30/2.30

  = 1

EH is ranged between 0 and 1.

Index of Similarity

$$S = [2C/ A+B] \times 100$$

Where;

S = index of similarity (in %)

A = number of species in sample A;

B = number of species in sample B,

C = number of species common to both A and B.

Alpha, beta, gamma Diversity

- Alpha -Diversity: Called intra-biotopic diversity or diversity within one components.

1. It measures the number of species in single community.
2. Diversity within a particular area, community or ecosystem is known alpha diversity.
3. i.e., Number of taxa (species usually) present in an ecosystem is a measure of alpha diversity.

Beta Diversity:

- Beta Diversity: Species diversity between two ecosystems is beta-diversity.
- It compare the differences of population between two adjacent biotopes, that is, diversity between two habitats,

1. for example, change in species composition along the environmental gradients.
2. Comparing the number of taxa that are unique to each of the ecosystem is beta-diversity

Gama- diversity

- gama-Diversity: It is also known as Macrodiversity,

For example,

- Mixed biotopes contained in geographical areas.
- Measure of overall diversity for different ecosystems within a region is gama-diversity.
- The area that is uniform in environmental conditions and in its distribution of animal and plant life is called biotope.

Concept of Law and Policy

1.1. Introduction

'Environment' is a very comprehensive term. It includes within its ambit a wide variety of phenomenon. It is a dynamic term that may be used to describe a limited area on one hand, and the entire planet on the other. The term Environment may be perceived in different connotations. There numerous definitions of the term as provided by different National and International legal instruments. Generally speaking, Environment includes the external conditions, resources, stimuli *etc*. with which an organism interacts. The Preamble of the United Nations Declaration on Human Environment, adopted in Stockholm in June 1972 states,
"Man is both creature and molder of his environment, which gives him physical substance and affords him the opportunity for intellectual, moral, social and spiritual growth".

The environment is clearly at risk from a variety of sources of harm, mostly of human origin. In order to tackle this problem it is important that we develop strategies for modifying human behavior towards environmentally benign practices and away from environmentally damaging ones. In very broad terms, techniques for modifying human behavior can be thought of as falling into two types: **incentives and disincentives**. Law is important as it creates a framework within which incentives and disincentives can operate. Law is all pervasive. Other methods for influencing human behavior are to a certain extent, voluntary or optional. Education, ethics, peer and family pressure: these all apply in various degrees. Law, on the other hand, cannot easily be avoided. It is axiomatic to the "rule of law" that law in a society applies equally to everyone at all times.

1.2. The Concept of Law

Law has been described as 'generally...a way of regulating human behavior" Hence, there is a need to closely consider the concept of "law"

• *Law as Commands*
One school of thought [2] is that the only thing that count as 'laws' are commands of a sovereign, backed up by sanctions in the event of disobedience. A sovereign, for Austin, is an individual or body that is clearly identifiable, habitually obeyed by society, and is not habitually obedient to any other superior. One problem with the command concept of law is that it doesn't fit very readily with laws that merely empower or permit one to do something. It fails adequately to separate legal coercion from non-legal coercion.

• *Law as Rules*
Problems with 'command' theories of law led to the development of "rule" theories of law. Hart (1961), the most eminent rule theorists, divided legal rules into primary rules and

secondary rules. Primary rules have substantive content (e.g. it is an offence to pollute a watercourse). Secondary rules are rules about primary rules. It is the possession of both primary and secondary rules which according to Hart, demarcates a legal system from other institutions for social control. This implies, incidentally, that less formal systems of social conventions and rules as much as those possessed by certain indigenous peoples may not achieve the status of 'legal system'.

The rule model of law faces certain problems. First, what should courts do if the law does not contain a rule governing a particular case or if the rule seems vague? Hart's answer is that laws, whilst generally comprehensive and clear, there may be situations where the judges must exercise discretion. This would imply that we must accept that judges actually make law where the legislature has been unclear or left a gap. The discretion explanation itself however is subject to criticism. Second, it is not certain that any clear rules exist. Some rules are made not by the legislature but by the judges. In the case of judge-made rules (precedents) the scope of any given rule is often unclear.

• *Laws as Principles*

Not everyone agrees that law consists of a body of clear rules surrounded by a woolly mantle of judicial discretion. Dworkin (1977), for one, famously argued that law also contains principles and does not contain discretion. He distinguished rules and principles as follows. He said that rules apply in an "all or nothing" fashion (e.g. river pollution is forbidden) whereas principles have the quality of 'weight'; that is to say, a principle is never absolute and is always subject to being balanced with and against other principles. An example of a principle might be 'a polluter shall pay for environment damage caused'. Unlike Hart, Dworkin denied that judges have discretion when faces with unclear or seemingly unjust cases. Instead he asserted that, in such hard access, judged should reach a solution based on the principles of their particular legal system.

