Core Courses

ENVIRONMENTAL STUDIES

Dayalbagh Educational Institute
(Deemed University)
Dayalbagh, Agra-282005

"It is not a big University or big building or larger number of teachers or larger number of departments which raises the status of a University. It is the quality of the work that makes a University great."

Most Revered Dr. M.B. Lal Sahab,
Founder Director, Dayalbagh Educational Institute

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UNIT 1

LESSON 1 INTRODUCTION TO ENVIRONMENT

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1. INTRODUCTION TO ENVIRONMENT

1.0 Objectives

The lesson aims to,

- Outline an introduction to planet Earth and it's evolution
- Provide a basic introduction to the environment
- Identify the environmental issues that threaten planet Earth
- Recognise the importance of Environmental Education and Environmental Science

1.1 Introduction

The Earth is a special place as it is the only place in the entire Universe where life thrives. Humans depend on the resources that Earth provides, whether it is the the air we breathe, the water we drink or the soil that gives us food or the other living creatures that contribute for our healthy survival. However, in the race towards socio-economic development, man has taken these resources for granted. Life can flourish only when there is a harmonious relationship and a balance between the different components in nature. These components comprise the environment. But due to their overuse and misuse, this balance has become skewed. It has led to various detrimental changes and their effects, unfortunately, have become visible. Global warming and climate change was a calamity waiting to happen. And now, it is happening! The natural calamities like unexpected flooding, forest fires, hurricanes, storms etc between 2019 and 2021 are proof enough.

This problem needs to be addressed on an urgent basis. This is only the tip of the iceberg that we are facing now, and the consequences that our future generations will face are unimaginable. Hence, it is important to create awareness among students and sensitise them to the environment and the various environmental challenges. Environmental Studies is knowing what constitutes the environment, its components, their interactions, and ways to establish a harmonious and long term relation in a sustained way where none is harmed. The study of physical components, natural resources, biodiversity, ecosystems, their protection and judicious use, all come under the purview of environmental studies.

It is heartening to know that young school children are aware of the gravity of the situation. Children across various continents hold demonstrations to seek a better and cleaner environment for the future. India too has its young eco- warriors. To name a few, Licypriya Kangujam, a 9 year old climate activist and recipient of the World Children Peace Prize 2019 from Manipur has been campaigning for laws to

curb the high pollution levels of India, and make climate-change literacy compulsory in schools. She even addressed world leaders at the United Nations Climate Change Conference 2019 in Madrid.

https://www.flickr.com/photos/unfccc/49214056863

Fig.1.0 Licypriya Kangujam at the COP25 Summit

This course would not only help students understand the basics and theoretical principles involved in environmental studies, but would help them analyse the dire environmental issues and their disastrous implications, through real case studies. The endeavour is to help students become responsible ecological citizens of the future.

1.2 Planet Earth

Earth is one of the nine planets in the Solar System with the Sun as the star at its center. It is well known that there are billions and trillions of stars out there in the Universe and associated with the stars are their respective planets just like our Earth. Yet, we cannot find life on other planetary bodies, or even on neighbors, Mars or Moon.

Fig.1.1 The unique and special planet Earth

So, what makes Earth so special that we have never found any other planet that can support life systems? Not even in the WHOLE UNIVERSE? Are there more planets

like Earth with life on them? And if we do have to look for life on other planets, what are the parameters we should set? Answers to these can be found if we ponder enough and appreciate the Earth and its uniqueness.

1.2.1 The Earth is born

It is thought that Earth was initially a giant space rock which was hit by another space rock which lead to formation of what we now know as Moon (Earth's natural satellite) and our planet EARTH.

It took billions of years for the strong cold upper part of Earth to form, and the conditions were, fortunately, very favorable,

a) to form **water**
b) and trap natural **air** in its few kilometers above surface
c) and strong cold upper part of Earth which is the **land**
d) and the **magnetic field** of Earth (called the **Magnetosphere**)

And finally, with all the above systems in place,

e) evolved the **living organisms** which includes all the plants, animals big and small

Refer to the video https://www.youtube.com/watch?v=JGXi9AVc to know about the planet Earth and how it came into existence.

1.2.2 Evolution of life

Early forms of life evolved in the water/oceans and were called **prokaryotes** (single cell organisms). These slowly evolved to form complex organisms and led to slow evolution of living organisms by harnessing the power of sunlight (through photosynthesis) and oxygenated the air. The next part of evolution involved organisms moving to the land and evolution of walking animals.

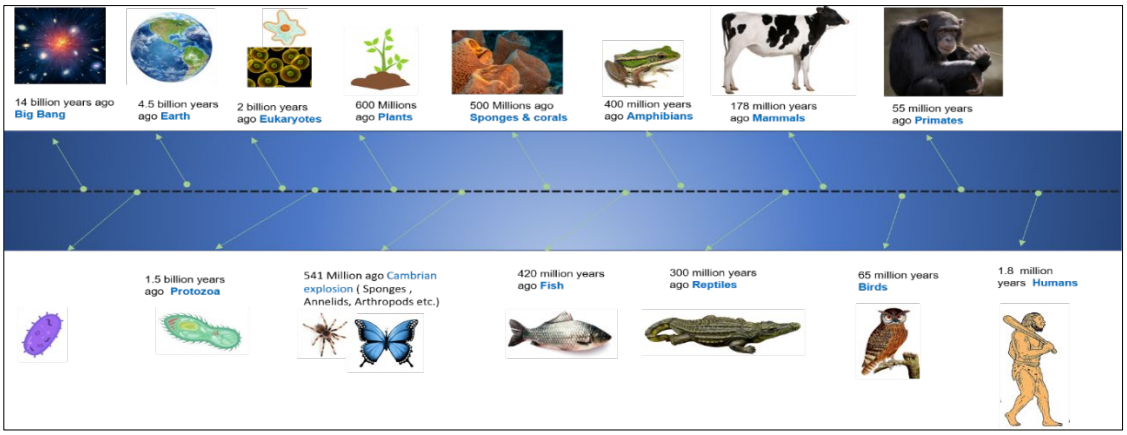


Fig. 1.2 Evolution of Life on Planet Earth

Watch the cosmic calendar video; https://www.youtube.com/watch?v=Bl-s4tqR8Bc to understand these events that led to life on Earth.

Along with formation of favorable conditions for creation of life, Earth has also witnessed many **extinction events**. Scientists consider 5 major extinction events that destroyed majority of life on Earth and brought a significant change in biodiversity on Earth along with many minor extinction events that changed life over regional scale (or on continental scale). These extinction events occurred due to natural causes like plate tectonics or volcanic events or asteroid collision with Earth (e.g. the Chicxulub Asteroid impact).

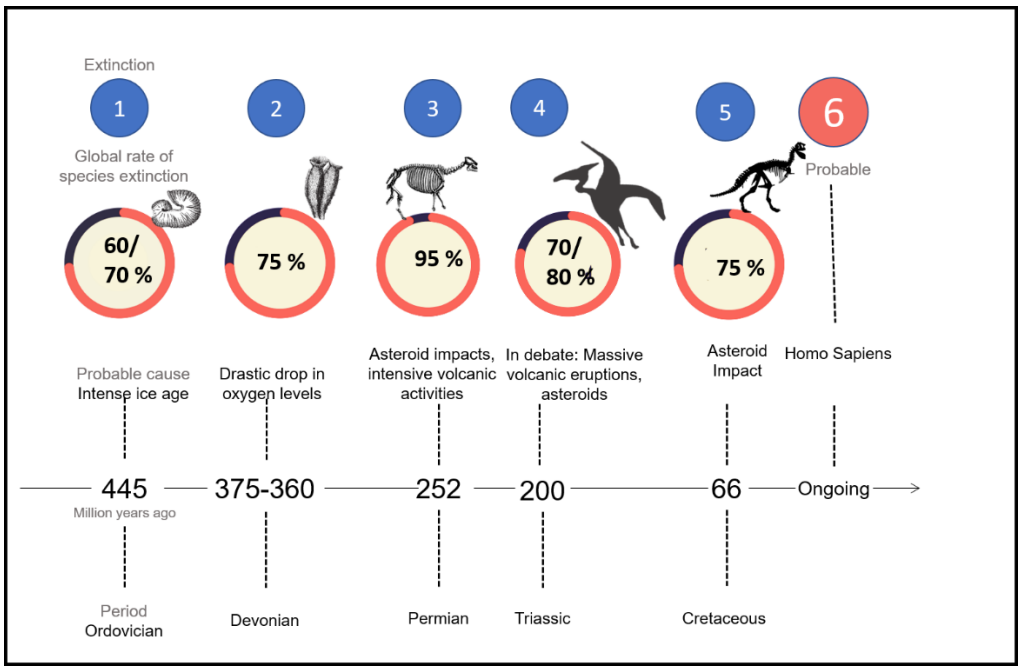


Fig. 1.3 Extinction Events on Earth

1.3 Environment

1.3.1 Realms of the Environment

The dictionary meaning of environment is 'surroundings of man, plant, animal, microbe in which they live and work'. But the Earth's environment is made of various components or realms. We just learnt that how conditions had become favourable on Earth to form air, water, land, living organisms and its magnetic field. These components became the **Earth's Environment.** The air formed the **atmosphere**, the water formed the **hydrosphere**, the land, the **lithosphere**, the magnetic field, the **magnetosphere**, and all living organisms, the **biosphere**. Thus, the Earth's environment is the system consisting of these realms along with the interactions between them. The natural environment or natural world encompasses all living and non-living things occurring naturally, meaning in this case, not artificial. This environment encompasses the interaction of all living species, climate, weather and natural resources that affect human survival and economic activity.

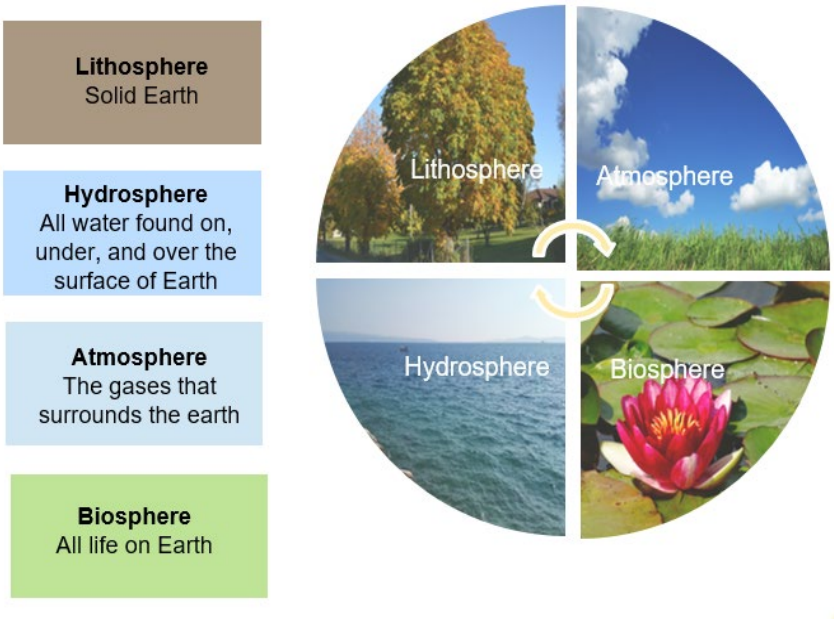


Fig. 1.4 Planet Earth and its Different Realms

1.3.2 Why Life Thrives on Planet Earth?

The integrated effect of all these realms is what makes life possible on Earth. Having air with sufficient oxygen, access to water, the strong lithosphere that we can stand on, the atmosphere for filtering out harmful rays and magnetosphere for protecting us from the influence of cosmic and other magnetic effects, makes the Earth's environment rich and suitable for life.

