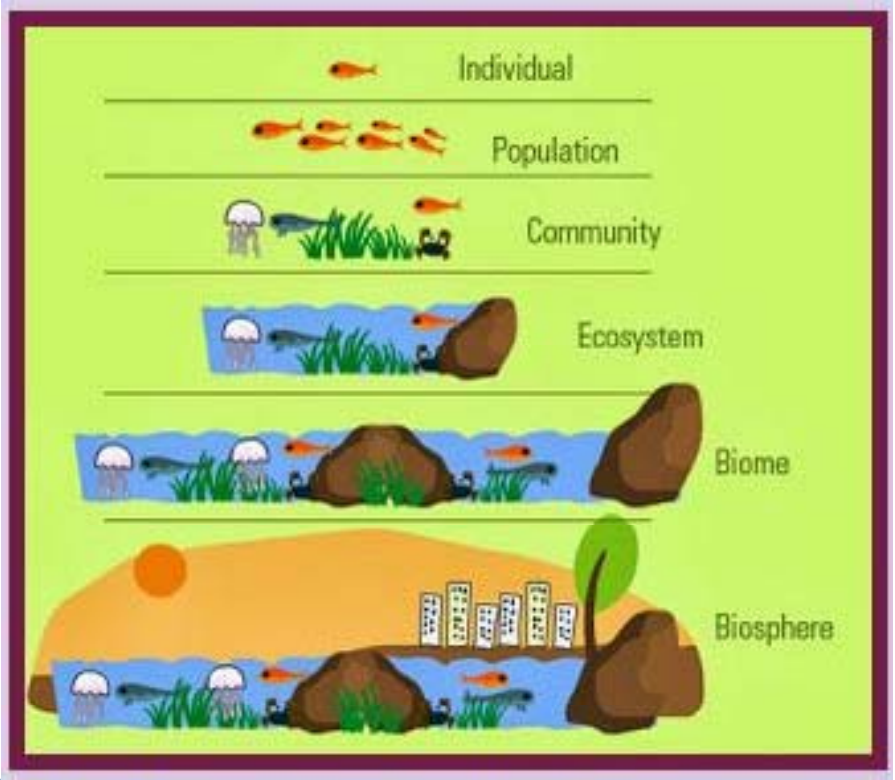
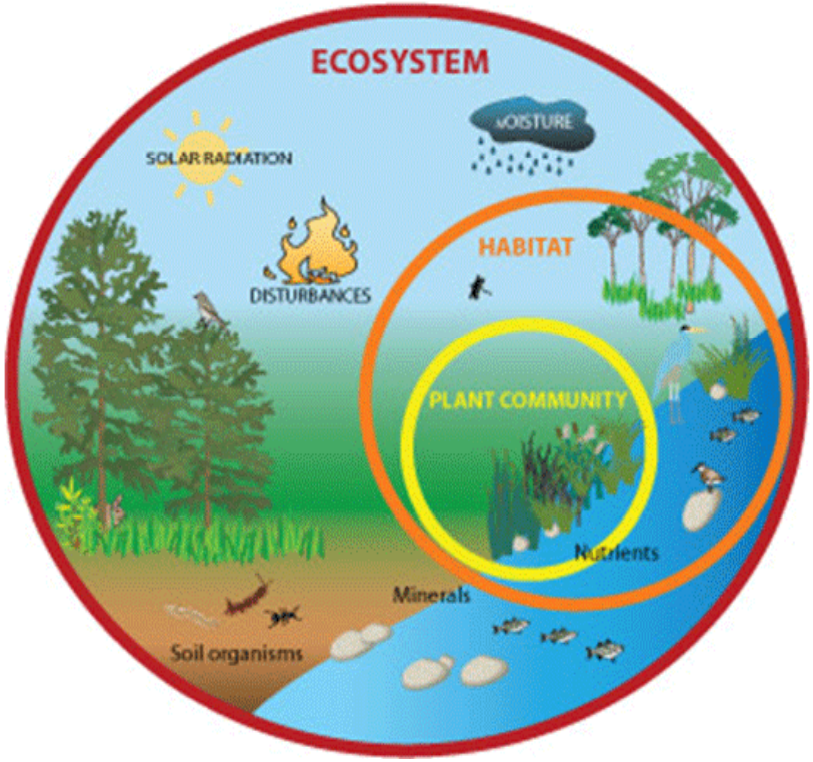
# Ecology and Sustainable Development

## CE102: Environmental Studies

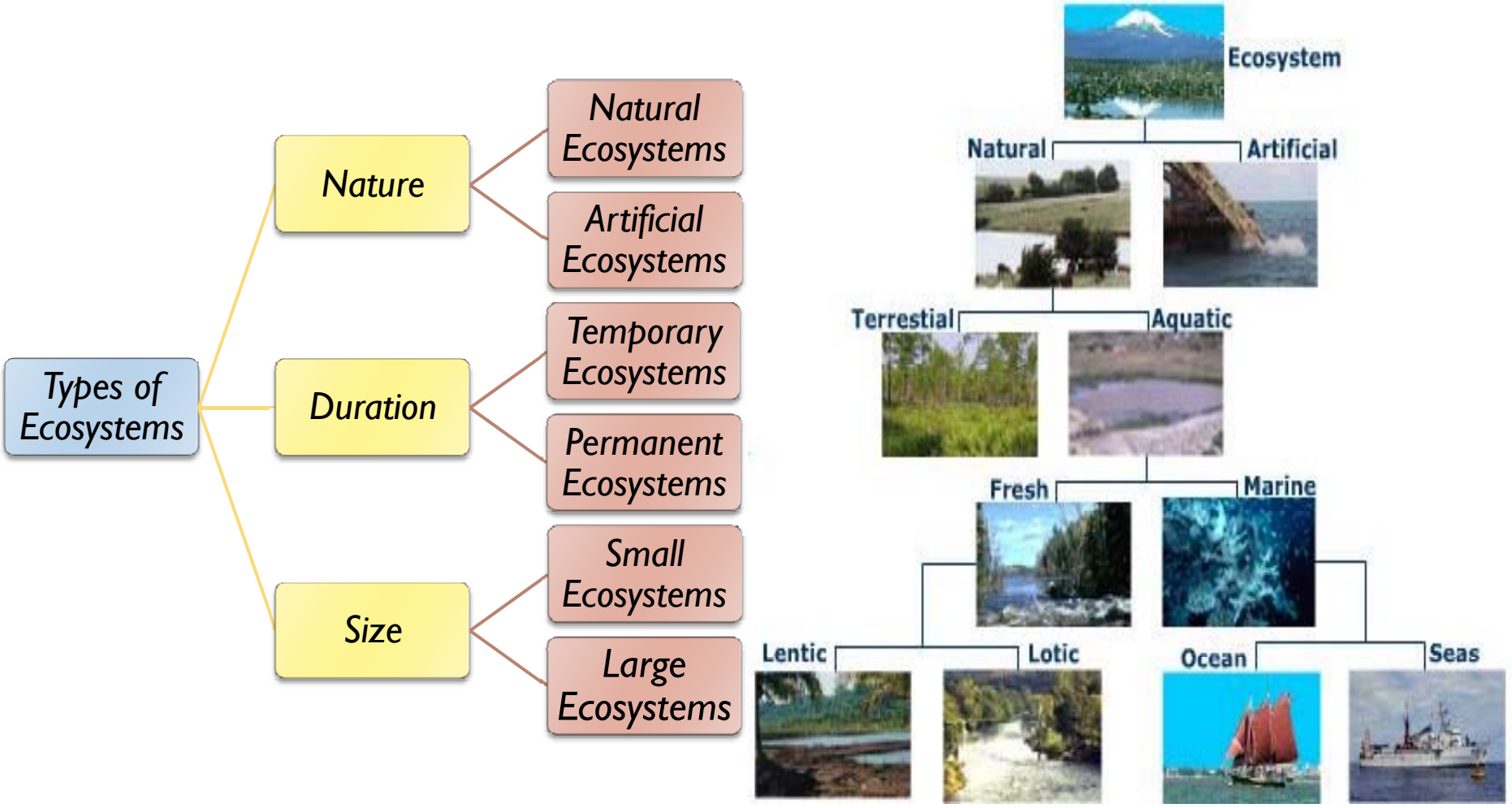
# Ecosystem: Sustaining Life on Earth

- Ecosystem is defined as structural and functional unit of the biosphere, comprising living (biotic) and non-living (abiotic) factors and their interaction.
  - Interactions of many organisms functioning together in ecosystems as well as
  - Physical and chemical environments



