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POST-GRADUATE DEGREE PROGRAMME (CBCS)

IN

GEOGRAPHY

SEMESTER-III

Paper Code: GEO/DSE/EG/T-316

Paper: Environmental Geography-I: BASIC CONCEPT (Special Paper)

Self-Learning Material

KALYANI
UNIVERSITY

DIRECTORATE OF OPEN AND DISTANCE LEARNING
UNIVERSITY OF KALYANI
KALYANI-741235, WEST BENGAL

COURSE MATERIALS COMPILED BY:

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Unit-2:	Ecosystem Approach in Environmental Studies	
Unit-3:	Structure and Function of Ecosystem	
Unit-4:	Fundamental Principles of Natural Ecology; Principles of Human Ecology	
Unit-5:	Concept of Environmental System, Environmental Balance and Environmental Degradation	
Unit-6:	Carrying Capacity of the Environment	
Unit-7:	Bio-geo-chemical Cycles: Types and Significance	
Unit-8:	Energy Flow and Balance of Energy in the Biosphere	
Unit-9:	Stationary State Economy and Equilibrium Population	
Unit-10:	Environmentalism in Geography	
Unit-11:	Approaches to the Study of Environment: Reductionist, Holistic and Organismic	
Unit-12:	Environmental Philosophy: Spaceship Earth, Deep Ecology and Gaia-hypothesis	

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Director's Message

Satisfying the varied needs of distance learners, overcoming the obstacle of Distance and reaching the unreached students are the three fold functions catered by Open and Distance Learning (ODL) systems. The onus lies on writers, editors, production professionals and other personnel involved in the process to overcome the challenges inherent to curriculum design and production of relevant Self-Learning Materials (SLMs). At the University of Kalyani a dedicated team under the able guidance of the Hon'ble Vice-Chancellor has invested its best efforts, professionally and in keeping with the demands of Post Graduate CBCS Programmes in Distance Mode to devise a self-sufficient curriculum for each course offered by the Directorate of Open and Distance Learning (DODL), University of Kalyani.

Development of printed SLMs for students admitted to the DODL within a limited time to cater to the academic requirements of the Course as per standards set by Distance Education Bureau of the University Grants Commission, New Delhi, India under Open and Distance Mode UGC Regulations, 2020 had been our endeavor. We are happy to have achieved our goal.

Utmost care and precision have been ensured in the development of the SLMs, making them useful to the learners, besides avoiding errors as far as practicable. Further suggestions from the stakeholders in this would be welcome.

During the production-process of the SLMs, the team continuously received positive stimulations and feedback from **Professor (Dr.) Kallol Paul, Hon'ble Vice-Chancellor, University of Kalyani**, who kindly accorded directions, encouragements and suggestions, offered constructive criticism to develop it with in proper requirements. We gracefully, acknowledge his inspiration and guidance.

Sincere gratitude is due to the respective chairpersons as well as each and every member of the PG-BoS (DODL), University of Kalyani. Heartfelt thanks are also due to the Course Writers-faculty members at the DODL, subject-experts serving at University Post Graduate departments and also to the authors and academicians whose academic contributions have enriched the SLMs. We humbly acknowledge their valuable academic contributions. I would especially like to convey gratitude to all other University dignitaries and personnel involved either at the conceptual or operational level of the DODL of University of Kalyani.

Their persistent and coordinated efforts have resulted in the compilation of comprehensive, learner-friendly, flexible texts that meet the curriculum requirements of the Post Graduate Programme through Distance Mode.

All the Self-Learning Materials are self writing and collected from e-book, journals and websites.

Director
Directorate of Open and Distance Learning
University of Kalyani

Syllabus

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Introduction

Environmental geography is the branch of geography that describes the spatial aspects of interactions between humans and the natural world. It requires an understanding of the dynamics of climatology, hydrology, biogeography, geology and geomorphology, as well as the ways in which human societies conceptualize the environment. Environment Geography is a valuable branch of Geography, which interacts with the Environment. Environmental Geography is mainly the collaboration of the Human and Environment system. Environmental geography prepares students for careers in environmental planning, design, and restoration, as well as in environmental assessment and monitoring, resource management, natural areas preservation, and outdoor and environmental education. Students completing the program will develop competencies in a broad array of subjects spanning the natural and social sciences, as well as complementary analytical techniques.

The interface of air, water and land forming life supporting layer known as Biosphere is the broadest geo ecosystem (ecosystem) which is the spatial unit for the study of environmental geography. The prime concern of environmental geography is thus to study the components of natural environment separately and together their linkage at various levels through environmental and biological processes and human responses to environment. Environmental geographers are not just familiar with how natural systems function, but they also identify that humans are a dominant agent of change in nature. They realize that it is not possible to understand environmental problems without understanding the physical processes as well as the demographic, cultural, and economic processes that lead to increased resource consumption and waste. Environmental geographers thus follow a variety of academic paths, and these paths converge with those of other disciplines. By its very nature geography is a discipline that seeks to integrate and synthesize knowledge.

Learning Objectives

After reading this special paper on Environmental Issues in Geography, the learners will be able to know in more or less details the concepts of: -

- Nature, scope and content of Environmental Geography
- Ecosystem and Ecology

- Environmental system
- Carrying capacity of environment
- Energy flow and balance of energy
- Bio-geo-chemical cycles
- Stationary state economy
- Equilibrium population
- Reductionist, holistic and orgasmic approach
- Spaceship earth & deep ecology
- Gaia-hypothesis

Assessment of prior knowledge

To assess the student's prior knowledge, they may be asked: -

- What do you mean by environment?
- What are the current and emerging environmental issues?
- What are the requirements to study environment?

Learning Activities

The learning process will involve personal contact programmes, discussion, debate, and interaction and student themselves and teacher. During the personal contact programmes, students may be assigned to prepare assignment on the issues of optimum population, deep ecology, gaia-hypothesis, comparative evaluation of different earth summits, environmental management planning and environmental audit etc.

Feedback of Learning Activities

Once the learning process is completed, internal assessments will be conducted. On the basis of evaluation reports of the internal assessments, some areas of the syllabus will be refocused depending on student's requirements.

UNIT: - 1

Environmental Studies and Environmental Geography; nature, Scope and Content of Environmental Geography

Introduction

Environmental geography is the branch of geography that describes the spatial aspects of interactions between humans and the natural world. It requires an understanding of the dynamics of climatology, hydrology, biogeography, geology and geomorphology, as well as the ways in which human societies conceptualize the environment. Environmental geography prepares students for careers in environmental planning, design, and restoration, as well as in environmental assessment and monitoring, resource management, natural areas preservation, and outdoor and environmental education. Students completing the program will develop competencies in a broad array of subjects spanning the natural and social sciences, as well as complementary analytical techniques.

The study of environment was always a burning theme in geography but during the period between 1950 and 1970 this branch of geography faced severe setback due to spatial sciences and location analysis and also because of the introduction of Quantitative Revolution in geography which promoted the use of statistical techniques in geography (Singh, 2006). But during the last two decades there has been a sudden increase in the activities giving more emphasis on the environmental education. This has resulted in the development of different kinds of extra curriculum out of school activities and literature. The purpose behind emphasising more on the environmental education is to regenerate man's interest in preservation, conservation and improvement of the environment before it is too late and reaches the point of no return i.e., extinction or exhaustion. The term environment etymologically means surroundings. Literally it is an English word (the word environment is derived from French word "Environ" which means "surrounding) formed by the combination of two words 'environ' and 'ment' which means 'encircle' or all around.

Thus environment is a complex of many variables which surrounds man as well as all living organism. Any external force, substance or condition which surrounds or affects the life of organism in any way becomes the factor of its environment. The place where an organism lives is called habitat. It is also known as 'milieu' which means 'total set of surroundings' (Saxena, 2004).As far as the question of environmental studies in geography is concerned it is the interdisciplinary academic field which systematically studies human interaction with the environment in the interests of solving complex problems. It is a broad field of study that also includes the natural environment, built-up environment, and the sets of relationships between them. The field encompasses study in basic principles of ecology and environmental science, as well as associated subjects such as ethics, policy, politics, law, economics, philosophy, environmental sociology and environmental justice, planning, pollution control and natural resource management.

Meaning of environment

- The term environment has been derived from a French word ¯Environ means to surround.
- Environmental geography refers to both biotic and abiotic factors, which includes plants, animals, mountains, rocks, etc...
- Environment regulates the life of the organisms including human beings. Human beings interact with the environment more vigorously than other living beings.
- Ordinarily environment refers to the materials and forces that surrounds the living organism

Environmental studies

Environmental geography is the branch of geography that describes the spatial aspects of interaction between humans and the natural world. More specifically, it is concerned with the use and misuse of natural and human resources, environmental quality & vulnerability and management of environment. Human relationship with the environment has changed due to technical change& globalisation; as a result a new approach was needed to understand the dynamics. Environmental studies deal with every issue that affects an organism. It is essentially a multidisciplinary approach that brings about an appreciation of our natural world and human impacts on its integrity. It is an applied science as it seeks practical answers to making human civilization sustainable on the earth's finite resources (Baskar & Baskar, 2007).

Environmental study is the scientific study of all the components or factors that make or influence our life-supporting biophysical environment. As per some academicians, environmental science is a methodological study of the environment and includes the study of all biophysical as well as anthropogenic conditions or circumstances under which an organism lives (Prasad et al., 2015). It is the study of the interactions between the physical, chemical, and biological components of the natural world, including their effects on all types of organisms and how humans impact their surroundings. Environment is everything that affects an organism during its lifetime. In turn, all organisms, including people, affect many components in their environment. From a human point of view, environmental issues involve concerns about science, nature, health, employment, profits, law, politics, ethics, fine arts, and economies. Therefore, environmental science is by its nature a multidisciplinary field. The science of Environment studies is a multi-disciplinary science because it comprises various branches of studies like chemistry, physics, medical science, life science, agriculture, public health, sanitary engineering etc. It is the science of physical phenomena in the environment (Singh, 2006).

Concepts of Environmental Studies

Environmental study is basically the study of total environment of the earth as a living planet having both physical and biotic components. The fundamental study unit of environmental study is the life layer of the earth having atmospheric, lithospheric and hydrospheric components, which is responsible for the support of all types of life. This lifesupportinglayerisverycommonlyknownasbiosphere,ischaracterizedbythe operation of several physical and biological processes., mutual interaction and interdependence of abiotic and biotic components of the biospheric ecosystem, production and consumption of ecological resources, various positive and negative responses of interactions between different components of the environment resulting into stability or instability of biospheric ecosystem at different levels (local, regional and global), environmental degradation and pollution arising out of increasing pressure of economic and technological man on the environment and man's renewed efforts and struggle to stabilize the disturbed ecosystem, to conserve and manage the ecological resources and the ameliorate environmental degradation and pollution through different pollution-control and abatement programmes. There are certain basic principles which govern the basic aspects of environmental studies viz. natural processes, both physical and biological in the life supporting layer (biosphere) and relationships between man and environment and man and environmental processes, integrated functional unit of the biotic and abiotic components of the environment (ecosystem), functioning of ecosystem, ecological evolution and succession, climatic changes and ecological modification, and environmental degradation and pollution arising out of human activities and ecological resources and their conservation and management.

Defining Environmental Geography

The term 'environmental geography' is not one that most geographers to whom it could reasonably apply usually use to identify themselves or their work. Instead, geographers more typically imagine their discipline as one of two halves – human and physical. Within those two broad churches, there are numerous subfields, like economic geography or geomorphology, with which specialists identify. Although activity and interaction between human and physical geography (e.g., by geographers of 'natural hazards' and 'natural resources') is being increasingly acknowledged, through, for example, various conference sessions designed to speak across 'the divide' (e.g., Harrison et al., 2004), this dualism still dominates the organisation of the discipline in which Progress in Physical Geography is imagined as something separate from Progress in Human Geography (these names, for readers unfamiliar with them, refer to two leading geography journals).

This view of things may surprise non-geographers or pre-university geography students. After all, geography's public image is partly that of an 'integrative' discipline, while much of the subject's popularity in schools is due precisely to its focus on human-environment interactions. Yet the reality is that for most academic geographers 'environmental geography' is a small and often pretty elusive thing compared with the dominant human and physical wings of the discipline. (It may also be less familiar to North American readers where environmental geography has maintained more of a central role in some departments and topics, following for example, the traditions of human-environment geographers such as Carl Sauer or Gilbert White.)

One impetus for this book is to raise the profitable of environmental geography both within and beyond the discipline. The environment is now widely touted as one important reason for 'Rediscovering Geography', to quote the title of a US National Academy of Sciences (1997) report on the future of geography. Echoing such calls, (Billie Lee Turner, 2002; cf. Zimmerer, 2007) is just one of a number of prominent figures urging geographers to embrace their long-ignored human-environment tradition so as to revitalise the discipline and secure its historically precarious place in the academy. Environmental geography, according to this way of thinking, provides a unifying link holding the two parts of the discipline together. It promises to make good on the integrative vision of geography celebrated by Mackinder, Davis and Ratzel but foiled as the discipline has become progressively more segmented and specialised since the Second World War.

Historically, this kind of symmetrical understanding of human–environment relations was achieved and embodied by the individual geographer. Indeed, Mackinder made little distinction between individual geographers and the wider discipline they comprised. For him the integrative role as bridge between the natural and social sciences applied equally to both. But specialisation within the sciences, along with the exponential increase in the stock of scientific knowledge, has meant that even at the smallest geographical scale, this kind of all-encompassing and fully symmetrical account of human–environment relations is very difficult, if not impossible for any one individual to achieve: it requires broad expertise and a great deal of time if it is to be done well. Furthermore, the sorts of integrative and symmetrical understandings that individual geographers could provide also run the risk of being dismissed by specialists as trivial for failing to advance knowledge in more narrowly defi ned areas of research. For all these reasons, few geographers even try to achieve fully symmetrical understandings ideal typically associated with environmental geography.

Multidisciplinary Nature of Environmental Geography

The Environment studies is a multi-disciplinary science because it comprises various branches of studies like chemistry, physics, medical science, life science, agriculture, public health, sanitary engineering etc. It is the science of physical phenomena in the environment. It studies about the. sources, reactions, transport, effect and fate of physical and biological species in the air, water, soil and the effect of from human activity upon these.

As the environment is complex and actually made up of many different environments like natural, constructed and cultural environments, environmental studies is inter disciplinary in nature including the study of biology, geology, politics, policy studies, law, religion engineering, chemistry and economics to understand the humanity's effects on the natural world. This subject educates the students to appreciate the complexity of environmental issues and citizens and experts in many fields. By studying environmental science, students may develop a breadth of the interdisciplinary and methodological knowledge in the environmental fields that enables them to facilitate the definition and solution of environmental problems.

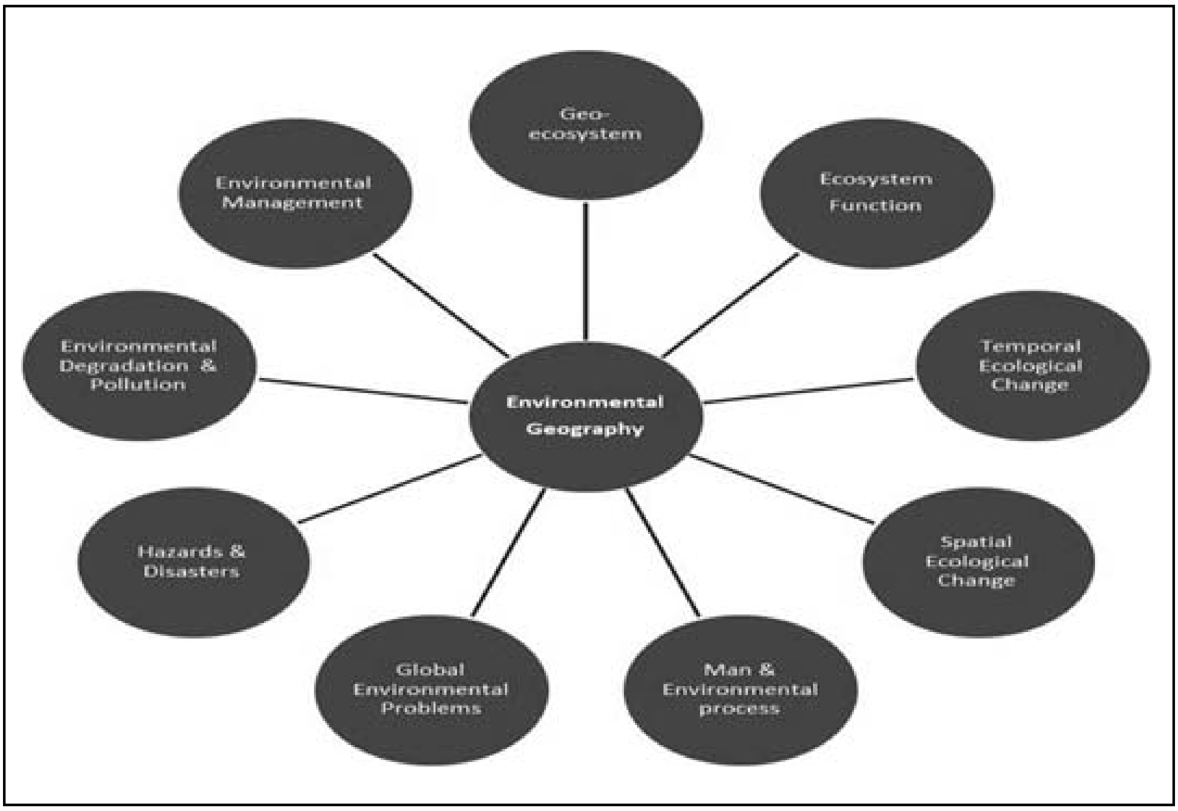
Scope and Content of Environmental Geography

As we look around at the area in which we live, we see that our surroundings were originally a natural landscape such as a forest, a river, a mountain, a desert, or a combination of these elements. Most of us live in landscapes that have been heavily modified by human beings, in villages, towns or cities. But even those of us who live in cities get our food supply from surrounding villages and these in turn are dependent on natural landscapes such as forests, grasslands, rivers, seashores, for resources such as water for agriculture, fuel wood, fodder, and fish. Thus, our daily lives are linked with our surroundings and inevitably affects them. We use water to drink and for other day-to-day activities. We breathe air, we use resources from which food is made and we depend on the community of living plants and animals which form a web of life, of which we are also a part. Everything around us forms our environment and our lives depend on keeping its vital systems as intact as possible. Our dependence on nature is so great that we cannot continue to live without protecting the earth's environmental resources.

Thus most traditions refer to our environment as 'Mother Nature' and most traditional societies have learned that respecting nature is vital for their livelihoods. This has led to many cultural practices that helped traditional societies protect and preserve their natural resources. Respect for nature and all living creatures is not new to India. All our traditions are based on these values. Emperor Ashoka's edict proclaimed that all forms of life are important for our well being in Fourth Century BC. The industrial development and intensive agriculture that provides the goods for our increasingly consumer oriented society uses up large amounts of natural resources such as water, minerals, petroleum products, wood, etc. Non-renewable resources, such as minerals and oil are those which will be exhausted in the future if we continue to extract these without a thought for subsequent generations.

Renewable resources, such as timber and water, are those which can be used but can be regenerated by natural processes such as regrowth or rainfall. But these too will be depleted if we continue to use them faster than nature can replace them. For example, if the removal of timber and firewood from a forest is faster than the regrowth and regeneration of trees, it cannot replenish the supply. And loss of forest cover not only depletes the forest of its resources, such as timber and other non-wood products, but affects our water resources because an intact natural forest acts like a sponge which holds water and releases it slowly. Deforestation leads to floods in the monsoon and dry rivers once the rains are over. Such multiple effects on the environment resulting from routine human activities must be appreciated by each one of us, if it is to provide us with the resources we need in the long-term.Our natural resources can be compared with money in a bank. If we use it rapidly, the capital will be reduced to zero. On the other hand, if we use only the interest, it can sustain us over the longer term. This is called sustainable utilisation or development.

Fig: - Scope of Environmental Geography



Source: - Savinder Singh, 2018

Main scopes of environmental geography (https://gacbe.ac.in/pdf/ematerial/18MGE14E-U1.pdf): -

A. Environmental System:

- Understand the interaction among four spheres viz. Biosphere, Atmosphere, Hydrosphere and Lithosphere.
- Ecosystem and ecological degradation.
- Structure and components of ecosystem.
- Energy flow in the ecosystem.
- Biogeochemical cycles and circulation of matter in the ecosystem.
- Ecological changes in the ecosystem.
- Ecosystem stability and instability.

B. Man-Environment Relationship in geography:

- Determinism or Environmentalism
- Possibilism
- Neo-determinism

C. Environment policy, Laws & Rules:

- Agriculture, Industry, Health & Sanitation,
- Energy & fuel, Water development, Flood
- Control & Irrigation

D. Global Environment issues:

- Climate change
- Global warming & greenhouse effect
- GHG emission
- Thinning of the Ozone layer

E. Environment-Man-Society:

- Fundamental theories and aspects of environment and its relationships with man and society.

- Meaning, composition and types of environment.
- Relationship between geography and environment, man and nature.
- Man-ecological procedures relationship.
- Theory of ecology.
- Eco-development.
- Ecological ethics and law.
- Ecological modernization.
- Ecological policy and politics.
- Environment and health.

F. Environmental Management:

- Sustainable Development.
- Natural Resources Management.
- Disaster Management and Mitigation.
- Energy Policy.
- Ecological Impact Assessment.
- Ecological Monitoring and Planning.
- Ecological Quality Control.
- Ecological Modelling.
- Biodiversity Conservation.

G. Significance of Environmental Geography:

- It helps to understand the aerial distribution of phenomena.
- To understand the spatial patterns and spatial organization.
- Locational analysis, Regional analysis, Ecological studies.
- To understand the man-environment relationship.
- Find solutions to manage ecological problems.
- Make people aware to protect the environment.

- Proper use of natural resources.
- Sustainable development and biodiversity conservation.

The Need for Environmental Studies

Nature or environment sustains life. As a conscious and rational being, man needs to know the importance of environment and help keep the environment as healthy and productive as it can be. It is the environment that has made this beautiful world possible for him. Hence, there is an ever-demanding need for environmental studies. The natural environment that mankind had before the onset of industrialization, urbanization, and exponential growth in population was expectedly healthy and resilient. Nature was able to replenish the loss of its resources, which was very limited. After the onset of modern civilization, the overall health and efficiency of natural environment started deteriorating gradually and went on to such an extent that nature has virtually lost its natural ability to replenish the loss of resources caused by man. Environmentalists, geographers, and biologists the world over is constantly endeavouring for a sustainable solution to restore a sustainable environment. There is a need for focus on environmental management, laws governing environment protection, pollution and recycling of non-bio-degradable material, etc. There is also a need for careful and cautious use of natural resources in the present time to establish sustainability in every aspect of nature. There is a need to clarify modern environmental concepts such as how to conserve biodiversity and maintain an ecological balance.

Environment is not a single subject. It is an integration of several subjects that include both Science and Social Studies. To understand all the different aspects of our environment we need to understand biology, chemistry, physics, geography, resource management, economics and population issues. Thus, the scope of environmental studies is extremely wide and covers some aspects of nearly every major discipline. We live in a world in which natural resources are limited. Water, air, soil, minerals, oil, the products we get from forests, grasslands, oceans and from agriculture and livestock, are all a part of our life support systems. Without them, life itself would be impossible. As we keep increasing in numbers and the quantity of resourceseach of us uses also increases, the earth's resource base must inevitably shrink. The earth cannot be expected to sustain this expanding level of utilization of resources. Added to this is misuse of resources.

We waste or pollute large amounts of nature's clean water; we create more and more material like plastic that we discard after a single use; and we waste colossal amounts of food, which is discarded as garbage. Manufacturing processes create solid waste byproducts that are discarded, as well as chemicals that flow out as liquid waste and pollute water, and gases that pollute the air. Increasing amounts of waste cannot be managed by natural processes. These accumulate in our environment, leading to a variety of diseases and other adverse environmental impacts now seriously affecting all our lives. Air pollution leads to respiratory diseases, water pollution to gastro-intestinal diseases, and many pollutants are known to cause cancer. Improving this situation will only happen if each of us begins to take actions in our daily lives that will help preserve our environmental resources. We cannot expect Governments alone to manage the safeguarding of the environment, nor can we expect other people to prevent environmental damage. We need to do it ourselves. It is a responsibility that each of us must take on as one's own (Baskar & Baskar, 2007).

Importance of environmental study

Environmental study is based upon a comprehensive view of various environmental systems. It aims to make the citizens competent to do scientific work and to find out practical solutions to current environmental problems. The citizens acquire the ability to analyze the environmental parameters like the aquatic, terrestrial and atmospheric systems and their interactions with the biosphere and anthrosphere.

The major importanceare: -

- World population is increasing at an alarming rate especially in developing countries.
- The natural resources endowment in the earth is limited.
- The methods and techniques of exploiting natural resources are advanced.
- The resources are over-exploited and there is no foresight of leaving the resources to the future generations.
- The unplanned exploitation of natural resources lead to pollution of all types and at all levels.
- The pollution and degraded environment seriously affect the health of all living things on earth, including man.

- The people should take a combined responsibility for the deteriorating environment and begin to take appropriate actions to space the earth.
- Education and training are needed to save the biodiversity and species extinction.
- The urban area, coupled with industries, is major sources of pollution.
- The number and area extinct under protected area should be increased so that the wild life is protected at least in these sites.
- The study enables the people to understand the complexities of the environment and need for the people to adapt appropriate activities and pursue sustainable development, which are harmonious with the environment.
- The study motivates students to get involved in community action, and to participate in various environmental and management projects.
- It is a high time to reorient educational systems and curricula towards these needs.
- Environmental studies take a multidisciplinary approach to the study of human interactions with the natural environment. It integrates different approaches of the humanities, social sciences, biological sciences and physical sciences and applies these approaches to investigate environmental concerns.
- Environmental study is a key instrument for bringing about the changes in the knowledge, values, behaviors and lifestyles required to achieve sustainability and stability within and among countries.

Principles of environmental study

1. ***Environmental system or ecosystem is the fundamental ecological unit for the study of the environmental study:***The planet earth is the only living planet that has atmosphere, environment and living organisms including plants, animals and micro-organisms. Since the environment is both physical and biological concept, it encompasses both the non-living (abiotic) and living (biotic) components of the planet earth. Environment is the comprehensive term which in general refers to surroundings. The earth is the only known planet having different kinds of life forms where in there are complex sets of interrelationships

between the physical and biological components. Various linkages between physical and biological components at different levels maintain the unity of the biospheric ecosystem.

2. ***The biospheric ecosystem is governed by discernible processes:*** The dynamic evolving earth system in general and the biospheric system in particular are governed by discernible processes, both physical and biological. The physical or biological processes operate through a set of cycles, the broadest being geocycle. In fact the endogenetic and exogenetic processes create different types of habitats on the earth surface for living organisms on the one hand and sometimes destroy the habitats on the other hand. The driving force of the endogenetic processes comes from within the earth. Endogenetic forces create different types of relief features of various magnitudes on the earth's surface. Exogenetic forces originate from the atmosphere and are engaged in continuous process of denudation of surface irregularities caused by endogenetic processes.

3. ***There is continuous creation, maintenance, destruction and recreation of surface materials of the earth:*** Various physical, chemical and biological processes are continuously engaged in the creation, maintenance, destruction and recreation of surface materials of the earth's surface (both organic and inorganic). The process involved in the creation of the earth materials (inorganic) is known as 'geologic cycle' which includes a set of several sub cycles. The earth materials are not only created but also maintained, change in their properties transferred from one place to another and even destroyed by geologic cycle but these materials are even passing through the aforesaid pathways remain initially uncontaminated and are very useful for man, they became contaminated and are seldom available for human use because either they are dispersed to such locations which may not be reached by man for fairly long period of time or they become so deformed and contaminated that they are not reusable. Sometimes, some renewable natural resources are so contaminated that they become non-renewable.

4. ***Physical and biological processes operate according to the law of uniformitarianism:*** Physical and biological processes operate according to the law of uniformitarianism. James Hutton's law of uniformitarianism having two basic principles of 'the present is key to the past' and 'no vestige of a beginning: no prospect of an end' postulated in 175 and related to 'cyclic nature

of earth's history' states that 'all the physical law and processes that operate today, operated throughout geologic time, although not necessarily always with the same intensity as now'. In other words, the very nature of the operation of physical processes remains almost the same throughout geologic history of the earth though their frequency and magnitude may vary. So, the biological processes which operate today might have operated in the past though with varying degree of relationships between biological communities and physical or natural environment and between organisms.

5. ***Natural environmental system is governed by homeostatic mechanism:***Physical and biological processes of the natural environmental system operate in such a way that any change in any part of the environment at any place in a specific time period is suitably compensated by negative feedback mechanism in a natural condition. Thus the natural environmental system has 'inbuilt self regulating mechanism' known as homeostatic mechanism through which any change in the natural ecosystem is counterbalanced by responses of the system to the change and ultimately ecosystem stability or environmental equilibrium is restored. Sometimes this situation also leads to the evolution of new species.

6. ***There is reciprocal relationship between abiotic and biotic components of the natural environmental system:***There is reciprocal relationship between biotic and abiotic (physical) components of the environment. The physical processes create suitable habitats for biological communities on the one hand, biological communities (mostly man) modify the environment on the other hand. In fact life has continued to modify and alter the atmospheric, lithospheric and oceanic components of the biosphere since the very beginning of the life on the planet earth.

7. ***The energy flow and circulates of nutrients in the biospheric ecosystem help in the sustenance of life on the planet earth:***The natural ecosystems are open systems characterised by continuous input of energy (solar radiation) and matter (nutrients) and output of energy and matter and they tend to be in relatively stable equilibrium unless there is disturbance in one or more con trolling factors. The circulation of elements or matter or nutrients (both organic and inorganic) in the biospheric ecosystem is made possible through energy flow. In other words, energy flow is the main driving force of materials (nutrients) circulation in various biotic components of the ecosystem.

8. ***There are temporal and spatial variations in species:***There are temporal and spatial variations in species. The Darwin's theory of evolution of species states that there is progressive evolution of species through the processes of natural selection and adaptation to environmental condition which lead to gradual modification and diversification of species over a long period of time.

9. ***Ecosystem diversity and complexity enhances and maintains ecological stability:***The stability of ecosystem refers to balance between production and consumption of each element of the ecosystem. In other words ecosystem stability means balance between input and output of energy and normal functioning of different biogeochemical cycles and stable condition of concentration of all elements.

Different Approaches of Environmental Geography

An approach is a way of getting closer.The study of relationships between man and environment has always been,in one way or another,a focal theme in Environmental Geography.But the facets of man –environment relationship change through time with the development of human society and the dimension of environment. The man – environment relationships,thus,can be perceived and evaluated in a variety of ways and approaches.

1. ***Environmental Deterministic Approach:***This approach is based on the basic tenet of 'earth made man'and pays more attention on the complex control of physical environment on man and his activities.In fact, according to deterministic activities of manenvironment relationships man is subordinate to natural environment in all aspects of human life like, physical, social, economic, political, ethical, aesthetic, etc. not only depend but are dominantly controlled by physical environment.

   Though this deterministic approach blossomed in the writings of E.C. Semple (1910) in the second decade of the 20th century but its seeds were already sown in the second half of the nineteenth century.In fact, the publication of 'The Origin of Species 'of Charles Darwin in 1859 laid the foundation stone of the concept of environmental influences on man and other organisms.The concept of environmentalism culminated in 1910 when American Geographer

E.C.Semple published her book ‘Influences of Geographic Environment’ wherein she opined that ‘man is product of the earth’s surface.This means not merely that he is a child of the earth, dust of her dust, but the earth has mothered him, fed him, set him tasks, directed the thoughts, confronted him with difficulties that have strengthened his body and sharpened his wits, given him problems of irrigation and navigation and at same time whispered hints for their solutions.

2. ***Teleological approach:*** Teleological approach is based on religious faith of man being superior to nature and all other creatures. This approach of man-environment relationship led to excessive and rapid rate of exploitation of natural resources in North America and Western Europe as well as in other parts of the world which were their colonies. A host of scientists and environmentalists have held this religious tradition responsible for present-day ecological crisis. This approach of man towards nature and environment stimulated Europeans to spread all over the world in search of unexplored land and resources. Consequently numerous colonies were established in all of the inhabited continents. After 1750, there began a race for rapacious exploitation of natural resources and widespread industrialization in Europe and America. The process continued for the last three centuries and created most of the present-day environmental problems.

3. ***Possibilistic approach:*** Possibilistic approach to the study of ma-environment relationships emerged through the criticism of environmental determinism and overtone of teleological approach. Right from the inception of the school of environmental determinism there was dissenting voice raised by those who believed that ‘no doubt physical environment influences man and his activities but there is ample scope for man to change the environment so much so that it becomes suitable for man and his society’. This concept of possibilism was founded by Febvre who has remarked, ‘man is a geographic agent and not the least. He everywhere contributes his share towards investing the physiognomy of the earth with those ‘changing expressions’ which are the special charge of geography to study’. Two French geographers, Vidal de la Blache and Jeans Bruhnes and American geographers Isiah Bowman and Carl Sauer founded the school of possibilism which is based on the philosophy of possibilism in nature at every stage in a given space and time as remark by Febvre, ‘There are no

necessities, but everywhere possibilities and man as a master of these possibilities is the judge of their use'.

