INTERNATIONAL ENVIRONMENTAL MOVEMENT

Environmental impacts of developmental activities are being sounded since the early 1960s. One of the first and most influential warnings was *Silent Spring,* a book about the use of pesticides, written by Rachel Carson and published in 1962. In the mid-1960s some scientists were sounding warnings about the possibility of climate change due to increased carbon dioxide levels in the atmosphere resulting from burning of fossil fuels. The same period witnessed early environmental conferences like the two British "Countryside in 1970" conferences of 1963 and 1965, and the U.S. White House conference on “Natural Beauty” of 1965.

In the United States of America (USA), this climate of thought and innovative legislators produced a law that represented a landmark in environmental management not only in the United States but worldwide – the National Environmental Policy Act (NEPA), 1969. Revise The NEPA required "in agency planning and decision making an integrated interdisciplinary use of the natural and social services and the environmental design arts". It also required agencies to take account of non-quantified values, and to use ecological information and concepts in planning and decision-making affecting the quality of the environment.

"Spaceship Earth" arrived in the 1970s with concern growing, some warnings, and a piece of new style landmark legislation to be added to the many pieces of air and water pollution control law that existed already around the globe. The 1970s was an era of response and action. The most influential responses were the United Nations Conferences on the Environment (1972), Population (1974) and Human Settlements (1976).

The UN Conference was held in June 1972 in Stockholm, Sweden. As a result, the United Nations Environment programme

(UNEP) was set up together with a fund to finance major projects. A 26-point declaration of environmental principles was adopted, calling for commitments by countries to deal with environmental problems of international significance. Approval was given to the Earth-Watch Program – a co-ordinated plan to use and expand existing monitoring systems to measure pollution levels around the world and their effects on climate. A convention to control ocean dumping of shore-generated wastes was endorsed. The International Whaling Commission was urged to adopt a ten-year moratorium on commercial whaling. Other proposals for conservation conventions were endorsed (e.g., the World Heritage Trust to protect areas of unique natural, historical or cultural value that are part of the heritage of all humankind, and a convention to protect endangered species of plants and animals, etc.).

Three months prior to the U N Conference a report on phase one of the Club of Rome's projects on the *Predicament of Mankind* was published. *The Limits to Growth* described the work on a global model of the five factors that determine and limit growth – population, agricultural production natural resources, industrial production and pollution. The Club of Rome first came together in 1968 out of the concern of thirty individuals from ten countries to discuss the present and future predicament of humanity and to foster understanding of the interdependent components that make up the global system.

Another conference, less visible than that of the United Nations, but like Limits to Growth, something as pointer to future, occurred also in 1972. This was the Second World Conference on National Parks and Protected Areas, held under the aegis of the World Conservation Union (IUCN). IUCN was established in 1948, and its work and influence would become of increasing importance, as biodiversity and the still accelerating forces of population growth, technology and pollution reduced the gene stocks of wild nature.

(In 1972 world population was 3.7 billion.) At this time the now well-known conflicts and concerns about the loss of tropical forests were yet to come. At this time also, conservation and development were seen as opposing, rather than complementary objectives as inferred by UNCED.

In parallel with, and following the Stockholm Conference, there was a surge of policy-making and institution building in the developed world. In the decade of the 1970s, many governments introduced environmental legislation, established agencies with environmental responsibilities, or grafted these onto existing departments. Others moved more cautiously, with "pilot" policies that could be elaborated after experience had been gained. Environmental impact assessment (EIA), the discipline that could steer decision-making towards allowance for environmental factors was introduced in some countries. Often regarded with suspicion as an unnecessary impediment to legitimate developmental objectives and progress, EIA took a decade to be acknowledged as a tool that could actually produce projects superior in both quality and value.

In 1971, the World Bank established an environmental section to promote environmental reconnaissance of hydro-projects in recognition of one of the fundamentals of environmental management. The principle is that; knowledge of the environmental context of development proposals should be a base within which planning proceeds with constant reference to potential impacts. The major negative impacts of some hydro-projects had already included spread of water-borne disease. Loss of biodiversity due to destruction of habitat and wildlife, water quality effects on reservoirs and downstream locations, induced seismicity and decline of productive ecosystems. One of the objectives of the World Bank initiative was *capacity building.* Bank agents may have carried out the initial reconnaissance but borrowers were aided and encouraged towards developing competence and setting up of in-house environmental units.

Development economic growth, technological expansion and exponential population increase continued and problems of global scale surfaced. By 1980, the handling and disposal of hazardous wastes was recognised as a national and global issue. Through the 1970s and 1980s, the growth of chemical manufacturing in developing countries exceeded that of the developed world. Samples showed that developing world populations ranked high in exposure to toxic chemicals, blood lead levels and DDT contamination of human milk. Effective national regulation and control programmes existed in developed countries, but not elsewhere. The discovery of grossly contaminated sites (a danger to water supplies, food chains, and human health generally) in the developed world could only raise questions, but not answers, about the developing world where disposal is haphazard, and neither disposal facilities nor national control frameworks exist.

In l970, most air pollution legislation treated air pollution as a local phenomenon. By 1980, it had become global and was affecting the forests and lakes of Europe and North America. The major cause was the burning of fossil fuels. Global emissions of sulphur dioxides grew by an estimated 470% and emissions of carbon dioxide tenfold, in the 20th century. Nitrous oxide emissions in the USA have increased nine times over the same period. Given suitable atmospheric conditions, sulphur dioxides and nitrous oxides can be transported long distances and transformed into acids. It was realised that acid rain affected not only lakes and streams but also crops and vegetation.