So, to address the question that came up at the start of the chapter, what makes the Earth special? The **Earth** is special because it **has all the necessary resources in place for a thriving life**. As we see, in the case of Earth, all these realms are important and play their respective roles. If there was even one realm missing, it would have been tough for living organisms to survive this long. Again, it's important to note that all the realms working together enabled life to evolve on Earth, which unfortunately was not the case for say, Mars. Hence, it is a tightly knit interdependent system of interactions between the realms that made life possible. **With a small disturbance in one of the realms, it will have serious impacts on other realms of the environment and a potential to destroy entire systems.**

1.3.3 Position of Man in the Environment

Though humans are the most recent entrants on planet Earth, they seem to occupy the central position in the Environment. Due to their gift of intelligence, humans have gradually gained control as much as they can on the other realms and have ended up exploiting the resources responsible for life on Earth. We are on the verge of destroying the delicate balance between the components of the environment to a point of no return.

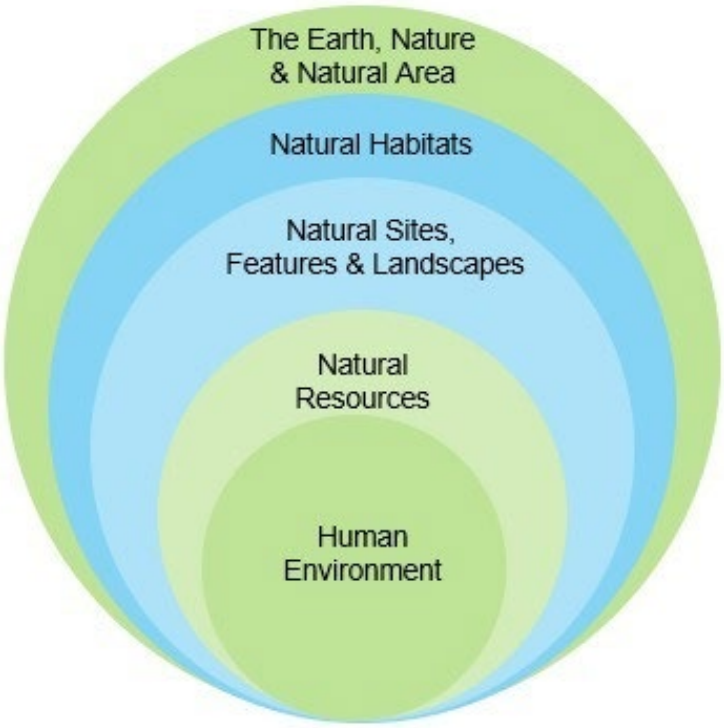


Fig. 1.5 Levels of Interactions for Humans to Survive
Adapted from https://www.iucn.org/news/commission-environmental-economic-and-social-policy/202003/redefining-concepts-around-natural-resources-and-environment

1.4 Environmental Issues

At present, a great number of environment issues have grown in size and complexity day by day, threatening the survival of mankind on Earth. In the last few decades, with booming population and increased prosperity, mankind has brought about massive environmental destruction to meet his socio-economic needs. Scientists think that continuous exploitation of environment for the natural resources may well reach a “tipping point” beyond which the environment cannot heal itself anymore and will result in irreversible damage to the environment. So, it is of vital importance for mankind to scientifically understand not just the various components of environment (realms) but also their complex web of interactions, as we have only one Earth and it is the only planet that we know can support life. We cannot fail this environment. The consequences to indiscriminate use of the environment was expected, but now it is happening. Large-scale and abrupt changes in environment have triggered extreme climate events. The destruction may reach a point that is irreversible and uncontrollable.

1.4.1 Impact of Man on the Environment

Research indicates that evidence about the cascading changes in biosphere caused by human activities are triggering a risk across a range of ecosystems.

Fig. 1.6 Impact of Humans on Planet Earth

1) Global warming in general is causing increased temperature in oceans and has led to loss of half the shallow water corals of the Australia's Great Barrier Reef. 99% of the tropical corals are expected to be lost if global temperature rises by 2°C, owing to interactions between global warming, ocean acidification and pollution.
2) Arctic Ice is at its minimum from as of 1980. It is observed that Arctic warming is at twice the global average and ice is melting at a record rate, resulting in large scale insect disturbances and increase in fires, as evidenced by forest fires across the globe. This warming is also causing an irreversible thaw in permafrost across the Arctic that can release trapped CO_2 and methane (a greenhouse gas that is around 30 times more potent than CO_2) over a 100-year period. Greenhouse gases are responsible for global warming and this will increase their concentration in atmosphere resulting in more global warming and more dramatic climate change effects.
3) Global warming has led to an increase in the melting in Arctic and Antarctica ice shelves and glaciers, leading to an increase in sea levels globally. The global mean sea level (GMSL) has increased in the range of 21-24 cm since 1880. According to the IPCC report, the GMSL rise was 1.4 mm/ year from 1901 to 1990, rose to 2.1mm/ year from 1970-2015, to 3.2mm/year between 1993 and 2015, to finally 3.6mm/year between 2006 and 2015. Thus, the rate at which it is accelerating, it will finally lead to partial submerging and flooding in the coastal cities globally, by 2050.
4) It is observed that extreme weather events are occurring more frequently with higher severity. Extreme heat waves, droughts, severe flooding, hurricanes, forest fires, thunderstorms and lightning have become much more common in the last decade affecting almost all countries.

1.4.2 Holocene Extinction

Along with formation of favorable conditions for creation of life, Earth has also witnessed many **extinction events.** Scientists consider 5 major extinction events that

destroyed majority of life on earth and brought a significant change in biodiversity on Earth along with many minor extinction events that changed life over regional scale (or on continental scale). These extinction events occurred due to natural causes like plate tectonics or volcanic events or asteroid collision with Earth (e.g. Chicxulub Asteroid impact).

Scientific evidence suggests that we are in the **sixth great extinction event** (called ***Holocene extinction***). The massive biodiversity loss is estimated to be about 1000 times more than average (background) extinction rates and the extinction rate has increased multiple times since 1980. The 2019 global biodiversity assessment by IPBES asserts that out of an estimated 8 million species, 1 million plant and animal species are currently threatened with extinction. The mass extinction is a result of human activity, driven by population growth and overconsumption of the Earth's natural resources.

1.4.3 Major environmental disasters

While there are many environmental disasters in every country, we take a look at some of the major environmental disasters that resulted in (or still ongoing) loss of biodiversity and life.

Environmental disasters generally fall into two categories.

Natural Disasters

Some disasters are caused by **natural climate** or **weather events**. These include wild fires, landslides, floods, earthquakes, droughts, tornadoes, tsunamis, and volcanic eruptions. Even though the causes of these natural environmental disasters do not involve human activities, in some cases the effects are worsened by the influence of people. For example, because of coastal construction, damage to mangroves and coral reefs, the effect and damage of Indian Ocean Tsunami 2004 was more severe and resulted in major loss of life and property.

Man-made Disasters

The second category of environmental disasters are **man-made**. Examples of human induced environmental disasters include oil spills, chemical spills, and nuclear incidents. In many cases, man-made environmental disasters have longer lasting effects on the environment than catastrophes brought on by natural events. For example, the enormous oil spill that occurred when the Exxon Valdez supertanker ran aground in Prince William Sound in 1989 continues to have major environmental repercussions. The nuclear accident in Chernobyl in 1986 made an area 4,143 square km still uninhabitable around the nuclear plant in Ukraine. Bhopal in India is still reeling under the aftermath of the Bhopal Gas Tragedy due to a chemical gas leak on the fateful night of 2-3 December. Even after 35 years, the generations being born have birth defects and nearly a million of survivors still suffering the side effects of inhaling the poisonous gas like lung cancer, kidney, liver failures, eye disorders etc. Can you imagine the mental state of these people as their generations and generations continue to be not normal?

Read this article to know the gory details of the after effects of the Bhopal Gas Tragedy

https://www.firstpost.com/india/a-new-generation-inherits-poisoned-genes-of-bhopal-gas-tragedy-and-the-broken-promises-of-govts-too-6146901.html

Watch the video to know about the most disastrous man made calamities

https://www.youtube.com/watch?v=PVXgrgiJjFM

1.4.4 Interconnected Risks

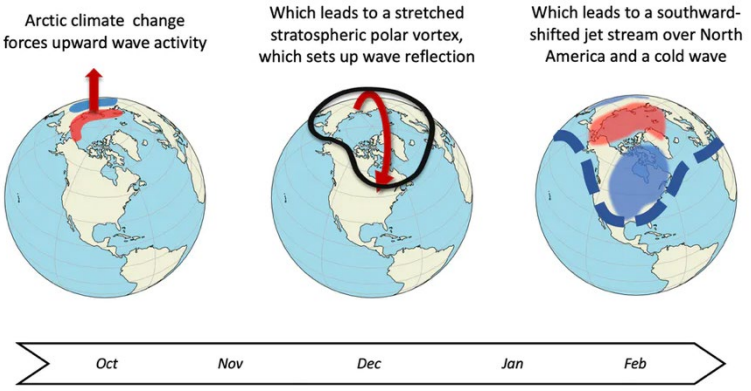
A new report, Interconnected Disaster Risks 2020/2021, released recently by the United Nations University – Institute for Environment and Human Security (UNU-EHS) helps us understand how recent environmental disasters are interconnected to each other. The report (O'Connor et al., 2021) analyses 10 environmental disasters in 2020-21 that occurred in vastly different locations. Even though they appear to have much in common, they are thought to be interconnected with each other.

One of the key findings of the recent IPCC 6th Assessment Report is that the extreme events, such as droughts, forest fires and floods are increasingly compounding each other. The extreme events are observed mostly as a consequence of human influence

on environment. This new report shows in detail how not only climate disasters, but human-made disasters in general build on the impacts of the past and pave the way for future environmental disasters.