4. ***Economic deterministic approach:*** This approach is based on the basic ideology of the man's mastery over environment and continued economic and industrial expansion through the application of modern technologies. Economy decides the fate of man's interaction with environment. This approach suggests an economic growth is essential for political, social and economic stability, the quality of environment normally assumes lower priority in planning. This approach based itself on two assumptions firstly; positive correlation between the population of a green region and the level of economic development secondly; the interaction of people resources and society are governed by universal economic principles.

5. ***Ecological approach:*** Ecological approach of environmental studies is based on the basic concept of ecology. Ecology is a study of mutual interactions between organisms and physical environment on one hand and interactions among organism in a given ecosystem. This approach suggests man as an individual part of the ecosystem and his action should be symbiotic and not exploitative nor suppressive. C.C. Park, the advocate of this approach says the relationship between man and environment is two directional as the environment affects and influences man in turn man also influences and modifies the environment. This relation is mutual and symbiotic. All these approaches into studying man-environment relationship have gained importance from time to time and from place to place. Hence an historical analysis of the issue becomes, important for the understanding of this project problematic. This school recognizes man, being most skilled and intelligent, as the leader of all biota of the earth. This approach further lays emphasis on wise and restrained use of natural resources, application of appropriate environmental management programmers, policies and strategies keeping in view the ecological principles so that already depleted natural resources are replenished (wherever possible), degraded environment is set right and ecological balance is maintained.

6. ***Geographical Approach:*** The Geographic Approach in environmental study refers to using geographic science supported by GIS as a framework for understanding our world and applying geographic knowledge to solve problems

and guide human behaviour. Geography is the science of our world, describing the physical and cultural patterns and processes of our planet. This science provides humans with awareness of what's going on, predictions of what may happen, and systematic information for planning and decision making. Geography helps us to better understand various spatial phenomena and their interrelationships, for example the relationships between land use change, surficial hydrology, flooding, biodiversity, etc. These understandings are helping the society to become more conscious and aware of the interrelatedness of our world and how our cumulative behaviour is affecting the evolution of the planet. Today GIS is extending the power of geography by providing digital tools that abstract and organize geospatial data, model geographic processes, and visualize these data and models with advanced computer techniques. GIS is helping us apply geographic knowledge to ledge a host of problems, ranging from organizational inefficiencies to supporting location decisions that require examining many geographic factors. For example, when selecting the route for a new highway, GIS and the geographic approach can be used to consider the physical and human factors that should guide its layout and design: the environment, existing land use, terrain, and social impacts, as well as engineering constraints and costs. Considering all these factors can be over whelming, particularly when trying to make complex trade-offs. This is where the use of GIS is particularly valuable.

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UNIT: - 2

Ecosystem Approach in Environmental Studies

Introduction

The ecosystem approach emerged early as a central principle in the implementation of the Convention on Biological Diversity. At its second meeting, held in Jakarta in November 1995, the Conference of the Parties adopted the ecosystem approach as the primary framework for action under the Convention, and subsequently referred to it in the elaboration and implementation of the various thematic and cross-cutting programmes of work, and in the guidelines that were developed as part of these programmes of work. At the present time, each of the Convention's work programmes incorporates the ecosystem approach in its goals and activities, and the central role of the ecosystem approach is also reflected in the Strategic Plan of the Convention.

Even though the ecosystem approach is a central concept to the Convention, it has proven difficult to define in a simple manner. At its fourth meeting, in Bratislava in May 1998, the Conference of the Parties acknowledged the need for a workable description and further elaboration of the ecosystem approach, and requested the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) to develop principles and other guidance on the ecosystem approach (Shepherd, 2008).

The Ecosystem Approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. In the past, mitigation of environmental pollution was dealing with reduction of certain pollutants, new technological anti-pollution measures and restrictions in the most important pollution sources. Scientists assessing the new approach introduced new dimensions and more ecologically sounded objectives. In addition, application of the ecosystem approach will help to reach a balance of the three objectives of the Convention of Biological Diversity. These objectives are: conservation of biological diversity, sustainable use of its components and appropriate access to genetic resources and appropriate transfer of relevant technologies which take into account all rights over those resources (Brunner & Clark, 1997; Interagency Ecosystem Management Task Force, 1995).

The Convention of Biological Diversity (1992, Earth Summit in Rio de Janeiro, Brazil) was a radical approach to conservation of living resources of the Earth's ecosystems. It was based on the application of appropriate scientific methodologies focused on levels of biological organization which encompass the essential processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems. The history of (EAM) of environmental resources started in Ecological Approach Management 1995 when Vice President Gore's National Performance Review in USA called for agencies of the federal government to adopt a proactive approach to ensuring a sustainable economy and environment through principles of ecosystem management (Costanza et al, 1997; Clark, 1999).

Description of the ecosystem approach

1. The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Thus, the application of the ecosystem approach will help to reach a balance of the three objectives of the Convention: conservation; sustainable use; and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.
2. An ecosystem approach is based on the application of appropriate scientific methodologies focused on levels of biological organization, which encompass the essential structure, processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems.
3. This focus on structure, processes, functions and interactions is consistent with the definition of "ecosystem" provided in Article 2 of the Convention on Biological Diversity: "'Ecosystem' means a dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit." This definition does not specify any particular spatial unit or scale, in contrast to the Convention definition of "habitat". Thus, the term "ecosystem" does not, necessarily, correspond to the term's "biome" or "ecological zone", but can refer to any functioning unit at any scale. Indeed,

the scale of analysis and action should be determined by the problem being addressed. It could, for example, be a grain of soil, a pond, a forest, a biome or the entire biosphere.

4. The ecosystem approach requires adaptive management to deal with the complex and dynamic nature of ecosystems and the absence of complete knowledge or understanding of their functioning. Ecosystem processes are often non-linear, and the outcome of such processes often shows time-lags. The result is discontinuities, leading to surprise and uncertainty. Management must be adaptive in order to be able to respond to such uncertainties and contain elements of "learning-by-doing" or research feedback. Measures may need to be taken even when some cause-andeffect relationships are not yet fully established scientifically.

5. The ecosystem approach does not preclude other management and conservation approaches, such as biosphere reserves, protected areas, and single-species conservation programmes, as well as other approaches carried out under existing national policy and legislative frameworks, but could, rather, integrate all these approaches and other methodologies to deal with complex situations. There is no single way to implement the ecosystem approach, as it depends on local, provincial, national, regional or global conditions. Indeed, there are many ways in which ecosystem approaches may be used as the framework for delivering the objectives of the Convention in practice (Secretariat of the Convention on Biological Diversity, 2004).

Why do we need an ecosystem approach?

An ecosystem approach can help to:

- resolve problems like poor quality surroundings, declining resources and increased demands on the environment
- resolve conflicts between competing priorities, making clear what decisions mean for different interests
- make visible those ecosystem services that don't have a market value, like health benefits

- promote collaboration and efficiency across different public policies and plans
- save money by allowing nature to work for people rather than relying only on human solutions
- encourage people to think about the implications of decisions for future generations and for those beyond the local area.

Evolution of Ecosystem Approach

At its second meeting, held in Jakarta, November 1995, the Conference of the Parties (COP) of the Convention on Biological Diversity (CBD) adopted the ecosystem approach as the primary framework for action under the Convention, and subsequently has referred to the ecosystem approach in the elaboration and implementation of the various thematic and cross-cutting issues work programmes under the Convention. The thematic and crosscutting issues concerned include biological diversity of inland water ecosystems, marine and coastal biological diversity, agricultural biological diversity, forest biological diversity, indicators of biological diversity and incentive and environmental impact assessment. At its fourth meeting in Bratislava in May 1998, the COP acknowledged the need for a workable description and further elaboration of the ecosystems approach, and requested the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) to develop principles and other guidance on the ecosystem approach. At the eighth meeting of the COP, decisions concerning the ecosystem approach can be found under other thematic programmes and cross cutting issues: on Island biodiversity, on Implications of the findings of the Millennium Ecosystem Assessment, on the Global Initiative on Communication, Education and Public Awareness: overview of implementation of the programme of work and options to advance future work, on Forest biological diversity: implementation of the programme of work, on Biological diversity of inland water ecosystems: reporting processes, improving the review of implementation and addressing threats, on Agricultural biodiversity, on Protected areas, on Incentive measures: preparation for the in-depth review of the programme of work on incentive measures, on Impact assessment: At COP 9, Parties agreed to strengthen and promote the use of the ecosystem approach more widely, and to increase capacity building activities (CBD, 2004).

The 12 principles of the Ecosystem Approach

The principles of the ecosystem approaches are (Shepherd, 2008): -

1. The objectives of management of land, water and living resources are a matter of societal choice.
2. Management should be decentralized to the lowest appropriate level.
3. Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
4. Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should: (i) reduce those market distortions that adversely affect biological diversity; (ii) align incentives to promote biodiversity conservation and sustainable use; and (iii) internalize costs and benefits in the given ecosystem to the extent feasible.
5. Conservation of ecosystem structure and functioning, to maintain ecosystem services, should be a priority target of the ecosystem approach.
6. Ecosystems must be managed within the limits of their functioning.
7. The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.
8. Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.
9. Management must recognize that change is inevitable.
10. The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.
11. The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.
12. The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

The Framework of Applying the Ecosystem Approach

The Ecosystem Approach has been established as a tool providing a framework for implementing the objectives of the Convention on Biological Diversity (CBD). The principles underlying the Ecosystem Approach are purposely flexible to address management issues in varying social, economic and environmental contexts. Implementing the ecosystem approach can be as simple as including its principles in national and regional polices, planning processes and sectoral plans. Smaller projects may be more conveniently adapted to the ecosystem approach on local levels. The CBD website contains step by step guidance, from problem identification through to management plan and project implementation. The searchable component of the ecosystem approach sourcebook can be used to find information on case studies and tools which have met some or all of ecosystem approach principles. There is much to be learned from the experiences of others when attempting to use the CBD ecosystem approach. Sharing lessons of successful implementation at all appropriate levels can reap rewards and benefits far outweighing the investment of time, money and manpower. Sustaining Earth's finite natural resources through the unified efforts of the international community is a truly lofty goal, elevating mankind to a level of stewardship hardly believed attainable by previous generations (Smith, 2003).

Steps to apply Ecosystem Approach

The ecosystem approach is a tool; it provides a framework that can be used to implement the objectives of the Convention on Biological Diversity, including the work on, inter alia, protected areas and ecological networks. There is no single correct way to apply the ecosystem approach to management of land, water, and living resources. The principles that underlie the ecosystem approach can be translated flexibly to address management issues in different social, economic and environmental contexts. There are a number of options for implementing the ecosystem approach. For example, the principles can be included in national and regional policies, planning processes and sectoral plans. The principles can also be applied at a local level to smaller projects (https://www.cbd.int/ecosystem/).

Ecosystem management differs from prior management concepts in several important ways (Christensen et al. 1996):

Its emphasis is on sustainability and future generations. Non-commodity values are included, and managers are asked to manage for the well-being of many life forms and the integrity of ecological processes. It takes a landscape perspective, moving beyond boundaries set by ownership and recognizing the reciprocal influence of neighbouring ecosystems on the system being managed. It places management in the context of natural disturbance. It requires broad participation throughout the project with scientists participating in the initial design and subsequent monitoring, analysis, and adaptation of management options.

As per Lackey (1998), the seven core principles, or pillars, of ecosystem management define and bound the concept and provide operational meaning:

1. Ecosystem management reflects a stage in the continuing evolution of social values and priorities; it is neither a beginning nor an end;
2. Ecosystem management is place-based and the boundaries of the place must be clearly and formally defined;
3. Ecosystem management should maintain ecosystems in the appropriate condition to achieve desired social benefits;
4. Ecosystem management should take advantage of the ability of ecosystems to respond to a variety of stressors, natural and man-made, but all ecosystems have limited ability to accommodate stressors and maintain a desired state;
5. Ecosystem management may or may not result in emphasis on biological diversity;
6. The term sustainability, if used at all in ecosystem management, should be clearly defined—specifically, the time frame of concern, the benefits and costs of concern, and the relative priority of the benefits and costs; and
7. Scientific information is important for effective ecosystem management, but is only one element in a decision-making process that is fundamentally one of public and private choice.

The Framework of Ecosystem Approach to Fisheries

The EAF (Ecosystem Approach to Fisheries) framework has developed on the founding principles and conceptual goals emerging from the decades-long process of elaboration of the foundations for sustainable development, aiming at both human and ecosystem well-being. Binding international instruments of great relevance to EAF have been adopted during the past three decades: 1971 RAMSAR Convention on Wetlands; 1973 CITES Convention on International Trade in EndangeredSpecies;1979 Bonn Convention on Migratory Species of Wild Animals; 1982 Law of the Sea Convention; 1992 Convention on Biological Diversity; and in 1995 Fish Stocks Agreement.

The ocean fishing process became industrialized in the early 19th century when English fishers started operating steam trawlers and soon rendered more effective by power winches and diesel engines. After 1945 the industrialization of fishing was regulated by freezer trawlers, radar and acoustic fish finders. Fisheries science advanced after the two world wars had shown that strongly exploited fish populations would recover most, if not all, of their previous abundance when released from fishing. With global catches declining since the late 1980s, continuation of present trends will lead to supply shortfall, for which aquaculture cannot be expected to compensate. Reducing fishing capacity to appropriate levels will require strong reductions of subsidies (Pauly et al. 2002).

All these environmental instruments provided intersecting, sometimes contradictory, principles and conceptual goals. Most environmental instruments were organized to provide a background for an integrated framework for fisheries, a process of selection and reformulation which was matured in the 1995. The UN organization Food and Agriculture Organization (FAO, Rome) has established a reference framework “Code of Conduct for Responsible Fisheries” for sustainable fisheries (adopted October 1995), addressing practically all the ecosystem considerations, principles, and conceptual goals needed for an EAF. This Code is voluntary. However, certain parts of it are based on relevant rules of international law, including those reflected in the UN Convention on the Law of the Sea of 10December 1982. The Code also contains provisions that may be or have already been given binding effect by means of other obligatory legal instruments amongst the Parties, such as the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (1993).The FAO International Plans of Action aiming at conservation and management of sharks and a reduction of incidental catch of seabirds will contribute to the implementation of an Ecosystem Approach to Fisheries (EAF) (Garcia, etal. 2003).

The Ecosystem Approach to Marine Environment Planning and Management

The marine environment with its vital diversity of marine and estuarine animals and plants is an integral part of the natural heritage of the Earth. The world's oceans cover 72% of the Earth's surface, and comprise 95% of the global water supply. Reasonably they are called the Earth's lungs. Because the oceans produce70% of its oxygen and 80% of its plant and animals' life. The marine environment is the most precious natural resource but also very fragile because of environmental pressures and hazardous pollution inputs. The marine environment provides a wide range of essential goods and services, including food, regulation of climate and nutrient cycling, as well as a setting for transport, recreation and tourism. But the marine environment is extremely complex and very sensitive to development pressures and other forms of human influence and economic activities (UN, 2007).

A good example is the United Kingdom's new laws to protect marine resources (UK, England, Wales, Scotland and N. Ireland). The 2010 Marine Act draws upon the experience of town and country planning and brings into being a new system of MSP. A common feature of all these developments is an appreciation that more integrated forms of planning and management are required for seas and new arrangements must draw together understanding from natural science, social science and many other perspectives (Kidd et al. 2011).

Ecological Modelling for Ecosystem Approach

Ecological modelling tools were applied worldwide to support the ecosystem-based approach of marine resources (EAM). In the last decades, numerous applications were attempted in the Mediterranean Sea, mainly using the Ecopath with Ecosim (EwE) tool. These models were used to analyse a variety of complex environmental problems. [Ecopath software, serves to parametrize systems of coupled difference and differential equations, which are used to depict changes in biomasses and trophic interactions in time (Ecosim) and space (Ecospace). The outcomes of these simulations can then be used to modify the initial parameterization]. Scientific publications outline applications which analysed the ecosystem impacts of fishing and assessed management options. Other studies dealt with the accumulation of pollution through the food web, the impact of aquaculture or the ecosystem effects of climate change. They contributed to the scientific aspects of an ecosystem-based approach in the region because they integrated human activities within an ecosystem context and evaluated their impact on the marine food web, including environmental factors. Also, these studies collected a significant amount of information at an ecosystem level which has been useful for future environmental projects. Results in these analyses highlighted differential traits between Mediterranean ecosystem types, which illustrate the environmental heterogeneity of the Mediterranean Sea and the importance of top predators, small pelagic fish and the structural role of benthos and plankton organisms. The impact of fishing was high and of a similar intensity in the western, central and eastern regions and showed differences between ecosystemtypes (Coll & Libralato, 2012).

An ecosystem approach model was applied to the fisheries of the Ionian Sea. Scientists used a mass-balance food web model that was developed for the Greek Ionian Sea ecosystem, including 39 functional groups [Functional groups are defined as sets of species showing either similar responses to the environment or similar effects on major ecosystem processes] and 6 fisheries at depths between 50and 1100 m during the 1990s. The study area was among the most oligotrophic in the Mediterranean Sea, having a complex food web structure, high numbers of energy pathways, trophic levels and functional groups and high rates of matter cycling, all of which are indicative of a mature system. To separate the effects of discards and landings, analyses and indicators were estimated through two models with the same parameterization: one included all catches and the other only landings. The primary production required to sustain the fisheries was low, and approximately half of it was used for sustaining by-catches and discards. Discards have greater impacts than landings on the flows and energy necessary to support the fisheries. Although fishing mortality by each gear type was moderate, the cumulative fishing impact estimated from all gears combined exceeded safe limits, thus enhancing the benefits of moving toward a multi-gear/multi-species approach to fisheries. This study was a first step toward quantifying discards in a multispecies/multigear system and considering the uncertainties in quantifying discard quantities, especially for low trophic levels (Moutopoulos, 2012).

Ecosystems are constituents of the biosphere – the complete assembly of the Earth’s ecosystems. Ecosystems include habitats, places where the living components of an ecosystem survive. The ecosystem approach is based on the application of appropriate scientific methodologies focused on levels of biological organisation which encompasses the essential processes and interactions among organisations and their environment.

There is no single or unique ecosystem approach. The final goals of the approach acknowledge human participation and interests, emphasising on maintenance of the interactions within and functioning of natural systems and can be applied over wide range of scales. Ecosystem approach is a holistic way of dealing with natural resource management in an approach that recognizes the inter-connectivity between ecological, social-cultural, economic and institutional structures (Lacky, 1998).

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UNIT: - 3

Structure and Function of Ecosystem

Introduction

The ecosystem has been a key organizational concept in ecology for many years, an important theoretical and applied concept for studying global change, and human environmental impacts. The ecosystem concept has provided a conceptual framework for studying nature and for sustainable management of natural resources (Odum, 1969; Aber et al., 1989; Vitousek et al., 1997). Ecosystem concept has proved to be of practical value to understand the complexity of natural systems and ecosystem properties. A lake, an island or a watershed are good examples of ecosystems in the context of systems theory of ecosystem analysis. In 1935, A.G. Tansley, a British ecologist, defined an ecosystem as a basic unit of nature, composed of the set of organisms and physical factors forming the environment. Raymond Lindeman, while working on the Cedar Bog Lake in Minnesota, USA gave the trophic dynamic concept in 1942 and popularised the idea of the ecosystem as an energy transforming system. E.P. Odum has been one of the most influential ecologists of the twentieth century, laid foundations of the concept of ecosystem in ecological studies. It has been defined as a "basic functional unit of nature which includes organisms and their non-living environment, each interacting with the other and influencing each other's properties, and both necessary for maintenance and development of system" (Odum, 1957).

A more elaborate definition according to Odum (1971) is "the structural and functional unit of nature that includes all of the organisms (i.e., "the community") in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity and material cycles". According to the CBD (Convention on Biological Diversity), an ecosystem is "a dynamic complex of plant, animal and micro-organism communities and their non-living environment, interacting as a functional unit", an integral component of which are humans (Naveh, 2000). In all definitions, the concept of "interacting functional unit" in which living and non-living components of the ecosystem are variously coupled is emphasized. Associated with the concept of ecosystem are those of structure and ecosystem functioning. Structure is related to the organization and distribution of elements within an ecosystem. Ecosystem functioning are related to the exchange of materials and the flow of energy in an ecosystem.

What is an Ecosystem?

An ecosystem is the basic functional unit of an environment where organisms interact with each other (living and nonliving), both necessary for the maintenance of life on earth. It includes plants, animals, microorganisms, and all other living things along with their nonliving environment, which includes soil, land, air, water, dust, and other parts of nature.

If ecology has to be studied in detail, the basic unit starts from the Ecosystem. The study of the Ecosystem deals with how organisms living together interact with each other and how energy flows through the chain of organisms in the Ecosystem. It also studies how an organism lives in a relationship that is harmful or benefitted by one another to live in a sustainable manner. It is seen in nature that the Ecosystem can be as large or small. It depends on the number of abiotic components available in the environment. The ecosystem in the north or south poles does not have much flora and fauna as compared to a tropical climate like a forest due to the extreme climate the animals are subjected to. Only organisms that are resistant to such an environment will be able to make up the Ecosystem. Overall, it is understood that different ecosystems combined would make up the biosphere (https://www.vedantu.com/biology/ecosystem).

Characteristics of Ecosystem

According to Smith (1966), the ecosystem has the following general characteristics:

- It is a major structural and functional unit of ecology.
- Its structure is related to its species diversity; the more complex ecosystems have high species diversity and vice versa.
- Its function is related to energy flow and material cycling through and within the system.
- The relative amount of energy needed to maintain an ecosystem depends on its structure. The more complex the structure, the lesser the energy it needs to maintain itself.
- It matures by passing from fewer complexes to more complex states. The early stages of each succession have an excess of potential energy and a relatively

high energy flow per unit of biomass. Later (mature) stages have less energy accumulation and they flow through more diverse components.

- Both the environment and the energy fixation in any given ecosystem are limited and cannot be exceeded without causing serious undesirable effects.
- Alternations in the environment represent selective pressures upon the population to which it must adjust.
- Organisms that are unable to adjust to the changing environment must necessarily vanish.

Types of Ecosystem

In ecology, ecosystems are classified into different types based on the region or on the basis of the environment like land or water. It can also be grouped based on the amount of energy the Ecosystem consumes.

Classifications in basic ecosystem are:

1. Terrestrial Ecosystem
2. Aquatic Ecosystem

All other types will fall on either of these ecosystems and hence can be subcategorized into different types.

1. Terrestrial Ecosystem

These ecosystems can only be found on land. Different landforms will have different ecosystems based on the climate, temperature, types of organisms residing, the food chain, energy flow, and other factors. This Ecosystem has a relative scarcity of water percentage than the aquatic Ecosystem, and also there is better availability of sunlight as the major source of energy. Types of terrestrial ecosystems are:

a. Forest Ecosystem: These ecosystems are a densely packed environment of various flora and fauna. It has the highest number of organisms living per square km. It is important to conserve this ecosystem as many rare species of the earth are found here. Most of the oxygen in the world is supplied by the forests. These ecosystems have an abundance of flora or plants and hence in these ecosystems a large number of organisms live in a small space. This means that these ecosystems have a high density of living organisms. These ecosystems are classified according to their climate type as tropical, temperate or boreal i.e; tropical evergreen forest, tropical deciduous forest, temperate evergreen forest, temperate deciduous forest and taiga. In the tropics, rainforest ecosystems contain more diverse flora and fauna than ecosystems in any other region on earth. In these warm, moisture-laden environments, trees grow tall and foliage is lush and dense, with species inhabiting the forest floor all the way up to the canopy. In temperate zones, forest ecosystems may be deciduous, coniferous or oftentimes a mixture of both, in which some trees shed their leaves each fall, while others remain evergreen year-round. In the far north, just south of the Arctic, boreal forests – also known as taiga – feature abundant coniferous trees.

b. Desert Ecosystem: Deserts are defined as ecosystems that receive rainfall of less than 25cm indicating extreme climate. Even in harsh temperatures, there are organisms that have resistance towards high temperatures and plants that require very little water to survive, having modified their leaves and stem to conserve water. Camels, rattlesnakes, and cacti are a few examples. The common defining feature among desert ecosystems is low precipitation, generally less than 25 centimetres, or 10 inches, per year. Almost 17% of all the land on this planet is occupied by the desert ecosystems. The fauna and flora in these ecosystems is generally not much developed because of the high temperatures, intense sunlight and low availability of water. The main vegetation of such regions are the shrubs, bushes and a few grasses and trees. The stems and leaves of these plants are also developed in order to conserve as much water as possible. Camels, reptiles and some insects and birds are the living creatures which are found in such regions. Not all deserts are hot – desert ecosystems can exist from the tropics to the arctic, but regardless of latitude, deserts are often windy. Some deserts contain sand dunes, while others feature mostly rock.

c. Mountain Ecosystem: Mountains are regions of high altitude above sea level with scattered vegetation. It also has an extreme climate, and animals of these regions have developed thick fur on the skin to survive the cold climate.

d. Grassland Ecosystem: It mainly includes shrubs, herbs, and few trees which are not as dense as the forests. These basically include grazing animals, insectivores, herbivores. The temperatures are not too extreme in these ecosystems. There are two main forms: The savannas and prairies. The savannas are the tropical grasslands. It dries seasonally with many predators and grazers. The prairies are temperate grassland, which lack large shrubs and trees.The grasslands are the areas which comprise mainly of the grasses with a little number of shrubs and trees. Grazing animals, insectivores and herbivores are the main types of organisms which are found in these regions. The three major types of grasslands are the prairies, savannas andsteppes. Grassland ecosystems are typically found in tropical or temperate regions, although they can exist in colder areas as well, as is the case with the well-known Siberian steppe. Grasslands share the common climactic characteristic of semi-aridity. Trees are sparse or non-existent, but flowers may be interspersed with the grasses. Grasslands provide an ideal environment for grazing animals. Savanna are the tropical grasslands which are dry seasonally and have a large number of predators and grazers. Prairies are temperate grasslands which are totally devoid of large shrubs and trees. Prairies are of three different types, mixed grass, tall grass and short grass prairies.

e. Tundra Ecosystems

As with deserts, a harsh environment characterizes ecosystems in the tundra. In the snow covered, windswept, treeless tundra, the soil may be frozen year-round, a condition known as permafrost. The mountain ecosystem is the most scattered and diverse in terms of the habitats that it provides. A large number of animals and plants are found in this ecosystem. Though the conditions at the very high altitudes can be very demanding allowing only the survival of the treeless alpine vegetation. Another important feature about these ecosystems is that the animals which live here have thick fur coats for protection against cold and generally have a long hibernation period in the winters. The slopes at lower altitudes are generally covered with coniferous forests. During the brief spring and summer, snows melt, producing shallow ponds which attract migrating waterfowl. Lichens and small flowers may become visible during this time of year. The term “tundra” most commonly denotes polar areas, but at lower latitudes, tundra-like communities known as alpine tundra may be found at high elevations.

2. Aquatic Ecosystem

The aquatic ecosystem consists mainly of animals and organisms that stay in the water bodies, such as lakes, oceans and seas. Amphibians, fish, sea creatures all come under this ecosystem. Since water is in abundance, organisms survive using the oxygen dissolved in water. This ecosystem is much larger than the terrestrial ecosystem as it acquires a greater part of the earth. The two types of aquatic ecosystems are:

a. Marine Ecosystem: Marine ecosystems are the biggest ecosystems. They cover around 71% of earth's surface and also contain almost around 97% of the total water present on earth. High amounts of minerals and salts are generally present in the water in the marine ecosystems and to better understand the amount and composition of the different minerals and salts in the water in different marine ecosystems. Marine ecosystems differ from freshwater ecosystems in that they contain saltwater, which usually supports different types of species than does freshwater. Marine ecosystems are the most abundant types of ecosystems in the word. They encompass not only the ocean floor and surface but also tidal zones, estuaries, salt marshes and saltwater swamps, mangroves and coral reefs.

b. Freshwater Ecosystem: The freshwater ecosystems are very small in magnitude as compared to the marine ecosystems as these covers only 0.8% of the earth's surface and only account for 0.009% of the total water present on earth. There are three basic kinds of freshwater ecosystems and these are Lentic, Lotic, and Wetlands. The lentic ecosystems are slow-moving or still water like ponds or lakes. Lotic ecosystems are fast-moving water like rivers. The wetlands are those systems where soil remains saturated for a long period of time. Many different species of reptiles, amphibians, and around 41% of the world's fish species live in these ecosystems. The faster moving waters contain more dissolved oxygen than the slow-moving waters and hence support greater biodiversity.

i) ***Pond Ecosystems –*** These are usually relatively small and contained. Most of the time they include various types of plants, amphibians and insects. Sometimes they include fish, but as these cannot move around as easily as amphibians and insects, it is less likely, and most of the time fish are artificially introduced to these environments by humans.

ii) ***River Ecosystems –*** Because rivers always link to the sea, they are more likely to contain fish alongside the usual plants, amphibians and insects.

These sorts of ecosystems can also include birds because birds often hunt in and around water for small fish or insects. As is clear from the title, freshwater ecosystems are those that are contained to freshwater environments. This includes, but is not limited to, ponds, rivers and other waterways that are not the sea (which is, of course, saltwater and cannot support freshwater creatures for very long). Freshwater ecosystems are actually the smallest of the three major classes of ecosystems, accounting for just 1.8% of the total of the Earth's surface. The ecosystems of freshwater systems include relatively small fish (bigger fish are usually found in the sea), amphibians (such as frogs, toads and newts), insects of various sorts and, of course, plants. The absolutely smallest living part of the food web of these sorts of ecosystems is plankton, a small organism that is often eaten by fish and other small creatures (https://www.deshbandhucollege.ac.in/pdf/resources/1587401626_BA(H)-Psc-Eco-Eng-BA(P)-II-Ecosystem.pdf)

Ecosystem Components and Structure

The ecosystem has two major kinds of components: (1) Abiotic (non-living) and (2) Biotic (living) components.

Abiotic Components: - The abiotic structure is characterized by the quantity and distribution of non-living materials, edaphic factors and the climate regime (light, rainfall and temperature). The inorganic substances are carbon, nitrogen, oxygen, CO2, and water, which are present in soil, water and air. The atmosphere supplies carbon and nitrogen, whereas soil minerals, and dissolved nutrients in water are a source of nutrients required by living organisms. The organic compounds such as proteins, carbohydrates, lipids, and other complex molecules, form a link between biotic and abiotic components of the system. The climatic factors like solar radiation and temperature determine the abiotic conditions within which organisms carry out their life functions. Soil is a medium of plant growth representing a mixture of minerals and organic matter, capable of supplying all the essential nutrients and water.

Biotic Components: - The organisms that make up the living part of the ecosystem (biotic community) are divisible into two major categories, viz., autotrophs (producers) and heterotrophs (consumers). This division is based on the function of the organisms.

Autotrophs: - These are the chlorophyll bearing organisms which produce their own food by assimilating the solar energy and making use of the simple inorganic abiotic substances. In terrestrial ecosystems, the autotrophs are generally rooted plants (herbs, shrubs and trees). In open water such as deep aquatic ecosystems and oceans, the dominant producers are phytoplankton, which is -mostly microscopic organisms that float or drift in the water. In freshwater and marine ecosystems, algae and plants are the major producers near shorelines.

The Heterotrophs: - are the organisms, which cannot manufacture their own food. The heterotrophs are two types:

Phagotrophs or Macro-Consumers: - The macro-consumers include mainly the animals that ingest other organisms or particulate organic matter (e.g., snail that ingests organic particles). The food of consumers consists of organic compounds produced by other living organisms. The phagotrophs may be herbivores (ingesting plants, e.g., goat, deer), or carnivores (ingesting other animals - e.g., tiger, lion) or omnivores (ingesting both plants and animals, e.g. bear, man). A primary consumer that derives nutrition by eating plants is an herbivore. The secondary consumer or carnivore is an animal that preys upon an herbivore of other animals.

Microconsumers or Saprotrophs: - The saprotrophs are certain types of bacteria and fungi. These are also called decomposers, which break down complex dead organic matter in to simple inorganic forms, absorb some of the decomposition products, and release inorganic nutrients that are reused by the producers.

Functions of an Ecosystem

Ecosystem function is the capacity of natural processes and components to provide goods and services that satisfy human needs, either directly or indirectly. Ecosystem functions are subset of ecological processes and ecosystem structures. Each function is the result of the natural processes of the total ecological sub-system of which it is a part. Natural processes, in turn, are the result of complex interactions between biotic (living organisms) and abiotic (chemical and physical) components of ecosystems through the universal driving forces of matter and energy. There are four primary groups of ecosystem functions (1) regulatory functions, (2) habitat functions, (3) production functions and (4) information functions. This grouping concerns all ecosystems, not only for forests.

General characterizations of ecosystem functions are:

(1) Regulatory functions: this group of functions relates to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems through bio-geochemical cycles and other biospheric processes.

In addition to maintaining the ecosystem (and biosphere health), these regulatory functions provide many services that have direct and indirect benefits to humans (i.e., clean air, water and soil, and biological control services).

(2) Habitat functions: natural ecosystems provide refuge and a reproduction habitat to wild plants and animals and thereby contribute to the (in situ) conservation of biological and genetic diversity and the evolutionary process.

(3) Production functions: Photosynthesis and nutrient uptake by autotrophs converts energy, carbon dioxide, water and nutrients into a wide variety of carbohydrate structures which are then used by secondary producers to create an even larger variety of living biomass. This broad diversity in carbohydrate structures provides many ecosystem goods for human consumption, ranging from food and raw materials to energy resources and genetic material.

(4) Information functions: Since most of human evolution took place within the context of an undomesticated habitat, natural ecosystems contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, recreation and aesthetic experience (http://eagri.org/eagri50/ENVS302/pdf/lec04.pdf).