Principles which can be found in most legal systems include- proportionality, nondiscrimination, natural justice, and equitable principles. The idea that law contains legal principles is not unproblematic[3]. One issue is whilst Dworkin characterizes principles as having 'weight', he never explains how this 'weight' is to be ascertained. It is not clear that Dworkin's characterisation of rules as absolute is correct; it may be that where rules appear to conflict, they can also be 'weighted' against one another. If that is the case then the distinction between the two types of law collapses and the need for principles disappears. A third problem is that of identification. Protocols exist for identifying legal rules, the same does not appear to be true of legal principles.

• *Law as Ethics or Morality*

The argument that there is some degree of necessary connection between law and morality (or ethics) is generally known as natural law theory[4]. More specifically, natural law is the idea that law must have a certain reasonable moral content in order to be called law at all. Part of importance of natural law thinking is that it can be used to undermine unethical

legislation and defeat attempts to justify morally repugnant acts (e.g. genocide) by appeal to the claims of 'only following the law'. Human rights law which is driven by natural law theories is of increasing importance in environmental protection[5]. The recent development of the field of 'environmental ethics' raises the question of a role for natural law in promoting or protecting basic ethical values in nature.

Natural law theory is subject to certain criticisms. Most obvious is the difficulty of ascertaining or reaching agreement on, those ethical principles and values that should inform or limit law's content.

• *Law as Social Norm and Customs*

The western concept of law is not shared universally. In particular, many indigenous peoples exist within less formalized systems of law in which the boundary between social norms and 'legal' rules is blurred or non-existent. Laws based on local custom-'customary law'-continue to be of considerable practical importance in many developing countries, especially in Africa. Individuals often rely on customary rights to protect their environment, and their own homes, from the threat of development. Many important concepts existing within one legal culture may be absent, or present only in altered form, in others. Sometimes law cannot replace the social functions of tradition and custom. Attitudes and behaviors formed from thousands of years of custom and tradition can be almost impossible for law alone to alter. The practice in China and Hong Kong of eating wild animals, often exotic and/or endangered species has been little affected by laws rendering such practices illegal. Furthermore, the use of wild animal parts in medicinal preparations in these countries is not considered to be morally wrong.

• *Laws as Written Documents*

It is assumed in the modern western society that laws must exist in a written form. This stems, historically, from the need for dissemination of laws. It also acts as a safeguard against corruption or mischievous interpretation. The requirement is met in modern times, by the publication of statutes, or, in civil law countries, 'codification' of the whole environmental law. In recent times access to environmental legislation-at international, regional and domestic levels-has been significantly improved by creation of numerous Internet sites which facilitate access.

The desirability of setting laws in written form led to an increase in written reports of courts' judgment. In addition to the traditional medium of the printed page, decided cases are increasingly disseminated via electronic media such as CD ROMs and the Internet.

• *Law Distinguished From Policy*

An important distinction in the concept of law is the one between law and policies. Government circulars, strategies or advice documents cannot substitute for the hard-edged character of legislation which is necessary so that 'individuals are in a position of legislation which is necessary so that 'individuals are in a position to know their rights in order to rely upon them where appropriate'. Two factors distinguish law from policy. First,

policy is generally advisory in nature, recommending objectives or setting targets, rather than prescribing particular actions. Second, policy may derive from any number of institutional processes whereas law must pass strict secondary rules of recognition before it has legal quality. The ‘relegation’ of some instrument to the field of policy rather than law does not exclude it from legal importance. Failure to take relevant policies into account or, conversely, consideration of irrelevant policies may invalidate decisions of public bodies. Not surprisingly, disputes not infrequently arise concerning the relevance, hence permissibility, of environmental policies taken into account by public authorities. Sometimes environmental policies must be taken into account. For instance, in UK development control law, governing advice about development controls, issued in the form of Planning Policy Guidance (PPG) notes, must be taken into consideration in the determination of applications for planning permission.

1.3. Environmental Law and Policy

Environmental Law is a body of law, which is a system of complex and interlocking statutes, common law, treaties, conventions, regulations and policies which seek to protect the natural environment which may be affected, impacted or endangered by human activities. Some environmental laws regulate the quantity and nature of impacts of human activities: for example, setting allowable levels of pollution or requiring permits for potentially harmful activities. Other environmental laws are preventive in nature and seek to assess the possible impacts before the human activities can occur. Environmental law as a distinct system arose in the 1960s in the major industrial economies. It is fast becoming an important and specialized branch of law. Many of its doctrines are gradually becoming clear. The questions addressed to by environmental law are substantive in nature, whereas, the remedies of these issues are mainly procedural. In recent years, environmental law has become seen as a critical means of promoting sustainable development. Policy concepts such as the precautionary principle, public participation, environmental justice, and the polluter pays principle have informed many environmental law reforms in this respect. There has been considerable experimentation in the search for more effective methods of environmental control beyond traditional "command-and control" style regulation. Eco-taxes, tradable emission allowances, voluntary standards such as ISO 14000 and negotiated agreements are some of these innovations.

Introduction to Environmental Laws & Policies

The protection of environment is a global issue as it concerns all countries irrespective of their size, stage, development or ideology. With the development of science and technology and with the increase in population, tremendous changes in the environment have taken place and this ultimately changes the eco system of the world.