Heat wave in Arctic and Cold wave in Texas

An example of this is the recent heat wave in the Arctic and cold wave in Texas. In 2020, the Arctic (near North Pole) experienced the second-highest air temperature and second-lowest amount of sea ice cover on record because of global warming. The increasing temperature in the Arctic destabilizes the polar vortex, a spinning mass of cold air above the North Pole, allowing colder air to move southward into North America. Thus, changes at the north pole of Earth is found to influence locations far away from the Arctic and likely also contributed to the below-freezing temperatures in Texas, a state that is used to warm weather all around the year. Around 4 million people were without electricity as the power grid froze up, and 210 people died.



https://theconversation.com/how-arctic-warming-can-trigger-extreme-cold-waves-like-the-texas-freeze-a-new-study-makes-the-connection-16655

Fig. 1.7 Mechanism of Heat Wave in Arctic and Cold Wave in Texas

The case of cyclone "Amphan"

The Sundarbans in West Bengal, is a delta region characterized by one of the largest mangrove forests in the world that supports rich biodiversity and acts as a shield from extreme weather like floods and cyclones. It provides livelihood to millions of people, almost 50% of whom are under the poverty line. The recent disaster, Cyclone Amphan in Sundarbans occurred simultaneously with COVID-19 pandemic and compounded each other. The COVID-19 pandemic and subsequent lockdowns left many people without income options. Migrant workers who were forced to return to their homes were housed in cyclone shelters while under quarantine. When the region was hit by Cyclone "Amphan", many people, concerned over social distancing, hygiene and privacy, avoided going to cyclone shelters and spread out to insecure locations. Health centers were destroyed and COVID-19 cases spiked in some areas. "Amphan" itself caused over 100 fatalities, damages in excess of 13 billion USD and displaced 4.9 million people.

Fig. 1.8 Relief Work during Amphan Cyclone, May 2020

1.5 The Indian Context

India is a developing country where 41% of workforce is engaged in agriculture and associated industries. India has an extensive coastline and a majority of that population depends on an entire ocean resources system for their livelihood. It also has a major human-made economic infrastructure in marine, maritime, and onshore coastal zones. As such, there is an increasing threat of climate change on the socio-economic fabric of the nation. From depending on monsoons for agriculture, to major coastal cities that are trading and economic hubs, it is vital for the Indian government and citizens alike to preserve the environment and try and insulate themselves from climate extremities. Or at the very least work towards mitigating those effects.

Fig. 1.9 Delhi's Famous Smog of Winters

Air pollution in India, is expected to reduce life expectancy by 8-9 years and has resulted in a significant rise in respiratory problems in majority of the people. According to IQAir, Indian cities figure in top 50 of the world's most polluted cities in terms of PM 2.5 data from ground-based air pollution measurements. (https://www.iqair.com/world-

most-polluted-cities). New Delhi has been recorded as the world's most polluted capital from 2019 to 2021. Over 50 % of this pollution comes from industry and thermal power plants, followed by 27 % from vehicles, 17 % from crop burning and 7 % from domestic cooking. Over 2 million Indians lose their lives to causes attributed to air pollution. Some scientific reports suggest that pollution levels in North India are 10 times worse than those found anywhere else in the world.

Fig. 1.10 Unsustainable Industries Causing Localized Droughts

Similarly, around 70% of India's water is severely polluted because raw sewage, silt and garbage is dumped into the country's rivers and lakes. This leads to undrinkable water and the populace thus has to rely on illegal, and expensive, sources. Each year, more than 1.5 million Indian children die from diarrhea. Underground water, the main source of water in many regions, is decreasing at an alarming rate across the country. Research reveals that chemicals such as arsenic have increased in groundwater sources, which could potentially result in rising cases of neurological and cardiovascular disease. The state of Bihar, in particular, saw more than one million people die from groundwater poisoning, which was found to be contaminated with arsenic.

Soil sample analysis from six major cities including New Delhi and Mumbai, and state of Goa indicate that the average concentration of polychlorinated biphenyls (PCBs) in Indian soil is almost twice the amount found globally. PCBs are synthetic organic chemicals used in electrical equipment, adhesives, paints, plastics and several other products. With growing industrialization and economic reforms that encourage manufacturing electrical, chemical equipment along with lack of policy, management and law enforcement in dumping of waste from these sectors pose a serious problem to soil contamination. Soil resources are facing threats from deliberate use of contaminated organics, amendment materials and irrigation water or from spillage of effluents etc.

In April 2016, India brought in a policy under which manufacturing and importing polychlorinated biphenyls (PCBs) will be banned after December 31, 2025. Informal
e-waste recycling process is an emerging and growing problem. Besides, proper waste

disposal, open burning of dumped waste should be stopped. Not only PCBs, but several other organic pollutants can be released due to incomplete combustion of waste, particularly plastics, e-waste and biomedical waste. In the rural context, the main factors of soil pollution are the high state of soil erosion, excessive use of chemical fertilizers, biocides (pesticides, insecticides and herbicides), polluted liquids and solids from industrial areas, forest fires, water-logging and related capillary processes, leaching, drought, etc.

1.6 Environmental Education

There is an increasing realization that with the current trends in our lifestyle and demand for more resources, there is a serious threat to environment that affects livelihood and economic status of nations going forward. Therefore, it is essential, especially for developing countries, to find alternative paths to an alternative goal. We need a goal ultimately of an environmentally sound and sustainable development. And ideally it should be the common goal of all citizens of our Earth. To achieve this goal, it is important to understand the problem from various perspectives including ecological, economic, cultural, social, political perspectives. Moreover, it requires deep understanding and a creative problem solving approach.

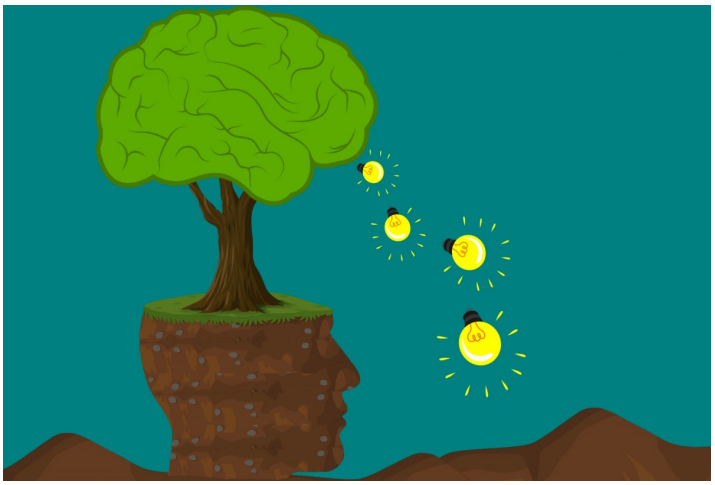


Fig. 1.11 Environmental Solutions: The Need of the Hour

Environmental education equips students with the awareness and sensitivity to the environment and environmental challenges. Environmental education does not advocate a particular viewpoint or course of action. Rather, the aim is to provide enough knowledge and case studies about the environment that enables individuals to weigh various sides of an issue through critical thinking to enhance their own problem-solving and decision-making skills. It is important for students to be ready with knowledge, skills, and motivation to address complex environmental challenges in the 21st Century. It should motivate youth to participate more in activities that may lead to the resolution of environmental challenges.

1.6.1 Environmental Science

So, what is Environmental Science?

Environmental science is an interdisciplinary academic field that integrates physical, biological and information sciences, including ecology, biology, physics, chemistry, plant science, zoology, mineralogy, oceanography, limnology, soil science, geology and physical geography, and atmospheric science. This aids in the study of the environment, and in finding a resolution to environmental problems. It provides an integrated, quantitative, and interdisciplinary approach to the study of environmental systems.

Environmental studies incorporate more of the social sciences for understanding human relationships, perceptions and policies towards the environment. Environmental engineering focuses on design and technology for improving environmental quality in every aspect.

Environmental scientists study subjects like the understanding of Earth processes, evaluating alternative energy systems, pollution control and mitigation, natural resource management, and the effects of global climate change. Environmental issues almost always include an interaction of physical, chemical, and biological processes. Environmental scientists bring a systems approach to the analysis of environmental problems. Key elements of an effective environmental scientist include the ability to relate space, and time relationships as well as quantitative analysis.

1.7 Earth Observation

"The single location where we can learn the most about our planet is found nowhere on Earth but high up above it." – European Space Agency

Earth's environment encompasses the whole globe and likewise many natural processes in the atmosphere or biosphere also occur on global scales. While local studies at city or region or country scale provides an understanding of the local weather or climate or environment, most of the time these are affected by events occurring on regional and global scale.

Observing the planet Earth from space provided a better vantage point to understand, monitor and understand a lot of environmental processes. Earth observation began shortly after the invention of photography. In 1858, a person named Gaspard Felix Tournachon captured the first recorded aerial photograph from a balloon. He quickly realized the potential his images could have, offering his services to the French military. Shortly after, balloon photography and mounted pigeon cameras to take aerial pictures of surface of earth became famous. With the invention of the airplane, aerial photography became common place.

Fig. 1.12 Earth Observation Satellites

The next major development is the development of rockets and in 1957, launch of an artificial satellite Sputnik 1 changed Earth observation forever. TIROS (Television Infrared Observation Satellite) was NASA's first programme to test the viability of satellites for Earth observation, to help make decisions on the ground. TIROS programme produced the first accurate weather forecasts based on satellite data and began providing continuous coverage of Earth's weather. Data from Earth Observation (EO) satellites has also enabled us to see how the human activity is changing the surface of Earth. According to the Union of Concerned Scientists (UCS), there are over 700 Earth observation satellites are in orbit in 2019. They are an important scientific tool with a wide range of applications in areas such as:

- Weather forecasting
- Wildlife conservation
- Agriculture
- Resource management
- Natural disaster response
- Climate science

Earth Observation satellites provided a new perspective to understand Earth's environment. EO satellites not only accelerated our understanding of environment over global scales but also helped in international collaborations in observing and monitoring natural processes.

1.7.1 Earth Observation: India

India is a leader in launching and maintaining Earth observing or remote sensing satellites.

Fig. 1.13 Indian Earth Observation Satellites

Starting with IRS-1A in 1988, ISRO has launched many operational remote sensing satellites today. India has one of the largest constellations of remote sensing satellites in operation. Currently, **thirteen** operational satellites are in Sun-synchronous orbit – RESOURCESAT-1, 2, 2A CARTOSAT-1, 2, 2A, 2B, RISAT-1 and 2, OCEANSAT-2, Megha-Tropiques, SARAL and SCATSAT-1, and **four** in Geostationary orbit- INSAT-3D, Kalpana & INSAT 3A, INSAT -3DR. A range of scientific instruments are onboard these satellites to provide necessary data in a diversified spatial, spectral and temporal resolutions to cater to different user requirements in the country and for global usage. The data from these satellites are used for several applications covering agriculture, water resources, urban planning, rural development, mineral prospecting, environment, forestry, ocean resources and disaster management and decision making in India as well as South Asia.

