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SYLLABUS

B. Com. (Hons.) Semester - 1

ENVIRONMENTAL STUDIES

(One-semester compulsory core module for undergraduate programmes)

Course Learning Outcomes: The course will empower the undergraduate students by helping them to–

(*i*) Gain in-depth knowledge on natural processes and resources that sustain life and govern economy.

(*ii*) Understand the consequences of human actions on the web of life, global economy, and quality of human life.

(*iii*) Develop critical thinking for shaping strategies (scientific, social, economic, administrative, and legal) for environmental protection, conservation of biodiversity, environmental equity and sustainable development.

(*iv*) Acquire values and attitudes towards understanding complex environmental-economic-social challenges, and active participation in solving current environmental problems and preventing the future ones.

(*v*) Adopt sustainability as a practice in life, society and industry.

UNIT 1: INTRODUCTION TO ENVIRONMENTAL STUDIES *(2 LECTURES)*

- **Multidisciplinary nature of environmental studies:** Components of environment: atmosphere, hydrosphere, lithosphere and biosphere.
- Scope and importance; Concept of sustainability and sustainable development; Brief history of environmentalism.

UNIT 2: ECOSYSTEMS *(6 LECTURES)*

- Definition and concept of Ecosystem
- Structure of ecosystem (biotic and abiotic components); Functions of Ecosystem; Physical (energy flow), Biological (food chains, food web, ecological succession), and Biogeochemical (nutrient cycling) processes. Concepts of productivity, ecological pyramids and homeostasis.
- **Types of Ecosystems:** Tundra, Forest, Grassland, Desert, Aquatic (ponds, streams, lakes, rivers, oceans, estuaries); importance and threats with relevant examples from India.
- Ecosystem services * (Provisioning, Regulating, Cultural and Supporting); Ecosystem preservation and conservation strategies; Basics of Ecosystem restoration.

UNIT 3: NATURAL RESOURCES *(8 LECTURES)*

- **Land resources:** Minerals, soil, agricultural crops, natural forest products, medicinal plants, and forest-based industries and livelihoods; Land cover, land use change, land degradation, soil erosion and desertification; Causes of deforestation; Impacts of mining and dam building on environment, forests, biodiversity and tribal communities.
- *Water resources:* Natural and man-made sources; Uses of water; Over exploitation of surface and ground water resources; Floods, droughts and international and interstate conflicts over water.
- *Energy resources:* Renewable and non-renewable energy sources; Use of alternate energy sources; Growing energy needs; Energy contents of coal, petroleum, natural gas and bio gas; Agro-residues as a biomass energy source.
- *Case studies:* Contemporary Indian issues related to mining, dams, forests, energy, etc. (e.g., National Solar Mission, Cauvery river water conflict, Sardar Sarovar dam, Chipko movement, Appiko movement, Tarun Bharat Sangh, etc.)

UNIT 4: BIODIVERSITY AND CONSERVATION *(8 LECTURES)*

- Definition of Biodiversity; Levels of biological diversity: genetic, species and ecosystem diversity.
- India as a mega-biodiversity nation; Biogeographic zones of India; Biodiversity hotspots; Endemic & endangered species of India; IUCN Red list criteria and categories.
- **Value of biodiversity:** Ecological, economic, social, ethical, aesthetic and informational values of biodiversity with examples; sacred groves and their importance with examples.
- **Threats to biodiversity:** Habitat loss, degradation and fragmentation; Poaching of wildlife; Man-wildlife conflicts; Biological invasion with emphasis on Indian biodiversity; Current mass extinction crisis.
- **Biodiversity conservation strategies:** *in-situ* and *ex-situ* methods of conservation; National Parks, Wildlife Sanctuaries, and Biosphere reserves; Keystone, Flagship, Umbrella, and Indicator species; Species reintroduction and translocation.
- **Case studies:** Contemporary Indian wildlife and biodiversity issues, movements and projects (e.g., Project Tiger, Project Elephant, Vulture breeding program, Project Great Indian Bustard, Crocodile conservation project, Silent Valley movement, Save Western Ghats movement, etc.)

UNIT 5: ENVIRONMENTAL POLLUTION *(8 LECTURES)*

- Environmental pollution (Air, water, soil, thermal and noise): causes, effects, and controls; Primary and Secondary air pollutants; Air and water quality standards.
- Nuclear hazards and human health risks.
- Solid waste management: Control measures for various types of urban, industrial waste, Hazardous waste, E-waste, etc; Waste segregation and disposal.
- **Pollution case studies:** Ganga Action Plan (GAP), Delhi air pollution and public health issues, Plastic waste management rules, Bhopal gas tragedy, etc.

UNIT 6: GLOBAL ENVIRONMENTAL ISSUES AND POLICIES *(7 LECTURES)*

- Causes of Climate change, Global warming Ozone layer depletion and Acid rain; Impacts on human communities, biodiversity, global economy and agriculture.
- **International agreements and programmes:** Earth Summit, UNFCCC, Montreal and Kyoto protocols, Convention on Biological Diversity (CBD), Ramsar convention, The Chemical Weapons Convention (CWC), UNEP, CITES, etc.
- **Sustainable Development Goals:** India's National Action Plan on Climate Change and its major missions.
- **Environmental legislation in India:** Wildlife Protection Act, 1972; Water (Prevention and Control of Pollution) Act, 1974; Forest (Conservation) Act 1980; Air (Prevention & Control of Pollution) Act, 1981; Environment Protection Act, 1986; Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006.

UNIT 7: HUMAN COMMUNITIES AND THE ENVIRONMENT *(6 LECTURES)*

- **Human population growth:** Impacts on environment, human health; and welfare; Carbon foot-print.
- Resettlement and rehabilitation of developmental project affected persons and communities; relevant case studies
- **Environmental movements:** Chipko movement, Appiko movement, Silent valley movement, Bishnois of Rajasthan, Narmada Bachao Andolan, etc.
- **Environmental justice:** National Green Tribunal and its importance.
- **Environmental philosophy:** Environmental ethics; Role of various religions and cultural practices in environmental conservation.
- **Environmental communication and public awareness:** Case studies (e.g., CNG vehicles in Delhi, Swachh Bharat Abhiyan, National Environment Awareness Campaign (NEAC), National Green Corps (NGC) "Eco-club" programme, etc.)

Contents

UNIT 1

Introduction to Environmental Studies

Important Terms to Know

- **Environment.** It is the sum total of water, air and land, their interrelationship among themselves and with the human beings, other living beings and property
- **Biosphere.** It is the part of the environment where the living organisms exist. It includes the lithosphere, hydrosphere, atmosphere and other "spheres" (For example, cryosphere etc.)
- **Environmental Studies.** This is concerned with the environmental disturbances and minimization of their impact through changes in the society.
- **Environmental Science.** It deals with the study of the processes in water, air, soil and organisms which lead to pollution or environmental damage and to know a scientific basis for establishing a standard which can be considered acceptably clean, safe and healthy for humans and the natural ecosystem.

Q. 1. Define the term environment. Give its scope and importance.

Ans. *Environment* is the sum total of water, air and land, their interrelationship among themselves and with human beings, other living beings and property. The word '*environment*' is derived from the French word "*Environ*" which means to encircle or surround. It includes all those things on which we are directly or indirectly dependent for our survival.

Scope of Environmental Study. Our dependence on our environment is not new to humankind. Since ages, civilizations have been established near or around the water bodies. Our natural landscapes such as rivers, mountains, forests, deserts or a combination of these elements are an essential part of our sustenance.

Despite the modernization we are part of and are still dependent on the natural landscapes such as forests and grasslands for our food and needs of life. We use water to drink and for other day to day needs, we breathe air and we are a part of global network of food web. Everything around us forms our environment and the services are vital and priceless.

Our dependence on the environment is so great that we cannot continue to live without protecting the earth's environmental resources. With time which is evident from advent of industrial revolution and population explosion. The greed of man has increased ever since. This has led to rapid unplanned economic

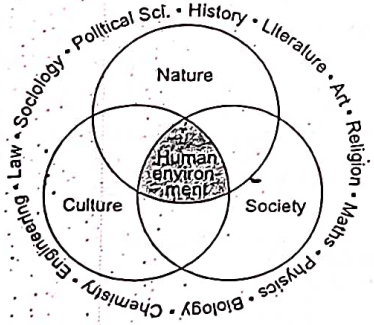
growth. The ill-effects of this type of development has led to environmental degradation.

Development has paved the way for the use of non-renewable resources such as minerals and oils extensively, thus resulting in their exhaustion in the near future. Non-renewable resources are not easy to replenish and take millions of years to form.

A switch to the renewable resources, *e.g.*, timber and water which can be replenished easily by natural processes such as regrowth or rainfall, can be appreciated. But it is important to use even these resources wisely so that we conserve the resources we need in the long-term. This is called sustainable utilisation or development. Thus environmental studies envisage the awareness of our resources along with the problems caused due to their exploitation and degradation. It is also important that each individual realises the importance of environment and changes the ways in which we use energy resources.

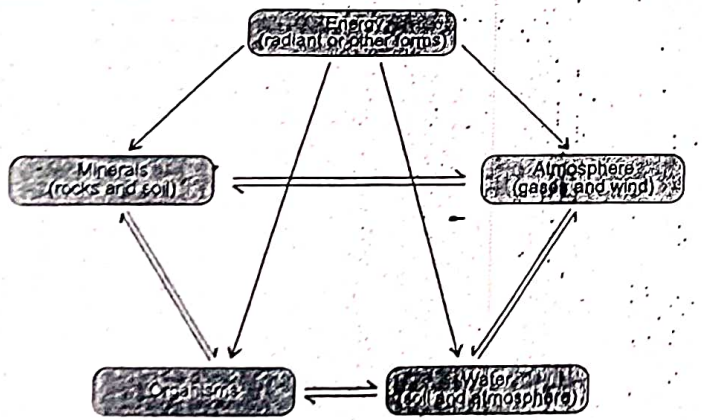
Unsustainable utilization can result from overuse of resources, because of population explosion and because many of us are using more resources than we actually need.

Environment is multidisciplinary in nature. It is not a singular subject. It covers the diversification of nature, culture and society. Thus, its scope is extremely wide and covers some aspects of nearly every major discipline.



Various fields of Environmental Studies

Importance of Environmental Studies. Importance of environmental studies lies in the fact that by being well-acquainted with the environment and its elements one can lead a healthy, spiritual and long life. The life of an organism is affected by the sum of all environmental factors.



Importance of environmental factors

The interrelation of these five factors affects human life and these factors work in conjunction and not in isolation. Thus, the study of environment is important for sustenance of life.

The importance of environment can be further explained under the following divisions:

(*i*) **Productive value of nature.** With the advancement of new fields such as biotechnology and development of new medicines and industrial products, it is clear that the world's species contain an incredible and uncountable number of complex compounds. These form the raw material and thus, open up the scope for further advancement in product development, useful for humankind.

(*ii*) **Aesthetic Recreational value of nature.** The beauty of nature and the values associated with it are priceless. One can appreciate the magnificence of a mountain, the power of the sea, but recreating the same is not possible. The National Parks and Wildlife Sanctuaries in relatively undisturbed areas create a true experience of wilderness. It brings about an understanding of the oneness of nature and the fact that we are entirely dependent on the intricate functioning of ecosystems.

(*iii*) **The option values of nature.** The increasing dependence on the ecosystem for not only our needs but also for our greed has made us available to the option values of nature. We can greedily use the resources and deplete them leaving nothing for the generations to come. Alternatively, we can sustainably use the Nature's bounties, its goods and services and save them for future.

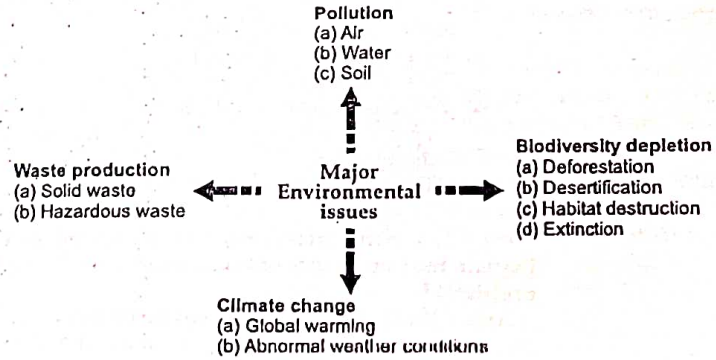
Q. 2. Why is the 'study of the environment' the need of the hour?

Or

What are the objectives and guiding principles of environmental study?

Ans. Human beings have neglected to acknowledge the tremendous benefits Nature provides. It is impossible to truly estimate the real value of what Nature has given to us. *For example,* forests prevent soil erosion, landslides and flooding; maintain the purity of air and water; affect local and global rainfall; regulate climate fluctuations; and promote watersheds and biodiversity.

Environmental studies give a great importance to the impact on environment caused due to human activities. In this, the major environmental issues are assessed and the gravity of these problems is measured and their solutions are found.



The objectives of environmental studies include:

(*i*) **Awareness.** Acquire an awareness of and sensitivity to the total environment and its allied problems.

(*ii*) **Knowledge.** Gain a variety of experiences and acquire a basic understanding of the environment and its associated problems.

(*iii*) **Attitude.** Acquire a set of values and feelings of concern for the environment and the motivation for active participation in environmental improvement and protection.

(*iv*) **Skill.** Acquire skills for identifying and solving environmental problems.

(*v*) **Evaluation ability.** Evaluate environmental measures and education programmes in terms of ecological, economic, social, aesthetic and educational factors.

(*vi*) **Participation.** Provides an opportunity to be actively involved at all levels in working towards the resolution of environmental problems.

The guiding principles associated with environmental studies are:

- To consider the environment in its totality (natural, artificial, social, economic, moral, cultural, etc.).
- To consider a continuous life process.
- To be interdisciplinary in approach.
- To emphasize on active participation in prevention and solution to environmental problems.
- To examine major environmental issues from local, national, regional and international points of view.
- To focus on current, potential environmental situations.
- To consider environmental aspects in plans for growth and development.
- To stress upon the complexity of environmental problems and the need to develop critical thinking and problem-solving skills.
- To promote the value and necessity of local, national and international cooperation in the prevention and solution of environmental problems.
- To utilise diverse learning about the environment and different approaches to teaching and learning about environment.
- To help learners to discover the symptoms and the real causes of environmental problems.
- To relate environmental sensitivity, knowledge, problem-solving and value-clarification at energy grade level.
- To enable learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences.

Q. 3. Elaborate on the multidisciplinary nature of environmental studies.

Or

Why is Environmental studies considered as a multi disciplinary subject? Explain the importance of this course in providing solutions to our environment problems? *[2018 May*

Ans. Although the realm of 'environmental study' implies a single subject, but its essence is multidisciplinary in nature. It is thus considered multidisciplinary as it teaches us to protect and sustain our natural resources of land, water, air and vegetation. Sustainability is the ultimate goal.

Since the environment is complex comprising everything around us, so environmental studies is the inter-disciplinary examination of how biology, geology, politics, policy studies, law, religion, engineering, chemistry and economics combine to inform about the consideration of humanity's effects on the natural world.

Physics. To understand the change of material and energy interaction and to make mathematical models of environment.

Chemistry. To understand the molecular interactions in the system.

Biology. To describe the effects within the plant and animal kingdom and their diversity.

Atmospheric Science. To examine the phenomenon of the gaseous outer layers of the Earth. It comprises meteorological studies, greenhouse effect, airborne contaminants, sound propagation, phenomena related to noise pollution and even light pollution.

Ecology. Branch of science that deals with the study of relationship between organisms and their surroundings. These studies could be on—endangered species, predator species and their interactions, effect upon populations by environmental contaminants etc.

Environmental Chemistry. To study the chemical alterations in the environment. Principal areas of study include soil contamination and water pollution.

Geo Science. It includes environmental geology, environmental soil science, volcanic phenomena and evolution of the earth's crust.

Mathematics and Computer Science. Used in environmental modeling and analysis of environment related data.

Economics. It deals with economical aspects of various components of the environment.

Law. It helps in framing environment related laws, acts, rules and their monitoring.

Social Science. It helps in dealing with population and health related issues.

Q. 4. Discuss the need for public awareness about the environment.

Ans. Since the advent of industrialisation, the natural resources are rapidly being used and thus, the degradation of environment by human activities has increased. The population explosion worsened the condition—with more people come more needs and hence more greeds. Thus, there came an urgent need to protect our environment so that we do not destroy it further, but also try to replenish what is lost for the generations to come.

It is not only the duty of the government, but also the responsibility of every individual to actively participate in protecting the environment. As there is a saying, *every drop counts*, similarly every single step towards sustainable environment is necessary and beneficial. To prevent ill-effects on the environment by our actions is economically more viable than cleaning up the environment once it is damaged.

- Individually we can reduce wasting natural resources and we can act as watchdogs that inform the Government about sources that lead to pollution and degradation of our environment.
- The role of mass media such as newspapers, radio, television, etc. is also very important to make people aware regarding environment. These

can strongly influence public opinion and even reach the high officials stating the dire need of green policies.

- There are various institutions, which are playing a positive role in environmental awareness such as BSI (Botanical Survey of India), ZSI (Zoological Survey of India), WII (Wildlife Institute of India).
- Role of Non-Government organisations that support conservation also adds in spreading the awareness and motivating youth to take environmental degradation as a serious issue of concern.

Education about the environment focuses on environmental improvement. Thus, the education of the subject involves values, activity, attitudes and ethics. To solve our environmental problems it is important to consider our values and take into account the ethics associated with it. Then only can we be able to move a step further in this regard.

Q. 5. Elaborate on the importance of Environmental Science as a compulsory course towards conservation of Environment in India. Describe the major challenges in implementing and achieving the goal of this course. *[2017 Dec.*

Ans. ***The importance of environmental science as a compulsory course can be understood from the following points:***

(*i*) **The subject gives a direct contact with nature and the knowledge of it.** The subject environmental science gives students an ample scope for 'application'. They will get some real-time knowledge and skill which is required when they are actually dealing with environmental problems and the possible solutions. They can actually see the knowledge of physics and chemistry and for that matter even biology helps them to protect environment. This could give the student community a sense of 'empowerment'.

(*ii*) **EVS encompasses many other science domains.** In Environmental Science, we find a classic amalgamation of many other branches of science. This will expose students to a variety of theories and practical approaches thus enriching their knowledge.

(*iii*) **EVS encourages collaborative studies.** Environmental issues are usually complex in nature. This helps to sharpen the analytical and problem solving skills of the students. Since the nature of environmental problems is both complex and critical, besides being huge, it demands team and collaborative work. This helps students to improve their interpersonal skills and they will emerge great leaders and team players in the future.

(*iv*) **Make students conscious towards the problems of the planet earth.** The study of environmental science could itself be an instrument in making students realize the peril of survival. Students might become aware of the danger that many may be unknowingly or ignorantly unleashing upon the planet we are living in.

The major challenges in implementing and achieving the goal of this course include:

(*i*) Lack of qualified teachers is a major concern. Often environmental science is allotted to any teacher with a basic science background which is not enough.

(*ii*) Environmental educators must come up with new knowledge and techniques. It is required that we reexamine the way we do research and train environmental professionals and educators, as well as the way we communicate environmental information to the students.

(*iii*) Environmental education must teach about science itself and about the use of the scientific method to help evaluate and respond to environmental threats. Educational materials that omit the important role of science and the general rules of scientific inquiry are damaging to the field of environmental education.

(*iv*) Environmental Science is considered a moral education subject in schools and colleges. It is considered as merely a qualifying examination. So, neither teachers nor students give it much consideration.

(*v*) Lack of jobs—Although environmental science is included in all spheres of education but its importance is still based on the lack of job opportunities it provides as a field of work. There is lack of employment in the field, whatever jobs are there, they are filled by other fields leaving students unemployed.

Q. 6. Brief up the history of environmentalism.

Ans. Beginning in Europe, in the very early 1800s, environmentalism came into existence and gradually grew strong in Britain as response to the Industrial Revolution. Industrial Revolution greatly affected water and air resources with widespread factories leading to people calling for wild spaces to the be protected.

The environmental movement began to take shape in North America when John Muir, one of the earliest environmentalist, convinced the U.S. congress to create the Yosemite National Park to preserve the beautiful valley. Many other conservation efforts began to take place across the continent with people trying to protect the dwindling American bison population. And in 1916, president Woodrow Wilson founded the National Park Service to support the growing environmental movement. In the early 20th century, environmental laws and government agencies began to emerge all over the world and especially in Nazi Germany. The environmental movement continued to grow in 1950s, 60s and 70s with many influential books such as 'A Sand Country Almanac (1949)' and 'Silent spring (1962)'.

Silent spring by Rachel Carson was largely influential as it exposed the harmful and dangerous effects of the pesticide DDT.

The book lead to the creation of the Environmental Protection Agency in 1970 and DDT was banned in 1972. The 1970s were greatly important for the green movement with many groups, like Greenpeace, forming in the 1970s. The first Earth Day and the UN's first environmental conference also happened in the 70s. In 1980s, the growing awareness on global warming brought the environmental movement even more into the mainstream. But unfortunately, the environmental movement's strength had declined since the late 2000s after the great recession.

UNIT 2

Ecosystems

Important Terms to Know

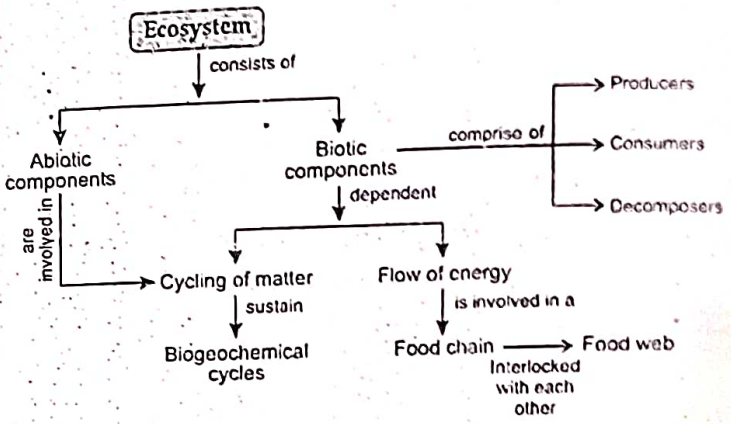
- **Ecology.** The branch of science that deals with the relationship between living organisms and their surrounding environment.
- **Ecosystem.** The system resulting from the integration of all the living (plants, animals and microorganisms) and non-living (air, water and soil) factors of the environment.
- **Producers.** Photosynthetic plants, bacteria and algae which convert solar energy into chemical energy by chlorophyll present in them.
- **Consumers.** Animals which cannot prepare their own food and are dependent on producers for their survival.
- **Decomposers.** Bacteria, fungi, insects and worms which breakdown the dead organic materials of producers and consumers into simpler compounds.
- **Gross Primary Productivity (GPP).** Total rate of photosynthesis including the organic matter used up in respiration during the measurement period.
- **Net Primary Productivity (NPP).** The rate of storage of organic matter in plant tissues in excess of the respiratory utilisation by plants during the measurement period.

  NPP = GPP minus R, [where R is energy used in respiration
- **Food Chain.** The transfer of food energy from producers, through a series of organisms (producers to consumers to decomposers), where each organism is dependent on the next as a source of food.
- **Food Web.** The interlocking pattern connecting different food chains with one another.
- **Ecological Succession.** Process through which ecosystems tend to change over a period of time.
- **10% Law.** According to this law, the flow of energy occurs from one trophic level to the other at the rate of 10% and the rest 90% is lost.

Q. 1. Define Ecosystem. Give an account of the structure and function of an ecosystem.

Ans. Ecosystem. The term ecosystem was proposed by A.G.Tansley in 1935, who defined it as the system resulting from integration of all the living (plants, animals and microorganisms) and non-living (air, water and soil) factors of the environment. However, the term ecosystem is most preferred, where 'eco' implies

the environment and 'system' implies an interacting, inter-dependent complex. Ecosystem is a structural and functional unit of ecology wherein it varies greatly in size, location, climate and the components that make them.



Structure of an Ecosystem. The structure of an ecosystem is composed of two major components namely *biotic* and *abiotic*, which interact with each other.

I. ***Abiotic components.*** Abiotic components of an ecosystem include non-living substances and physical-chemical factors.

These include:

(*i*) Climatic factors like light, humidity, atmospheric temperature, wind etc.
(*ii*) Edaphic factors like soil and its types, organic matter etc.
(*iii*) Inorganic substances like water, carbon, sulphur, nitrogen etc.
(*iv*) Organic substances like proteins, carbohydrates, lipids etc.

II. ***Biotic components.*** Biotic components of an ecosystem include living organisms (plants, animals and microorganisms).

These are further classified as:

1. **Producers (Autotrophs).** These include photosynthetic plants, bacteria and algae which convert solar energy into chemical energy with the help of chlorophyll present in them. As the green plants prepare their own food they are known as autotrophs. The process by which green plants prepare their own food in the presence of sunlight, water and chlorophyll is called photosynthesis.

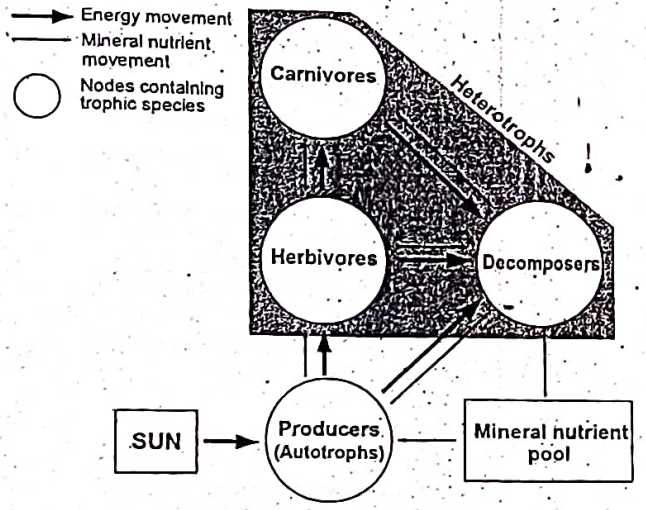
2. **Consumers (Heterotrophs).** These are animals which cannot prepare their own food and hence are termed as heterotrophs. They are rather dependent on producers for their survival directly or indirectly. Consumers are further categorised according to their availability in trophic levels:

- *Primary Consumers or Herbivores.* These include animals which are directly dependent on producers for their food. They eat green plants as their food. *E.g.*, cows, rabbits, grasshoppers etc.
- *Secondary Consumers or Primary Carnivores.* These include animals which feed on Primary consumers. *E.g.*, frogs, fishes, cats, snakes, dogs, etc.

- *Tertiary Consumers or Secondary Carnivores.* These include large animals which feed on secondary consumers. *E.g.,* wolves, peacocks, large fishes, etc.
- *Top Carnivores.* These include the largest carnivore animals which feed on tertiary consumers and cannot be eaten up by any other animal. *E.g.,* lions, tigers, vultures, etc.

3. **Decomposers (Reducers).** These are animals which break down the dead organic complex materials of producers and consumers into smaller simpler particles. As they degrade the bodies of organisms, they can be termed as Reducers. They can also be termed as Saprophytes.

Functioning of an Ecosystem. The functioning of ecosystem is related to the flow of energy and cycling of materials through the components of ecosystem.



Generalised model of Ecosystem with structure and functioning

The producers, *i.e.,* the green plants with the help of solar energy and minerals (C, H, O, N, P, Ca, Mg, etc.) from soil and atmosphere (nutrient pool) build up complex organic matter (carbohydrates, fats, etc.).

We can observe energy flows unidirectionally from the Sun to producers to consumers and finally to decomposers. But minerals on the other hand keep on moving in a cyclic manner. The cycling of the minerals is accomplished by various biogeochemical cycles which operate in the ecosystem.

Productivity of Ecosystem. It refers to the amount of organic matter accumulated in any unit time. It is of the following types:

Primary Productivity. It is the rate at which autotrophs store energy. These are basically the producers including the green plants, phytoplanktons and some photosynthetic bacteria.

Gross Primary Productivity (GPP). It is the total rate of photosynthesis including the organic matter used up in respiration during measurement period. It is also called as total photosynthesis or total assimilation.

Net Primary Productivity (NPP). It is the rate of storage of organic matter in plant tissues in excess of the respiratory utilisation by plants during the measurement period. It thus includes rate of increase in biomass and hence called as apparent photosynthesis or net assimilation.

$$NPP = GPP - R,$$

[where R is energy used in respiration.

Secondary Productivity. It is the rate of storage of energy at consumer's level. It simply passes from one trophic level to the other converting food matter to different tissues.