# Ecosystems and its types

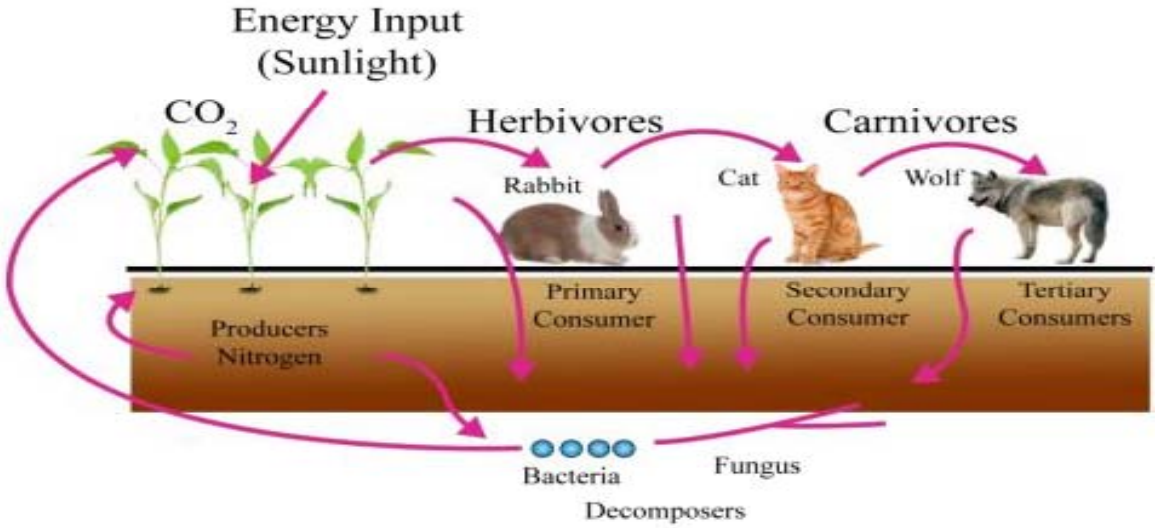


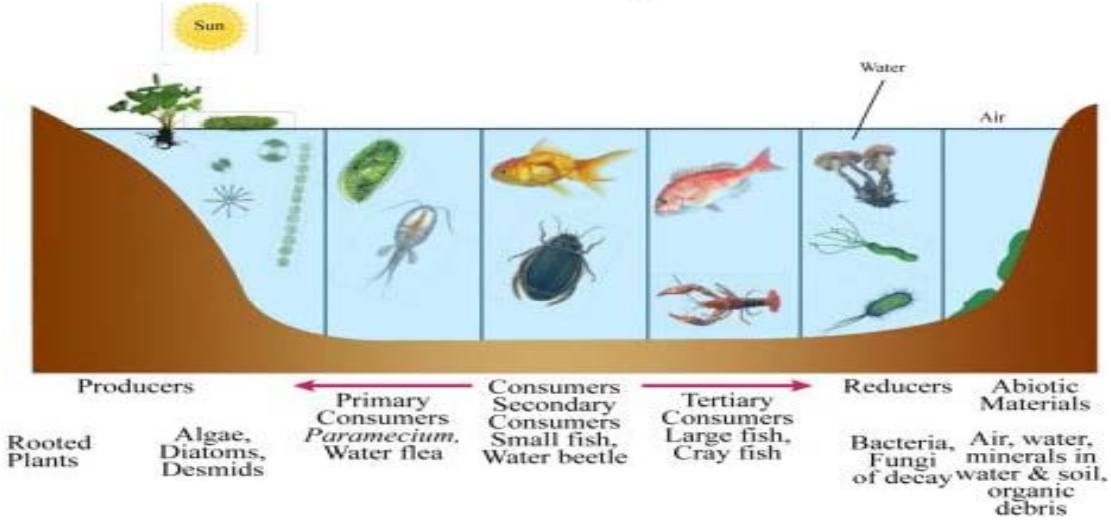
# Basic Characteristics of Ecosystems

**Ecosystem Structure:**

Made up of two major parts

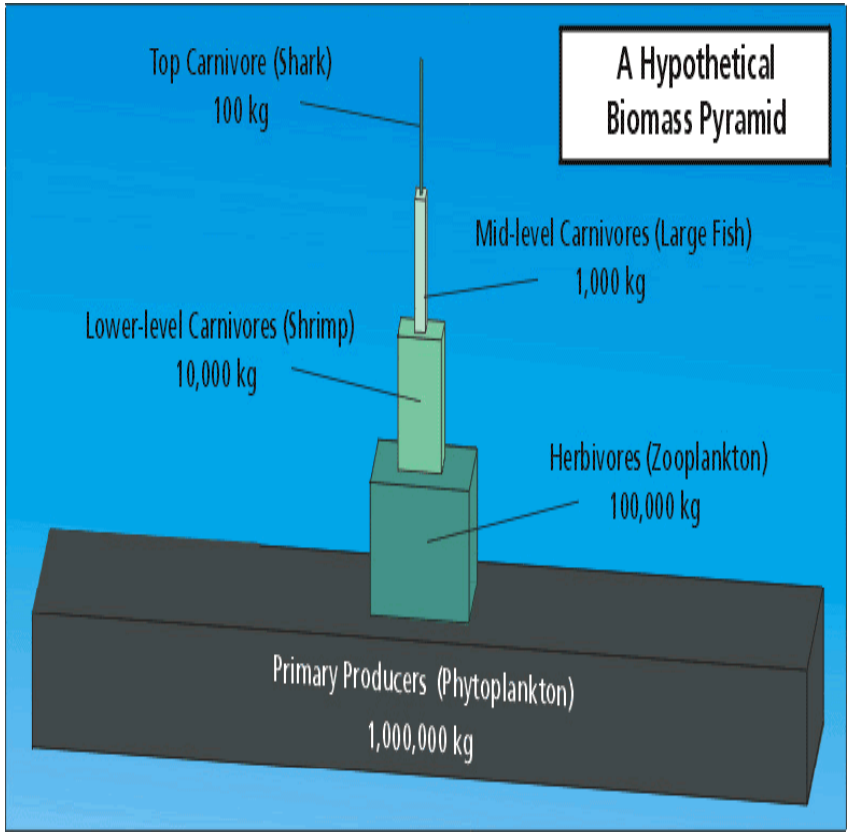
- Biotic Structure:
- *Living (ecological community)*
  - Producers
    - Photoautotrophs
    - Chemoautotrophs
  - Consumers
  - Decomposers
- Abiotic Structure:
- *Non living (physical & chemical environment)*
  - Inorganic substances
  - Organic compounds
  - Climatic factors

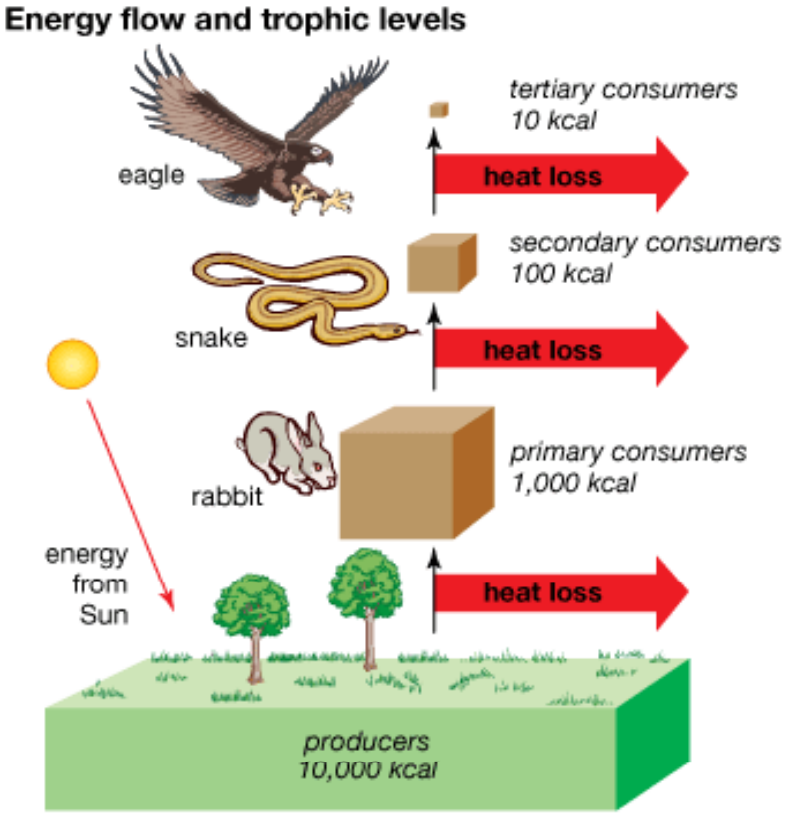


# Basic Characteristics of Ecosystems

- **Ecosystem Processes:**
  - Cycling of chemical elements (Mass Flow )
  - Flow of energy (Energy Flow)