1.8 Summary

Planet Earth is unique and special and life thrives on it due to the presence and balance of various realms of the environment viz. atmosphere, lithosphere, hydrosphere, biosphere and magnetosphere. Earth offers a protective and resourceful environment it provides for humankind to exist comfortably. However, we exploit the natural

resources provided by Earth's environment for our economic and social wellbeing. But with increased demand for more natural resources because of population explosion and changing lifestyle of mankind, there is greater stress on the environment to replenish natural resources at the same rate. This has resulted in an imbalance, destruction and collapse of various interdependent systems, threatening the life of all organisms including humans, and the loss of livelihood sources. The human impact has become starkly visible in the form of various natural calamities frequently and all over the globe. Given, the Earth environment is complex from microscopic scale to global scale, it had become more crucial to understand, monitor and manage the environment and the natural resources it provides. Thus, the importance of environmental sciences and environmental education has to take precedence especially for the future generation.

1.9 Self-Check Questions

1) Fill in the blanks

1. ……....., a 9 year old climate activists is recipient of the World Children Peace Prize 2019 from Manipur has been fighting for laws to curb the high pollution levels of India and make climate change literacy compulsory in schools.
2. The Earth has witnessed ..... major and many minor extinction events
3. Scientific evidence suggests that we are in the sixth great extinction event called **……..**
4. Environmental Disasters can be ..... and .....
5. A cold wave in warm Texas and heating of Arctic is an example of .....

2) Match the following

a)	**Hydrosphere**	1)	the living organisms which includes all the plants, animals big and small
b)	**Atmosphere**	2)	strong cold upper part of Earth
c)	**Lithosphere**	3)	trap natural air in its few kilometers above surface
d)	**Magnetosphere**	4)	Our surroundings
e)	**Biosphere**	5)	water on earth's surface
		6)	the magnetic field of earth

3) Multiple Choice Questions

1. Name the earth's natural satellite.
   a) Saturn

b) Venus
c) Moon
d) Pluto

2. Single celled organism that are considered as early form of life are known as
   a) Eukaryotes
   b) Prokaryotes
   c) Virus
   d) Elements

3. The most recent species on the Earth is
   a) Birds
   b) Mammals
   c) Primates
   d) Humans

4. What is a major cause of environmental destruction?
   a) Growing green cover
   b) Growing population
   c) Agriculture
   d) Diversity of Flora and Fauna

5. What are the adverse effects of Global Warming?
   a) increase in the melting in Arctic and Antarctica ice shelves
   b) extreme weather events like heat waves, droughts, severe flooding, hurricanes, forest fires etc.
   c) destruction of coral reefs
   d) All of the above

4) State whether True or False

1. Life on Earth thrives due to the balance, interaction and contribution of each realm.
2. Environmental education equips students with the awareness and sensitivity to the environment and environmental challenges.
3. Major Indian population is dependent on agricultures and ocean resources.
4. The amount of Poly Chlorinated Biphenyls (PCBs) is twice the global level in Indian soils.
5. New Delhi is the world's most polluted capital.

5) Briefly describe the environment crisis in India.

1.10 Answers to Self-Check Questions

1) Fill in the blanks

1. **Licypriya Kangujam** a 9 year old climate activists is recipient of the World Children Peace Prize 2019 from Manipur has been fighting for laws to curb the high pollution levels of India and make climate change literacy compulsory in schools..
2. The Earth has witnessed **5** major and many minor extinction events
3. Scientific evidence suggests that we are in the **sixth great extinction event** called ***Holocene extinction***
4. Environmental Disasters can be **Natural** and **Man-Made**
5. A cold wave in warm Texas and heating of Arctic is an example of **Interconnected Risks**

2) Match the following

1. **Hydrosphere**	5. water on earth's surface
2. **Atmosphere**	3. trap natural air in its few kilometers above surface
3. **Lithosphere**	2. strong cold upper part of Earth
4. **Magnetosphere**	6. the magnetic field of earth and finally
5. **Biosphere**	1. the living organisms which includes all the plants, animals big and small

3) Multiple Choice Questions

1. Name the earth's natural satellite.
   a) Saturn
   b) Venus
   c) Moon
   d) Pluto

2. Single celled organism that are considered as early form of life are known as
   a) Eukaryotes
   b) Prokaryotes
   c) Virus
   d) Elements

3. The most recent species on the Earth is
   a) Birds

b) Mammals
c) Primates
d) Humans

4. What is a major cause of environmental destruction?
   a) Growing green cover
   b) Growing population
   c) Agriculture
   d) Diversity of Flora and Fauna

5. What are the adverse effects of Global Warming?
   a) increase in the melting in Arctic and Antarctica ice shelves
   b) extreme weather events like heat waves, droughts, severe flooding, hurricanes, forest fires etc
   c) destruction of coral reefs
   d) All of the above

4) State True or False

1. Environmental education equips students with the awareness and sensitivity to the environment and environmental challenges. **True**
2. Major Indian population is dependent on agricultures and ocean resources. **True**
3. The global mean sea level (GMSL) has decreased due to global warming. **False**
4. The amount of Poly Chlorinated Biphenyls (PCBs) is twice the global level in Indian soils. **True**
5. New Delhi is the world's least polluted capital. **False**

1.11 Case Study Based Question: The Strange Cyclone Gulab

You have studied about the interconnected risks, where Texas had a cold wave due to melting of Arctic ice miles away. Did you know, that the Cyclone Gulab that hit India on 26th September, 2021, was also a consequence of melting of Arctic ice?

Watch this short video https://youtu.be/tVQVVZJtUOw to learn about it.

Answer the following questions after seeing the video carefully.

1) State whether the statements are true or false

1. India has a monsoon season but no cyclone season.
2. For the first time in 40 years, a cyclone crossed the Bay of Bengal in the east to the Arabian Sea in the west of India.
3. The cause of rainfall in September 2021 in India is the melting of Arctic ice.
4. As the moisture in the air increases, the speed of cyclones decreases.
5. Climate change has no role in increasing the intensity and frequency of subtropical cyclones.

2) Choose the correct option

1. What is so unique about cyclone Gulab?
    a. It has arrived early and devastated the Bay of Bengal coast.
    b. It has arrived on time but crossed from the Bay of Bengal to the Arabian Sea.
    c. It has arrived early and crossed the Bay of Bengal to the Arabian Sea.
    d. It arrived early and devastated the Arabian Sea coast.

2. The cyclone season of India is
    a. March to April
    b. June to July
    c. September to October
    d. October to November

3. Cyclone Gulab was caused due to
    a. Melting of Arctic ice
    b. High sea level pressure over Western Europe and North Eastern China
    c. Moving of planetary waves South-eastwards instead of Eastwards
    d. All the above

4. September cyclones are generally weak because of
    a. Low sea surface temperature
    b. Warm sea temperature
    c. More moisture in air
    d. Strong Southwesterly winds

5. Cyclone Gulab made its landfall on September 26, 2021,
    a. Bhubaneswar, Orissa
    b. Kutch, Gujarat
    c. Thiruvananthapuram, Kerala
    d. Kalingapatnam, Andhra Pradesh

1.12 Case Study Question Answers

1) State whether the statements are true or false

1. India has a monsoon season but no cyclone season. **False**
2. For the first time in 40 years, a cyclone crossed the Bay of Bengal in the east to the Arabian Sea in the west of India. **True**
3. The cause of rainfall in September 2021 in India is the melting of Arctic ice. **True**
4. As the moisture in the air increases, the speed of cyclones decreases. **False**
5. Climate change has no role in increasing the intensity and frequency of subtropical cyclones. **False**

2) Choose the correct option

1. What is so unique about cyclone Gulab?
    a. It has arrived early and devastated the Bay of Bengal coast.
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- *What is so strange about Cyclone Gulaab?* (2021, September 30). [Video]. YouTube. https://youtu.be/tVQVVZJtUOw (Case Study Question)

1.14 Suggested Videos and Readings

- *Bhopal Gas Tragedy. (2019). Firstpost.Com. https://www.firstpost.com/india/a-new-generation-inherits-poisoned-genes-of-bhopal-gas-tragedy-and-the-broken-promises-of-govts-too-6146901.html*
- *Chronology of 25 major events in the history of Earth. (2015). Bbc.Om. http://www.bbc.com/earth/bespoke/story/20150123-earths-25-biggest-turning-points/*
- *David Attenborough: A Life on Our Planet. (2020, October 4). [Video]. YouTube. https://www.youtube.com/watch?v=64R2MYUt394, Duration 2 minutes)*
- *Everything You Need to Know About Planet Earth. (2014). Youtube.Com. https://www.youtube.com/watch?v=JGXi_9A__Vc_(Duration 7:45 minutes)*
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1.15 Glossary

- **Atmosphere**: The envelope of air that surrounds the Earth's surface.
- **Air:** The mixture of gases that makes the atmosphere.
- **Anthropogenic sources**: involving, connected to, or resulting from human influence on nature.
- **Biosphere:** The area on, above, and below the Earth's surface where life exists including the atmosphere, on land and in ocean depths.
- **Biodiversity:** Variety of living organisms in an area from minute bacteria to plants, animals etc.
- **Conservation:** Care and preservation of resources so that they can be passed down to future generations.
- **Climate**: Is a region's long-term weather pattern, which is typically averaged over a period of 30 years.
- **Climate Change**: The long-term change of temperature and usual weather patterns in a place.
- **Hydrosphere:** all water on the surface as well as above the surface of the earth surface, such as oceans, seas, rivers lakes, other water bodies and clouds.
- **Environment**: The surroundings of an organism, including climate, soil, other living things and so on
- **Ecology**: Study of organisms and their interactions with their surroundings
- **Ecosystem**: A system that comprises all living species as well as their physical environment in a given area
- **Evolution**: Is the process of progress and change of a species over numerous generations

- **Extinction**: a situation when one species is totally eliminated
- **Global warming**: The long term increase in the Earth's average temperature
- **Greenhouse effect**: trapping of heat in the earth's atmosphere due to presence of carbon dioxide and other greenhouse gases
- **Greenhouse gases**: Gases like CO2, methane, CFC, that are able to trap heat in Earth' atmosphere and cause greenhouse effect
- **Groundwater**: Water present and collected underground in rocks and soils which can naturally emerge on the surface in form of springs and streams or can be accessed by digging bore wells
- **Lithosphere**: Is the crust and solid outermost layer of the upper mantle of the Earth and extends to a depth of around 100 km. It consists of both the crust of the ocean (oceanic lithosphere) and of land (continental lithosphere).
- **Natural resources**: Resources freely available in nature on form of soil, forests, air etc.
- **Plate tectonics**: The theory states that the lithosphere is made of a number of crustal plates, which can collide with, slide under, or move past adjacent plates
- **Prokaryotes**: Single celled micro-organisms
- **Photosynthesis**: The process by which plants make food by absorbing **CO_2** and converting to **glucose** and in turn release **oxygen**.
- **Sustainability**: Satisfying our own demands and needs without endangering future generations' ability to meet their own with respect to resources
- **Unsustainable**: not capable of being maintained or continued for an extended period of time
- **Weather**: Short term conditions of the atmosphere including rain, humidity, temperature of a region

LESSON 2. NATURAL RESOURCES: LAND RESOURCE

TABLE OF CONTENTS:

2. NATURAL RESOURCES: LAND RESOURCE

2.0 Objectives

The lesson aims to

- Introduce the concept of natural resources
- Classify the different natural resources
- Appreciate the resources provided by land, their importance.
- Comprehend the degradation of land resources and their impacts
- Know forest resources, their degradation, consequences and efforts to conserve the forests.