At ground level, ozone is also damaging to crops and vegetation. But in the upper atmosphere ozone acts as a filter by absorbing harmful wavelengths of ultra-violet radiation. In 1985, it was confirmed that the ozone shield over the Antarctic was thinning, and a "hole" had developed, and an unprecedented, international action followed for a world action plan. Its main components were global monitoring, estimating the impact of changes in the ozone layer on radiation, skin cancer, ecosystems and regional climate, and collecting data on production and emissions. While the world action plan was developing, an international convention was being hammered out. The Montreal Protocol, providing a framework for action by each country, was agreed in 1987. Officials from most of the CFC producing/using countries agreed to a 50% reduction by 1999. But, new scientific evidence indicated that the situation was more serious than had been thought. The Helsinki Declaration of 1989 stated the intention of 80 countries to completely phase out CFCs by the year 2000.

Another, and greater, global concern was also growing as the ozone saga unfolded. The concerns about increasing CO_2 levels, expressed by a few scientists in 1960s were confirmed in the 1980s by a large proportion of the scientific community. Data showed increasing concentrations, not only of CO_2 but also nitrous oxide (NO_2), methane (CH_4) and specific chlorofluorocarbons. Their addition to the atmosphere permits it to absorb more of the infrared radiation emitted from the earth.

The understanding and application of the concept that environment and development are integrated, complementary and indivisible, and are to be thought of as one, is fundamental to environmental management. This new message was given in 1980 in the World Conservation Strategy, published by the World Conservation Union (IUCN), the United Nations Environment Programme (UNEP) and the World Wide Fund for nature (WWF). Its successor document, *Caring for the Earth,* was published in 1991. This strategy, so clearly complement to *Our Common*

Future sets out the rationale and the strategic actions needed to achieve a sustainable future.

The original World Conservation Strategy of 1980 introduced an important innovation in environmental management – the national level conservation strategy, subsequently prepared by over 50 countries. These identify the country's most urgent environmental needs, assist decision-makers in determining priorities, allocate resources and build institutional capacity to handle complex environmental issues. Preparation includes fundamental re-examination of laws, policies and institution. Similar to these national conservation strategies were national environmental action plans sponsored by the World Bank.

In the early 1980s, the then Minister of the Environment of the Government of Norway, Dr. Gro Harlem Brundtland worried by the growing incompatibility between human development on Earth and the possibility for Nature to withstand the resulting ecological stress undertook to launch a global investigation of this incompatibility. With the assistance of a former Vice President of the Republic of Sudan, she managed to assemble a team of 26 concerned persons of high calibre into what was named the World Commission on Environment and Development (WCED). The WCED project was given the green light - but not a full endorsement - by the United Nations and succeeded in obtaining support in kind and cash from a good number of countries. There were some noticeable exceptions to the supporting countries, such as the USA, Japan, France, the United Kingdom andGermany.

Nevertheless, the WCED had sufficient means to commission a wide range of necessary surveys and studies by competent and well known scientists and professionals, access the statistics of many countries and all international organizations, and undertake a series of hearings in a sample of countries around the world. Its exploration of the issues ended sometime in 1986. With the help of some countries (e.g., Canada), the WCED undertook to prepare a summary of its findings, with a synthesis, conclusions and recommendations. The result was a paperback report, under the title *Our Common Future*, published in April 1987 by Oxford University Press, gradually translated into a large number of languages and distributed widely around the world. The report was officially presented to the general Assembly of the United Nations in November 1987, and enthusiastically approved by most, if not all members.

At the core of the recommendations made by the Commission was the goal of *sustainable development*, which was defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Our Common Future was a precursor, though not the only one, to United Nation's Conference on Environment and Development (UNCED) of June 1992 (popularly known as the Rio Earth summit). Both the report and the Conference link environment and development, bringing together within the concept of systems and interdependence, environment and development objectives once considered being in opposition. And, in 1992, *Agenda 21*, a global plan of action for sustainable development was adopted. In addition to adopting Agenda 21, the assembled leaders from over 100 countries signed the *Framework Convention on Climate Change* and the *Convention on Biological Diversity* and endorsed the *Rio Declaration* and the *Forest Principles*.

The Rio Declaration represents a set of 27 agreed principles aimed at the objective of a new and suitable global partnership, international agreements that respect the integrity of the global environmental and developmental system, and recognition of the integral and interdependent nature of Earth, our home.

The outcomes of the discussion of *Agenda* 21 occupy more than 450 pages. *Agenda* 21 is the operational plan for moving humankind into the age of sustainability. It should be read and given profound consideration by all people, especially all technologists. Its implementation will demand commitment and the capacity of all nations, people and individuals.

More than half the sections of *Agenda* 21 are of direct or indirect relevance to science and technology, e.g., those dealing with the protection of human health, human settlement, integration of environment and development in decision-making, protection of the atmosphere, integrated approaches to the planning and management of land resources, combating desertification and approaches to planning and management of land resources, combating desertification and drought, sustainable mountain development, conservation of biological diversity, environmentally sound management of biotechnology, toxic chemicals, hazardous wastes, solid wastes, radioactive wastes, the scientific and technological community, transfer of environmentally sound technology, education, national mechanisms, institutional arrangements and information.

The Commission on Sustainable Development (CSD) was created in December 1992 to ensure an effective follow-up of UNCED; to monitor and report on implementation of the Earth Summit agreements at the local, national, regional and international levels. The CSD is a functional commission of the UN Economic and Social Council (ECOSOC), with 53 members. It was agreed that a five-year review of Earth Summit progress would be made in 1997 by the United Nations General Assembly meeting in special session. Earth Summit + 5: The Special Session of the General

Assembly held in June 1997 adopted a comprehensive document entitled *Programme for the Further Implementation of Agenda 21* prepared by CSD. It also adopted the programme of work of the Commission for 1998 - 2002.