In order to balance ecology and economy and its sustainability, two main international conferences on the development of environmental law have been held. The first was Stockholm Conference, 1972 which is known as 'Earth Summit' and the Second International Conference was 'R10 Conference' on sustainable development popularly known as 'R10 Declaration' was held in the year 1992. The main object of 'R10 Conference' was to strike a balance between ecology and economy and its sustainability.

In India, laws have been enacted to check water and air pollution and also for the safety and protection of forests and wild life. These Law are to prevent and control Water Pollution, Air pollution and the Environment Protection.

Global environmental crisis has questioned the modernity and its values. The very existence and survival of man and other forms of life have become a matter of deep concern. The basic environmental principle that follow is "the blessings of the environment should be enjoyed by the present generation and succeeded to the future generations, a sustainable society should be created where environmental pressure by human activities are minimized.

THE POLLUTER PAYS PRINCIPLE

In environmental law, 'the Polluter Pays Principle' has been enacted to make the party responsible for producing 'pollution' to pay for the damage done to the natural environment. In simple words "The Polluter Pays Principle is the commonly accepted practice that those who produce pollution should bear the costs of managing it to prevent damage to human health or the environment."
For instance, a factory that produces a potentially poisonous substance as a byproduct of its activities is usually held responsible for its safe disposal. 'Polluter Pays Principle' is also known as 'Extended Producer Responsibility' (EPR). This is a concept that was described by *Thomas Lindhqvist* for the Swedish Government in 1990.
The credit for popularizing the 'Polluter Pays Principle' for the first time goes to **Organisation for Economic Co-operation and Development** (OECD). The OECD defines EPR as "a concept where manufacturers and importers of products should bear a significant degree of responsibility for the environmental impacts of their products throughout the product life-cycle, including upstream impacts inherent in the selection of materials for the products, impacts from manufacturers' production processes itself, and downstream impacts from the use and disposal of the products."

The Supreme Court of India interpreted '**Polluter Pays principle**' as the absolute liability for harm to the environment extends not only to compensate the victims of pollution but also the cost of restoring the environmental degradation.

The **Environment Protection Act, 1986** expressly empowers the government "to take all such measures as it deems necessary or expedient for the purpose of protecting and improving the quality of environment". Thus, it includes environmental costs as well as direct costs to the people or property. So, it means that polluter should bear the cost of pollution as the polluter is responsible for it.

The 'Polluter Pays Principle' has been incorporated into the **European Community Treaty**. Article 102 Rule 2 of the Treaty states that environmental considerations are to play a part in all the policies of the community, and that action is to be based on three principles:

i. The need for preventive action;
ii. The need for environmental damage to be rectified at source; and
iii. That the polluter should pay

The 'Polluter Pays Principle' finds prominent place in the **'Rio Declaration of 1992**'. Principle 16 of the Declaration proclaims that national authorities should endeavour to promote the internationalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.

TWO-FOLD LIABILITY

The 'Polluter Pays Principle' exposes the polluter to two-fold liability namely:

(i) Compensation to the victims of pollution; and
(ii) Ecological restoration

But despite its different impact on pollution, the doctrine of Polluter Pays Principle is limited in the sense that it can be applied only at the remedial stage i.e. after the pollution has already taken place. It means one may "pay and pollute".

THE PRECAUTIONARY PRINCIPLE

'Precautionary Principle' plays a significant role in determining whether the development process is sustainable or not. Precautionary Principle underlies sustainable development which requires that the developmental activity must be stopped and prevented if it causes serious and irreversible environmental damage.

The Precautionary Principle ensures that a substance or activity posing a threat to the environment is prevented from adversely affecting it, even if there is no conclusive scientific proof linking that particular substance or activity to the environmental damage. Inadequacies of science are the real basis that has led to the emergence of Precautionary Principle.

The Principle is based on the theory that it is better to be on the side of caution and prevent environmental harm which may indeed become irreversible. The Precautionary Principle has been given utmost importance in the **United Nation's Conference on Environment and Development** held at Rio in 1992.

Principle 15 of the **'Rio Declaration'** states: "In order to protect the environment, the precautionary approach shall be widely applied by the States according to their capabilities, where there are threats as serious as of irreversible environmental degradation." The Supreme Court of India in case of ***Vellore Citizens' Forum v. Union of India***, held that the Precautionary Principle is a part of the environmental law of the country.

Precautionary Principle

The essential ingredients of Precautionary Principle are:

- Environmental measures by the State Government & the statutory authorities like state pollution boards must anticipate, prevent and attack the causes of environment degradation.
- Where there are threats of serious and irreversible damage, lack of scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

LEGAL MECHANISM IN RELATION TO ENVIRONMENT PROTECTION

By: Abhishek Sir

Definition of Environmental Law

- "**Environmental Law**" as an instrument to protect and improve the environment and control or prevent any act or omission polluting or likely to pollute the environment.