2.1 Introduction

All the components of the environment namely land (lithosphere), air (atmosphere), water (hydrosphere), and living organisms (biosphere) are useful to man in some way or the other. They are freely available in nature for man to use and hence are known as natural resources. There resources can be categorized into different types. In this lesson, you will be learning all about them. The resources have been used extensively by man for his benefits. Some have been exploited beyond means and are on the verge of being non-existent. However, there are some resources that are present in abundance and can be replenished easily but these are not as extensively used. Land is a very important natural resource and includes the soil from where we get our food, land on which our homes, roads, schools etc. are build, forests and minerals and materials found in various kinds of rocks above and beneath the Earth. In this lesson, you will also learn about land and forests as a resource, their uses, their degradation due to overuse and the ways to restore them.

2.2 Natural Resources

A resource is a material or being freely available in the environment or nature that can be used by living organisms. When humans need and value these materials or resources available in nature they are known as **Natural resources.** Natural resources do not require the intervention of humans for their formation or production. They are important because they determine the survival of humans and other life forms on the planet.

Thus, any part of our natural environment, such as water, air, forest, wildlife, marine organisms and land with the minerals – all that man can utilize to support life and make it easier, may be regarded as a natural resource. Man has this special ability to use these resources as such or transform them. In fact, all manmade or artificial objects or materials are made from natural resources at a fundamental level. For

humans, a resource is any form of energy or matter that is required to meet physiological, socio-economic, and cultural needs at individual as well as community level. Any form of energy or matter that fulfills the physiological, socio-economic and cultural needs, of a person, a community and a society as a whole is a natural resource. Though the five main types of natural resources are air, water, land, flora (plants) and animals (fauna) as illustrated in Fig.1, there are many natural resources that man relies on.

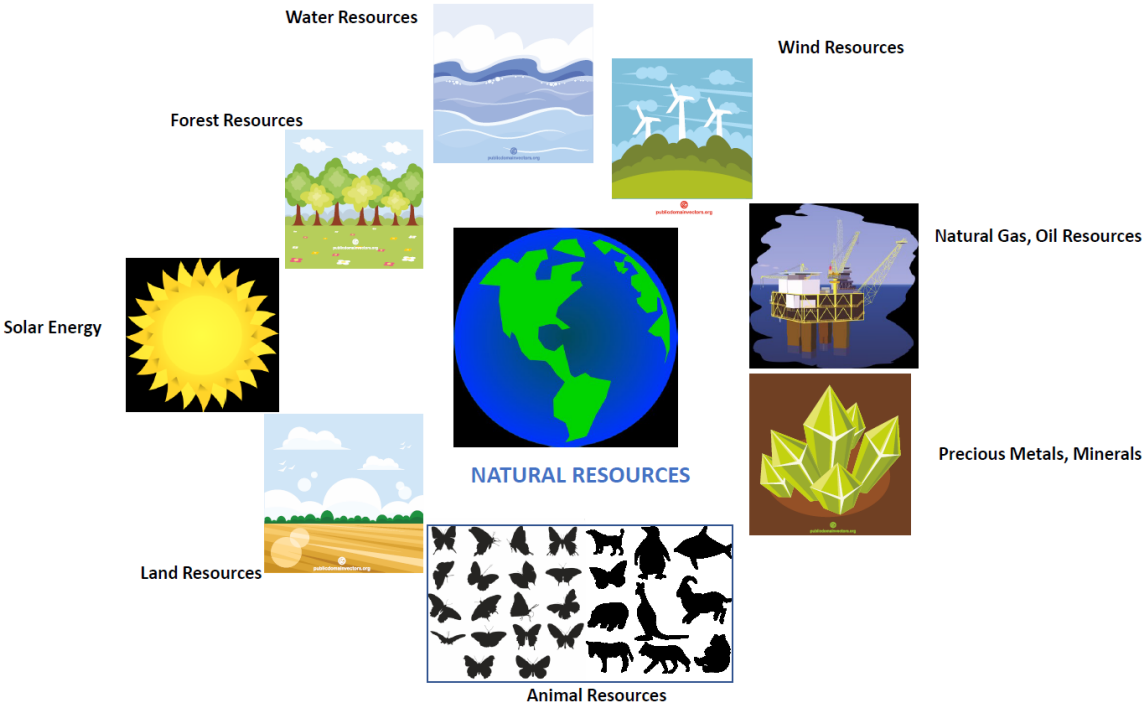


Fig. 2.1 Natural Resources

Some examples of Natural Resources and their use to man include:

1) Air: oxygen, wind energy
2) Water in lakes, rivers, streams, seas and oceans: water, salt, fish, seafood, ocean currents to produce electricity.
3) Land: space to build a house, metals, petrol, minerals etc.
4) Forests: oxygen, keeping the environment cool, timber, paper, medicines etc.
5) Fossil fuel: diesel, petrol, coal etc. to run vehicles, generate electricity, run industries etc.
6) Sunlight: dry clothes, photosynthesis in plants, solar energy

2.2.1 Classification of Natural Resources

The quantity and quality of resources are scattered throughout space. Some resources are finite, while others can be replenished at various rates. Natural

resources can be categorized based on their source of origin or whether they can be renewed, and in many other ways.

A. On the basis of origin:

1) **Biotic** natural resources are those that are obtained from living material like trees, plants, micro-organisms of from organic material which includes decayed plants and animals of many years. Examples include vegetables, fur, coal, petroleum (coal and petroleum are formed from decayed organic matter).

2) **Abiotic** natural resources are those that come from nonliving material Examples include land, air, water, metals like iron, copper, silicon, and salt.

B. On the basis of their recovery rate:

1) **Renewable Resources:** Natural resources are that can be replenished naturally. Renewable resources are those whose rate of replenishment/ recovery surpasses the rate of consumption from a human-use perspective.

Examples:

a. **Solar energy** which does not reduce if we use more. **Ocean waves** is another example of natural resource that doesn't reduce with consumption.
b. Imagine taking out a lot of fish out of a pond so that we don't give enough time to enable new fish to be born and grow. Thus, fish population if managed carefully is considered as a renewable resource.

2) **Non-renewable resources:**

These are natural resources that can be replenished, but at an extremely slower rate. This also depends on the rate of consumption. If we don't allow time for replenishment, these otherwise renewable resources will become non-renewable. Although, there are some natural resources that are not renewable in any way.

Examples:

a. Fossil fuels like petroleum, natural gas and coal - they take millions of years for conversion of organic matter to petroleum/coal.
b. Minerals like limestone, granite, calcium, iron have taken thousands of years to form naturally through their geological cycles.
c. Radioactive metals that decay to heavy metals cannot be renewed. They cannot be renewable in any way.
d. Forests are potentially renewable resources. But if utilized indiscriminately, they can become non-renewable, if used for a prolonged period of time, at a rate faster than it is renewed by natural processes.
e. Similarly endangered species of plants and animals as they are at the verge of extinction.

To secure a sustainable future, humanity must balance short-term rates of consumption against long-term availability.

C. On the Basis of Utility

1. Some resources are used as **raw materials**

Examples: Minerals and ores, for instance are used to make metals and extract minerals which are in turn, used to make cars, televisions, computers.

2. Some resources are used as **energy sources**

Examples: Coal, natural gas, oil, diesel, petrol provide sources of energy that is utilised by humans for various activities like driving a car, generating electricity etc.

D. Stock resources

Natural resources that are available in the environment but lack the essential expertise or technology to be used are known as stock natural resources. An example is Hydrogen.

2.2.2 Conventional and Non-Conventional Energy Resources

Natural resources may also be classified into conventional and non-conventional energy resources.

Conventional Energy Sources	Non-conventional Energy Sources
These sources of energy are not abundant and are present in limited quantity. e.g. coal, petroleum, natural gas.	These sources of energy are present abundantly in nature. e.g. solar, wind, tidal energy, biogas etc.
They are not replenished continuously and thus can get exhausted if over-used. They are formed over a million years.	They are replenished continuously by natural processes and hence don't have the risk of getting exhausted.
They are generally non-renewable natural resources	They are generally renewable natural resources
They emit toxic gases and cause pollution of the environment. They also contribute to global warming.	They are eco-friendly and do not cause pollution of the environment.
It is expensive to maintain and use these sources of energy as they have to be transmitted to long distances to use e.g. transportation of petrol from refineries or electricity from coal	It may be a little expensive to install them but they are less expensive to use and maintain as they are used locally. e.g. generating electricity using solar power

These have been used since the past like coal and fire wood and still are more extensively used than non-conventional sources.	These have been introduced recently and are still less extensively used.

If we need to sustain this planet and maintain the balance, it is high time we start replacing the use of conventional sources with non-conventional sources of energy.

2.3 Land Resources

Less than 30% of the surface of Earth is land. And even though it appears as if land is available infinitely, it is in fact, a scarce resource.

Land Resources refer to the physical, biotic environmental components associated with a land unit that are of use for living organisms. Land resources includes natural resources associated with the land - gold, timber, coal, iron ore, uranium, oil, near surface water, soil, air, plants, animals, and the physical land form itself.

Land is used for a variety of purposes as in like agriculture, building homes, malls, schools and airports, railways etc. This is termed as **"Land Use"**.

2.3.1 Soil

Soils are dynamic and diverse natural systems that lie at the interface between Earth, air, water, and life and are essential for the sustenance of all living beings on Earth. Improvement, conservation and management of soil is one of the greatest challenge of the 21st century.

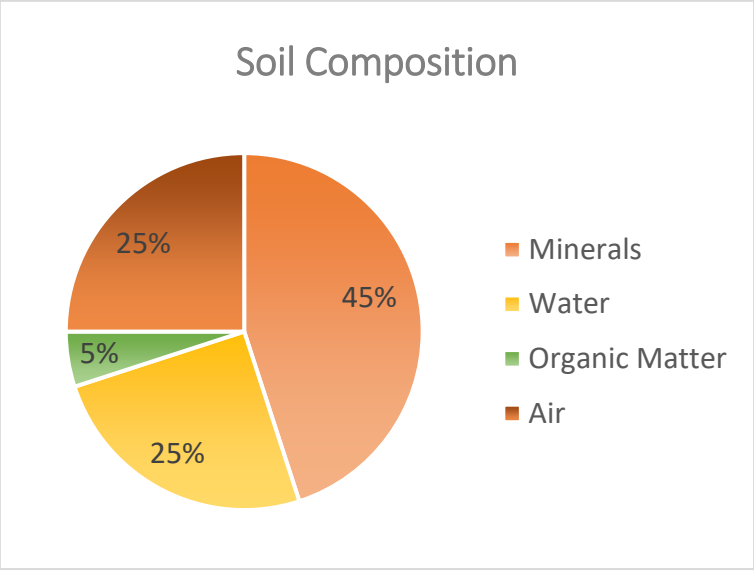


Fig. 2.2 Composition of Soil

Soil is made up of 45% minerals, 25% water, 5% organic matter and 25% air. Plant, animal, and microbial wastes in various stages of decomposition make up soil organic matter. It is a critical ingredient. In fact, the percentage of soil organic matter in a soil is among the best indicators of agricultural soil quality.