# Basic Characteristics of Ecosystems

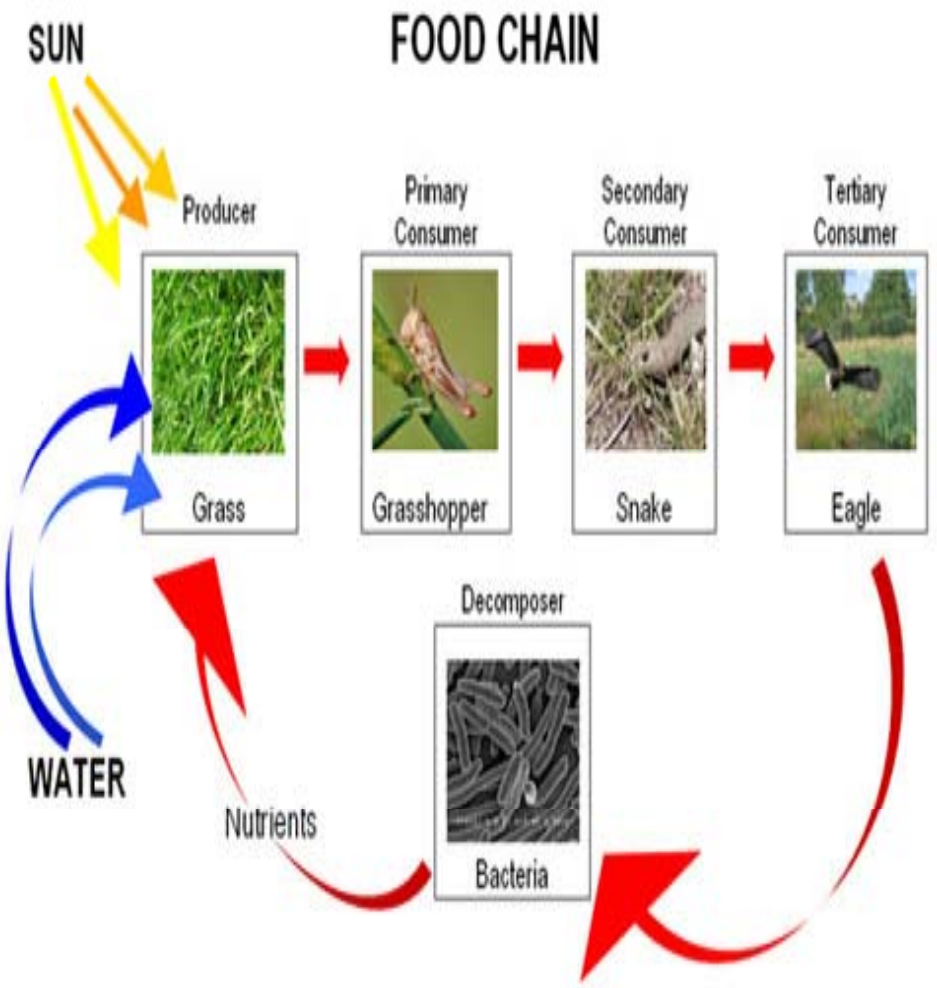
- At its simplest an ecosystem community will have:
  - At least one species that is a producer
  - Another species that is a decomposer
  - Plus a fluid medium
- Ecosystem: For complete recycling of chemical elements, several species must interact i.e.
  - Photosynthetic organisms must produce sugar from carbon dioxide and water and then,
  - From sugar and inorganic compound they make other organic compounds (protein, woody tissue)
  - Decomposers must then act to get back the produced into its respective inorganic compounds

# Functional Attributes of Ecosystems

- Every ecosystem performs under natural conditions in a systematic way.
- It receives energy from the sun and passes it on through various biotic components and in fact, all life depends upon this flow of energy.
- Besides energy, various nutrients and water are also required for life processes which are exchanged by the biotic components within themselves and with their abiotic components within or outside the ecosystem.
- The biotic components also regulate themselves in a very systematic manner and show mechanisms to encounter some degree of environmental stress.
- The major functional attributes of an ecosystems are as follows:
  - (i) Food chain, food webs and trophic structure
  - (ii) Energy flow
  - (iii) Cycling of nutrients (Biogeochemical cycles)
  - (iv) Primary and Secondary production
  - (v) Ecosystem development and regulation