Rio + 10, the Earth Summit + 10, the Johannesburg Summit or formally, *The World Summit on Sustainable Development* took place in Johannesburg, South Africa, 2 - 11 September, 2002. Thousands participated at the Johannesburg Summit: heads of State and Government, national delegates and representatives from business and industry, children and youth, farmers, indigenous people, local authorities, non-governmental organisations, scientific and technological communities, women and workers and trade unions.

According to General Assembly resolution 55/199 of 20 December 2000, the review would focus on the identification of accomplishments and areas where further efforts are needed to implement Agenda 21 and other outcomes of the UNCED. At the national level, Governments are encouraged to prepare national assessments on the progress achieved and challenges encountered. At the regional level, the UN Department of Economic and Social Affairs (UNDESA) have sponsored round tables of eminent persons and UN regional commissions facilitated regional ministerial preparatory meetings. At the global level, the *UN Secretariat for the Summit* organised three substantive meetings in the first half of the year 2002 before convening the Summit in September.

Ecology and Environment

Ecology is derived from the Greek word *eco* that means 'house' and *logy* means 'study', this means '***the study of one's house'.*** It is the study of systems that include interactions among and between the organisms and also their interaction with non living **Environment**. It deals with the ways in which organisms are adapted to their surroundings, how they make use of these surroundings, and how an area is altered by the presence and activities of organisms. These interactions involve energy and matter. For the survival of the living things constant flow of energy and matter are essential; if not the organisms die.

Study of this complex interaction was important and was founded as an academic subject in 1866 by Ernst Hackle. In simple words it is surroundings that affect an organism during its lifetime.

Environment: It is surroundings that affect an organism during its lifetime.

Kinds of organism interactions

All organisms are dependent on others to use it for energy and raw material. For example grass is the raw material for mice, rabbits etc. A predator like lion's kills and eats zebras as their prey where it gets harmed. One organism may temporarily use another without harming it. For example, in oceans, many sharks have a smaller fish known as remora attached to them. Remoras hitch a ride on sharks and feed on the scraps of food lost by the sharks. This is benefit to the remoras where sharks do not get affected by their presence (commensal interaction). One organism may provide raw material for another for example animals distributes plant seeds; plants such as burdock have hooks to which seed is attached. These hooks get caught in the fur of mammals as they pass by the plant. These seeds fall at a considerable distance from parent and at right environmental conditions it grows in to a new plant. However it is useful to look at ecological relationships from a broader perspective. The two other interactions that focus on ecological relationships are community and ecosystem, which we shall discuss next.

Community and Ecosystem: A **community** is an assemblage of all the interacting **populations** of different **species** that live and interact within area at the same time.

> **Species** are group of organisms interbreed with the other to produce offspring

> **Population** is a group of organisms of same species that live in the same area at the same time

An **ecosystem** is a defined space in which interactions take place between a community, with all its complex interrelationships, and the physical environment. An ecosystem, thus, is the basic functional unit and includes both organisms and abiotic environment, each influencing the properties of the other and both necessary for maintenance of life on the earth. The cycling of materials between living and non-living factors is an ecological system or ecosystem

Interrelation between the human and environment is shown in the figure below as illustration of interrelation among ecological elements.

Figure 1.1 illustrates the interrelationship among ecological elements.

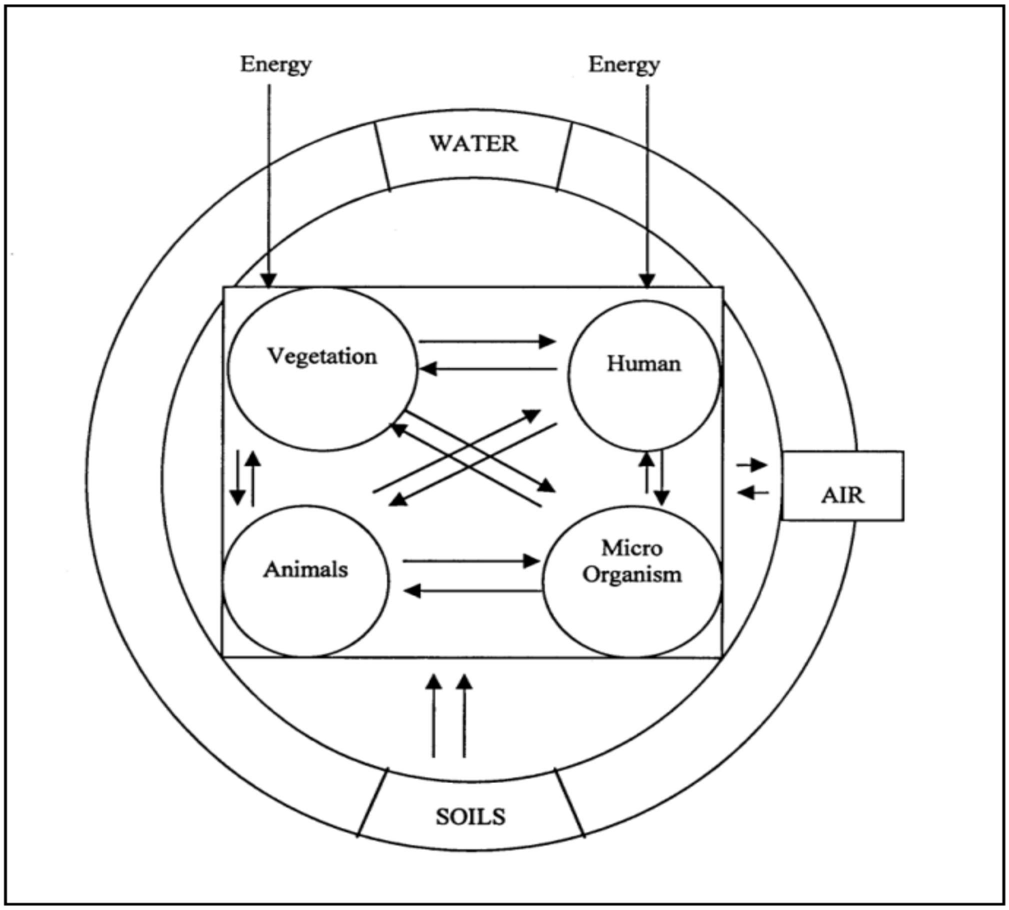


Figure 1.1 Interrelationships of Ecological Elements

Sustained life on earth, then, is a characteristic of ecosystems, not of individual organisms or populations. To understand important environmental issues, such as conserving endangered species, sustaining renewable resources, and minimizing the effects of toxic substances, we must understand certain features of ecosystem.