Every soil has a profile, or a series of layers (horizons) that descend vertically into the non-soil zone, known as the parent material. Parent materials can be soft rock, glacial drift, windblown sediments, or alluvial materials. The nature of the soil profile is critical in defining a soil's ability to support root growth, water storage, and plant nutrient supply.

Importance of Soil

Soils are fundamental to life. We get food, fibre, fuel and feed for our livestock from soils. They provide the right aeration and conditions for healthy growth of plants. Soils store and cycle essential nutrients and minerals. They are a store house for water and habitat for millions of essential microbes and insects. Most antibiotics that humans use comes from microbes of the soil. According to the USDA, “every 1% increase in organic matter results in as much as 25,000 gallons of available soil water per acre.” and “one teaspoon of healthy soil contains, 100 million-to-1 billion individual bacteria alone.” *(25 Reasons To Be Grateful For Soil: Why Soil Is Important, 2020)*

They are nature’s filters and filter the dust and contaminants from the surface water making underground water the cleanest water. Besides, healthy soils even protect the Earth from climate change. Soils remove nearly 25% of the world's fossil fuel emissions each year, according to Columbia University's Earth Institute. Healthy soils also help to prevent erosion. Healthy soils even protect the land from erosion.

Thus, it is our duty to maintain the health of the soil. It is a non-renewable resource. It takes hundreds to thousands of years to form a centimeter of soil while to lose a single centimeter of soil, it takes just one year of erosion.

2.4 Land Degradation

With increasing human population and associated human needs, the demand for the use of land resources like soil, water, plants and animals is growing multitudinously. Most of the forest land is diverted to agricultural land, or for mining, or townships, i.e., there is a change in land use on a massive scale all around the world. When land resources are continuously exploited without enabling the recovery of the same, the resources deplete and degrade and become a non-renewable resource. Deterioration of quality in urban and rural environment due to injudicious land use has developed into a threat to the whole socio-economic systems across nations.

In an urban setting, unsafe dwelling, flooding and urban heat islands are becoming more of a common feature because of lack of land use planning and mismanagement of environment. Examples include Chennai floods, Mumbai seasonal floods, water shortage in Bengaluru and Chennai.

In a rural setting, excessive agriculture and associated practices like usage of fertilizers, pesticides, insecticides etc. and overexploitation of groundwater has resulted in decreased fertility of land, lack of drinking water, soil erosion, drought, fallow land and loss of livelihood. Examples include Marathwada (Maharashtra), Karnataka

2.4.1 Land Degradation: Causes and Effects

Land is one of the primary natural resources vital to mankind. Land degradation can be defined as the loss of productive capacity of land resulting in loss of biological productivity, ecological integrity or value to humans. Land degradation is a global problem that will lead to food insecurity, increasing food prices, loss of biodiversity, environmental hazards and climate change.

Land degradation is caused by multiple factors, including extreme weather conditions like droughts, floods, cyclones and also significantly by use by humans for agriculture (over-cultivation), livestock production (overgrazing), urbanization and massive deforestation for land and timber .

A repercussion of deforestation, unmindful urbanization and unsustainable agricultural land management has led to a major problem of soil erosion, land degradation and land loss. Besides, land destruction, clearing forest to make farms or buildings, agriculture and other land use activities has resulted in 23% of global greenhouse gas emissions and additionally, Additionally, agriculture, land destruction, and other land-based sources contribute to 44% recent human-driven methane emissions, a strong greenhouse gas.

Globally, 25 % of the total land area has been degraded and has severely affected people's livelihoods. Scientists have recently warned that 24 billion tons of fertile soil is being lost per year, largely due to unsustainable agriculture practices. If this trend continues, 95 % of the Earth's land areas could become degraded by 2050. The pie chart depicts the global state of land degradation (according to the Land degradation SOLAW Background Thematic Report)

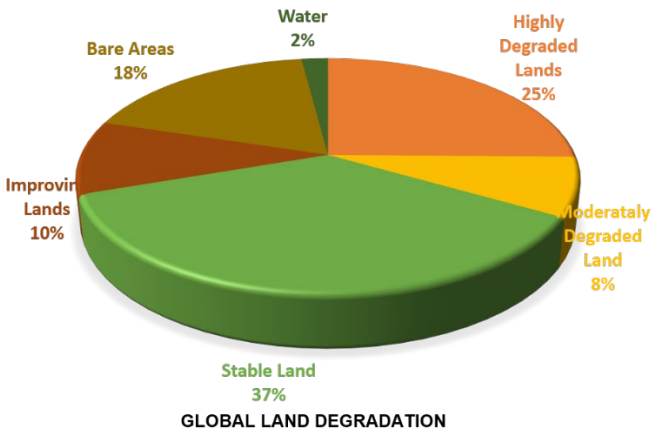


Fig. 2.3 Degradation of Land Globally

Land degradation leads to soil carbon and nitrous oxide being released back into the atmosphere, making it one of the most important contributors to climate change and reduced rates of carbon uptake. Land degradation and climate change, both individually and in combination, have profound implications for natural resource-based livelihood systems and societal groups.

The figure gives a glimpse of the various processes that lead to land degradation, the causes, effects and few steps to reverse it. Let us learn more about them in detail.

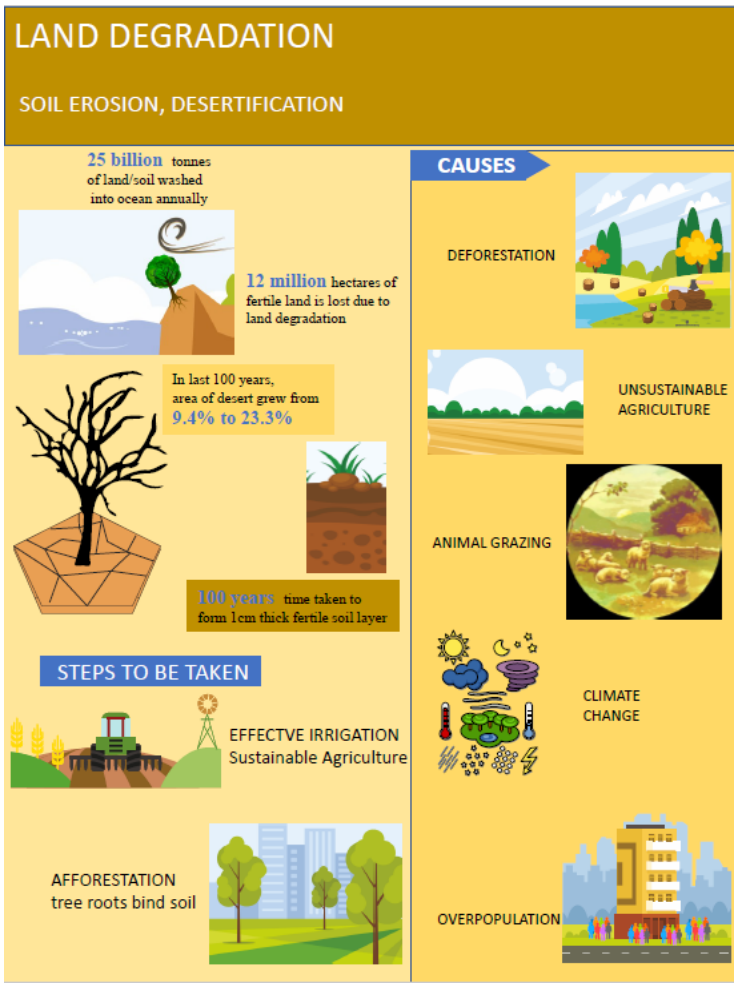


Fig. 2.4 Few Causes, Effects, and Solutions of Land Degradation

It is urgently required to address the problem of land degradation. By applying sustainable land management, restoration, and rehabilitation strategies that bring many benefits, land degradation can be avoided, minimised, or reversed.

2.5 Desertification

Desertification does not mean expansion of a desert land but the degradation of productive land in arid or semi-arid areas (land having no or little rain). **Excessive land degradation where fertile land gradually gets deteriorated into a wasteland is called Desertification.** It is the loss of soil productivity and biodiversity over time,

making cropping and land cultivation impossible. Deterioration of such lands occurs at a continuous rate, resulting in desert-like conditions and would eventually lead to permanent loss of land resources. According to the World Atlas of Desertification published by the European Commission, more than 75% of total land area has already been degraded, with more than 90% at risk of being degraded by 2050.

It is estimated that 30% of the India's land (around 147 million hectares, according to a report by TERI) is undergoing degradation and many districts in almost all states are in a state of more than 50% desertification.

Fig. 2.5 Land Undergoing Desertification

2.5.1 Agricultural Land and Desertification

According to the article *(Desertification in India: How Green Revolution Hastened the Man-Made Soil Degradation, 2021),* the cultivated lands in India are in the grips of desertification. Agricultural land is undergoing desertification almost everywhere. In the long run, despite the huge amount of external inputs applied in agriculture, cultivated land will get irreversibly and permanently degraded. It suggests that the agronomic activities of the green revolution to increase productivity has taken a huge toll on the quality of agricultural land. The soil has been manipulated due to heavy use of fertilizers and chemicals leading to the erosion of its most fertile layer and overall degradation of the soil and land. Land degradation, soil erosion and desertification are interlinked.

2.5.2 Factors Leading to Desertification

The expansion of farming in marginal lands, inadequate soil and water conservation measures, intensive agricultural systems, poor irrigation management, and overexploitation of groundwater are the main causes of desertification in India.

Soil fertility is a 'byproduct' of the decomposition processes by microorganisms in the soil and they thrive on nutrients of organic matter. Organic matter in the soil comes from the decomposed parts of the plants, the nutrients are absorbed by plants and reconverted to food by the plants. It is an exceptional example of recycling and reuse. As part of nitrogen cycle, bacteria in soil, fix atmospheric nitrogen in the soil and make it available to the plants. But chemical fertilizers and agrochemicals destroy these bacteria, affect the natural organic matter as well as the overall balance of this natural process, thus degrading the quality of the soil and accelerating desertification.