Net Productivity. It is the rate of storage of organic matter not used by consumers, *i.e.,* NPP – Consumption, during unit period. It is thus the rate of increase of biomass of primary producers left by consumers.

Q. 2. Give a brief account of types of ecosystems, taking relevant examples from India. [*2019 Nov.*

Ans: An ecosystem is a collection of organisms that, considered together, form a distinct system. The interdependent interactions of these organisms with each other and with their environment, is known as an ecosystem.

There are so many ecosystems in existence throughout the world. Main types of ecosystems are:

1. Natural ecosystem
2. Aquatic ecosystem
   - Marine ecosystem
   - Fresh water ecosystem
     - – Lotic ecosystem – Running water ecosystem
     - – Lentic ecosystem – Stagnant water ecosystem
3. Terrestrial ecosystem
   - Forests
   - Deserts
   - Grasslands
   - Tundra
4. Artificial ecosystem
   - Garden
   - Agriculture
   - Afforestation

1. Natural ecosystems. These are ecosystems that exist naturally in the world without being created by humans.

2. Aquatic ecosystems. Aquatic ecosystems are ecosystems that exist on or under water.

- **Marine ecosystems:** Marine ecosystems are salt water ecosystems that consist of the plants, animals and environments of the sea. Seaweeds, fish and turtles can all be part of a particular marine ecosystem. Marine ecosystems can take many forms, including lagoons, coral reefs, deep sea ecosystems and salt marshes and estuaries. They can be tidal or non tidal, depending on the location. Major coral reef ecosystems in India are in Gulf of Mannar, Gulf of Kachchh, Andaman and Nicobar, and Lakshadweep Islands.

- **Fresh water ecosystems:** A fresh water ecosystem is an ecosystem that consists of fresh water as opposed to the salty water of the sea. There are various types of fresh water ecosystems, including:
  - **Lotic ecosystems** – In these ecosystems, the water is on the move all the time. River ecosystems is an example of lotic ecosystem.
  - **Lentic ecosystems** – Here, the water is still and does not move, as in Pond ecosystems, Lake ecosystem, and Swamps and bog ecosystems. Freshwater ecosystems and habitats of India are distributed in diverse biogeographic regions or environments, from cold arid Trans-Himalayan to wet Terai regions of Himalayan foothills and Gangetic plains, extending down to the Southern peninsula of the mainland, and beyond to the two archipelagoes of the Andaman and Nicobar Islands in the Bay of Bengal and Lakshadweep Islands in the Arabian Sea.

3. Terrestrial ecosystems. Terrestrial ecosystems are ecosystems that exist on the land. There are four main types of terrestrial ecosystem:

- **Forest ecosystems:** A forest ecosystem consists of a forest and the organisms that live in it. Thus, a forest is any body of trees, and a forest ecosystem can contain all kinds of plants, animals, insects and birds alongside these trees. In India, forest ecosystem are found in slopes of the Western Ghats, North eastern parts of the peninsular plateau, Chhotanagpur plateau, Western Himalayas, etc. Forest ecosystems can be divided into Rain-forests, Taiga forests and mountain forests, Mainland forests, Mangrove swamps, Deciduous and Evergreen.
- **Desert ecosystems: These include life in deserts, however, which may seem to be something of a contradiction, as desert is somewhere that is uninhabitable. When we look closer at desert ecosystems and we see that they are full of life.** *For example:* The Thar desert in Rajasthan. There are three key types of desert ecosystem,
  - **Sand deserts:** made up of sand and usually existing in hot climates.
  - **Ice deserts:** though they are the opposite extreme and are very cold.
  - **Deep sea deserts:** the cold and dark regions of the ocean floor.
- **Grasslands:** Grasslands are other important ecosystems in the world that are usually situated in the more temperate regions of the earth. They are wide open grassy spaces that are home to many kinds of animals. Here, migratory animals, low lying shrubs and many different species of birds and insects may live. In India, grassland ecosystem is mainly found in peninsular India, northern portion of Gujarat, Western U.P., Rajasthan; part of Gangetic plains etc.
- **Tundra:** Tundra is the name for the iciest parts of the earth in which the topsoil is always frozen. This is known as permafrost.

4. Artificial ecosystems. Some ecosystems can also be man made, such as.

- **Gardens:** From ornamental rockeries to lawns with ponds and trees, these human made ecosystems can attract a large amount of wildlife.
- **Agriculture:** Growing crops can lead to changes in the landscape and the mineral composition of the soil, creating a distinct human made ecosystem.

- **Afforestation:** Forests planted by humans can look much the same as natural forests. However, these are a distinct type of human made ecosystem.

Q. 3. What do you understand by the term food chain? Giving illustrative examples explain detritus and grazing food chains of an ecosystem.

Or

What is food chain? Differentiate between Grazing and Detritus food chain.

Ans. The transfer of food energy from the producers, through a series of organisms (producers → consumers → decomposers) with repeated eating and being eaten, is know as food chain. Each organism in a food chain is dependent on the next organism as a source of food. Every organism requires energy to live. Food chains in an ecosystem help to maintain the biodiversity of nature, flow of energy and transfer of nutrients.

For example, consider a simple food chain

Grass → Grasshopper → Frog → Snake → Eagle

At each successive step only 10% of the energy is transferred and the rest 90% is lost in the form of heat.

Grazing and Detritus Food Chain

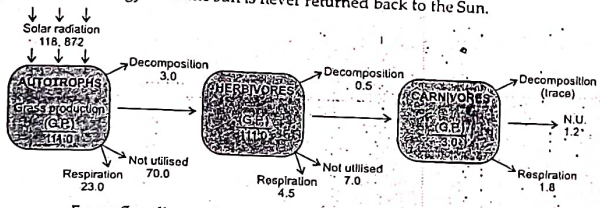
	Grazing Food Chain	*Detritus Food Chain*
(*i*)	It begins with green plants and algae, and from there the energy passes through various levels of consumers.	It begins with dead organic matter called 'detritus', which mainly include fallen leaves, plant parts or dead animal bodies which are consumed by insects, worms and bacteria.
(*ii*)	This type of food chain is directly dependent on the energy captured by producers from the Sun and thus, the passage of this energy through various trophic levels.	This type of food chain is dependent on the amount of organic matter produced in another system.
(*iii*)	This food chain involves transfer of 10% of energy from one trophic level to another.	This food chain is involved in decomposing the complex organic matter and nutrient recycling in the environment for reuse.
(*iv*)	*Example:* Grass → Rat → Snake Here, grass is eaten by the rat and the rat by the Snake. Grass obtains energy by capturing sunlight and passes 10% of this energy to the successive trophic levels.	*Example:* Dead leaves → Woodlouse → Blackbird Here, the dead leaves are decomposed by woodlouse which are being eaten by blackbird.

Q. 4. "Energy flow is always unidirectional". Explain giving description of a model.

Or

Explain the process of energy flow operating in an ecosystem explaining Lindemann law of energy transfer.

Ans. Energy flows through ecosystems by means of food chains and food webs. Solar energy is absorbed by plants and converted into chemical energy through the process of photosynthesis. This energy is utilized by other living organisms by the transfer of energy according to Lindemann's law. Lindemann in 1942 stated that the flow of energy occurs from one trophic level to the other at the rate of 10%, the rest 90% is lost in the form of heat. This energy thus, follows a unidirectional path *i.e.*, the energy from the sun is never returned back to the Sun.



Energy flow diagram for a lake (fresh water ecosystem) in gcal/cm²/yr (modified from Lindemann 1942)

It is clear from the diagram that the energy flow is unidirectional, *i.e.*, one way flow. The energy that is captured by autotrophs does not reach back to the Sun; and that which passes to the herbivores does not reach back to the autotrophs. As it moves to the successive level it is no longer available to the previous level. Thus, due to one way flow of energy, the system will collapse in case the primary source, *i.e.*, the Sun, were to be cut off. Thus, the three trophic leveled energy flow model, makes evident that the energy flow is greatly reduced at each successive trophic level from producers to herbivores and then to carnivores. The losses are characterized as heat losses, decomposition losses or respiratory losses etc. Thus, of the total gross productivity 111.0 gcal/cm²/yr only 3.0 gcal/cm²/yr is reached till the 3rd trophic level. Secondary productivity tends to be about 10 per cent at successive consumer trophic levels, *i.e.*, herbivores and carnivores.

Q. 5. Compare the environmental conditions and biodiversity of the desert and North-east biogeographic zones of India. *[2017 Dec.*

Ans. *Desert.* Deserts are characterized by their rainfall—or rather, their lack of it. Most deserts get less than ten inches of precipitation each year and evaporation usually exceeds rainfall. Plants, animals and other organisms that live in deserts have evolved to survive harsh conditions, scarce water and barren landscapes. Some desert habitats are short-lived—springing up to brighten the landscape only when the rains come. Many desert plants, like cacti in the Americas, are able to absorb and store water, letting them survive long periods of drought. Animals have adapted to get water from the food they eat and to conserve what little they obtain. They often come out only at night to avoid the worst of the heat.

North-east biogeographic Zones of India. The area is one of the richest in biological values, high in endemism and holds a large number of rare species that

are now under serious threat. Hotspots are areas that are extremely rich in species, have high endemism and are under constant threat due to human pressure (having lost 70% of their original habitat). The Northeast is among the 34 Hot Spots of the world, identified in India, the other being the Western Ghats. Northeast India forms one of the major regions of tropical forests in India, especially the species-rich tropical rain forests. The tropical semi-evergreen and moist deciduous forests in the lowlands of this region extend south and west into the subcontinent, and east into Southern China and Southeast Asia. *[2015 Dec.*

Q. 6. Discuss the ecosystem services.

Or

What do you understand by ecosystem services? Write explanatory notes on its importance. *[2016 May*

Ans. Ecosystem Services. Our health and well being depends upon the services provided by ecosystem and their components: water, soil, nutrients and organisms. Therefore, ecosystem services are the processes by which the environment produces resources utilised by humans such as clean air, water food and materials. Some of the services which are provided to us by ecosystem are:

1. *Ecological Values.* All the species in ecosystems participate in the numerous ecological processes that occur within and between the ecosystems. Thus, the ecological role can be studied as—

- **Cycling of water and nutrients.** All the components of ecosystem take part whether biotic or abiotic. They help in regulation of water, nitrogen, phosphorous, carbon etc.
- **Food production.** Plants are directly or indirectly related with food production. They are the soul source of food.
- **Climatic stability.** A forest is one of the main sources of rain which in turn controls climate.
- **Reduction in pollution.** Some micro—organisms as well as some plants and animals have the capacity to breakdown pollution, thus helping in pollution reduction.
- **Soil generation and reduction in soil erosion.** Diverse living organisms both plants and animals help in the formation of soil in the long run.
- **Production of energy or producers.** Green plants convert solar energy to chemical energy and pass on this energy to different trophic levels.
- **Reduction in natural calamities.** Natural calamities like droughts, floods, earthquakes etc. are often the result of loss or destruction of biodiversity. A healthy ecosystem has the capability of quick recovery from any natural calamities.
- **Decomposers and decomposition.** Microorganisms breakdown large molecules into smaller molecules and thus help in the recycling of materials. This process is known as *decomposition* and the micro-organisms are known as *decomposers.*

2. *Social Values.* Biodiversity has been preserved and protected by traditional societies that valued it as a resource and recognised that its depletion would be a great loss to their society. Many plants and animals are considered holy and sacred in India and are worshipped. *For example,* Tulsi, Peepal, Cows, Snakes, etc. are regarded as sacred in India.

3. *Economical Values.* These include the services provided by biodiversity including both consumptive use values and productive use values. Consumptive values include fossil fuels, woods, drugs and medicines. Productive use values include the products which are directly sold in the market. *For example,* Textile, Leather, Silk, Paper and Pulp industry etc.

4. *Ethical Values.* These values relate to the importance of protecting all forms of life. All the existing forms of life on earth must be conserved and protected and it is the duty of every individual as biodiversity is valuable for the survival of human race.

5. *Aesthetic Values.* Biodiversity provides an implicit pleasure and beautification. Thus, natural landscapes are priceless and provide opportunities for recreational activities like bird watching, photography etc. It also promotes eco-tourism.

6. *Optional Values.* Keeping future possibilities open for their use is called optional value. It is difficult to predict which of the species would turn out fruitful in near future.

Q. 7. What is an aquatic ecosystem? Discuss various types of aquatic ecosystems with relevant examples.

Ans. An aquatic ecosystem is an ecosystem in a body of water. It includes a group of interacting organisms which are dependent on one another and their water environment for nutrients and shelter. Aquatic ecosystem includes freshwater habitats like lakes, ponds, rivers, oceans and streams, wetlands, swamp etc. and marine habitats include oceans, intertidal zone, reefs, seabed and so on. Plants and animals in an aquatic ecosystem show a wide variety of adaptations which may involve life cycle, physiological, structural and behavioural adaptations.

Different types of aquatic ecosystems are as follows:

1. **Freshwater Aquatic Ecosystem.** They cover nearly 0.8 percent of earth. Freshwater includes lakes, ponds, rivers and streams, wetlands, swamps and temporary pools. These are classified into the following:

- **Lotic Ecosystems.** These are rapidly flowing water that move in a unidirectional way including the rivers and streams. These environment harbor numerous species of insects such as beetles, mayflies, stoneflies and several species of fishes including trout, eel, minnow etc. Apart from these, they also include various mammals such as beavers, river dolphins and otters.
- **Lentic Ecosystems.** They include all standing water habitats. Lakes and ponds are the main examples of lentic ecosystem. The word lentic mainly refers to stationary or relatively still water. These ecosystems are home to algae, crabs, shrimps, amphibians such as frogs and salamanders, for both rooted and floating-leaved plants and reptiles including alligators and other water snakes are also found here.
- **Wetlands.** Wetlands are marshy areas and are sometimes covered in water which has a wide variety of plants and animals, Swamps, marshes, bogs, black spruce and water lilies are some examples in the plant species found in the wetlands. The animal life consists of dragonflies and damselflies, birds such as Green Heron and fishes such as Northern Pike.

2. **Marine Aquatic Ecosystems.** It covers the largest surface area of the earth. Two third of the earth is covered by water and they constitute of oceans, seas, intertidal zone, reefs, seabed, estuaries and rock pools. The marine ecosystem is more concentrated with salts which make it difficult for freshwater organisms to live in. Similarly, marine animals cannot survive in freshwater. Their body is adapted to live in saltwater if they are placed in less salty water, their body will swell. Marine ecosystem can be divided into many zones depending upon water depth and or shareline features.

- **Ocean ecosystem.** Oceans serve as a home to more than five lakh aquatic species. Few creatures of these ecosystems include shellfish, shark, tube worms; crab small and large ocean fishes, turtles, crustaceans, blue whales, reptiles, marine mammals, seabirds, plankton, corals and other ocean plants.
- **Coastal systems.** These are the open systems of land and water which are joined together to form the coastal ecosystems. The coastal ecosystems have a different structure and diversity. A wide variety of species of aquatic plants and algae are found at the bottom of the coastal ecosystem. The fauna is diverse and it mainly consists of crabs, fish, insects, lobsters snails, shrimps etc.

Q. 8. Describe the process of Ecosystem Restoration.

Ans. Ecosystem restoration is the "process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed."

It is a means of sustaining the diversity of life on earth and re-establishing an ecologically healthy relationship between nature and culture. Ecosystem restoration should be a fundamental component of conservation and sustainable development programs throughout the world by virtue of its inherent capacity to provide people with the opportunity to not only repair ecological damage, but also improve the human condition.

Ecosystem Restoration is thus a significant contribution to the application of the ecosystem approach, eg. in informing the negotiation of land use options and enhancement of healthy ecological networks. The Commission on Ecosystem Management (CEM) has identified ecosystem restoration as one of its 19 priority thematic areas.

For restoration to be successful, it is essential to have understanding of the dynamics of the ecosystem being restored, and to ensure the genetic integrity of its plants by using locally propagated species.

For information on science and practice of ecosystem restoration, the Society for Ecological Restoration (SER) provides the following documents:

- SER Primer on ecological restoration is a concise statement of restoration principles and includes the most cited definition of what restoration is.
- SER guidelines for developing and managing restoration projects describes the procedures for conducting restoration in accord with the norms of the discipline that were established in the SER primer.
- Ecological restoration— a mean of conserving biodiversity and sustaining livelihoods is a call to action by the ecological restoration joint working group of SER and the IUCN commission on ecosystem management.
- Ecosystem restoration in protected areas.

The reasons for ecosystem restoration are:

(*i*) Restoring natural capital such as drinkable water or wildlife populations.
(*ii*) Helping human communities and the ecosystems upon which they depend, adapt to the impacts of climate change.
(*iii*) Mitigating climatic change.
(*iv*) Helping threatened or endangered species.
(*v*) Aesthetic reasons
(*vi*) Moral reasons
(*vii*) Environmental health of nearly populations.
(*viii*) Regulated harvest, particularly for subsistence.

Q. 9. Give comparative account of the following:

(*a*) **Forest ecosystem and Grassland ecosystem**
(*b*) **Desert ecosystem and Aquatic ecosystem**
(*c*) **Pond ecosystem and Lake ecosystem**
(*d*) **Biosphere and Atmosphere** [*2015 Dec.*
(*e*) **Fresh water ecosystem and Marine ecosystem** [*2015 Dec., 2017 May*
(*f*) **Grassland ecosystem and Desert ecosystem** [*2018 Nov.*
(*g*) **Atmosphere and Lithosphere** [*2018 Nov.*
(*h*) **Biotic and Abiotic factors.** [*2017 May*
(*i*) **Endangered and endemic species.** [*2016 May*
(*j*) **Bio-amplification and Bio-diversity.** [*2016 May*
(*k*) **Soil Erosion and Eutrophication.** [*2019 May*

Ans. (*a*) Forest ecosystem and Grassland ecosystem

	Forest ecosystem	*Grassland ecosystem*
(*i*)	It is a terrestrial unit that is made up of plants, animals and microorganisms that are interacting among themselves and with the environment in which they live.	Grasslands are sea of grass, formed in the places where the rainfall is better than the desert and lower than the forest area.
(*ii*)	Occupy about 38% of Earth's surface.	Occupy about 19% of Earth's land area.
(*iii*)	They are more productive and have greater biodiversity.	These lands are very fertile.
(*iv*)	The world's biggest and largest tropical forest area is located in South America's Amazon basin.	These are located in North America (called Prairies), South America (called Pampas) and in West Asia (called Steppes).
(*v*)	Deforestation, due to the greed of the humans is the biggest threat to forest ecosystem.	Grazing of land by cattle, sheep and goats threatens the grasslands.

(*b*) Desert ecosystem and Aquatic ecosystem

	Desert ecosystem	*Aquatic ecosystem*
(*i*)	An ecosystem that receives annual rainfall less than 25 cm. turns into a desert, thus, there is low availability of water.	It is an ecosystem in a body of water.
(*ii*)	33% of total geographical area comprises of deserts.	Around 71% of Earth's surface accounts for oceans and seas and 0.80% for freshwater ecosystems.
(*iii*)	Generally seen in between the Tropic of Cancer and Tropic of Capricorn. *Example*, Sahara, Gobi, Asian deserts.	These include lentic (lakes, ponds), lotic (streams, rivers), wetlands and marine ecosystems everywhere on the earth.
(*iv*)	Highly specialised and sensitive ecosystems with all plants and animals having adaptation quality for conservation of water and high temperature. *Example* of animals seen: Camel, Kangaroo. *Example* of plants seen: Cactus and Euphorbia.	These are ecosystems with high biodiversity with plants and animals having special adaptations of living in water with swimming aids. *Example* of animals seen: Fish, Whales, Cod, Haddock. *Example* of plants seen: Hydra, microscopic algae.
(*v*)	Climate change and loss of biodiversity are considered the major threats to such kind of ecosystems.	Climate change, waste discharge, oil spills, etc. are considered as major threats to aquatic ecosystems.

(*c*) Pond ecosystem and Lake ecosystem

	Pond ecosystem	*Lake ecosystem(Giant permanent pond)*
(*i*)	A pond is a temporary water body and has water only in the monsoons.	Lake is an aquatic ecosystem having water throughout the year.
(*ii*)	The temperature changes with air temperature and is relatively uniform.	Temperature layering or stratification takes place in summer and winter and these layers turn over in spring and fall.
(*iii*)	When a pond begins to fill during the rains, its life forms such as algae and microscopic animals come out of the floor of the pond where they have remained dormant in the dry phase and gradually form more complex animals. Thus, starting the food chain.	Energy cycles through the lake ecosystem from sunlight that penetrates the water surface to plants. Energy is then transferred to herbivores and carnivores. Animal excreta from the bottom of the lake is broken down and used as nutrients material by aquatic plants for their growth. During this oxygen is released which is used by aquatic animals which filter water through their respiratory system. Thus, forming the food web.

(d) Biosphere and Atmosphere

	Biosphere	*Atmospliere*
(i)	Biosphere is a zone on Earth in which living beings exist.	The Atmosphere in a blanket of air surrounding the earth composed of Nitrogen, Oxygen, Carbon dioxide and inert gases.
(ii)	It serves as the highest level of organization. It consists of the life giving areas of Lithosphere, Hydrosphere and Atmosphere.	It is one of the four realms of the Earth.
(iii)	It has many ecosystems. All the ecosystem of the Earth together make up the biosphere.	It is composed of 5 layers: Troposphere, Stratosphere, Mesosphere, Thermosphere and Exosphere.

(e) Fresh water ecosystem and Marine ecosystem

	Fresh water ecosystem	*Marine ecosystem*
(i)	It includes some wetlands, streams, rivers, ponds and lakes.	It includes coral reef and sea grass bed.
(ii)	They are low salinity areas.	They are salty areas.
(iii)	These have distinct animal and plant life that is typically unable to adjust to higher concentrations of salt water.	These have aquatic life that can only stay alive in water with high salinity levels.
(iv)	The content of organic chemicals is very low.	Have high organic chemicals.
(v)	Species can adapt to a change in habitat, like the rise and fall in water levels. *For example*, Goldfish, Catfish, etc.	Species cannot survive changes in temperature. *For example*: Sharks, common dolphin, etc.

(f) Grassland ecosystem and Desert ecosystem

	Grassland ecosystem	*Desert ecosystem*
(i)	Grasslands are sea of grass, formed in the places where the rainfall is better than the desert and lower than the forest area.	An ecosystem that receives annual rainfall less than 25 cm. turns into a desert, thus, there is low availability of water.
(ii)	Occupy about 19% of Earth's land area.	33% of total geographical area comprises of deserts.
(iii)	These lands are very fertile.	Highly specialised and sensitive ecosystems with all plants and animals having adaptation quality for conservation of water and high temperature.

		Example of animals seen: Camel, Kangaroo. Example of plants seen: Cactus and Euphorbia.
(iv)	These are located in North America (called Prairies), South America (called Pampas) and in West Asia (called Steppes).	Generally seen in between the Tropic of Cancer and Tropic of Capricorn. *Example*, Sahara, Gobi, Asian deserts.
(v)	Grazing of land by cattle, sheep and goats threatens the grasslands.	Climate change and loss of biodiversity are considered the major threats to such kind of ecosystems.

(g) Atmosphere and Lithosphere

	Atmosphere	*Lithosphere*
(i)	The Atmosphere is a blanket of air surrounding the earth composed of Nitrogen, Oxygen, Carbon dioxide and inert gases.	It is the rigid outermost shell of a terrestrial-type planet or natural satellite.
(ii)	It is one of four realms of the Earth.	It is a part of biosphere.
(iii)	It is composed of 5 layers: Troposphere, Stratosphere, Mesosphere, Thermosphere and Exosphere.	Lithosphere is composed of the crust and the portion of the upper mantle. It has the ecosystem of land.

(h) Biotic and Abiotic Factors

Basis	*Abiotic factors*	*Biotic factors*
Introduction	In ecology and biology, abiotic components are non-living chemical and physical factors in the environment which affect ecosystems.	'Biotic' describes a living component of an ecosystem; *For example*, organisms, such as plants and animals.
Examples	Water, light, rain, wind, soil, humidity, minerals, gases.	All living things— autotrophs and heterotrophs—plants, animals, fungi, bacteria.
Factors	Affect the ability of organisms to survive, reproduce; help determine types and numbers of organisms able to exist in environment; limiting factors restrict growth.	Living things that directly or indirectly affect organisms in environment; organisms, interactions, wastes; parasitism, disease, predation.
Affects	Individuals of a species, population, community, eco-system, biome, biosphere.	Individuals of a species, population, community, eco-system, biome, biosphere.

(i) Endangered species and Endemic species

	Endangered species	*Endemic species*
(i)	Endangered species are those whose number has been reduced to a critical number.	Endemic species are found only in a particular region.
(ii)	Global warming and habitat destruction are the reasons for disappearance of many endangered species. *Examples:* Bengal Tiger, Bengal Fox, Asian Elephant, etc.	Habitat loss due to human activities and pollution are the reasons for their decline. *Examples:* Nilgiri Langur, Lion-tailed Macaque, Brown Palm Civet, etc.

(j) Bio-amplification and Bio-diversity

	Bio-amplification	*Bio-diversity*
(i)	It is the increase in concentration of a substance that occurs in a food chain such as pesticides.	It is the measure of the variety of organisms present in different eco-systems.
(ii)	It suggests that all the trophic levels in an ecosystem are connected. That is, something that occurs on the lowest trophic level will amplify and affect higher orders from animals belonging to higher trophic levels. This state of equilibrium is essential for the survival and growth of organisms at all levels.	It is an essential component of nature and it ensures the survival of human species by providing food, fuel, shelter, medicines and other resources to mankind.

(k) Soil Erosion and Eutrophication

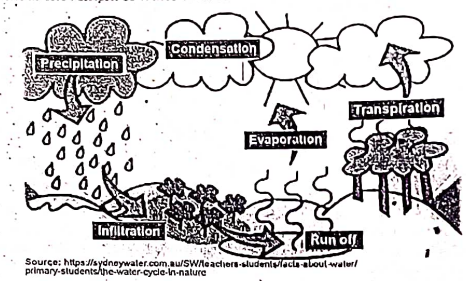
	Soil Erosion	*Eutrophication*
(i)	It is the removal of upper most layer of soil.	It is the process of deterioration of water quality.
(ii)	In this, the fertility of soil is lost and its binding capacity gets eroded.	In this, there is gradual increase in the concentration of P, N and other minerals in the water body.
(iii)	It has many causes such as air, water and wind.	It is generally caused by excessive fertilizer washed away into water bodies by agriculture.
(iv)	It occurs only naturally.	It occurs both naturally wherein the decay occurs slowly and man-made eutrophication where the decay happens very fast.

Q. 10. Elaborate the following:
(a) Nutrient cycles *[2016 May; 2019 May*
(b) Ecological succession *[2015 Dec.*
(c) Ecological Pyramids

Ans. (a) ***Nutrient cycles or Biogeochemical cycles.*** The movement and exchange of organic and inorganic matter (carbon, hydrogen, nitrogen, oxygen, phosphorous, water, calcium, iron, etc.) through an ecosystem is known as biogeochemical cycle or nutrient cycle. For any system to work there should always be a movement of minerals. The nutrient cycle describes how nutrients move from the physical environment into living organisms and are subsequently recycled back to the physical environment.

Some important cycles are:

1. Water cycle. The cycle that involves change of water into water vapour and back to water involving various processes is termed as water cycle. This cycle is responsible for the continuous movement of water between the earth and the atmosphere.



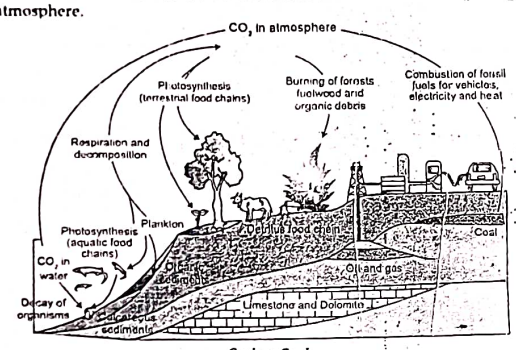
Source: https://sydneywater.com.au/SW/teachers-students/facts-about-water/primary-students/the-water-cycle-in-nature

Water cycle starts with the process of evaporation or transpiration. Sun heats up the water in oceans and seas forming water vapours. This process of changing water into water vapour is termed as evaporation.

Transpiration is the process of movement of water and removal from the aerial parts of plants such as leaves, stems and flowers. In the atmosphere, water vapour cools and forms millions of water droplets which further forms clouds via the process of *condensation*. On further cooling, clouds lose their water as rain or snow, which is called *precipitation*. The water is transported across the globe and even percolates into the ground. This water is known as ground water. Some ground water finds openings in the land surface and comes out as freshwater springs. Over time, the water returns to the ocean, to continue the water cycle.