Ecosystem and its Characteristics

The biotic and abiotic elements, as shown in Figure 1.1, are interrelated and function in an orderly manner as a definite system. To fully develop the concept of ecosystem, we will look at characteristics of ecosystems from three points of view:

1. **Structure** of ecosystem that consists of nonliving and living parts. Nonliving parts include water, air and rocks. Living community called ecological community is set of interacting species within ecosystem.
2. Processes such as energy flows through it and chemical element cycle within it.
3. Process of succession that changes an ecosystem over a time and can undergo development.

Let's discuss in detail about these characteristics one after the other.

Structure of Ecosystem

From the structural point of view ecosystem comprises of biotic and abiotic components.

Biotic components: On the basis of their nutritional (trophic) status, organisms in an ecosystem are broadly divided into **autotrophs** and **heterotrophs**. Autotrophs are organisms that can produce their own food such as green plants (with chlorophyll) and certain bacteria, which obtain their energy from the sun and through photosynthesis, produce food. These are usually known as *producers (shown in the figure below)*, since these organisms produce food for all the other organisms. Heterotrophs, known as *consumers*, depend directly or indirectly upon the autotrophs for their food. They are grouped into:

- **Primary consumers:** These include herbivorous animals (e.g., rodents, cows, deer, goats, buffaloes, etc.), which depend on green plants for their food.
- **Secondary consumers:** These include carnivores and omnivores (e.g., sparrows, crows, foxes, wolves, dogs, etc.)

- **Tertiary consumers:** These are top carnivores (e.g., lions, tigers, hawks, vultures, etc.), which prey upon herbivores and omnivores.
- **Decomposers and transformers:** These are the living components of the ecosystem such as fungi and bacteria. They decompose the dead remains of the producers (i.e., autotrophs) and consumers (i.e., heterotrophs) and convert the complex organic substances into simple organic compounds. These are further broken down by bacteria and converted into inorganic forms, which are taken up by green plants (Mukherjee, 2002).

See role of organisms in an ecosystem in Annexure 3

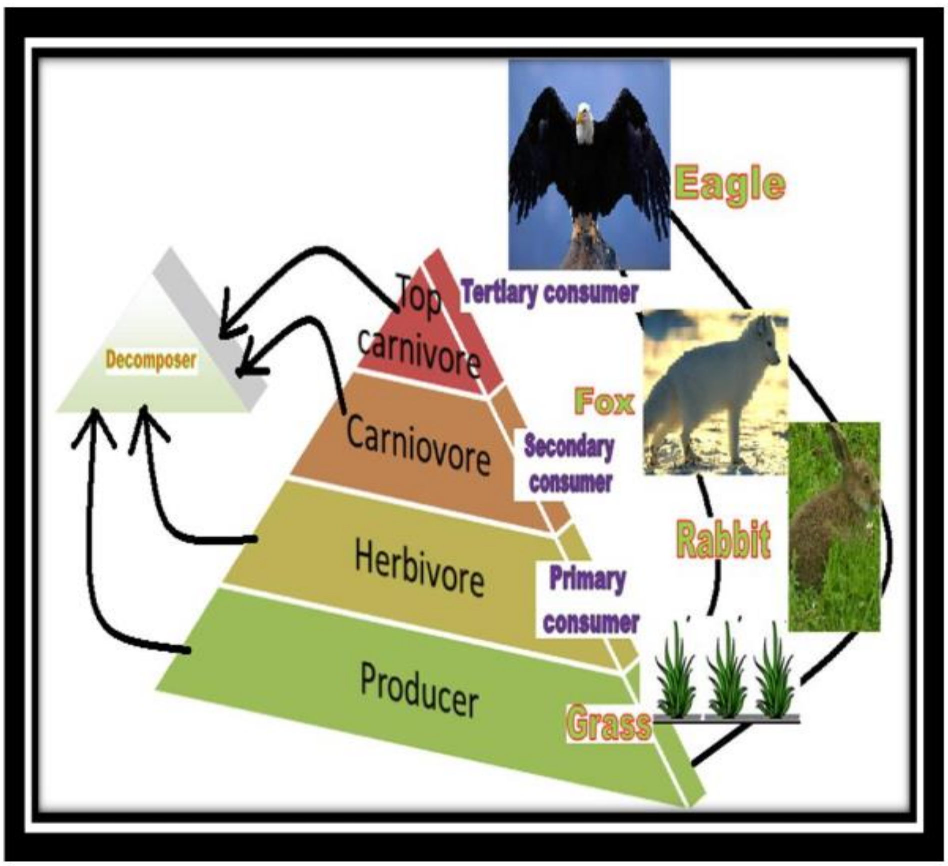


Figure 1.2: Trophic levels in an Ecosystem

Abiotic components: Abiotic components of the ecosystem include a variety of organic compounds and basic inorganic elements and compounds such as soil, water, oxygen, calcium, carbonates and phosphates. The physical factors such as moisture, wind direction and solar radiation also form part of abiotic components. The amount of non-living components (e.g., calcium, phosphorous and nitrogen) present at any given time is known as *standing state*.