2.5.3 Addressing the problem of Desertification

To reduce the severity of desertification process, it is important to

1. Adopt proper agricultural and land management practices.
2. Plant trees on barren and near agricultural land as roots of trees hold soil together and prevent soil erosion from wind and rain.
3. Identify and reforest suitable areas with selected tree species.
4. Manage soil erosion by adopting area specific surface land and water conservation practices.
5. Properly and efficiently manage water for irrigation and for recharging underground aquifers.
6. Expand the biodiversity base of agriculture by planting a variety of crops to increase the versatility of the land.
7. Improve the quality of soil by planting legumes, recycling nutrients and nurturing the soil with organic manure and organic fertilizers.
8. Reduce over grazing.
9. Place magic stones (or bunds) on the ground to retain water on the soil rather than allowing it to run off.
10. Use drip irrigation, which involves watering plants slowly and locally through pin-sized holes in a hose set on top of the soil. It can be distributed using a solar pump, which saves water waste and boosts efficiency.

Fig. 2.6 Solution to Desertification in Morocco by building sand fences

However, it is important to consider the net effect of any intervention. If forests are planted on native grasslands, they could actually lower the amount of carbon stored in soil, hampering the effort. Similarly, some interventions may lower greenhouse gas emissions, but could increase temperatures. If a dark evergreen forest is planted at high latitudes, the darker surfaces, would absorb more solar radiations especially during winters. So, planting certain tree or plant species may threaten other species and ecosystems.

Case Study: The Marthwada Desertification Crisis

Adapted from: *Parth, M. N. (2020, October). Marathwada is close to desertification – and yet it won't give up farming water-guzzling sugarcane,IndiaSpend.Com.*

Tale of 2016

Two farmers Shankar and Chandrakala Tandale of Khamaswadi village, Osmanabad of Marthwada region recall how in the summer of 2016, three borewells and two wells on their farmland completely dried up. Though sugarcane growers, they were forced to grow tur/arhar dal/pigeon pea on 8 acres of their land out of total 10 acres that year. While sugarcane soaks water like a sponge, tur dal hardly needs any.

The agricultural region of Marathwada had been hit by two successive droughts in 2016. The rainfall in this region is mostly scanty (783 mm) in comparison to state average (1,146 mm). A number of farmers took to tur cultivation due to the acute water shortage and the area of sugarcane cultivation decreased to 93,000 hectares from the normal 205,000 hectares.

A lost opportunity

The shifting to tur was believed to be a blessing in disguise, as the popularity of sugarcane cultivation in arid, drought-prone Marathwada, had always been questionable. It was an opportunity to promote planting crops that required less water and conserve the water in that region.

Unfortunately, the opportunity and crisis was not handled well by the government. Even though it was a bumper crop farmers clambered to sell it. 64% of farmers had to wait for between 31 and 123 days till their stocks were procured. Shankar Tandale spent money carrying his 70-80 quintals of tur for days together to the APMC market 16 km away from his village. Though the government-set minimum support price was Rs 5,050, he could finally sell in December end, at the rate of Rs 4,000 a quintal.

The condition of other farmers was even worse and because of the disheartening experience, the farmers went back to cultivating sugarcane as the condition of the rain improved. According to Purandare, the water expert, an opportunity to initiate conservation of water, and change cropping patterns that are wasteful, was lost.

Marathwada, a hub of sugarcane

The region, currently, has 54 sugar factories that procure sugarcane directly from farmers according to the data from Aurangabad divisional commissioner's office. Marathwada produced 14.7 million MT of sugarcane in 2018-2019 out of the 91.7 million MT total production of the state. What is overwhelming is that sugarcane occupies 4% of farms and consumes 70% of the irrigated water. To elaborate, while the total drinking water requirement for Marathwada is 590 mm^3 annually, the average water consumption of sugarcane is 10 times more at 6,159 mm^3.

Heading towards desertification

If things continue unchanged, water-stressed regions such as Marathwada could be heading towards desertification. According to Shashank Deshpande, a senior geologist "With sugarcane, we are extracting more groundwater than we ever did. As sugarcane is being cultivated throughout the year, groundwater is being extracted through bore wells all 12-months. Some bore wells are drilled deeper than 500 feet which entails that we are extracting over 1000 years old groundwater. It would need the same time to replenish. At this rate, Marthwada is definitely heading towards desertification.

Probable Solutions

- Water conservation is just not recharging and replenishing water, it requires cultivating water-efficient crops like lentils. Once upon a time Marathwada used to be a hub of lentils.
- If 50% of sugarcane area were brought under drip irrigation, around 3,080 mm^3 of water could be saved. This is more than what the Jayakwadi Dam, Marathwada's largest dam, can store (2,909 mm3)

But why sugarcane?

In spite of the water crisis, why do farmers continue to cultivate sugarcane:

- They have the certainty that they will sell their produce. In fact, the sugar factories pre-book the harvest. None of the other crops have this assurity.
- There is a high prospect of making profits. They invest 40,000 for an acre of sugarcane, harvest around 60 tonnes per acre and sell it at Rs 2,250 per tonne.
- It is a social status symbol in the village to cultivate sugarcane. If you want to get married, cultivating sugarcane improves your prospects.

And how did sugarcane get this social status? The sugar factories are owned directly or indirectly by people close to politicians from all political parties and the system promotes sugarcane.

2.6 Forest Resources

2.6.1 Importance of Forests

Forests are important renewable resources. It is estimated that 30% of the land area on Earth is covered by forests. More than half of the world's forests are in only five countries the Russian Federation, Brazil, Canada, the United States of America and China. In India, it is estimated that 20.6% of the total geographic area is forest cover (as of 2005).

Forests provide socio-economic benefits as they are source for food, medicines and biofuel for more than 1 billion people all across the world. Forest products include various oils, gums, resins, herbal medicines, honey as edible items. The wood, timber from tress in the forests are used for making furniture and also as firewood. Other associated products made from jute fiber etc. are all economic benefits we derive from the forest. Forest lands are also used for agriculture and grazing and mining purposes.

Additionally, they are indispensable to our planet. They act as an important tool in conserving biodiversity of the planet as they are home to millions of animal and plant species. Forests protect the soils and help prevent soil erosion. They help in water circulation on the planet. Forests act as a major factor in the carbon cycle, acting as a carbon dioxide sink and regulating the amount of carbon in the atmosphere. They thus, help in tackling climate change. These are some of the protective functions of the forest

ecosystem. Thus, forests have immense potential to support sustainable development of mankind.

Exploration of forest resources for the wellbeing of man has been prevalent for centuries. In older times, the exploitation of forests was compensated by natural growth of forests. However, the increasing population and the increasing demand for food and associated lifestyle habits has led to a large scale depletion of forest resources.

Fig. 2.7 Numerous Uses of Forests

2.6.2 Deforestation

Deforestation refers to the long term permanent loss of forest cover. The global forest area continues to shrink by an average of 4.7 million hectares per year. About 30 percent of all forests globally is managed primarily for the production of wood and non-wood forest products. Deforestation is a major source of land and environmental degradation as it is carried out by small farmers, villagers, loggers, plantation firms, builders, industrialists and used for state infrastructure. Many countries have developed policies and laws designed to promote the sustainable and multipurpose use of forests and trees. While India and some Asian countries have witnessed a slight increase in forest cover recently, the global forest cover is decreasing.

Read and watch the shrinking of the Amazon forest cover over the years
https://www.nasa.gov/mission_pages/landsat/news/40th-top10-amazon.html

2.6.3 Causes of Deforestation

1. Increase in Agriculture and Grazing

Deforestation occurs when forest area is cleared of trees and shrubs to make way for agriculture or grazing. It is reported that just four commodities are responsible for tropical deforestation: beef, soy, palm oil and wood products. It is estimated around 38,300 square km area/year equivalent to the size of Switzerland is lost to deforestation. Many of the forested hill slopes were cleared to cultivate the land. Cattle grazing also leads to significant deforestation where huge tracts of rainforests are burned down for pasture.

2. Shifting Cultivation

This practice is prevalent in many areas where forest lands are cleared to grow subsistence crops. It is estimated that a principle cause of deforestation in the tropics of Africa, Asia and tropical America is estimated to be 70, 50, and 35% respectively. Shifting cultivation which is a practice of slash and burn agriculture, is estimated to clear more than 5 lakh hectares of land annually. In India, shifting cultivation is prevalent in the North-East, and to a limited extent in Madhya Pradesh, Bihar and Andhra Pradesh and is contributing significantly to deforestation.

3. Firewood Collection and Timber Harvesting

It is an important deforestation agent. Trees are felled to collect logs of wood for various purpose especially buildings and furniture. Trees like ebony, teak, mahogany, pine are extensively used.

Besides, using the wood, the new logging lots allows for shifting cultivation and fuel wood gatherers access to new logged areas. As the world's population grows, so does the demand for fuel wood, which is a major deforestation factor, especially in dry forests.

4. Usage in Food and Other Industries

Forests offer raw materials for industry, which has put enormous strain on them. Increased demand for plywood as a backing material has put pressure on other species, including fir, which is used as a backing material for transportation of apples in Jammu and Kashmir and tea in the Northeastern states. An increase in agribusiness products and cash crop cultivation of oil palm, rubber, fruits, and ornamental plants has put tremendous pressure to cut forests and extend space for their cultivation.

5. Increasing Population and Urbanisation

As the population grows, the demand for electricity, irrigation, construction, mining increases leading to deforestation and reallocating the land for infrastructural needs. These projects typically require large tracts of forest land to be cleared leading to millions of people being displaced and large-scale loss of biodiversity in the forest land.

6. Building Dams and Road Infrastructure

Major-scale forest devastation is required to construct large dams, broad roads and highways disrupting the region's natural ecological equilibrium. In such places, floods, droughts, and landslides become more common.

7. Forest Fires

Though forest fires cause major loss of forests, in the past they used to be few and were mostly due to natural causes. However, in recent years, 2019 – 2021, the frequency, intensity and the forest areas catching fire have increased tremendously. In fact, even colder regions like Siberia are experiencing massive forest fires. These are due to man-made effects of global warming and climate change.

Time to Ponder: How much forest resource does an Indian student use during her/his study life?

Adapted from: Saving Trees, A Textbook at a Time. (2018). Gobar Times, 92.

"Can you calculate how many trees have you used till now for your studies and how much electricity and water was used in this process?"

2.6.4 Consequences of Deforestation

1. Soil Erosion

Deforestation leads to increase in major soil erosion and loss of fertile top surface soil that is the most productive for agriculture. The roots of plants/trees anchor the soil in place against the rain wash-away and strong winds.