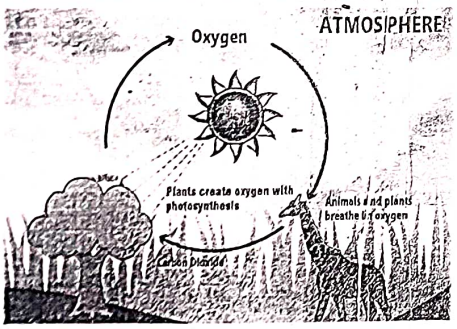
2. Carbon Cycle. The carbon cycle is the process by which the carbon moves from the atmosphere into the earth and its organisms, and then back again into the atmosphere. In the atmosphere, carbon exists in the form of carbon dioxide (CO_2). During photosynthesis, plants absorb carbon dioxide and form carbohydrates and other organic substances. Carbon dioxide is released back into the atmosphere

as a result of respiration. Carbon dioxide is being converted from organic matter by microorganisms in the food chain. Some of the detritus is converted to coal, oil and natural gas after being buried for millions of years in the earth. The fossil fuels produce CO_2 on burning in the process known as combustion. Carbon is also stored in oceans as carbonates and bicarbonates. These oceans exchange CO_2 with the atmosphere.

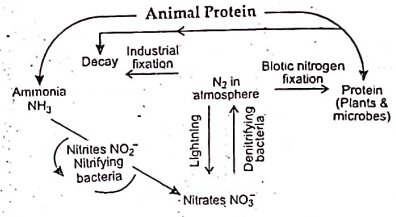


Carbon Cycle

3. **Oxygen Cycle.** Circulation of oxygen in various forms through nature is called the oxygen cycle. Plants and animals use oxygen to respire and return it to the air and water as carbon dioxide (CO_2). CO_2 is then taken up by algae and green plants and converted into carbohydrates during the process of photosynthesis, where oxygen is released as a by-product. The waters of the world are the main oxygen generators of the biosphere. Their algae replace about 90 per cent of all oxygen used.



4. **Nitrogen Cycle.** Nitrogen is present in the form of N_2 in atmosphere. N_2 gas is converted to nitrate compounds by nitrogen-fixing bacteria in soil or root nodules. Lightning also converts nitrogen gas to nitrate compounds. The Haber process converts nitrogen gas into ammonia used in fertilizers. Nitrifying bacteria converts ammonia to nitrates. Plants absorb nitrates from soil and use these to make proteins. The plant is eaten by the animal and its biomass is used to produce animal protein. Urea and complex compounds are decayed by decomposers. This returns nitrogen to ammonia. In some conditions, denitrifying bacteria in the soil break down nitrates and return nitrogen to the air.



(*b*) *Ecological succession.* It is the process through which ecosystem tends to change over a period of time. Seasonal environmental changes lead to succession, thus creating changes in community of plants and animals living in the ecosystem. Succession also includes longer period of time starting from a barren land or changing an entire ecosystem due to change in environmental factors.

Consider for an example, a forest is cleared. It will initially be colonised by plants and animals and gradually turn into a grassland, then a shrubland and finally woodland and then a forest. Succession always leads to a stable state or the climax stage. In between, various processes lead to the development of pioneer stage and a series of changes known as seral stage.

Example of succession changes are observed from the pond ecosystem.

Dry terrestrial habitat → Early colonisation by small aquatic species after the monsoon
↓
Mature aquatic ecosystem

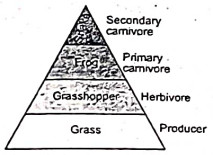
There are two main types of succession:

1. **Primary Succession.**
   - It occurs when succession starts on entirely new land without any established soil—basically on sand dunes, rocks.
   - As the organisms which first colonise a region die and decompose, they establish a layer of soil for future organisms and ecosystems to utilise.
   - On exposed rock, lichen and moss may initially colonise the area and provide a layer of soil for seeds to germinate.
2. **Secondary Succession.**
   - It occurs when succession starts on existing soil basically on a burnt-forest.

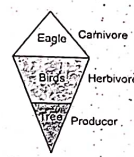
- Natural or artificial upheaval of the primary succession.
- During secondary succession, dominance is usually achieved by the fastest growing plants.

(c) *Ecological Pyramids.* At each successive step in a food chain a considerable amount of energy is lost as heat. As a result, organisms in each trophic level pass on lesser energy to the next trophic level than they actually receive. Thus, this limits the number of trophic levels to 4 or 5. Because of this tapering off of available energy in the food chain a pyramid is formed known as ecological pyramid. These are of three types:

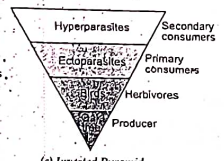
1. **Pyramid of Number.** This type of pyramid shows the number of individual organisms at each trophic level in an ecosystem. The pyramid of number varies from ecosystem to ecosystem. There are thus, three types of number pyramids—



(a) Upright Pyramid of Number



(b) Spindle-shaped Pyramid of Number



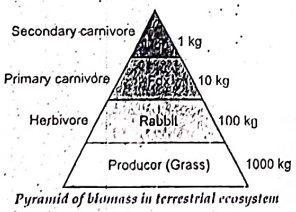
(c) Inverted Pyramid of Number

(a) *Upright pyramid of number.* In this pyramid a large number of producers are being eaten by less number of herbivores which are further eaten by lesser number of carnivores. Thus, making the base wide and top peak narrower. This type of pyramid is observed in grassland and aquatic ecosystem.

(b) *Spindle-shaped pyramid of number.* When a large tree supports larger number of birds who are eaten by smaller number of eagles, it forms a spindle-shaped pyramid of number. It generally is observed in a forest ecosystem.

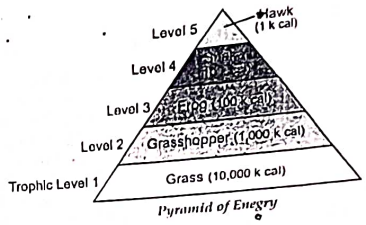
(c) *Inverted pyramid of number.* In this case an oak tree supports various birds which are further supported by various ectoparasites. And ectoparasites are supported by larger number of hyperparasites. Thus, forming a narrower base. It is an example of parasitic food chain.

2. **Pyramid of Biomass.** It represents the total mass of living organisms present in a trophic level in an ecosystem at any time. The biomass decreases gradually as we move from one trophic level to the other. Thus, always forming an upright pyramid with broad base.



Pyramid of biomass in terrestrial ecosystem

3. **Pyramid of Energy.** As we move from one trophic level to the other there is a gradual decrease of energy. Only 10% of energy passes on from one trophic level to another and rest is lost as heat. Thus, pyramid of energy is always upright.



Pyramid of Energy

Q. 11. Explain the following terms:

(a) Estuaries (b) Streams and River ecosystems
(c) Freshwater ecosystem (d) Oceans
(e) Trophic level (f) Food Chain [*2015 Dec.; 2017 Dec.; 2019 Nov.*
(g) Food web (h) One-horned Rhinoceros [*2016 May*
(i) Asiatic Lions [*2016 May* (j) Mangrove forest [*2016 May*
(k) Ecotourism [*2018 May*

Ans. (a) *Estuaries.* Estuaries are a transitional zone formed between river environments and maritime environments. An estuary is a partially enclosed water body along the coast from where freshwater from rivers and streams meets and mixes with salt water of the ocean. Estuaries are among the world's most productive ecosystems.

Estuaries provide water filtration and habitat protection. Marshes and mangrove forests act as filters, filtering pollutants such as heavy metals, pesticides, sediments and nutrients. Thus, estuaries are not only highly fertile regions with nutrient-enriched matter but also the most polluted ecosystems.

Estuaries also act as sponges, soaking up the excess water thus protecting streams, river channels and coastal shores from calamities such as floods, erosion etc.

(b) *Streams and River ecosystems (Lotic ecosystem).* Moving waters represent streams and river ecosystems in which all the living forms are adapted to different rates of flow of water. The larger surface area of river accounts to greater photosynthesis rate which leads to higher amount of inorganic nutrients such as nitrogen and phosphorous flowing down the stream.

The living organisms present in streams or rivers are dependent on the current, clarity, flow and oxygen content, temperature, pressure, pH, salinity and nutrient availability in the stream. These conditions vary according to the location and size of the stream and river.

The bed of the stream or river also influences the species of plants and animals.

(c) *Freshwater ecosystem.* Freshwater ecosystems occupy 0.80% of the Earth's surface, occupying 41% of the world's known fish species. There are three types of fresh water ecosystems—

(i) **Lentic or standing water ecosystem.** These have stagnant or slow moving water, *e.g.*, lakes, ponds and pools.

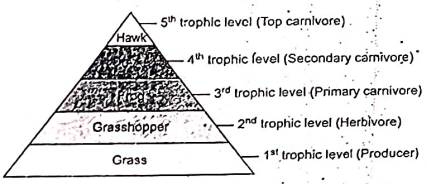
(ii) **Lotic or moving water ecosystem.** These have faster moving water e.g., springs, streams and rivers.

(iii) **Wetlands.** Wetland is a place where land is covered with water either permanently or seasonally. Marshes and ponds, the edge of a lake or ocean, the delta at the mouth of a river, low-lying areas that frequently flood, all of these are wetlands.

(d) *Oceans or Marine Ecosystem.* Oceans cover approximately 71% of the Earth's surface and contain 97% of the planet's water. Thus, they form the largest ecosystem of the earth. Oceans have high salt content and form a major part in global circulation of nutrients. They usually have a large biodiversity ranging from phytoplanktons and zooplanktons to larger fishes. The ecosystem of oceans is characteristic of factors such as geology, temperature, tides, light availability and geography. Oceans have characteristic producers, consumers and decomposers.

- The microscopic algae traps the sun energy and forms food—Producers.
- Consumers are of three types:
  1. *Primary consumers.* Zooplanktons such as protozoa float on the surface of the sea.
  2. *Secondary consumers.* Nektons such as fish, whales, etc. feed on the primary consumers.
  3. *Tertiary consumers.* Benthos such as corals, cod, mussels, etc. feed on the secondary consumers.
  4. *Decomposers.* Fungi and Bacteria in the muddy floor of the sea.

(e) *Trophic level.* The transfer of energy from producers to different organisms with repeated eating and being eaten is termed as food chain. Each successive step in a food chain representing organisms is termed as Trophic level. The trophic levels are generally represented in a pyramidal shape. The pyramidal shape is a representative of magnitude of trophic levels as we move from base towards the top. The food chain reduces in size at each successive level from the base to the apex. As we can see in the diagram, the food chain depicts that grass is eaten by a grasshopper representing the 2nd trophic level which is further eaten by a frog in the next trophic level which is further eaten by a snake then by the hawk.



There are generally, 4 to 5 trophic levels in a particular food chain as energy gets reduced with every successive level.

(f) **Food chain.** The transfer of food energy from the producers, through a series of organisms (producers → consumers → decomposers) with repeated eating and being eaten, is known as *food chain.* Each organism in a food chain is dependent on the next organism as a source of food. Every organism requires energy to live. Food chains in an ecosystem help to maintain the biodiversity of nature, flow of energy and transfer of nutrients.

For example, consider a simple food chain.

Grass → Grasshopper → Frog → Snake → Eagle

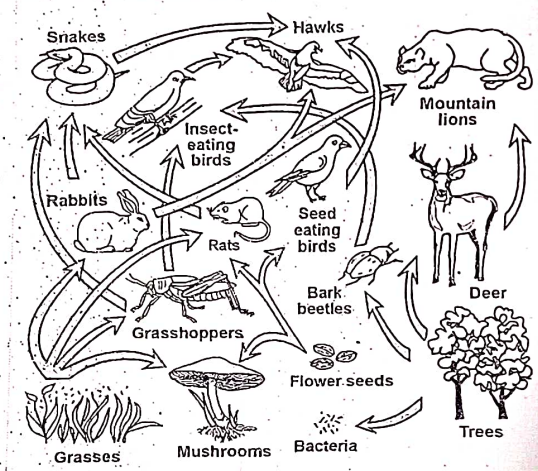
At each successive step only 10% of the energy is transferred and the rest 90% is lost in the form of heat.

(g) *Food web.* The interlocking pattern formed due to interaction of various food chains is termed as food web. Many food chains exist in an ecosystem and it is not practically possible that a food chain operates in isolation. There are many overlapping trophic levels which are connected to different food chains in an association. Thus, each living thing in an ecosystem is part of multiple food chains. Consider for an example in a food chain,

Grass → Rats → Snakes → Owls

Sometimes rats are not eaten by snakes but directly by owls or by hawks.

Thus, it maintains the interlinking of individuals. Food web, thus maintains the stability of the ecosystem. The greater the number of alternate pathways, more stable will the community of living things be. *For example,* decrease in the population of rats would naturally cause an increase in the population of alternative herbivores. Thus, maintaining the ecosystem.



Food Web

(h) *One horned rhinoceros.* It is a species of rhinoceros native to Indian subcontinent. It is listed as vulnerable species on the IUCN Red list. The Indian rhinoceros has a thick brown skin with pinkish skin folds and a black horn which

is present in both males and females. The number of rhinoceros has declined due to human and livestock encroachment. The Indian rhinoceros lives in wild and their habitat is indiscriminately reduced by mankind for its need and greed. Kaziranga National Park in Assam hosts two third of the world's great one-horned rhinoceros. At present the great India one-horned rhinoceros are found in southern Nepal, northern Bengal and the Brahmaputra valley. Once they were seen frequently in Royal Manas National Park but today they are restricted to habitats surrounded by human-dominated landscapes adjacent to cultivated areas, pastures and secondary forests. These rhinoceros have been hunted extensively for their horns.

(*i*) ***Asiatic lions.*** Asiatic lion also known as the Indian lion is a subspecies found in the Gir National Park of Gujarat. It is listed as endangered in IUCN red list. The number of Asiatic lions declined due to loss of their habitat. Because of deforestation their natural habitats have been destroyed. These were also hunted for pride. Government is taking initiatives to preserve their species. Now the number of these lions is increasing in Gir National Park and Wildlife Sanctuary.

(*j*) ***Mangrove forests.*** Mangroves are shrubs or small trees that grow in coastal saline or brackish water. Mangrove forests are present at the deltas of rivers where a lot of sediments are present.

Mangrove roots collect sediments and slow the water's flow. Thus, they help in protecting and increasing the coastline and prevent erosion. Mangroves provide safe habitat and a nursery for a variety of fish, birds, crustaceans and shellfish.

Mangrove forests and estuaries are the breeding and nursery grounds for a number of marine organisms including the commercially important shrimp, crab and fish species. Mangrove trees are also used for house building, furniture, transmission as well as telephone poles and certain household items.

Mangroves are now looked after by scientists or saviors in the today's scenario of global warming.

(*k*) ***Ecotourism.*** It is a form of tourism which involves visiting fragile, pristine and relatively undisturbed natural areas, intended as a low-impact and often small scale alternative to standard commercial (mass) tourism. It basically means responsible travel to natural areas conserving the environment and improving the well-being of the local people. It's purpose may be to educate the traveller, to provide funds for ecological conservation, to directly benefit the economic development and political empowerment of local communities, or to foster respect for different cultures and for human rights.

Q. 12. Write the case studies of the following ecosystems:

(*a*) Forest Ecosystem

(*b*) Grasspond Ecosystem

(*c*) Desert Ecosystem

(*d*) Aquatic Ecosystem (Ramsar site)

Ans. (*a*) *Forest Ecosystem.*

Case Study—Chipko Movement. Chipko is a movement mainly begun and supported by local women in the hills of Uttarakhand and Garhwal, where the women have had to bear the impact of deforestation. The word "chipko" refers to "to stick" or "to hug", thus signifying villagers hugging the trees, in order to save them from the contractor's axes. This movement started in response to the needs of the people. The rate of heavy depletion of forests was resulting is destruction,

making the Himalayan mountain range barren leading to serious floods. Thus, the main objective of the movement was to ensure an ecological balance and the survival of the tribal people whose economic activities revolved around these forests. The movement was a great success proving to the world that the forests of the hills are the life-support systems of local communities and are of immense value not only in terms of local manufactures but also ecological services such as soil conservation and maintenance of the natural water regime.

(*b*) ***Grassland Ecosystem.***

Case Study—Altay Prefecture, Xinjiang, China. Raising livestock is the main land use and livelihood in large areas of arid and semi-arid temperature zones of Asia's grasslands. One of the major constraints to improve livestock production and family incomes is the lack of feed during winter and early spring which reduces the number of animals that can be carried through the winter and also means that pregnant breeding stock may be at their most susceptible in the period of lowest feed availability Altay Prefecture is located in the northern part of Xinjiang, Uygur Autonomous Region in China near the border with Kazakhstan and Mongolia. This is an area with a markedly continental climate, hot summers, very cold winters, snow and low rainfall. Here, many areas of high pastures are open for less than 3 months each year with good summer. In spring and autumn, grazing occurs on the heavily grazed transition routes and winter grazing occurs on the desert plains. The transhumance route is long, 180 to 200 km from the desert plains to the high summer pastures. A number of rivers and areas of comparatively flat land provided the base for an irrigation based solution to the winter feed problem.

(*c*) ***Desert Ecosystem.***

Case Study—Impact of Human Activities on Southern California Deserts. Human interference has extremely affected the insensitive but fragile ecosystem of Southern Californian deserts. The large parts of the Mojave and Colorado deserts have been negatively affected by humans and their activities in due course of this century. Development, off-highway vehicle use, livestock overgrazing, construction of roads and utilities, military training exercises, air pollution and spread of non-native plant species are some of the causes of altered ecosystem. Because of the desert's high temperatures, intense Sun, strong winds, low soil fertility and minimal rainfall, natural restoration of the ecosystem is extremely slow. Even with intense restoration work, recovery can take many years.

(*d*) ***Aquatic Ecosystem.***

Case Study—Threatening the Biodiversity in Rudrasagar Lake (Ramsar Site). Increased population growth in the lakeshore and wider catchment coupled with an increase in human activity is threatening the sustainability of the Rudrasagar lake as a rich resource base. Fishing pressure, sedimentation and pollution are threatening the lake's biodiversity to a great extent in Rudrasagar lake. The water of the Rudrasagar lake is reasonably cloudy in most parts and is a bit clear near the agricultural land but that part is full of algae and water hyacinth. Eutrophication caused due to excessive growth of algae and water hyacinth is considered to be the major parameter for poor water quality management in Rudrasagar lake.

A restoration program with an ecosystem perspective through best management practices can help in correcting point and non-point sources of pollution. This along with regulations and planning for wildlife habitat and fishes will help in

arresting the declining water quality and the rate of loss of wetlands. These goals require intensive planning, leadership funding with active involvement from all levels of organizations.

The Aral Sea Tragedy. The sea started receding in the 1960s after Soviet Union diverted its water sources to irrigate cotton and boost cotton production in the arid region. Cotton production soared, making the region the world's fourth largest producer. The salinity level increased, destroying the sea's flora and fauna. The change in water chemistry wiped out enormous populations of fish. This has increased the salt in the water up to 4 times, contributed to large dust storms in the region and has even caused increase in diseases.

What was the fourth biggest inland sea is now mostly desert. Currently, after countless studies and written reports, experts say that restoration is unfeasible and efforts should now focus on avoiding a humanitarian disaster.

UNIT 3

Natural Resources: Renewable & Non-Renewable Resources

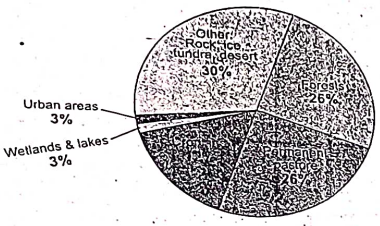
Important Terms to Know

- **Resource.** Everything available in our environment which can be used is termed as a resource.
  - Abiotic: constitute non-living resources (e.g.; land, air, water, etc.)
  - Biotic: constitute resources from living organisms (e.g., products obtained from forests, animals and their products).
- **Natural Resource.** Resources which are derived from nature are termed as natural resources.
  - Renewable resources: can be replenished naturally in short duration of time.
  - Non-Renewable resources: the replenishment rate is less than that of consumption. Thus, they take millions of years to replenish.
- **Land Degradation.** The deterioration in the productive capacity, quality of vegetation, soil and water resources associated with land.
- **Soil Erosion.** The removal of top layer of soil due to water, wind, etc.
- **Desertification.** The degradation of a formerly productive land is termed as desertification.
- **Deforestation.** The process of removal of forests in order to make land available for other uses.
- **Floods.** An abnormal progressive rise in the water level of streams or rivers which results in overflowing.
- **Drought.** Deficiency of precipitation for a long period resulting in failure of crops and loss of yield.
- **Energy resources.** Sources which can provide energy in different forms like heat energy, light, power, etc.

Q. 1. Explain the importance of land as a resource. Also list the causes and impact of converting terrestrial land into other uses.

Ans. Land as a resource becomes the most important for us as we dwell on the same. Land resources generally comprise all the resources available from land like agricultural land, underground water, various minerals like, coal, bauxite, gold and other raw materials. It also includes the land which is available for degradation, for buildings and townships. 20 per cent of the earth's surface is covered under land resources. It covers around 13000 million hectares of the area.

Unfortunately, land has been overused and abused over the centuries. The conversion of terrestrial land into another type for specific reasons is called land use change. Changes in land use and land cover are due to direct and indirect results of human actions on land resources.



Land Use—Worldwide

Causes of land use change. Land use is changing with the changing lifestyle and population explosion. The following are the causes of land use change:

(*i*) **Industrialisation.** An increase in industrialisation has led to urbanisation with a large number of people from rural areas moving and migrating to urban areas.

(*ii*) **Changing practices of agriculture.** Agriculture was the main occupation of the people but the need for more land due to increased population led to the intensification of agricultural land only to the most productive areas thus leaving the left unproductive land to get converted for other uses.

Impacts of land use change. Land use change poses the greatest environmental concerns to human population. Some of them are listed below:

- Climate change
- Biodiversity loss
- Pollution of air, water and soil
- As it has been associated with birth of agriculture, it leads to deforestation and desertification.
- Increase in concentration of carbon dioxide due to loss of forest cover.
- It leads to extinction of many species of flora and fauna, caused by the reduction in their habitat where they inhabitate.

Q. 2. "Land degradation and desertification are one of the major challenges faced by humanity today". Justify this statement with respect to social, economic and environmental impacts. [*2018 Nov.*

Ans. Land degradation affects crop production, livestock production, and forest production. The consequences differ according to the type and degree of degradation. Land where degradation reaches the severe degree but was formerly productive land must be abandoned. *For example,* Salinization patches in India and Pakistan, where the outlines of fields can still be seen in areas where whole farms have been abandoned. Large tracts of land have totally gone out of production.

Socio-economic and environmental impacts of degradation:

1. **Reduced crop yields.** Where land has been subject to light or moderate degradation, the same level of inputs will give lower outputs. There may be reduced crop yields or lower livestock production. For Andhra Pradesh, India, a study based on artificial removal of topsoil showed clear and strong relations between top soil depth and crop yields, the slope of the loss curve being greater for high rainfall than low rainfall years.

For rangelands, a reduction in livestock productivity to 10-50 per cent of its potential is estimated for desertified rangelands.

2. **Forest productivity is also reduced** on degraded land, although this is mitigated by the capacity of some tree species to tolerate poor soils, and the recuperative effects upon soil of appropriate reforestation.

3. **Increased inputs and greater costs.** The level of poverty of many farmers is such that they cannot accept the consequence of reduced yields. Instead, they must attempt to maintain their food supplies from the degraded land, by means of increased inputs. This is now widely the case where attempts are made to combat soil fertility decline by increased inputs of fertilizers. Another response is to attempt to maintain livestock numbers despite a reduced carrying capacity of pastures, thus leading to a vicious circle of further degradation.

4. **Reduced responses to inputs.** It is now accepted that fertilizers are best utilized by application of low to moderate amounts, whilst seeking to obtain high responses. Land degradation, particularly the lowering of soil organic matter, has the opposite effect, that of lowering fertilizer responses.

5. **Reduced productivity on irrigated land.** A specific case of lower crop yields and reduced responses to inputs occurs on the irrigated lands which are widespread in the region. These irrigation systems have been established at high cost, whether of capital, as in the case of tubewells and the large reservoir and canal schemes, or labour, as in the cases of hand-dug wells and earth dams. Lowered productivity, as a result of soil fertility decline, waterlogging and salinization, reduces the benefits from irrigation, leading to less efficient use of capital and labour inputs.

6. **Loss of flexibility in land management.** Reduced crop yields can force farmers to grow only basic food crops, particularly cereals (Joshi and Jha, 1992). Again there is a feedback effect, since continuous cereal production causes further decline in soil fertility.

7. **Greater risk.** Degraded land is less resilient, less able to recover from recurrent disasters, such as drought. One of the major effects of erosion is reduced water-holding capacity of the soil. Increase in risk places constraints on land management, making farmers reluctant to use up scarce capital on fertilizers.

8. **Loss of water for irrigation.** An off-site effect of deforestation and erosion of watershed areas is destabilization of river flow regimes, causing flooding after rains and reduced flows in subsequent dry periods. Where there are downstream irrigation systems, this reduces water availability at times when it is most needed. Lowering of the water table increases irrigation costs, and can make groundwater totally unavailable to farmers with small landholding, who cannot afford deep tubewells.

9. **Diversion of resources to reclamation.** As already noted with respect to fertilizer inputs, pressure to make ends meet forces farmers to make great efforts in an attempt to maintain production. Thus they may construct gabions across gullies, or build terraces with finest of stones, requiring large amounts of labour, or construct deeper tubewells. This has been called 'defensive expenditure'. All such inputs, whether of labour or capital, carry an opportunity cost, that of the alternative, productive, uses to which the resources could have been applied.

Consequences for the people. The effects of land degradation upon production have impacts upon agricultural population, whether engaged in crop production, livestock production, or dependent upon forest products—

Increased landlessness. Landlessness among the rural population is a problem of a vast scale. The causes are many, among which abandonment of degraded land is only one.

Lower and less reliable food supplies. Lowering of crop yields means reduced production of food crops, increased risk means lowered food security.

Increased labour requirements. Reduced crop yields and increased inputs both have the effect of reducing the farmers' returns from labour. Labour used in reclamation and rehabilitation of land is labour lost from production.

Lower incomes. Out of all the consequences of land degradation, the most serious for the rural population is lower incomes. These result from either or both of the factors noted above: increased inputs or reduced outputs.

Land degradation and its impact on the poor:

Whenever adverse changes occur in the less developed world, it is usually the poor who suffer most. This situation arises from the very definition of the poor, those who lack adequate access to the basic necessities of life and the resources needed to obtain them.

This is certainly the case with land degradation. In the past rural population, however low their incomes may seem in modern terms, had access to adequate land to meet their needs. When a disaster, such as flood, drought, attack by pests, or war, destroyed their normal means of livelihood, there were spare land resources to fall back upon. They could take new land into cultivation, kill the few livestock they possessed which fed upon natural pastures, or go into the forest and extract roots or hunt wildlife.

Because of land shortage, accentuated by degradation, these options are no longer available. Farmers with less than one hectare are dependent on that small area for all of their agricultural income. The only alternatives open to them are to work on the lands of others, non-agricultural occupations, migration to the cities, or ultimately, dependence on famine relief.

It is in these tightly constrained circumstances that land degradation hurts most. Production begins to fall. Because production is close to the limit for supplying basic needs, a response must be made to secure these needs in the short term. This may be clearance of fragile lands, for the sustainable management of which, poor farmers lack the resources. It may be increased inputs, particularly the attempt to maintain yields by nitrogen fertilizers. The non-sustainable land management leads to further degradation.

Larger farmers are less likely to degrade land. Certainly, cases are known where irresponsible rich farmers exploit the land, but by and large they will conserve their resources. When disasters occur, they can tighten their belts, turn to alternative sources of income, or borrow and repay in better years. These options are not open to the poor.

It is the poor who suffer most from land degradation.

Desertification and its socio-economic impact:

Desertification is a global issue with serious implications worldwide on biodiversity, ecosafety, poverty eradication, socio-economic stability and sustainable development. Dry lands are already fragile. As they become degraded, the impact on people, livestock and environment can be devastating. The impact of desertification on the socio-economic life of rural households leads to reduction in crop and animal production, as well as causing, livestock deaths and rise in the prices of foodstuffs. People migrate as a consequence of drought and desertification to urban areas or to other rural areas, in order to engage in economic activities such as farming, grazing and fishing. Migration impacts on family life leads to separation of families—wives and children and ultimately the destruction of family patterns as women, children and the elderly ones are often left with the burden of agricultural activities.