1. Ministry of Environment and Forests (MoEF)

- The Ministry of Environment & Forests (MoEF) is the nodal agency in the administrative structure of the Central Government for planning, promotion, coordination and overseeing the implementation of India's environmental and forestry policies and programmes.
- The primary concerns of the Ministry are implementation of policies and programmes relating to conservation of the country's natural resources including its lakes, rivers, biodiversity, forests and wildlife, ensuring the welfare of animals, and the prevention and abatement of pollution.

The broad objectives of the Ministry are:

- Prevention and control of pollution;
- Protection of the environment; and
- Ensuring the welfare of plants & animals

2. The Constitution of India:

- The 'Right to Life' contained in Article-21 of the Constitution of India includes the right to clean and human environment. It means you have the right to live in a clean and healthy environment.
- Article-48A of the Constitution declares "The State shall endeavor to protect and improve the environment and safeguard forests and wildlife of the country."
- Article-51A(g) of the Indian Constitution says: "It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wild life, and to have compassion for living creatures."

3. The Water (Prevention and Control of Pollution) Act, 1974

- The Water (Prevention and Control of Pollution) Act was enacted in 1974 to provide for the prevention and control of water pollution, and for maintaining or restoring of wholesomeness of water in the country.
- This is the first law passed in India whose objective was to ensure that the domestic and industrial pollutants are not discharged into rivers, and lakes without adequate treatment. The reason is that such a discharge renders the water unsuitable as a source of drinking water as well as for the purposes of irrigation and support marine life.
- In order to achieve its objectives, the Pollution Control Boards at Central and State levels were created to establish and enforce standards for factories discharging pollutants into water bodies.

4. The Air (Prevention and Control of Pollution) Act, 1981

- The Air (Prevention and Control of Pollution) Act, 1981 was enacted to provide for the prevention, control and abatement of air pollution in India.
- It is a specialised piece of legislation which was enacted to take appropriate steps for the preservation of natural resources of the earth, which among other things include the preservation of the quality of air and control of air pollution.
- The prime objectives of the Act are the following:
- Prevention, control and abatement of air pollution;
- Establishment of central and state pollution control boards to implement the aforesaid purpose; and
- To maintain the quality of air.

5. The Environment Protection Act, 1986

- It was the ***Bhopal Gas Tragedy*** which necessitated the Government of India to enact a comprehensive environmental legislation, including rules relating to storing, handling and use of hazardous waste.
- On the basis of these rules, the Indian Parliament enacted the Environment Protection Act, 1986.
- This is an umbrella legislation that consolidated the provisions of the Water (Prevention and Control of Pollution) Act of 1974 and the Air (Prevention and Control of Pollution) Act of 1981.

Continue…..

- Within this framework of the legislations, the government established Pollution Control Boards (PCBs) in order to prevent, control, and abate environmental pollution.
- The objective of the Environment Protection Act is to protect and improve the environment in the country.

NATIONAL AMBIENT AIR QUALITY STANDARDS

S. No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (notified by Central Government)	Methods of Measurement
(1)	(2)	(3)	(4)	(5)	(6)
1	Sulphur Dioxide (SO_2), $\mu g/m^3$	Annual*	50	20	- Improved West and Gaeke
		24 hours**	80	80	-Ultraviolet fluorescence
2	Nitrogen Dioxide (NO_2), $\mu g/m^3$	Annual*	40	30	- Modified Jacob & Hochheiser (Na-Arsenite)
		24 hours**	80	80	- Chemiluminescence
3	Particulate Matter (size less than 10µm) or PM_{10} $\mu g/m^3$	Annual*	60	60	- Gravimetric - TOEM
		24 hours**	100	100	- Beta attenuation
4	Particulate Matter (size less than 2.5µm) or $PM_{2.5}$ $\mu g/m^3$	Annual*	40	40	- Gravimetric - TOEM
		24 hours**	60	60	- Beta attenuation
5	Ozone (O_3) $\mu g/m^3$	8 hours**	100	100	- UV photometric - Chemilminescence
		1 hour**	180	180	- Chemical Method

6	Lead (Pb) $\mu g/m^3$	Annual* 24 hours**	0.50 1.0	0.50 1.0	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper - ED-XRF using Teflon filter
7	Carbon Monoxide (CO) mg/m^3	8 hours** 1 hour**	02 04	02 04	- Non Dispersive Infra Red (NDIR) spectroscopy
8	Ammonia (NH_3) $\mu g/m^3$	Annual* 24 hours**	100 400	100 400	-Chemiluminescence -Indophenol blue method
(1)	(2)	(3)	(4)	(5)	(6)
9	Benzene (C_6H_6) $\mu g/m^3$	Annual*	05	05	- Gas chromatography based continuous analyzer - Adsorption and Desorption followed by GC analysis
10	Benzo(a)Pyrene (BaP) - particulate phase only, ng/m^3	Annual*	01	01	- Solvent extraction followed by HPLC/GC analysis
11	Arsenic (As), ng/m^3	Annual*	06	06	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper
12	Nickel (Ni), ng/m^3	Annual*	20	20	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper

BHOPAL DISASTER

- The Bhopal disaster, also referred to as the Bhopal Gas Tragedy, was a gas leak incident in India, considered one of the world's worst industrial disasters.
- It occurred on the night between 2nd and 3rd December, 1984 at the Union Carbide India Limited (UCIL) pesticide plant in Bhopal, Madhya Pradesh. Over 500,000 people were exposed to methyl isocyanate gas and other chemicals.
- The toxic substance made its way in and around the shanty-towns located near the plant. Estimates vary on the death toll. The official immediate death toll was 2,259.
- The government of Madhya Pradesh confirmed a total of 3,787 deaths related to the gas release. According to other estimates, around 8,000 died within two weeks and another 8,000 or more have since died from gas-related diseases.
- A government affidavit in 2006 stated the leak caused 558,125 injuries including 38,478 partial disabling injuries and approximately 3,900 severe and permanent disabling injuries.

6. The Noise Pollution (Regulation and Control) Rules, 2000

- There was no direct provision for 'noise pollution' under the Environment Protection Act, 1986 or any other legislation. The increasing ambient noise levels in public places from various sources like industrial activity, generator sets, loud speakers, vehicular horns etc. have harmful effects on human health.
- It was the need of the hour to come with a law which would regulate and control noise producing sounds with the objective of maintaining the ambient air quality standards in respect of noise.
- Therefore, the Central Government framed 'The Noise Pollution (Regulation and Control) Rules, 2000'.

Continue…..

- These rules have been laid down by the government to reduce environmental noise pollution. Certain standards, such as the ambient air quality standards, have been set by the government.
- The permissible levels of noise are different for different areas, such as industrial, commercial, residential areas and silence zones (area within the vicinity of hospitals, educational institutions or courts).

Ambient Noise Standards

Area code	Category of Area / Zone	Limits in dB(A) Leq*	
		Day Time	Night Time
(A)	Industrial area	75	70
(B)	Commercial area	65	55
(C)	Residential area	55	45
(D)	Silence Zone	50	40

7. The Public Liability Insurance Act, 1981

- This Act aims to provide immediate relief to the persons affected by accident occurring while handling any hazardous substance.
- It provides that every owner shall take out, before he starts handling any hazardous substance, one or more insurance policies providing for contracts of insurance.
- The objective of taking insurance is that the compensation resulting from the possible future accident is guaranteed.

Continue…..

- The collector of the area has been empowered to verify the occurrence of any accident at any place within his jurisdiction and also cause publicity to be given for inviting applications from the victims for any compensation.
- Apart from the insurance contract, the funding for the purpose of compensation is also generated by the Central Government by the establishment of "Environment Relief Fund." This fund may be utilized by the collector for paying the compensation.

8. The National Environment Tribunal Act, 1995

- This Act is aimed to provide for strict liability for damages arising out of any accident occurring while handling any hazardous substance and for the establishment of a National Environment Tribunal for effective and expendition disposal of cases arising from such accident, with a view to giving relief and compensation for damages to persons, property and the environment and for matters connected with it.
- The beauty of this Act lies in the fact that the liability of the owner of hazardous substance has been made strict in case of any accident and the resultant injury to public.

Continue…..

- In any claim for the compensation, the claimant is not required to plead and establish that the death, injury or damage in respect of which the claim has been made was due to any wrongful act, neglect or default of any person.
- So, the burden of proof does not rest upon the claimant of compensation which is a big relief for the victims.

9. The National Environment Appellate Authority (NEAA) Act, 1997

- The National Environment Appellate Authority (NEAA) was set up by the Ministry of Environment and Forests to address cases in which environment clearance is required in certain restricted areas.
- It was established by the National Environment Appellate Authority Act 1997 to hear appeals with respect to restriction of areas in which any industries, operations, processes or class of industries, operations or processes shall or shall not be carried out, subject to certain safeguards under the Environment Protection Act, 1986.

10. The Ozone Depleting Substances (Regulation and Control) Rules, 2000

- The Ozone Depleting Substances (Regulation and Control) Rules have been laid down for the regulation of production and consumption of ozone depleting substances.
- The main objective of this rule is protection of the Ozone layer. The rule restricts unauthorized sale, purchase, import, export and use of ozone depleting substance.

The Central Pollution Control Board

- The Central Pollution Control Board (CPCB) a statutory organization, was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974 to deal with the rise in pollution. Further, CPCB was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981.
- Principal functions of the CPCB:

(i) to promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution, and

(ii) to improve the quality of air and to prevent, control or abate air pollution in the country.