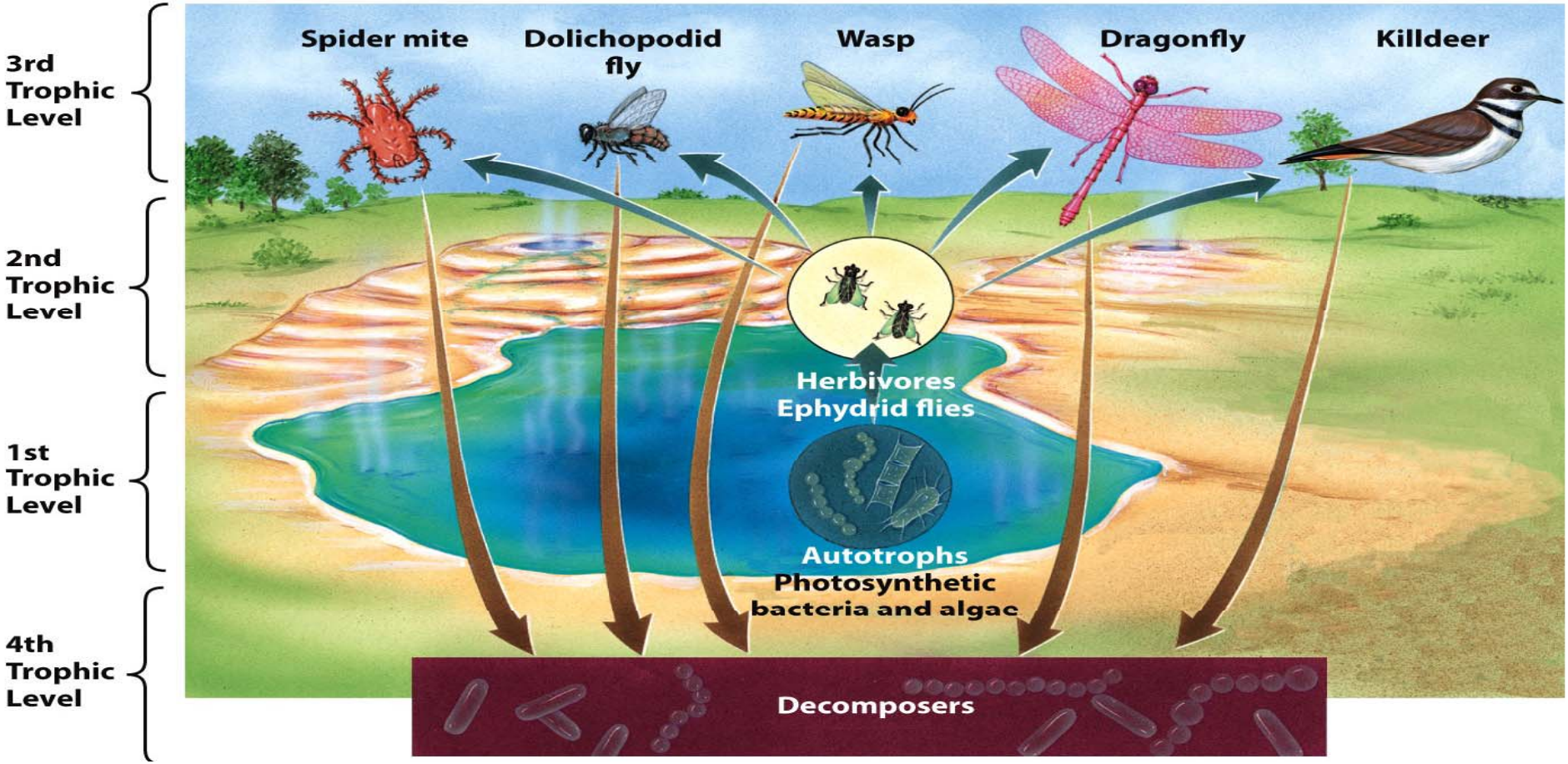
# Food Chain

- **Food chain**
  - Linkage of who feeds on whom
  - The sequence of eating and being eaten in an ecosystem is known as food chain
  - Energy, chemicals and some compounds are transferred from creature to creature along food chains or food webs (more complex)
  - Grouped by trophic level



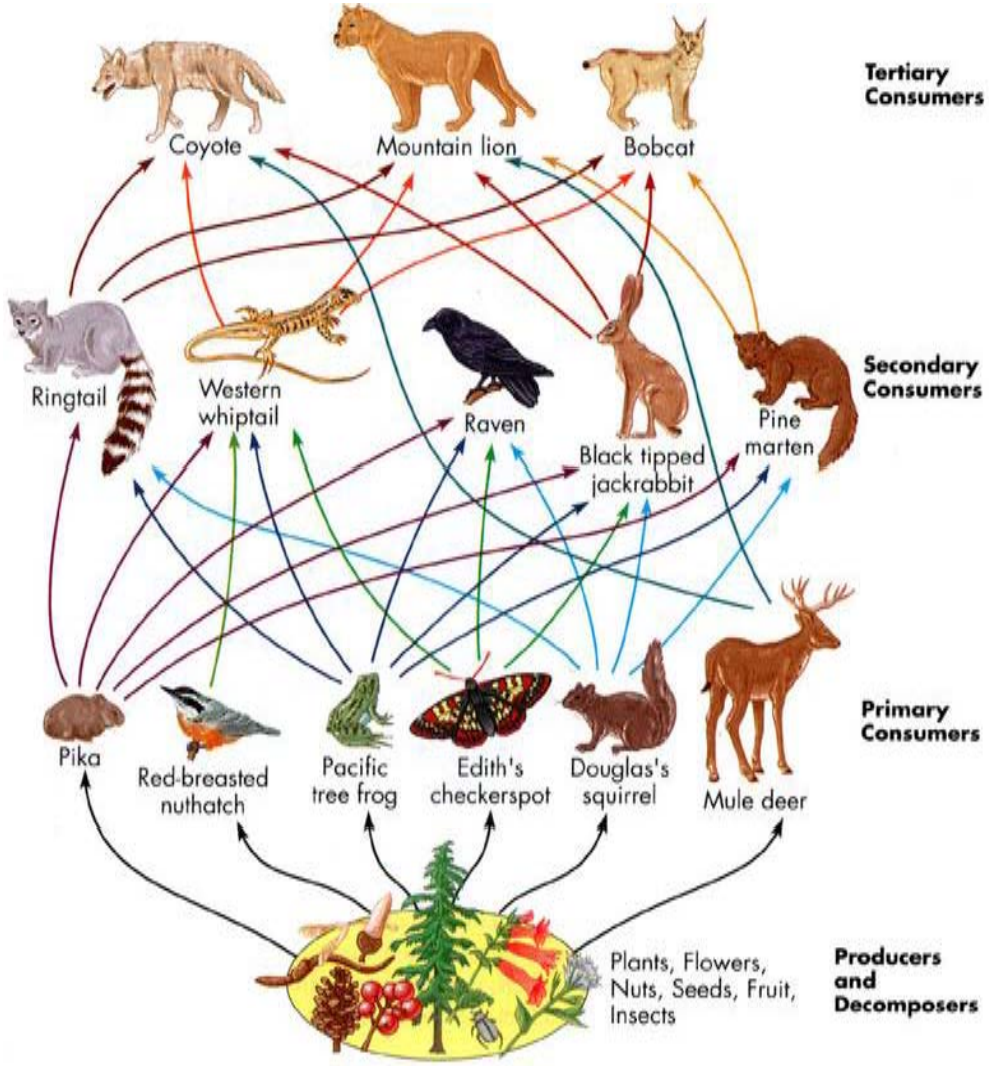
# Food Chain

(a) First trophic level: Use energy from the sun and carbon dioxide from the air to photosynthesizes called autotrophs (b) Second trophic level: Organisms that feed on autotrophs called herbivores (c) Third trophic level: Feed directly on herbivores called carnivores (meat eaters) (d) Forth trophic level: Carnivores that feed on third-level carnivores (e) Decomposers-feed on waste and dead organisms of all trophic levels



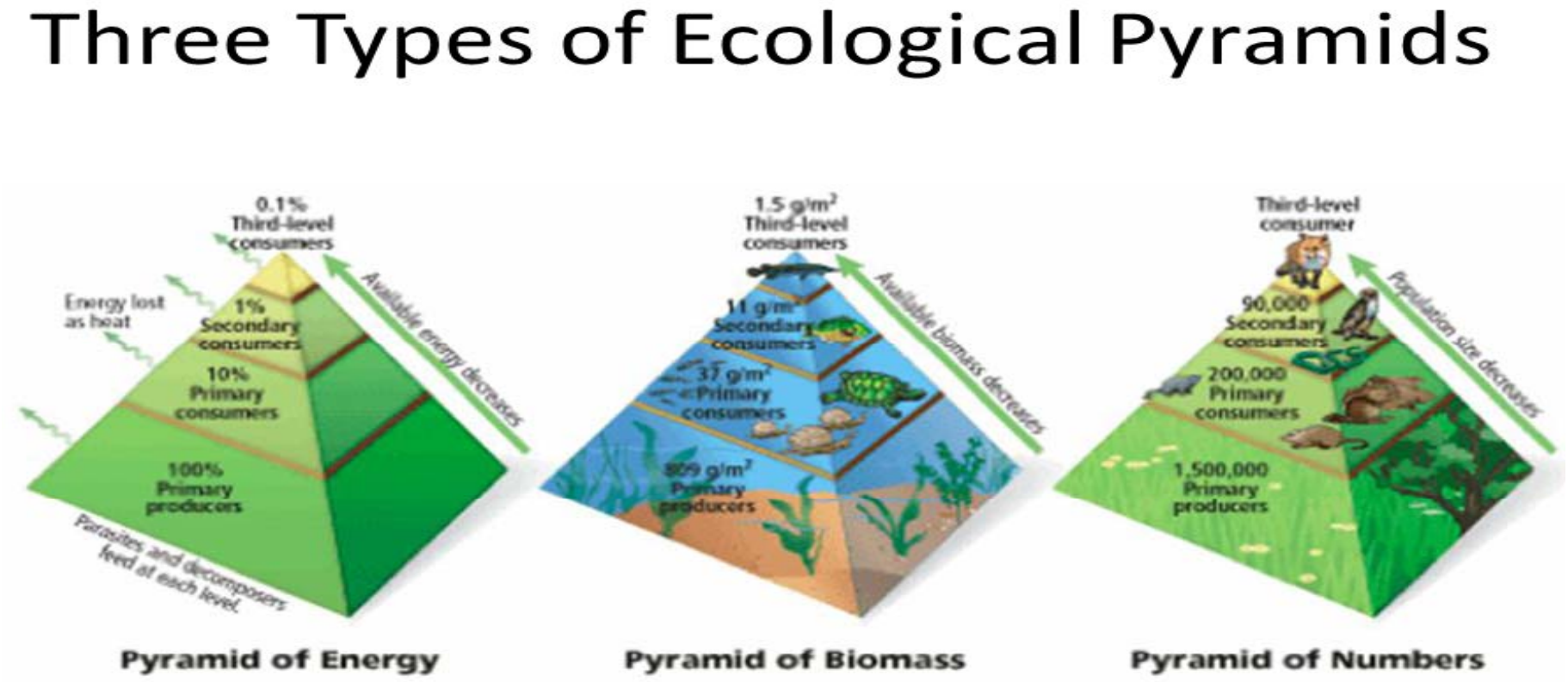
# Food Webs

- The different food chains are inter connected at various trophic level to develop a food web.
- Food web are never straight.
- Food web is formed due to interlinking of food chains.
- A food web in the ecosystem brings alternate source of food.
- The complex food web gives better stability to the ecosystem.