The soil becomes infertile. As desertification occurs, the soil can be blown or washed away, and valuable soil nutrients are lost. Through the use of unsustainable irrigation techniques, salt can also build up in the soil, rendering the soil useless for growing crops or other plants.

Vegetation is damaged or destroyed. Desertification reduces the ability of land to support plant life. Loose soil bury plants, or their roots become exposed and cannot fulfill their function. With plants dying, rainwater gets washed away instead of being drawn into the soil, which only scales up the problem as remaining plants do not have enough moisture to survive dry spells as they used to.

Soil erosion. The reduction in plant cover increases the erosion of the soil due to increased runoff and direct exposure to wind. This results in the decrease of water storing capacity of soils. The process of desertification is worsened as the soil becomes increasingly arid, and there are no more plants to hold it in place and distribute nutrients.

Disasters. Desertification makes natural disasters worse. Events such as flooding, dust storms, and pollution, all become stronger in areas with heavily degraded soils. Without any plants stabilizing the soil and slowing down the runoff, rainwater easily accumulates and floods human settlements.

Polluted sources of drinking water. Vegetation plays an important role in cleaning our water. Plants and trees function like natural filters, storing pollutants such as heavy metals from water in their own bodies. Barren soils lack this green filter, and therefore, more of these harmful substances enter our groundwater reservoirs.

Famine, poverty and starvation. Due to drought conditions and a loss of productive land, local people find themselves experiencing famine and poverty, as well as potentially the starvation of themselves and their livestock.

Q. 3. Discuss in detail impacts of mining and dam building on the environment.

Ans. The combination of mines and building of dams has devastating impacts on the environment, forests, biodiversity and on the people of the surrounding area.

These impacts not only cause serious environmental destruction and suffering for the affected communities, but also violate the collective rights of the indigenous people.

Major impacts of mining and dam building include:

(*i*) **Deforestation.** For both mining and dam building there is a need to clear forest area. Cutting of forests is known as deforestation and it also further affects the balance of biogeochemical cycles such as oxygen, carbon and water cycles.

(*ii*) **Land destruction, subsidence and water loss.** Land which is cleared off is considered as waste land. Mining and dam building generally create subsidence of land, making land unproductive and vulnerable.

(*iii*) **Pollution of water and soil.** In the case of acid mining, a lot of water is polluted and also the soil becomes polluted as the water takes with it a lot of debris from the mine area containing acidic residues.

(*iv*) **Siltation.** The steadily rising level of silt in the dam reservoirs which later on destroys more and more fields.

(*v*) **Submergence of forests.** When a dam is to be built, a large area of forest sometimes needs to be submerged leading to great level of deforestation and loss of an entire forest including its biodiversity.

(*vi*) **Health problems.** Serious health problems can occur due to water, soil and air pollution. Contamination of water, soil and air contributes to increased toxic levels in people's bodies. Asthma and other respiratory problems often affect local communities as well as mine workers. When the health of people deteriorates, their ability to work and earn money is reduced even further.

(*vii*) **Loss of flora, fauna, biodiversity and food insecurity.** Especially due to dam building, fishkills occur every rainy season, attributed to the release of water from the tailings dams. The loss in aquatic life is a major change in the life support system of the communities who rely on the river for daily food. Not only are livelihood sources affected, but also, the general biodiversity is damaged causing breakdowns in the food web.

(*viii*) **Dislocation of indigenous people.** Large-scale corporate mining and dams dislocate the indigenous people from their ancestral lands and traditional livelihoods. These activities thus, have devastating effects on the tribals of the area and their survival is highly affected. *For example,* Narmada Bachao Andolan for the first time, systematically revealed how building dams can result in total dislocation of tribal societies. Official figures state that almost 42,000 families were displaced for this project.

Q. 4. Taking one example discuss how dam building has affected the ecological balance of ecosystem? [*2015 Dec.*

Ans. Dams are generally constructed on a river for generation of electricity as an aid to generating energy. Construction of a dam leads to many problems and has many adverse effects.

Sardar Sarovar Dam, the largest of all the constructed dams, was made on river Narmada. The dam is experiencing agitation on various issues since its construction. One of the issues being its effect on the environment. In total over

32,000 hectares of land have been submerged by the Sardar Sarovar Dam, 13,000 of which is forest land and 11,000 hectares of agricultural land.

Types of environmental problems caused by dam building on Sardar Sarovar Dam:

(*i*) Reproduction of migrating fishes is hindered by the floods that harm the egg beds.

(*ii*) Temperature of water, salt and oxygen distribution may change vertically as a consequence of reservoir formation. This may cause the generation of new living species.

(*iii*) The population of fish decreases as dam works as a barrier in the passage.

(*iv*) Fishes can also get damaged while passing through the floodgates, turbines and pumps of dams.

(*v*) **Habitat loss.** Fish is a major food of the tribal people of the area. Due to irrigation, salinisation, and destruction of plants, fish supplies have been considerably depleted. Further, waterlogging renders land useless, therefore starvation ensues as foods and crops cannot grow. Salinisation means significant decline in drinkable water around the areas where the water is being irrigated. These changes affect the surrounding system seriously.

(*vi*) **Destruction of forests and agricultural lands.** A lot of land has been submerged by Sardar Sarovar Dam and its construction including forest land and agricultural land.

(*vii*) An estimated 1,50,000 people will be displaced due to the Sardar Sarovar Dam. This is not just a simple matter of relocation as these people are indigenous farmers and peasants, with a set cultural and social inter relationship with one another. Their entire way of life is being destroyed if they have to move to the larger cities.

Q. 5. Construction of dams is a problem to the biodiversity and local tribes. Discuss giving any one example from India. What are the measures that should be undertaken to overcome this problem? [*2017 May*

Ans. *Dam building—A problem to biodiversity and local tribes.* *See Q. 4, Page 38.*

Although hydroelectricity is a renewable energy, hydropower is not necessarily 'green' unless dams are located and operated in a carefully considered way.

The measures that can be taken to reduce the stress on environment and tribal people include:

(*i*) Relocation of people who lost their houses and jobs.

(*ii*) Proper allocation of people in residential complexes.

(*iii*) Easy reimbursement of money granted to them due to their loss.

(*iv*) Afforestation of lost forests.

Q. 6. Explain the causes of depleting forest cover and its impacts on human communities. [*2019 May*

Ans. *Causes for depletion of forest cover are:*

(*i*) Depletion of forests on an extensive scale was carried out in the colonial period. The beginning and the expansion of railways during this period led to the destruction of huge chunks of forests.

(ii) In independent India, clearing of forest land for the purpose of cultivation has also led to the depletion of forest cover in the country.

(iii) Timber has become an important commercial resource. It is used for building and making furniture. The felling of the trees for the purpose of obtaining timber is an important cause of reduced forest cover in India.

(iv) Many forests have been cleared for the purpose of building large scale dams in the country.

(v) Rapid Industrialization, urbanisation and expansion of cities has also led to the destruction of forest cover in the country. Buildings, schools, factories, cities, and roads—these are all accounts of infrastructure expansion. Urbanization has occupied the forests. Road expansions lead to cutting down of trees. The erection of buildings requires the destruction of tropical forests

(vi) Animal grazing, mining, collection of fire wood in rural areas are some other reasons of forest depletion in the country. Deplétion of forests is caused mainly due to the commercial use of timber, expansion of agriculture and the construction of large dams.

(vii) Forest fires are a natural occurrence that takes place when the temperature in the forests increases due to long periods of dry seasons. It can also be caused by a lightning strike.

Impact on human communities:

(i) Millions of people depend on forests for livelihood—hunting, gathering, medicine and small-scale agriculture. When the forests will be gone, there will be a loss of livelihood. In some parts of Southeast Asia, deforestation caused people to migrate to urban areas.

(ii) Deforestation also leads to poor quality of life. Without trees, oxygen will lack supply. Carbon dioxide and greenhouse gases will occupy the air, promoting various diseases. Deforestation will also increase the global temperature which leads to climate change and global warming.

(iii) Due to deforestation, the water cycle has been disrupted which causes extreme weather conditions, unexpected patterns of precipitation and river flows which ultimately have an impact on human life.

Q. 7. Explain the steps and measures that need to be taken at the individual level and by the government for water conservation in India. *[2018 Nov.*

Ans. *Water conservation means conserving water which is present in abundant amount but not available for use.*

The supply of water will always be limited and treating dirty water is expensive. Governments and communities can educate the public and restrict water use but ultimately it is the responsibility of each individual to use water wisely.

Individual role in water conservation at home—

Taking short showers and planting drought-resistant gardens are just a few ways the average person can help the community conserve limited global water supplies.

It is important to find every opportunity to conserve water in our homes. Fix leaky faucets as soon as the problem arises.

Use water saving shower heads and fixtures for your taps and toilets and turn off taps when brushing your teeth or shaving.

Replace or adapt older, less water efficient fixtures or appliances. A lot of innovative water saving devices are available on the market that can reduce water use by up to 40%. Replace your showerhead with a water saving device or alternatively bathe with a bucket and mug. When bathing, be careful not to overfill the tub. Avoid flushing the toilet unnecessarily.

Ways to control outdoor water use—Use rain catchers or barrels to collect and store rainwater for use in the lawn and garden.

Run sprinklers during the coolest part of the day.

Role of the Government—The government is conserving water through collecting and storing the rain water and then treating through process to make it potable so that it can be used for human consumption.

The State Government has decided to have two percolation tanks for each borewells sunk by the government across the State. The government took this decision in order to conserve water and recharge the borewells.

The best way to curb water losses is by creating awareness. Running programmes to educate people about conservation measures is very important. Including water conservation in the habits of children from a younger age is required. Also strict laws in public toilets needs to be implemented to alert one and all. Also it is a resource that requires immediate attention of all. So known celebrities and reputed NGO's should take responsibility and promote this cause through every visual and social medium possible.

Q. 8. Explain the effect of use and over-exploitation of water resources.

Or

Explain the effect of use and over-exploitation of water resources with reference to:

(a) Floods

(b) Droughts

Ans. Water resources constitute all the sources of water which are useful. Water demands have been ever increasing due to urbanisation and expansion of irrigated land. This has led to over-exploitation of both surface and ground-water resources.

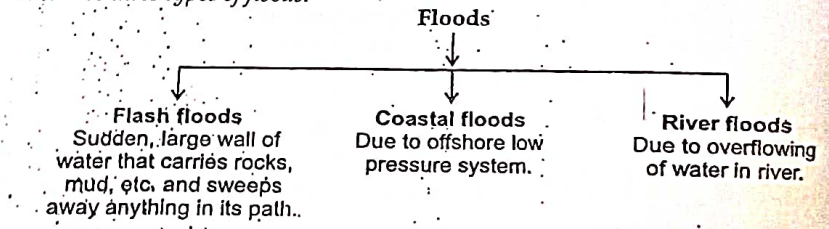
The problems hindering the use of surface and groundwater:

- Depletion due to extraction of groundwater.
- Water-logging and salinization.
- Pollution due to agricultural, industrial and other human activities.

Use and over-exploitation of water can lead to:

(a) **FLOODS:** Floods are defined as abnormal rise in the water level of streams or rivers which may result in overflowing.

There are three types of floods:



Causes of floods:

- *Deforestation* in the upper catchment area.
- *Prolonged high intensity rainfall* generally causes river floods.
- *Anthropogenic activities.* Construction of bridges, reservoirs and land use changes.

Impacts related to floods:

- Loss of lives
- Widespread crop destruction
- Associated economic disasters.

(*b*) DROUGHTS. Drought is a prolonged period of deficient precipitation which causes extensive damage to crops resulting in loss of yield.

Causes of droughts:

- Inadequate rainfall in some areas leading to water scarcity.
- Deforestation leading to low rainfall.
- Shift in agricultural practices again leading to lower precipitation.
- High water loss due to inadequate water availability.

Impacts related to droughts:

- *Economic Impacts.* Droughts lead to an adverse economic impact in agriculture and related sectors which are entirely dependent on precipitation.
- *Environmental Impacts.* These are the losses that result from damage to plant and animal species, wildlife habitat, air and water quality, loss of biodiversity and soil erosion.
- *Social Impacts.* Droughts can result in migration of people thus creating stress on urban areas due to sudden increase in population leading to increased poverty and social unrest.

Q. 9. Write a brief history on national and international conflicts of water.

Ans. Water conflicts may be described as conflicts between countries, states or groups over access to water resources.

Causes of water conflicts include:

(*i*) Demand of water resources

(*ii*) Control over access and allocation of water may be disputed.

(*iii*) Inadequate supply of water resources that contributes to unequal access to water resources.

Water Conflict Cases. Water conflicts can occur at the international and inter-state levels:

- International conflicts occur between two or more neighbouring countries that share a trans-boundary water source, such as a river, sea or groundwater basin.
  For example, the Middle East has only 1% of the world's freshwater shared among 5% of the world's total population.
- Inter-state conflicts take place between two or more parties in the same country. Middle East, Africa, Central Asia generally encounter interstate water conflicts.
- An example of interstate water dispute occurring in India includes the Narmada water dispute.
  States affected: Rajasthan, Madhya Pradesh, Gujarat and Maharashtra.

Inter State water disputes in India:

- Interstate water disputes in India often prolong over long periods and tend to recur.
- These long delays are partly due to elaborate judicial proceedings and deliberations. But more importantly, the adjudication proceedings are often circumvented and impeded by variety of political interests.

The following are other examples of inter-state water disputes and tribunals:

(*i*) Ravi-Beas water tribunal

(*ii*) Vamsadhara River water dispute

(*iii*) Cauvery water dispute

Q. 10. Although India has a vast coastline, most social and political problems are due to water. Discuss giving examples. [*2016 May*

Ans. Although India has a vast coastline but still India faces a state level competition on sharing of available freshwater. With increasing unplanned urbanization the need for water has turned into greed now. The ground water resources have been abused, water is neither being recharged nor stored in ways that optimizes its use. Waste is being discharged to the water bodies emerging into crisis of water.

Take example of Hyderabad, it has several aquifers and water bodies. These have been supplying drinking water to the city for well over a hundred years. But population explosion coupled with unplanned construction in all directions has resulted in reduction of water level in traditional aquifers, which existed in and around the city.

India also has water-sharing issues with neighbouring countries. China and India are competing for resources along the Brahmaputra River, which flows through parts of Asia that have been prone to territorial disputes. South Asia is water scarce. Mass dam-building and diversion of course of river are source of major tension between India and China.

Climate change, depleting aquifers, rapid population growth and urbanisation are placing pressure on scarce water resources within the country and also with our neighbouring countries.

China's dam building agenda has created apprehension within India about the risk of flash floods and landslides affecting millions of people living in downstream areas. In June 2000, due to lack of hydrological data exchange between the two countries a dam burst in Tibet caused flash floods downstream in Arunachal Pradesh.

These issues unnecessarily disturb the relations with other neighbouring countries. Although, we are not at war with any country but there is always a war like argument going on caused by man-made reasons due to such unresolved issues like water.

Fresh water issues occur due to the following reasons:

- Inefficient use of water for agriculture.
- Reduction in traditional water recharging areas.
- Sewage and wastewater drainage into traditional water bodies.
- Release of chemicals and effluents into rivers, streams and ponds.
- Lack of on time desilting operations in large water bodies that can enhance water storage capacity during monsoon.

- Lack of efficient water management and unmanaged distribution of water between urban consumers and the agriculture sector and industry.

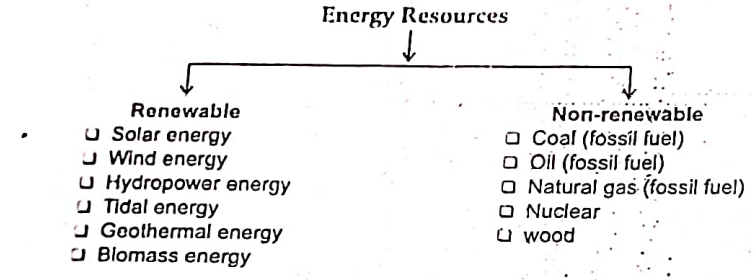
Q. 11. What are the major sources of energy on Earth? Explain giving examples of renewable and non-renewable sources of energy.

Ans. Sources which can provide energy in different forms like heat energy, light, power, electricity etc. are called energy resources.

There are two types of sources of energy:

(*a*) Renewable sources of energy,

(*b*) Non-Renewable sources of energy



(*a*) RENEWABLE SOURCES OF ENERGY

These can be used over and over again. They generate less pollution both in gathering and production. These include the following:

1. *Solar Energy.* It is the energy obtained from the sun. It is trapped in solar panels, solar thermal collectors and materials with favourable thermal mass.

Advantages:

(*i*) The power source of the Sun is absolutely free.

(*ii*) The technology is cost effective and pollution free.

(*iii*) Generally requires low maintenance input with a lifespan of 30 to 40 years.

Disadvantages:

(*i*) Can only be harnessed during day time and on sunny days.

(*ii*) Solar cells, panels and solar collectors are expensive.

(*iii*) Large areas of land are needed to capture the Sun's energy.

Applications:

(*i*) In agriculture and horticulture, solar pumps are being used effectively all over the world. Greenhouses convert solar light to heat, enabling year-round production and growth.

(*ii*) In transportation solar energy is used by development of solar power or working on the stored battery of solar energy.

(*iii*) Solar cooker, solar heating, solar thermal, water treatment.

(*iv*) Electricity production etc. are other applications.

2. *Wind Energy.* It is the energy obtained from moving wind. The wind turbines convert the wind energy into electrical form in the wind farms.

Advantages:

(*i*) It is a free of cost source and is a cleaner source of producing energy.

(*ii*) The wind farm can be used for other purposes as well. The turbines are very tall and thus the land below can be made useful for agricultural purposes.

Disadvantages:

(*i*) It is an unreliable source as some areas have poor wind strength.

(*ii*) Commercial wind turbines are associated with noise pollution.

(*iii*) Wind turbines produces a lot less electricity than the average fossil fueled power station.

Applications:

(*i*) Electricity generation—Wind turbines convert kinetic energy of wind to mechanical energy which is further converted to electrical energy.

(*ii*) Wind powered water pumps—Wind helps to pump water out of the ground. It is very helpful and sometimes acts as a much needed tool in some countries.

3. *Hydel Energy/Hydropower Energy.* It is the power derived from the energy of falling water and running water. It is the most widely used form of renewable energy accounting for 16 per cent of global electricity generation.

Advantages:

(*i*) Once a dam is constructed, electricity can be produced at a constant rate.

(*ii*) No generation of green house gases during electricity generation.

Disadvantages:

(*i*) Dams are extremely expensive to build and must be built to a very high standard.

(*ii*) Dam building may lead to flooding, earthquakes, disturbing the natural water table level.

(*iii*) The building of large dams can cause serious geological damage.

(*iv*) Dams also lead to the dislocation of people living in the villages and towns of the valley to be flooded for dam building.

Applications:

(*i*) Generation of electricity.

(*ii*) Facilitates irrigation.

(*iii*) Flood risk management—It gives a control of exactly when to empty the basins in preparation for winter weather and when to refill them in the spring to store water.

4. *Tidal Energy.* A form of hydropower that converts the energy of tides into useful forms of power, mainly electricity.

5. *Geothermal Energy.* It is the thermal energy generated and stored in the earth. The geothermal energy of the earth's crust originates from the original formation of the planet (20%) and from radioactive decay of minerals (80%).

6. *Biomass.* It is biological material derived from living or recently living organisms. It most often refers to plants or plant-derived materials. These can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of biofuel.

(*b*) NON-RENEWABLE SOURCES OF ENERGY

It is a resource that does not renew itself at a sufficient rate for sustainable economic extraction. The different non-renewable sources of energy are:

1. *Fossil Fuels:*
   (*i*) *Coal (fossil fuel).* Formed from fossilized plants and consisting of carbon with various organic and some inorganic compounds.
   (*ii*) *Oil (fossil fuel).* A carbon-based liquid formed from fossilized animals.
   (*iii*) *Natural Gas (fossil fuel).* Methane and some other gases trapped between seams of rocks under the earth's surface.

Advantages:
   (*i*) They are readymade fuels.
   (*ii*) They provide a large amount of concentrated energy for a relatively low cost.
   (*iii*) They can be easily available and transported wherever needed through fuel stations and pipelines.

Disadvantages:
   (*i*) These when burnt release greenhouse gases in the environment.
   (*ii*) Only a limited supply is available.

Applications:
   (*i*) Generally used to power cars, heat homes, and give people electricity. 55% of the energy used in the industrial processes is from the non-renewable types of energy.

2. *Nuclear energy.* Electricity is generated from the energy that is released when the atoms of radioactive minerals are split in nuclear reactors.

Advantages:
   (*i*) A small amount of radioactive material produces a lot of energy.
   (*ii*) No atmospheric pollutants are released.

Disadvantages:
   (*i*) Nuclear power plants are expensive to run.
   (*ii*) Nuclear waste is highly toxic, and needs to be safely stored for hundreds or thousands of years.

Applications:
   (*i*) *Nuclear Power plants* are definitely one of the finest usages of nuclear energy. These plants run on nuclear reactors.
   (*ii*) *Radiation therapy.* Used in treatment of cancer by destroying cancerous cells in the patient's body.

3. *Wood energy.* Obtained from felling trees, burned to generate heat and light.

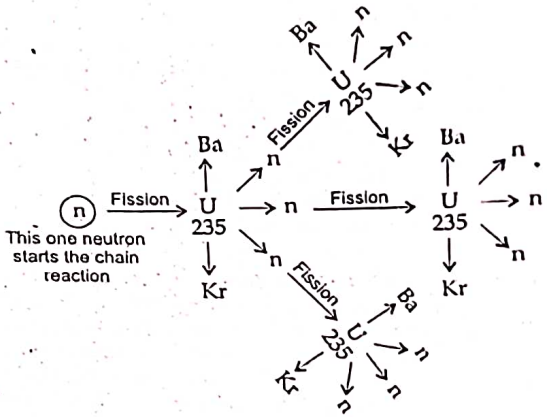
Q. 12. Why is nuclear power an economical form of energy? Discuss its risks and applications in the society.

Or

What is Nuclear energy? Elaborate its advantages, disadvantages and applications in society.

Ans. Nuclear energy is produced when an atom's nucleus is split into smaller nuclei by the process called fission. The fission of large atoms, such as Uranium 235 and Plutonium 239, produces a great deal of energy. When a Uranium atom absorbs a neutron and undergoes fission, in addition to producing two lighter elements, it releases three neutrons. These neutrons further react with other Uranium atoms, releasing more neutrons. If uncontrolled, this system could blow itself up in a very short time by creating too much heat. Thus, a reactor is made to prevent this situation from occurring. The energy produced by the fission of

Uranium or Plutonium can be harnessed to produce electricity, to propel space crafts and to power weapons like the Atomic Bomb.



Process of Nuclear Fission of U_{235}

Advantages:
   (*i*) A small amount of radioactive material produces a lot of energy. Thus, nuclear power is an economical source of energy. Coal , oil and gas, although much more plentiful in the world, do not contain as much potential energy as Uranium, when equal amounts are compared.
   (*ii*) Though Uranium may cost more to mine because it is rarer, the money saved through its use makes it more economical than coal, oil or gas. Similarly, though the initial cost of a nuclear power plant is much higher than that of other energy plants, the money saved by using nuclear energy would cover the cost of its construction within its first six months of operation. After the initial six months of use, the nuclear plant will save money and make it much more economical than other types of energy plants for the duration of its life, usually about forty years.
   (*iii*) Another economic advantage of nuclear power is that it costs less to transport its constituents to the site of the plant.

Disadvantages:
   (*i*) Nuclear waste is highly toxic, and needs to be safely stored for hundreds or thousands of years.
   (*ii*) Leakage of nuclear materials can have a devastating impact on people and the environment. The worst nuclear reactor accident was at Chernobyl Nuclear Plant, Ukraine in 1986.
   (*iii*) Another problem is with the inception of the breeder reactor. The breeder reactor uses liquid sodium as opposed to water for its heat transfer. Sodium is extremely explosive when combined with oxygen. Therefore , any sodium that leaks into the air or water would produce a devastating explosion.

Applications:

(i) *Nuclear Power Plants.* These are power plants that run on nuclear reactors. Nuclear fission produces heat which is used in the creation of electricity in a nuclear power plant.

(ii) *Radiation Therapy.* This therapy is used in the treatment of cancer by destroying cancerous cells in the patient's body. Also known as radiotherapy.

(iii) *Food Processing.* If nuclear energy is exposed to food in small amounts, then it is possible to kill harmful germs, micro-organisms and bacteria present in it which cause decaying and diseases.

(iv) *Nuclear Submarines.* These are powered by a nuclear reactor which makes use of high enriched fuel for getting the desired amount of power.

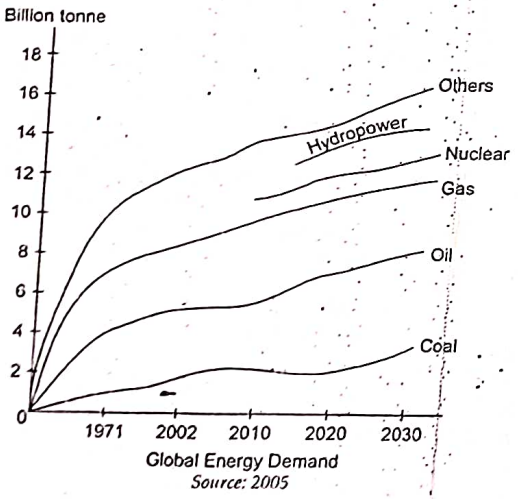
(v) *Industrial Applications of Radiation.* Radio isotopes help in detecting faults in goods produced. The radio isotopes, which are used as tracer's aid in monitoring the corrosion of useful industrial equipment. Radioactive materials are used in the place of oil and natural gas in the petroleum and mining sector whereas in the automobile sector, it is used to check steel quality.

Q. 13. Explain: "The world's energy needs would be more than 50% higher in 2030 than today, at an average annual growth rate of 1.6%".

Or

Briefly discuss the energy demand of the world.

Ans.



Global Energy Demand
Source: 2005

Energy is derived from non-renewable and renewable resources and the former are in the process of depletion. Furthermore, it is proposed that global energy needs will grow steadily.

If governments stick with current policies, then—

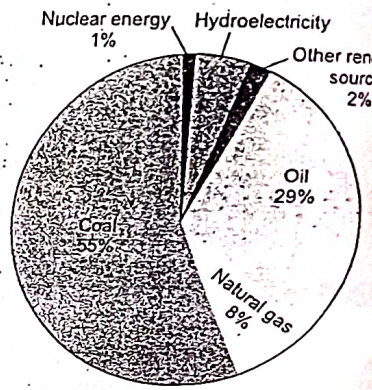
the world's energy needs would be more than 50% higher in 2030 than today, at an average growth rate of 1.6%. Global demand for energy has risen inexorably

in the last 150 years in step with industrial development and population growth. Fossil fuels till date continue to dominate energy supplies and are expected to remain the same for the coming years. Fossil fuels (coal, petroleum, natural gas etc.) are responsible for more than 80% of the projected increase in primary energy demand.

Reasons for increase in worldwide energy demands:

- Industrialization, especially in emerging markets. Business and factories in particular, require significant amounts of energy in the form of both electricity and petroleum-based fuels in order to operate. As economies industrialize, energy demand increases.
- Increasing wealth in emerging markets, especially China and India. When economies grow, their energy needs also grow. This leads to increased energy demand and consumption.
- Globalization. Transportation is one of the largest consumers of energy in the world, accounting for more than 50% of liquid fuel consumption in countries. The energy utilised for transportation has thus increased with increased globalization.

Concern has recently shifted towards environmental impact. Burning of fossil fuels has contributed to increase in green house gas emissions. Pressure to replace fossil fuels has focused more attention on renewable sources, *for example,* solar and wind energy—non-polluting and enduring, they offer an attractive alternative.



Growing energy needs in India. Due to rapid economic expansion, India has one of the world's fastest growing energy markets. India is expected to be the second-largest contributor to the increase in global energy demand by 2035, accounting for 18% of the rise in global energy consumption. Given India's growing energy demands and limited domestic fossil fuel reserves, the country plans to expand its renewable and nuclear power industries.

Q. 14. Giving instances elaborate on the success of alternate energy sources—a step towards sustainability.

Or

Briefly discuss the successful positive steps taken to combat energy demand.

Ans. Keeping in view the current energy situation in the world, there is a dire need to shift to alternative sources of energy. Many countries have proved successfully that with research and development we can achieve our goals to establish a mature technology of renewable resources.