Ecosystems exhibit a natural tendency to persist which has been made possible by a variety of functions performed by the structural components. 'Functions' refer to the biological, geochemical and physical processes that take place within an ecosystem. Ecosystems are thermodynamically open, which exhibit the exchange matter and energy with their environment. The key functional aspects of ecosystems are energy flow, food chains and food webs, biogeochemical cycling, ecosystem development, and ecosystem regulation and stability.

Energy Flow: - The green plants capture the solar energy and convert it through the process of photosynthesis into chemical energy of food and store it into their body. This process is called primary productivity. The rate of total capture of energy or total organic matter production by autotrophs (primary producers) is known as gross primary production. The autotrophs use some of the energy they acquire for respiration. The remainder is the net primary production, the amount of energy left for the heterotrophic organisms. The energy is lost from the ecosystem when organic matter is oxidized back to CO2 by the respiration of autotrophs and heterotrophs. At the trophic level of heterotrophs, the rate of assimilation of energy is called secondary productivity.

Generally, primary productivity on land increases from Polar regions, to the equator except for the intervening strongly water-limited deserts. The greater productivity of tropical regions to a large extent is due to the favorable combination of high incident solar radiation, warm temperatures, abundant rainfall, and high biological diversity. These factors result into longer, almost year-round growing season. Aquatic gross primary production depends on the quantity of phytoplankton and the vertical profile of light and other physical factors. Microscopic phytoplankton's living in oceans are responsible for more than 40% of Earth's photosynthetic production, but the ecosystem with the greatest net primary production per unit area is the tropical rain forest.

Biogeochemical Cycling: - Nutrients move through the ecosystem in biogeochemical cycles. A chemical element moves through the biotic and the abiotic components of an ecosystem. Of the 30 to 40 elements necessary to life, six rank as the most important: carbon, hydrogen, oxygen, nitrogen, sulphur and phosphorus. These nutrients move from non-living to the living and back to the non-living again in a cyclic manner. The biogeochemical cycles are driven by energy flow and are crucial for the maintenance of life on earth in its present form. The biogeochemical cycles are of two basic types, viz., gaseous and sedimentary types. In the gaseous cycles (such as nitrogen and carbon) the reservoir is in the atmosphere or hydrosphere (ocean). In sedimentary types (for example, phosphorus cycle), the reservoir is in the lithosphere. The nutrients are first taken up by the autotrophs, bound in the organic matter and move along the food chain to heterotrophic level and ultimately from all trophic levels, with the detritus, to the decomposer food-chain. The decomposers break down the complex organic compounds and release the nutrients to the soil from where they are again taken up by the plants. These biogeochemical cycles provide the foundation to understand how human activities lead to eutrophication (nutrient enrichment) and global climate change.

Food Chains and Food webs: - A trophic level is the position occupied by an organism in a food chain. A linear arrangement of trophic levels is called food-chain along which the energy flows. At each trophic level some energy is lost as heat and respiration, as a result available energy decreases moving away from the first trophic level. Therefore, the number of trophic levels in a food chain is limited. The herbivorous animals derive the energy by ingesting plants or plant parts. These animals are eaten by carnivorous animals (first order carnivore) which in turn are eaten by other carnivorous animals (second order carnivore). In this chain of eating and being eaten away, the green plants form the first trophic level, the herbivores the second trophic level, and the carnivores constitute second order and the third trophic level, and so on.

The food chains are of two types, i.e., Grazing food chain and Detritus food chain. The interlocking patterns of food chains in an ecosystem constitute the food webs. These are briefly described as follows:

Grazing food chain: The food chain that starts from green plants constitutes the grazing pathway

Green plants → herbivores → first order carnivores → second order carnivores

Some examples of grazing food chain in an ecosystem would be:

Grass → Rabbit → Fox

Phytoplanktons → Zooplanktons → Fish → Man

***Detritus Food Chain:* -** In many cases, the principal energy input is not green plants but dead organic matter. These are called detritus food chains. Examples of detritus food chains include the forest floor, a salt marsh, and the ocean floor in very deep areas.

Example of such a forest floor food chain is:

Dead leaves → Fungi → Collembola → Predatory mite

Detritivores get their nutrition by feeding on detritus, or freshly dead organisms, before they are fully decomposed. Detritus feeders include earthworms, some insects, hyenas, and vultures. In natural ecosystems, decomposers and detritivores eliminate the buildup of plant litter, animal wastes, and dead plants and animals. Therefore, these organisms are the key to nutrient cycling.

***Food Web:* -** An ecosystem contains several food-chains, often these food chains are inter-linked forming a food web. Food webs provide another way to describe the flow of energy through ecosystems. A food web is a complex network of interconnected food chains. Food webs are useful in studies at the ecosystem level. Elton’s high Arctic ‘food web’ diagram is the classic study which has depicted major pathways of nutrient/ energy flux and the interdependence between the terrestrial and aquatic ecosystems (Summerhayes and Elton, 1923). A more recent study has shown that there are the intricate food web relationships among different types of organisms in this high arctic region. A long-term study on invertebrate communities on W. Spitsbergen (500 km N of Bear Island), Svalbard has contributed a more detailed and realistic terrestrial food web based on a variety of published and unpublished data. The main characteristics of the food web worked out in this study are: (i) the presence of high number of species, (ii) the higher levels of connectivity among species, (iii) the occurrence of the significantly longer food chains. The simple vertebrate food web and its relationship to invertebrate food web for the high arctic region are shown.

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UNIT: - 4

Fundamental Principles of Natural Ecology; Principles of Human Ecology

Introduction

Ecology is the scientific study of the relationships between organisms and their environment. These relationships are complex, varied and hierarchical. The word 'ecology' was first used by German biologist Ernst Haeckel in 1869. The word is derived from the Greek words, oikos (meaning 'house' or 'dwelling place') and logos (meaning the study of). Haeckel defined ecology as 'the study of the natural environment including the relations of organisms to one another and to their surroundings'. Ecology describes the relationships between living organisms and their environments, the interaction of organisms with each other and the pattern and cause of the abundance and distribution of organisms in nature. The environment includes everything (biotic as well as abiotic) that surrounds an organism. Thus, it is the science that attempts to answer questions about how the nature works. According to one of the most widely accepted definition, 'Ecology is the scientific study of the distribution and abundance of organisms and the interactions that determine distribution and abundance' (Mina, 2011).

Biology is the science of life. Ecology is basically a branch of biology. It deals with study of interactions among organisms and their biophysical environment. This biophysical environment includes both biotic and abiotic components. The word "ecology" ("Ökologie") was coined in 1866 by the German scientist Ernst Haeckel. It is derived from the Greek words Oikos- home + logos- study. The Biophysical environment in which all interactive mechanisms happen is called as an ecosystem. Since the ecosystem is a geographic area where plants, animals, and other organisms, as well as weather and landscapes, work together to form a bubble of life, earth science becomes the backbone of ecology.

Ecology deals with organisms, populations, communities, ecosystems and the biosphere. The place of living is the organism's environment. Hence, ecology is sometimes, called as environmental biology. In general, ecology is recognized as one of the natural sciences. It is considered to be a science concerned with the nature and the interrelations of living world. The term ecology has been derived from the Greek word “oikos” meaning ‘habitation’ or ‘house’ or ‘living place’. One of the first ecologists may have been Aristotle or perhaps his student, Theophrastus, both of whom had interest in many species of animals. Theophrastus described interrelationships between animals and between animals and their environment as early as the 4th century BC. Ecological thoughts are mostly derived from established concepts of philosophy, ethics, politics and natural history. Ancient Greek philosophers such as Hippocrates and Aristotle laid the foundations of ecology in their studies on natural history. Modern ecology became a much more rigorous science in the late 19th century. Evolutionary concepts relating to adaptation and natural selection became the lead areas of study. In its early stages, the field was dominated by scientists trained as botanists and zoologists.

Ecology is an interdisciplinary science

Ecology, as a unifying science, is integrating the knowledge of life on our planet. It has changed from a basic science to applied science. It has become an essential science in learning how life survive and grow. Several questions such as why do animals live in groups, what determines the distribution of a species, how does organism interact with biotic and abiotic components, behavioural aspects of animals often drive us to look into this subject. Ecology is not just biology but an interdisciplinary science that deals with the totality of living organisms and their relationship with the environment. Different kinds of physical, chemical and biological processes occurring within ecological systems involve complex interactions among different components of the system. To study these interactions, ecologists must involve other sciences like physiology, biochemistry, genetics, geology, hydrology and meteorology. Ecology has turned into more experimental rather than philosophical subject. With increasing scientific information, this science also involves complex mathematical modelling and algorithms – true interdisciplinary sciences (Mina, 2011).

Why it is Important to Study Ecology?

Existence in the world is made up of living and non living things. The two groups have to coexist in order to share the resources that are available within the environmental ecosystem. To understand about this mutual co relationship we need to study and understand ecology. Survival of all organisms is actualized due to ecological balance. Various species survive because favourable ecosystems were created. One core goal of ecology is to understand the distribution and abundance of living things in the physical environment. Attainment of this goal requires the integration of scientific disciplines inside and outside of biology, such as biochemistry, physiology, evolution, biodiversity, molecular biology, geology, and climatology. Some ecological research also applies many aspects of biology, geology, chemistry and physics, and it frequently uses mathematical models. Ecologists study these relationships among organisms and habitats of many different sizes, ranging from the study of microscopic bacteria growing in a fish tank, to the complex interactions between the thousands of plant, animal, and other communities found in a desert. Ecologists also study many kinds of environments. For example, ecologists may study microbes living in the soil under your feet or animals and plants in a rain forest or the ocean (https://www.researchgate.net/publication/335715336_INTRODUCTION_TO_ECOLOGY).

The fundamental principles of ecology

The general theory of ecology consists of seven fundamental principles. These principles were in place by the 1950s and were widely accepted by most ecologists after the coalescence of the field of ecosystem ecology and the cementing of the Modern Synthesis in evolutionary biology. Of course, the roots of all of the principles go back much further.

The first fundamental principle—the heterogeneous distribution of organisms—is a refinement of the domain. It encompasses the basic object of interest and its most important property. The heterogeneity of distribution is one of the most striking features of nature: all species have a heterogeneous distribution at some, if not most, spatial scales. Arguably, the origins of ecology as a discipline and the first ecological theories can be traced to its recognition (Forster 1778; von Humboldt 1808). This heterogeneous distribution is both caused by and a cause of other ecological processes. The fundamental principles are not independent causal mechanisms; rather, the mechanisms that they encompass interact.

The second fundamental principle—interactions of organisms—includes within it the vast majority of ecological processes responsible for heterogeneity in time and space. Many definitions of ecology are equivalent to this principle. Within this principle, particular interactions that are part of constituent theories act to unpack the general theory.

The third fundamental principle—contingency—represents either the inclusionary rule or the exclusionary rule, depending on views of the history of theories in ecology. We discuss the exclusionary nature of this principle at the time of its genesis. Since that time, recognition of the importance of contingency in all ecological processes has increased steadily and now appears in a wide variety of constituent theories and models. Contingency is an important cause of the heterogeneous distribution of organisms, both at very large extents of time and space (e.g., a particular species arose on a particular continent) and at very small extents (e.g., a seed lands in one spot and not another).

The fourth fundamental principle—environmental heterogeneity—is a consequence of processes from the domains of the earth and space sciences. For example, seasonal variation in temperature is the result of orbital properties of the Earth, whereas a variety of geophysical processes create heterogeneity in environmental stressors like salt (e.g., wave action near shores) or heavy metals (e.g., geologic processes that create differences in bedrocks). It is beyond the scope of this paper to detail all of those processes and their domains. Indeed, this principle encompasses many constituent theories and contains a broad class of underlying mechanisms for the heterogeneous distribution of organisms. As with the second principle, particular mechanisms pertain to particular constituent theories. Again, the fundamental principle captures a wide range of theories and mechanisms so as to provide a unifying framework.

The fifth principle—finite and heterogeneous resources— is again a consequence of processes from the domains of the earth and space sciences. Although variation in resources is similar to variation in environmental conditions, a fundamental distinction is the finite nature of these resources. Unlike an environmental condition, a resource is subject to competition. For example, seasonal variation in light and temperature are caused by the same orbital mechanisms, but light is subject to competition (e.g., one plant shades another), whereas temperature is a condition and not subject to competition. This distinction in the nature of environmental factors with regard to competitive processes can result in very different ecological outcomes (e.g., patterns of â diversity in plant communities, Scheiner and Rey-Benayas 1994). Whether a particular environmental factor is a condition or a resource can be context dependent. For example, water is sometimes a resource subject to competition (e.g., plants in a desert), and sometimes a condition (e.g., fish in the ocean) (Scheiner& Willing, 2008).

The sixth fundamental principle—the mortality of organisms—is the result of processes that come from the domain of organismal biology, physiology, and development. By “mortal” we mean that no organism is invulnerable, i.e., any organism might die as the result of predation, stress, or trauma. We do not mean by this principle that all organisms senesce. The senescence of organisms is a more narrow version of this principle that would apply to particular constituent theories. Although the majority of multicellular species apparently senesce, this has not been demonstrated for some multicellular species. We are not aware of an articulated theory of development or physiology that predicts the necessity of or conditions for senescence, but suspect that it could be accomplished given current knowledge of organisms. We will let philosophers argue whether a bacterium that splits into two represents a single, immortal organism or (our position) the end of one individual and the creation of two new individuals. This fifth principle, either in the more general version of vulnerability or in the more narrow version of senescence, forms the basis of a large number of constituent theories concerning phenomena as wide ranging as life histories, behavior, demography, and succession.

The seventh principle—the evolutionary cause of ecological properties—is the result of processes that derive from the theory of evolution. The inclusion of evolution within ecological thinking was an important outcome of the Modern Synthesis. Although evolutionary thinking about ecological processes goes back at least to Darwin (1859), evolutionary thinking had been infusing ecology more widely at least since the 1920s (Collins 1986; Mitman 1992) and its widespread acceptance occurred primarily in the latter half of the 20th century. The acceptance of this principle led to such disciplines as behavioral ecology and population biology, and the demise of the Clementsian super organism theory. It is in this latter capacity that this principle can be considered under the exclusionary rule and the causal rule.

Principles of Human Ecology

Human ecology is an interdisciplinary and trans-disciplinary study of the relationship between humans and their natural, social, and built environments. The philosophy and study of human ecology has a diffuse history with advancements in ecology, geography, sociology, psychology, anthropology, zoology, epidemiology, public health, and home economics, among others. Human ecology is the discipline that inquires into the patterns and process of interaction of humans with their environments. Human values, wealth, life-styles, resource use, and waste, etc. must affect and be affected by the physical and biotic environments along urban-rural gradients. The nature of these interactions is a legitimate ecological research topic and one of increasing importance. Human Ecology is the study of the interactions between man and nature in different cultures. Human Ecology combines the ideas and methods from several disciplines, including anthropology, sociology, biology, economic history and archaeology. Our multidisciplinary approach enables us to comprehensively address issues of environmental justice, sustainability and political ecology. Human Ecology studies human life and human activity in different ecosystems and different cultures in the present and in the past in order to gain a better understanding of the factors which influence the interaction between humans and their environment. The ambition to achieve a more complete view requires an integrated perspective that transcends traditional boundaries between the humanities, social sciences, natural sciences, and technology. A fundamental issue in human ecology is how people's cultural beliefs about the nature affect and are affected by their livelihoodsandthesocialorder(https://www.bhattadevuniversity.ac.in/docs/studyMaterial/Dr.BharatiGogoi_Geography/UG_4thSem_M_Human_ecology_by_Dr._Bharati_Gogoi.pdf).

Considerable disagreement exists within anthropology regarding the application of ecological concepts and principles to the study of human social behavior. Although many anthropologists have applied ecological concepts and principles in their study of human populations, (Gall and Saxe, 1977) other anthropologists have rejected such applications as largely naive and inappropriate uses of biological concepts (Vayda and McCay, 1975~ Bennett, 1980). Such disagreement even exists among anthropologists who have adopted an explicit ecological orientation (Moran& Herrera, 1984). Ecological anthropologists who view themselves as human ecologists generally see ecology as providing a testable framework for examining both human and non human social behavior within a unified theoretical perspective. Those who view themselves as cultural ecologists, on the other hand, are more likely to reject a strict application of ecological principles to the study of the human condition on the grounds that culture acts as a mediating force which renders human adaptation to the environment analytically distinct from that of all other species.

For cultural ecologists, ecology serves more as an orientation for the study of human environmental relations than as an operational set of theoretical principles which can be used to explain specific human social behaviors. This is clearly illustrated by the history of the use of such concepts as niche and ecosystem in the anthropological literature. For the most part, these concepts have been extended to human populations completely separated from the theoretical systems from which they derive their utility and meaning. They have, instead, mostly served as metaphors organizing a largely functionalist view of human environmental relations among preliterate non-western peoples (Vaidya & Rappaport, 1968).

Human ecology: Basic Definition

Human ecology is the study of the interactions of humans with their environments, or the study of the distribution and abundance of humans. This definition is based directly on conventional definitions of biological ecology. Ecology is usually defined as the study of interactions of organisms with their environments and each other. More pointedly, it can be defined as the study of the distribution and abundance of organisms. This definition is deceptive. It implies much more than it says explicitly because virtually everything that human are or do (and the same goes for any species) affects their distribution and abundance. Thus, using the term "human ecology" actually expresses a broad ambition to understand human behavior (Odum, 1968; Odumei al., 2005). So, it is the study of the relationships between humans and their environments is a field with a large scope and complex history. It arose out of multiple disciplines—animal biology, anthropology, geology, ecology, and sociology—in the early 1900s as scientists struggled to make sense of the impact of humans on the man-made and natural environment and the impact of environments on the social systems of humans. Human ecology is also viewed by many as a methodology or framework for studying human activities and social institutions, often in conjunction with the health and functioning of the natural environment (Jaiswal, 2013).

The Origins of Human Ecology

Since ancient times there have been many attempts to explain events in terms of environmental influences on human behavior. Astrology represents one early system of thought relating environmental forces to human actions. Although wholly discredited as a scientific theory by modern astronomy, the belief that the movement of the stars controls human destiny retains a strong hold on the popular imagination, as evidenced by the appearance of astrological advice columns in many daily newspapers. In a vein more compatible with modern scientific thought, the ancient Greek philosophers recognized that man was both influenced by nature and a force for change in the environment. It was suggested, for example, that the different forms of political organization of the Greek city states and the Eastern empires reflected the influences o f climate on the personalities of their citizen. This theme later was developed by Montesquieu and other French writers of the Enlightenment and advocated in recent times by the American geographer Samuel Huntington. Other classical writers commented on the destruction of the natural landscape of Attica and North Africa resulting from deforestation and overgrazing, a theme taken up in the mid-1800s by George P. Marsh, whose book, Man and Nature, or, Physical Geography as Modified by Human Action was a precursor of the ecological catastrophe writings so popular recently.

These early writings, however, were generally anecdotal rather than presenting a coherent theory of human-environment relationships. It was only with the development of geography and anthropology as scientific disciplines in the latter part of the nineteenth century that human ecology became the subject of systematic study. The first theoretical approach to be tried, however, was that of environmental determinism—a false starts that greatly retarded subsequent development of human ecology (Bennett, 1996).

Scope of Human Ecology

Human ecology has been defined as a type of analysis applied to the relations in human beings that was traditionally applied to plants and animals in ecology. Toward this aim, human ecologists (which can include sociologists) integrate diverse perspectives from a broad spectrum of disciplines covering wider points of view. Scopes of topics in human ecology are:

i. The role of social, cultural, and psychological factors in the maintenance or disruption of ecosystems;

ii. Effects of population density on health, social organization, or environmental quality;

iii. New adaptive problems in urban environments;
iv. Interrelations of technological and environmental changes;
v. The development of unifying principles in the study of biological and cultural adaptation;
vi. The genesis of mal-adaptions in human biological and cultural evolution;
vii. Genetic, physiological, and social adaptation to the environment and to environmental change;
viii. The relation of food quality and quantity to physical and intellectual performance and to demographic change;
ix. The application of computers, remote sensing devices, and other new tools and techniques

While theoretical discussions continue, research published in Human Ecology Review suggests that recent discourse has shifted toward applying principles of human ecology. Some of these applications focus instead on addressing problems that cross disciplinary boundaries or transcend those boundaries altogether. Human ecology is neither anti-discipline nor anti-theory, rather it is the ongoing attempt to formulate, synthesize, and apply theory to bridge the widening schism between man and nature. This new human ecology emphasizes complexity over reductionism, focuses on changes over stable states, and expands ecological concepts beyond plants and animals to include people.

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UNIT: - 5

Concept of Environmental System, Environmental Balance and Environmental Degradation

Introduction

Everything that surrounds or affects an organism during its life time is collectively known as its environment or simply put everything surrounding a living organism like people; place and things constitute its environment which can be either natural or man-made. The word environment has been derived from a French word ‘environner’ meaning to encircle or to surround. In the beginning, environment of early man consisted of only physical aspects of the planet earth such as land (lithosphere), air (atmosphere) and water (hydrosphere) along with biotic communities but, with the passage of time and advancement of society man extended his environment to include his social, economic and political functions too. At the organismic level it is essentially physiological interaction which tries to understand that how different organisms are adapted to their environment in terms of not only survival but also reproduction and propagation of their population.

All organisms (from virus to man) are obligatorily dependent on the environment for various essential needs such as food, shelter, water, oxygen etc. The surrounding that affects an organism during its lifetime is collectively known as its environment. In another words “Environment is sum total of water, air and land inter-relationships among themselves and also with the human being, other living organisms and material goods”. It comprises all the physical and biological surrounding and their connections. Environmental studies give an approach towards understanding the environment of our globe and the impact of human life upon the environment and vice-versa. Thus environment is actually universal in nature and it is a multidisciplinary subject counting physics, chemistry, geology, geography, history, economics, physiology, biotechnology, remote sensing, geophysics, soil science and hydrology etc. Environment belongs to all the biotic and abiotic components and therefore is, vital for all. Consequently, everyone is affected by environmental issues like global warming, depletion of ozone layer, dwindling forest, depleting energy resources, loss of biodiversity etc. Environment also deals with the analysis of the processes in hydrosphere, atmosphere, lithosphere, and organisms which leads to pollute biosphere. Environment helps us for setting benchmark for safe and healthy natural ecosystem (http://www.dspmuranchi.ac.in/pdf/Blog/satyapriya52dspmucomS12.pdf).

Environmental System Conception

The conception of systems is very general. In system science it is used to analyze complexity, to bring a greater amount of transparency into the interaction of parts. It maps the flow of information or energy or material etc. through the complex system. It is based on the decomposition of the complex system into subsystems. The chosen subsystems should be simple to handle. Mostly, they are object-orientated. The topology of the real object determines the structure of the mapped system. Systems are characterized by inputs and outputs. They can be controlled via the inputs and observed via the outputs. The difficulty of analysing and especially forecasting the environment consists in the fact that man as an actor is himself part of the complex environmental system/complex ecosystem – the biosphere. The concept of systems builds a bridge between the world of real objects and mathematics. Typical terms of systems methodology are linear and nonlinear systems, continuous and discrete systems, lumped parameter and distributed parameters, automata, events, hierarchical systems etc. Terms of modelling are systems identification, and parameter estimation, input and output analysis sensitivity analysis, uncertainty, fuzzy sets, control, decision making, etc.

Systems analysis requires to design a conceptual model consisting of sub models. The conceptual model is a plan for mathematical modelling. Mathematical modelling is based on measurement before or during the control process. Modelling is not a purpose for itself. Its focus is to solve problems and according to the problems, selected models are developed. Some models are developed only for one problem. Generally, the systems approach provides models for control, decision and planning processes. Vice versa one physical object would be modelled by different descriptions. So, the term environmental system is more or less a synonym for models describing a set of models. Naturally, the selection/choice of a model starts with the topology of the environmental object and generally with the analysis of the planning/decision/control/problem (Sydow, 2004).

Complexity of Environmental Systems

The complexity of environmental systems is known to all who need to make decisions in the management of plants, in environmental politics or in the study of global change, etc. (Figure 2). The complexity is inherent in the nonlinearity of mathematical models, the dynamic and stochastic nature of natural resource problems, the multipurpose, multi-objective attributes of decision problems. The complexity is also caused by the natural coupling and interaction of parts of the biosphere. The complexity depends also on problems of measuring, transmitting, processing and analysing data and the decision-making process under environmental, technical, institutional, economic and political aspects. Systems methodology provides theoretical and computational tools for modelling, analysing, understanding and controlling, optimizing or planning complex, environmental systems. The systems approach brings transparency into the interactions of the system's parts. Simulation tools support numerical insights into the system behaviour. The idea of sustainable development is the overall goal in treating the biosphere and its parts, which takes into consideration their high complexity (Sydow, 2004).

Environmental Systems Analysis

Decisions are made based on information of different kinds. Several tools have been developed to facilitate the inclusion of environmental aspects in decision making on different levels. Which tool to use in a specific decision making situation depends on the decision context. This thesis discusses the choice between different environmental systems analysis (ESA) tools and suggests that key factors influencing the choice of ESA tool are object of study, impacts considered and information type regarding site specificity and according to the DPSIR framework. Waste management in Sweden is used as an example to illustrate decision making situations, but discussions concerning choice of tools are also thought to be of general concern. It is suggested that there is a need for a number of ESA tools in waste management decision making. Procedural tools like Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) should be used e.g., by companies applying for development of waste management facilities and by public authorities preparing plans and programmes. Within these procedural tools analytical tools providing relevant information could be used, e.g., Risk Assessment (RA), Life Cycle Assessment (LCA) or Substance Flow Analysis (SFA). Analytical tools may also be used separately. If the decision making situation concerns a choice between different waste management options, such as recycling, incineration and landfilling, environmental aspects could be assessed using LCA or Material Input Per Unit Service (MIPS).

To study certain substances within the waste system, RA or SFA could be used. An LCA of different strategies for treatment of municipal solid waste was made. A conclusion from this study is that the waste hierarchy is valid as a rule of thumb. Suggestions resulting from this study are that decisions promoting recycling of paper and plastics should be pursued, preferably in combination with decisions promoting the use of plastics replacing plastics made from virgin sources. The study further identifies a need for limiting transportation by private car for options requiring source separation of waste. When recycling is not an alternative, incineration is in general preferable to landfilling. Key issues that may affect the ranking of the waste treatment options include alternative energy sources, the material the recycled material replaces and the time perspective chosen. It is suggested that LCA may be a useful tool in waste management, both on its own and as a part of an SEA. Results from LCAs can provide advice on ranking of alternatives. More importantly, key assumptions and value choices that may influence the rankings can be highlighted and thus made clear to the decision makers. In general, LCA results are not site specific and provide information in the form of potential environmental impacts, and thus could be combined with other tools if other type of information is needed (Moberg, 2006).

Environmental Balance

The Environmental Balance describes trends in the state of the environment in the Netherlands and the effectiveness of the policies pursued. It also evaluates the degree to which the stated goals of environmental policy have been achieved.

In the universe there is enormous diversity and variety of form and function. The various elements of universe fulfil human welfare. God has created everything in universe in due proportion and measure. Man is part of this universe the elements of which are complementary to one another. All of the resources upon which life depends have been created by God as a trust in our care. In Islam the utilization of these resources is the right and privilege of all people and all species. Butat the same time it necessarily involves an obligation on man’s part to conserve these resources.It follows that man has no right to cause degradation of environment or its alteration making unfavourable for life on earth. Whereas abuse of resources is categorically prohibited it also implies its conservation of natural resources and development thereof (Anjum & Wani, 2018).

Environmental balance is achieved through the following processes or ways (https://stoplearn.com/environmental-balance/):

1. Hydrological (water) cycle
2. Carbon cycle

- Mineral nutrient cycle.

1. Nitrogen cycle
2. Food chain and food web

Hydrological (water) cycle

1. This is the natural exchange or circulation of water between the oceans, the atmosphere and the land
2. The atmosphere receives water through:
3. Evaporation from ocean, rivers and from land
4. transpiration form plants,
5. breathing or respiration by plants and animals.

Importance of Water Cycle or Hydrological Cycle and Interdependence

1. water is an important agent of weathering of rocks
2. water helps to dissolve plant nutrients in solutions for easy absorption by plants

- water is also required by plants for photosynthesis

1. all living organism require water for normal life processes
2. transpiration by plants aids cooling of the plants

Carbon Cycle

Carbon cycle involves the series of processes which contributes to the circulation of carbon in nature. Carbon is circulated in form of carbon dioxide

Loss of carbon from the air

1. Carbon dioxide is removed from the air during photosynthesis as green plants use it to manufacture their food
2. Carbon is also lost in form of carbonates of calcium and magnesium through leaching and drainage

Gain of Carbon in the air: The atmosphere gains carbon dioxide through:

1. Burning of fuel like coal, wood and petrol
2. The action of volcanoes which release carbon dioxide

- Through respiration by plants and animals

1. The dead, decaying and putrefaction of plants and animals.

Importance of Carbon Cycle (carbon cycle and interdependence)

1. Carbon cycle provides carbon dioxide which is an important gas in the atmosphere
2. Plants depend on carbon dioxide for photosynthesis

- Carbon dioxide trapped in the leaves with the presence of sunlight is used to manufacture food

1. Animals, therefore, depend on plants either directly or indirectly for their food
2. Animals take in oxygen and release carbon dioxide to the atmosphere
3. Plants absorb carbon dioxide and release oxygen during photosynthesis.

- **Nitrogen Cycle**
- Nitrogen cycle involves the complex process by which nitrogen is circulated between the atmosphere, soil plants and animals
- Plants can only use nitrogen in form of nitrate.

Soil and plants gain nitrogen through

- Symbiotic nitrogen fixation: Through the root nodules of leguminous plants with the aid of some bacteria
- Electrical discharge: When oxygen combines with nitrogen in the atmosphere to form nitrate during lightning.
- Non-symbiotic nitrogen fixation: With the aid of some bacteria, nitrogen is fixed aerobically or an aerobically into the soil.
- Ammonification and nitrification: Ammonification involves the conversion of dead and decaying organic matter into ammonium compounds while nitrification converts the ammonium compound first into nitrite and finally into nitrate with the aid of some bacteria
- Application of organic manure and nitrogen fertilizers: these add nitrogen into the soil

Loss of Nitrate from the Soil

- Denitrification: This is the major way by which nitrate in the soil is lost by its conversion to gaseous nitrogen with the aid of some denitrifying bacteria
- Other methods include leaching, erosion, soil Ph, crop removal, etc.

Importance of Nitrogen Cycle (nitrogen cycle and interdependence)

- It provides nitrogen which is an important gas in the atmosphere
- It provides nitrate which is the main source of protein synthesis in plants
- Nitrate is used to produce proteins for animals
- It also provides food for micro-organisms in the root nodules of legumes
- The bacteria in turn decompose plants and animals tor release nutrients when they die.
- **Mineral Nutrient Cycle**
- This refers to the circulation of mineral nutrients between plants and the soil
- These mineral nutrients include calcium, iron, sulphur, zinc, sodium, phosphorus and potassium.

Mineral Nutrient Cycle and Interdependence

1. Plants absorb these nutrients from the soil for growth and production
2. When plants die, they decay and the nutrients are returned to the soil

- The decomposition and release of nutrient are aided by micro-organisms in the soil.

Food Chain Trophic Level and Food Web

Definition: Food chain is defined as the linkage of a series of organism in a habitat through the flow of energy of consumer levels and their nutritional sequence. In other words, food chain involves energy transfer in which each organism feeds on the one before it in a sequence. Examples of food chain are as follows:

1. Grass - sheep - main
2. Grass - grasshopper - toad - snake - hawk

- Diatoms - euglena - water fleas - tilapia

The first in each group is usually called **autotroph (or producer)** e.g. grass, while the next e.g. sheep is called the **primary consumer** while the last e.g. man is called the **secondary consumer.**

Trophic level

Trophic level refers to the feeding stages found in a food chain, e.g.

Grass - grasshopper - toad - snake - hawk

The above food chain has five trophic levels.

Food web

Definition: Food web is a complex feeding relationship of organism made up of many interrelated food chains. It involves a wider range of energy transfer. The food web in fig. 50.4 contains five different food chains.

Environmental Interventions

Meaning: Environmental intervention refers to the forces of nature and the activities of man that alter the natural existence of the components of the ecosystem

Types of Environmental intervention

There are two types of interventions in our environment. These are natural and human interventions.

- Natural interventions: natural intervention is caused by a number of natural processes which include:

1. Desert encroachment
2. Sea level changes

- Tectonic movement

1. Volcanism
2. Earthquakes
3. Climatic changes

- Drought
- Hurricane

1. Flooding

The effects of these natural intervention include:

1. New features different from those initially there are produced e.g. volcanism creates volcanic mountains
2. Changes in the landscape of the area e.g. earthquake will result in digging trenches and gullies where it was not initially present.

- Raising and lowering of beaches

1. Widespread destruction or extinction of aquatic life e.g. drought results in drying up the water and this will lead to the extinction of water animals
2. Displacement of animals
3. Displacement of man.

- Human intervention: Man has interfered with the ecosystem through many of his activities. This human (man) intervention include the following:

1. Deforestation
2. Pollution

- Mining/quarrying

1. Cloud seeding
2. Hunting
3. Urbanization

- Land reclamation
- Farming activities, e.g. burning

1. Construction
2. Fishing
3. Industrialization

- Grazing

Some of these interventions are now discussed in detail.