Ecological Communities and Food Chains

We have identified an ecological community as the set of interacting species that makes up the living part of ecosystem. It is difficult to know the entire set of species interacting in same place and functioning together. Hence, we confine our definition to particular area where the community consists of all the species whether they are known to interact or not. According to this, example for ecological community would be the animals in a zoo placed in different cages.

One way individuals in a community interact is by feeding on one another. The food chain shows how each living thing gets its food from the other to gain energy for its growth and survival. Energy, chemical elements, and some compounds are thus transferred from creature to creature along food chains and in complex cases called food webs.

Food web is representation of the interlocking food chains that connect all organisms in an ecosystem.

The transfer of energy from the autotrophs (i.e., plants) through a series of organisms that consume and are consumed is called the **food chain**.

At each transfer, a proportion (often as much as 80 or 90%) of the potential energy is lost as heat. Therefore the shorter the food chain the greater is the energy available to that population.

Food chains are of two basic types, and these are:

(i) **Grazing food chain**, which, starting from a green plant base, goes to grazing herbivores and on to carnivores;

(ii) **Detritus food chain**, which goes from non-living organic matter into micro organisms and then to detritus-feeding organisms (detritivores) and their predators.

In an ecosystem, at each level of food chain there is energy transfer from one organism to the other. Hence, the organism is assigned a trophic level based on the number of energy transfer steps to that level. Trophic is derived from a Greek word "*Tropho"* means "Nourishment". Trophic level also consists of all those organisms in a **food web** that have same number of feeding levels away from original source of energy. For example, in an aquatic ecosystem, producers such as algae or phytoplankton constitute the first trophic level. Herbivores such as zooplankton constitute to second trophic level. Third trophic level consists of carnivores such as worms and molluses. Tertiary consumers such as fish constitute to the fourth trophic level. Note that this trophic classification is one of function and not of species as such. In other words, a given species population may occupy one or more than one trophic level according to the source of energy actually assimilated. The energy flow through a trophic level equals the total assimilation (A) at that level, which, in turn, equals the production (P) of **biomass** and organic matter plus respiration (R).

> The total amount of organic matter on earth or in any ecosystem or area is called its **biomass**.

Processes of Ecosystem

This section presents Ecological Energy Flow and Chemical element cycles.

Ecological Energy Flow

Many factors can limit the growth of trees and other forms of life, but the ultimate limit on production of organic matter is energy flow. Before determining the maximum possible production of organic matter of any kind, it is necessary to understand the basic concepts of biological or biomass production, energy and energy flow. We will study these, next.

Biological production

Biological production involves the capture of usable energy and the production of organic compounds in which the energy is stored. This includes all living things and their products. Once an organism has obtained a new organic matter, it can use the energy to move and to produce and reproduce new compounds. The use of energy in organic matter in both heterotrophy and autotrophy is accomplished through respiration. In respiration, an organic compound is combined with oxygen to release energy and produce carbon dioxide and water.

There are three measures of production, viz., biomass, energy content and carbon content. Biomass is usually measured as the amount of total organic matter per unit surface area of the earth, for example g/m^2 or metric tons per hectare, MT/ha. The change in biomass over a given period of time is called net production.

There are three steps in the production of biomass and its use, as a source of energy, by autotrophs. First, an organism produces organic matter within its body; next, it uses some of this new organic matter as a fuel in respiration and finally, some of the newly produced organic matter is stored for future use. That is to say:

Net production = Gross production - Respiration

For example, the net production of the tree is energy contained in what is left at the end of the year and includes new wood laid down in the trunk, new buds that will develop into leaves and flowers the next year, and new roots. Net production results in the increase of total weight, energy content and stored carbon (Botkin and Keller, 1995).

Energy in ecological systems

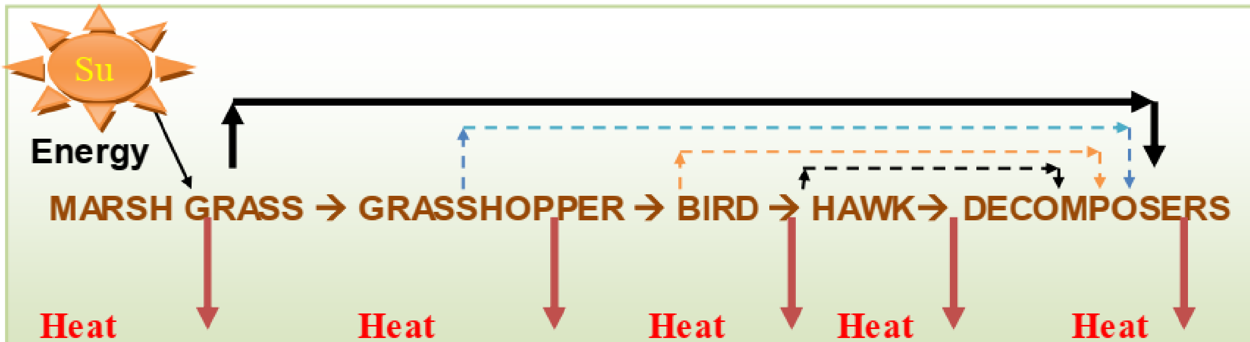
Energy is defined as the ability to do work. The law of entropy or thermodynamics describes the behavior of energy. The first law of thermodynamics, or energy conservation, states that energy may be transformed from one type into another but is neither created nor destroyed. According to the second law of thermodynamics, no process involving an energy transformation will spontaneously occur, unless there is a degradation of the energy from a concentrated form into a dispersed form.