CASE STUDY 1:

The local government of a city can actively support the establishment of local renewable energy industries. *For example,* Dezhou, China which has actively

supported the establishment of renewable energy industries now boasts over 120 solar energy enterprises which generate an annual turnover of USD 3.46 billion. In 1997, the municipality and local government of Dezhou in China elaborated a Development Plan for the Dezhou Economic Development Zone to centralise solar technology research and development, manufacturing, education and capacity building. It has led to establishment of a mature technology innovation system.

CASE STUDY 2:

Belo Horizonte, Brazil, has reduced green house gas (GHG) emission substantially and since 2007, by turning a closed landfill site into a waste-to-energy facility, has taken a huge step towards this. A landfill site in Belo Horizonte, operational for 32 years, was once the largest single source of GHG emissions in the city, the conversion of methane to CO_2 has substantially reduced the GHG emissions and since its closure, the Municipal Waste Treatment Centre has made it into a waste-to-energy facility.

CASE STUDY 3:

Sydney in Australia and Nagpur in India are cities where energy efficiency and renewable energy have reduced emissions from the public street lights. These are examples of local governments choosing suitable options for public lightening. In Sydney, light emitting diodes are being chosen which are expected to save around USD 830,000 a year in electricity bills, reducing electricity consumption by 51% and CO_2 emissions by 2,185 tonnes a year. In Nagpur, PV-powered street lighting systems have been installed.

India has also stepped into the world of renewable energy. The various steps in this way are:

(*i*) A box type folding two-step asymmetric reflector solar cooker has been developed which is commercially available.

(*ii*) A solar dryer has been developed a replacement to aluminium trays reducing not only the duration but increasing efficiency.

(*iii*) A low cost Kaccha-Pacca drum type biogas plant has been designed for fermentation of cattle dung to create clean kitchen fuel and manure.

(*iv*) Low cost Janta biogas plants have been developed.

(*v*) Kalyan Gasifier and Jai Kisan Gasifier have been developed for conversion of wooden pieces to produce gas and application of gas as supplementary fuel.

Q. 15. Differentiate between:

(*a*) Renewable and Non-Renewable resources [*2016 Dec., 2017 May*

(*b*) Desertification and Deforestation [*2016 May*

(*c*) Geothermal energy and Energy of fossil fuels.

(*d*) Biogas and liquefied petroleum gas (LPG). [*2017 Dec., 2019 May*

(*e*) Biodegradable and Non-biodegradable waste [*2017 May*

(*f*) Conventional and Non-conventional energy resources [*2015 Dec., 2016 May*

(*g*) Nuclear energy and geothermal energy. [*2016 May*

Ans. (*a*) Renewable and Non-Renewable resources

	Renewable Resources	*Non-Renewable Resources*
(*i*)	These are resources which can be replenished naturally in a short period of time.	These are resources which are naturally occuring but take a very long time for replenishment.
(*ii*)	Rate of replenishment of these resources is usually faster than the rate of consumption of these resources.	Rate of replenishment is less than that of the rate of consumption of these resources.
(*iii*)	These resources are continuously available like sunlight, air, water, wind, etc.	These resources can be used directly such as oil, coal, etc.
(*iv*)	These resources although available but their quantity is getting noticeably disturbed due to human activities. *For example,* water, land are being degraded.	These resources need to be preserved because they are being consumed on a large scale, thus making them available for not more than 50 years from now.
(*v*)	These resources can be recycled like water, land, etc.	These resources cannot be recycled once consumed.

(*b*) Desertification and Deforestation

	Desertification	*Deforestation*
(*i*)	Degradation of formerly productive land is known as desertification.	Permanent removal of forests in order to make land available for other uses is called deforestation.
(*ii*)	It occurs in dry and fragile ecosystems.	It occurs in forest areas.
(*iii*)	It affects terrestrial areas (top soil, earth, groundwater reserves and surface run-off), animal and plant populations as well as human settlements and their amenities.	If affects the carbon level in the atmosphere, it causes loss of species due to loss of their habitat. It disturbs the water cycle and also causes soil erosion.
(*iv*)	*Causes of Desertification:* • Increased population and live-stock pressure on marginallandsaccelerates desertification. • Drought and poor practices in farming. • Deforestation.	*Causes of Deforestation:* • Forests are cleared for the purpose of mining and building, etc. • To use land for agricultural purpose. • To illegally use the cut trees as fuel. • To make more land available for housing and urbanisation • To harvest timber to create commercial items such as paper, furniture and homes. • To create ingredients that are highly prized consumer items. • To create room for cattle ranching.

(c) Geothermal energy and Energy of fossil fuels

	Geothermal energy	*Energy of fossil fuels*
(i)	It is thermal energy generated and stored in the Earth. It originates from the original formation of the planet (20%) and from radioactive decay of minerals (80%).	It is formed from fossilized-plants (coal), animals (oil) and from methane and some other gases trapped between seams of rocks under the earth's surface (natural gas).
(ii)	These have gases trapped deep within the earth; these emissions are low in per energy unit.	These are burnt to utilise the energy; the emissions are high in energy per unit.
(iii)	It is a lifetime energy source and thus a renewable resource. We can use it and reuse it over and over again.	It is a readymade fuel and thus a non-renewable resource. We can not reuse it.
(iv)	These are clean sources of energy because they do not burn and do not cause pollution.	The burning of fossil fuels in producing electricity releases carbon dioxide and other green house gases in the air causing global warming.
(v)	Geothermal energy cannot be obtained at all places, we need to find a good spot where there is substantial and continuous amount of heat.	Fossil fuels can be made available to fuel stations from where they can be easily accessed.
(vi)	Applicable for generation of electricity and heat, in industrial processes such as digesting paper, wood pulp and drying timber, geothermal prawn farming and horticulture, etc.	It is used to generate electricity, power vehicles, heat homes and provide power to even large machineries in industries.

(d) Biogas and Liquefied Petroleum Gas (LPG)

	Biogas	*Liquefied Petroleum Gas (LPG)*
(i)	It is obtained from shrubs, farm wastes, animal and human wastes.	It is obtained in natural form.
(ii)	It is available in limited quantities.	It is available in large quantities.
(iii)	It is not used as a raw material.	It is used as a source of power. It is also used as raw material in petrochemical industries.
(iv)	Decomposition of organic matter yields gas, which has higher thermal efficiency in comparison to kerosene, dung cake and charcoal. It gives no smoke. Hence, quite useful.	It is supplied for household use as LPG (Liquefied Petroleum Gas) and also used for running vehicles as CNG (Compressed Natural Gas)
(v)	It releases lesser greenhouse gases	Releases CO_2 which is a green house gas but is cleaner when compared to gasoline.
(vi)	It is lighter than air and hence disperses quickly in the event of spillage.,	It is highly inflammable. It is heavier than air and on leakage will settle to the ground..

(e) Biodegradable and Non-biodegradable wastes

	Biodegradable waste	*Non-biodegradable waste*
(i)	They are decomposed and degraded by microbes.	They cannot be decomposed by microbes.
(ii)	Degradation process is rapid.	Degradation process is slow.
(iii)	They are not accumulated but are used up in a short time.	They often accumulate.
(iv)	These are used to produce energy manure, compost and biogas.	These can be separated and recycled but the process is very expensive.
(v)	Biodegradable wastes become part of biogeochemical cycles and give back rapid turnover.	Most of these wastes never enter into Biogeochemical cycles. Even if these do the process is very slow and toxic.

(f) Conventional and Non-conventional energy resources

	Conventional energy resources	*Non-conventional energy resources*
(i)	The sources of energy which has been in use for a long time. *Example*, coal, petroleum, etc.	The resources which are yet in the process of development over past few years. *Example*, solar energy, wind energy, tidal energy, etc.
(ii)	They are exhaustible except water.	They are inexhaustible.
(iii)	They cause pollution when used, as they emit smoke and ash.	They are generally pollution-free.
(iv)	They are very expensive to be maintained, stored and transmitted as they are carried over long distance through transmission grid and lines.	Less expensive due to local use and easy to maintain.

(g) Nuclear Energy and Geothermal Energy

	Nuclear Energy	Geothermal Energy
(i)	It is released by splitting (fission) or merging together (fusion) of the nuclei of atoms.	Geothermal energy is harvested from the inside of the Earth.
(ii)	It uses the steam created from radioactive material heating water to run the turbine.	The heat from the earth rises up in the form of hot wind to run a turbine to produce electricity.
(iii)	It is the cleanest and most efficient form of energy produced.	It produces hot gases which can harm the environment.
(iv)	It is cost effective.	It is not cost effective or sustainable.

Q. 16. Write notes on the following:

(a) Use of alternate sources of energy
(b) Soil erosion
(c) Land degradation
(d) Biomass energy [2015 Dec., 2018 Nov.
(e) Tidal energy
(f) Groundwater recharge
(g) Importance of rainwater harvesting in urban areas [2016 May
(h) Mass Extinction Crisis [2019 Nov.
(i) Biofuels
(j) Land Resources [2017 Dec.
(k) Over exploitation of surface and ground water resource.
(l) Agro residues as a biomass energy resource.
(m) Joint Forest Management
(n) Increasing water crisis in megacities. [2017 Dec., [2019 May
(o) Impacts of dam construction on tribal populations [2016 Dec., 2018 Nov.
(p) Hydropower

Ans. (a) *Use of alternate sources of energy.* The increasing use of and dependence on fossil fuels for energy demands has resulted in the depletion of fossil fuels. The non-renewable fossil fuels according to a Census are only available for 50 years from now. This means that there is a need for switching our energy requirements to alternate sources, *i.e.*, sources which are renewable such as—solar, wind, biofuels, hydel energy etc. These resources are abundantly available on earth and can be used efficiently according to their availability and thus will prove to be better sources of energy. Renewable energy sources do not release pollutants, thus are even ecofriendly. India ranks 4th largest with regard to installed power generation capacity in the field of renewable energy sources. India has high sunshine days and abundance of sites, many rivers, coasts, biomass fuels—all these sources make India ideal to harness the much-needed energy from these resources.

(b) *Soil erosion.* The loss of top soil due to natural physical processes like water and wind is termed as soil erosion. Top soil is high in organic matter and directly associated with the fertility of soil. So, soil erosion reduces cropland productivity.

Causes of soil erosion:

(i) *Rainfall Intensity and Run-off.* The flow of water due to rainfall or surface run-off can be considered a cause of water erosion. The impact of rain drops leads to breaking down of soil. The dispersed material is easily taken away with water.
(ii) *Soil erodibility.* It depends on the texture of soil. Soil with higher levels of organic matter tends to be less erodible.
(iii) *Slope Gradient and Length.* The steeper the slope of a field, greater the amount of soil loss from erosion by water.
(iv) *Vegetation.* If the soil has very low or no vegetative cover of plants or crops then it is highly susceptible to soil erosion.

(c) *Land Degradation.* It is deterioration in the productive capacity, quality of vegetation, soil and water resources associated with land. It is caused by anthropogenic actions. Land degradation affects the associated biodiversity, natural ecological processes and ecosystems of the affected region. Across the world, over 20% of cultivated areas, 30% of forests and 10% of grasslands are suffering from degradation.

Causes of land degradation:

(i) Clearance of vegetative cover
(ii) Soil erosion by wind or water
(iii) Natural conditions, *for example,* soil type, topography; weather/climatic conditions, *for example,* high intensity rainfall, natural hazards, etc.
(iv) Invasive species
(v) Pollution
(vi) Drought, *i.e.,* precipitation is significantly lower than average record level for a prolonged period.
(vii) Unsuitable agricultural practices.
(viii) Habitat alteration, *for example,* urban expansion.

(d) *Biomass energy.* Biomass is biological material derived from living or recently living organisms. It most often refers to plants or plant-derived materials. As a renewable energy source, biomass can either be used directly *via* combustion to produce heat, or indirectly after converting it to various forms of biofuel.

Advantages:

(i) It can be used to make a variety of fuels to generate electricity.
(ii) Biomass waste can help in reducing disposal costs.
(iii) Biomass waste can extend the life of landfills.
(iv) Biomass uses waste products and therefore has negative fuel costs.
(v) Biomass has several uses as it can provide electricity, heat, biogas and biofuels.

Disadvantages:

(i) Biofuels have lower energy output than traditional fuels.
(ii) As demand for food crops such as corn grows for biofuel production, it may also raise prices of necessary staple food crops.
(iii) Using valuable cropland to grow fuel crops could have an impact on the cost of food and could lead to food shortages.
(iv) Pollutants such as carbon dioxide (CO_2) are released into the atmosphere on the production of biofuels.

Applications:

(i) Used for basic life functions. All the food we eat contains biomass, whether vegetables, animals or products derived from them.

(ii) Direct combustion of biomass—Most biomass is in solid form and can be burned and used in various places.

(iii) Charcoal production from biomass and combustion.

(iv) Production of liquid fuel, ethanol production, biodiesel production and production of gaseous fuels..

(e) *Tidal energy.* It is a form of hydropower that converts the energy of tides into useful forms of power, mainly electricity. The movement of tides drives turbines.

Advantages:

(i) Tidal and wave energy is free, renewable and is a clean source of energy.

(ii) Energy capturing and conversion mechanism may help protect the shoreline.

Disadvantages:

(i) It leads to the displacement of wildlife habitats.

(ii) It only produces electricity during tidal surges.

(iii) The barrage systems disrupt fish migration and kill fish passing through the turbines. Therefore there is also a risk of destruction of the aquatic ecosystem that relies on the coming and going of tides.

Applications:

(i) Tidal electricity—Tidal energy is used in the generation of electricity.

(ii) Provides protection to coasts in high storms. Tidal barrages can prevent damage to the coasts during high storms and also provides an easy transport method between the arms of a bay or an estuary on which it is built.

(f) *Groundwater Recharge.* It is a process through which surface water seeps into the ground and increases the water table of the underground water. Recharge is the primary method through which water enters an aquifer. It can occur both naturally and artificially.

Natural Recharge. Groundwater is recharged naturally by rain and snow-melt and to a smaller extent by surface water (rivers and lakes).

Artificial recharge. It is done to store water and conserve it for various purposes.

Groundwater recharge is an important process for sustainable groundwater management, wherein the volume of water extracted from an acquifier should always be less than the volume of water that is recharged. Recharge can help move excess salts that accumulate into the groundwater system.

(g) *Importance of Rainwater Harvesting in Urban Areas.* It is a technique used for collecting, storing and using rainwater for landscape irrigation, animal rearing, gardening and for other uses. The rainwater is collected from various hard surfaces such as rooftops and for other man-made above-ground hard surfaces. This ancient practice is growing in popularity due to interest in reducing the consumption of potable water and the inherent qualities of rainwater.

Urban centres in India are facing an ironical situation today. On one hand there is the acute water scarcity and on the other, the streets are often flooded during the monsoons. This has led to serious problems with quality and quantity of groundwater.

This is despite the fact that all these cities receive good rainfall. However, this rainfall occurs during short spells of high intensity. (Most of the rain falls in just 100 hours out of 8,760 hours in a year). Because of such short duration of heavy rain, most of the rain falling on the surface tends to flow away rapidly leaving very little for recharge of groundwater. Most of the traditional water harvesting systems in cities have been neglected and fallen into disuse, worsening the urban water scenario. One of the solutions to the urban water crisis is **rainwater harvesting** - capturing the runoff.

Why to harvest rain?

- In areas where there is inadequate groundwater supply or surface resources are either lacking or insufficient, rainwater harvesting offers an ideal solution.
- Helps in utilising the primary source of water and prevent the runoff from going into sewer or storm drains, thereby reducing the load on treatment plants.
- Reduces urban flooding.
- Recharging water into the aquifers helps in improving the quality of existing groundwater through dilution.

(h) *Mass Extinction Crisis.* Our planet is now in the midst of its sixth mass extinction of plants and animals—the sixth wave of extinctions in the past half-billion years. We're currently experiencing the worst state of species die-offs since the loss of the dinosaurs 65 million years ago.

Although extinction is a natural phenomenon, it occurs at a natural "background" rate of about one to five species per year.

Scientists estimate were now losing species at up to 1,000 times the background rate, with literally dozens going extinct every day, with as many as 30 to 50 percent of all species going extinct by 2050.

Unlike past mass extinctions, caused by events like asteroid strikes, volcanic eruptions, and natural climate shifts, the current crisis is almost entirely caused by us—humans.

Causes of Mass Extinctions:

1. **Climate change.** We are heating up the planet by burning fossil fuels and chopping down rain forests.
2. **Agriculture.** People have converted 37% of Earth's land surface into farms and pastures due to ever increasing population.
3. **Wildlife crime.** Environmental crime including wildlife crime is one of the most lucrative black markets.
4. **Pollution.** Dumping of plastics and other waste materials into the oceans.
5. **Disease.** The final cause is different kinds of diseases with which animals may suffer.

In fact, 99 percent of currently threatened species are at risk from humans activities, primarily those driving habitat loss, introduction of exotic species and global warming because the rate of change in our biosphere is increasing and because every species extinction potentially leads to the extinction of others bound to that species in a complex ecological web, number of extinctions are likely to snowball in the coming decades.

(*i*) ***Biofuels.*** Biofuel is fuel produced from renewable biomass material, commonly used as an alternative, cleaner fuel source to burning fossil fuels. Biofuels are low in carbon intensity so they don't directly affect global warming. They do not contribute to global warming as carbon dioxide released, is taken up by their feedstocks. Biofuels are cost-effective when compared to fossil fuels. Unlike other alternative energy sources like wind and solar energy, relatively small amount of biofuels can produce a significant amount of energy, which is best-suited for transport applications. The two most common biofuels is use today are ethanol from starch or sugar crops and biodiesel from oil rich plants.

(*j*) ***Land Resources.*** Land resources mean the resources available from the land. Thus, land resources refer to a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes and swamps), the near-surface sedimentary layers and associated groundwater and geo-hydrological reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc.).

Uses of land resources.

(*i*) Land provides food, wood, minerals, etc.
(*ii*) Land is a major resource for agricultural development worldwide.
(*iii*) Land nurtures plants and animals that provide us food and shelter.
(*iv*) Land may be used as watershed or reservoir.
(*v*) The complete transport system of the country works on land.
(*vi*) Land acts as a dustbin for the wastes generated by modern society.
(*vii*) Land is used for constructing buildings and industries.
(*viii*) Land is used for residential purposes.
(*ix*) Land can be used for recreational purposes as well like for parks, sports ground, etc.

(*k*) ***Over exploitation of surface and ground water resource.*** Ground water is located underground in large aquifers and must be pumped out of the ground after drilling a deep well. Surface water is found in lakes, rivers and streams and is drawn into the public water supply by an intake. Over extraction of surface and ground water is recognised as one of the major challenge to India's economic and social development. Not only the quantity but the quality of water is under stress. Ninety percent of our major surface water sources are gone and of what is available, significant amount is polluted. The major causes being domestic sewage, inadequate sanitation facilities, poor septage management and the absence of sanitation and wastewater policy frameworkes.

On the other hand, groundwater has mostly been considered a reliable and safe source of water, protected from surface contamination by geological filters that remove pollutants from the water, which percolates through the soil. But according to recent trends, it is estimated that 60% of groundwater sources will be in a critical stage of degradation within the next twenty years.

Some of the negative effects of ground water depletion are:

(*i*) Lowering of the water table.
(*ii*) Increased cost for pumping water farther to reach the surface.

(*iii*) Reduced surface water supplies.
(*iv*) Land subsidence due to loss of support below ground.
(*v*) Salt waters contamination can occur.
(*vi*) As large aquifers are depleted, food supply and people will suffer.
(*vii*) Lack of groundwater limits biodiversity and dangerous sinkholes resulting from depleted acquifers.

Causes of surface and Groundwater Depletion

(*i*) Groundwater depletion most commonly occurs because of the frequent pumping of water from the ground.
(*ii*) Due to continuous pumping of groundwater from aquifers, it does not have enough time to replenish itself.
(*iii*) Agricultural needs require a large amount of water.
(*iv*) Increased population.
(*v*) Groundwater depletion can also occur naturally.

Solutions to surface and Groundwater Depletion:

(*i*) As individuals, we should use less water for luxury purposes.
(*ii*) We should reduce our use of chemicals and dispose of them properly.
(*iii*) More comprehensive research and additional funding can help with surface and groundwater depletion.
(*iv*) We should find alternative sources of water.
(*v*) The pumping of groundwater should be regulated.

(*l*) ***Agro residues as a biomass energy resource.*** Agro residues are highly important sources of biomass fuels for both the domestic and industrial sectors. The term agricultural residue is used to describe all the organic materials which are produced as by-products from harvesting and processing of agricultural crops. They can be further classified as primary and secondary. Agro residues generated in the filed at the time of harvest, are primary and those co-produced during processing are called secondary.

Availability of primary residues for energy applications is usually low since collection is difficult and they have other uses as fertilizer, animal feed etc. However, secondary residues are available in relatively large quantities at the processing site and may be used as captive energy source for the same processing plant involving minimal transportation and handling cost.

Agro residues encompasses all agricultural wastes such as straw, stem, stalk, leaves, husk, shell, peel, pulp, stubble etc. from cereals, cotton, groundnut, jute, legumes, coffee, cocoa, tea, fruits and palm oil. Rice produces both straw and husks at the processing plant. Maize produces, cob, sugarcane produces fibrous bagasse, coconuts produces shells and fibre that can be utilised while peanuts leave shells. All these materials can be converted into useful energy by a wide range of technologies.

(*m*) ***Joint Forest Management.*** Joint Forest Management often abbreviated as JFM is the official and popular term in India for partnerships in forest movement involving both the state forest departments and local communities. Joint Forest Management (JFM) programme in the present form can be traced to the Arabari experiment initiated by foresters in the state of West Bengal. This experiment provided a strong feedback for incorporation of the system in the National Forest Policy of 1988. In many locations people's voluntary groups were engaged in

protection of forests without any initiative from the Government. Subsequently, based on the experience, the process of institutionalizing people's participation in forest protection and regeneration began. This type of collective endeavour in protection and management of forests through people's involvement was later termed as Joint Forest Management.

(n) *Increasing water crisis in megacities.* India is facing the worst water crisis in its history and 21 Indian cities will run out of groundwater by 2020, affecting 100 million people.

The triggers are rapid groundwater depletion, the decline in average rainfall and increasing dry monsoon days.

Groundwater in India depleted 10-25 mm per year between 2002 and 2016.

Average rainfall declined from 1050 mm in the kharif—summer cropping season of 1970 to less than 1,000 mm in kharif season in 2015. Similarly, in Rabi season, average rainfall declined from 150 mm in 1970 to about 100 mm in 2015.

Dry days—days without rainfall—during the monsoons have increased from 40 to 45% in 2015.

If mitigation measures are not implemented, India will face a six per cent loss in its GDP by 2050. India holds about 4% of global freshwater and 16% of its population. Water intensive agricultural practices and growing water demand for industrial, energy production and domestic purposes are significantly stressing India's limited water resources.

(o) *Impacts of dam construction on tribal populations.* In several cases, the environmental impacts of dam projects have resulted either in the displacement of tribes or dramatic ecosystem changes which reduce livelihood needs for the tribes. Compulsory displacement typically has a negative effect on health outcomes in tribal communities. Larger reservoirs which are created along with dams, have stagnant water causing serious tropical diseases such as malaria.

Tribal populations who lose the most are considered least by planners. There is often no to minimum compensation provided to these indigenous communities although they get severely affected. As a result of displacement a majority of them end up with less income than before, less work opportunities, inferior houses, less access to the resources of the common people such as fuel wood and fodder, poor nutrition and poor physical and mental health. Developmental projects often lead to the dispersal of communities, the breakdown of traditional support systems and the devaluation of their cultural identity.

(p) *Hydropower.* Hydropower or hydroelectricity refers to the conversion of energy from flowing water into electricity. It is considered as a renewable source of energy because the water cycle is constantly renewed by the sun.

Humans have been harnessing the energy of river currents for centuries, using water wheels spun by rivers initially to process grains and cloth. Today, hydropower provides about 16 percent of the world's electricity.

A typical hydroelectric plant is a system with three parts: a power plant where the electricity is produced, a dam that can be opened or closed to control the water flow, and a reservoir where water is stored. The water behind the dam flows through an intake and pushes against the blades in a turbine, causing them to turn. The turbine spins a generator to produce electricity.

Hydropower has several advantages:

- Once a dam has been built and the equipment installed, the energy source *i.e.*, flowing water is free of cost.
- It is a clean fuel source renewed by snow and rainfall.
- Hydropower plants can supply large amounts of electricity.
- They are relatively easy to adjust for demand by controlling the flow of water through the turbines.

Q. 17. Discuss the following—

(a) National Solar Mission

(b) Cauvery river water conflict **(c) Tarun Bharat Sangh** [2018 May

Ans. (a) The National Solar Mission is a major initiative of the Government of India and state government to promote solar power. This mission is one of The National Action Plan on Climate Change (NAPCC). It promotes ecologically sustainable growth while addressing India's energy security challenge. It will also constitute a major contribution by India to the global effort to meet the challenges of climate change.

Importance and relevance of solar energy. For India, solar energy is environment friendly as it has zero emissions while generating electricity or heat. It is the most secure of all sources, since it is abundantly available. Theoretically, a small fraction of the total incident solar energy (if captured effectively) can meet the entire country's power requirements.

Objective and Targets.

(i) Its objective is to establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible.

(ii) To create an enabling policy framework for the deployment of 200,000 MW of solar power by 2022.

(iii) To create favourable conditions for solar manufacturing capability, particularly solar thermal for indigenous production and market leadership.

(iv) The immediate aim of the mission is to focus on setting up an enabling environment for solar technology penetration in the country both at a centralised and decentralised level.

The mission adopted a 3 phase approach. Spanning the remaining period of the 11th plan and first year of the 12th plan (upto 2012-13) as phase 1, the remaining 4 years of the 12th plan (2013-17) as phase 2 and the 13th plan (2017-22) as phase 3. At the end of each plan, and mid -term during the 12th and 13th plans , there was an evaluation of progress, review of capacity and targets for subsequent phases, based on emerging cost and technology trends, both domestic and global.

Mission Strategy (Phase 1 and 2)

To meet the objectives and target following strategy was followed.

The first phase will announce the broad policy frame work to achieve the objective of The National Solar Mission by 2022. The policy announcement will create the necessary environment to attract industry and project developers to invest in research, domestic manufacturing and development of solar power generation and thus create the critical mass for a domestic solar industry. The mission will work closely with state Governments, Regulators, Power utilities and local self government bodies to ensure that the activities and policy framework being laid out can be implemented effectively.

(b) ***Cauvery River water Conflict.*** The sharing of waters of the Cauvery River has been the source of a serious conflict between the two states of Tamil Nadu and Karnataka. The genesis of this conflict rests in two agreements in 1892 and 1924 between the Madras Presidency and Kingdom of Mysore. The 802 kilometers Cauvery river has 44,000 km^2 basin area in Tamil Nadu and 32,000 km^2 basin area in Karnataka. The inflow from Karnataka is 425 TMCft whereas that from Tamil Nadu is 252 TMCft.

Based on the inflow, Karnataka-is demanding-its-due share of water-from the river. It states that the pre-independence agreements are invalid and are skewed heavily in the favour of the Madras Presidency, and has demanded a renegotiated settlement based on "equitable sharing of the waters". Tamil Nadu, on the other hand, pleads that it has already developed almost 3,000,000 acres of land and as a result has come to depend very heavily on the existing pattern of usage. Any change in this pattern, it says, will adversely affect the livelihood of millions of farmers in the state.

Decades of negotiations took place. In 1990, finally Indian government constituted a tribunal to look into the matter, which came to a final verdict after 16 years. In its verdict, the tribunal allocated 419 TMC of water annually to Tamil Nadu and 282 TMC to Karnataka, 30 TMC of Cauvery river water to Kerala and 7 TMC to Puduchery. Karnataka and Tamil Nadu being the major shareholders, Karnataka was ordered to release 192 TMC of water to Tamil Nadu in a normal year from June to May. However, the dispute did not end there, as all four states decided to file review petitions seeking clarifications and possible renegotiation of the order.

(c) **Tarun Bharat Sangh** is a non-profitable environmental NGO; with headquarter in Bhikampura, Alwar, Rajasthan. Dr.Rajendra Singh (known as water man of India) is the incumbent chairman of TBS since 1985. The organisation and Dr. Rajendra Singh are best known for doing ecological research and land development to provide clean and fresh water to people. Tarun Bharat Sangh was founded in 1975 in Jaipur by a group of student and professors from the university of Rajasthan.