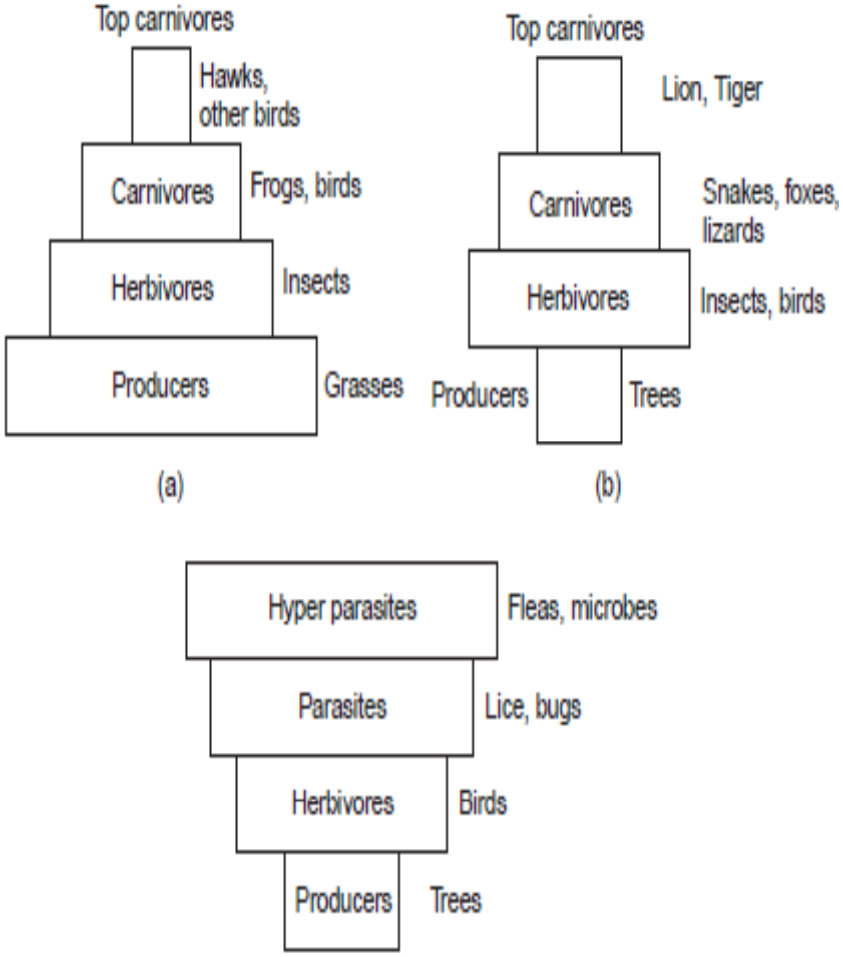
# Ecological Pyramids

- Graphic representation of trophic structure and function of an ecosystem, starting with producers at the base and successive trophic levels forming the apex is known as an ecological pyramid.



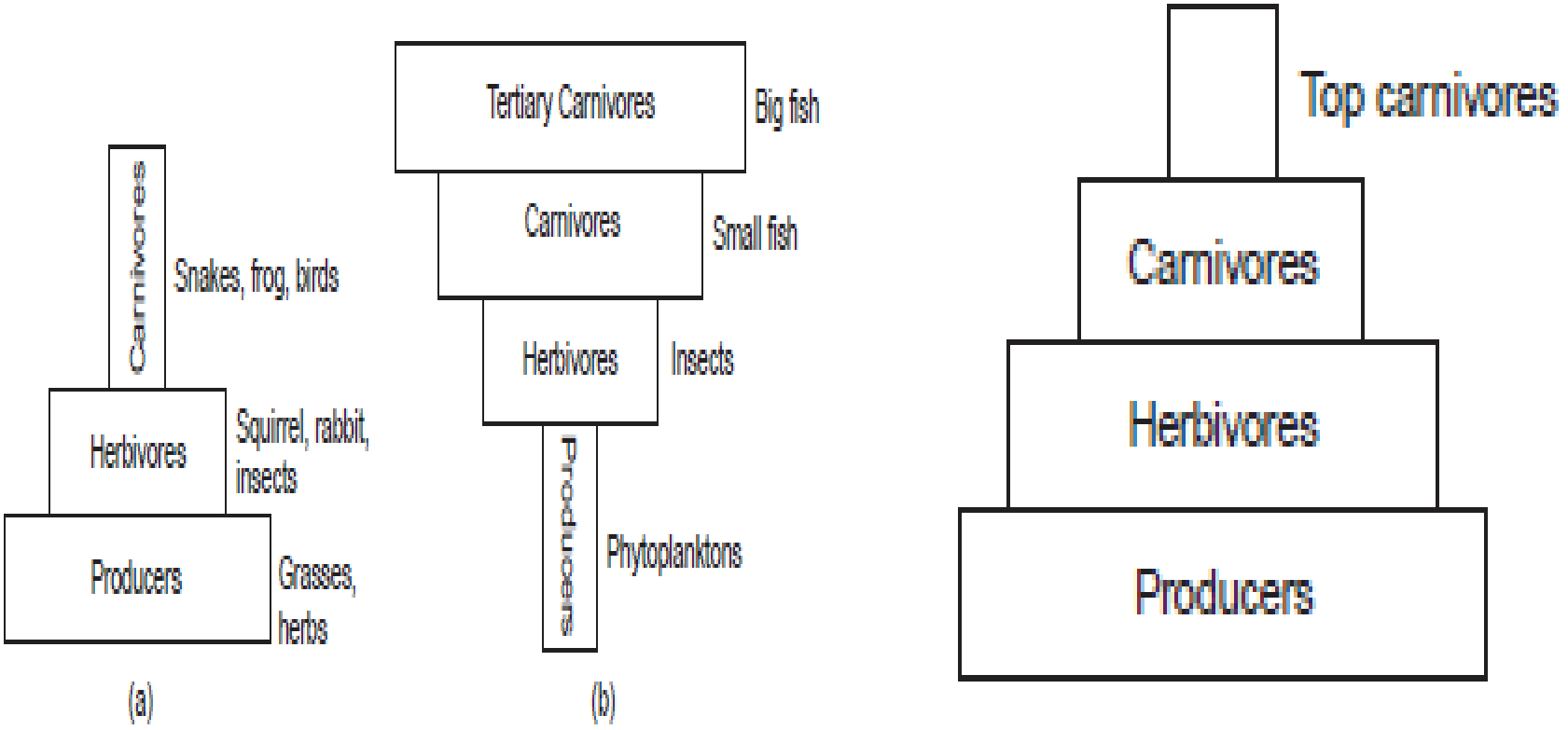
# Ecological Pyramids

- Pyramid of Numbers: It represents the number of individual organisms at each trophic level. May be upright or inverted.
- Pyramid of Biomass: It is based upon the total biomass (dry matter) at each trophic level in a food chain. The pyramid of biomass can also be upright or inverted.
- Pyramid of Energy: The amount of energy present at each trophic level is considered for this type of pyramid. Pyramid of energy gives the best representation of the trophic relationships and it is always upright.