The State Pollution Control Boards

- The State Governments also have their Pollution Control Boards for example, UPPCB (Uttar Pradesh Pollution Control Board), DPCC (Delhi Pollution Control Board), HPCB (Haryana State Pollution Control Board), RPCB (Rajasthan Pollution Control Board), etc.
- **Functions of State Boards**
- To advise the State Government on matter relating to pollution and on 'siting' of industries;
- To plan programmes for pollution control;
- To collect and disseminate information;
- To carry out inspection of polluting industries and areas;
- To lay down effluent and emission standards; and
- To issue consent to industries and other activities for compliance of prescribed emission and effluent standards

Questions

- 1. The Ministry of environment and Forests (MOEF) is the nodal agency for planning, promotion, cooperations and overseeing the implementation of India's environmental and forestry policies and programmes. (True/False)
- 2. The Water (Prevention and Control of Pollution) Act, 1974 was enacted to provide for the prevention and control of water pollution. (True/False)
- 3. The Air (Prevention and Control of Pollution) Act, 1981 was enacted to provide for the prevention, control and abatement of air pollution in India. (True/False)

Questions

- 4. The objective of the Environment Protection Act, 1986 is to protect and improve the environment in the country. (True/False)
- 5. The Noise Pollution (Regulation and Control) Rules, 2000 lays down rules to reduce environmental noise pollution. (True/False)
- 6. The Public Liability Insurance Act, 1981 aims to provide immediate, relief to the persons affected by accident occurring while handling any hazardous substance. (True/False)
- 7. The main objective of the 'Ozone Depleting Substances (Regulation and Control) (ODS) Rules, 2000' is protection of ozone layer. (True/False)

`

Thank You

ORIGIN AND DEVELOPMENT (STOCKHOLM TO RIO)

1. Stockholm Declaration, 1972

Global inter-governmental action began with the United Nations Conference on the Human Environment in Stockholm in 1972. This led to the 'Stockholm Declaration' and an action plan with over 100 recommendations on environmental assessment, management, and support measures. The Stockholm slogan was "Only One Earth". The environmental debate centred around the Club of Rome Report on the "Limits to Growth", and talk of economic development (the precursor of Sustainable Development). The Report highlights the consequences of unrestrained growth and the linkages between several global problems.

2. Brundtland Commission 1983

Post Stockholm concerns for the environment continued to grow. There was widespread deforestation, industrial pollution and environmental degradation. The ozone hole, the warming of the earth, increased carbon dioxide in the environment all added to the growing environmental concerns. A need was felt to link environmental concerns with industrial development and growth. With this in mind, the United Nations, in 1983, established the "World Commission on the Environment and Development" or as it is commonly referred to as the "Brundtland Commission". The Brundtland Commission Report – *'Our Common Future'* in 1987 defined 'Sustainable Development'. As we have discussed in the earlier sections -"development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

3. Rio Declaration 1992- Agenda 21

Twenty years after Stockholm, the United Nations Conference on Environment and Development was held in Rio de Janeiro in 1992. 'The Earth Summit', as it was called adopted the 'Rio Declaration' and an action plan of 40 chapters called Agenda 21 was adopted by over 100 Nations. Agenda 21 was geared towards achieving Sustainable Development in the 21st century. The 'Rio Concept' can be summarised as:

- Equal consideration of environment, society and economy;
- Intergenerational solidarity keeping in mind the needs of the future generations;
- A global consensus and political commitment at the national and international levels;
- Involvement of the Non-Government Organisations (NGOs);
- Provides a blueprint for the governments to attain a balance between the environment and the needs of the population; and
- A Commission on Sustainable Development (CSD) was established to follow up the Rio agreements, and it monitors the agreements of the Earth Summit at the local, national, regional and international levels

The Rio Summit Follow up

The Rio Summit was followed by several other Conferences to focus on 'Sustainable Development'. These include conferences like the "Global Conference on Sustainable Development of Small Island Developing States" in Barbadosin 1994: "The World Summit on

Social Development" in Copenhagen in 1995: "The Fourth World Conference on Women", Beijing 1995; and the "Second UN Conference on Human Settlements, Habitat II", Istatbul in 1996. The focus was on following the path of 'Sustainable Development' in all countries in all parts of the ecosystem whether on land, water or air. The effort has also been an all-inclusive development that reaches all sections of the population with a special focus on the vulnerable sections like women, children or the marginalised. A five year review of the progress of the 'Earth Summit' was held in **1997** by the United Nations General Assembly. This was followed by a ten-year review in **2002** by the World Summit on Sustainable Development (WSSD). The WSSD was held in **Johannesburg, South Africa**. It urged the Nations to make progress in the formulation and implementation of strategies for sustainable development and to begin implementing them by 2005.

Millennium Development Goals

In 2000, the largest-ever gathering of world leaders agreed to a set of timebound and measurable goals for combating poverty, hunger, disease, illiteracy, environmental degradation and discrimination against women, to be achieved by 2015. These are called the Millennium Development Goals.
The following is a brief overview of some significant decisions and agreements that were reached by the various countries:

In 2004, **Delhi Mandates** the use of compressed natural gas in city buses and auto rickshaws, responding to rising civil society pressure over air pollution.

In 2005, **Kyoto Protocol** enters into agreement which legally bound the developed countries to go for greenhouse gas emission reductions, and establishing the Clean Development Mechanism for developing countries.

In 2007, **Montreal Protocol** was signed on Substances that deplete the 'Ozone Layer'. Countries agreed to an accelerated phase-out schedule for hydrochlorofluorocarbons (HCFCs). NASA has reported that the 'ozone layer' is recovering, in part due to reduced concentrations of CFCs, phased out under the '**Montreal Protocol**'.