TBS started their work with mobilising communities around the issue of water and supporting them in reviving and revitalising the traditional systems of water management through construction of 'Johads' Anicut' and 'Bands' for rain water harvesting from shramdan and partly by TBS. TBS has built on existing cultural traditions of the area to revive the feeling of oneness with nature which existed in the village communities and to create an understanding and ethos of integrated ecosystem development. At present the contribution of the organisation is spread around 1000 villages of 15 districts of the state of Rajasthan. The organisation has been part of rejuvenating and reviving 11 rivers in the state of Rajasthan naming, Ruparel, Sarsa, Arvari, Bhagani, Jahajwali, Shabi and establishment of about 11,800 Johads. The United Nations World Water Development Report (WWDR) declared that Tarun Bharat Sangh's low cost, community led approach is responsible for not only conserving water but also for improving the socio-economic condition of rural populations where it is used. As a result of these contributions, TBS was awarded with Stockholm Water Prize (Nobel prize for water) in 2015.

UNIT 5

Environmental Pollution

Important Terms to Know

- **Pollution.** It is the effect of undesirable changes in our surroundings that have a harmful effect on plants, animals and human beings. It is also termed as environmental pollution.
- **Pollutants.** Solid, liquid or gaseous substances present in abundance which have a detrimental effect on human health are called pollutants.
- **Air Pollution.** Air pollution occurs due to the presence of undesirable solid or gaseous particles in the air in quantities that are harmful to human health and the environment.
- **Water Pollution.** The contamination of water bodies like lakes, rivers etc. when pollutants are discharged directly or indirectly without treatment of toxic compounds.
- **Soil Pollution.** The contamination of soil by human and natural activities which may cause harmful effects on living organisms and the environment.
- **Noise Pollution.** Any disturbing or unnecessary noise which may harm the activity or balance of human or animal life.
- **Nuclear Hazards.** Hazards caused by the release of radioactive nuclides in the environment either by natural sources or man-made sources.
- **Solid Waste.** It is any useless solid material generated from different sources such as households, public places, hospitals, commercial centres, construction sites, industries etc.
- **Source reduction** or waste prevention means consuming and discarding less to help reducing waste generation.
- **Recycling.** It refers to the removal of items from the waste stream to be used as raw materials in the manufacture of new products.
- **Incineration.** The process of burning municipal solid waste in a properly designed furnace under suitable temperature and operating conditions.
- **Vermicomposting.** It is the process of producing a natural organic manure produced from the excreta of earthworms fed on scientifically semi-decomposed organic waste.
- **Hazardous Waste.** Wastes of industrial, institutional or consumer origin that are potentially dangerous either immediately or over a period of time to human beings and the environment.

Q. 1. Elaborate on Air Pollution with reference to the following:
(*i*) Sources (*ii*) Causes
(*iii*) Effects (*iv*) Control

Or

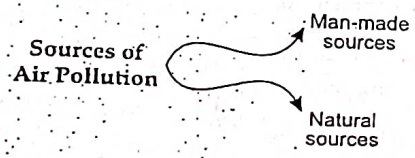
Explain how air pollution deteriorates the environment and also measures to control it.

Ans. Air pollution is defined as the presence of any undesirable solid, liquid or gaseous substances in the atmosphere like dust, mist, smoke that are injurious to human beings, plants and animals. It is directly or indirectly involved in causing harm to human beings and other living organisms, or interferes with the environmental processes. Air pollutants are agents of air pollution. These can be undesirable solid, liquid or gaseous particles.

(*i*) SOURCES OF AIR POLLUTION

Sources of air pollution are of two types:

1. **Natural Sources.** Natural sources are those which are caused due to natural phenomena. These include dust carried by wind from uncultivated land, volcanic eruptions, during decay, pollen grains, etc. All the natural sources including Volatile Organic Compounds (VOCs) on warmer days.
2. **Anthropogenic Sources.** These are artificial sources which are created by humans. Burning of various types of fuel, smoke from power plants or factories, heating devices like furnaces, traditional biomass burning, vehicular emissions etc.



(*ii*) CAUSES OF AIR POLLUTION

1. **Burning of fossil fuels.** Sulphur dioxide released from combustion of fossil fuels and from factories is the major cause of air pollution. Emissions from vehicles cause massive amounts of pollution. Carbon monoxide and nitrogen oxide is released as a result of incomplete combustion in vehicles.
2. **Exhaust from factories and industries.** Manufacturing units discharge carbon monoxide, hydrocarbons, organic compounds and chemicals into the air.
3. **Agricultural activities.** Agricultural activities release ammonia in the atmosphere. Use of insecticides, pesticides and fertilizers also release harmful chemicals into the air.
4. **Indoor air pollution.** Household cleaning products and painting materials produce toxic chemicals which are released in the air which cause air pollution.
5. **Mining operations.** Dust and chemicals are released in the air during the process of mining.
6. **Suspended Particulate Matter.** It can either be *natural* such as dust, seeds, spores, pollen grains, algae, fungi, bacteria and viruses or it can be *anthropogenic* such as mineral dust, cement, asbestos dust, fibres, metal dust, fly ash, smoke particles from fibres, etc.

(*iii*) EFFECTS OF AIR POLLUTION

1. **Effect on human health.** Air pollutants are responsible to cause several respiratory infections, heart disease, stroke and lung cancer, and other threats to the the human body.
   - Carbon monoxide causes headaches, drowsiness and blurred vision.
   - Sulphur dioxide irritates respiratory tissues.
   - Nitrogen oxides irritate the lungs, intensify asthma or chronic bronchitis and also make a person vulnerable to infections such as influenza or common cold.
2. **Effect on agriculture.** Air pollution affects the yield of crops. It has drastically decreased crop yield in the past 30 years.
3. **Effect on plants.** Leaves of the plants are affected as a result of air pollution. Exposure to pollution interferes with the photosynthesis process and plant growth, reducing the nutrient uptake and hence, causing leaves to turn yellow, brown or even drop off.
4. **Effect on wildlife.** Animals are also affected by air pollution. They too face severe diseases due to exposure to pollutants. Animals change their habitat for a noble place.
5. **Acid Rain.** The pollutants such as nitrogen oxides and sulphur oxides are released into the atmosphere. When it rains, these pollutants react with water and form acids and reach the surface of the earth causing great damage to human beings, animals and crops.
6. **Eutrophication.** It is the condition in which a high amount of nitrogen present in pollutants gets deposited on the surface of the water body that turns itself into algae. This affects the life of fish, acquatic plants and animal species present there.
7. **Effect on climate.** Global warming and Greenhouse effect—Due to the trapping of infrared radiations from the earth, the pollutants cause global warming increasing thermal energy or heat in the atmosphere. Thus, the global temperature is increased causing the Greenhouse effect.

(*iv*) PREVENTION AND CONTROL OF AIR POLLUTION.

Several attempts can be made to prevent and control air pollution. These are:

1. More emphasis on using public mode of transport should be made so that less emissions are created due to vehicular pollution.
2. Emission rates should be restricted to permissible levels by each and every industry. There are certain set emission standards of discharge of pollutants. Their proper regulation and enforcement can contribute towards reducing the air pollution.
3. Air quality monitoring including some of the important pollutants such as sulphur dioxides and nitrogen oxides needs to be focussed on.
4. Control indoor air pollution by replacing the traditional use of wood and dung cakes by cleaner fuels such as biogas, kerosene or electricity.
5. Planting trees along busy streets as they remove particulates, carbon dioxide and also absorb noise.
6. Catalytic converters should be used to help control emissions of carbon monoxide and hydrocarbons.

7. Control of Industrial pollution by using cleaner fuels like Liquefied Natural Gas (LNG) in power plants, fertilizer plants, etc. which is not only environmentally friendly but cheaper too.
8. **Conserve energy.** Switch off the fans and lights when they are not in use.
9. **Shift to renewable sources of energy.** Clean sources of energy should be used instead of fossil fuels.
10. **Reduce, Reuse and Recycle.** Reducing the pollutant discharge, reusing the items instead of throwing them and recycling wastes as far as possible will help controlling pollution.
11. **Use of energy efficient devices.** CFC/LED lights consume less electricity as compared to the traditional bulbs. These have longer life, consume less electricity and also help to reduce pollution.

Q. 2. Describe the causes of air pollution in Delhi. What steps should be taken by the government to control the air pollution? *[2017 May*

Ans. *Causes of Air pollution in Delhi:*

- *Growing population of the city. The pressure and haphazard growth of the population is deteriorating the environment.*
- *There has been highly haphazard and unplanned development of industries and factories.*
- *There has been a huge rise in the vehicular population, in spite of the metro railways, aggravating traffic congestion and increasing air and noise pollution.*
- *There has also been an ever-increasing number of diesel vehicles plying on the roads, which are largely responsible for the air pollution.*
- *Everyday almost 8,000 metric tonnes of solid waste is being generated in Delhi, accumulating more and more garbage in the city.*
- *There has been no proper technology or methods to treat solid, liquid, waste water, industrial and hospital wastes in the city.*
- *There has been too much dependence on fossil fuels like coal-fired power plants, improper use of energy in buildings and the excessive use of biomass for cooking and heating, etc.*

Government's steps to control pollution in Delhi:

- *There are mobile enforcement teams deployed at various locations for monitoring polluting vehicles and vehicles not having PUC certificates.*
- *A Mass Rapid Transport System (MRTS) has been constructed with the aim of providing a non-polluting, useful and affordable rail-based mass rapid transit system for Delhi, integrated with other modes of transport.*
- *With a view to reducing vehicular pollution, there has been a ban imposed on the plying of more than 15 years old commercial/transport vehicles, taxis and autos that run on conventional fuels, including diesel driven city buses.*
- *There has also been tightening of mass emission standards for new vehicles.*
- *The quality of the fuel being supplied in Delhi has significantly improved over the years by the ban of selling leaded petrol, introduction of low sulphur diesel, reduction of sulphur and benzene content in petrol.*

- *There has been proper placement of dustbins, purchase of additional front-end loaders, mechanical sweepers, dumper placers, tipper trucks, to collect and dispose of garbage.*
- *Steps are taken to transform garbage into compost by developing new sanitary land-fill sites.*
- *The Delhi Government has constituted a committee to implement the Bio-Medical Waste management and handling.*

Q. 3. Write the Effect of air pollution on flora and fauna. *[2017 Dec.*

Ans. *Effect of air pollution on flora and fauna.* Some air pollutants harm plants and animals directly. Other pollutants harm the habitat, food or water that plants and animals depend on for their survival.

Effects of air pollution on Fauna:

- Formation of the acid rain in the air damages fish life in lakes and streams.
- Rays from ozone layer with excessive ultraviolet radiation coming from the sun may cause skin cancer in animals.
- Rays from ozone in the lower atmosphere may destroy lung tissues of the animals.

Effects of air pollution on flora:

- Acid rain because of air pollution damages the trees and plants.
- Chemicals such as sulfur dioxide, ozone, fluorides damage the leaves of plants. Sulfur dioxide causes change in the colours of leaf tissue. Ozone damage on leaves appears in the form of yellow, black or brown mottled dots.
- Ultraviolet radiation from the sun owing to the hole in ozone layer directly impacts the trees and plants and deprives them of their natural features.
- Air pollution weakens plants and makes them more susceptible to insect infestation.

Q. 4. With appropriate examples, explain the role of technology in curbing air pollution.

Ans. *Anti-pollution laws and policies.* *See Q. 10, Page 101.*

Contributions made by technology in curbing air pollution:

- **Electric cars.** Major cause of air pollution is emission of harmful gases from vehicles. The development of electric cars is a boon to curb air pollution and tackle the problem of harmful emissions.
- **Cleaner industry.** Factories, processing plants and refineries pollute the air through fossil fuel emissions containing CO_2, CH_4 and NO.
- With newer technology, wind turbines and solar energy are among the forms of renewable energy that are being used in order to replace fossil fuels, but they are not the only strategy being put into place. Making places that are still reliant on fossil fuels cleaner is equally important.
- **Pollution control systems.** Such systems act as a type of filter extracting harmful and unwanted elements from the emissions made by industrial plants at source.
- **Food packaging.** It is an area where technology may be able to make a significant impact. The development of technology increases shelf life for

food and is made from eco-friendly materials—grapefruit seed extract being just one of them.

Q. 5. "Solving the problem of air pollution in Delhi needs a multidisciplinary and multisectoral approach." Justify the statement. [*2019 Nov.*

Ans. Unfortunately, Delhi, India's capital, is one of the most polluted cities of the world, as per WHO. The inferior air quality in many regions of India is harming the population, environment and economy. The critical question that comes up is, why Delhi is facing the serious problem of air pollution?

It is not that there has been no serious effort. Numerous legal, regulatory and institutional measures have been initiated, and schemes implemented since early 1980s. But the results are far from encouraging. It needs to be understood why the administration is unable to respond effectively, and what needs to be done to improve the situation.

There are *four reasons* why Delhi's air quality is unlikely to improve anytime soon.

First, an efficient governance mechanism is central to the success of any anti-pollution effort. Air pollution in Delhi is managed by an autonomous government body, the Environmental Pollution Control Authority (EPCA). The authority has published a plan that calls for responses commensurate with the severity of air pollution. *For example,* as the air quality hits the "severe" mark (PM2.5>250g/m3), the plan requires the EPCA to direct the Delhi Pollution Control Committee (DPCC) to halt all construction activity, stop the use of diesel generators and close brick kilns and power plants. Unfortunately, at least 16 different agencies are currently involved in the implementation of this plan. Some are under the control of the Union government, some under the Delhi government, and some are under the administrative control of neighbouring states. These agencies are ruled by fierce political rivals, and there is no apparent effort to promote coordination among them. The agencies are involved in a continuous public blame game in which various political factions try to make themselves look good. Consequently, policy measures are not effectively enforced.

Second, Delhi's air pollution is a regional problem, and there is very little that Delhi can do about it on its own. A study conducted by the International Institute for Applied Systems Analysis (IIASA) and the National Environmental Engineering Research Institute (NEERI) in Nagpur, India, showed that about 60% of the PM2.5 burden in Delhi is due to the neighbouring states. No policy is likely to work unless it takes regional considerations into account. So, Delhi's pollution needs to be treated as a regional, if not national problem, and inter-agency efforts need to be controlled and coordinated by a central source.

Third, Delhi needs to search for the sources of emissions. During the past decade, there have been 15 source apportionment studies of which 10 have been based on direct sampling method while five are based on secondary data. While sources of emissions remain the same in all the studies, the contribution from different sources to Delhi's pollution varies greatly. This only underscores both the unreliability of existing studies as well as the difficulty in making accurate estimates, which is partly due to Delhi's complex meteorology and the changing nature of the sources of emissions, both in space and time.

Finally, Delhi lacks infrastructure. It has only half the buses it needs for public transport (that's the lowest level in the past eight years). This means that private automobile use continues to grow, adding to the air pollution problem. The DPCC, which has a mandate to enforce compliance with air pollution rules in the city, suffers from a serious scientific and technical manpower shortage (operating at about three-quarters strength since 1990). These gaps in public infrastructure undermine public confidence in the city's ability to address the worsening air pollution problem.

Since air pollution in Delhi is a regional issue, and not city-specific, a regional approach needs to be applied. It will be ideal for various central/state/local government departments to work together, and engage with citizens, research institutions and private companies. Further, the expertise of regional planners must be utilised, since proper at the regional level can help enormously in improving air quality. The regional plan of NCR and city plans should contain policy directions for various administrative agencies – transport, industry, construction, sanitation, environment, agriculture, etc. A deliberate collaboration among various stakeholder groups (e.g., government, civil society and private sector) and sectors (e.g., health, environment and economy) to jointly achieve a policy outcome is necessary. By engaging multiple sectors, partners can leverage knowledge, expertise, reach and resources, benefiting from their combined and varied strengths as they work towards the shared goal of producing better health outcomes. Improving public health (PH) in Delhi is challenging because of the size of its population and wide variation in its geography. MSA helps in addressing identified health issues in focused way as it helps in pooling the resources and formulating the common objectives. One of the major advantages is optimization of usage of resources by avoiding duplication of inputs and activities which tremendously improve program effectiveness and efficiency. Willingness at the leadership and mandate at the policy level are necessary to plan and execute the successful multidisciplinary and multisectoral coordination. All the major stakeholders require to share the common vision and perspective. Unless the planning and administrative agencies display excellence in performing their roles, there is every possibility that air pollution is likely to rise in the coming years.

Q. 6. What do you understand by water pollution? Explain its causes and effects. Describe the measures to prevent water pollution.

Ans. Water pollution is defined as the contamination of water bodies like lakes, rivers, oceans, etc. when pollutants are discharged directly or indirectly without treatment of toxic compounds. It is caused by various human activities like industrial discharge, agricultural run off and domestic wastes. Let us briefly study them:

CAUSES OF WATER POLLUTION

1. **Industrial Waste.** Wastes such as heavy metals and toxic chemicals are discharged from industries into water bodies such as rivers, canals and eventually into the sea. This further leads to eutrophication making the water body dead in due course of time.

2. **Sewage and waste water.** The treated sewage and waste water are released into the sea with fresh water. The sewage water carries harmful bacteria and chemicals that cause serious health problems.

3. **Chemical fertilizers and pesticides.** These are sprayed on the crops for protection from insects and pests. These combine with run-off water and flow down to rivers and canals causing serious diseases.

4. **Leakages.** Sewer line leakage, leakage from landfills, and leakage of coal and other petroleum products through underground pipes also contributes to water pollution.

5. **Mining activities.** Mining process extracts elements in raw form which contains harmful chemicals and can enhance the quantity of toxic elements when mixed up with water which results in several health problems.

6. **Oil leakage.** Oil is immiscible with water, therefore accidental oil spill can cause serious problems for local marine life such as fish, birds and other aquatic organisms. Water pollution due to oil spills occurs as a result of leakage from ships, oil tankers, pipelines, etc.

EFFECTS OF WATER POLLUTION

Water pollution is harmful to humans, animals and aquatic life:

1. **Effect on human health.** Drinking contaminated water can cause stomach infections, vomiting, diarrhoea, or some water borne diseases such as cholera, hepatitis and tuberculosis. Toxic metals get accumulated in fish causing dangerous diseases, *for example,* the 'Minamata Disease' caused by mercury toxicity. Other harmful pollutants include lead which causes displexia while cadmium poisoning causes Itai-itai disease, etc.

2. **Effect on aquatic animals.** Aquatic life depletes with the pollutant discharge into the river. Oil spill in the water causes animals to die when they ingest it or come in contact with it. Since oil does not dissolve in water, so it causes suffocation in fish and birds. The nutrient enrichment causes eutrophication in water bodies, thus making it fatal for animals to survive.

3. **Effect on ecosystems.** Sewage, fertilizers and agricultural run-off contain organic materials which when discharged into water increase the growth of algae, which causes the depletion of oxygen. The low oxygen levels in the water bodies are not able to support most indigenous organisms in the area and thus, upset the natural ecological balance in rivers and lakes.

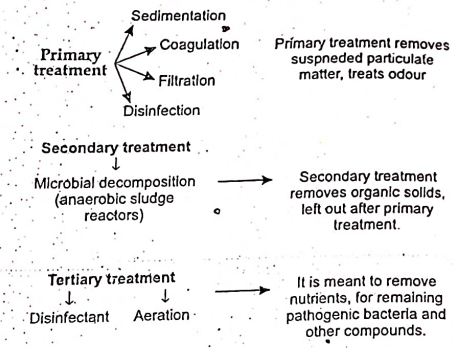
PREVENTION AND CONTROL OF WATER POLLUTION

The prevention and control of water pollution can be accomplished by including local governments and local councils.

The following measures can be adopted:

1. **Proper dumping of waste.** Toxic products like paints, polishes and cleaning products should not be dumped into water directly. These products should be properly treated before disposing off.

2. **Treatment of sewage water.** Waste water from domestic or industrial sources or from garbage dumps is usually known as sewage. It also contains rain water and surface run off. This water should be treated before it is further discharged into rivers. The treatment involves primary, secondary and tertiary treatments. This includes:



3. **Use environment-friendly products.** It is important to use eco-friendly household products like eco-friendly home cleaners, etc. Natural fertilizers and pesticides should be used or if not, we must try to limit the use of insecticides.

4. **Recycling of water.** Recycling refers to the use of waste water by the original user prior to discharge either to a treatment system or to a receiving water body.

5. **Afforestation** also helps in preventing water pollution. As when it rains, chemicals do not easily drain into water.

6. Scientific techniques should be adopted for environmental control of catchment areas of rivers, ponds or streams.

Q. 7. Elaborate the causes, effects and measures to control:
(*a*) Soil Pollution **(*b*) Noise Pollution**

Or

Explain Soil pollution and Noise Pollution in detail.

Ans. (*a*) Soil Pollution. It is defined as the contamination of soil by natural and human activities which may cause harmful effects on living organisms and the environment.

CAUSES OF SOIL POLLUTION

1. **Industrial wastes.** Wastes such as fly ash, chemical residues, metallic and nuclear wastes, industrial chemicals, dyes, acids, etc. are disposed off from pulp and paper mills, oil refineries, distilleries, mining industries and others. These pollutants badly affect the chemical and biological properties of soil. They can also enter the food chain and harm animals and humans.
2. **Urban wastes.** Dried sludge, sewage, garbage and rubbish materials like plastic, glass, rubber, leaves etc. are dangerous for the soil as they can not be easily degraded and although these materials are disposed off separately they can still be dangerous.
3. **Agricultural practices.** Farm wastes, manure, slurry, debris, fertilizers containing mostly inorganic chemicals—all cause soil pollution.

4. **Radioactive pollutants.** The nuclear dust and radioactive waste penetrate the soil and accumulate giving rise to soil pollution. *Example,* Radionuclides of Radium, Thorium, Uranium are usually found in soil, rock, water and air.
5. **Biological agents.** Soil is exposed to large amounts of human and animal excreta which contribute to soil pollution.

EFFECTS OF SOIL POLLUTION

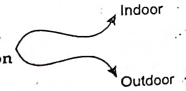
1. **Effect on human health.** The polluted soil affects human health either by inhalation, indigestion or direct contact. In either case the dose of the pollutant determines the severity of the disease. Soil generally has heavy metal toxicity, which may cause cancer or other chronic health conditions.
2. **Effect of ecosystem.** Soil pollution will directly affect the organisms living in it. Thus, microorganisms will show alteration of metabolism disturbing the food chain which in turn disturbs the ecosystem.
3. **Effect on agriculture.** The contaminated soil is no longer fit to support crops, because the chemicals can leach into the food and harm people who eat it. Plantation carried out on an affected land will produce less yield thus creating soil erosion and economical loss to the farmer.

PREVENTION AND CONTROL OF SOIL POLLUTION

1. **Reforestation.** Soil erosion can be controlled by restoring the lost forest. It can be controlled by a variety of farm practices like planting trees on barren slopes, contour cultivation and strip cropping. Crop rotation or mixed cropping improves the fertility of land.
2. **Use of natural fertilizers.** Organic fertilizers should be preferred over synthesized chemical fertilizers. *For example,* biopesticides can be used.
3. **Proper discarding of waste.** Waste should be properly segregated and accordingly disposed off using techniques like vermicomposing, incineration, etc.
4. **Banning toxic chemicals.** DDT, BHC pesticides should be banned which have harmful affects on plants and animals. Nuclear explosions and improper disposal of radioactive wastes should be banned.
5. **Recycling and reuse of waste.** Waste should be reused if possible like paper, plastic, glass and also recycled to generate less waste thereby contributing less to soil pollution.

(b) Noise Pollution. Noise pollution is defined as the disturbing or unnecessary noise which may harm the activity or balance of human or animal life.

SOURCES OF NOISE POLLUTION



1. **Indoor Sources.** Noise produced by television, radio, electric fans, air coolers, generators, air conditioners basically inside the house.
2. **Outdoor Sources.** Noise of loudspeakers, automobiles, industrial activities, rail traffic, airplanes, market places, etc. During festivals, get-togethers, meetings and every noise which crosses the range is included under a source of noise pollution.

CAUSES OF NOISE POLLUTION

1. **Industrialisation.** Industries use big machines capable of producing large amount of noise. Therefore, workers wear ear plugs to minimize the effect. Textile mills, printing presses, engineering establishments all add to noise pollution.
2. **Poor urban planning.** In developing countries, poor urban planning contributes to congested houses, large families fighting over resources. This disrupts the environment of society.
3. **Transportation.** The ever-increasing number of vehicles, aeroplanes, trains add to noise pollution. There has been an unprecedented increase in traffic creating chaos on roads with people stuck in jams with hooting horns. This is a major source of noise pollution.
4. **Noise due to** construction activities, agricultural machines and defense equipments all adds to noise pollution greatly.
5. **Household chores.** Domestic gadgets like TV, mobile, mixer-grinder, pressure cooker, machines etc. are minor contributors to quantity of noise. Further household chores include noise of infants, fights, moving of furniture. This also adds significantly to noise pollution.
6. Blasting, bull dozing, stone crushing etc. in manufacturing units also create noise.

EFFECTS OF NOISE POLLUTION

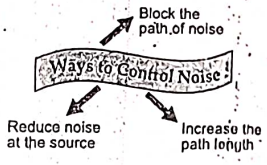
1. **Hearing problems.** Prolonged exposure to noise damages the eardrum. Below a sound level of 80 dB(A), hearing loss does not occur at all, however hearing losses are possible beyond this level. Hearing losses can be temporary, temporary threshold shift (TTS) or permanent loss, Noise induced permanent threshold shift (NIPTS).
2. **Effect on health.** Noise pollution affects health and behaviour. It can lead to psychological disorder. It includes headaches, anxiety, aggressive behaviour, stress, fatigue etc. It can also lead to cardiovascular effects, related heart problems and increased heart rate.
3. **Effect on wildlife.** Noise can have more disastrous effects in animals, as their survival depends on hearing. Some animals require sound waves for locomotion, some for prey, some for navigation and some to hide. *For Example,* Whales use hearing to find food, communicate, defend and survive in the ocean. Excessive noises cause a lot of injuries and deaths to whales.
4. **Sleeping disorders.** Loud noise can definitely obstruct our sleeping pattern and lead to annoyance and uncomfortable situations.
5. **Tired and exhaustion.** A man feels tired and exhausted in a state of prolonged sound pollution. Those who engaged in different professions suffer from mental exhaustion or apathy in work and these tendencies gradually tells upon their efficiency and this factor may deprive the sufferer of his power of audibility in the long run.

PREVENTION AND CONTROL OF NOISE POLLUTION

There are four basic ways in which noise can be controlled.

1. **Reduce noise at the source**

- It can be reduced by appropriate insulation and introduction of noise regulations for take off and landing of aircrafts at the airports.
- In industries, use of absorptive material for controlling interior noise.
- Power tools, very loud music and land movers, public functions using loudspeakers, etc. should not be permitted at night. Use of horns, alarms, fire crackers, etc. should be limited and prohibited.
- Traffic volume and speed are directly proportional to sound levels. Doubling the speed increases the sound levels by about 9 dB and doubling the traffic volume increases sound levels by about 3 dB. Therefore, it is a must to control the volume and speed of traffic.



2. **Block the path of noise.** It can be blocked by constructing temporary or permanent barriers.
   - Construction of vertical barriers alongside the highway.
   - A green belt of trees is an efficient noise absorber.
   - In industries, highly absorptive interior finish material can be used for walls, ceilings and floor.

3. **Increasing the path length.** Soundlevels drop significantly with increasing distance from the noise source. Increasing the path length between the source and the recipient offers a passive means of control.

4. **Protect the recipient.** Use of earplugs and earmuffs can protect individuals effectively from excessive noise levels.

Q. 8. Explain the various dangers and problems associated with landfills in metropolitan areas like Delhi. Also, write a note on solid waste disposal measures that need to be taken to reduce the burden on existing landfills. [2018 Nov.

Ans. *Dangers and problems associated with landfills:*

1. **Air pollution and atmospheric effects.** There are more than ten toxic gases emitted from landfills, of which methane gas is the most serious. Methane gas is naturally produced during the process of organic matter decay. On this account, EPA records that the methane expelled during the decomposition of organic matter in unmanaged landfills has the potential of trapping solar radiation 20 times more effective than carbon dioxide. This results in increased urban and global temperatures. Dust, particulate matter and other non-chemical contaminates can also be expelled into the atmosphere, further contributing to air quality issues.

2. **Ground water pollution.** The primary environmental problem arising because of landfills is groundwater contamination from leaches. There are several hazardous wastes that find way into the landfills and once they are there, the inevitable is the natural deterioration of ground water.

3. **Health effects.** Increases in the risk of severe health implications such as birth defects, low birth weight, and particular cancers have been reported in individuals living next to landfill areas in numerous studies. Landfill toxic gas releases and water pollution are also associated with lung and heart diseases respectively.