Pyramid of Numbers

# Ecological Pyramids




- Pyramid of Biomass (a) & (b); Pyramid of Energy (c)

# Ecosystem as System

- An ecosystem is the minimal entity that has the properties required to sustain life
- Vary greatly in:
  - Structural complexity and clarity of their boundaries
  - Size
  - Composition
  - Proportion of non-biological constituents
  - Degree of variation in time and space

# Ecosystem Energy Flow

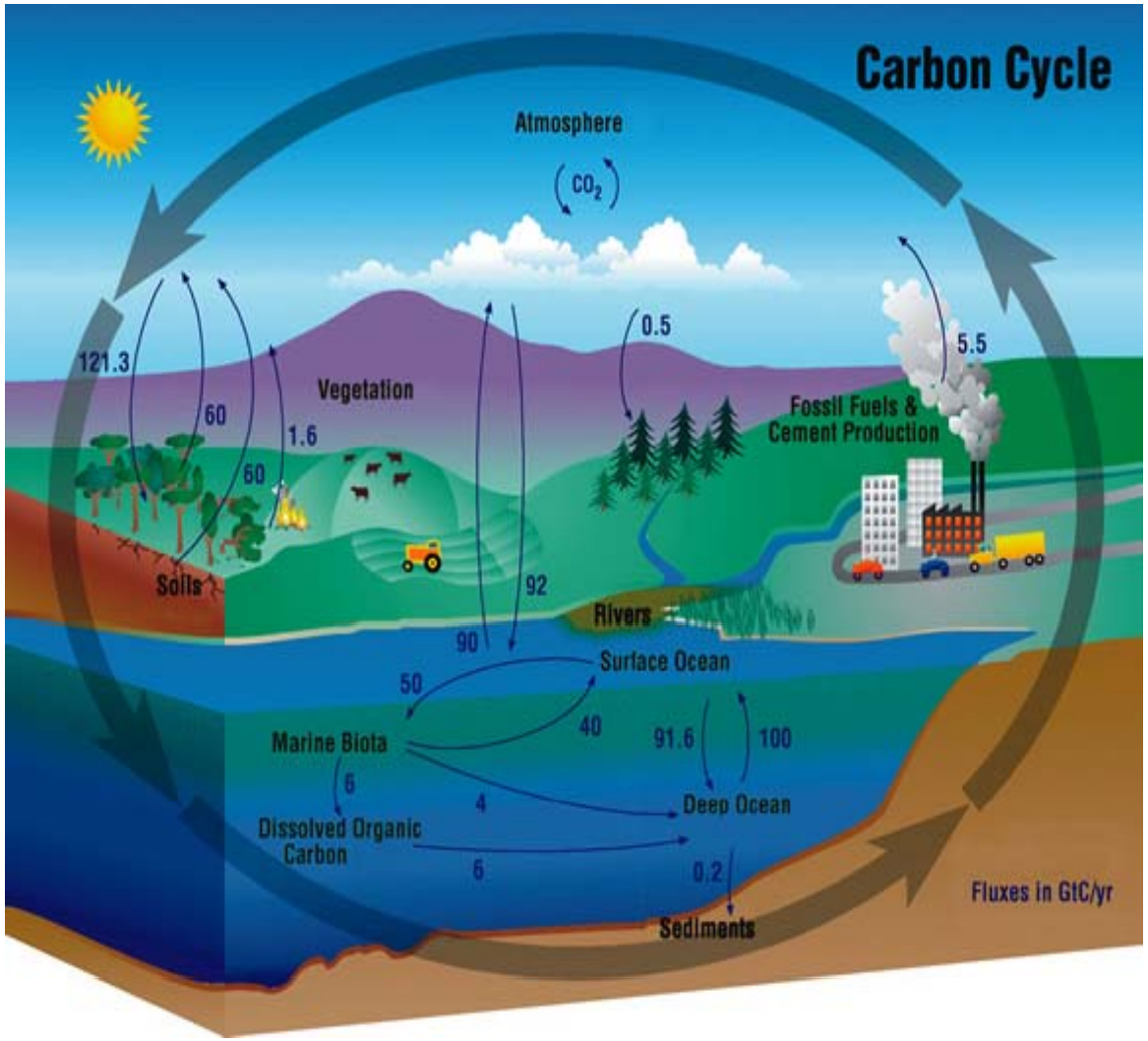
- All life requires energy for the ability to do work
- Energy enters an ecosystem by two pathways:
  - Energy fixed by organisms
  - Transfer of heat energy by air, water, soil and living things
- Ecosystem energy flow
  - Movement of energy through an ecosystem from the external environment through a series of organisms and back to the external environment.

- **<u>Energy Efficiency and Transfer Efficiency</u>**
- *Trophic-level efficiency*
  - Ratio of production of one trophic level to the production of the next trophic level
    - 1–3% in natural ecosystems
    - 10% may be maximum
  - 90% of all energy lost as heat

# Natural Cycles: Bio-geo-chemical cycles

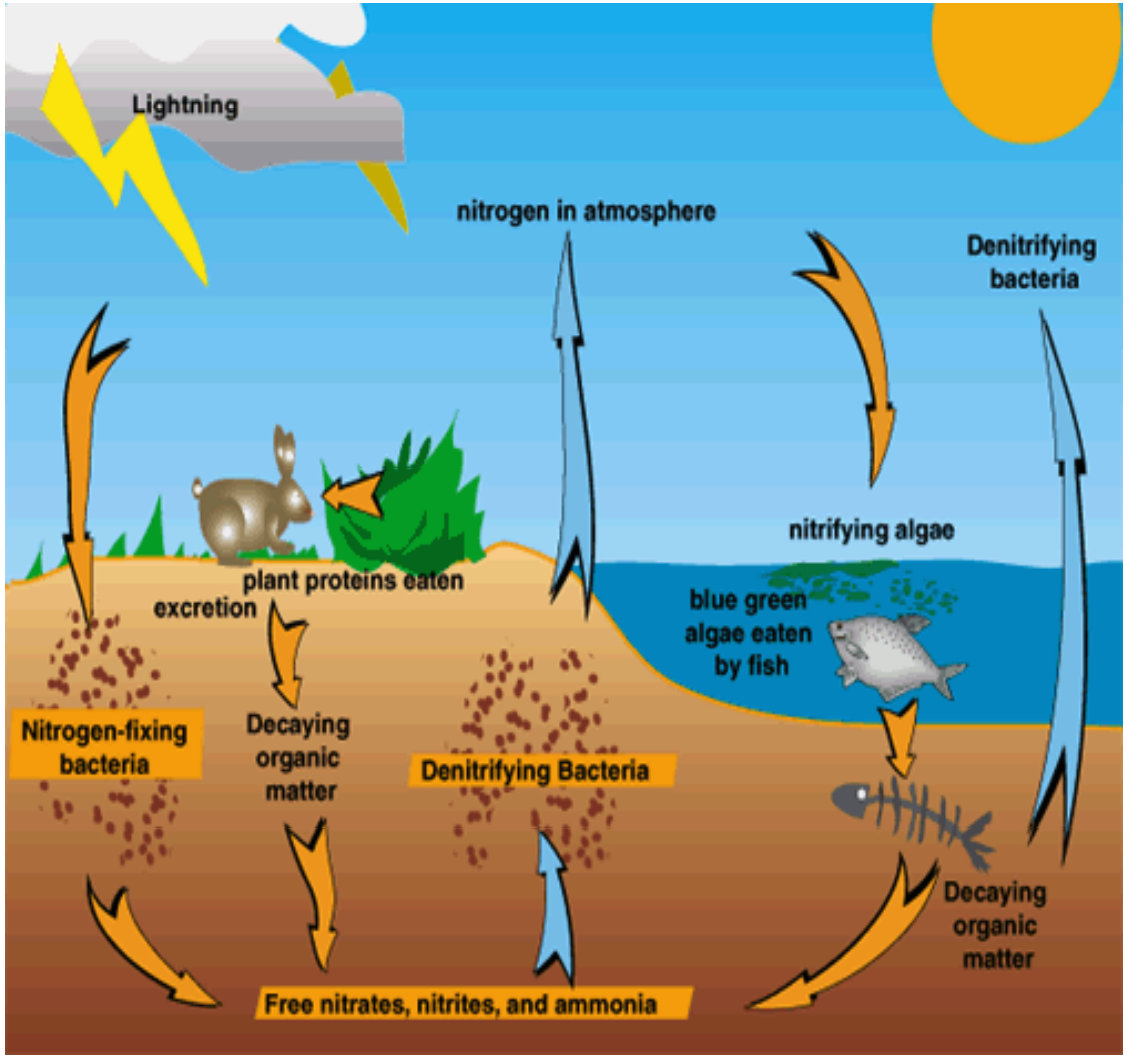
- Carbon cycle
- Nitrogen cycle
- Phosphorous cycle