Organisms, ecosystems and the entire biosphere possess the essential thermodynamic characteristics. In other words, these can create and maintain a high state of internal order, or a condition of low entropy (i.e., a low amount of disorder or unavailable energy in a system). *Low entropy* is achieved by continually and effectively dissipating energy of high utility (e.g., light or food) to energy low utility (e.g., heat). Ecosystems and organisms are, accordingly open, non-equilibrium, thermodynamic systems that exchange energy and matter with the environment continuously to decrease internal but increase external entropy.

Energy flow

Energy flow is the movement of energy through an ecosystem – from the external environment through a series of organisms and back to the external environment. It is one of the fundamental processes common to all ecosystems. Energy enter ecosystem in two paths. One path is energy fixed by organisms is shown in Figure 1.3 given below.

Figure 1.3: Energy Flow through a food chain



Energy flow through a food chain

Other path is heat is transferred by the air or water currents or by convention through soils and sediments and warms lining things. For example if warm air passes over a forest, heat energy is transferred from the air to the land and to the organisms. Figure 1.4 illustrates detailed energy flow within an ecosystem.

Having studied the concepts of biomass production, energy and energy flow, let us now understand the general relation between biomass (B) and net production (NP). The equations used for measuring biomass are:

$B_2 = B_1 + NP$ **Equation 1**

$NP = B_2 - B_1$ **Equation 2**

Where B_2 is the biomass at the end of the time period; B_1 is the amount of biomass at the beginning of the time period and NP is the change in biomass during the time period. The general production equations are:

$GP = NP + R$ **Equation 3**

$NP = GP – R$ **Equation 4**

Where GP is the gross production; NP the net production and R is respiration.

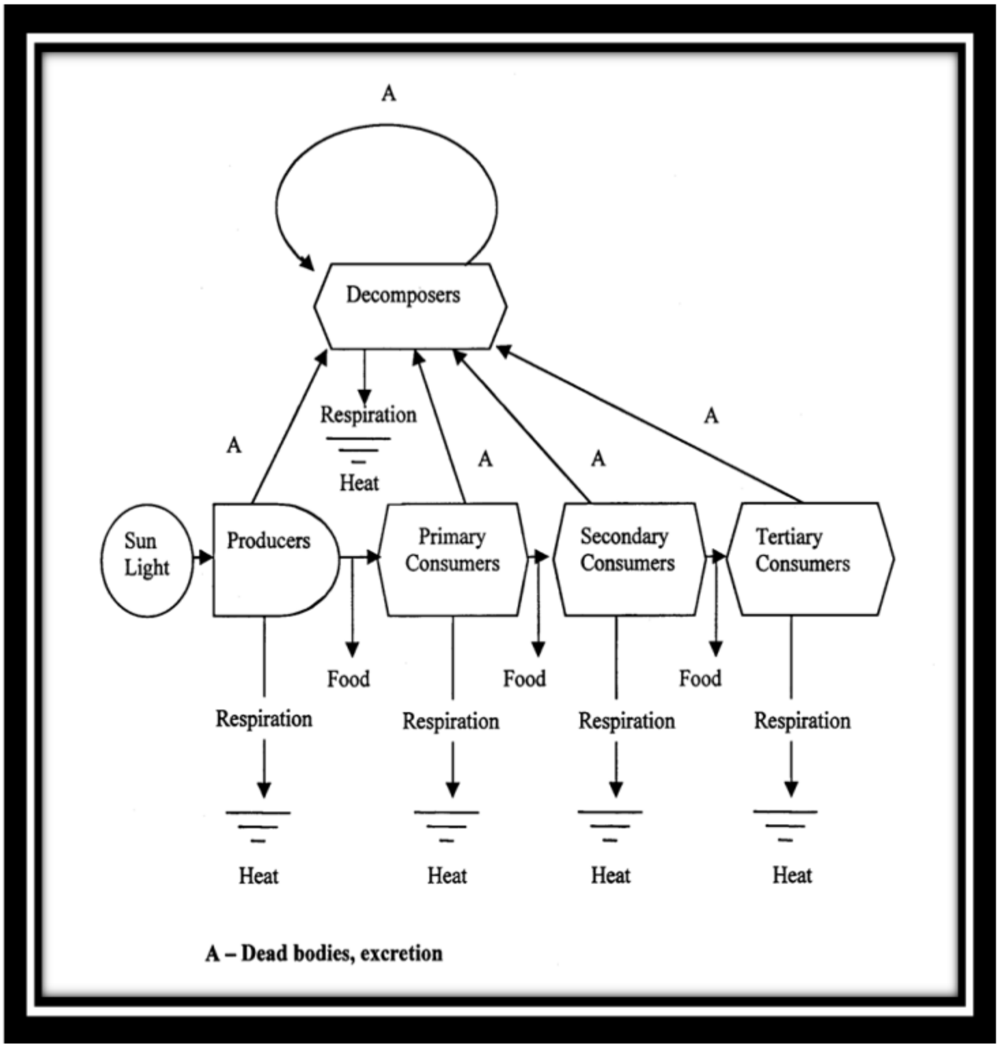


Figure 1.4 Energy Flow within an Ecosystem

Note that the average of the energy in vegetation is approximately 21 kJ/gm (1 kJ = 1000 J = 0.24 kilocalorie). The kilocalorie (kcal) is the amount of energy required to heat a kilogram of water by 1 degree Celsius (from $15^0 – 16^0C$).

To understand the energy flow equations better, let us now work out a problem.