- Deforestation

1. Deforestation causes increased runoff and flooding
2. It leads to destruction of natural habitat

- It leads to changes in energy balance

1. It leads to erosion and reduction in rainfall.

- Land reclamation

1. It leads to less rainfall
2. It changes the drainage pattern

- It reduces the amount of soil moisture content

1. It leads to loss of some organism and plants

- Pollution (soil, water, atmospheric and noise)

1. Atmospheric and water pollution destroy plants and animals
2. Oil spillage and water polluting alter the type of plant that can grow in an area

- Land pollution exposes the soil surface

1. It leads to changes in the chemical composition of the soil, e.g. chemicals used in agricultural practises such as fertilizer
2. It can also lead to reduction in agricultural land.

- Grazing

1. Overgrazing leads to reduction in agricultural land
2. It depletes the vegetative cover of the soil

- It leads to soil compaction through excessive trampling by animals

1. It destroys the soil structure and causes soil erosion

- Farming activities e.g. Burning

1. It causes the destruction of weeds
2. It burns the organic matter content of the soil

- It causes the destruction of pest and natural habitat

1. Some may be harmful to man
2. It can also lead to soil erosion

- Mining

1. Mining causes pollution of the land
2. Ti causes the reduction of farm lands

- It leads to pollution of surface and underground water

1. It also leads to disintegration of settlement

- Urbanization

1. It causes reduction in agricultural land
2. Wastes produced can cause pollution

- It can lead to loss of some organism and plants

1. It exposes the soil to erosion and flooding

- Construction

1. It destroys the soil structure
2. It can cause soil erosion

- It can also kill plants and animals

Environmental Degradation

The environment is something we are very familiar with. It's everything that makes up our surroundings and affects our ability to live on the earth. Environmental degradation is a very serious problem worldwide which covers a variety of issues including pollution, biodiversity loss, and animal extinction, deforestation and desertification, global warming, and a lot more (Brown et al., 1987; Tian et al., 2004). The environmental degradation is deterioration of the environmental through depletion of resources which includes all the biotic and abiotic element that form our surrounding that is air, water, soil, plant, animals, and all other living and non-living element of the planet of earth (Bourque et al., 2005; Malcolm and Pitelka, 2000). Environmental degradation is also having a useful aspect, more new genes have been created, and some species have grown as someone have declined. For natural selection, species are constantly regenerating as the environment changes, and human activity is the main driver's power. Human is also a product of nature; this shift is to natural replacement.

Most of the people about three-fourths of its population depends directly for their livelihood on activities based on natural resource and the remainder of the population relies on these resources directly for food, fuel, industrial output, and recreation. Most of the natural resources including the environment in India are in a serious state of degradation. The use of agriculture fertilizer is a major factor for the degradation of soil quality, soil erosion, salinity and general loss of fertility of agricultural land as well as the loss of the production of the quality crop. Similarly, groundwater aquifers are overexploited in many arid and semi-arid areas, surface water sources are highly polluted and consequently, water for drinking and irrigation is increasingly getting scarce and polluted. Fishery yields are declining, and air quality is deteriorating. Increasing levels of air, water, and land pollution pose a serious threat to human health and longevity (Malik et al., 2014; Yadav et al., 2019). Good environmental management is essential for economic growth and development. It is not a sometime mistakenly asserted just a luxury for wealthy countries concerned with aesthetics. Climate change and environmental degradation affect all types of development projects in all countries. If the development agencies are seriously contributing to the reduction of poverty in the communities in which they work, they must give consideration to the climatic and environmental hazards which impact their projects. Climate change and environmental degradation are proceeding rapidly and are already affecting many communities in developing countries. O'Neill et al. (2010) reported that slowing population growth could provide 16-29% of the emissions reductions, and suggested to be necessary by 2050 to avoid dangerous climate change. His study in 35 countries suggested that, slowed population growth could save 1.4 to 2.5 billion tons of carbon emissions per year by 2050, certainly help to solve the climatic problem.

Causes of Environmental Degradation

The major causes of the environmental degradation are modern urbanization, industrialization, over-population growth, deforestation etc. Environmental pollution refers to the degradation of quality and quantity of natural resources. Various types of the human exercises are the fundamental reasons of environmental degradation. These have prompted condition changes that have turned out to be hurtful to every single living being. The smoke radiated by the vehicles and processing plants expands the measure of toxic gases noticeable all around. The waste items, smoke radiated by vehicles and ventures are the fundamental driver of contamination. Spontaneous urbanization and industrialization have caused water, air and sound contamination. Urbanization and industrialization help to expand contamination of the wellsprings of water. So also, the smoke discharged by vehicles and ventures like Chlorofluorocarbon, nitrogen oxide, carbon monoxide and other clean particles dirty air. Neediness still remains an issue at the base of a few ecological issues (Chopra, 2016).

A. Social Factors

1. Population: - The rapid population growth and economic development in country are degrading the environment through the uncontrolled growth of urbanization and industrialization, expansion and intensification of agriculture and the destruction of natural habitats. One of the significant reasons for environmental degradation in India could be ascribed to quick development of population which is antagonistically influencing the natural resources and condition. The developing population and the ecological weakening face the test of maintained improvement without natural harm. The presence or the nonattendance of ideal characteristic assets can encourage or hinder the procedure of economic development. Population is an important source of development, yet it is a major source of environmental degradation when it exceeds the thresh hold limits of the support systems. Unless the connection between the multiplying population and the existence emotionally supportive network can be settled, improvement programs, howsoever, imaginative are not prone to yield wanted outcomes.

Population impacts on the environment primarily through the use of natural resources and production of wastes and is associated with environmental stresses like loss of biodiversity, air and water pollution and increased pressure on arable land. The increase in population has been due to the improvement in health conditions and control of diseases. The density of population has gone up from 117 in 1951 to 312 in 2001 and further to 382 persons in 2011 per square kilometer. A few push and draw factors are ventured to be agent towards trouble out relocation from rural to urban regions. This may be because of the declining asset accessibility per capita and contracting financial open doors in rural territories and better monetary openings, wellbeing and instructive offices and so on in urban regions giving chances to more elevated amount of human capital improvement could be the basic variables for country out movement. India supports 17 per cent of the world population on just 2.4 per cent of world land area.

2. Poverty: - Poverty is said to be both cause and effect of environmental degradation. The round connection amongst poverty and environment is a to a great degree complex marvel. Imbalance may cultivate un sustainability in light of the fact that poor people, who depend on normal assets more than the rich, drain characteristic assets quicker as they have no genuine prospects of accessing different kinds of assets. As the 21st century starts, developing number of individuals and rising levels of utilization per capita are draining regular assets and corrupting the earth. The poverty-environmental damage nexus in India must be seen in the context of population growth as well. The pressures on the environment intensify every day as the population grows. The fast increment of human numbers joins with urgent poverty and rising levels of utilization are draining natural resources on which the vocation of present and future ages depends. Poverty is amongst the consequences of population growth and its life style play major role in depleting the environment either its fuel demands for cooking or for earning livelihood for their survival. The unequal dispersion of assets and constrained open doors cause push and force factor for individuals living underneath poverty line that results in overburdened the population thickness in urban zones and condition get controlled by manifolds, subsequently, urban ghettos are produced in urban zones. Moreover, degraded environment can accelerate the process of impoverishment, again because the poor depend directly on natural assets. Although there has been a significant drop in the poverty ratio in the country from 55 percent in 1973 to 36 percent in 1993-94 and further to 27.5 per cent in 2004-05. The absolute number of poor has also declined from 320 million in 1993-94 to 301 million in 2004-05.

3. Urbanization: - Urbanization in India started to quicken after freedom because of the nation's reception of a blended economy which offered ascend to the advancement of the private area. Urbanization is occurring at a quicker rate in India. Population living in urban territories in India, as per 1901 statistics, was 11.4%. This tally expanded to 28.53% as indicated by 2001 enumeration, and intersection 30% according to 2011 evaluation, remaining at 31.16%. As indicated by a review by UN State of the World Population report in 2007, by 2030, 40.76% of nation's population is required to dwell in urban zones. According to World Bank, India, alongside China, Indonesia, Nigeria, and the United States, will lead the world's urban population surge by 2050. Lack of opportunities for gainful employment in villages and the ecological stresses is leading to an ever-increasing movement of poor families to towns. Such fast and spontaneous extension of urban areas has brought about debasement of urban condition. It has extended the hole amongst request and supply of infrastructural administrations, for example, vitality, lodging, transport, correspondence, instruction, water supply and sewerage and recreational pleasantries, along these lines exhausting the valuable ecological asset base of the urban areas. The outcome is the developing pattern in decay of air and water quality, age of squanders, the expansion of ghettos and bothersome land utilize changes, all of which add to urban poverty.

B. Economic Factors

Environmental degradation, to a large scale, is the result of market failure, namely the non-existent or poorly functioning markets for environmental goods and services. In this unique situation, environmental degradation is a specific instance of utilization or generation externalities reflected by uniqueness amongst private and social costs/benefits. Absence of very much characterized property rights might be one reason for such market disappointment. Then again, showcase contortions made by value controls and endowments may irritate the accomplishment of environmental goals.

The level and pattern of economic development also affected the nature of environmental problems. India's development objectives have consistently emphasized the promotion of policies and programmes for economic growth and social welfare. The production innovation received by the vast majority of the ventures has set an overwhelming burden on condition particularly through concentrated asset and vitality use, as is clear in common asset consumption (petroleum derivative, minerals, timber), water, air and land sullying, wellbeing risks and debasement of characteristic eco-frameworks. With high extent petroleum derivative as the fundamental wellspring of modern vitality and real air contaminating enterprises, for example, iron and steel, composts and bond developing, mechanical sources have added to a generally high offer in air pollution.

Large quantities of industrial and hazardous wastes brought about by expansion of chemical-based industry have compounded the wastes management problem with serious environmental health implications. Transport exercises have a wide assortment of consequences for the earth, for example, air pollution, noise from street activity and oil slicks from marine delivery. Transport foundation in India has extended impressively as far as system and administrations. In this way, street transport represents a noteworthy offer of air contamination stack in urban areas, for example, Delhi. Port and harbourextend mostly effect on touchy waterfront eco frameworks. Their development influences hydrology, surface water quality, fisheries, coral reefs and mangroves to shifting degrees.

Direct impacts of agricultural development on the environment arise from farming activities which contribute to soil erosion and loss of nutrients. The spread of green revolution has been joined by finished misuse of land and water assets, and utilization of manures and pesticides have expanded numerous overlap. Shifting cultivation has also been an important cause of land degradation. Leaching from extensive use of pesticides and fertilizers is an important source of contamination of water bodies. "Intensive agriculture and irrigation contribute to land degradation particularly salination, alkalization and water logging" (Economic Survey, 1997-98).

C. Institutional Factors

The Ministry of Environment & Forests (MOEF) in the Government is responsible for protection, conservation and development of environment. The Ministry works in close coordinated effort with different Ministries, State Governments, Pollution Control Boards and various logical and specialized establishments, colleges, nongovernmental associations and so on.

Environment (Protection) Act, 1986 is the key legislation governing environment management. Other important legislations in the area include the Forest (Conservation) Act, 1980and the Wildlife (Protection) Act, 1972. The shortcoming of the current framework lies in the implementation abilities of natural foundations, both at the middle and the state. There is no effective coordination amongst various Ministries/Institutions regarding integration of environmental concerns at the inception/planning stage of the project. Current policies are also fragmented across several Government agencies with differing policy mandates. Absence of prepared work force and far-reaching database postpone numerous activities.

The greater part of the State Government organizations are moderately little experiencing deficiency of specialized staff and assets. Although overall quality of Environmental Impact Assessment (EIA) studies and the effective implementation of the EIA process have improved over the years, institutional strengthening measures such a straining of key professionals and staffing with proper technical persons are needed to make the EIA procedure a more effective instrument for environment protection and sustainable development.

D. Land Degradation

Land degradation is any change or disturbance to the land perceived to be undesirable. Land degradation can be caused by both manmade and natural reasons such as floods and forest fires. It is estimated that up to 40 per cent of the world's agricultural land is seriously degraded. The main causes of the land degradation include climate change, land clearance and deforestation, depletion of soil nutrients through poor farming practices, overgrazing and over grafting. In India, water erosion is the most prominent reason of land degradation. The growing trends of population and consequent demand for food, energy, and housing have considerably altered land-use practices and severely degraded India's environment. The growing population put immense pressure on land intensification at cost of forests and grazing lands because the demand of food could not increase substantially to population. Thus, horizontal extension of land has fewer scopes and relies mostly on vertical improvement that is supported by technical development in the field of agriculture i.e. HYV seeds, Fertilizers, Pesticides, Herbicides, and agricultural implements. All these practices are causing degradation and depletion of environment.

E. Air Pollution

Air pollution in India is a serious issue with the major sources being fuel wood and biomass burning, fuel adulteration, vehicle emission and traffic congestion. Air pollution is also the main cause of the Asian brown cloud, which is causing the monsoon to be delayed. India is the world's largest consumer of fuel wood, agricultural waste and biomass for energy purposes. Traditional fuel (fuel wood, crop residue and dung cake) dominates domestic energy use in rural India and accounts for about 90 per cent of the total. In urban areas, this traditional fuel constitutes about 24 per cent of the total. Fuel wood, agri-waste and biomass cake burning releases over 165 million tons of combustion products into India's indoor and outdoor air every year. These biomass-based household stoves in India are also a leading source of greenhouse emissions contributing to climate change.

On per capita basis, India is a small emitter of carbon dioxide greenhouse. In 2009, IEA estimates that it emitted about 1.4 tons of gas per person, in comparison to the United States' 17 tons per person, and a world average of 5.3 tons per person. However, India was the third largest emitter of total carbon dioxide in 2009 at 1.65 Gt per year, after China (6.9 Gt per year) and the United States (5.2 Gt per year). With 17 percent of world population, India contributed some 5 percent of human-sourced carbon dioxide emission; compared to China's 24 percent share.

Effects of environmental degradation

The environmental degradation is the deterioration of the environment through depletion of resources which includes all the biotic and abiotic element that form our surrounding that is air, water, soil, pant animals, and all other living and non-living element of the planet of earth. The major factor of environmental degradation is human (modern urbanization, industrialization, overpopulation growth, deforestation, etc.) and natural (flood, typhoons, droughts, rising temperatures, fires, etc.) cause. Today, different kinds of human activities are the main reasons for environmental degradation. The automobile and industries increase the number of poisonous gases like SOx, NOx, CO, and smoke in the atmosphere. Therefore, the government must enhance filling the gap in the legal system to avoid illegal activities. This chapter discusses the impact of environmental degradation with its future impacts, city planners, industry, and resource managers plan to be considered to mitigate the long-term effects of developmental environmental degradation (Maurya et al., 2020). The major impacts are: -

Impact on Human Health

The greatest effects on the health of individuals and populations result from environmental degradation. Human health might be at the receiving end as a result of the environmental degradation. Areas exposed to toxic air pollutants can cause respiratory problems like pneumonia and asthma. Millions of people are known to have died of due to indirect effects of air pollution. Air pollution Indian cities are among the most polluted in the world. Air in metropolitan cities has become highly polluted and pollutant concentrations exceeds limit considered safe by the World Health Organization (WHO). Suspended particulate levels in Delhi are many times higher than recommended by the World Health Organization (WHO). The urban air pollution has grown across India in the last decade is alarming. Some of the most important air pollutants are residual suspended particulate matter (RSPM), suspended particulate matter (SPM), nitrogen dioxides (NO2), carbon monoxide (CO), lead, sulphur dioxide (SO2) etc. The main factors account to urban air quality deterioration are growing industrialization and increasing vehicular pollution, industrial emissions, automobile exhaust and the burning of fossil fuels kills thousands and lives many more to suffer mainly from respiratory damage, heart and lung diseases. In the countryside, nitrates from animal waste and chemical fertilizers pollute the soil and water, and in the cities, the air is contaminated with lead from vehicle exhaust. In India’s largest cities - Mumbai and Delhi - about one-half of children under age 3 show signs of harmful exposure to lead, defined as to or more micrograms of lead per decilitres of blood. The illness and pre-mature deaths due to ambient suspended particulate matter (SPM) in the air in mega cities of Calcutta, Chennai, Delhi and Mumbai have risen significantly in less than five years. The indoor air pollution may pose an even greater hazard for human health. Cooking and heating with wood, crop residues, animal dung, and low-quality coal produce smoke that contains dangerous particles and gases. When fuels such as these are burned indoors, using inefficient stoves and poor ventilation, they can cause tuberculosis, other serious respiratory diseases, and blindness (Chopra, 2016).

Loss of Biodiversity

Biodiversity is important for maintaining balance of the ecosystem in the form of combating pollution, restoring nutrients, protecting water sources and stabilizing climate. The main cause of loss of biodiversity are deforestation, global warming, overpopulation and pollution are few of the major causes for loss of biodiversity. In fact human beings have deeply altered the environment, and have modified the territory, exploiting the species directly, for example by fishing and hunting, changing the biogeochemical cycles and transferring species from one area to another.

Poverty

In the majority of developing countries, poverty is attributed to poor crop harvests and lack of quality natural resources that are needed to satisfy basic survival needs. The inadequacy basic survival resources and lack of quality of food is the direct result of environmental degradation in the regions. Most vulnerability situations brought about by water shortages, climate change, and poor crop yields in developing countries are tied to environmental degradation. Hence, the lack of access to adequate basic needs such as water and food directly induce poverty.

Atmospheric Changes

Environmental degradation can alters some of the natural process such as the water cycle and the normal processes of animal and plant activities. Also, environmental degradation aspects such as deforestation and mining destroy the natural land cover. This, together with air, water, and land pollution pose several atmospheric alteration threats. The alterations include global warming and climate change which can increase the risks of climatic natural disasters, and ozone layer depletion which increases the risk of skin cancer, eye disease, and crop failure.

Ozone Layer Depletion

Ozone layer is responsible for protecting earth from harmful ultraviolet rays. The most important reason for ozone layer depletion is the production and emission of chlorofluorocarbons (CFCs). This is what which leads to almost 80 percent of the total ozone layer depletion. There are many other substances that lead to ozone layer depletion such as hydro chlorofluorocarbons (HCFCs) and volatile organic compounds (VOCs). Such substances are found in vehicular emissions, by-products of industrial processes, aerosols and refrigerants. All these ozone depleting substances remain stable in the lower atmospheric region, but as they reach the stratosphere, they get exposed to the ultra violet rays. This leads to their breakdown and releasing of free chlorine atoms which reacts with the ozone gas, thus leading to the depletion of the ozone layer. Global warming is another result of environmental degradation (Chopra, 2016).

Loss of Ecotourism

The environment and ecological features are beautiful enough to attract tourists towards it. Natural disasters, the greenhouse effect, deforestation, and increased endangered species are the causes of loss of tourism and affect the economy to a large extent.The pollution on the beach and the gradual accumulation of wastes also causes distractions. A report said that the tourism sector loses 50% of its income from tourists. Many people are also losing their livelihood for this.

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UNIT: - 6

Carrying Capacity of the Environment

Introduction

The concept of carrying capacity is derived from ecology, with widespread contentions of its theoretical connotations and applications in the international academic community, especially the impact of human activities on the environment. Disputes on carrying capacity have been occurring not only among biologists and ecologists, but also among mainstream economists. Based on their efforts, the author makes an attempt to describe its origin, connotations, problems, measurement, and at the same time note the latest international progress in this field. At first glance, "carrying capacity" seems like a fairly straightforward concept. Bridges are engineered to a specified load-bearing capacity; ocean-going freighters can carry only so much cargo. When it comes to ecosystems, ecologists speak of the maximum population deer or elk that can be supported indefinitely in a defined habitat without permanently impairing its productivity and any old-time dairy farmer knew just how many cows he could safely graze on the back forty without wrecking the pasture. It therefore doesn't seem like much of a stretch to estimate the human carrying capacity of a region or a country – or even the whole Earth. Look again. The demands of non-human species on their habitats are fixed and limited to food and sometimes shelter, the simplest of material requirements. However, human demands are hardly simple and are constantly evolving. Thus, when biologist Joel Cohen asked, "How many people can the Earth support?", he was able to find published answers ranging across three orders of magnitude, from less than a billion to over a trillion – a thousand billion! Some analysts argue that the present population of six billion is already several times over the sustainable carrying capacity of the earth; others purport to show that Earth is still practically empty of people. It seems like the short answer to Cohen's question is "it depends"– it depends on the quality of the data used in making the estimates and on the assumptions, values, and beliefs of the assessor (Rees, 2002).

a. Population Carrying Capacity

Catton (1986), defined an environment's carrying capacity as its maximum persistently supportable load. In ecology, carrying capacity is normally defined as the maximum population of a given species that can be supported indefinitely in a defined habitat without permanently impairing the productivity of that habitat (Rees, 1992). The concept of carrying capacity is rooted in the logistic equation depicting population dynamics under simple density-dependent regulation and has been developed across different hierarchical levels of living systems and in many sectors of human society (Seidl and Tisdell, 1999; Monte-Luna et al., 2004). In the Malthusian equation, the probability that an organism will reproduce or die is assumed to remain constant and is independent of the density of the population. Obviously, this can only be true when there is no competition among the individuals, normally when the population density is low. The growth of any population in a limited environment will eventually halt due to the shortage of resources. When the demand of the existing population on the resource (i.e., the population size times the basic per capita resource consumption rate required for maintaining life) is equal to the rate of resource supply, the population will reach its saturation level. This saturation level is decided by both the resource supply and the per capita resource consumption rate, called the carrying capacity of the environment for the focal population.

b. Ecological Carrying Capacity

Ecological carrying capacity is a measure of the number of renewable resources in the environment in units of the number of organisms these resources can support. Normally, K is a function of both the species and the environment, and is expected to change only in evolutionary time (Daily and Ehrlich, 1992). Rees (1992) suggested that carrying capacity is the number of individuals of a given species that a given habitat can support without being permanently damaged. If the population of a given species exceeds the carrying capacity of a given habitat, then either the resources required to meet the needs of that species will be depleted, or the wastes produced by that species will build to the point of poisoning members of the species, or both, and the population will crash. In livestock management, carrying capacity is affected by many factors, such as habitat, climate, vegetation, soil profile, food quantity and quality and accessibility, inter- and intra-competition, foraging, parasitism, diseases, population density, social behavior, and anthropogenic disturbance. In terms of nutrition intake, carrying capacity has been defined as the accessible and utilizable energy in the habitat divided by per capita energy consumption. In terms of space, carrying capacity is also affected by aggregation or social group behavior, group size, dispersal distance, and habitat suitability, and can be defined as the amount of habitat available divided by the expected individual territory area for a given life stage (Ayllon et al., 2012). It is closely related to subsistence density, tolerance density, security density, maximum harvest density, minimum impact density in livestock and wildlife management (Hobbs and Hanley, 1990).

Carrying capacity is not a static number but is affected by the abundance and distribution of limited resources and by how individuals compete for these limiting resources. This notion is especially relevant in organisms that compete via both exploitation and interference because of behavioral responses, such as competition avoidance, induced by aggressive interactions typically result in a much-reduced exploitation of the limited resource than could be accounted for by resource depletion alone. In territorial species, the behavioral adjustment of the size and shape of territories has profound consequences for their population regulation, demography, and spatial ecology. In practice, carrying capacity is determined by the resource in the least supply, 'the weakest link' as it were. For production purposes, accurate estimation of carrying capacity will affect the maximum sustainable yield, which is thought to be obtained when the population is maintained at half of the carrying capacity. By contrast, in conservation efforts, the maximum carrying capacity is the desired target (Ayllon et al., 2012).

c. Carrying Capacity of Ecosystems

The directionality of community succession is a powerful concept for conservation biology, analogous to the irreversibility of time in physics, and has revolutionized the understanding of complex adaptive systems. By definition, succession is 'an orderly process of community change' after disturbance. Knowing the directionality of succession is necessary for (1) distinguishing new from mature communities (i.e., defining the age of a community), (2) understanding how communities evolve and respond to disturbance (e.g., habitat loss and climate change), and (3) designing more efficient conservation and restoration plans. Two important concepts of an ecosystem are productivity (often measured by the total biomass) and biodiversity (often measured by species richness or the Shannon index that considers the relative abundance of species). The directionality of succession can potentially be indicated by the increase of net primary production. Per capita community productivity can be very high during the initial phases of succession, and decreases progressively as an upper limit to biomass is reached, and this phenomenon may be expressed as a sigmoid curve roughly akin to the logistic growth curve of a population. The upper limit of net primary production, or the maximum potential biomass, has been suggested to indicate the carrying capacity of biomass in a community. If the number of species in a habitat is relatively low, immigration and diversification through disruptive selection will take place, which progresses until the region attains a maximum supportable load of species.

This can also define the directionality of succession and, thus, the carrying capacity of biodiversity, depicting the maximum number of species or the 'biodiversity ceiling' that an environment can support. In fact, the form of species diversification on evolutionary timescales resembles the logistic population growth. By analogy, the number of species resembles the number of individuals or biomass, and the difference between rate of speciation and extinction the difference between fecundity and mortality (i.e., the intrinsic growth rate). The carrying capacity of biodiversity may be regulated by both physical factors such as climate and habitat heterogeneity and biotic interactions between species. Once the biodiversity reaches its ceiling, interspecific interactions can lead to competitive exclusion of some taxa, and adaptive niche partitioning. This can be further related to the r/K selection theory in ecology. It specifies a life history trade-off between the values of r and K that a species can possess. Species with high r and low K are opportunistic and often occur at the early stage of succession, whereas species with low r and high K are good competitors for limiting resources and often occur at the late stage of succession. An intermediate level of disturbance in a landscape, arguably, can create patches at different levels of succession, thus promoting the coexistence of these two types of species at the regional scale (Monte-Luna et al., 2004).

d. Human Carrying Capacity

Our planet is practically a closed system in terms of physical resources, and all human activity depends on these limited resources. Due to the continue growing of the world population and the rapid diminishing of pristine ecosystems from our exploration for consumption, the concept of carrying capacity is essential and should be considered paramount in our future planning. The Club of Rome has warned us the possible consequences of world population growth and industrialization for food production and resource exhaustion. They projected that within 50 years from now, the planet would reach its limit of growth and thus advocated an urgent mutually beneficial integration of economics and ecology. Approaching carrying capacity means the deterioration of ecosystem services, the loss of biodiversity and habitat heterogeneity and the breakdown of ecosystem resilience. This could lead to irreversible change, enlarged uncertainty to the biosphere, and even a regime shift of the world's living and climate systems. This concern has greatly influenced the popularity of environmentalism and the creation of the United Nations Environment Program (Arrow et al., 1995).

Human carrying capacity describes the number of human beings that can be supported on a sustainable basis in a given area (or on the whole Earth) within natural resource limits and by human choices concerning social, cultural, and economic conditions. This concept is twofold: Biophysical carrying capacity is the maximum population that can be supported by the resources of planet Earth at a given level of technology, whereas social carrying capacity is the sustainable biophysical carrying capacity within a given social organization. In the case of very efficient agriculture the carrying capacity is only determined by the ratio of the total productive area and the non-agricultural used area (per person). For 2005 land cover, it can support 11.4 billion (Franck et al., 2011). In a Malthusian framework, economic growth generates population growth; the population growth increases pressure on the natural resource base; the deterioration of the natural resource base decreases per capita food output; and the reduced per capita food limits population growth which, in turn, limits exploitation of the environment. This moderating feedback loop (density dependence) can be diverged by technological improvements. Population pressure on the resource base stimulates technological improvements in food production and hence facilitates continued population growth, which intensifies exploitation of the resource base (Berck et al., 2012).

e. Biocapacity

Since the concept of sustainable development was put forward, it has become an ideal development mode and a common policy goal. To date, many indicators have been developed to assess the status of sustainable development, such as the lifecycle assessment, human development index by the United Nations Development Programme, barometer of sustainability, index of sustainable economic welfare, environmental pressure indicator, genuine progress indicator, sustainable technology development, environmental sustainability index, and ecological footprint (Rees, 1992). The latter has gained popularity due to its compatibility with the data format commonly derived from economic and social surveys. The ecological footprint for a particular population is defined as the total area of productive land and water ecosystems required to produce sufficient resources and assimilate wastes. Biocapacity can be defined as the locally available carrying capacity of the ecosystem for generating resources and absorbing wastes and is constrained by the carbon sequestration rate of the ecosystem. According to the global average rate of carbon sequestration, we need to have about 17 ha of land

and ocean area to absorb 1 metric ton of carbon emission. Ecological footprint and biocapacity, thus, represent the demand on and the supply from a regional ecosystem, respectively. As both ecological footprint and biocapacity are measured in the same unit (the global hectare: gha), it is straightforward to calculate regional ecological budget as surplus and deficit, after discounting the influence of trading. This specifies whether a regional population is potentially self-sufficient or is at least partially reliant on imported biocapacity. An ecological surplus has been proposed as a minimum criterion for sustainability (Rees and Wackernagel, 1994).

Carrying Capacity and Ecosystem Resilience

The environmental resource base upon which all economic activity ultimately depends includes ecological systems that produce a wide variety of services. This resource base is finite. Furthermore, imprudent use of the environmental resource base may irreversibly reduce the capacity for generating material production in the future. All of this implies that there are limits to the carrying capacity of the planet. It is, of course, possible that improvements in the management of resource systems, accompanied by resource-conserving structural changes in the economy, would enable economic and population growth to take place despite the finiteness of the environmental resource base, at least for some period of time. However, for that to be even conceivable, signals that effectively reflect increasing scarcities of the resource base need to be generated within the economic system. Carrying capacities in nature are not fixed, static, or simple relations. They are contingent on technology, preferences, and the structure of production and consumption. They are also contingent on the everchanging state of interactions between the physical and biotic environment. A single number for human carrying capacity would he meaningless because the consequences of both human innovation and biological evolution are inherently unknowable. Nevertheless, a general index of the current scale or intensity of the human economy in relation to that of the biosphere is still useful. For example, Vitousek et al. calculated that the total net terrestrial primary production of the biosphere currently being appropriated for human consumption is around 40%. This does put the scale of the human presence on the planet in perspective (Vitousek et al., 1986).

A more useful index of environmental sustainability is ecosystem resilience. One way of thinking about resilience is to focus on ecosystem dynamics where there are multiple (locally) stable equilibria. Resilience in this sense is a measure of the magnitude of disturbances that can be absorbed before a system centred on one locally stable equilibrium flips to another. Economic activities are sustainable only if the life-support ecosystems on which they depend are resilient. Even though ecological resilience is difficult to measure and even though it varies from system to system and from one kind of disturbance to another, it may be possible to identify indicators and early-warning signals of environmental stress. For example, the diversity of organisms or the heterogeneity of ecological functions have been suggested as signals of ecosystem resilience. But ultimately, the resilience of systems may only he tested by intelligently perturbing them and observing the response with what has been called "adaptive management" (Arrow et al., 1995).

Need for Assessing Carrying Capacity and Sustainability

It is a situation to be thought over seriously by all of us. We must focus on the Carrying capacity. The negative effects of the same can cause huge damages. Also, the concept of sustainability must be kept in mind. All kinds of environmental imbalances result from the same. Global warming is also caused due to the same. Sustainable development also must take the form of providing equal work opportunities. Furthermore, eradication of poverty and provision of the traditions, practices, beliefs of the residents of host place is also included. Carrying capacity and sustainability is a relative concept. Also, both are interrelated. Thus, the conservation of ecology, biodiversity and other important aspects require the proper monitoring of this concept. This must be done at respective intervals so that human beings are able to survive and develop in an eco-friendly manner.

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UNIT: - 7

Bio-geo-chemical Cycles: Types and Significance

Introduction

Earth is a closed system for matter, except for small amounts of cosmic debris that enter the Earth's atmosphere. This means that all the elements needed for the structure and chemical processes of life come from the elements that were present in the Earth's crust when it was formed billions of years ago. This matter, the building blocks of life, continually cycles through Earth's systems, the atmosphere, hydrosphere, biosphere, and lithosphere, on time scales that range from a few days to millions of years. The biogeochemical cycle definition is the flow of nutrients and other components through both the biotic and abiotic spectrums of the Earth. Basically, it is any of the natural pathways through which the essential elements of living matter are circulated. The term biogeochemical refers to the biological, geographic and chemical aspects of each cycle. The purpose of biogeochemical cycles or nutrient cycles is to maintain a hot equilibrium state that ensures the sustainability of life on the Earth's surface. Depending on the state of matter, there are sedimentary and gaseous cycles. Gaseous cycles include the transfer of carbon, nitrogen, oxygen, and water. On the other hand, the phosphorus, sulphur and water cycles come under sedimentary cycles.

Each cycle can be considered to have two parts, a reservoir pool which is a larger, slow-moving, usually abiotic portion that is full of nutrients, and a smaller but more active pool concerned with the quick exchange of an ecosystem's biotic and abiotic components. For an ecosystem to survive, all chemical aspects that comprise the living cells must be recycled continuously. Biogeochemical cycles can be classified as gaseous in which scenario the reservoir is in the air or in water, or sedimentary, in which case the reservoir is in the earth's crust. Gaseous cycles can include nitrogen, carbon, and water cycles. While sedimentary cycles include iron, sulphur, phosphorus and more-soil bound elements. Gaseous cycles tend to move faster than sedimentary cycles and can adjust more readily to the changes in the biosphere because of the large atmospheric reservoir. For example, local accumulations of Carbon Dioxide are very easily dissipated by winds or are taken up by plants. Unnatural disturbances like global warming, do, however, affect the quality of self-adjustment. Sedimentary cycles can vary from element to element, but each cycle is fundamentally comprised of a solution phase and a rock phase. During the solution phase, minerals in the form of salt are released from rocks due to weathering. some of whichdissolve in water and ultimately end up in the settlement in the seas, out of circulation (https://www.vedantu.com/biology/biogeochemical-cycles).