4. **Soil and land pollution.** Landfills directly render the soil and land where it is located unusable. It also destroys the adjacent soil and land area because the toxic chemicals spread over the surrounding soil with time.

5. **Economic costs.** The economic and social cost of landfill management is very high. From the management of the gases coming out of the landfills to ground-water contamination management, and ensuring compliance with environmental regulatory policies drains a lot of the municipality's and tax payer's money in terms of integrated waste management.

6. **Landfill fires.** Landfill gases together with a substantive amount of landfill waste, can easily start a fire. Once fires are ignited, it can be challenging to put it out and further cause air pollution. If not put out immediately, they can get out of control and destroy the neighboring habitats.

Solid waste disposal measures. See Q. 17, Page 107.

Q. 9. What are oil spills? How do they contribute to marine pollution? [2017 May

Ans. ***Oil spills.*** An oil spill is the release of a liquid petroleum hydrocarbon into the environment, especially marine areas, due to human activity, and is a form of pollution. Oil spills may be due to release of crude oil from tankers, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products (such as gasoline, diesel) and their by-products, heavier fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil.

Oil spills are harmful to marine birds and mammals as well as fish and shellfish –

- Oil destroys the insulating ability of fur-bearing mammals, such as sea otters, and the water repellency of a bird's feathers, thus exposing these creatures to the harsh elements. Without the ability to repel water and insulation from the cold water, birds and mammals die from hypothermia.
- Many birds and animals also ingest oil when they try to clean themselves, which may poison them.
- Fish and shellfish may not be exposed immediately, but can come into contact with oil if it is mixed into the water column. When exposed to oil, adult fish may experience reduced growth, enlarged livers, changes in heart and respiration rates, fin erosion, and reproduction impairment. Oil also adversely affects eggs and larval survival.

Q. 10. Despite various anti-pollution laws and policies, India's metropolitan cities remain among the most polluted cities in the world. Why? [2017 Dec.

Ans. In India, the legislative framework for the protection of environment is provided by Constitutional provisions, General laws (IPC, CrPC), Special acts (more than 300 acts such as IFA, WPA, EPA, Air Act, Water Act, FCA, National Green Tribunal 2009, etc.) and Policies (National Environment Policy 2006, National Forest Policy, National Agriculture Policy).

This shows that there is no dearth of legislation for environmental protection in India, however despite all these laws, India's metropolitan cities remain among the most polluted cities in the world–

- Air pollution in India is worsening and has become a national problem that is killing 1.2 million Indians every year and costing the economy an

estimated 3% of GDP. Recently, New Delhi's air quality became extremely toxic and the PM 2.5 levels reached over 20 times the safe limit.

- Water pollution is a serious problem with about 70% of India's surface water resources and a growing number of its groundwater reserves have been contaminated with toxic pollutants.
- Municipal Solid Waste (MSW) and Industrial hazardous waste disposal on land pits is another major concern. The infamous case of Uranium poisoning in Punjab is evident of land contamination with toxic pollutants which brought severe abnormalities in Children in the region.
- Our forests are degrading at an alarming rate with increasing deforestation. Overall, the environmental condition in India is degrading and making it difficult to live a quality life in a healthier and safer environment.

Air pollution in India is quite a serious issue with the major sources being fuelwood and biomass burning, fuel adulteration, vehicle emission and traffic congestion. In autumn and winter months, large scale crop residue burning in agriculture fields—a low cost alternative to mechanical tilling—is a major source of smoke, smog and particulate pollution. Most Indian cities continue to violate India and World Air Quality PM 10 targets. Respirable particulate matter pollution remains a key challenge for India. Despite the general non-attainment, some cities showed far more improvement than others. A decreasing trend has been observed in PM 10 levels in cities like Solapur and Ahmedabad over the last few years. This improvement may be due to local measures taken to reduce sulphur in diesel and stringent enforcement by the government. Most Indian cities greatly exceed acceptable levels of suspended particulate matter. This may be because of refuse and biomass burning, vehicles, power plant emissions, industrial sources. Kolkata was a close second, followed by Mumbai. Chennai air pollution was least of the four.

Cities need to curb pollution from all sources, but vehicles need special attention as they emit toxic fumes within our breathing zone. Even as Indian cities remain exposed to critically high levels of toxic substances in their air, the absence of comprehensive data collection makes things worse.

Q. 11. Explain the term Nuclear Hazard. Explain its sources and effects.

Ans. Nuclear hazards are the hazards caused by the release of radioactive nuclides in the environment either by natural sources or man-made sources.

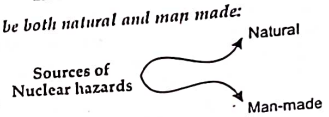
Radioactive nuclides are the elements (Uranium-235, Uranium-283, Thorium-232, etc.) with unstable atomic nuclei and on decomposition release energy or ionizing radiations in the form of alpha, beta and gamma rays. The energy which is released is known as nuclear energy.

Nuclear energy can be both beneficial and harmful depending on the way in which it is used. X-rays are used to examine bones for fractures. We treat cancer with radiation and diagnose diseases with the help of radioactive isotopes. About 17% of the electrical energy generated in the world comes from nuclear power plants. Nevertheless, in contrast destruction, that nuclear bombs caused in cities of Hiroshima and Nagasaki is not to be forgotten. The radioactive wastes from nuclear energy have caused serious environmental damage.

Sources of Nuclear Hazards. *It can be both natural and man made:*

(i) Natural sources include:

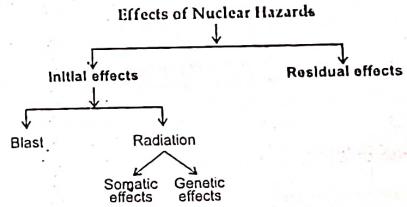
- Cosmic rays from outer space.
- Emissions from radioactive materials in the earth's crust (rocks, marine, sediments etc.)



(ii) Man-made sources include nuclear waste produced during:

- Mining and processing of radioactive ores.
- Use of radioactive materials in power plants.
- Use of radioactive isotopes in medical technology (X-ray machines, radioisotopes used in medicines)
- Industrial applications include wastes from nuclear reactors.
- Research applications include radioactive fallouts during nuclear weapons testing.
- Accidental leakages in nuclear power plants also release nuclear radiations.
- Uranium mining and milling, nuclear reactors and reprocessing of nuclear fuel all cause nuclear pollution.

Effects of Nuclear Hazards. The effects of nuclear hazards can be either initial or residual:



Initial effects occur in the immediate areas of explosion and are hazardous immediately after the explosion whereas the **Residual effects** last for days or years and cause disease and death. The principal initial effects are blast and radiation. Blast causes damage to lungs, ruptures eardrums, structure-collapse and causes immediate death or injury. Radiation emitted causes extensive fires, skin burns and flash blindness.

Radiation effects can be somatic or genetic:

(*i*). **Somatic Effects.** Damage to cells that are not associated with reproduction. It includes loss of hair, reddening of skin, etc. It can also lead to cancer and death.

(*ii*) **Genetic Effects.** Damage to cells associated with reproduction. This damage can subsequently cause genetic damage from gene mutation resulting in abnormalities in future generations.

Q. 12. Explain Merits and demerits of investing in nuclear electricity production. [2019 *May*

Ans. *Merits and demerits of investing in nuclear electricity production.* Nuclear energy is one of the sources of electricity.

Advantages:

(a) High efficiency level over other sources such as fossil fuels.
(b) Abundant supply as Uranium is the significant element in the process of nuclear fission, with enough supply to last for 70 to 80 years.
(c) *Environment friendly.* It has lower greenhouse emissions.
(d) *Less maintenance.* Nuclear power plants do not need regular maintenance as well as operation can last between 40-60 years.

Disadvantages:

- It is harmful as increasing number of nuclear reactors put the health and safety of the people living near at risk.
- *Expensive.* A substantial amount of investment is needed to build the plant.
- Nuclear waste disposal issues are another major concern.
- Danger of potential leakages.

Q. 13. Write explanatory notes on the lessons learned from Fukushima Nuclear disaster that occurred in 2011 in Japan. Do you think India should invest heavily in expanding its nuclear energy power sector? Justify your answer. *[2017 Dec.*

Ans. Fukushima accident, also called Fukushima Nuclear accident or Fukushima Daiichi nuclear accident, occurred in 2011 at the Fukushima Daiichi ("Number One") plant in northern Japan, the second worst nuclear accident in the history of nuclear power generation.

The 2011 Fukushima Daiichi nuclear accident should serve as a wake-up call to nuclear plant operators and regulators on the critical importance of measuring, maintaining, and restoring cooling in spent fuel pools during severe accidents and terrorist attacks. This water leak was accidental but also unforeseen, because it replenished water lost from the Unit 4 pool by evaporation, likely preventing water levels from dropping to the tops of the racks where the spent fuel was being stored. Keeping the fuel covered with water is essential for cooling and radiation shielding. Uncovered fuel would have substantially increased radiation levels above and around the pool, limiting personnel access to the pool and nearby areas, and could have resulted in severe damage to the fuel, increasing the potential for large radioactive material releases into the environment.

The committee also found that extreme external events and severe accidents can cause widespread and long-lasting disruptions to security infrastructure, systems, and staffing at nuclear plants. Such disruptions can create opportunities for spiteful acts and increase the susceptibility of critical plant systems to such acts.

Yes, India should definitely spend heavily in expanding its nuclear energy power sector. The nuclear plant operators and their regulators must upgrade and/or protect nuclear plant security infrastructure and systems and train security personnel to cope with extreme external events and severe accidents in order to handle adverse situations.

Q. 14. Comment on the statement 'environmental damage can give rise to tremendous social and economic inequality.' *[2017 Dec.*

Ans. The statement 'environmental damage can give rise to tremendous social and economical inequality' is truly correct in a way humans consider resources. The consumerist society believes in a non-sustainable division of resources. With industrialization came the degradation of environment in the world. Large

amount of CO_2 emissions in the atmosphere and high consumption of non-renewable resources has already stressed our environment in many ways. The given statement is an apt depiction of the blooming social evil of inequality.

Environmental damage in any form is a curse. Environmental damage stresses the availability of resources, and thus creates inequality. Social inequality is caused when limited resources are available. The socially elite class want things for them at the earliest at the cost of others. If water gets polluted the sufferer remains the class which can not afford purifiers. If air gets polluted sufferer still remains the deprived class. Thus, the system creates more nuisance in one form or the other. Damage to agriculture as an effect of environmental degradation again is going to deprive the already suffering class and face them with more challenges.

Many environmental problems reflect and illustrate social inequality based on social class . As with many problems in our society, the poor and people of lower classes often fare worse when it comes to the environment.

According to the findings of a report by American Sociological Association, global climate change will have its greatest effects on the poorest nations: "Many of the countries least responsible for the rise in greenhouse gases will be most likely to feel its impacts in changes in weather, sea levels, health care costs, and economic hardships"

In most countries it has been observed that Almost all the hazardous waste sites are located in or near neighborhoods and communities that are largely populated by low-income people. When factories dump dangerous chemicals into rivers and lakes, the people living nearby are very likely to be from the underprivileged and low-income strata of society. Around the world, the people most affected by climate change and other environmental problems are those in poor nations and, even within those nations, those who are poorer rather than those who are wealthier.

So if we continue at this pace the richer will get richer day by day and the sufferers will suffer as nothing in this world can cure the challenge of inequality.

Q. 15. What is solid waste? Classify it and explain its different types. *[2015 Dec.*

Ans. Waste refers to the useless material generated from different sources such as households, public places, hospitals, commercial centres, construction sites, industries, etc. Waste can either be solid, liquid or gaseous. Solid waste can be classified according to its origin, *i.e.*, domestic, industrial, commercial or institutional, according to its contents, *i.e.*, organic material, glass, metal, etc. or according to hazard potential, *i.e*, toxic, non-toxic, radioactive, impervious, etc.

Classification of Solid Waste:

It can be classified into different types depending on their source as follows:

1. Municipal Solid Waste
2. Industrial Waste
3. Agricultural Waste
4. Hazardous Waste
5. **Infectious Waste:** Biomedical or Hospital Waste

1. **Municipal Solid Waste (MSW).** It is also called as trash or garbage. It includes non-hazardous solid waste from a city, town or village which requires routine collection and transport to a processing or disposal site. The main sources of

municipal solid waste include private homes, commercial establishments and institutions, as well as industrial facilities. Nevertheless municipal solid waste does not include wastes from industrial processes, construction and demolition debris, sewage sludge, mining waste or agricultural wastes. Municipal solid waste is further classified as:

- **Wet Garbage.** It includes food wastes like meat and vegetable material, eggshells, leftover food, etc.
- **Dry Garbage.** It includes paper, plastic, plastic cans, tetrapacks, cardboard boxes, newspaper, aluminium foil, glass bottles, metal items, wood pieces, etc.

2. **Industrial Waste.** It consists of process wastes, ashes, demolition and construction wastes, hazardous wastes, etc. generated due to industrial activities. These wastes contains more of toxic compounds therefore require special treatment. The sources of industrial waste include food processing industries, metallurgical, chemical and pharmaceutical units, sugar mills, paper and pulp industries, fertilizer and pesticides industry. The toxic waste released from these industries severely affect health of the people. It may cause nervous disorders, genetic defects, skin diseases and even cancer. The effluents released into the water bodies by these industries cause foul odour, formation of sediments etc.

3. **Agricultural Waste.** It consists of spoiled foodgrains and vegetables, agricultural remains, litter etc generated from fields, orchards, farms, vineyards etc. In developing countries like India, this waste does not pose a serious problem as most of it is used. *Example,* dung is used for manure, straw is used as fodder. Some of the waste is also generated by some agro-based industries like rice-milling, production of tea, tobacco etc.

4. **Hazardous Waste.** These are wastes of industrial, institutional or consumer origin that are potentially dangerous either immediately or over a period of time to human beings and the environment. A waste is characterized as hazardous if it has atleast one of the following properties that is: toxicity, reactivity, ignitability and corrosivity.

(*i*) Toxic wastes are those substances that are poisonous even in very small or trace amounts.

(*ii*) Reactive wastes are those that have a tendency to react vigorously with air or water, are unstable to shock or heat, generate toxic gases or explode during routine management.

(*iii*) Ignitable wastes are those that burn at relatively low temperatures (less than 60°C) and are capable of spontaneous combustion during storage, transport or disposal.

(*iv*) Corrosive wastes are those that destroy materials and living tissue by chemical reaction.

5. **Infectious Waste: Biomedical or Hospital Waste.** It includes human tissues from surgery, used bandages and hypodermic needles, microbiological materials etc. It includes any matter which has the potential to transmit infection further. It basically includes waste from hospitals, biomedical laboratories, experimental laboratories etc. Infectious waste is one which needs to be handled carefully as it can lead to dangerous effects and an epidemic of disease.

Q. 16. Explain briefly the steps measures that can be taken for solid waste management at your college level. *[2017 Dec.*

Ans. *There are three steps that may be taken to properly manage solid waste:*

(*i*) **Identify Wastes.** Students must be aware of the wastes that they produce and appropriate process should be taken for each type of waste.

Example: A University employee may produce ("generate") various types of waste and employ a few waste management mechanisms. It must be understood that unwanted office paper and newspapers go to the paper recycling bins. Candy wrappers and eaten apples go into the solid waste trash basket. Dead batteries go into the battery recycling bucket. The old personal computer contains lead and other toxins in its components so it should be collected for electronics recycling by established collection systems.

(*ii*) **Evaluate Wastes.** Students must evaluate their waste for its physical, chemical, and biological characteristics to determine how it is to be properly managed. Mismanaged waste may endanger human health and the environment. Consider reuse, recycling or composting as part of a waste minimization and pollution prevention strategy.

Strategies also include answering the following questions—

Why is the waste being generated? Can the waste be eliminated?

If the waste is hazardous, can it be replaced by something non-hazardous or can the process generating the waste be modified to render the waste non-hazardous?

A waste may be—

- Recyclable material (*e.g.*, paper, coke/ sprite/ juice cans etc.)
- Compostable organic waste (*e.g.*, food, animal bedding, biodegradable plastics).
- Non-hazardous solid waste
- Hazardous Radioactive Waste—waste containing or contaminated with a radioactive isotope.
- Hazardous Biological Waste—waste containing or contaminated with an infectious or potentially infectious agent, a biological toxin, an animal carcass, a genetically modified organism, recombinant DNA, etc.
- Hazardous Chemical Waste—waste chemicals, products which are chemical in nature (cleaning agents, paint, motor oil, and pharmaceutics), products that contain chemicals (fluorescent lamps, thermometers) or materials contaminated with chemicals (contaminated soil or rags)
- Otherwise Regulated Material (asbestos, car batteries, contaminated soil and construction debris)

(*iii*) **Manage Wastes.** Once the waste has been identified and evaluated, generators must manage their waste according to waste management instructions. These waste management instructions can be developed to keep the College/ University in compliance with all applicable laws and regulations and to induce a safe and healthy workplace.

Q. 17. What is Solid Waste Management? Explain measures to control urban and industrial wastes.

Ans. Systematic control of generation, collection, storage, transport, source reparation, processing, treatment, recovery and disposal of solid wastes is known

as solid waste management. The management of solid waste reduces or eliminates undesirable impacts on the environment and human health and supports development and improved quality of life. A number of processes are involved in efficiently managing waste.

An integrated waste management includes mainly:

1. **Source Reduction.** It means reduction or waste prevention from source itself. That means consuming and discarding less. It is a successful method of reducing waste generation. The common-methods include-manufacturing products with minimal packaging, avoid buying disposable items and also by avoiding plastic bags. Encouraging customers to use reusable bags for packaging, using reusable products such as cloth napkins, reuse of plastic and glass containers, backyard composting and sharing and donating any unwanted items rather than discarding them are all effective means of reducing waste. All of these methods require public awareness and training to educate the public about their role in the process of waste management.

2. **Recycling.** It is the process of extracting and reusing useful substances found in waste. It implies that the waste product of one process may be utilized as a raw material of some other new product. Thus, recycling occurs in three phases.

First, the waste is sorted and recyclables are collected. The recyclables are used to create raw materials. These raw materials are then used in the production of new products. Some materials such as aluminium and steel can be recycled many times. Metal, paper, glass and plastic are recyclable. The sorting of recyclables is done at the source for selective collection by the municipality or to be dropped off by the waste producer at a recycling centre.

Recycling although decreases the value of material but it conserves resources for future generation, prevents emissions of greenhouse gases and pollutants.

3. **Disposal.** The disposal of solid waste is done most commonly through a sanitary landfill or through incineration.

Landfill Disposal:

(i) Solid waste is placed in a properly selected and prepared landfill site in a carefully prescribed manner.

(ii) The waste material is spread out and compacted with suitable heavy machinery.

(iii) The waste is covered each day with a layer of compacted soil.

(iv) A liquid is generated out of the waste termed as leachate which needs to be removed properly as it pollutes ground water. Landfill sites release landfill gases constituting 50 to 60 per cent methane by volume. These gases contaminate the environment causing air pollution.

Incineration. *It is the process of burning municipal solid waste in a properly designed furnace under a suitable temperature and operating conditions. It can reduce the waste by above 90 per cent in volume and 75 per cent in weight. It includes high calorific value waste with a large component of paper, plastic, packaging material, pathological waste, etc.*

Vermicomposting. *Vermicompost is the natural organic manure produced from the excreta of earthworms fed on scientifically semi-decomposed organic waste. Vermicomposting is one of the easiest methods to recycle agricultural wastes and to produce quality compost.*

All dead and dry leaves and twigs decompose and are broken down by organisms such as worms and insects and are finally broken down by bacteria and fungi, to form a dark rich soillike material called compost. These organisms in the soil use the organic material as food, which provides them with nutrients for their growth and activities. These nutrients are returned back to the soil to be used again by trees and other plants. This process recycles nutrients in nature.

Q. 18. Explain briefly, the 3R's principle of waste management, *'Waste segregation is the primary step for efficient solid waste management, yet it is in minimal practice in India'. Justify the statement.* [2018 May

Ans. *3R's principle of waste management*—

Reduce: The first step in the three R's strategy is reduce. In order to reduce the amount of waste produced, it is essential to focus on the source of the waste. Source reduction is when products are designed, manufactured, packaged, and used in a way that limits the amount or toxicity of waste created. The first goal of source reduction is simply to reduce the overall amount of waste that is produced and secondly to conserve resources by not using raw, unused materials. By following source reduction, fewer raw materials will have to be used to produce products. A common industrial example of source reduction includes the creation of merchandise using fewer materials.

Reuse: The second most important strategy of the three R's is to reuse, which is when an item is cleaned and the materials are used again. There are two main ways that the concept of reusing can be applied to reduce waste. First, when purchasing a new item, you can look for a product that can be used repeatedly instead of a version that is only used once and thrown away. The second way to reuse is to buy an item secondhand, borrow, or rent an item, instead of buying the product new. Examples of reuse—Old jars and pots can be used to store items in kitchen. They can also be used to store loose items together such as computer wires. Old tyres can either be sent to recycling stations or can be used to make tyre-swings. Used wood can be used as firewood or can be used as woodcrafts.

Recycle: The last stage of the waste hierarchy is to recycle. To recycle something means that it will be transformed again into a raw material that can be shaped into a new item. There are very few materials on the earth that cannot be recycled. Carefully choosing the products that can be recycled, is the first step towards efficient recycling. Some ways to recycle include: (*i*) Buy products from market that are made up of recycled materials, *i.e.*, the product should be environment friendly; (*ii*) Buy products that can be recycled such as glass jars; (*iii*) Avoid buying hazardous materials that could pose to be difficult to recycle; (*iv*) Buy products that have been made from recycled materials; (*v*) Use recycled paper for printing or making paper handicrafts.

Solid waste management. See Q. 17, Page 107.

Q. 19. Explain the term hazardous waste. How do hazardous waste pose a threat to the environment? What are the disposal strategies associated with them?

Or

What do you understand by hazardous waste? Why are the disposal strategies for treating hazardous waste different from municipal solid waste.

Ans. Hazardous waste is waste that poses substantial or potential threats to public health or the environment. Characteristics of hazardous waste should

include one of the following: ignitability, reactivity, corrosivity and toxicity. These wastes can be found in different physical states such as gaseous, liquids or solids. It is a special type of waste because it cannot be disposed off by common means like other by-products of our everyday lives. Depending on the physical state of the waste, treatment and solidification processes might be required.

Environmental and Health risks of Hazardous Waste.

Generally hazardous wastes are disposed off on or in the land, therefore the most serious environmental effect is contaminated groundwater.

Lead, mercury and arsenic are hazardous substances which often add to toxicity of materials. Lead is used in batteries, fuels, pesticides, paints, pipes etc. This lead is stored in the bones of people and wildlife. Lead can affect red blood-cells by reducing their capacity to carry oxygen and shortening their life span. Lead can also damage nerve tissue which can result in brain disease.

Mercury is used in the production of chlorine and as a catalyst in production of plastic. Mercury exhibits bio-accumulation by getting concentrated at each level of the trophic level. It is a cumulative poison that proves fatal to fishes, birds and humans and is likely to cause brain diseases. Minamata disease is a famous outbreak of mercury poisoning that took place in 1956 in Japan.

- Pesticides from agricultural run off cause acute or chronic poisoning. Vinyl chloride which is a chemical used in manufacture of plastic causes deafness, vision problems, circulation disorders and bone deformities. It can also cause birth defects.

Disposal of Hazardous Waste.

The most common methods for disposing off hazardous wastes are land disposal and incineration.

- Land disposal means disposing off wastes in the land. This process focusses on burying the waste in the land. There is a process used that eliminates the odours and dangers before it is placed in the ground. It is common in countries where land is in abundance and available for disposal like North America.
- Incineration. It is a preferred method for disposal. It is the process of heating wastes at high temperature in furnaces reducing the volume of the waste. *Example,* in Europe and Japan land is not readily available so incineration is a preferred method of waste disposal.

Industries need to be encouraged to generate less hazardous wastes in their manufacturing processes. Although toxic wastes cannot be entirely eliminated, technologies are available for minimizing, recycling and treating wastes.

Q. 20. Discuss the problems and challenges of e-waste management in India. [*2015 Dec.*

Ans. "E-waste" or Electronic waste nearing the end of their "useful life". E-wastes are dangerous, as these products contain materials that are hazardous, depending on their condition and density. The hazardous content of these materials pose a threat to human health and environment. Discarded computers, televisions, VCRs, stereos, cell phones and batteries all come under E-waste. They can leach lead and other substances into soil and ground water. Many of these can be reused or recycled as an aid to management.

E-waste management includes:

1. **Inventory Management.** It includes reducing the quantity of hazardous materials usage. It also includes using of less of hazardous materials as raw materials in stock. This can be achieved by preventing the hazardous material usage in the processes involved. Procedures should require that all materials be approved prior to purchase. In the approval process all production materials are evaluated to examine if they contain hazardous constituents and whether alternative non hazardous materials are available.

2. **Production Process modification.** Changes are made in the production process, which will reduce waste generation. This is done by changing the raw materials used to make products or by the more efficient use of input materials in production process or both. It can be done as:

   (*i*) *Improved procedures of operation and maintenance* includes reviewing current operational procedures or lack of procedures and examination of the production process for ways to improve its efficiency.

   (*ii*) *Material change.* Hazardous materials used in either a product formulation or a production process may be replaced with a less hazardous or non-hazardous materials.

   (*iii*) *Process-equipment modification.* This includes installation of more efficient process equipment or modifying existing equipment to take advantage of better production techniques. This can significantly reduce waste generation.

3. **Volume Reduction.** This step includes those techniques that remove the hazardous portion of a waste from non-hazardous portion. These techniques are usually to reduce the volume, and thus the cost of disposing off waste material. This includes source segregation and waste concentration to reduce waste.

   (*i*) *Source Segregation.* Waste containing different types of metals, can be treated separately so that the metal value in the sludge can be recovered.

   (*ii*) *Waste Concentration.* Concentration of a waste stream may increase the livelihood that the material can be recycled or reused.

4. **Recovery and Reuse.** This method eliminates waste disposal costs, reduce raw material costs and provide income from waste. Recycling of hazardous products has little environmental benefit if it simply moves the hazardous substance into products that eventually have to be disposed off.

Q. 21. Discuss the role of industrialization in cities as a source of pollution and give any *two* measures that had been taken to control its effects. [*2017 May*

Ans. *Role of industrialization as a source of pollution*—With industrialisation, the pollution in cities has increased manifold.

1. *Toxic Chemicals.* The toxic chemicals used by industries in processing and manufacturing are the biggest contributors to industrial pollution. These substances are a threat to attaining quality life and are hazardous to human health and the environment. These toxic chemical pollutants are released into the environment resulting in various forms of pollution.

2. *Industrial Consumer Products.* Industrial end products such as electronics, car parts, plastics, metals and chemical utilities such as petroleum, paints, sprays and cleaning solvents created for human consumption are a major cause of pollution. All these industrial products at some point in their lifetime become obsolete, and

a good number of them end up in landfills or water bodies thus causing land and water pollution respectively. Besides, these consumer products contain poisonous chemical elements which can have an adverse effect on the human and animal health, and plant life.

3. *Hazardous Waste Streams.* Hazardous waste streams treatment is for the most part not done efficiently in majority of industries. In particular, water streams are the ones that negatively suffer from such trends. Long-term discharge of hazardous waste streams into water bodies causes severe health problems and reduces water quality.

4. *Greenhouse Gas Emissions.* Carbon dioxide (CO_2) gas is known as a greenhouse gas due to its ability to absorb thermal radiation, leading to global warming and climate change. Industrial energy used during production emits high scores of carbon dioxide gas into the atmosphere, making it a leading source of CO_2 emission.

5. *Degradation and Depletion of Natural Resources.* Industries need a consistent supply of fresh raw materials used to produce their respective final products. As a result, all kinds of raw materials including metals, minerals, and oils are extracted from beneath the earth thereby depleting the resources at the same time degrading land and water resources.

6. *Use of Outdated Technologies.* A number of industries still utilize technologies of the past in their production processes instead of embracing cleaner and green technologies. This is one of the causative factors of industrial pollution in the contemporary era. Use of outdated technology merely generates and adds large quantities of harmful wastes into the environment.

7. *Industrial Sprawl.* Industrial sprawl is a major problem in most industrial townships. Most industrial townships are set up without considering proper land use planning such that it has made it difficult to manage wastes and utilize production energy efficiently. As a result, it has given rise to improper dumping of hazardous wastes and continued emission of toxic gases.

Measures taken to prevent industrial pollution include:

(i) Using cleaner fuels like Liquefied Natural Gas (LNG) in power plants, fertilizer plants, etc. which is not only environment friendly but also cheaper.