In 2008, **Green Economy** ideas enter the mainstream. National Governments allocate more funds to further stimulate environmental actions and green growth becomes the new objectives for the future economy. Also in 2008, scientist's document says that the oceans are growing more acidic due to increasing levels of atmospheric carbon dioxide. This they predict, would have disastrous consequences for the earth's ecosystem.

In 2009, **Copenhagen** climate negotiations were held. However, the participating countries failed to reach an agreement on new emissions reductions commitments beyond 2012 (the end of the 'Kyoto Protocol' time frame). An important outcome was that thrust now shifted towards national and regional efforts to reduce emissions.

In 2009, the **G20 Pittsburgh Summit** was held. Leaders called for making fossil fuel like petrol and diesel more expensive in order to phase them out. They also agreed to provide a targeted support for the poorest people.

In 2011, climate change negotiations were held in **Durban**. The negotiations' outcome was a step forward in establishing an international agreement beyond Kyoto. It was agreed to cut carbon emissions in all countries, including developed countries and several major developing countries. In 2012, one of the first of the Millennium Development Goal targets is achieved, in advance of the 2015 deadline. The percentage of the world's people without access to safe drinking water is cut in half. The 2012 **United Nations Climate Change Conference was held in Doha**. It was agreed to extend the 'Kyoto Protocol' that was to end in 2012 to 2020. It was also agreed to renegotiate the agreement reached in Durban by 2015 and to implement it by 2020.

From the 'Stockholm Declaration' of 1972 to the latest Conference held in Doha in 2012, more than forty years have passed. We are actively involved in greening the planet and in developing clean energy solutions. The world as a whole is committed towards combating hunger, disease, illiteracy, poverty, reducing inequalities and so on. The target is to ensure that the benefits of development accrue to all sections of society and not at the cost of the future generations.

NEED FOR SUSTAINABLE DEVELOPMENT

The world as a whole is steadfast in its commitment towards achieving a balance between the environmental, economic and social development. The agenda of 'Sustainable Development' is also an all-inclusive growth. That means a pattern of development that involves all sections of the community – the well off, the poor, men and women. Such a pattern of growth is based on the need to preserve the diversity of the eco-system. Sustainable Development involves:

- Preservation of biological diversity in terrestrial, freshwater and marine
- systems;
- Sustainable use of resources and minimising the depletion of resources;
- Caring for the environment;
- Improving the quality of life including social and economic concerns;
- Conservation of natural capital **both** for renewable and non- renewable resources;
- Conservation of natural and cultural diversity;
- Limits on natural resource utilisation and assimilation of wastes;
- Efficiency of resource utilisation by all societies;
- Social equity through poverty reduction and gender equity;
- Reduction of emission of greenhouse gases;
- Reduction in use of ozone depleting substances;
- Reduction in air pollution;
- Reduction in use of chemical fertilisers;
- Stopping desertification; and
- Stopping deforestation

SUSTAINABLE DEVELOPMENT

Today there is a serious concern about the earth's growing fragility. The earth's by increasing population is perceived as a threat. Man with his thoughtless acts has had an adverse effect on the earth's ecological system. As global citizens we have to recognise that our actions have consequences for the entire world.

Economic development cannot be viewed in isolation from social and ecological development. We have to ensure that the path of development that we follow ensures the welfare of the earth's ecology and that of its inhabitants. This is only possible if there is cooperation amongst the nations of the world.

'Sustainable Development' is concerned with the rate of consumption and use of natural resources. The focus is on ensuring that we do not consume the resources at a rate that makes it difficult for us to substitute or replace them. If we use cars then we have to make sure that we use eco-friendly fuel and technology that minimises air pollution. If we use ground water then we also have a responsibility of recharging it through various techniques like rain water harvesting.

'Sustainable Development' is thus, responsible development. It is economic development that keeps in mind the needs of the society and environment. It is development that is inclusive development that reaches all sections of society. It is development that benefits all sections of society and is not at the cost of the earth's ecology.

1. What is Sustainable Development?

In 1987, the United Nations released the Brundtland Report, which included what is now one of the most widely recognised definitions: "Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (from the World Commission on Environment and Development's (the Brundtland Commission) Report 'Our Common Future'. According to the same Report, the above definition contains within it two key concepts:

- the concept of 'needs', in particular the essential needs of the world's poor; and
- the idea of limitations imposed by the state on technology and social organization on the environment's ability to meet present and future needs

This means we have to meet the needs of all sections of society particularly the underprivileged. While meeting the needs we have to make sure that what we take from nature does not increase the degradation of the earth's natural resources and threatens biodiversity. Nature is finite and we need to set a limit to our consumption of natural resources. There is a need for a strategic approach to maintaining a balance between social, economic and environmental challenges. Sustainability recognises an integrated view of the world that links a community's economy, environment and society. This recognises the

fact that an economy exists within the society which in turn exists within the environment of the earth's ecosystem. The view emphasises the fact that humans are a part of nature.