# Carbon Cycle



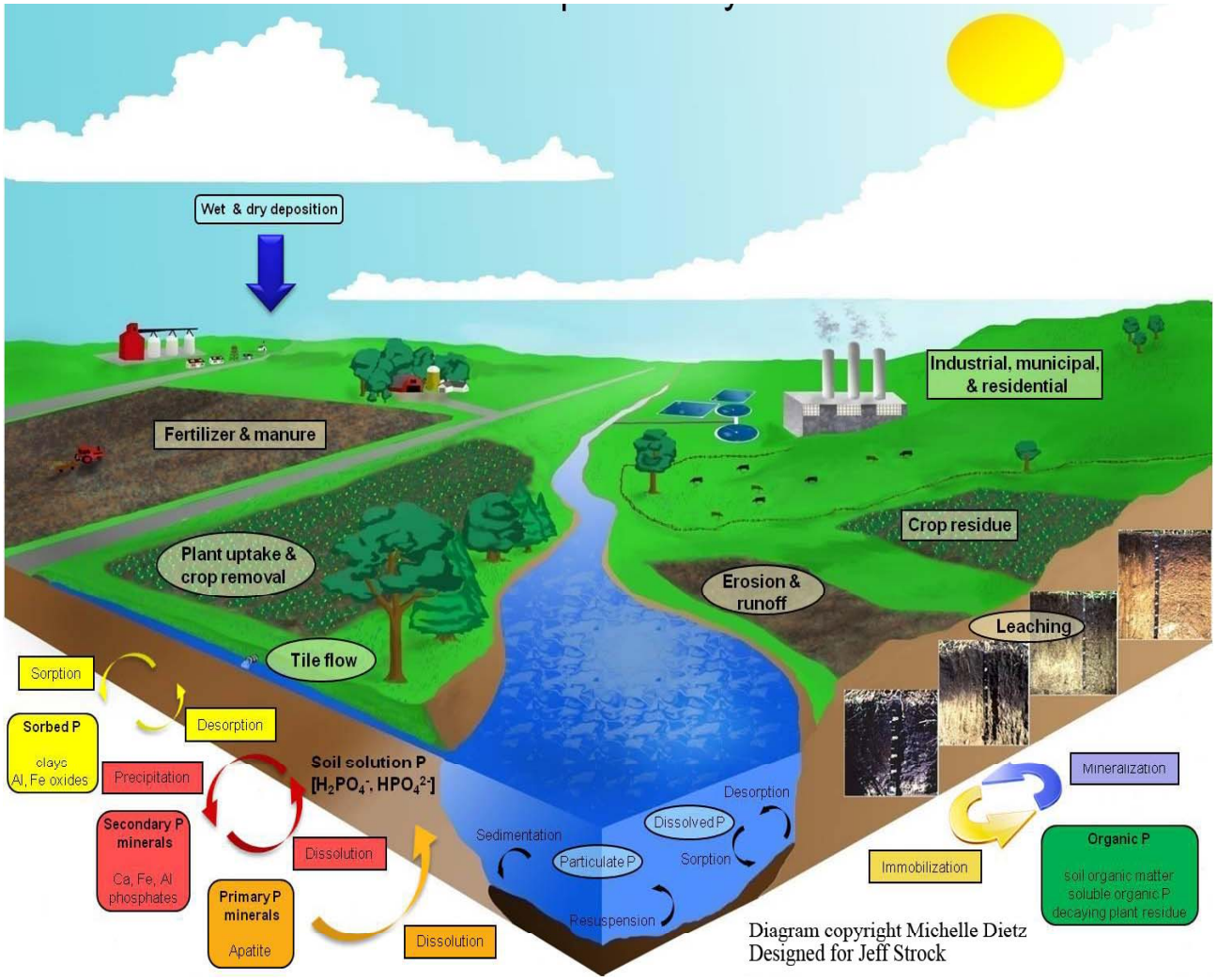

- Carbon has a gaseous phrase
  - Enters atmosphere ($CO_2$ and $CH_4$) through respiration, fires and diffusion
  - Removed from the atmosphere by photosynthesis
- Carbon occurs in the ocean in several forms
  - Dissolved $CO_2$, carbonate and bicarbonate, marine organisms and their products, $CaCO_3$
- Enters the ocean by
  - Simple diffusion then dissolves, transfer from land in rivers as dissolved carbon, wind
- Carbon enters the biota through photosynthesis and then returned by respiration or fire

# Nitrogen Cycle




- Free $N_2$ makes up 78% of atmosphere
  - But most organisms can't use it directly
  - Relatively unreactive element must be converted to $NO_3^-$ or $NH_4^+$
  - Performed by bacteria
- Nitrogen fixation - process of converting atmospheric N to $NO_3^-$ or $NH_4^+$
- Denitrification - process of releasing fixed N back to molecular N
- N combines with O at high temperatures
  - Oxides of N a source of air pollution

# Phosphorous Cycle




- P one of the "big six" required for life
  - Often a limiting factor for plant and algal growth
- Does not have a gaseous phase
  - Rate of transfer slow
- Enters biota through uptake as phosphate by plants, algae and some bacteria
  - Returns to soil when plants die or is lost to oceans via runoff
  - Returned to land via ocean feeding birds (guano)
- Guano deposits major source of P for fertilizers

# Biodiversity

- On dividing the whole earth's mass into 10 billion parts, it is only in one part where life exists and the astounding variety of living organisms numbering somewhere around 50 million species are all restricted to just about a kilometer- thick layer of soil, water and air.
- Biodiversity refers to the variety and variability among all groups of living organisms and the ecosystem complexes in which they occur. From the driest deserts to the dense tropical rainforests and from the high snow-clad mountain peaks to the deepest of ocean trenches, life occurs in a marvellous spectrum of forms, size, colour and shape, each with unique ecological inter-relationships.
- In the Convention of Biological Diversity (1992) biodiversity has been defined as the variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part.

**Levels of Biodiversity**

- Units of biodiversity may range from the genetic level within a species to the biota in a specific region and may extend up to the great diversity found in different biomes.
  - Genetic diversity
  - Species diversity
  - Ecosystem diversity

# India: a Mega-diversity Nation

- India is one of the 18 mega-diversity countries in the world in terms of both the hotspots and the relative biodiversity with respect to the endemic flora and fauna varieties.
- The Ministry of Environment and Forests, Govt. of India (2000) records 47,000 species of plants and 81,000 species of animals which is about 7% and 6.5% respectively of global flora and fauna.
- A large proportion of the Indian Biodiversity is still unexplored.
- There are about 93 major wetlands, coral reefs and mangroves which need to be studied in detail. Indian forests cover 64.01 million hectares having a rich biodiversity of plants in the Trans-Himalayan, north-west, west, central and eastern Himalayan forests, western ghats, coasts, deserts, Gangetic plains, deccan plateau and the Andaman, Nicobar and Lakshadweep islands.
- Due to very diverse climatic conditions there is a complete rainbow spectrum of biodiversity in our country.