Types and Significance of Bio-geo-chemical Cycles

Biogeochemical cycles are categorized into two types: Gaseous and sedimentary. Atmosphere remains the reservoir for gaseous and earth crust is the reservoir for sedimentary cycle. Carbon, nitrogen and oxygen are included in gaseous biogeochemical cycle and phosphorus and Sulphur are grouped under sedimentary cycle. The sedimentary cycle consists of two phase, one water phase and the other soil/ sediment phase. The elements gets weathered and dissolved in the water phase, moves through the biotic components and returns back to the sediment phase. Unlike sedimentary cycle, the movement is very rapid within the gaseous cycle as it involves the atmosphere as reservoir. Since the cycle involves the geological, biological and chemical component in the cycle it is termed as biogeochemical cycle.

The six aforementioned elements are used by organisms in a variety of ways. Hydrogen and oxygen are found in water and organic molecules, both of which are essential to life. Carbon is found in all organic molecules, whereas nitrogen is an important component of nucleic acids and proteins. Phosphorus is used to make nucleic acids and the phospholipids that comprise biological membranes. Lastly, sulfur is critical to the three-dimensional shape of proteins.

The cycling of these elements is interconnected. For example, the movement of water is critical for the leaching of sulfur and phosphorus into rivers, lakes, and oceans. Minerals cycle through the biosphere between the biotic and abiotic components and from one organism to another.

a. The Water Cycle

The **hydrosphere** is the area of Earth where water movement and storage occurs: as liquid water on the surface (rivers, lakes, oceans) and beneath the surface (groundwater) or ice, (polar ice caps and glaciers), and as water vapor in the atmosphere. The human body is about 60 percent water and human cells are more than 70 percent water. Of the stores of water on Earth, 97.5 percent is salt water. Of the remaining water, more than 99 percent is groundwater or ice. Thus, less than one percent of freshwater is present in lakes and rivers. Many organisms are dependent on this small percentage, a lack of which can have negative effects on ecosystems. Humans, of course, have developed technologies to increase water availability, such as digging wells to harvest groundwater, storing rainwater, and using desalination to obtain drinkable water from the ocean. Although this pursuit of drinkable water has been ongoing throughout human history, the supply of fresh water continues to be a major issue in modern times.

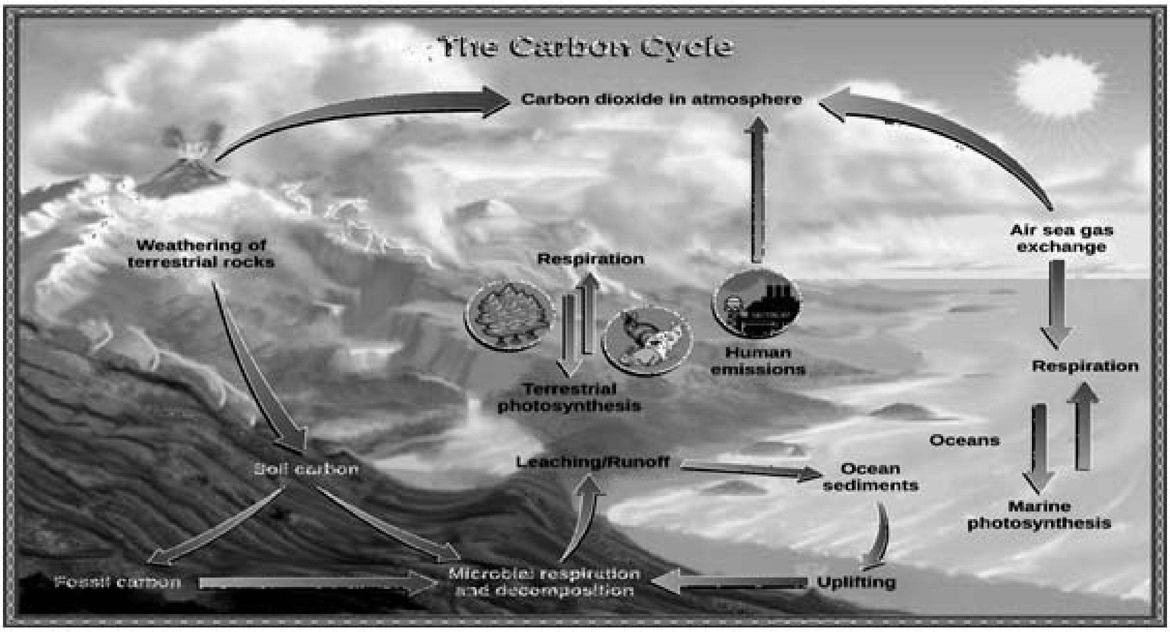
The **water cycle** is driven by the Sun's energy as it warms the oceans and other surface waters. This leads to **evaporation** (liquid water to water vapor) of liquid surface water and **sublimation** (ice to water vapor) of frozen water, thus moving large amounts of water into the atmosphere as water vapor. Over time, this water vapor condenses into clouds as liquid or frozen droplets and eventually leads to **precipitation** (rain, snow, hail), which returns water to Earth's surface. Rain reaching Earth's surface may evaporate again, flow over the surface, or percolate into the ground. Most easily observed is **surface runoff**: the flow of freshwater over land either from rain or melting ice. Runoff can make its way through streams and lakes to the oceans.

In most natural terrestrial environments rain encounters vegetation before it reaches the soil surface. A significant percentage of water evaporates immediately from the surfaces of plants. What is left reaches the soil and begins to move down. Surface runoff will occur only if the soil becomes saturated with water in a heavy rainfall. Water in the soil can be taken up by plant roots. The plant will use some of this water for its own metabolism and some of that will find its way into animals that eat the plants, but much of it will be lost back to the atmosphere through a process known as **transpiration:** water enters the vascular system of plants through the roots and evaporates, or transpires, through the stomata (small microscope openings) of the leaves. Ecologists combine transpiration and evaporation into a single term that describes water returned to the atmosphere: **evapotranspiration.** Water in the soil that is not taken up by a plant and that does not evaporate is able to percolate into the subsoil and bedrock where it forms groundwater.

Groundwater is a significant, subsurface reservoir of fresh water. It exists in the pores between particles in dirt, sand, and gravel or in the fissures in rocks. Groundwater can flow slowly through these pores and fissures and eventually finds its way to a stream or lake where it becomes part of the surface water again. Many streams flow not because they are replenished from rainwater directly but because they receive a constant inflow from the groundwater below. Some groundwater is found very deep in the bedrock and can persist there for millennia. Most groundwater reservoirs, or **aquifers,** are the source of drinking or irrigation water drawn up through wells. In many cases these aquifers are being depleted faster than they are being replenished by water percolating down from above. Rain and surface runoff are major ways in which minerals, including phosphorus and sulfur, are cycled from land to water. The environmental effects of runoff will be discussed later as these cycles are described (https://openoregon.pressbooks.pub/envirobiology/chapter/3-2-biogeochemical-cycles/).

b. The Carbon Cycle

Carbon cycle is one of the important atmospheric cycles. The cycle mainly portrays the circulation of carbon between the atmospheric gas carbon dioxide, assimilation of carbon as organic matter via photosynthesis and its subsequent release back into the atmosphere through respiration. The following figure depicts the carbon circulation through the carbon cycle. As we all know carbon is an important constituent of all life molecule. It is present in air as carbon dioxide (0.03%) and as carbonates and bicarbonates (CO_3 -, HCO_3 -) or molecular CO_2 (aq) in surface water and groundwater. It is also present in minerals associated mainly with magnesium and calcium as carbonates. Coal, lignite, petroleum and natural gas are the sources of carbon fixed due to high pressure and temperature deep below the earth's surface. The organic matter fixed as oil shale is termed as hydro carbonaceous kerogen and it contributes a major portion of the fixed carbon.



Source: - https://brainly.in/question/14305968*(credit: modification of work by John M. Evans and Howard Perlman, USGS)*

Carbon is an element that cannot be broken down or converted into simpler ones. The amount of carbon in the earth is fixed but the dynamic nature of the earth moves it from one form to the other, between living to non-living. The carbon cycle occurs in a series of steps. It begins with the fixing of carbon in the biological systems by capturing solar energy via the process of photosynthesis. Plants utilize the carbon dioxide from the atmosphere and fix them as carbon in their various plant parts. The carbon is gradually transferred to herbivores, carnivores and other life forms through the food chain. The animals through the process of respiration inhales oxygen and release the carbon as carbon dioxide back to the atmosphere. The death and decay of plants and animals returns the carbon back to the soil by the action of decomposers such as bacteria, fungi etc. Microorganisms play a crucial role in carbon cycle by mediating a number of biochemical reactions. They degrade and fix organic carbon which later is transformed through various biochemical reactions into fossil fuels such as coal, lignite, peat, petroleum etc. Majority of the organic contaminants (xenobiotics) are degraded by the microorganisms to release the carbon back into the soil.

Carbon circulates within the ocean too where the photosynthetic algae fixcarbondioxide and produce biomass. The carbon dioxide gas from the atmosphere dissolves in the water to form weak carbonic acid. The carbonic acid further dissociates into hydrogen ions and bicarbonate ions. The hydrogen ions react with the minerals and alters them resulting in clay and other ions such as sodium, potassium and calcium. Corals, a marine organism precipitates calcium and bicarbonates to form calcium carbonate. Calcium carbonate is stored in the sediments in the ocean floor as reserves. The calcium carbonates in the sediments are metamorphosed in deep subduction zones and orogenic belts. During volcanic eruptions, a huge amount of CO2 is evolved from the mid oceanic ridges and hot spot volcanoes. The metamorphosed calcium carbonate is the source of CO2 released from the ocean. The released carbon dioxide once again cycles back in three routes: dissolved in ocean water, some are bound as carbonate rocks and some bound as biomass. Thus, carbon cycle is very vital because carbon is the backbone of life on earth. It has a lot of sources and sinks. The speed of carbon movement from source to sink is not same all the time and it varies for sources. Carbon cycle is altered by various anthropogenic emissions leading to impacts on global level. The impacts caused by anthropogenic activity are provided below.

- Burning fossil fuels leads to the release of huge amount of CO2.
- As discussed earlier, trees sequester carbon dioxide during photosynthesis. Deforestation increases the level of in CO2 air.

- Alteration in CO2 level due to man-made activities causes increase in temperature of the earth due to greenhouse effect.
- The global warming results in destruction of the earth due to sea level rise, floods, drought, increased temperature and changing weather patterns.

c. Oxygen cycle

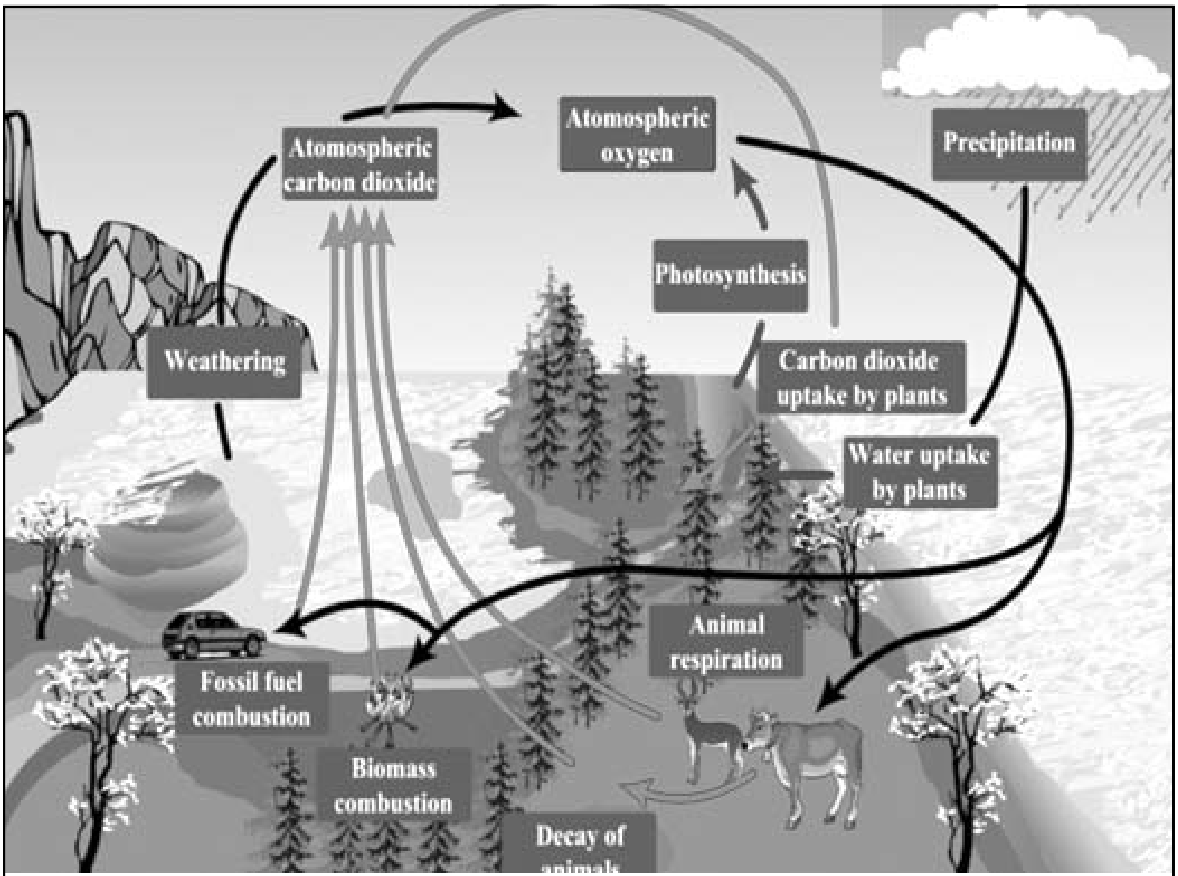
Oxygen is an important element playing a vital role in the environment. It is highly reactive gas which turns to a bluish liquid at -183° C. Figure 2 depicts the oxygen cycle. It circulates between the atmosphere and bound forms of oxygen (chemically and biological bound) eg. Water, carbon dioxide, carbon monoxide, sulphur dioxide, nitrogen dioxide, organic matter and minerals. Atmosphere is the huge reservoir of free oxygen containing almost 21% oxygen. The biosphere has some free oxygen released by the living organisms by the process of photosynthesis. Majority of oxygen is present in the lithosphere in the chemically bound form as silicates and oxides. Lithosphere is considered to be the largest source of oxygen than atmosphere. The oxygen from the atmosphere is taken up by the living organisms through the process of respiration. During aerobic respiration, the oxygen combines with carbon and releases carbon dioxide which is used by plants in photosynthesis. The oxygen utilized in respiration is returned back to the atmosphere during the process of photosynthesis. Oxygen plays an important role in combustion of fossil fuels and methane resulting in release of CO2, SOx and NOx. Inorganic substances and other minerals are also oxidized by oxygen. The degradation and decomposition of dead organic matter and waste generated from living organisms too requires oxygen. The aerobic bacteria involved in decomposition require oxygen for degradation of waste material.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

In the aquatic environment, Oxygen supports the aquatic life in the dissolved form (i.e) dissolved oxygen. Chemical weathering of materials resulted in release of oxygen present in combined forms in lithosphere. An important aspect of the oxygen cycle is the generation of stratospheric ozone. Oxygen is broken down by UV radiations into free oxygen radical which again combines with oxygen to form ozone in the stratosphere. The stratospheric ozone protects the earth from harmful UV radiations by absorbing them. The Oxygen cycle is strongly tied with other biogeochemical cycles and influences them. Similar to other cycles, the oxygen cycle is also affected by the human activities.

Increased burning of fossil fuels results in decreased oxygen and increased emission of carbon dioxide, thereby altering both the carbon and oxygen cycle.



animals

Source: - https://in.pinterest.com/pin/240801911300405733/

d. Nitrogen cycle

Getting nitrogen into living organisms is difficult. Plants and phytoplankton are not equipped to incorporate nitrogen from the atmosphere (where it exists as tightly bonded, triple covalent N_2) even though this molecule comprises approximately 78 percent of the atmosphere. Nitrogen enters the living world through free-living and symbiotic bacteria, which incorporate nitrogen into their organic molecules through specialized biochemical processes. Certain species of bacteria are able to perform **nitrogen fixation**, the process of converting nitrogen gas into ammonia (NH_3), which spontaneously becomes ammonium (NH_4^+). Ammonium is converted by bacteria into nitrites ($NO_2^{''}$) and then nitrates ($NO_3^{''}$). At this point, the nitrogen-containing molecules are used by plants and other producers to make organic molecules such as DNA and proteins. This nitrogen is now available to consumers.

Organic nitrogen is especially important to the study of ecosystem dynamics because many ecosystem processes, such as primary production, are limited by the available supply of nitrogen. As shown in Figure 4 below, the nitrogen that enters living systems is eventually converted from organic nitrogen back into nitrogen gas by bacteria (Figure 4). The process of **denitrification** is when bacteria convert the nitrates into nitrogen gas, thus allowing it to re-enter the atmosphere. Human activity can alter the nitrogen cycle by two primary means: the combustion of fossil fuels, which releases different nitrogen oxides, and by the use of artificial fertilizers (which contain nitrogen and phosphorus compounds) in agriculture, which are then washed into lakes, streams, and rivers by surface runoff. Atmospheric nitrogen (other than N_2) is associated with several effects on Earth's ecosystems including the production of acid rain (as nitric acid, HNO_3) and greenhouse gas effects (as nitrous oxide, N_2O), potentially causing climate change. A major effect from fertilizer runoff is saltwater and freshwater **eutrophication**, a process whereby nutrient runoff causes the overgrowth of algae, the depletion of oxygen, and death of aquatic fauna.

In marine ecosystems, nitrogen compounds created by bacteria, or through decomposition, collects in ocean floor sediments. It can then be moved to land in geologic time by uplift of Earth's crust and thereby incorporated into terrestrial rock. Although the movement of nitrogen from rock directly into living systems has been traditionally seen as insignificant compared with nitrogen fixed from the atmosphere, a recent study showed that this process may indeed be significant and should be included in any study of the global nitrogen cycle (https://openoregon.pressbooks.pub/envirobiology/chapter/3-2-biogeochemical-cycles/).

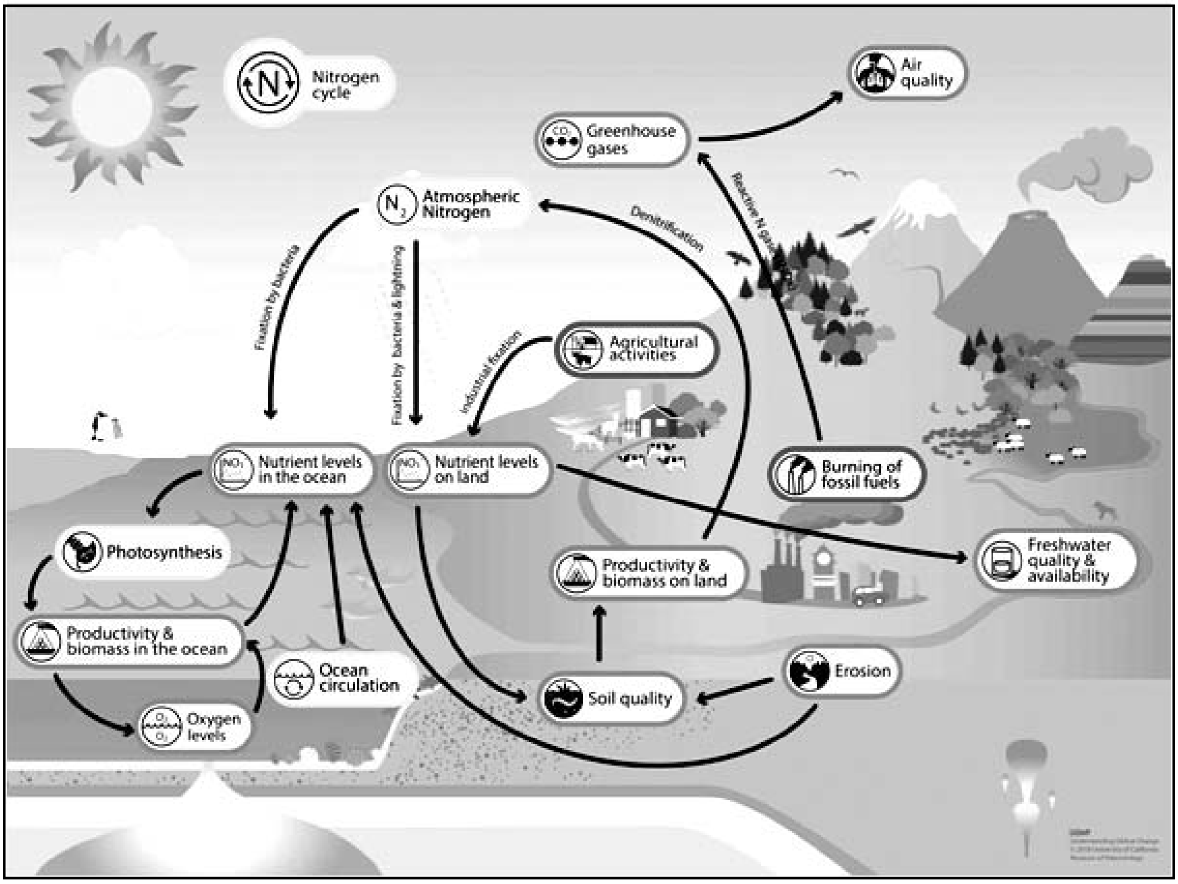
Impact of human activities on nitrogen cycle

1. The N2O which is produced as an intermediate during denitrification is a greenhouse gas and possess more global warming potential than methane and carbon dioxide.
2. The N2O warms the atmosphere and leads to depletion of stratospheric ozone
3. Combustion of fuel at high temperature releases a huge amount of NO to the atmosphere which later gets converted to NO2 and HNO3 in the atmosphere. The HNO3 reaches the earth as acid rain and causes environmental and health effects.

4. As mentioned earlier, nitrate is readily soluble in water and leaches out into the water bodies. Excessive use of nitrate in fertilizers can contaminate ground and surface water which is harmful for the health of an individual especially the infants.

5. Agricultural run-off and sewage discharge into water bodies leads to eutrophication problems

6. Deforestation also leads to alterations in nitrogen cycle.



Source: - https://ugc.berkeley.edu/background-content/nitrogen/

e. Phosphorous Cycle

Thephosphorus cycleis the biogeochemical cycle that describes the movement of phosphorus through thelithosphere, hydrosphere, and biosphere. Unlike many other biogeochemical cycles, the atmosphere does not play asignificant role in the movement of phosphorus, because phosphorus and phosphorus-based compounds are usuallysolids at the typical ranges of temperature and pressure found on Earth.The production of phosphine gas is allowed only in specialized, local conditions. Low phosphorus (chemical symbol,P) availability slows down microbial growth, which has been shown in studies of soil microbial biomass. Soilmicroorganisms act as sinks and sources of available P in the biogeochemical cycle. a. however, the major transfersin the global cycle of P are not driven by microbial reactions. b. further studies need to be performed for integratingdifferent processes and factors related to gross phosphorus mineralization and microbial phosphorus turnover ingeneral (Turner, 2005).

Phosphorous in the Environment: -

Ecological Function: - Phosphorus is an essential nutrient forplants and animals in the form of ions. Phosphorus is a limiting nutrient foraquatic organisms. Phosphorus formsparts of important life sustainingmolecules but are very common in thebiosphere. Phosphorus does not enterthe atmosphere, remaining mostly onland and in rock and soil minerals.Eighty percent of the phosphorus is used to make fertilizers and a type of phosphorus such as dilute phosphoric acidis used in soft drinks. Phosphates may be effective in such ways but also causes pollution issues in lakes and streams. Over enrichment of phosphate can lead to algae bloom, because of the excess nutrients. This causes more algae togrow, bacteria consume the algae and causes more bacteria to grow in large amounts. They use all the oxygen in thewater during cellular respiration, causing many fish to die.Phosphorus normally occurs in nature as part of a phosphate ion, consisting of a phosphorus atom and some numberof oxygen atoms, the most abundant form is orthophosphate. Most phosphates are found as salts in ocean sedimentsor in rocks. Over time, geologic processes can bring ocean sediments to land, and weathering will carry thesephosphates to terrestrial habitats. Plants absorb phosphates from the soil, then bind the phosphate into organiccompounds. The plants may then be consumed by herbivores who in turn may be consumed by carnivores. Afterdeath, the animal or plant decays, and the phosphates are returned to the soil. Runoff may carry them back to theocean or they may be reincorporated into rock (Turner, 2005).

Biological Function: -The primary biological importance of phosphates is as a component of nucleotides, which serve as energy storagewithin cells (ATP) or when linked together, form the nucleic acids DNA and RNA.The double helix of our DNA isonly possible because of the phosphate ester bridge that binds the helix. Besides making biomolecules phosphorus isalso found in bones, whose strength is derived from calcium phosphate in enamel of mammalian teeth; exoskeletonof insects and phospholipids (found in all biological membranes).It also functions as buffering agent inmaintaining acid base homeostasis in the human body (http://www.enviroliteracy.org/article.php/480.html).

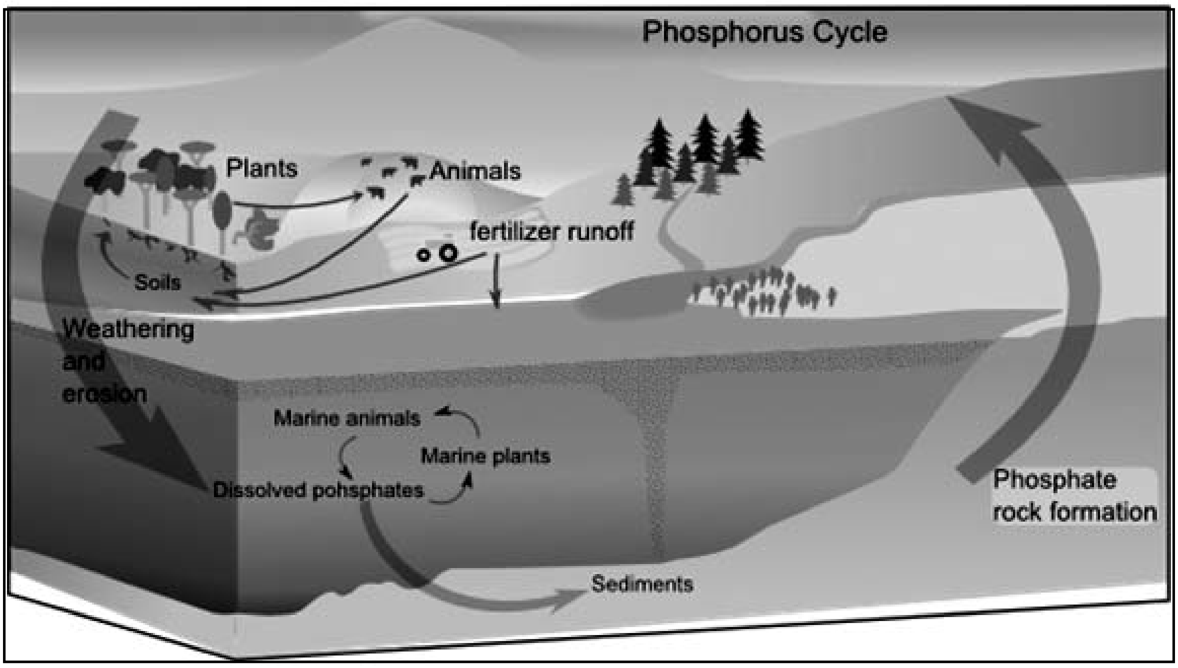
***Process of the Cycle:* -**Phosphates move quickly through plants and animals; however, the processes that move them through the soil orocean are very slow, making the phosphorus cycle overall one of the slowest biogeochemical cycles.Unlike other cycles of matter compounds, phosphorus cannot be found in air as a gas. This is because at normaltemperature and circumstances, it is a solid in the form of red and white phosphorus. It usually cycles through water,soil and sediments. Phosphorus is typically the limiting nutrient found in streams, lakes and fresh waterenvironments. As rocks and sediments gradually wear down, phosphate is released. In the atmosphere phosphorus ismainly small dust particles.Initially, phosphate weathers from rocks. The small losses in a terrestrial system caused by leaching through theaction of rain are balanced in the gains from weathering rocks. In soil, phosphate is absorbed on clay surfaces andorganic matter particles and becomes incorporated (immobilized). Plants dissolve ionized forms of phosphate.Herbivores obtain phosphorus by eating plants, and carnivores by eating herbivores. Herbivores and carnivoresexcrete phosphorus as a waste product in urine and feces. Phosphorus is released back to the soil when plants oranimal matter decomposes and the cycle repeats (Schelde et al., 2006).

***Phosphorous Minerals:* -** The availability of phosphorus in ecosystem is restricted by the rate of release of this element during weathering. Therelease of phosphorus from apatite dissolution is a key control on ecosystem productivity. The primary mineral withsignificant phosphorus content, apatite [Ca5(PO4)3OH] undergoes carbonation weathering releasing phosphoruscontained different forms.This process decreases the total phosphorus in the system due to losses in runoff (Schlesinger& Bernhardt, 2013). Little of this released phosphorus is taken by biota (organic form) whereas, large proportion reacts with other soilminerals leading to precipitation in unavailable forms. The later stage of weathering and soil development. Availablephosphorus is found in a biogeochemical cycle in the upper soil profile, while phosphorus found at lower depths isprimarily involved in geochemical reactions with secondary minerals. Plant growth depends on the rapid root uptakeof phosphorus released from dead organic matter in the biochemical cycle. Phosphorus is limited in supply for plantgrowth. Phosphates move quickly through plants and animals; however, the processes that move them through thesoil or ocean are very slow, making the phosphorus cycle overall one of the slowest biogeochemical cycles (Oelkers, 2008).

Low-molecular-weight (LMW) organic acids are found in soils. They originate from the activities of variousmicroorganisms in soils or may be exuded from the roots of living plants. Several of those organic acids are capableof forming stable organo-metal complexes with various metal ions found in soil solutions. As a result, theseprocesses may lead to the release of inorganic phosphorus associated with aluminium, iron, and calcium in soilminerals. The production and release of oxalic acid by mycorrhizal fungi explain their importance in maintaining andsupplying phosphorus to plant (Harrold, S. A., &Tabatabai, 2006). The availability of organic phosphorus to support microbial, plant and animal growth depends on the rate of theirdegradation to generate free phosphate. There are various enzymes such as phosphatases, nucleases and phytaseinvolved for the degradation. Some of the abiotic pathways in the environment studied are hydrolytic reactions andphotolytic reactions. Enzymatic hydrolysis of organic phosphorus is an essential step in the biogeochemicalphosphorus cycle, including the phosphorus nutrition of plants and microorganisms and the transfer of organicphosphorus from soil to water bodies.Many organisms rely on the soil derived phosphorus for their phosphorusnutrition (Turner, 2003).

Human Interference: -Nutrients are important to the growth and survival of living organisms, and hence, are essential for development andmaintenance of healthy ecosystems. However, excessive amounts of nutrients, particularly phosphorus and nitrogen,are detrimental to aquatic ecosystems. Natural eutrophication is a process by which lakes gradually age and becomemore productive and may take thousands of years to progress. Cultural or anthropogenic eutrophication, however, iswater pollution caused by excessive plant nutrients, which results in excessive growth in algae population. Surfaceand subsurface runoff and erosion from high-P soils may be major contributing factors to fresh water eutrophication.The processes controlling soil P release to surface runoff and to subsurface flow are a complex interaction betweenthe type of P input, soil type and management, and transport processes depending on hydrological conditions (Branom& Sarkar, 2004). Repeated application of liquid hog manure in excess to crop needs can have detrimental effects on soil P status. Inpoorly drained soils or in areas where snowmelt can cause periodical waterlogging, Fe-reducing conditions can beattained in 7 –10 days. This causes a sharp increase in P concentration in solution and P can be leached. In addition,reduction of the soil causes a shift in phosphorus from resilient to more labile forms. This could eventually increasethe potential for P loss. This is of particular concern for the environmentally sound management of such areas, wheredisposal of agricultural wastes has already become a problem. It is suggested that the water regime of soils that are tobe used for organic wastes disposal is taken into account in the preparation of waste management regulations (Ajmone-Marsan et al., 2006).

Eutrophication will impact the global carbon cycle, but will probably do little to offset anthropogenic carbonemissions. Total excess input from 1600 to 3600 AD is 1860 Tg (teragrams) of phosphorus. Given that, in the marineenvironment, between 106 and 170 units of carbon are buried per unit of phosphorus one can predict that excessphosphorus would effectively bury 76,000 to 123,000 Tg carbon. In essence, this burial removes carbon from theatmosphere through the biological fixation of carbon dioxide during photosynthesis. The present annual rate of anthropogenic carbon addition to the atmosphere is 7900 Tg carbon, so the phosphorus eutrophication effect wouldonly account for about 10-15 years of anthropogenic carbon emissions to the atmosphere over the next 2000 years(i.e. only 0.6% of total projected carbon emissions, if emissions stay constant). Although the net effect as a carbon sequestration mechanism is minimal, the ecological impact of phosphorusfertilization to the ocean could be extreme. Given the other assaults on marine ecosystems, including warming, andacidification of surface ocean waters from higher carbon dioxide levels, it would be pure speculation to project howP eutrophication would affect ecosystem structure and distribution in the future. However, those who have witnessedlocal eutrophication in ditches, streams, ponds, and lakes can attest to the ecological devastation that excess nutrientsand the proliferation of monocultures can cause in such isolated environments. The eutrophication of coastal andopen-marine ecosystems would result in a grim future for ecological diversity (Filippelli, 2008).