What leads to unsustainability?

Let us try and understand the threats to 'Sustainable Development'. Economic disparity, social inequality and environmental degradation are threats to sustainability.

Some of the causes of unsustainability are as follows:

- increasing human population;
- over exploitation of resources to meet human needs like fuel, fodder and shelter;
- activities like fishing, agriculture, overuse of fresh water, deforestation and industrialisation;
- land clearing leads to problems like soil degradation, pollution, loss of biodiversity, deforestation, desertification, climate change; and
- social degradation due to factors like increasing unemployment, health crisis, armed conflict, urbanisation, poverty, income inequity

What are the components of Sustainable Development?

The various components of sustainability can be included under three headings– economy, society and environment. In order to attain 'Sustainable Development' the government has to ensure that there are institutional mechanismsin place to achieve sustainable development in all three areas. These institutional mechanisms make certain that there is a sustained, organised and coordinated effort at all levels to bring about socio economic development and environmental sustainability.

These include the various ministries and departments at the central as well as state level. The diagrams in the following sections broadly illustrate the various parts of the economy, society and environment that are targeted for sustainable development. Figure 2 shows the broad components of the economy. Figure 3 shows the broad components of society and Figure 4 shows the broad components of the environment

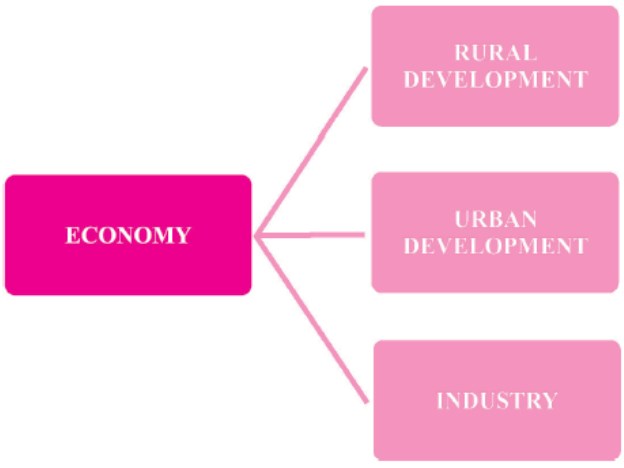


Figure 25.2: Some Targeted areas of Sustainable Development for the Economy

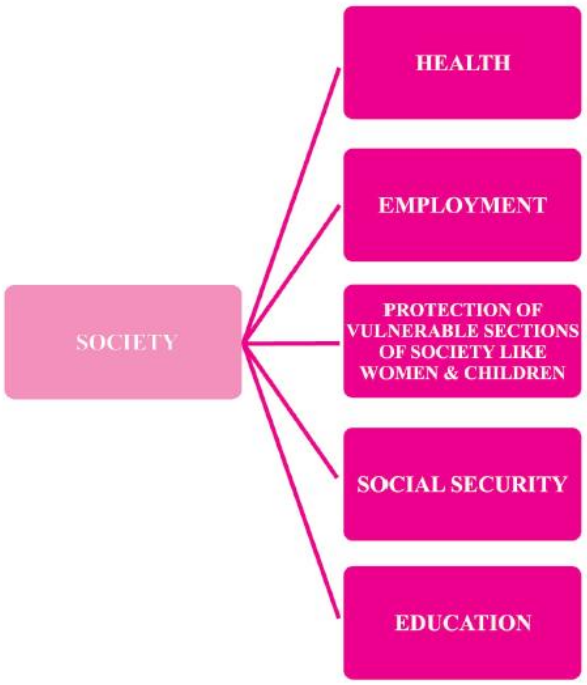


Figure 25.3: Some Targeted areas of Sustainable development in Society

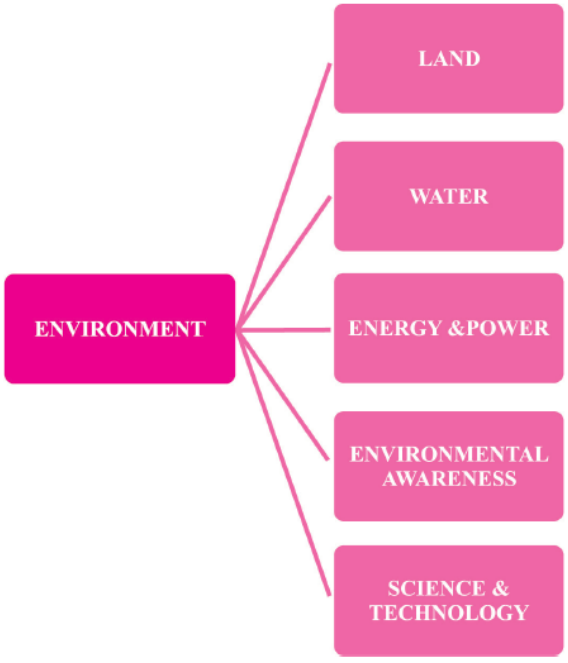


Figure 25.4: Some Targeted Areas of Environmental Sustainability