Problem: Consider a forest with an annual increase in forest biomass as 1060 g/m^2 per year. This figure is the annual net production rate or net change in biomass. If the biomass at the beginning of the year was measured at 9700 g/m^2, so that the new biomass in the forest at the end of 1 year would be:

$B_2 = 9700\ g/m^2 + 1060\ g/m^2 = 10{,}760\ g/m^2$

Since, on average, 1 gm of completely dried vegetation contains about 21 kJ of energy, the net production of this forest at the end of one year in terms of energy would be:

$NP = 21\ kJ/g \times 1060\ g/m^2/year = 22,\ 260\ kJ/m^2/year$

About 45% of vegetation in dry matter is carbon, so we can estimate the change in carbon during the year as:

$NP = 0.45 \times 1060\ g/m^2 = 477\ g/m^2$

The total amount of carbon after 1 year would be:

$B_2 = 0.45 \times 9700\ g/m^2 + 0.\ 45 \times 1060\ g/m^2 = 4842\ g/m^2$

This problem demonstrates how we can calculate the energy and carbon production from the biomass production.

Example for energy flow in a stream or river

Producers such as algae are relatively low in a stream hence most the primary consumers feed on dead leaves and twigs of vegetation on the land. Other grazing animals move along the surfaces of rocks and scrape off attached algae. Many predators are larvae of land dwelling insects, such as dragon flies. Some animals capture prey from land or air, as in case of trout that catch flying insects. For example, food chain based on external food input occurs in floodplain of the Amazon River basin, where fish feed on fruits and nuts carried in to streams during rainy season. Where herbivores (fish) increases its population from producers alone, yielding an abundant food supply for human populations of the region.

Energy Efficiency and Transfer Efficiency

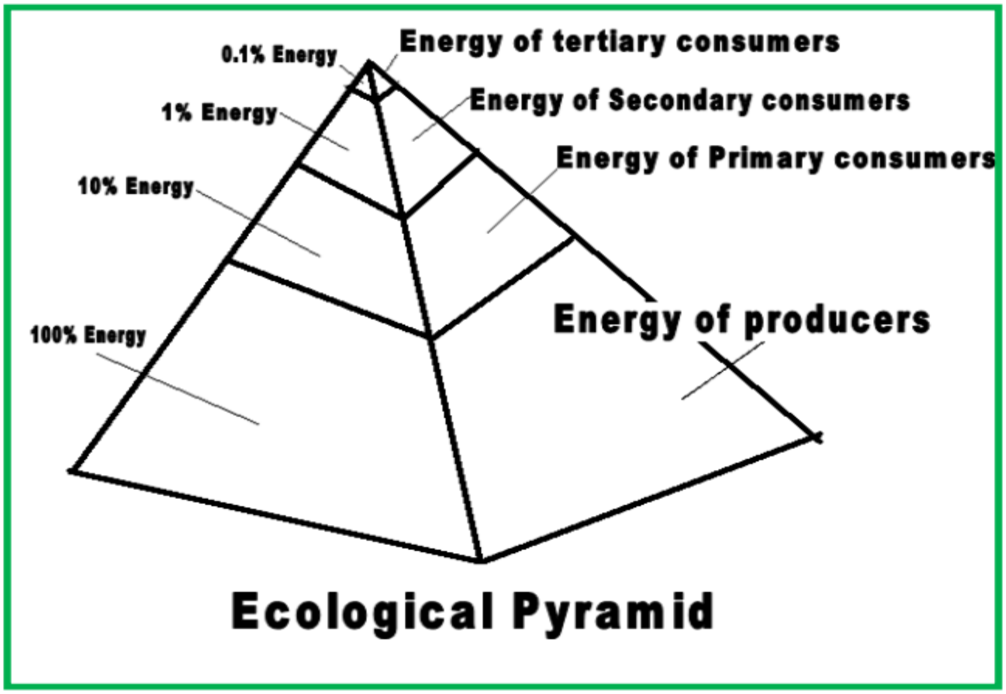


Figure 1.5: Ecological Pyramid

Energy flow in an ecosystem is the flow from one tropic level to the other. While energy is getting transferred there is a need for us to understand the efficiency of flow. Transfer of matter and energy to next tropic level is considered as low efficient process.

The rule of thumb for ecological trophic energy efficiency is not more than 90% of all energy transferred between trophic levels is lost as heat. Less than is fixed as new tissue. Hence 10% energy and transfer rule was depicted. This can be explained with the help of an **ecological pyramid** (shown in figure 1.6)

Ten % energy and transfer rule

Lindemann (1942) has given ten percent law for the transfer of energy from one tropic level to the next. According to the law, during the transfer of organic food from one tropic level to the other only 10 percent of organic matter is stored as flesh and the remaining is lost during transfer or broke down during respiration process.

Nutrients are atoms and molecules that are essential for the growth of plants and trees. Examples of nutrients that are important to plants are carbon (C), nitrogen (N), magnesium (Mg), calcium (Ca), iron (Fe) and phosphorus (P). Note that nutrients are not the same as energy, which comes originally from the sun and is converted, via photosynthesis, into sugars that feed the plant. The fundamental difference between energy and nutrient transfer is that the pattern of nutrient transfer is basically circular or cyclical.

Different nutrients are important to different chemical processes within and between plant cells. For example, plants use nitrogen to synthesize proteins, DNA and many other molecules. Magnesium is a component of chlorophyll, i.e., the molecule that helps plants capture solar energy.

Cycling ensures that nutrients do not get stuck somewhere in the soil. For instance, when a plant dies, all its nutrients end up in the soil. Bacteria and fungi break down the plant tissue and free up the nutrients, which other plants growing in the same soil consume. Recyclers (mainly fungi and bacteria) are important in maintaining availability of nutrients in all ecosystems. Physical processes such as air and water movement influence the fate of these nutrients to variable extents. The cycles also differ in scale from local to global, and each is increasingly subject to human impact – deliberate or accidental. The major cycles occurring in nature include the following:

- **Water cycle:** This essentially involves physical processes of precipitation, evaporation and water flow with solar energy as the driving force. However, organisms and especially plants modify evaporation and precipitation. The presence of water in oceans and the atmosphere makes this a global cycle.