Source: - https://en.wikipedia.org/wiki/Phosphorus_cycle#/media/File:Phosphorus_cycle.png

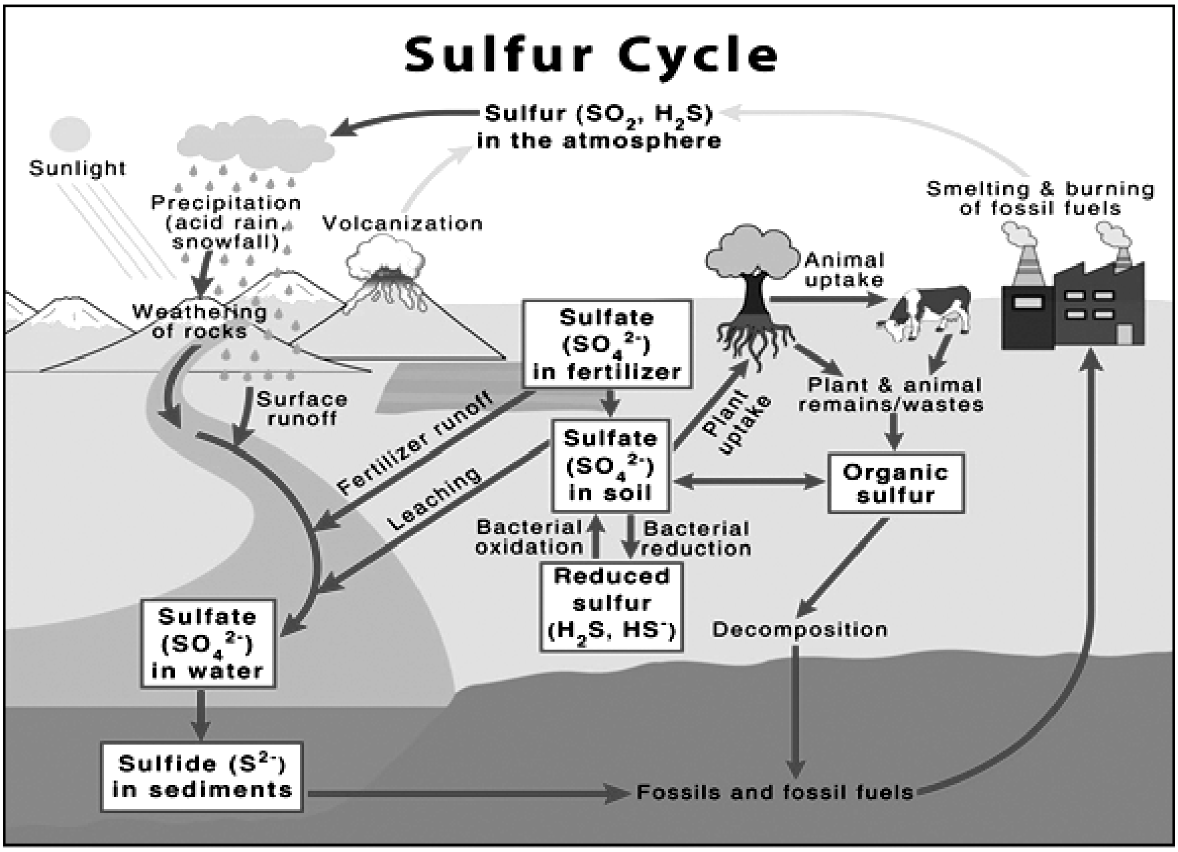
f. Sulfur Cycle

Sulfur (S), the tenth most abundant element in the universe, is a brittle, yellow, tasteless, and odorless non-metallic element. It comprises many vitamins, proteins, and hormones that play critical roles in both climate and in the health of various ecosystems. The majority of the Earth's sulfur is stored underground in rocks and minerals, including as sulfate salts buried deep within ocean sediments. The sulfur cycle contains both atmospheric and terrestrial processes. Within the terrestrial portion, thecycle begins with the weathering of rocks, releasing the stored sulfur. The sulfur then comes into contact with air where it is converted into sulfate (SO4). The sulfate is taken up by plants and microorganisms and is converted into organic forms; animals then consume these organic forms through foods they eat, thereby moving the sulfur through the food chain. As organisms die and decompose, some of the sulfur is again released as a sulfate and some enters the tissues of microorganisms. There are also a variety of natural sources that emit sulfur directly into the atmosphere, including volcanic eruptions, the breakdown of organic matter in swamps and tidal flats, and the evaporation of water.Majorsulfur-producing sources include sedimentary rocks, which release hydrogen sulfide gas, and human sources, such as smelters and fossil-fuel combustion, both of which release sulfur dioxide into the atmosphere. Sulfur-containing proteins are degraded into their constituent amino acids by the action of a variety of soil organisms. The sulfur of the amino acids is converted to hydrogen sulfide (H2S) by another series of soil microbes. In the presence of oxygen, H2S is converted to sulfur and then to sulfate by sulfur bacteria. Eventually the sulfate becomes H2S. Hydrogen sulfide rapidly oxidizes to gases that dissolve in water to form sulfurous and sulfuric acids. These compounds contribute in large part to the "acid rain" that can kill sensitive aquatic organisms and damage marble monuments and stone buildings.

Economic importance: -Sulphur is intimately involved in production of fossil fuels and a majority of metal deposits because of its ability to actas an oxidizing or reducing agent. The vast majority of the major mineral deposits on Earth contain a substantial amount of sulfur including, but not limited to: sedimentary exhalative deposits(SEDEX), Mississippi Valley-Type(MVT) and copper porphyry deposits. Iron sulfides, galena and sphalerite will form as by-products of hydrogensulfide generation, as long as the respective transition or base metals are present or transported to a sulphate reduction site (Machel, 2001).Important sources of sulfur in ore deposits are generallydeep-seated, but they can also come from local country rocks, sea water, or marine evaporites. The presence or absence of sulfur is one of the limiting factors on both the concentration of precious metals and its precipitation fromsolution. pH, temperature and especially redox states determine whether sulfides will precipitate. Most sulfidebrineswill remain in concentration until they reach reducing conditions, a higher pH or lower temperatures. Ore fluids aregenerally linked to metal rich waters that have been heated within a sedimentary basin under the elevated thermalconditions typically inextensional tectonic settings. The redox conditions of the basin lithologies exert an importantcontrol on the redox state of the metal-transporting fluids and deposits can form from both oxidizing and reducingfluids (Lyons& Gill, 2010)

Human Impact: -Human activities have had a major effect on the global sulfur cycle. The burning of coal, natural gas, and other fossil fuels has greatly increased the amount of S in the atmosphere and ocean and depleted the sedimentary rock sink. Without human impact sulfur would stay tied upin rocks for millions of years until it was uplifted through tectonicevents and then released through erosion andweathering processes. Instead, it is being drilled, pumped and burned ata steadily increasing rate. Over the most polluted areas there has been a 30-fold increase in sulfate deposition (Pham et al., 1996). Although the sulfur curve shows shifts between net sulfur oxidation and net sulfur reduction in the geologic past, themagnitude of the current human impact is probably unprecedented in the geologic record. Human activities greatlyincrease the flux of sulfur to the atmosphere, some of which is transported globally. Humans are mining coal andextracting petroleum from the Earth's crust at a rate that mobilizes 150 x 10^{12}gS/yr, which is more than double therate of 100 years ago.

The result of human impact on these processes is to increase the pool of oxidized sulfur(SO4) in the global cycle, at the expense of the storage of reduced sulfur in the Earth's crust. Therefore, humanactivities do not cause a major change in the global pools of S, but they do produce massive changes in the annualflux of S through the atmosphereWhen SO2is emitted as an air pollutant, it forms sulfuric acid through reactionswith water in the atmosphere. Once the acid is completely dissociated in water the pH can drop to 4.3 or lowercausing damage to both man-made and natural systems. According to the EPA acid rain is a broad term referring to amixture of wet and dry deposition (deposited material) from the atmosphere containing higher than normal amountsof nitric and sulfuric acids. Distilled water (water without any dissolved constituents), which contains no carbondioxide, has a neutral pH of 7. Rain naturally has a slightly acidic pH of 5.6, because carbon dioxide and water in theair react together to form carbonic acid, a very weak acid. Around Washington, D.C., however, the average rain pHis between 4.2 and 4.4. Since pH is on a log scale dropping by 1 (the difference between normal rain water and acidrain) has a dramatic effect on the strength of the acid. In the United States, roughly 2/3 of all SO2and 1/4 of all NO3come from electric power generation that relies on burning fossil fuels, like coal (Oenema& Postma, 2003).



Source: - https://www.sciencefacts.net/sulfur-cycle.html

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UNIT: - 8

Energy Flow and Balance of Energy in the Biosphere

Introduction

Energy is the ability to do work and work is the transfer of energy from one form to another. In practical terms, energy is what we use to manipulate the world around us, whether by exciting our muscles, by using electricity, or by using mechanical devices such as automobiles. Energy comes in different forms - heat (thermal), light (radiant), mechanical, electrical, chemical, and nuclear energy (Omer, 2008).Energy systems models are important methods used to generate a range of insight and analysis on the supply and demand of energy. Developed over the second half of the twentieth century, they are now seeing increased relevance in the face of stringent climate policy, energy security and economic development concerns, and increasing challenges due to the changing nature of the twenty-first century energy system. In this paper, we look particularly at models relevant to national and international energy policy, grouping them into four categories: energy systems optimization models, energy systems simulation models, power systems and electricity market models, and qualitative and mixed-methods scenarios (Pfenninger et al., 2014).

Various Forms of Energy

There are two types of energy - stored (potential) energy and working (kinetic) energy. For example, the food we eat contains chemical energy, and our body stores this energy until we release it when we work or play. The various form of energy are (Ristinen, et al., 2022)

A. ***Potential Energy: -***Potential energy is stored energy and the energy of position (gravitational). It exists in various forms.

- ***a.*** ***Chemical Energy: -*** Chemical energy is the energy stored in the bonds of atoms and molecules. Biomass, petroleum, natural gas, propane and coal are examples of stored chemical energy.

b. ***Nuclear Energy: -*** Nuclear energy is the energy stored in the nucleus of an atom - the energy that holds the nucleus together. The nucleus of a uranium atom is an example of nuclear energy.

c. ***Stored Mechanical Energy: -***Stored mechanical energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

d. ***Gravitational Energy: -*** Gravitational energy is the energy of place or position. Water in a reservoir behind a hydropower dam is an example of gravitational energy. When the water is released to spin the turbines, it becomes motion energy.

B. ***Kinetic Energy: -*** Kinetic energy is energy in motion- the motion of waves, electrons, atoms, molecules and substances. It exists in various forms.

a. ***Radiant Energy***: - Radiant energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Solar energy is an example of radiant energy.

b. ***Thermal Energy: -*** Thermal energy (or heat) is the internal energy in substances- the vibration and movement of atoms and molecules within substances. Geothermal energy is an example of thermal energy.

c. ***Motion: -*** The movement of objects or substances from one place to another is motion. Wind and hydropower are examples of motion.

d. ***Sound: -*** Sound is the movement of energy through substances in longitudinal (compression/rarefaction) waves.

e. ***Electrical Energy: -*** Electrical energy is the movement of electrons. Lightning and electricity are examples of electrical energy.

Thermodynamics Principle of Energy: - Energy transformation in ecosystems can also be explained in relation to the laws of thermodynamics, which are usefully applied to closed systems. The laws are (Jones, 1974): -

A. ***First Law of Thermodynamics (law of conservation of energy): -*** It state that in a closed system, energy can neither be created nor destroyed but can only be transferred from one form into another. When fuel is burnt to drive a car, the potential energy in chemical bond of fuel is converted into mechanical energy to drive the car. The key point is, the total amount of energy consumed and compare with the total amount of energy produced would always be equal. Such type of energy conservation is also found in biological system. In ecological systems solar energy is converted into chemical energy stored in food materials which is ultimately converted into mechanical and heat energy. Thus, in ecological systems, the energy is neither created nor destroyed but is converted from one form into another. Thus, when wood is burned the potential energy present in the molecules of wood equals the kinetic energy released, and heat is evolved to the surroundings. This is an exothermic reaction. In an endothermic reaction, energy from the surrounding may be paid into a reaction. For example, in photosynthesis, the molecules of the products store more energy than the reactants. The extra energy is acquired from the sunlight, but even then there is no gain or loss in total energy.

B. Second Law of Thermodynamics: -The second law of thermodynamics states that processes involving energy transformation will not occur spontaneously unless there is degradation of energy from a non-random to a random form. In other words, the disorder (entropy) in the universe is constantly increasing and that during energy conservation, an energy transformation will spontaneously occur unless there is degradation of energy from a concentrated form into a dispersed form. For example, in man-made machines (closed systems), heat is the simplest and most recognizable medium of energy transfer. The outcome of this law is very significant in biological system. But in biological systems, energy transfer is not a useful medium, as the living systems are fundamentally isothermal and there is no significant variation in temperature between different cells in the organism or between various cells in a tissue of the organism. At each level of conservation, some of the energy is lost as heat. Therefore, the more conservation taking place between the capture of light energy by plants and the trophic level being considered, the less the energy is available to that level. The efficiency of the transfer ofenergy along food chain from one trophic level to another is generally less than 10 percent as the 90 percent of energy is lost as heat.

The study of energy flow is important in determining limits to food supply and the production of all biological resources. The capture of light energy and its conversion into stored chemical energy by autotrophic organisms provide ecosystems with their primary energy source. The total amount of energy converted into organic matter is the gross primary production varies between different systems. The energy stored in the food material is made available through cell respiration. Chemical energy is released by burning the organic compound with oxygen using enzyme mediated reactions within cells. It produces carbon dioxide and water as waste products. Energy flow is the movement of energy through a system from an external source through a series of organisms and back to the environment. At each trophic level within the system, only the small fraction of the available energy is used for the production of new tissue. Most is used for respiration and body maintenance.

Energy Flow in an Ecosystem: **-**Energy flow is a fundamental process which occurs in all ecosystems. Energy is defined as the capacity to do work. It is the basic force responsible for all metabolic activities. The flow or movement of energy through a series of organisms in an ecosystem is called energy flow. The energy flows from producer to top consumers in unidirectional form. The study of trophic level interaction in an ecosystem gives an idea about the energy flow through the ecosystem. As all organisms require energy to do work this energy is obtained from the chemical energy of food which they consume. This chemical energy is obtained, by the producers which has the ability to convert solar energy to chemical energy.Living organisms can use energy in two forms radiant and fixed energy. Radiant energy is in the form of electromagnetic waves, such as light. Fixed energy is potential chemical energy bound in various organic substances which can be broken down in order to release their energy content. Organisms that can fix radiant energy utilizing inorganic substances to produce organic molecules are called autotrophs. Organisms that cannot obtain energy from abiotic source but depend on energy-rich organic molecules synthesized by autotrophs are called heterotrophs. Those which obtain energy from living organisms are called consumers and those which obtain energy from dead organisms are called decomposers (DeAngelis, 1980: Odum, 1968).

Energy Flow through Tropic Level: **-**Trophic level interaction deals with how the members of an ecosystem are connected on the basis of their nutritional needs. Organisms are either producers or consumers in terms of the energy flow through the ecosystem. Energy flows through the trophic level from producers to subsequent trophic level-

- In the first trophic level Plants acts as producers. They take energy from sunlight and convert it into organic material through the process of photosynthesis. Thus, the plants are primary producers.
- At the second trophic level, the herbivores feeds on plants. This gives them energy. Most of this energy is used up in performing metabolic functions such as breathing, food digestion, the growth of tissues, maintaining body temperature and blood circulation.
- At the next trophic level come carnivores. Carnivores feed on the herbivores and derive energy for their growth and sustenance. Large predators are present in subsequent trophic levels and they derive their energy by consuming smaller carnivores. Some organisms like human beings consume both plants (producers) and animals for their food.

There is loss of some energy in the form of heat at each trophic level and thus in each trophic level the energy level decreases. Organisms that can fix radiant energy utilizing inorganic substances to produce organic molecules are called autotrophs/ producers. Plants are examples of autotrophs. Heterotrophs are organisms that cannot obtain energy from abiotic sources and rely on energy-rich organic molecules synthesised by autotrophs. Consumers are those that obtain energy from living organisms and decomposers are those that obtain energy from dead organisms.At each trophic level (also called feeding level), heat energy is released thereby reducing the amount of energy passing onto each level. That means energy is degraded. The flow of energy is also only unidirectional. At the last level, all organisms die and become detritus or food for decomposers. Here, the last remnants of energy are extracted and released as heat energy, while the inorganic nutrients are returned to the soil or water only to be taken up again by primary producers. The energy is lost or released while the inorganic nutrients are recycled. The ultimate source of energy is the sun. Ultimately, all energy in ecosystems will get They take energy from sunlight and convert it into organic material through the process of photosynthesis. This takes place at the first trophic level and plants are primary producers.

At the second trophic level are herbivores who use plants as food. This gives them energy. Most of this energy is used up in performing metabolic functions such as breathing, food digestion, the growth of tissues, maintaining body temperature and blood circulation. At the next trophic level come carnivores. Carnivores feed on the herbivores and derive energy for their growth and sustenance. Large predators are present in subsequent trophic levels and they derive their energy by consuming smaller carnivores. Some organisms like human beings consume both plants (producers) and animals for their food. Organisms that can fix radiant energy utilizing inorganic substances to produce organic molecules are called autotrophs/producers. Plants are examples of autotrophs. Heterotrophs are organisms that cannot obtain energy from abiotic sources and rely on energy-rich organic molecules synthesised by autotrophs.

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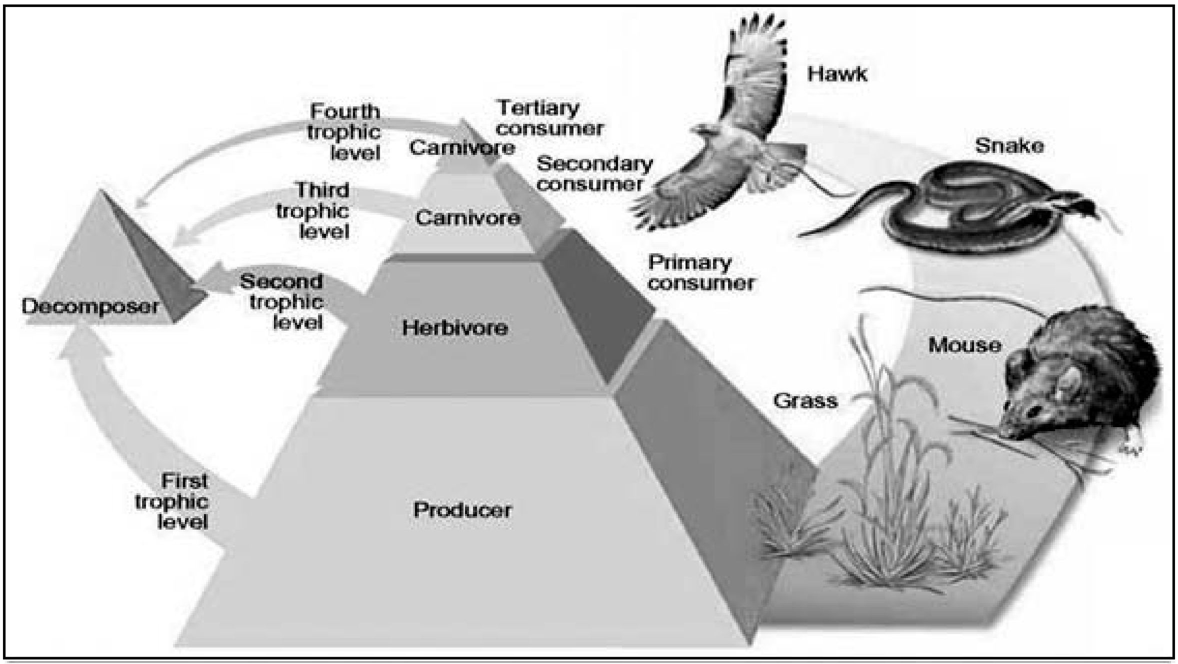
Figure: - ***Energy Flow in an Ecosystem***



Source: - https://schoolbag.info/biology/concepts/100.html

Food Chain: **-**In the ecosystem, green plants alone are able to trap in solar energy and convert it into chemical energy. The chemical energy is locked up in the various organic compounds, such as carbohydrates, fats and proteins, present in the green plants. Since virtually all other living organisms depend upon green plants for their energy, the efficiency of plants in any given area in capturing solar energy sets the upper limit to long-term energy flow and biological activity in the community. The food manufactured by the green plants is utilized by themselves and also by herbivores. Animals feed repeatedly. Herbivores fall prey to some carnivorous animals. In this way one form of life supports the other form. Thus, food from one trophic level reaches to the other trophic level and in this way a chain is established. This is known as food chain. A food chain may be defined as the transfer of energy and nutrients through a succession of organisms through repeated process of eating and being eaten. In food chain initial link is a green plant or producer which produces chemical energy available to consumers. For example, marsh grass is consumed by grasshopper, the grasshopper is consumed by a bird and that bird is consumed by hawk (Post et al., 2000).

Types of Food Chain: -Food chains are of two basic types: -

Grazing Food Chain: **-** The grazing food chain is the major food chain dominantly occurring in ecosystems. As obvious from the name, it starts from the green plants; the major source of energy for this chain is taken from the sun as plants carry out the process of photosynthesis in presence of sunlight. The green plants are the primary producer and eaten up by herbivores, which in turn are eaten up by carnivores. This food chain doesn’t consist of microbes or other decomposers; it is carried out by the macroscopic organisms. Examples are:

Plant $\rightarrow$ Deer $\rightarrow$ Tiger (Forest Ecosystem)

Grass $\rightarrow$ Insect $\rightarrow$ Sparrow $\rightarrow$ Snake $\rightarrow$ Hawk (Grassland Ecosystem)

Detritus Food Chain: **-** The detritus food chain starts from the dead organic matter such as dead bodies of animals or fallen leaves, which are eaten by microorganisms and then followed by detritus feeding organisms (detritivores) and their predators. This food chain has the remains of detritus as the major source ofenergy, and this process gets completed by the subsoil organisms, which can either be macroscopic or microscopic.

Thus, these food chains are less dependent on direct solar energy. Unlike the grazing food chain, detritus food chain produces a large amount of energy to the atmosphere. This type of food chain ensures maximum utilization and minimum wastage of the available material. It is useful in fixation of inorganic nutrients and utilizing up to the maximum. For example, the food chain operating in the decomposing accumulated litter in a temperate forestecosystem is a detritus food chain.

Leaf Litter → Bacteria → Protozoa → Small fish → Big fish

In an example of detritus food chain given by Odum and Heald (1972, 1975) in Southern Florida, leaves of red mangrove (Rhizophora mangle) fall into brackish waters at an annual rate of 9 metric tons per hectare. Of the total annual net primary production, only 5% of the leaf material is removed by grazing insects before leaf abscission and rest in the form of fallen leaves is widely dispersed over large areas of bay and estuaries. This dead organic matter is ingested upon a group of small detritusfeeders, often called meiofauna, comprising small crabs, shrimp, nematodes, polychaete worms, small bivalves and snails, and insect larvae. Leaf fragments acted upon by the detritus feeders and colonized by algae are eaten and re-eaten by small detritus consumers, which in turn provide the main food for carnivores' game fish, birds, etc. The grazing and detritus food chains are shown as separate flows in a Y-Shaped or two channel energy flow model. One arm represents the grazing food chain and the other arm represents detritus food chain.

The Y-shaped energy flow model further indicates that the two food chains are in fact, under natural conditions, not completely isolated from one another. For example, dead bodies of small animals that were once part of grazing food chain become incorporated in the detritus food chain as do the faeces of grazing food animals. The importance of two food chains may differ in different ecosystems, in some cases, grazing is more important and in others, detritus is more important.In shallow waters and heavily grazed grassland, 50% or more of the net production may pass down the grazing pathway. But aquatic systems like deep oceans, marshes or forests operate as detritus systems, for, over 90% of primary production is not consumed by heterotrophs until plant parts die and reach water, sediments and soils. This delayed consumption increases the structural complexity and biodiversity as well as the storage and buffering capacities of ecosystems. There would be no forests if all the trees seedlings were grazed down as soon as they appeared (http://www.dspmuranchi.ac.in/pdf/Blog/aksinghdspmuranchiacinA21.pdf).

Food Webs: -Food web is a network of food chains which become interconnected at various trophic levels so as to form a number of feeding connections amongst the different organisms of a biotic community. A food web is simply the total set of feeding relationships in a biotic community. The advantage of having such complex web of feeding relationships in the community is that it gives stability to the ecosystem. Even if one or more of these relations is altered, the community will remain stable (https://www.pw.live/chapter-ecosystem-botany-class-12/energy-flow). A food web is made up of interconnected food chains. Most communities include various populations of producer organisms which are eaten by any number of consumer populations. The green crab, for example, is a consumer as well as a decomposer. The crab will eat dead things or living things if it can catch them. A secondary consumer may also eat any number of primary consumers or producers. This non-linear set of interactions which shows the complex flow of energy in nature is more easily visualized in the following diagram. In a food web nutrients are recycled in the end by decomposers. Animals like shrimp and crabs can break the materials down to detritus. Then bacteria reduce the detritus to nutrients. Decomposers work at every level, setting free nutrients that form an essential part of the total food web.

In nature, the food chains never exist as isolated linear sequence; rather they are interconnected to form a network called food web. Therefore, a food web can be defined as a network of food chains interconnected to each other so that a number of options of eating and being eaten are available at each trophic level. It was Charles Elton who presented the notion of food web what he referred to as food cycle (Krebs & Davies, 2009).

Different Parts of Food Web: - A group of overlapping or connected food chains is called a food web. A food web can be big or small. It can contain many different types of animals or just a few. Whether a food web is big or small, the organisms fall into one of two categories: producers or consumers. These are discussed below (https://www.acaedu.net/cms/lib3/TX01001550/Centricity/Domain/389/5.9B%20Food%20Webs.pdf): -

Producers: Producers are organisms that get their energy directly from the Sun. Their cells are able to turn sunlight into food through a process called photosynthesis. In photosynthesis, producers combine carbon dioxide, water, and sunlight to produce oxygen and sugar (their food). Other organisms get energy by eating producers. Have you ever eaten lettuce or any other vegetable? If so, you have eaten a producer! The lettuce plant converts sunlight into food your body uses as fuel. Producers are very important to life on Earth. Without them, other organisms would not survive.

Consumers: A bald eagle is an example of a consumer. It cannot directly use the Sun's energy to make food. As a consumer it has to eat, or consume, other organisms for energy. A consumer may eat producers (such as a deer) or other consumers (such as the bald eagle). Animals, fungi, and some bacteria are types of consumers. Consumers that eat only plants are called herbivores. Consumers that eat only animals are called carnivores. If a consumer eats both plants and animals, it is called an omnivore.

Importance of Food Chains and Food Webs: - The major significance of Food Webs are (http://www.dspmuranchi.ac.in/pdf/Blog/aksinghdspmuranchiacinA21.pdf): -

1. The food chains and food webs help understand the feeding relationships and the interactions between organisms in any ecosystem.
2. Nutrient cycling and energy flow in an ecosystem takes place through food chains and food webs.
3. Food chains keep a check on the population size of different organisms. For example, in a food chain in grassland, if deer population increases, there will be more food for the carnivores, their population will increase, which in turn will reduce the deer population. If there are less deer, some of the carnivores will starve and die, letting the deer population to grow.
4. Food webs are very important in maintaining the stability of an ecosystem in nature. In a linear food chain, if one species become extinct or one species suffers then the species in the subsequent trophic levels are also affected. In a food web, on the other hand, there are a number of options available at each trophic level. So if one species is affected, it does not affect other trophic levels so seriously.
5. Each species of any ecosystem is kept under a natural check so that the system remains balanced. For instance, if the primary consumers (herbivores) had not

been in nature, the producers would have been perished due to overcrowding and competition. Similarly, the survival of primary consumers is linked with the secondary consumers (carnivores) and so on.

6. The study of food chain helps us to understand the problems of biomagnifications. Sometimes certain toxic substances, instead of dispersing, get concentrated at each level in the food chain and are referred to as biological magnification or bioaccumulation.

***Biomagnification:* -**Every living organism on this planet requires chemicals to function correctly. However, the Biomagnification definition suggests that when the accretion of some non-essential chemicals increases within living organisms, it can become harmful to them. Biomagnification is a kind of condition in which the chemical concentration extends the concentration of its food in an organism when the major exposure path occurs from the diet of an organism. The food web biomagnification is defined as the trophic enrichment of contaminants within food webs and results in the preceding increase in chemical concentrations with increasing animal trophic status.

Biomagnification means gathering various unimportant and, at times, harmful substances by organisms at different levels of a food chain. It occurs when industrial, agricultural, and human wastes are dumped into the oceans via rivers, sewers, streams, etc. Most of this waste is toxic and dangerous and deposited on the sea bed. The bottom feeders of a food chain consume these and gradually, it is carried to the top of that particular food chain.Furthermore, the concentration of toxic materials increases with every step up on a food chain. Ultimately, it affects humans as they sit on top of most of the food chains. Human beings consume fishes that are higher on the food chain. Therefore, they are likely to carry a substantial amount of these toxic elements.

The containment information about biomagnification states that heavy metals such as mercury and arsenic are also involved. Additionally, pesticides like polychlorinated biphenyls (PCBs) compounds and DDT are entering the human body via the food that they consume. Biomagnification is usually defined as the transfer of a xenobiotic chemical from food to an organism, resulting in a generally higher concentration within the organism than source. However, not all authors use this definition and some define biomagnification as the increase in concentration between trophic levels, if the biomagnification factor (concentration in predator/concentration in prey) >1, then the compound is biomagnified. The problem with this definition is that the mechanism leading to the increase may be simply due to accumulation from the surrounding water whereas Connell's definition restricts the term to concentration increases that result from food intake alone. I believe that restricting the definition solely to food intake is preferable as the mechanism of uptake is defined and follow this common usage of the term. (Gray, 2002).

Balance of Energy in the Biosphere

Energy neither has mass nor does it occupy space and hence cannot be touched or picked up. Energy is defined as the capacity to do work and transfer heat from a hot product to a cold one when they come in contact. Light, heat, electricity and energy are stored in sugal, coal, petroleum products etc. And moving matter such as wind, water and energy emitter from nuclei of certain isotopes are all source of energy. Thus, energy comes in many forms. Energy is classifies as either kinetic or potential.

Heat: **-** Heat refers to the total kinetic energy of all the moving atoms, ions or molecules within a given substance and temperature is a measure of the average speed of motion of the atoms, ions or molecules at a given time in a sample of matter. For example, the total heat content of a big pond is huge, but the average temperature of water is low, whereas a cup of hot tea has much lower heat content than the big pond but the temperature is much higher. Biological activity requires utilization of energy, which ultimately comes from the sun. Solar energy is transformed into chemical energy by the process of photosynthesis and then again converted into mechanical and heat forms of energy during metabolic activities.

The sun releases energy by the nuclear transmutation of hydrogen to helium with a concomitant release of considerable radiant energy in the form of the electromagnetic waves, involving a rhythmic exchange between potential and kinetic energy. The solar radiation extends from high-frequency short-wave x-rays and gamma rays to low-frequency long) wave radio waves. Approximately, 99% of the total energy remains in the region between ultraviolet and infrared wavelengths (from 0.136 to 4.0 u). The visible spectrum spreads over 0.38 to 0.77 u, involving about 50% of solar radiation. Only the fifty millionth of a sun's energy output reaches the earth's outer atmosphere, at a constant rate referred to as the solar flux, which is defined as the amount of radiant energy of all wavelengths that cross the unit area per unit time. The solar flux is about 8.368 J. At a given place, it varies diurnally because of the earth's rotation on its axis. It also varies seasonally with the latitude because of the earth's revolution around the sun and the inclination of the earth's equatorial plane with respect to its orbital plane. About 42% of the solar flux is reflected back (33% from the clouds and 9% from dust) and about 10% of it is absorbed or diffusely scattered by atmospheric gases like ozone, oxygen, water vapour, etc. Thus about 48% of the total solar flux actually reaches the earth's surface (Geiger, 1941). Of this 48%, a considerable amount may be reflected back from light surfaces or from clear, bright sand. The radiant energy absorbed in the troposphere is radiated outward in the infrared portion of the spectrum and some infrared radiation strikes the earth's surface.

The atmosphere, soil, water and the organisms on the earth's surface receive solar radiation, which includes infrared radiation. This radiation heats up the earth and affects the climate, the soil-forming processes, and physiological processes like photosynthesis. Heat energy evolves either during transformation of one form of energy into another, or when any work is done. Metabolism, growth, reproduction and other activities of organisms involve energy transformations and heat production. In any process, heat may be evolved (exothermic or exergonic) or absorbed (endothermic or endergonic). Nitrogen fixation by nitrogen fixing bacteria, an endergonic process, is always accompanied by the exothermic breakdown of organic substances. In this exothermic process, energy is evolved, part of which is utilized by the endergonic process. %n natural processes, changes of one form of energy to another (except heat) are usually incomplete, because energy conversion involves friction and heat production.