(ii) Use of energy efficient devices such as CFC/LED lights consuming less electricity as compared to traditional bulbs. These have longer life, consume less electricity and also reduce economic burden as well as pollution.

Q. 22. Briefly discuss the Ganga Action Plan.

Ans. The Ganga action plan was, launched by Shri Rajeev Gandhi, the then Prime Minister of India, on 14 Jan. 1986 with the main objective of pollution abatement, to improve the water quality by Interception, Diversion and treatment of domestic sewage and present toxic and industrial chemical wastes from identified grossly polluting units entering in to the river. The other objectives of the Ganga Action Plan are as under.

- Control of non-point pollution from agricultural run off, human defecation, cattle wallowing and throwing of unburnt and half burnt bodies into the river.

- Research and Development to conserve the biotic diversity of the river to augment its productivity.
- New technology of sewage treatment like Up-flow Anaerobic Sludge Blanket (UASB) and sewage treatment through afforestation.
- Rehabilitation of soft-shelled turtles for pollution abatement of river.
- Resource recovery options like production of methane for energy generation and use of aquaculture for revenue generation.
- To act as trend setter for taking up similar action plans in other grossly polluted stretches in other rivers.

The ultimate objective of the GAP is to have an approach of integrated river basin management considering the various dynamic inter-actions between abiotic and biotic eco-system.

Objectives of Ganga Action Plan I:

At the time of launching, the main objective of GAP was to improve the water quality of Ganga to acceptable standards by preventing the pollution load reaching the river. However, as decided in a meeting of the Monitoring Committee in June, 1987 under the Chairmanship of Prof. M. G. K. Menon, then Member, Planning Commission, the objective of GAP was recast as restoring the river water quality to the 'Bathing Class' standard which is as follows:

• Bio-Chemical Oxygen Demand	3 mg/l miximum
• (BOD)	5 mg/l minimum
• Dissolved Oxygen (DO)	MPN. 10,000 per 100 ml
• Fecal Coliform	MPN 45,00 per 100 ml

States Covered in Ganga Action Plan I		
Uttar Pradesh	Bihar	West Bengal

Achievements of GAP I

As a consequence of completion of works under GAP I, the Ganga river water quality has shown improvement over the pre-GAP period water quality due to the schemes completed under GAP I. The water quality monitoring has been done by independent reputed institutes like Central Pollution Control Board (CPCB), Bharat Heavy Electricals Ltd. (BHEL), Indian Institute of Technology (IIT), Kanpur, Indian Toxicological Research Centre (ITRC), Lucknow, etc. It may be observed that inspite of a phenomenal increase in population in the urban centers located upstream on the river Ganga, there is a clear improvement in terms of BOD of the river during this period at Kannauj, Kanpur, Allahabad, Varanasi & Patna. At Kanpur the values although decreasing are yet to achieve the desired standards because of the untackled pollution load remaining there.

GAP Phase 2

Notwithstanding some delay in the completion of the first phase of GAP, it has generated considerable interest and set the scenario for evolving a national approach towards replicating this program for the other polluted rivers of the country. The Government of India proposed to extend this model with suitable modifications to the national level through a National River Conservation Plan (NRCP).

The program of river cleaning was extended to other major rivers of the country under two separate schemes of GAP Phase - II and the National River Conservation Plan (NRCP). Yamuna and Gomati Action Plans were approved in April 1993 under Ganga Action Plan Phase - II. Programs of other major rivers were subsequently approved in 1995 under NRCP. After launching of NRCP in 1995, it was decided to merge GAP II with NRCP. A notification of this effect was issued on 05.12.1996.

Objectives of Ganga Action Plan II:

The Ganga Action Plan besides aiming at improving the water quality of river Ganga is to serve as a model to demonstrate the methodology for improving the water quality of other polluted rivers. Though the river water quality of Ganga has shown discernible improvement, the full impact of the action plan would be visible when the left out works in the 25 class I cities and the works in other class II and class III towns along the river Ganga are taken up. The important tributaries of river Ganga like, Yamuna, Gomati and Damodar which directly discharge into the river Ganga are heavily polluted and are taken up for pollution abatement programmes. For this purpose, the second phase of Ganga Action Plan was started in stages between 1993 & 1996. Both Central & State Government provided help and had equal share that is 50:50 in the working of Ganga Action Plan (Phase II). After April 1997 Central Government took the full responsibility of this project & sanctioned the total cost Under Ganga Action Plan. Other river conservation plans for Yamuna, Gomati and Damodar have also been accepted and the government has sanctioned Rs.2285.48 crore for the same. This money will help in starting 441 projects in 95 cities under the plan. Implementation of the plan finally commenced w.e.f. 1.4.2001. The funding pattern was changed to 70:30 between centre and state subsequently.

States Covered in Ganga Action Plan II						
Uttarakhand	Uttar Pradesh	Bihar	Jharkhand	West Bengal	Delhi	Haryana

Conclusion. The Ganga Action Plan launched in 1985 by the Government of India has not achieved any success despite expenditure of approximately 2,000 crore rupees. Even though the government claims that the schemes under the Ganga Action Plan have been successful, ground realities tell a different story. The failure of the GAP is evident but corrective action is lacking.

Media report that there are GAPING HOLES in GAP and its a shocking story of official apathy and corruption. All the money has gone down the drain Mismanagement, corruption and incompetence all are the major reasons of its failure.

Unfortunately, the statements/promises made by the late PM have been proven untrue. The expectations of the people have been dazed to the ground. The GAP I was extended to GAP II from 1993 onwards covering 4 major tributaries of Ganga, namely, Yamuna, Gomti, Damodar and Mahananda. The program was further broad-based in 1995 with the inclusion of other rivers under the National River Conservation Plan (NRCP). Ganga could not be cleaned but 34 other rivers have been taken up for cleaning with the same failed model of "GAP".

Moreover, in the last 21 years, leadership and staff of GAP have come and gone, often without any vision and commitment. There have been reviews and monitoring from time to time at different levels but the problems identified were never addressed and the decisions taken were never enforced. The lower level officials most often were unfamiliar with the work done by previous groups.

GAP needs a critical examination, a thorough review and a complete overhaul. Casual approach and cosmetic efforts will only worsen the condition of river Ganga.

Q. 23. Differentiate between the following:

(a) Primary and Secondary pollutants [2016 Dec.

(b) Point source and Non-point source pollution [2017 Dec.

(c) Smog and Photochemical smog

(d) Degradable, Non-degradable and Persistent pollutants

(e) Somatic and Genetic Effects

(f) Pesticide and Compost [2019 May

(g) Industrial waste and Agricultural waste [2018 Nov.

(h) Compost and Urea [2016 May

(i) Pollutants and toxicants [2016 May

(j) E-waste and Kitchen Wet Waste [2019 Nov.

Ans. (a) Primary and Secondary Pollutants

	Primary Pollutants	*Secondary Pollutants*
(i)	These are emitted directly from particular sources.	These are not emitted directly.
(ii)	These are produced by natural events in the form of particulate matter or gaseous form. *Example,* from volcanic eruptions, dust storms or human activities etc.	These are produced in the atmosphere. Certain reactions take place between primary pollutants and other substances in the atmosphere.
(iii)	*Examples:* Carbon Oxides (CO & CO_2), nitrogen oxides, sulphur oxides etc.	*Examples:* Sulphuric acid, nitric acid, smog, etc.

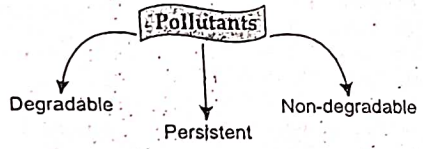
(b) Point Source and Non-point Source Pollution

	Point Source Pollution	*Non-point Source Pollution*
(i)	It refers to those sources of pollution which occur when the polluting substance is emitted directly from the source.	It occurs when pollutants are released from diffused sources or from a larger area.
(ii)	The source of pollution is a single identifiable source, hence easy to control.	The source of pollution is diffused, unspecified, numerous in number and contribution of each pollutant is of less significance.
(iii)	*For example,* discharge from wastewater treatment plants, operational wastes from industries that go into the water-ways from a single source like a pipe.	*For example,* fertilizers and pesticides from a field are carried into a stream by surface run-off.

(c) Smog and Photochemical Smog

	Smog	Photochemical Smog
(i)	It occurs as a result of smoke particles from industrial plumes mixing fog.	It occurs as a result of emissions from automobiles and other fossil fuels due to sun's energy.
(ii)	It occurs in foggy, cool weather.	It occurs in hot, dry climates, and particularly on sunny days.
(iii)	It is intense early in the morning.	It peaks at midday.
(iv)	Two primary components are SO_2 and particulate matter.	Primary components are nitrogen oxides, VOCs, tropospheric ozone and PAN (Peroxyacytyl nitrate).

(d) Degradable, Persistent and Non-degradable Pollutants:



Degradable or Non-persistent pollutants. These pollutants can be broken down rapidly by natural processes. *For example,* discarded vegetables, domestic sewage, etc.

Slowly degradable or Persistent pollutants. These pollutants remain in the environment for many years in an unaffected condition and take very long time to degrade. *For example,* DDT and plastics.

Non-degradable pollutants. These pollutants cannot be degraded by natural processes. They are accumulated in the environment. *For example,* toxic elements like lead and mercury.

(e) Somatic and Genetic Effects

	Somatic Effects	Genetic Effects
(i)	It refers to damage to cells that are not associated with reproduction.	It refers to damage to cells which are associated with reproduction.
(ii)	It includes redefining of the skin, loss of hair, ulceration, fibrosis of the lungs. It can also lead to cancer and death.	It imparts abnormalities due to mutation of genes.
(iii)	It does not pass on to the next generation.	It is an acquired character thus, is passed on from parents to offsprings.

(f) Pesticide and Compost

	Pesticide	Compost
(i)	It is a chemical fertilizer.	It is a natural fertilizer.
(ii)	These are mass produced and sold in bags, boxes and bottles in bulk. It is non-biodegradable.	These are derived from animal waste.
(iii)	It does not pass on to the next generation.	It is biodegradable.
(iv)	They usually have higher level and a larger percentage of soluble nitrogen.	These contain lower levels of N-P-K.

(g) Industrial waste and Agricultural waste

	Industrial waste	Agricultural waste
(i)	It consists of process wastes, ashes, demolition and construction wastes, hazardous wastes, etc. generated due to industrial activities. These wastes contain more of toxic compounds therefore require special treatment.	It consists of spoiled foodgrains and vegetables, agricultural remains, litter etc. generated from fields, orchards, farms, vineyards etc.
(ii)	The sources of industrial waste include food processing industries, metallurgical, chemical and pharmaceutical units, sugar mills, paper and pulp industries, fertilizer and pesticides industry. It is non-biodegradable.	Some of the waste is also generated by some agro-based industries like rice-milling, production of tea, tobacco etc.
(iii)	The toxic waste released from these industries severely affect health of the people. It may cause nervous disorders, genetic defects, skin diseases and even cancer. The effluents released into the water bodies by these industries cause foul odour, formation of sediments etc.	In developing countries like India, this waste does not pose a serious problem as most of it is used. Example, dung is used for manure, straw is used as fodder.

(h) Compost and Urea

	Compost	Urea
(i)	It is the organic kitchen or garden waste that can be added to soil to help plants grow.	Urea is a source of food and nitrogen for bacteria as they feed on it.
(ii)	Making a compost out of waste helps in keeping waste out of landfills where they take up space and release methane, a potent greenhouse gas.	Urea is added to compost as it is a source of nitrogen. It provides an alternate in case the green waste is not available. It can be added along with green waste also.
(iii)	It enriches the soil, reducing the need for chemical fertilizers.	It adds additional decomposing bacteria in the compost pile.

Pollutants and Toxicants

(i)	Pollutants	Toxicants
(i)	Pollutants are chemicals or matter that contaminate the environment. These have the potential to cause harm to human health of the environment.	Toxicants are those pollutants which act as poison depending upon the degree of exposure.
(ii)	Pollutants can be toxic or non-toxic. These can include solid waste, liquid water or gaseous waste. *Example*, pesticide DDT.	Toxicants exist as particulate matter or as vapour (gases). These include metals, particles and certain vapours from fuels. *Example*, Mercury is a toxic metal.

E-Waste and Kitchen Wet Waste

(j)	E-Waste	Kitchen Wet Waste
(i)	**What is E-waste?** E-waste or electronic waste consists of batteries, computer parts, wires, electrical equipment of any kind, electrical and electronic toys, remotes, watches, cell-phones, as well as bulbs, tubelights and CFLs, etc.	**What is E-waste?** Wet waste consists of kitchen waste – including vegetable and fruit peels and pieces, tea leaves, used coffee grounds, eggshells, bones and entrails, fish scales, as well as cooked food (both vegetarian and non-vegetarian).
(ii)	**How do I store e-waste?** Store them in separate container which is kept closed, away from moisture and in which nothing else is put.	**Can I compost at home?** Of course. Home composting can be easily done in Daily Dump's pot system, or in any aerated container.
(iii)	**How do I store e-waste?** Store them in separate container which is kept closed, away from moisture and in which nothing else is put.	**How to get rid of wet waste?** If you live in a large apartment building, a community composting system like tank composting or an OWC could be set up for all the wet waste from the residents. If not, the wet waste can be given out every day to the BBMP.

Q. 24. Elaborate the following:
(a) Plastic waste management rules
(b) Bhopal gas tragedy

Ans. (a) Plastic has multiple uses and the physical and chemical properties lead to commercial success. However, the indiscriminate disposal of plastic has become a major threat to the environment. In particular, the plastic carry bags are the biggest contributors of littered waste and every year, millions of plastic bags end up in to the environment vis-a-vis soil, water bodies, water courses, etc and

it takes an average of one thousand years to decompose completely. It has been estimated that around 15000 tonnes of plastic waste is generated every day, out of which 9000 tonnes is collected and 6000 tonnes is not being collected, Therefore, to address the issue of scientific plastic waste management, the Plastic Waste (Management and Handling) Rules, 2011 were notified in 2011, which included plastic waste management. The Government has notified the Plastic Waste Management Rules, 2016, in suppression of the earlier Plastic Waste (Management and Handling) Rules, 2011.

The Plastic Waste Management Rules, 2016 aim to:

- Increase minimum thickness of plastic carry bags from 40 to 50 microns and stipulate minimum thickness of 50 micron for plastic sheets also to facilitate collection and recycle of plastic waste.
- Expand the jurisdiction of applicability from the municipal area to rural areas, because plastic has reached rural areas also.
- To bring in the responsibilities of producers and generators, both in plastic waste management system and to introduce collect back system of plastic waste by the producers/brand owners, as per extended producers responsibility.
- To introduce collection of plastic waste management fee through preregistration of the producers, importers of plastic carry bags/ multilayered packaging and vendors selling the same for establishing the waste management system.
- To promote use of plastic waste for road construction as per Indian Road Congress guidelines or energy recovery, or waste to oil etc. for gainful utilization of waste and also address the waste disposal issue; to entrust more responsibility on waste generators, like payment of user charge as prescribed by local authority, collection and handing over of waste by the institutional generator, event organizers.
- An eco-friendly product, which is a complete substitute of the plastic in all uses, has not been found till date. In the absence of a suitable alternative, it is impractical and undesirable to impose a blanket ban on the use of plastic all over the country. The real challenge is to improve plastic waste management systems.

What's new in Plastic Waste Management Rules, 2016

- Rural areas have been brought in ambit of these Rules since plastic has reached to rural areas also. Responsibility for implementation of the rules is given to Gram Panchayat.
- First time, responsibility of waste generators is being introduced. Individual and bulk generators like offices, commercial establishments, industries are to segregate the plastic waste at source, handover segregated waste, pay user fee as per bye-laws of the local bodies.
- Plastic products are left littered after the public events (marriage functions, religious gatherings, public meetings etc) held in open spaces. First time, persons organising such events have been made responsible for management of waste generated from these events.
- Use of plastic sheet for packaging, wrapping the commodity, except those plastic sheet's thickness, which will impair the functionality of the

product, are brought under the ambit of these rules. A large number of commodities are being packed/wrapped in to plastic sheets and thereafter such sheets are left for littered. Provisions have been introduced to ensure their collection and channelization to authorised recycling facilities.

- **Extended Producer Responsibility.** Earlier, EPR was left to the discretion of the local bodies. First time, the producers (i.e persons engaged in manufacture, or import of carry bags, multi-layered packaging and sheets or like and the persons using these for packaging or wrapping their products) and brand owners have been made responsible for collecting waste generated from their products. They have to approach local bodies for formulation of plan/system for the plastic waste management within the prescribed timeframe.
- State Pollution Control Board (SPCBs) will not grant/renew registration of plastic bags, or multi-layered packaging unless the producer proposes the action plan endorsed by the concerned State Development Department.
- Producers to keep a record of their vendors to whom they have supplied raw materials for manufacturing carry bags, plastic sheets, and multilayered packaging. This is to curb manufacturing of these products in unorganised sector.
- The entry points of plastic bags/plastic sheets/multi-layered packaging in to commodity supply chain are primarily the retailers and street vendors. They have been assigned the responsibility of not to provide the commodities in plastic bags/plastic sheets/multi-layered packaging which do not conform to these rules. Otherwise, they will have to pay the fine.
- Plastic carry bag will be available only with shopkeepers/street vendors pre-registered with local bodies on payment of certain registration fee. The amount collected as registration fee by local bodies is to be used for waste management.
- Central Pollution Control Board (CPCB) has been mandated to formulate the guidelines for thermoset plastic (plastic difficult to recycle). In the earlier Rules, there was no specific provision for such type of plastic.
- Manufacturing and use of non-recyclable multi-layered plastic to be phased in two years.

Plastic Waste Management (Amendment) Rules 2018.

The Ministry of Environment, Forest and Climate Change has notified the Plastic Waste Management (Amendment) Rules 2018 on March 27, 2018.

The amended rules lay down that the phasing out of Multilayered Plastic (MLP) is now applicable to MLP, which are "non-recyclable, or non-energy recoverable, or with no alternate use".

The amended rules also prescribe a central registration system for the registration of the producer/importer/brand owner. The Rules also lay down that any mechanism for the registration should be automated and should take into account ease of doing business for producers, recyclers and manufacturers. The centralised registration system will be evolved by Central Pollution Control Board (CPCB) for the registration of the producer/importer/brand owner. While

a national registry has been prescribed for producers with presence in more than two states, a state-level registration has been prescribed for smaller producers/brand owners operating within one or two states.

In addition, Rule 15 of the Plastic Waste Management (Amendment) Rules, 2018 on explicit pricing of carry bags has been omitted.

(*b*) The Bhopal disaster, also referred to as the ***Bhopal gas tragedy,*** was a gas leak incident on the night of 2-3 December, 1984 at the Union Carbide India Limited (UCIL) pesticide plant in Bhopal, MP. It is considered to be the world's worst industrial disaster. Over 50,000 people were exposed to Methyl isocyanate (MIC) gas, the highly toxic substance.

The Bhopal UCIL facility housed three underground 68,000-liter liquid MIC storage tanks: E610, E611, and E619. In the months leading up to the December leak, liquid MIC production was in progress and being used to fill these tanks. UCC safety regulations specified that no one tank should be filled more than 50% (here, 30 tons) with liquid MIC. Each tank was pressurized with inert nitrogen gas. This pressurization allowed liquid MIC to be pumped out of each tank as needed, and also kept impurities out of the tanks.

On the night of December 2, 1984, disaster struck. Due to faulty safety mechanisms, water accidentally entered into a giant tank of methyl isocyanate. This started a chemical reaction that turned the chemical into gas, which built up pressure and eventually burst out of the factory and large amount of toxic gases were released into the environment. The pipes were rusty. The rust in the pipes made the reaction faster. All the contents of the tank were released within a period of about 2 hours. Over the next 45 minutes, somewhere between 30 and 45 tons of toxic gas entered the air.

Gases like this are heavier than the atmosphere, so rather than dissipating high in the sky, they formed a dense cloud of noxious fumes at ground level and caught the winds heading straight for Bhopal. As the cloud of gas hit the town, people woke from their sleep choking, gasping, and vomiting. Many were immediately affected, their skin burning and lungs failing. Those who survived the initial wave tried to flee, causing a massive panic in the densely packed town.

By the morning of December 3, thousands were dead. The official counts ranged from 2,259 to 3,787 dead, although local workers who collected bodies claimed that there were upwards of 15,000 victims. The government sent relief workers to Bhopal, but it became quickly apparent that they were unprepared to deal with a catastrophe of this scale. Health effects of the Bhopal methyl isocyanate gas leak exposure [8, 30-32].

Early effects (0–6 months)	
Ocular	Chemosis, redness, watering, ulcers, photophobia
Respiratory	Distress, pulmonary edema, pneumonitis, pneumothorax.
Gastrointestinal	Persistent diarrhoea, anorexia, persistent abdominal pain.
Genetic	Increased chromosomal abnormalities.
Psychological	Neuroses, anxiety states, adjustment reactions
Neurobehavioral	Impaired audio and visual memory, impaired vigilance attention and response time, Impaired reasoning and spatial ability, impaired psychomotor coordination.

Late effects (6 months onwards)	
Ocular	Persistent watering, corneal opacities, chronic conjunctivitis
Respiratory	Obstructive and restrictive airway disease, decreased lung function.
Reproductive	Increased pregnancy loss, increased infant mortality, decreased placental/fetal weight
Genetic	Increased chromosomal abnormalities.
Neurobehavioral	Impaired associate learning, motor speed, precision

Civil and criminal cases were filed in the district court of Bhopal, India, involving UCC and warren Anderson, UCC CEO at the time of disaster. In June 2010, seven former employees, including the former UCIL chairman, were convicted in Bhopal of causing death by negligence and sentenced for punishment.

Q. 25. Elaborate the following:

(a) Pollution in River Damodar in India.
(b) Groundwater pollution in India.
(c) Minamata: An important lesson about mercury.
(d) The Chernobyl Nuclear Disaster: A lesson in the technological disaster of human history.
(e) Environmental impact of Iceland Volcanic Eruption.
(f) Greenhouse Gases [2017 May
(g) Air Quality Index (AQI). [2016 Dec.
(h) Bhopal Gas Disaster [2017 Dec.
(i) Smog [2016 Dec.

Ans. (a) Pollution in river Damodar in India.

River Damodar is 563 kms in length and originates near Chandwa village in the Chhota Nagpur hills in Bihar's Palamau district, and drains into the Hooghly. It is the most polluted river in the country today due to the industries that have sprouted on its mineral-rich banks.

Indian industry depends heavily on the region as 60 per cent of the coal consumed in our country comes from the Chhota Nagpur belt. In addition, various industries such as steel, cement, fertilizer and explosive plants are also located here. The river Damodar is polluted with minerals, mine rejects, flyash oil and toxic effluents. Both its water and soil consist of coal dust and waste discharged from industries. Also there are seven thermal power plants nearby which dump ash in the valley.

(b) Groundwater pollution in India. The groundwater in more than half the country's districts is contaminated with poisonous substances.

Groundwater pollution in India caused by excessive extraction relates to fluoride contamination. It has spread to 19 states and in different geographical regions. It occurs when the bedrock weathers and the fluoride leaches into the water and soil. The extraction of groundwater leads to topping of aquifers with high fluoride concentrations. The central ground water board has revealed that 276 districts have high levels of fluoride in their groundwater. Fluoride is extremely harmful. It combines with the bones as it has an affinity for calcium

phosphate in bones. Excess intake of fluoride leads to dental fluorosis, skeletal fluorosis or non-skeletal fluorosis.

(c) Minamata: An important lesson about mercury.

The outbreak of Minamata disease took place in Japan in 1956. Methyl mercury was released as wastewater in the bay of Minamata from nearby chemical industries. The organic mercury entered into the tissues of fish which in turn was consumed by the people living in the area. The contaminated fish caused an outbreak of poisoning and affected several people. Mothers who had eaten the fish gave birth to infants with signs of mercury poisoning.

(d) The Chernobyl Nuclear Disaster: A lesson in the technological disaster of human history.

Nuclear fission in the reactor core produces a lot of heat which if not controlled can lead to a meltdown of fuel rods in the reactor core. This meltdown results in the release of large quantities of highly dangerous radioactive materials in the environment with disastrous consequences to humans, plants and animals. In 1986, a catastrophic nuclear accident occurred at the Chernobyl Nuclear power plant in Ukraine. Reactor four of the plant suffered a catastrophic power increase, leading to explosions in its core. This dispersed large quantities of radioactive fuel and core materials into the atmosphere. Two Chernobyl plant workers died on the night of the accident and a further 28 people died within a few weeks as a result of acute radiation poisoning. A total of upto 2000 people eventually died of radiation exposure from the chernobyl accident and many children were born with congenital abnormalities in times to come. The disaster damaged agricultural crops, plants and caused cancer, lung, eye and blood disorders.

(e) Environmental impact of Iceland Volcanic Eruption. In 2010, the volcanic eruption in Iceland affected economic, political and cultural activities in Europe and across the world. There was extensive air traffic disturbance caused by closure of airspace over many countries. The atmospheric dust not only hampers visibility but also harms aircraft engines, forcing them to shut down entirely. Volcanic ash can lower visibility in the upper atmosphere and knock out aircraft engines. Widespread ash from volcanic eruptions increase the earth's "Albedo Effect", cooling the temperature of the lower toposphere while increasing the temperature of the stratosphere.

Volcanic activity is estimated to be responsible for the release of 130 million tonnes of CO_2 into the atmosphere annually. Atmospheric dust from volcanoes can act as a magnet for other pollutants and water vapour, giving rise to atmospheric haze and heavy fog.

(f) Greenhouse gases. A greenhouse gas is a gas in an atmosphere that absorbs and emits radiation within the thermal infra-red range. This process is the fundamental cause of the greenhouse effect.

Much like the glass of a greenhouse, gases in our atmosphere sustain life on Earth by trapping the sun's heat. These gases allow the sun's rays to pass through and warm the earth, but prevent this warmth from escaping our atmosphere into space. The primary greenhouse gases in Earth's atmosphere are water vapour, carbon dioxide, methane, nitrous oxide and ozone. Without greenhouse gases, the average temperature of Earth's surface would be about –18°C (0°F), rather than the present average of 15 °C (59 °F).

The danger lies in the rapid increase of carbon dioxide and other greenhouse gases that intensify greenhouse effect. For thousands of years, the global carbon supply was essentially stable as natural processes removed as much carbon as they released. Modern human activity—burning fossil fuels, deforestation, intensive agriculture—has added huge quantities of carbon dioxide and other greenhouse gases.

(g) *Air Quality Index (AQI).* Air Quality Index is a number used by government to communicate to the public how polluted the air currently is or how polluted it is forecast to become. AQI is an index for reporting daily air quality. It tells you how clean or unhealthy your air is, and what associated health effects might be a concern. AQI focuses on health effects you may experience within a few hours or days after breathing unhealthy air. In India, as in many other countries, the Index is centred around five chief pollutants—Particulate Matter with a diameter less than 10 micrometres (PM10), Particulate Matter with a diameter 2.5 micrometers (PM2.5), Ozone (O_3), Nitrogen Dioxide (NO_2), and Carbon Monoxide (CO). As the AQI increases an increasingly large percentage of the population is likely to experience increasingly severe adverse health effects.

(h) *Bhopal Gas Disaster:*

Dates: 2 Dec 1984 – 3 Dec 1984

Cause: Methyl Isocyanate leak from Union Carbide India Limited storage tank.

Location: Bhopal

Deaths: At least 3,787; over 16,000 claimed

Non-fatal injuries: At least 5,58,125

Location: Madhya Pradesh

The Bhopal Gas disaster or Bhopal Gas tragedy was an industrial accident that occurred on the night of December 3rd, 1984 at a Union Carbide subsidiary pesticide plant in the city of Bhopal, India. A mixture of poisonous gases flooded the city, causing great panic as people woke up with a burning sensation in their lungs. Thousands died immediately from the effects of the gas. It is estimated that about 40 tonnes of methyl isocyante (MIC) gas and other chemicals leaked from the union carbide factory. The cause of the disaster remains under debate. The Indian government and local activists argue that slack management and deferred maintenance created a situation where routine pipe maintenance caused a backflow of water into a MIC tank, triggering the disaster. Union Carbide Corporation (UCC) contends water entered the tank through an act of sabotage.

(i) *Smog.* Smog occurs as a result of smoke particles from industrial plumes mixing with fog. It is caused when air pollution, emissions and fumes combine with fog and sunlight, forming a thick layer of smoke-like film in the atmosphere. According to experts, emissions from industries and vehicles and cutting of trees worsen the phenomenon. It occurs in foggy, cool weather. It is intense early in the morning. Two primary components of smog are SO_2 and particularte matter.