- **Carbon cycle:** This is also global but organic processes (e.g., photosynthesis and respiration) play a more dominant role than in the water cycle.
- **Nitrogen cycle:** This is perhaps the most complex in that so many organisms are involved in the transformations. Essentially, the only way nitrogen finds it way into the food chain is through nitrogen-fixing bacteria. Note that nitrogen is the limiting nutrient in many ecosystems.
- **Phosphorus cycle:** This is simpler than the nitrogen cycle and does not depend on a single class of organisms. Phosphorus is widely present in the earth's crust, although it may often be insoluble and unavailable to plants.

Usually, decomposers play a vital role in nutrient cycling in returning small molecules and ions back from the higher trophic levels to the soil, water or air, where they are available for reuse by the primary producers. However, there are certain factors that disrupt nutrient cycling including the following:

[1]. Acid rain can change the chemistry of soil and change the nature of certain nutrients.

[2]. Deforestation can strip away all the trees and lead to erosion, which washes away all the rich soil that is full of nutrients for future plants.

[3]. Natural disturbances such as fire or drought can interrupt the normal cycling of nutrients caused by movements of water.

Succession

Ecosystem changes over time and space, then areas without life on earth can be filled with living beings. This changing nature of communities and their ability to recover from disturbance in ecosystem is called ecological succession. There are two stages of succession

- ***Primary succession*** *which is an initial establishment and development of the ecosystem.* Forests that develop on new lava flows or at the edge of a retreating glacier are examples of primary succession.
- ***Secondary succession*** *is a reestablishment of an ecosystem.* In secondary succession, there are remnants of a previous biological community, including such things as organic matter and seeds in the soil of a forest. By contrast, in primary succession such remnants are non-existent or negligible. **A forest that develops on an abandoned pasture or one that grows after a flood or fire is an example of secondary succession.**

Role of succession in restoration and recovery of ecosystem

Studying the patterns of the change in ecosystems in response to natural or human disturbance is an important tool for learning how to restore lands damaged by people. Natural areas are subject to disturbances of many kinds. These disturbances are not always or even usually human-induced. For example, natural disturbances such as storms and fires have always been a part of the environment. Such disturbances have existed for so long that animals and plants have adapted to them to such an extent that the landscape actually benefits in the long run. When fires occur at natural rates and intensities, there are some beneficial effects. For example, trees in unburned forests appear more susceptible to insect outbreaks and disease. Thus, recent ecological research suggests that wilderness depends on change and that ecological succession and disturbances are continual processes that keep the landscape dynamic. Hence Succession plays an important role in restoration and recovery of ecosystem.

Feature of succession

One feature of succession is that the biological community changes. In early stages, biomass increases and so does the diversity of life forms. In middle stages of succession, there are many species and sizes of trees and a variety of other patterns that occur. Gross and net productions change during succession in that while the gross production increases, the net production decreases. Chemical cycling also changes and the organic material in the soil increases, as does the amount of chemical elements in the soil and trees. What the foregoing discussion shows is that natural processes could restore a damaged habitat into its previous or even into an improved state and that the environment overall is self-sufficient. However, the balance that is maintained is delicate. Removal or addition of certain factors, for example, can disrupt this balance and the result is an imbalance in the ecosystem. We will touch upon this, next.

Effect of imbalance on the ecosystem

In most cases, a habitat is in balance, with the right number of producers, herbivores and carnivores to keep it going. However, changes such as the introduction or removal of predators in a habitat, can throw the environment out of balance. Disturbances to biotic factors and abiotic factors will lead to environmental resistance. This will lead to an exponential decrease in population of ecosystems that will cause a high extinction rate of biodiversity. If this condition is severe, the ecology of the ecosystems will be permanently damaged. The imbalance in the ratio of producers, consumers and decomposers also distorts the pattern of energy flow through the food chain and food web, disrupting the ecological food pyramid. When the ecological food pyramid is disrupted, insufficient consumption of food leaves organisms deprived of energy, thus affecting the organism's metabolism. This leads to mass starvation and mortality in world population. Also, this leads to the extinction of particular species, while their predators dominate resulting in ecological niche in ecosystems change. Having studied some of the basic concepts of and the importance of preserving the ecosystem and the environment, let us now examine the tool necessary to attain a sustainable approach to environmental management.

In order to understand that 'How much nature do we have, compared with usage', let us take up the discussion on ecological footprint.

Ecological Footprint

The ecological footprint measures the demand upon our natural resources and our available bio-capacity to generate resources and provide services. In order to achieve this; a survey is made in assessing the biologically productive land and marine area required to generate the enough resources for growing population and also work out the corresponding waste. At the end of the survey the data is categorized for food, carbon, housing, goods and services along with level of consumption that indicates total footprint number to sustain world's population.

Now a day's ecological footprint is called as indicator of environmental sustainability. As it manages the resources throughout the economy; it can be used to explore the sustainability of individual lifestyles, organization groups, industrial sectors, cities and regions, goods and services and even the nations as a whole.

SUMMARY

In this Unit, we provided you with an overview of environmental management and pointed out that it is an extensive but loosely defined field. We then outlined the types of management processes and tools, and the responsibilities of professionals. The understanding of the environmental concerns and initiatives, we said, has led to the evolution of various approaches including the ecosystem approach. We also discussed some of the issues relating to environmental concerns and ethics in the management of environment. Finally, after providing an account of the global environmental movement, we presented the concerns in India. Then we deliberated on the concepts of ecology and environment with the significance of its management.