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UNIT: - 9

Stationary State Economy and Equilibrium Population

Introduction

The environmental strategy behind the market solution supposes that all significant long-period problems associated with economic growth in an economy-environment system of fixed mass may be resolved in the marketplace. It supposes that economic signals generated in the course of transactions between economic agents will be sufficient to head off such global depletion and pollution disasters as those predicted by the Club of Rome. More particularly, it supposes that the negative feedbacks of the price system will ensure that rational economic agents cannot overexploit their environment. It is important to appreciate, though, that the market solution represents an historically unique environmental strategy, and an historically unique sense of rationality. It has no direct parallels in other societies. Indeed, it shares very few features with the environmental strategies of other societies.To understand the *differentia specifica* of the market solution it is useful to look at other environmental strategies. Although this takes us beyond the bounds of the modern economy, and beyond the rationality of modern economic theory, it addresses similar issues to those raised in various modern debates about the environmental implications of economic growth. The Club of Rome debate, for example, was largely about alternative environmental strategies. The antigrowth elements in the arguments of Forrester et al. were, at the same time, positive pleas for a more quiescent approach to the management of the environment (https://www.cambridge.org/core/books/abs/economy-and-environment/stationary-state/457C515BC048F789D0BB02F9B8C0705E).

Stationary State Economy

John Stuart Mill was among the nineteenth century's greatest philosophers. Perhaps best known for his defense of moral utilitarianism and individual liberty, Mill was also a leading economic thinker of his day. His major work on economics, Principles of Political Economy, built upon the insights of Adam Smith, David Ricardo, and Thomas Malthus in an effort to better systematize the principles of laissez faire economics and explain its “progress in wealth.” Mill also explained, like his predecessors, why laissez faire economics would eventually culminate in what was then called a “stationary state economy,” a condition of economic stagnation whereby a society, having reached the physical limits of economic growth, would simply reproduce wealth by replacing worn- out goods, maintaining capital stocks, and carefully husbanding non-renewable resources. But unlike his predecessors who viewed a stationary state as a dismal condition, Mill welcomed it; for he thought it gave people a sufficient level of wealth to both free them from life’s necessary but coarser toils and provide them the leisure to develop their mental and moral capacities – necessary conditions for a happier life. In this way, Mill tied his positive assessment of a stationary state to his moral defence of liberty and utility maximization. This contrasts with contemporary views of a stationary state economy, which typically see it as a hindrance to wealth creation and thus a constraint on utility maximization. Moreover, well- functioning markets within which economies grow are seen as neutral arbiters of competing consumer choices, and therefore protective of individual liberty. As a result, contemporary economists offer a positive assessment of economic growth and market liberalization based on liberty and utility maximization, turning Mill’s view on its head (Buckley, 2011).

These opposing positions result from disagreement on how best to understand utility and describe markets. By retracing Mill’s thought and contrasting it with similar defenses of laissez faire economics, the place and purpose of a stationary state economy can be revived for today’s reader who might otherwise dismiss it as opposed to one’s self-interest and irrelevant to today’s issues.

Equilibrium population

A population in which the allelic frequencies of its gene pool do not change through successive generations. An equilibrium can be established by counteracting evolutionary forces (e.g., a balance between selection and mutation pressures) or by the absence of evolutionary forces.When a population is in equilibrium, both genotype and allele frequencies remain constant from one generation to the next. If a population satisfies the conditions necessary to ensure that genotypes are in Hardy–Weinberg proportions, it follows that it is also in equilibrium. Even if a population does not satisfy the Hardy–Weinberg conditions, however, it may still be in equilibrium. The frequency of recessive alleles preventing individual monkey flower plants from producing pollen, for example, is likely to represent a balance between the tendency of natural selection to eliminate the recessive allele and recurrent mutation that tends to increase its frequency. A population in which such forces are balanced might be said to be in dynamic equilibrium. Two dynamic equilibrium points in a gene regulatory network correspond to biological switch to a gene circuit.

The Hardy-Weinberg Equilibrium

The Hardy-Weinberg equilibrium gives us a tool to observe how populations evolve (or don't). It states that the frequencies of alleles and genotypes will stay the same through the generations as long as there are no evolutionary influences. In other words, our beetles will stay 86% green over time as long as the following requirements are met:

1. Mating must be random
2. Population size must be large, so one individual isn't accounting for a significant portion of the gene pool
3. No migration, meaning individuals can't be entering or leaving the population
4. No random mutations in the genes being studied
5. No natural selection on the genes being studied

As long as our beetles follow these tenets, they will be in a Hardy-Weinberg equilibrium. You can imagine that on our unpredictable planet this kind of stability isn't the norm. So what good is this concept? Well, it gives us a sort of baseline. If the population deviates from the equilibrium, we'll know something is up in terms of evolution.

The Hardy-Weinberg Equation

The Hardy-Weinberg equation allows us to calculate and predict genotype frequencies in large populations satisfying the equilibrium requirements. The Hardy-Weinberg equation is:

$$p^2 + 2pq + q^2 = 1$$

For a gene with two possible alleles, p and q represent the allelic frequency. Since we're dealing with frequencies and probabilities, the equation adds up to 1.

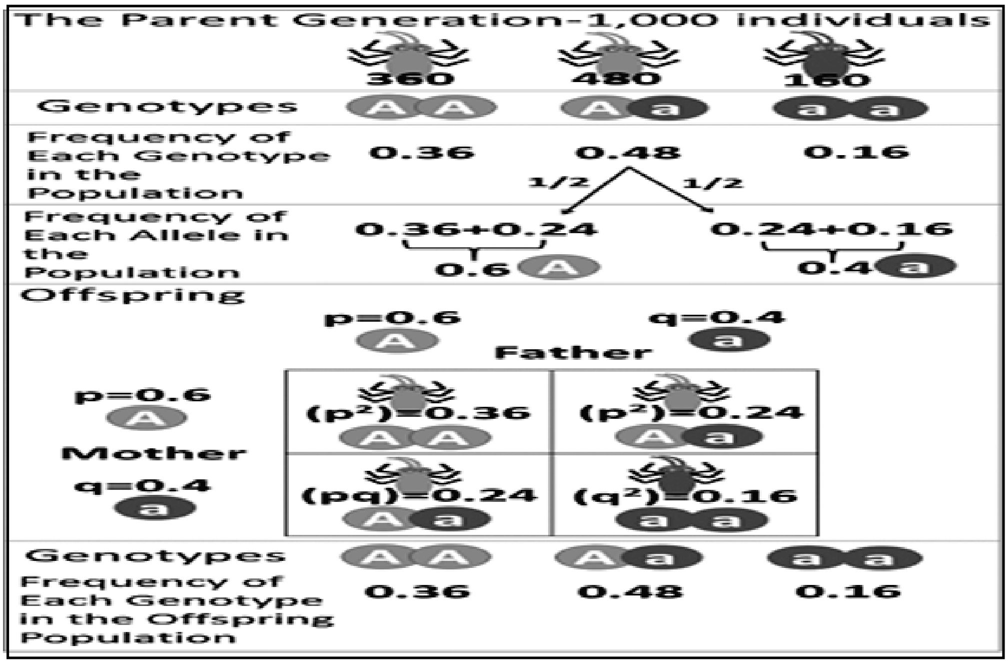
Let's use a diagram to see how this equation works with our beetles. There are only two alleles controlling the green and brown phenotype: 'A', the dominant green allele, and 'a', the recessive brown allele. We have 1,000 beetles in our parent population: 360 are green with the genotype AA, 480 are green with the genotype Aa, and 160 are brown with the genotype aa. So we can calculate the frequency of each genotype by dividing the number of each genotype by 1,000, giving us 0.36, 0.48, and 0.16. But what's the frequency of each allele? Remember, each genotype includes the two inherited alleles. For the AA and aa genotypes, every individual has two identical alleles, so the allelic frequency for those members can just be carried over from the genotype frequencies (0.36 and 0.16). For the Aa genotype, half the alleles will be A and half will be a, so we will split that frequency (0.48) in half for each allele and add it to the frequencies from our AA and aa individuals.

The frequency of 'A:' 0.24 + 0.36 = 0.6

The frequency of 'a:' 0.24 + 0.16 = 0.4

Now we can say that the frequency of 'A' is 0.6 and the frequency of 'a' is 0.4. If we randomly pick a beetle from our population, there is a 60% chance it carries an 'A' allele and a 40% chance it carries an 'a' allele.

Equilibrium Diagram



Source: - https://study.com/academy/lesson/hardy-weinberg-equilibrium-definition-equation-evolutionary-agents.html

Summary of Equilibrium Population

- Understanding of Population genetics principles, requires the basic concepts of Mendelian genetics: the result of segregation, the concept 'gene', 'phenotype', 'genotype', 'dominant', 'recessive' traits, 'allele' etc. Parental mating types and expected distribution of genotypes among the offspring.
- Hardy-Weinberg equilibrium is the solution to an intriguing question: what happens to gene frequency of a dominant character over generations in a population. With three times more frequent than normal does this will increase over generations?
- HWE law states that under the absence of intervening factors, especially in a large population, given random mating, no selection of any sort, no mutation and absence of demographic factors like migration, differential fertility and mortality etc., the allele frequency remain constant over generations. This can be proved theoretically, easily, for a 'biallelic locus and it can be extended to multilocus as well.
- The importance of HWE: it gives a methodology to estimate the allele frequency in a population based on phenotypic/genotypic information of the parental mating types. It helps us to investigate the relationship between change in gene frequency with respect to mutation, migration, selection, genetic drift etc. The entire investigation is the kernel of a branch of biomathematics or the new field: 'population genetics' and 'quantitative genetics'.
- HWE is the bench mark of qualitative test to check whether a trait, an allele, SNP, is in equilibrium. It tells how to distinguish between the effects of evolutionary forces from the demographic factors.
- Mutation is a non-systematic and random, but rate of mutation is site specific. Mutations are more frequent at hot-spots and are rare at the 'conserved region'. The mitochondrial non-coding genome has a higher frequency of mutations than the nuclear genome.
- Genetic drift is a non-systematic force which can lead to significant changes in gene frequency in a small population. If an allele is rare in a small population, it can get lost or get fixed in the population over generations.

- Founder effect is one form of genetic drift. The founders are a sample (represent a fraction of the genetic diversity) of original populations. The descendents of a few founders have the gene frequency that is dependent on the genetic composition and genetic structure of the founders. It can also happen as bottleneck effect, especially as a result of sudden population size reduction in a population, due to reasons such as natural causes or man-made causes or socio-cultural regulations. There could be serial founder effect as a result of waves of migration at different times. The mitochondrial investigation of human origins suggests that the human origins and migration to other continents appears as a result of serial founder effect from Africa.
- Natural selection is one of the complex systematic forces that can influence significant changes in gene frequency. Selection can operate in multitude ways and it is a slow process than to the effect of migration or admixture etc.
- Selection basically operates at differential fertility and mortality levels. It is measured as 'fitness' the ability to leave offspring and refers to 'relative rate of survival'. It is measured by 'selection coefficient' ('s') which is a function of fitness (W). The fitness or selection coefficient differs with respect to the type of dominance: complete, partial, over etc.
- The effect of 'directional selection' to shift the mean allele frequency towards its extremes. Or it could be stabilizing selection that shifts the allele frequency of extreme alleles as a result the heterozygote frequency will increase. Or it could be disruptive selection where the extreme allele frequency increases as against the heterozygote frequency.
- Selection can also be measured based on demographic factors of fertility and mortality trends. Crow's Index of opportunity for selection measures total selection intensity that a population can experience which depend on two components, fertility and mortality.
- Gene flow (migration/admixture) is a systematic factor which can bring rapid changes in gene frequency within a short period. In general, human populations follow a variety of restrictions or regulations that restrict gene flow between and within populations. The barriers for gene flow could be because of culture or due to geographical, political, religious and linguistic etc.

- There are theoretical models to investigate the effect of spatial gene flow or population structure between populations. Island model, stepping stone model, neighbourhood model help us to investigate the spatial gene flow in different situations of population structure (Stem, 1943).

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UNIT: - 10

Environmentalism in Geography

Introduction

"Environmentalism" and "determinism" are terms covering varied concepts. Environmentalism included both environmental determinism and the environmentalist definition of geography as the study of man-environment relationships. These were not identical: most who accepted the environmentalist definition preferred possibilism to geographical determinism. These two positions were not consistent extensions of the metaphysical concepts of free will and determinism: possibilism denied environmental control but not necessarily other determinants, whereas geographic determinism conflicted both with possibilism and all other particular single-factor determinisms. But since environmentalists never completely excluded cultural factors, they differed from possibilists and especially probabilists only in degree.

Nor has any challenge to general determinism eliminated deterministic systems, methodological constructs expressing lawful processes, frequently finding mathematical expression, and intersecting with other deterministic systems or contingencies. Thus environmental determinism may be included with other analogous systems in a broader framework including both lawfulness and choice. Allegedly antithetical constructs may play complementary roles in objective geographical analysis(Lewthwaite, 1966).

Environmentalism seeks to preserve the air and water we all depend upon; as well as conserve and protect entire ecosystems compromising of animals, plants, and humans found in different habitats throughout our planet. Along with preserving natural elements, this movement primarily seeks to protect the Earth's resources that humanity requires for survival and development. The most pressing issue of our global society today is climate change. This includes the issues of air and water pollution, water scarcity, food insecurity, deforestation, rising sea levels, loss of species and habitat biodiversity, and loss of indigenous environmental knowledge and traditions.

Civic environmentalism is a regional, local, or individual response to environmental issues. It is a type of social action where citizens cooperate and work together to solve environmental problems as a means to improve the communities they live and work in. The ultimate goal of civic environmentalism is to ensure a sustainable community or movement through collective participation. In this case, sustainability can be defined as a lifestyle made up of decisions that protect the natural environment and drive social and technological innovation to solve environmental problems. These lifestyle decisions are intended to preserve the ability of future generations to achieve the same quality of life (https://www.learningtogive.org/resources/environmentalism).

Environmentalism or environmental rights: - It is a broad philosophy, ideology, and social movement regarding concerns for environmental protection and improvement of the health of the environment, particularly as the measure for this health seeks to incorporate the impact of changes to the environment on humans, animals, plants and non-living matter. While environmentalism focuses more on the environmental and nature-related aspects of green ideology and politics, ecologism combines the ideology of social ecology and environmentalism. *Ecologism* is more commonly used in continental European languages, while *environmentalism* is more commonly used in English but the words have slightly different connotations.

Environmentalism advocates the preservation, restoration and improvement of the natural environment and critical earth system elements or processes such as the climate, and may be referred to as a movement to control pollution or protect plant and animal diversity.[1] For this reason, concepts such as a land ethic, environmental ethics, biodiversity, ecology, and the biophilia hypothesis figure predominantly.

At its crux, environmentalism is an attempt to balance relations between humans and the various natural systems on which they depend in such a way that all the components are accorded a proper degree of sustainability. The exact measures and outcomes of this balance is controversial and there are many different ways for environmental concerns to be expressed in practice. Environmentalism and environmental concerns are often represented by the colour green, but this association has been appropriated by the marketing industries for the tactic known as greenwashing. Environmentalism is opposed by anti-environmentalism, which says that the Earth is less fragile than some environmentalists maintain, and portrays environmentalism as overreacting to the human contribution to climate change or opposing human advancement (https://en.wikipedia.org/wiki/Environmentalism).

Introduction: the status of the 'environment' in geographical explanations

The immediate stimulus for this Forum is the perception among a number of geographers across the subfields of their discipline that 'the environment' has in certain spheres been brought into arguments that attribute it with powerful and singular causal power; and, moreover, that these arguments have been associated with the discipline in ways that have various effects on the nature of geographical explanations and their public prominence. In recent years a certain type of determinist environmental thinking has emerged It can be understood to be one strand in a broader discourse of what we can call academic 'environment talk' (which includes political ecology, environmental history, climatology, and many others). Yet this 'neo-environmental determinism' (Sluyter, this Forum) is characterized by an emphasis on the core explanatory power of non-human/non-animal components of the biophysical sphere in shaping human outcomes (in relation to development, disease, conflict, responses to climate change, etc). Whereas other forms of environmental talk, such as political ecology (eg, Peet and Watts, 2004), highlight the contingent historically and geo-graphically specific cultural meanings and human engagements with environmental processes, neo-environmental determinism claims to discern invariable dynamics between (certain kinds of) society and 'the' environment. These determinist frameworks differ from early twentieth-century versions of environmental determinism in a number of ways.

First, in intellectual terms, recent determinisms have emerged in the context of widespread knowledge of Darwinian evolution, atmospheric and climate science, 'new genetics', and detailed ecological and social knowledge's, all of which create a more knowledge-rich starting point (while also providing the basis of robust critiques of these same environmental determinisms; see below). Second, in terms of socio-political con-texts, current environmental determinisms reûect subtle arguments about 'cultural' determinism, rather than crass racial ideologies. However, as Felipe Fernández-Armesto makes clear (this Forum), the concept 'culture' can be used as if it were equivalent to a biologically determined entity, and he thereby reveals the biologisms that underlie certain strands of neo-environmental determinist thinking.

Many human geographers have expressed a combination of scepticism and surprise at the apparently inexorable rise of such arguments. Johnston (2007) calls Jared

Diamond – whose books have often provided a lightning rod for critique and debate – 'a late interloper … [but] not [a geographer] really'. Yet there has been a surprising lack of discussion about the implications of the rise of neo-environmental determinist arguments. Geographical journals have tended to engage with these arguments through book reviews, as well as indirectly in articles presenting de-tailed analyses of environment-society relations (as indeed do numerous books). Yet relatively little has been written systematically about these arguments in terms of their validity (or lack of it) within the discipline, about their implications for human geographers' and environmentalists' attempts to bring non-determinist research to a public audience, and the potential long-term consequences for the discipline of these high proûle representations of 'geography'.

Importance of Environmentalism

Climate change is the biggest problem that humanity faces today. The severity and urgency of the climate crisis stems from the bleak reality of the impact it will have on the lives of today's youth and future generations to come. There will be irreversible damage caused to every habitat and ecosystem of our planet. The rate or speed at which changes are taking place in our global atmosphere and on Earth is the primary cause of concern (Lindsey, 2019).

Our call to action and desire to minimize the damage and effects are greater than ever, especially in today's millennial, and Gen Z generations. Environmentally friendly products have increased in availability, and efforts such as recycling, reducing consumption, and online environmental petitions have advanced the space of environmental conservation. But, this isn't enough. The increase in global human consumption and population has contributed to a climate crisis that requires better environmental policies and radical change in legislation, consumer habits, and an overall change in human lifestyle.

The climate crisis does not recognize political borders nor does it discriminate across class, race, or national origin. However, government and human response to the climate crisis is impacted by social and political biases and discrimination. Environmentalism has a significant role in promoting equity and justice as communities of color and people living in poverty face greater environmental challenges and bear higher negative cost from environmental problems (The Lancet, 2018). Western and industrial nations, such as the USA, Russia, China, Germany and much of Europe, have emitted the most greenhouse gases, but developing nations are paying the price for the damage as they battle balancing economic growth and environmental protection. Similarly, the intangible and emotional connection to nature is at risk. The science might be dense behind environmental issues, but the human connection to the environment around us is the most natural connection in our life.

Civic environmentalism is the best way for each of us to play our part in the fight against climate change. Western and developed governments, along with giant corporations, should take most of the responsibility and action on reducing the effects of climate change. However, this is a human problem, and we can each do something. While some humans did more to cause it than others, we can all contribute to being environmentally friendly. As citizens, we can choose to recycle or reuse some materials and make purchases that use responsible packaging. Buying local and choosing bicycles and public transportation over vehicles that emit greenhouse gases is always helpful. We can reduce our consumption of meat and dairy products whose mass production is hard on the environment, and we can reduce our consumption overall. We don't have to give up things that we require or bring joy to us; we must only reduce, reuse, and recycle to play our individual parts (EPA, 2019).

Determinism

Determinism is the belief that all human behaviors flow from genetic or environmental factors that, once they have occurred, are very difficult or impossible to change. For example, a determinist might argue that a person's genes make him or her anxious. An extreme determinist would argue that gene-based anxiety cannot be altered, while a moderate determinist would argue that anxiety's genetic basis makes it more difficult to change.

In the history of geographical thinking, human – nature dialogue has been studied and analyzed from a number of different perspectives and views. The first amongst these approaches to deliberate on the human-nature relationship was determinism. In the words of Platt (1948) determinism, refers to the idea that everything in human life is caused inevitably by previous events or conditions. The primary initial source of determinists for an explanation was the physical environment, and the theoretical order was centered on the belief that the human activity was controlled by the parameters of the environment which was their habitat. Determinism is one of the most important philosophies, which continued in one form or other till World War II. In the context of this paradigm, it is believed that due to the difference in the natural environment, the variations in human behaviour in different parts of the world can be described. The spirit of deterministic ideology is that the level of development of history, culture, lifestyle and social group or nation is solely governed by the physical components of the environment at any scale. Determinists generally consider humans as a passive agent on whom physical factors are working continuously and thus determine their approach and decision-making process. In short, the determinists believe that most human activities can be explained as a response to the natural environment.

The Path of Determinism in Geography

In the discipline of geography, the paradigm of environmentalism had stirred considerable debate in the emerging field of geography. In this discipline, the terms 'environmentalism' and 'determinism' have often been used as synonyms with the simple definition that the natural environment is responsible for all human actions. Here we are not going into the debate that Environmentalism and determinism are not identical rather we will emphasize on the fact that this paradigm holds a special place in geographical thinking. In the words of Beck (1985) environmental determinism was at the center of one of the longest debates in the history of the social science of geography. Moreover, it provided geography the definition that it is the study of man-environment relationships. In spite of years of debate over the issue, there has yet to be any clearly defined disposition of the matter. Rather, it was an idea that stirred, eventually dispatched by the majority that felt it unworthy of further discourse. In spite of that ruling, the theory has reemerged periodically to bother scholars and the public alike. The fact that it continues to be revived among various writers, scholars, and others is cause for consideration. Rather a considerable work has been done in recent years on this perennial theme of man and the environment and it leaves little doubt that though some have pronounced environmentalism as dead as the dodo, it may prove to be, as Spate in his article Quantity and Quality in Geography published in the Annals of the American Geographers in 1960, has affirmed, an "Immortal bird, not born for death."

Environmental determinism was geography's entry into modern science (Peet, 1985). The biological roots of geography enabled it to serve as a highly significant component of legitimation theory in the naturalism fashionable in the post-Darwin period when science rather than religion legitimated social actions. Fulfilling this ideological function together with providing associated practical skills (like exploration, inventory, mapping, and boundary drawing) made geography a modern, mass reproduced, science. Determinism as an approach attempted to explain the imperial events of the late nineteenth and early twentieth-century capitalism in a scientific way; thus solidifying geography's position in sciences as an analytical science. To understand determinism and why it became an ideological pariah in human geography, it is imperative to consider its historical context.

In the context of the effect of natural conditions, the first attempt was made by Greek and Roman scholars explaining the physical characteristics and character traits of different people and their culture. At that time this effort was not contained only among geographers rather included scholars from different fields like the doctor Hippocrates, philosopher Aristotle, and Historians Thucydides, Polybius, and Herodotus. In the Greco-Roman era, regional studies were closely tied with the study of history; Thucydides and Polybius saw Athens's natural conditions and geographical position as factors for its greatness. For example, Aristotle explained the difference between Northern Europe and Asian people in the context of climate causes, while explaining the greatness and greatness of Rome, while mentioning similar incidents of Strabo.

In the eighteenth century, historian George Tatham, also explained the differences among the people, in relation to the differences between the countries in which they lived. Kant was also a determinant who had said that people of New-Holland (East Indies) kept half-closed eyes and till they did not touch their back, they would not see their head at any distance without bending. Thomas Malthus was a scientific determinant (1766-1834) he not only emphasized the effect of different environments but also emphasized the boundaries that were imposed on social milieu because of these different environments. Deterministic reasoning continued in the 19th century when geography itself was related to other sciences. Carl Ritter, a German geographer adopted an anti-human approach and laid the philosophical base of determinism in geography. Ritter tried to make a difference in the physical constitution of the body, body, and health of men living in the different physical environment. Many of his students considered geography as “a study of the relationship between people’s density and the nature of their land”. Many geographers of their school had declared that their main task was to identify the influence of physical cultural geographical conditions and the political fortunes of residents of any area in both East and present. Alexander von Humboldt, one of the founders of ‘Modern Geography’ and a contemporary of Ritter, also said that the life of the residents of a hill country is different from those in the plains.

At the end of the 20th century, in American geography, the prevalent view that wellfitted into the intellectual environment was the doctrine of determinism. Most of these were influenced by Darwin’s ideas which were further developed by William Morris Davis during the cycle of erosion model. The primary concern was with documenting the control or influence of the environment on human society. Friedrich Ratzel, the founder of ‘new’ determinism, supplemented the ‘classical’ geographical determinism with the elements of ‘Social Darwinism’ and developed the state’s theory as an organism. He believed in the existence of a qualification and saw the ‘man’ as the end product of development - a development which was natural selection of type according to the ability to adjust itself to the physical environment of the environment. He along with his disciple Ellen Churchill Semple became the most vocal expression of the deterministic approach in geography.

Criticisms of Determinism

After World War II, this philosophy was vehemently criticized in the United States, UK, Canada and many other countries. Geographers observed that this approach exaggerated the active role of nature while interpreting human history. The determinists only consider humans capable of being adapted but man’s efforts reveal many facts which the forces of the environment cannot explain. The does do not only become socially dysfunctional but was also subjected to an academic, theoretical critique. Barrows (1923) initiated a meek criticism from within the environmentalist paradigm where he argues that the relations between man and environment should be seen from the standpoint of human adjustment as this was "more likely to result in the recognition and proper valuation of all the factors involved, and especially to minimize the danger of assigning to the environmental factors a determinative influence which they do not exert."

Sauer (1963) had a stronger reservation where he states that a transposition of divine law into omnipotent natural law had caused the "eager adherents of the faith of causation" to sacrifice their earlier concerns in the name of a "rigorous dogma of naturalistic cosmology, most notably in American physiography and anthropogeography". As he later added, "natural law does not apply to social groups" (Sauer 1963); instead what man did in an area involves the active agency of culture that shapes of the landscape. Sauer's critique played the internal role in diminishing the place of determinism as the hegemonic theory of geography and initiated redefinition as a "social science, concerned with areal differentiation.

Now the question arises that did Sauer provided a valid alternative theoretical base to the geographical thinking. Peet (1985) states that the cultural geography of Blache and Sauer failed to establish a comprehensive theory within the discipline. In the 1930s, 1940s, and 1950s geography drifted towards a regional perspective as determinism was being critiqued without being effectively replaced. The chorological concept logically implies that relationships do not define the field. Whatever be the goal of the geographer, he should not be limited to or prejudiced against any particular technique or method. Literary description and levels of human insight are undoubtedly required, but in Hartshorne's (1939) words the geographer must analyze the relationships of earthly features, "regardless of whether these interrelations can be described in terms of 'natural laws' or 'social laws.' Therefore, determinism has not retreated from geography; rather, a number of deterministic systems have been evolved to assist the interpretation of spatial patterns, and have frequently been compressed into mathematical formulae. There is sufficient room for analysis of both physical and cultural factors, quantitative laws and artistic synthesis. Determinism was redefined, refined, reviewed, and redirected, but never completely dislodged.

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UNIT: - 11

Approaches to the Study of Environment: Reductionist, Holistic and Organismic

Introduction

In many respects, environmental degradation has become one of the most prominent adverse phenomena in today's world. The scope of environmental problems has grown substantially in the past decade and will continue to expand and diversify more in the future; no generation has ever faced a more daunting agenda. The world today confronts a multitude of environmental problems, more than ever before, over a wider range of spatial and temporal scales, and requiring various skills for proper control (Luthy et al. 1992). Consequently, the profession of environmental engineers and scientists is becoming increasingly multidisciplinary, and necessitates the integration of expertise from a wide range of fields (Luthy and Small 1990; Mino, 2000).

The total environment consists of and is impacted by various interconnected frameworks, namely, physical, biological, social, legal, political, economic, and cultural. The interrelationship between such elements is a major consideration needed to develop integrated environmental solutions that are acceptable from the standpoint of economics, political reality, and public attitudes. Today's environmental engineers and scientists are challenged to recognize the ramifications of the interdependence of such factors since environmental dilemmas cut across various disciplinary bounds, and thus cannot be resolved from a single perspective. It is well recognized that protecting and preserving environmental qualities require input from multidisciplinary experts, and that environmental engineering and sciences programs should be interdisciplinary in nature and include aspects of various engineering and science disciplines (Safferman et al. 1996; Bishop 2000; Mino 2000).

An environmental study is the interdisciplinary academic field which systematically studies human interaction with the environment in the interests of solving complex problems. It is a broad field of study that includes also the natural environment, built environment, and the sets of relationships between them. The field encompasses study in basic principles of ecology and environmental science, as well as associated subjects such as ethics, policy, politics, law, economics, philosophy, environmental sociology and environmental justice, planning, pollution control and natural resource management.

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Reductionist Approach

Reductionism is one of the most importantepistemological and methodological issues thatarise when considering both the relationshipsbetween different levels of organization of matter and the links between different scientiûcdisciplines (sociology, psychology, biology,physics, etc.). In the domain of psychology,reductionism is oft en linked with the mind-body problem. The issue of reductionism isalso connected with the examination of researchmethods of psychology as a science, particularlythe treatment of the analysis of psychologicalphenomena into their components as researchstrategy.

Reductionism is an epistemological and methodological stance which absolutizes the reduction of complex systems or problems to theirsimple components or elements. The term"reduction" originates from the Latin term "reducere" which meant to lead back, bringback, and restore. Reduction is a legitimateand useful method of scientiûc investigation of complex systems and problems throughanalysis of their components. The reductionof the higher-level structures to lower-level component s is constructive only when theresearchers are aware of the speciûc characteristics of the subject of their investigation, theconditions, and the limitation of reduction.Reductionism as the opposite of holism acceptsthe view that all objects or systems are reducible to lower levels in the hierarchy of theirconstitution.

Reductionism is the idea that all of the complex and apparently disparate things we observe in the world can be explained in terms of universal principles governing their common ultimate constituents: that physics is the theory of everything. Antireductionism comes in two varieties: epistemological and ontological. Epistemological anti-reductionism holds that, given our finite mental capacities, we would not be able to grasp the ultimate physical explanation of many complex phenomena even if we knew the laws governing their ultimate constituents. Therefore we will always need special sciences like biology, which use more manageable descriptions. There may be controversy about which special sciences cannot be replaced by reduction, but that there will be some is uncontroversial. Ontological antireductionism holds, much more controversially, that certain higher-order phenomena cannot even in principle be fully explained by physics, but require additional principles that are not entailed by the laws governing the basic constituents. With respect to biology, the question is whether the existence and operation of highly complex functionally organized systems, and the appearance of self-replicating systems in the universe, can be accounted for in terms of particle physics alone, or whether they require independent principles of order (Nagel, 2007).

The Limits of Reductionism

Classical science and engineering have used successfully a reductionist methodology, i.e. separate and simplify phenomena in order to predict their future. This approach has been applied in a variety of domains. Nevertheless, in recent decades the limits of reductionism have become evident in phenomena where interactions are relevant. Since reductionism separates, it has to ignore interactions. If interactions are relevant, reductionism is not suitable for studying complex phenomena. There are plenty of phenomena that are better described from a non-reductionist or 'complex' perspective. For example, insect swarms, flocks of birds, schools of fish, herds of animals, and human crowds exhibit a behavior at the group level that cannot be determined nor predicted from individual behaviors or rules. Each animal makes local decisions depending on the behavior of their neighbors, thus interacting with them. Without interactions, i.e. with reductionism, the collective behavior cannot be described. Through interactions, the group behavior can be well understood. This also applies to cells, brains, markets, cities, ecosystems, biospheres, etc. In complex systems, having the 'laws' of a system, plus initial and boundary conditions, is not enough to make a priori predictions. Since interactions generate neither novel information that is not present in initial nor boundary conditions, predictability is limited. This is also known as 'computational irreducibility', i.e. there is no shortcut to determine the future state of a system other than actually computing it. Since classical science and philosophy assume that the world is predictable in principle, and relevant interactions limit predictability, many people have argued that a paradigm shift is required, and several novel proposals have been put forward in recent years (Heylighen et al., 2006).

Holistic Approach

"The Holistic Approach to Environment" deals with exploring possibilities and developing the models of benevolent co-existence of all beings on Earth. It does not deal solely with one segment of environment, but it sees the life on the planet as a whole. It promote benevolent co-existence of all beings on Earth taking the perspective of certain sciences, e.g. ecology, chemistry, chemical technology, biology, zoology, mechanical engineering, metallurgy, philosophy, integrative bioethics, etc. and finding the solutions to the actual environmental issues of today (https://casopis.hrcpo.com).

Holism, which was first put forth by Jan Smuts, is traditionally understood as a philosophical theory that holds that the determining elements of nature are wholes that cannot be reduced to the sum of their parts and that the universe's evolution is a record of the activity and creation of such wholes. In a broader sense, it refers to the idea that wholes cannot be broken down into identifiable parts or reduced to them without leaving behind residuals that cannot be explained. Holism may also be defined by what it is not: it is not synonymous with organicism; holism does not require an entity to be alive or even a part of living processes. And neither is holism confined to spiritual mysticism, un-accessible to scientific methods or study. Holism's proponents contend that by putting an emphasis on community, processes, networks, participation, synthesis, systems, and emergent qualities, the "ills" of reductionism will be remedied. It is crucial to understand that holism does not require any other biological comparison outside organisms themselves in order to analyse any whole or the entirety of any individual in all its ramifications. Even in its most extreme version, a holistic approach on its own is unrealistic and would doom scholars to a life of fruitless wallowing in unmanageable complexity. For accessing and comprehending a reality that is getting more and more complicated, both holism and reductionism are necessary.

What is Holism?