# What Threatens Biodiversity?

- Extinction or elimination of a species is a natural process of evolution.
- However, the rate of loss of species in geologic past has been a slow process, keeping in view the vast span of time going back to 444 million years. The process of extinction has become particularly fast in the recent years of human civilization.
- Therefore the species are becoming endangered and finally extinct from the biosphere which is the serious threat to the biodiversity with major impacts on the ecological balance. The major causes of this phenomenon are:
  - Extinction: a natural process
  - HIPPO: Habitat destruction, Invasive species, Pollution, Population (of humans), and Overharvesting
    - Loss of Habitats
    - Poaching
    - Man-wildlife conflicts

# Man and Environment

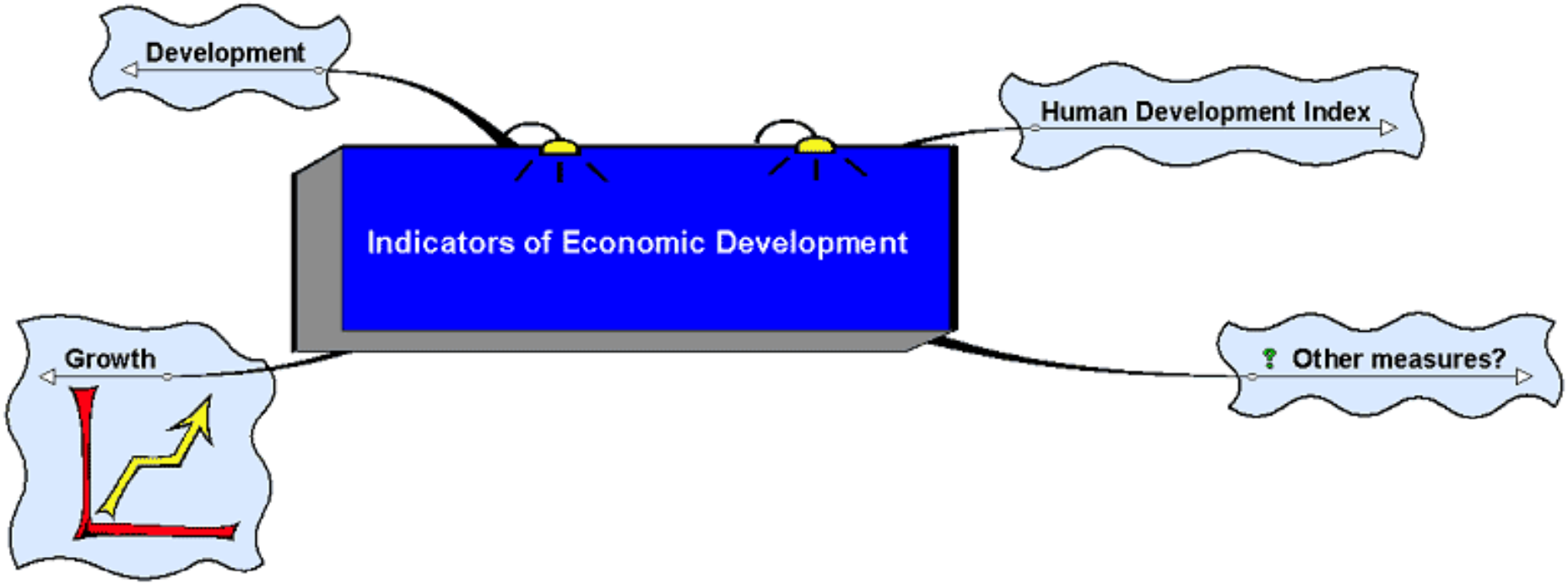
- The environment need to be protected and preserved with special emphasis on wildlife and plants.
- However, humans intervention especially in form of poaching and habitat destruction has lead to severe damage to the ecological biodiversity.
- *Therefore, minimal human intervention (with respect to pollution of ecosystems) is beneficial both form the ecosystem as well as environment. Trade-off must be done between development and ecosystem/environmental conservation*
- *Sustainable development: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs calls for a sense of responsibility with respect to our actions*

# Economic Growth *vs* Environmental Protection


- Industries are the backbone of any country's economic growth and economic development
- There is generally a positive relationship between rates of economic growth and environment degradation
- Environmental issues, with strong priority on growth with negative impacts on the environment, associated with developing countries include: Deforestation, Water quality deterioration, Diminished air quality and Loss of biodiversity
- Is there any difference between the concept of economic growth and economic development?
- Economic growth may be one aspect of economic development but is not the same
- *Economic growth*: A measure of the value of output of goods and services within a time period
- *Economic development*: A measure of the welfare of humans in a society

# Economic Growth
# *vs*
# Environmental Protection


*Indicators of economic development*



# Economic Growth *vs* Environmental Protection


## *Measures of indicators of economic development*

| Growth | Development | Human development | Other measures |
|---|---|---|---|
| Gross domestic product (GDP) | Poverty | Longevity - life expectancy | ? |
| Gross national product (GNP) | Progress | Knowledge - literacy rate | |
| Per capita income | Infrastructure | Standard of living (GDP per capita) | |
| | Inequality | | |
| | Freedom | | |

- *Gross domestic product (GDP)*: Gross domestic product is the market value of all officially recognized final goods and services produced within a country in a year, or over a given period of time
- *Gross national product (GNP)*: Gross national product is the market value of all the products and services produced in one year by labor and property supplied by the citizens of a country irrespective of their location
- Per capita income is the mean income of the people in an economic unit such as a country
- Should there be any other measures such as gross environmental product (GEP)?

# Economic Growth *vs* Environmental Protection


*I am going to read you two statements about the environment and economy. Please tell me which of these statements you agree most with:*

| | Protection of the environment should be given priority, even at the risk of curbing economic growth | Economic growth should be given priority, even if the environment suffers to some extent | Neither | Don't know/Refused |
|---|---|---|---|---|
| Indian adults | 45% | 35% | 6% | 14% |

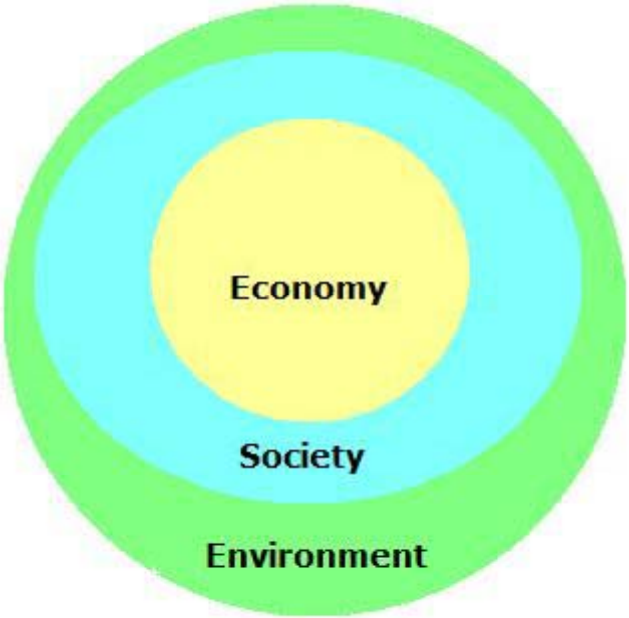
# Sustainable Development

- *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland Report, United Nations World Commission on Environment and Development , 1987)
- Environmental, economic and social well-being for today and tomorrow!
- Environmental protection and waste management (rather waste recycling) are must to achieve sustainable development

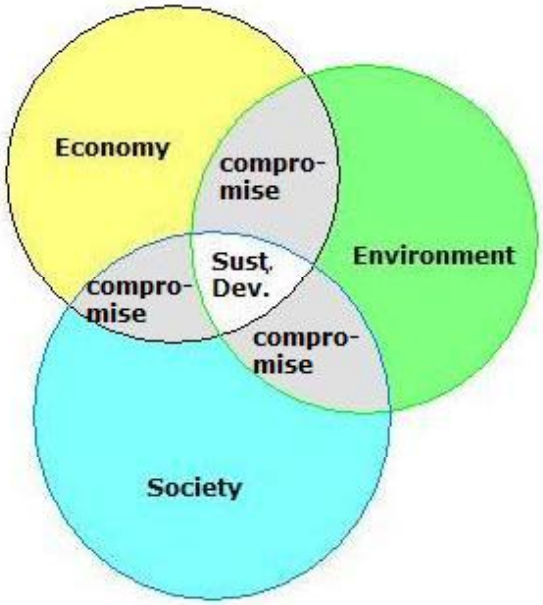
# Links between UN MDG and Environment

| UN MDG Goal(s) | Links to environment |
|---|---|
| Eradicate extreme poverty and hunger | Livelihood strategies and food security depend on healthy environment |
| Achieve universal primary education | Time spent colleting fuel and water by children |
| Reduce child mortality | Water-borne diseases kill 3 million people in developing countries |
| Improve maternal health | Indoor air pollution |
| Combat major diseases | 1/5$^{th}$ of the total burden of disease in developing countries may be associated with environmental risk factors |
| Ensure environmental sustainability | Environmental degradation must be reversed |

# Sustainability!




Strong Sustainability




Weak Sustainability

# Sustainability!


- Adopted by the UNGA on 25th September, 2015 at UN HQ in New York