The new paradigm of holism, which serves as the foundation for the Holistic Management decision-making process, can guide us toward a sustainable civilization. Allan Savory struggled to comprehend why natural resource management practices were failing (despite the largest number of scientists the world has ever known and were in fact leading to massive environmental degradation, social collapse, and failing economies), but he eventually found that human decisionmaking was the common cause of the massive loss of biodiversity and the symptoms associated with this loss. His more than 35 years of work to create a procedure for making decisions that are simultaneously socially, economically, and environmentally sound led to the creation of holistic management (Savory, 1988).

The Definition of Holistic Management

The principle of holism is the foundation of holistic management. A fresh perspective on the world is holism. We need to start thinking in terms of wholes, which are the only functional units in nature. As an illustration, the oxygen and hydrogen atoms that make up the water molecule. If we only examine the characteristics of oxygen and hydrogen, we will remain in the dark regarding the characteristics of water. The water molecule must be studied as a whole since it is more than the sum of its component parts. When we start thinking and acting holistically, we can clearly see how each of our choices affects the ecosystem and how our entire existence as humans depends on it.

By describing the entire being managed, the holistic management decision-making process is started. Every whole consists of the following: 1) the individuals in charge of managing the whole—these are the decision makers; 2) the resource base—this entails all of the resources available, such as land, machinery, skills, knowledge, etc.; and 3) individuals who influence or are influenced by the decision makers. If you wish to manage a "farm," for instance, the whole might include the family who lives there and runs it, the land, the structures and equipment on it, and the money the family has on hand or can make from the farm. The minimum whole comprises not only the land but also the associated human values, culture, and financial resources. This is thought of as a single entity for management.

The group as a whole then decides on a comprehensive objective. The holistic goal is a description of what the collective is managing in terms of the quality of life desired based on collective values, what must be produced to create this quality of life, and a description of the resource base as it must be far into the future in order to sustain what the collective produces. The motivation comes from human values. Here, we specify the level of prosperity and how the resource base will provide the income required to maintain the desired standard of living, such as through the sale of animals, crops, or any other business that does not go against our beliefs. In this case, we are merely outlining what we desire and not how to get there. The foundation of the holistic aim is sustainability of the resource base, which is required to support the profit and values outlined in the holistic objective. The hardest and most effective part of the holistic decision-making process is the holistic aim.

Organismic Approach

Organismic theory as we understand it here is not, properly speaking, one of the branches of theoretical biology, neither is it co-extensive with the latter. By way of introduction, it might be useful to approach its nature in terms of an analogy: if one studies the universe at large there is at one's disposal as a tool, the theory of general relativity. This theory is not a form of astrophysics nor is it even equivalent to cosmology. Instead, it is merely an abstract scheme obtained by comparatively simple generalization of a body of theory which is known to be valid in our small fraction of the universe. It imposes certain sharp restrictions upon models of the universe at large while at the same time admitting of a considerable and satisfying variety of such models. The actual construction of a cosmological scheme must be based upon observation. But in the absence of the relativistic formalism, one would be deprived of any theoretical guidance in cosmological questions and would be reduced to a rather crude form of incoherent empiricism. Organismic theory as we have tried to develop it over a number of years starts by assuming the unqualified validity of the laws of ordinary quantum mechanics for the physical and chemical processes going on in organisms (moreover, we assume the validity of the basic statistical postulates from which the second law of thermodynamics follows). The main subject of enquiry in organismic theory is the manner in which the basic state functions of quantum mechanics must be combined so as to form representations of that extreme complexity and inhomogeneity which characterizes organisms. We claim that the uncritical extrapolation of some of the rules of statistical mechanics as commonly practised leads to a disastrous undervaluation of the potentialities of such utterly complex systems. While leading up to a logical and statistical analysis of the consequences of extreme complexity and inhomogeneity this theory, owing to its formal character, prevents at the same time the introduction of speculative hypotheses such as vitalist concepts, or the abrogation of the second law of thermodynamics (Elsasser, 1964).

The theory of the organism-environment system starts with the propositions that in any functional sense organism and environment are inseparable and form only one unitary system. The organism cannot exist without the environment, and the environment has descriptive properties only if it is connected to the organism. Although for practical purposes we do separate organism and environment, this common-sense starting point leads in psychological theory to problems which cannot be solved. Therefore, separation of organism and environment cannot be the basis of any scientific explanation of human behavior. The theory leads to a reinterpretation of basic problems in many fields of inquiry and makes possible the definition of mental phenomena without their reduction either to neural or biological activity or to separate mental functions. According to the theory, mental activity is activity of the whole organism-environment system, and the traditional psychological concepts describe only different aspects of organization of this system. Therefore, mental activity cannot be separated from the nervous system, but the nervous system is only one part of the organism-environment system (Savory, 1988).

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UNIT: - 12

Environmental Philosophy: Spaceship Earth, Deep Ecology and Gaia-hypothesis

Introduction

Environmental Philosophy is the study of the concepts and principles relating to human interactions with nature and the natural environment, to related presuppositions about the relation of humanity and nature, and to practical implications for both individuals and societies. Environmental Ethics is a key branch of Environmental Philosophy, and studies relevant normative issues, values and principles. This chapter reviews the history, scope and development of Environmental Philosophy and Ethics, presents some of the key issues in these continually broadening fields, and considers possibilities and prospects for their further development. Some of the relevant concepts, principles, issues and values were used and/or debated during the ancient, medieval and early modern periods, and proposals for a new approach were made during the mid-twentieth century (Leopold, 1989).

Environmental philosophy in its modern form developed in the late 1960s, the product of concerns arising from diverse quarters: naturalists, scientists and other academics, journalists, and politicians. A sense of crisis and doom pervaded the time, reflecting fears about the Cold War and the threat of nuclear annihilation; this malaise helped to spawn the protest music and countercultural protests of the 1960s. In 1962 Rachel Carson published the best-selling book Silent Spring, which documented the accumulation of dangerous pesticides and chemical toxins throughout planetary food webs. In 1968 the journal Science published ¯ The Tragedy of the Commons by Garrett Hardin, who argued that human self-interest and a growing population would inevitably combine to deplete resources and degrade the environment. In the same year another best-seller, Paul Ehrlich's Population Bomb, anticipated hundreds of millions of deaths in the coming decades because of the failure of food supply to keep pace with an ever-expanding global population. Ehrlich also claimed to foresee an imminent and dramatic decline in U.S. population and life expectancy, and some of these gloomy predictions were echoed in The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind (Meadows et al. 1974).

Fears about nuclear war, threats of pollution, and emerging awareness of social injustice coalesced first in popular and folk music and then found less poetic expression in academic work. In a seminal essay that appealed to increasingly disenchanted Marxist and left-leaning thinkers, Murray Bookchin remarked that ecology was a critical science with ¯explosive implications because "in the final analysis, it is impossible to achieve a harmonization of man and nature without creating a human community that lives in a lasting balance with its natural environment" (Bookchin, 1970).

The Scope of Environmental Philosophy and Environmental Ethics

Environmental Ethics studies principles of value and obligation, the concepts involved, the status of these principles, and their application to practical issues such as the preservation of biodiversity, ecological restoration and the mitigation of climate change. It is usually regarded as a branch of applied ethics, akin to older branches such as medical ethics and the ethics of war and peace, and a neighbour of such new branches ofapplied ethics as business ethics and development ethics. Yet some of its findings, such as the suggestion that non-human living creatures have moral standing, challenge some of the longstanding tenets of normative ethics, and have thus contributed to ethical themes central to the whole gamut of mainstream ethical investigation and concern.Environmental philosophy studies philosophical issues that extend beyond ethical ones, including metaphysical ones concerning the relation of humanity to nature, and that of religious belief to both nature and humanity; aesthetic ones concerning the character of aesthetic value, as found in nature rather than in human art, and its place in education; issuessurrounding the interface of environmental ethics and environmental economics; and also issues of political decision-making, and the representation in decision-making forums both of current people and of future and nonhuman interests. Eco-feminists would add the study of parallels between the treatment of nature and of women, and the importance of forms of self-understanding which, instead of privileging the rational, adopt a rounded view of human relationships and identity, with persons recognised as embodied and involved in networks of relationships, both with other people and with other species. Yet others hold that the findings of environmental philosophy can reconfigure our self-understanding as agents, together with our attitudes to our environment and to (the rest of) nature.

History of Environmental Philosophy

Human geography seems to have 'gone back to nature', or at least returned to that central question of human environmental relations, now heavily armed with a critical sense of the social origins of ideas of nature, its materiality and the politics of environmental change. As cultural geography's double attention to the symbolic and material forms of land, environment, landscape or nature gets recast in Latourian moulds, and Marxist explorations of social justice get environmental, nature returns to historical geography via environmental history (Harvey, 1996).

Environmental philosophy has a long history in western culture. It can be traced back to the teachings of Saint Francis of Assisi, to literature works of romanticism poets and transcendentalists, such as Wordsworth and Thoreau, and to conservation movements led by Theodore Roosevelt and Gifford Pinchot (Gallagher, 1997). Although many factors contribute to the emergence of environmental philosophy, the 1960s is the critical period for the field to develop as it saw 'the rapid growth of information concerning a diverse array of environmental ethics, including overpopulation and its relation to poverty and famine, the depletion of non-renewable resources, and the harmful effects to human and non-human by chemical pollutants' (De Laplante, 2004). Other events such as the Great Smog of 1952 in London and the Japan Minamata disease in 1956 also evoked public environmental-protection consciousness. All these environmental problems prompted human beings to reflect on the relationship between human beings and nature.

In the 1960s, groundbreaking academic works were published, influential environmental movements were organized, and some policy reforms started taking place. Rachel Carson's best-selling book Silent Spring was published in 1962, and Lynn White's article The Historical Root of Our Ecological Crisiswas published in 1967. Numerous NGOs, like Sierra Club, which sued Disney for intending to build an entertainment resort in wilderness, were established and supported by citizens. Governments were forced to develop legislation to respond to environmental issues, such as, for example, the UK passing Clean Air Act in 1956 as a reaction to the Great Smog (Gallagher, 1997).

The philosophical and historical questions of difference, unity and domination in human–environmental relations have been central to geography and environmental history. Yet they have also been key areas of analysis and critique within feminism and feminist geography where the cultural meanings of the human, nature and the natural have been so thoroughly interrogated. Despite this, the historical focus of environmental history and the insights of feminist environmental philosophies have remained largely disconnected to the detriment of both. The problems of the isolation of these two areas of theory and research go far beyond the absence, with some exceptions, of questions of gender within environmental history, or the persistent gendering of nature. Feminist and postcolonial approaches to questions of gender, culture, nature and the environment clearly suggest ways in which environmental history could become more sensitive to social difference. But importantly also, environmental history can enrich the study of the material and symbolic relationships between gender and the environment. Most simply this means using environmental history to disaggregate the terms 'nature' or environment, and using the politics of social difference to disaggregate the notion of the 'human' in environmental history.Arising as it has from a concern with the adverse environmental effects of moderncapitalism and especially in contexts of European colonial settlement, environmental history is already an area of study with strong ethical, moral and critical dimensions. Its practitioners have also grappled with the challenges posed by both revisions of classical ecology and postmodern approaches to epistemology (1994).

Spaceship Earth

When you watch a spaceship take off or look at photos of life inside a spacecraft, it's easy to see that the spaceship's passengers have to carry everything they need with them, including enough food, water, and fuel to last the entire flight. There are no grocery stores or gas stations in space! The ship also has to have systems to control both the temperature and the quality of the air, which have to be just right for the astronauts to survive. Our little Spaceship Earth is only eight thousand miles in diameter, which is almost a negligible dimension in the great vastness of space. Our nearest star - our energy-supplying m other-ship, the Sun - is ninety-two million miles away, and the nearest star is one hundred thousand times further away. It takes approximately four and one third years for light to get to us from the next nearest energy supply ship star. That is the kind of space-distanced pattern we are flying. Our little Spaceship Earth is right now travelling at sixty thousand miles an hour around the sun and is also spinning axially, which, at the latitude of Washington, D.C., adds approximately one thousand miles per hour to our motion. Each minute we both spin at one hundred miles and zip in orbit at one thousand miles. That is a whole lot of spin and zip. When we launch our rocketed space capsules at fifteen thousand miles an hour, that additional acceleration speed we give the rocket to attain its own orb it around our speeding Spaceship Earth is only one-fourth greater than the speed of our big planetary spaceship. Spaceship Earth was so extraordinarily well invented and designed that to our knowledge humans have been on board it for two million years not even knowing that they were on board a ship. And our spaceship is so superbly designed as to be able to keep life regenerating on board despite the phenomenon, entropy, by which all local physical systems lose energy. So we have to obtain our biological life-regenerating energy from another spaceship: the sun (Visser, 2017).

Our sun is flying in company with us, within the vast reaches o f the Galactic system, at just the right distance to give us enough radiation to keep us alive, yet not close enough to burn us up. And the w hole scheme o f Spaceship Earth and its live passengers is so superbly designed that the Van Allen belts, which we didn't even know we had until yesterday, filter the sun and other star radiation which as it impinges upon our spherical ram parts is so concentrated that if we went nakedly outside the Van Allen belts it would kill us. Our Spaceship Earths designed infusion of that radiant energy of the stars is processed in such a way that you and I can carry on safely. You and I can go out and take a sunbath, but are unable to take in enough energy through our skins to keep alive. So part of the invention of the Spaceship Earth and its biological life-sustaining is that the vegetation on the land and the algae in the sea, employing photosynthesis, are designed to impound the life-regenerating energy for us to adequate amount.

But we can't eat all the vegetation. As a matter of fact, we can eat very little of it. We can't eat the bark nor wood of the trees nor the grasses. But insects can eat these, and there are many other animals and creatures that can. We get the energy relayed to us by taking the m ilk and m eat from the animals. The animals can eat the vegetation, and there are a few of the fruits and tender vegetation petals and seeds that we can eat. We have learned to cultivate more of those botanical edibles by genetically inbreeding (Buckminster, 1969).

Spaceship Earth is the collaborative work of millions of minds to achieve something better no matterwhat it is. Our individual experiences will ultimately influence the direction our planet heads no matterhow trivial it may seem. A person we meet for only a brief moment will retain something we, as anindividual, stated even if it was minute. In the end, what we say from what we think will change thefuture no matter how hard we attempt to avoid communicating that thought. Even if we remain silent,our bodies will be a trumpet of thoughts that communicate to be understood by others. However, it isall for the good of the globe. Our existence is written in the heavens with experiences that come from along unbreakable chain of experiences—the essence of progress for the future.

Deep Ecology

Deep Ecology is term devised by Norwegian philosopher Arne Naess (b. 1912) in 1972 to refer to an environmentalism that believes fundamental changes in the way our species conceives our relation to nature are necessary before we are to find a way out of the ecological crisis. As such it is a normative political philosophy, contrasted with shallow ecology, which assumes that minor "technical fixes" in our present way of doing things will solve our environmental problems (Naess, 1973). Tinkering with our present way of considering nature as resource will never work, according to deep ecology. Nature must be appreciated for its intrinsic value, or worth in itself, regardless of how humans might benefit from it. Starting from this axiom a whole new philosophy of living with nature will develop.

This is the term's political meaning, and it has thus been the guiding conceptual framework for several radical environmental movements, presenting a platform of deep ecology that usually expresses the following ideological principles:

1) The flourishing of human and nonhuman life on Earth has intrinsic value. The value of nonhuman life forms is independent of the usefulness these may have for narrow human purposes.
2) Richness and diversity of life forms are values in themselves.
3) Humans have no right to reduce this richness and diversity except to satisfy vital needs.
4) Present human interference with the nonhuman world is excessive, and the situation is rapidly worsening.
5) The flourishing of human life and cultures is compatible with a substantial decrease in the human population.
6) Significantchange of life conditions for the better requires change in economic and technological policies.
7) Life quality should be given more primacy than a high standard of living.
8) Those who subscribe to the foregoing points have an obligation to implement the necessary changes." (Naess 1989).

The eight points were developed by Arne Naess in collaboration with George Sessions, and are periodically revised so they do not approach a kind of dogmatic certainty that is anathema to the flexibility claimed by the movement. As an ideological platform, deep ecology has been adopted by the American radical group Earth First!, known for spiking trees and staging theatrical protests against logging companies and the forest service. It has been attacked by social ecologists who claim it is a politics based on naive nature worship, not a careful understanding of the inequal social structures in our culture. (Bookchin and Foreman 1991).

It is important to distinguish the philosophy of deep ecology from its aspect as a political manifesto. In this regard Naess starts with self-realization in a way so that individuality is found, not lost through contemplation of the whole of life. Concern for the environment should never be opposed to concern for the self. This way there is no conflict between the human and the nonhuman worlds. Identification with the struggles of all life forms is key, and with self-realization as the fundamental value, concern for the whole Earth naturally follows. This train of thought builds upon an awareness that the very term ecology, used by scientists as a name for the branch of biology that studies the relationships between organisms and their habitats, has a social and political root, as it was coined in 1866 by Ernst Haeckel, who started with science to come to spiritual conclusions about the totalizing direction humanity was taking toward the end of the last millenium. Haeckel's ideas were used, after his death, to build a sense of the unique value of 'German' nature and the people's disciplined obligation to protect it, and this is a bugaboo that all attempts at ecological philosophizing since then have had to acknowledge, and respond to with a sense of caution. This is why deep ecology should not be seen as totalizing, dogmatic, and exclusive. It is an open call to realize that the science of wholes and relationships in the biosphere involves a moral insistence on the preservation and admission of the intrinsic value of nature and the search for the best human place within it (Rothenberg, 1987).

As philosophy of science, deep ecology questions science but inserts values into science, giving humanity a sense of humility in the face of nature. Beyond simply studying the relationship between organisms and their environment and making a place for humans in such a relationship, it encourages us to take a moral stand. We are but one of many species. It is a higher form of cultural evolution to show concern for other species, indeed, perhaps an imperative of our biological heritage. In this way deep ecology has, in addition to its influence on environmental activists, inspired biologists to form the new discipline of conservation biology. Whereas previously biologists would be overly cautious and not feel comfortable calling biodiversity a good in itself, and rest content with studying it and collecting more data as the world's species vanish at an alarming rate, the moral imperative of deep ecology insists that scientists use their discipline and information to help preserve what they are studying because it is of intrinsic value, in itself, to the planet of which we are a part.Deep ecology thus respects the contributions of science, but asserts that they are not enough to preserve the life-giving qualities of our biosphere. Achange in human values is also essential, and this viewpoint gained perhaps its most mainstream advocate in American vice president Al Gore, who asserted, in his book Earth in the Balance (1992) that the ecological crisis will only be averted by "change in the fundamental values at the root of our civilization." This book introduced Al Gore's ecological credentials to the American public, and helped him get elected as vice-president. While in office together with Bill Clinton Gore was not known for passing any important environmental initiatives, but upon leaving office he became one of the most important advocates for mitigation of human-induced climate change, through his films An Inconvenient Truth (2006) and An Inconvenient Sequel (2017).

Some see climate change as a planetary threat that may unify people around the principles of deep ecology, to finally convince us that we really must change the way we define our species in relation to nature. The totalizing challenge of climate change has captivated the attention of philosophers in recent years, moving beyond earlier calls for recognizing the value nature has in itself, and the lighter idea that human societies could be made more 'sustainable' by using less energy and not growing at an intractable rate. Every year there is greater evidence that we are changing the planet in ever more severe ways. Some call this new era the anthropocene and want to argue that there is no such thing as an Earth anymore without human transformation of it. This is tantamount to entering a new geologic era, and we must change our behavior in relation to this (Naees, 2005). Deep ecologists tend to be uncomfortable with such an idea, saying it smacks of human hubris and imagining that humans are far more powerful than we are. Nature on its own will survive whatever damage we do to the planet, even if we eradicate a majority of the Earth's species, in what others have called the "Sixth Great Extinction" (the last being caused by a meteor hitting the Earth, which among other things wiped out most of the dinosaurs), over millions of years life will rebound. So what we are saving the planet for might rightly not be for nature, but for ourselves, so our own species can survive our inherent tendency to destroy and overreach. Deep ecology teaches humility, and fitting into this world instead of trashing it. The scale of damage humanity seems to be inflicting upon the planet seems huge, perilous, and ominously dangerous. The problem of climate can appear too great for us to wrap our thoughts around, and the more we learn about its complete grip on environment tragedy the less it seems we can do. Timothy Morton has named such huge looming threats 'hyperobjects,' calling them too big to simply pinpoint and greater than any one thing (Naess, 1989).

Critiques of Deep Ecology

The deep-ecological principles of biocentric egalitarianism and metaphysical holism have elicited robust critiques. Some of the most interesting debates have cantered on the normative status of Deep Ecology. Naess maintains that Deep Ecology is essentially descriptive. For Naess unmitigated empiricism or ‘‘ecophenomenology’’ (Brown and Toadvine 2003) promotes a direct experience of the qualities of nature—its ‘‘concrete contents’’ (Naess, 1985). Deep Ecology, he argues, is simply an enumeration of general principles that command the assent of persons open to the direct apprehension of nature. Scholars have found the disclaimer that Deep Ecology is not a normative system—and ought not be judged as such—disingenuous. They have treated Deep Ecology as the legitimate object of the analysis of moral philosophy. Some regard Deep Ecology as strident axiological egalitarianism that is useless in adjudicating conflicting interests. If all organisms are of equal value, then there is no basis upon which to make prescriptions because the kind of value distinctions necessary for evaluating the moral situations of environmental ethics are deliberately disqualified. The principle of biocentric egalitarianism, on this view, renders Deep Ecology impotent as an ethical theory. Environmental ethics is predicated on the possibility of a nonegalitarian axiology. In the words of the American philosopher Bryan Norton, ‘‘The 120,000th elk cannot be treated equally with one of the last California condors—not, at least, on a reasonable environmental ethic’’ (1991, p. 224). Baird Callicott has surmised that environmental ethics must manifestly not ‘‘accord equal moral worth to each and every member of the biotic community’’ (1980, p. 327). These scholars argue, therefore, that biocentric egalitarianism must be scrapped (Sylvan 1985).

Naess has steadfastly resisted any gradations or differentiations of intrinsic value among organisms in light of such criticisms. Responding to Fox, Naess wrote that some intrinsic values may differ, but not the kind he talks about. He and Fox, said Naess, ‘‘probably do not speak about the same intrinsic view’’ (Naess 1984, p. 202). Naess has reiterated his intuition that ‘‘living beings have a right, or an intrinsic or inherent value, or value in themselves, that is the same for all of them’’ (Naess 1984, p. 202). As Naess conceded early on (1973), brute bio spherical reality entails some forms of killing, exploitation, and suppression of other living beings; the aim is to do better than harm, to respect on an equal basis the right of every life form to flourish (Naess 1984). Nevertheless, some philosophers have found such a guideline essentially vacuous, like vowing honesty until lying is warranted (Sylvan 1985a), thus undermining the very foundation of the principle itself. If any realistic practice deals with few situations where biota may be valued equally, then the principle is empty.

According to some critics, there are irresolvable structural tensions between biocentric egalitarianism and metaphysical holism in ecological value systems (Keller 1997). They argue that, in light of the real functions of living natural systems, it is impossible to even come close to affirming both the ability of all individuals to flourish to old age and the integrity and stability of ecosystems. The necessity of exterminating ungulates such as goats and pigs for the sake of the health of fragile tropical-island ecosystems is but one example. Regard for the health of whole ecosystems might, therefore, require treating individuals differently, because individuals of different species have unequal utility (or disutility) for wholes; if that were the case, then viewed from the standpoint of an entire ecosystem, biocentric egalitarianism and metaphysical holism might be mutually exclusive and inconsistent with each other to the extent that at least one would have to be abandoned—or perhaps both (Keller 1997).

Gaya Hypothesis

The Gaia hypothesis, also known as Gaia theory or Gaia principle, proposes that all organisms and their inorganic surroundings on Earth are closely integrated to form a single and self-regulating complex system, maintaining the conditions for life on the planet. The scientific investigation of the Gaia hypothesis focuses on observing how the biosphere and the evolution of life forms contribute to the stability of global temperature, ocean salinity, oxygen in the atmosphere and other factors of habitability in a preferred homeostasis. The Gaia hypothesis was formulated by the chemist James Lovelock and co-developed by the microbiologist Lynn Margulis in the 1970s. Initially received with hostility by the scientific community, it is now studied in the disciplines of geophysiology and Earth system science, and some of its principles have been adopted in fields like biogeochemistry and systems ecology. This ecological hypothesis has also inspired analogies and various interpretations in social sciences, politics, and religion under a vague philosophy and movement.The Gaia theory posits that the Earth is a self-regulating complex system involving the biosphere, the atmosphere, the hydrospheres and the pedosphere, tightly coupled as an evolving system. The theory sustains that this system as a whole, called Gaia, seeks a physical and chemical environment optimal for contemporary life (Lovelock, 2009).

Gaia evolves through a cybernetic feedback system operated unconsciously by the biota, leading to broad stabilization of the conditions of habitability in a full homeostasis. Many processes in the Earth's surface essential for the conditions of life depend on the interaction of living forms, especially microorganisms, with inorganic elements. These processes establish a global control system that regulates Earth's surface temperature, atmosphere composition and ocean salinity, powered by the global thermodynamic desequilibrium state of the Earth system (Kleidon, 2011).The existence of a planetary homeostasis influenced by living forms had been observed previously in the field of biogeochemistry, and it is being investigated also in other fields like Earth system science. The originality of the Gaia theory relies on the assessment that such homeostatic balance is actively pursued with the goal of keeping the optimal conditions for life, even when terrestrial or external events menace them(Lovelock, 2009).

Regulation of the salinity in the oceans

Ocean salinity has been constant at about 3.4% for a very long time. Salinity stability in oceanic environments is important as most cells require a rather constant salinity and do not generally tolerate values above 5%. Ocean salinity constancy was a long-standing mystery, because river salts should have raised the ocean salinity much higher than observed. Recently it was suggestedthat salinity may also be strongly influenced by seawater circulation through hot basaltic rocks, and emerging as hot water vents on mid-ocean ridges. However, the composition of seawater is far from equilibrium, and it is difficult to explain this fact without the influence of organic processes. One suggested explanation lies in the formation of salt plains throughout Earth's history. It is hypothesised that these are created by bacteria colonies that fix ions and heavy metals during life processes (Gorham, 1991).

Regulation of oxygen in the atmosphere

The atmospheric composition remains fairly constant providing the ideal conditions for contemporary life. All the atmospheric gases other than noble gases present in the atmosphere are either made by organisms or processed by them. The Gaia theory states that the Earth's atmospheric composition is kept at a dynamically steady state by the presence of life (Lovelock, 2009). The stability of the atmosphere in Earth is not a consequence of chemical equilibrium like in planets without life. Oxygen is the second most reactive element after fluorine, and should combine with gases and minerals of the Earth's atmosphere and crust. Traces of methane (at an amount of 100,000 tonnes produced per annum) should not exist, as methane is combustible in an oxygen atmosphere (Cicerone&Oremland, 1988).

Regulation of the global surface temperature

Since life started on Earth, the energy provided by the Sun has increased by 25% to 30%however, the surface temperature of the planet has remained within the levels of habitability, reaching quite regular low and high margins. Lovelock has also hypothesised that methanogens produced elevated levels of methane in the early atmosphere, giving a view similar to that found in petrochemicalsmog, similar in some respects to the atmosphere on TitanThis, he suggests tended to screen out ultraviolet until the formation of the ozone screen, maintaining a degree of homeostasis. The Snowball Earthresearch, as a resultof "oxygen shocks" and reduced methane levels, that led during the Huronian, Sturtian and Marinoan/Varanger Ice Ages the world to very nearly become a solid "snowball" contradicts the Gaia hypothesis somewhat, although the ending of these Cryogenian periods through bio-geophysiological processes accords well with Lovelock's theory (Hoffman, 2001; Lovelock, 1995).

Biodiversity and stability of ecosystems

The importance of the large number of species in an ecosystem, led to two sets of views about the role played by biodiversity in the stability of ecosystems in Gaia theory. In one school of thought labelled the "species redundancy" hypothesis, proposed by Australian ecologist Brian Walker, most species are seen as having little contribution overall in the stability, comparable to the passengers in an aeroplane who play little role in its successful flight. The hypothesis leads to the conclusion that only a few key species are necessary for a healthy ecosystem. The "rivet-popper" hypothesis put forth by Paul R. Ehrlich and his wife Anne H. Ehrlich, compares each species forming part of an ecosystem as a rivet on the aeroplane (represented by the ecosystem). The progressive loss of species mirrors the progressive loss of rivets from the plane, weakening it till it is no longer sustainable and crashes (Richard, 2011).

Daisyworld

The Gaia hypothesis was greeted with hostility from many scientists and leading scientific journals, partly because of its mythological name. The first scientific criticism of the hypothesis was that it implies teleology, some conscious foresight or planning by the biota. Most subsequent criticisms have focused on the need for evolutionary mechanisms by which regulatory feedback loops could have arisen or be maintained. The Earth is not a unit of natural selection, and hence planetary self-regulation cannot have been refined in the same way as an organism's physiology. This posesthe challenge of explaining how planetary self-regulation could arise. The Daisyworld model was formulated to demonstrate that planetary self-regulation does not necessarily imply teleology. It provides a hypothetical example of climate regulation emerging from competition and natural selection at the individual level. Daisyworld is an imaginary gray world orbiting a star like our Sun that gets more luminous with time. The world is seeded with two types of life, black and white daisies. These share the same optimum temperature for growth of 22.5 degree C and limits to growth of 5degreeC and 40degreeC. When the temperature reaches 5 degree C, the first seeds germinate. The paleness of the white daisies makes them cooler than their surroundings, hindering their growth. The black daisies, in contrast, warm their surroundings, enhancing their growth and reproduction. As they spread, the black daisies warm the planet. This further amplifies their growth and they soon fill the world. At this point, the average temperature has risen close to the optimum for daisy growth.

As the Sun warms, the temperature rises to the point where white daisies begin to appear in the daisy community. As it warms further, the white daisies gain the selective advantage over the black daisies and gradually take over. Eventually, only white daisies are left. When the solar forcing gets too much, the white daisies die off and regulation collapses. While life is present, the system is a very effective temperature regulator. Solar input changes over a range that should heat the planet's surface by 55 degree C, yet it is maintained within a few degrees of the optimum temperature for daisy growth.Daisyworld illustrates the importance of feedback mechanisms for planetary self-regulation. Feedback occurs when a change in a variable triggers a response that affects the forcing variable. Feedback is said to be 'negative' when it tends to damp the initial change and 'positive' when it tends to amplify it. The initial spread of life is amplified by environmental positive feedback – the warming due to the spread of black daisies enhances their growth rate. The long period of stable, regulated temperature represents a predominance of negative feedback. However, if the temperature of the planet is greatly perturbed by the removal of a large fraction of the daisy population, then positive feedback acts to rapidly restore comfortable conditions and widespread life. The end of regulation is characterized by a positive feedback decline in white daisies – solar warming triggers a reduction in their population that amplifies the rise in temperature (Lenton, 2003).

Criticism

After initially being largely ignored by most scientists, (from 1969 until 1977), thereafter for a period, the initial Gaia hypothesis was ridiculed by a number of scientists, such as Ford Doolittle, Richard Dawkins and Stephen Jay Gould. Lovelock has said that by naming his theory after a Greek goddess, championed by many non-scientists,the Gaia hypothesis was derided as some kind of neo-Pagan New Age religion. Many scientists in particular also criticised the approach taken in his popular book "Gaia, a New look at Life on Earth" for being teleological; a belief that all things have a predetermined purpose. Responding to this assertion in 1990, Lovelock stated "Nowhere in our writings do we express the idea that planetary self-regulation is purposeful, or involves foresight or planning by the biota."Stephen Jay Gould criticised Gaia as merely a metaphorical description of Earth processes.He wanted to know the actual mechanisms by which self-regulating homeostasis was regulated. David Abram argued that Gould was unaware that mechanism was itself only metaphorical.Lovelock argues that no one mechanism is responsible, that the connections between the various known mechanisms may never be known, that this is accepted in other fields of biology and ecology as a matter of course, and that specific hostility is reserved for his own theory for other reasons (Abram, 1988; Gould, 1997).

Aside from clarifying his language and understanding of what is meant by a life form, Lovelock himself ascribes most of the criticism to a lack of understanding of non-linear mathematics by his critics, and a linearizing form of greedy reductionism in which all events have to be immediately ascribed to specific causes before the fact. He notes also that his theory suggests experiments in many different fields, but few of them in biology, which most of his critics are trained in. "I'm a general practitioner in a world where there's nothing but specialists... science in the last two centuries has tended to be ever-dividing" and often rivalrous, especially for funding, which Lovelock describes as overly abundant and overly focused on institutions rather than original thought. He points out that Richard Feynman not only shared this opinion (coining the term cargo cult science) but also accepted a lack of general causeand effect explanation as an inevitable phase in a theory's development, and believed that some self-regulating phenomena may not be explainable at all mathematically (Lovelock, 2001).

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Self-assessment Questions

Describe the component of an ecosystem.

Define ecological pyramids with suitable example.

Give an account of energy flow in an ecosystem.

Give an account of energy flow in an ecosystem.

Outline the salient features of oxygen and carbon cycling in an ecosystem.

Define the term ecology

Discuss the areas that ecology is concerned.

Elaborate the principles of natural ecology.

What is environment? Discuss the scope of environment.

Discuss the concept of environmental balance.

What do you mean by natural environment?

Discuss the various types of environment.

What is your concern about environmentalism in geography?

Elaborate the concept of spaceship earth and deep ecology.

Disclaimer

This self-learning material is based on different books, journals and web-sources.