When deforestation happens and trees are cleared, the soil get loosened leading to mudslides, and in hilly regions, dangerous landslides, destroying the settlements, roads, bridges and dams along the river banks. Large volumes of soil can flow into nearby streams and rivers, blocking waterways and damaging hydroelectric and irrigation infrastructure. A major catastrophe due to the above reasons were the 2013 Uttarakhand Floods. To read in detail visit, https://www.downtoEarth.org.in/news/natural-disasters/man-made-reasons-for-uttarakhand-disaster-41407

2. Disruption of Water Cycle

Water from surface of water bodies like oceans, seas, rivers evaporate and condense to form clouds. All plants and trees absorb ground water through their roots and release it in the atmosphere from their leaves during various processes like photosynthesis and transpiration. Clouds precipitate as rain, and seep into the ground to form groundwater and also some of it reaches back to the water bodies and oceans. However, with deforestation, the release of water to the atmosphere has decreased leading to less rainfall. This is leading to increasing dry conditions and desertification in many areas.

To read more on how deforestation is affecting the water cycles across the globe, visit

https://e360.yale.edu/features/how-deforestation-affecting-global-water-cycles-climate-change

3. Flooding

On one hand, deforestation leads to drought like conditions, while on the other hand, it even leads to flooding. A water shed is a piece of land that directs rain and snowmelt into creeks, streams, and rivers, so that they eventually flow into reservoirs, bays, and the oceans. Deforestation results in watersheds that are no longer able to sustain and regulate water flows from rivers and streams. Trees play a major role to keep the amount of water in watersheds at a manageable level by absorbing large quantities. Along with soil erosion, it leads to too much water gushing

down quickly leading to flooding. The cases have increased in such parts of the world, where it was never imagined including Germany, Poland, New York etc. When the water reaches the cities, due to excessive cementation and pavement building and blockage of drains, it is neither able to seep into the soil nor flow in rivers or seas.

4. Climate Change

Greenhouse gases like carbon dioxide trap heat in the Earth's atmosphere leading to increase in land surface temperature. Trees absorb carbon dioxide in the process of photosynthesis and in this process, effectively act as greenhouse gas filter and develop organic products that are of use for mankind. After trees are removed from a large piece of land, the carbon dioxide in that area can no longer be absorbed as before.

Climate change, which is caused by the accumulation of greenhouse gases in the atmosphere, has an impact on wild animals, plants, and humans through weather variations and an increased risk of natural disasters. Deforestation is thought to produce as much as 30% of global greenhouse gas emissions each year. Deforestation is estimated to produce around 30% global greenhouse gas emissions every year.

Read how rapid deforestation is causing flooding in South India in this article

https://scroll.in/article/936999/rampant-deforestation-in-the-western-ghats-is-causing-recurring-floods-in-southern-india

5. Loss of Biodiversity

Deforestation alters land use too quickly for plants and animals to cope and replenish, which means many of them do not survive the changing conditions. Humans are responsible for the extinction of other species by overharvesting, hunting, introducing invasive species to wild species and pollution, and conversion of wetlands and forests to croplands and urban areas. Even the rapid growth of the human population is causing extinction by taking over and ruining natural habitats.

Fig. 2.8 The True Picture which no one is ready to accept

Read more about it and the deteriorating condition of Biodiversity in India in the article

https://india.mongabay.com/2020/09/nature-in-peril-as-biodiversity-losses-mount-alarmingly-states-the-living-planet-report/

6. Threat to Survival of Indigenous Communities

There are few tribal and indigenous people who have been living and depending on the forests resources for food and shelter. Forests are their life. They don't know how to live otherwise. Deforestation is a major threat to their survival and displacement of their homes.

Before going ahead, watch this video on deforestation to understands its causes, effects and prevention

https://youtu.be/Ic-J6hcSKa8

2.7 Sustainable Forest Management

In order to restore and conserve the forest resources, a lot of steps are being taken and these fall under Sustainable Forest Management.

SFM (Sustainable Forest Management) is a method for preserving and improving the economic, social, and environmental qualities of all types of forests for the benefit of present and future generations. Managing forests sustainably will make positive impact on both the people and the planet by

- bolstering livelihoods of dependent communities
- providing clean air and water
- conserving biodiversity
- responding to climate change

There are techniques to manage the world's forest ecosystems in such a way that its biodiversity is conserved and used sustainably.

2.7.1 Key Aspects of Sustainable Forest Management

1. Conservation of Ecosystems and Biological diversity

Sustainable Forest Management can enhance and sustain the critical ecosystem. The choice of replanted tree species based on the climate and land conditions, can directly influence the tree diversity and also indirectly enhance ecosystem conditions for the forest fauna dependent on them.

2. Reforestation and Forest restoration

Reforestation is an opportunity to reverse deforestation. The natural or planned restoration of existing forests and woods by replanting in areas destroyed, by deforestation, is known as reforestation (also known as reafforestation). The aim is to plant a large number of trees in that area.

Forest restoration differs from reforestation as its prime focus is recovery of biodiversity and protection of the environment. Collectively, forest restoration are the actions that have been undertaken for the recovery of forest structure, ecological functioning and biodiversity levels to those of natural forests before any human disturbance. Forest restoration, when done correctly, aids in the restoration of habitats and ecosystems, as well as the creation of jobs and income. It is also an effective nature-based solution to climate change.

3. Afforestation

Afforestation is the establishment of forest stands (group of similar trees) to build a forest in an area where there was previously no tree cover. Many government and non-governmental organisations are directly involved in attempts to improve carbon capture and develop forests through afforestation. afforestation is becoming an increasingly popular technique for combatting climate change and preventing desertification, as it is proven to increase soil quality and organic carbon levels in the soil,.

4. Intensive Plantation

With the growing demand for timber and wood fiber, there is always the problem of natural forest loss. Intensive plantations are being undertaken to lessen the need to cut and log natural forests, and thus contribute to the conservation of forest biodiversity. The tropical plantation forest estate is growing, and comprises of trees that were primarily produced as agricultural plantation crops but are now supplying wood to the forest industry. Some 90% of plantation forests have been established primarily to provide industrial wood, and their relative global importance in this role is rapidly increasing. Most of the remaining 10% of plantation forests were established primarily to supply fuel or wood for non-industrial use.

5. Agroforestry

Agroforestry is a land use management system described as a combination of traditional agriculture and forestry. Trees, shrubs and other forest products are grown in and around agricultural lands and pastures. These forest products are carefully selected and used within agricultural systems, livestock, or forests. This diversification helps to establish an agro-ecological succession, similar to that found in natural ecosystems, and so begins a cycle of events that improve the farming system's functionality and sustainability. To improve the productivity and economic benefits of agroforestry systems, good agricultural expertise, careful species selection, and appropriate tree and crop management are required. They have proven to be advantageous over conventional agriculture as well as forest production systems through increased productivity, improved economic benefits and social outcomes, and enhanced ecological goods and services provided.

6. Social forestry

Social forestry refers to the management of forests for the benefits of local communities. It includes various aspects like forest protection, and afforestation with the objective of improving the livelihoods of forest dependent communities and for their social development. With around 12% of the total population in low-income countries dependent on forests for their livelihood, it is vital to acknowledge the local communities in the forest management practices. Some of the practices of forest management like Social Forestry prioritizes local communities by giving them rights to manage and at the same time restore the forests thus providing an important option for climate mitigation, forest conservation and sustainable development.

2.7.2 Climate Change and Sustainable Forest Management

Climate change is expected to affect the distribution of forest types and tree species, and thus their productivity in terms of timber and fiber. Also affected are the site and soil conditions, and changes in weather leading to severity and impact of wildfire, invasive alien species, insects, disease, floods, drought, temperature extremes, landslides and storm surges. Recent changes in climate have been observed to cause considerable ecological impacts and massive socio-economic losses.

It is reported that without adaptation further climate change, combined with factors such as deforestation, forest degradation, poor forest management practices and extreme weather events threatens 20–30 percent of global plants and animals living in forest ecosystem. Sustainable Forest Management (SFM) techniques, on the other hand, can help to sustain forest ecosystem services and increase resilience.

2.7.3 Forest Policy

According to FAO (Food and Agriculture Organization of United Nations), “Forest policy is a negotiated agreement amongst the government and relevant stakeholders, on a shared vision and goals for a country's forests and trees, adopted by government”. The aim of forest policy is to engage all stakeholders, government and non-government organizations in building a shared vision for guiding decisions and strategies related to forest management. The forest policies are formulated at various levels including between governments or each country having their forest policy aligning with their resources and environmental goals.

2.7.4 Monitoring Tools

It is necessary to have adequate and accessible information on forests, by monitoring, assessing and reporting on implementation of Sustainable Forest Management, as well as scientific analysis. Monitoring tools help in assessing the impact of various initiatives, and monitor progress to help facilitate decision making at national and regional level.

To know what is in the tool box of SFM read

http://www.fao.org/sustainable-forest-management/toolbox/modules/forest-management-monitoring/basic-knowledge/en/

2.8 The Chipko Movement

The Chipko movement, or the Chipko Andolan, was a very famous Indian forest conservation campaign that began in 1973 in Uttarakhand (then Himalayan region of Uttar Pradesh). It was a one of its kind at that time and since then become a rallying point for many subsequent environmental campaigns around the world. Sunderlal Bahuguna, a Gandhian activist, was behind the success and proper implementation of this movement, though the majority of the movement's supporters were women. His slogan was "Ecology is the Permanent Economy". The movement created a stir and the world took notice of this simple but effective non-violent movement to save forests. It has since inspired many eco-warriors and groups and has helped to slow down rapid deforestation, expose vested interests, increase social and ecological awareness and the need to save trees. Above all, it sparked the civil society, to address the issues of tribals and marginalised people.

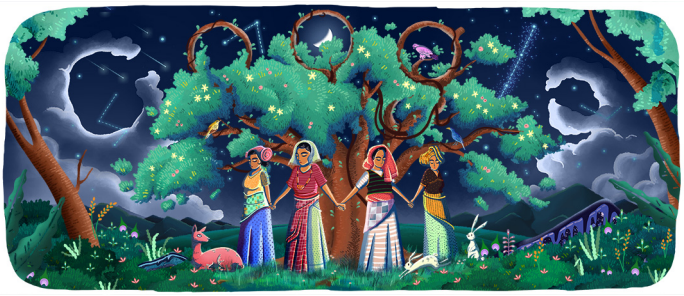


Fig. 2.9 Commemoration of the 45th Chipko Movement Anniversary on Google

https://www.google.com/doodles/45th-anniversary-of-the-chipko-movement

Also known as the 'hug the tree' movement, the Chipko Movement is an example of the power and contribution of ordinary citizens towards forest conservation. It started from an instance in 'Reni', a remote village in Garhwal (Himalayas). The people of this village especially the women folk clasped their arms around tree trunks to shield the trees from being cut down by contractor's workers. They could save mass deforestation from happening and saved their environment. The Movement swiftly spread throughout all communities, assisting in forest conservation and, as a result, environmental protection. The Right Livelihood Award was given to the Chipko movement in 1987 "for its dedication to the conservation, rehabilitation, and environmentally sound use of India's natural resources."

2.9 Summary

Natural resources are available freely on planet Earth and man relies on them for all its activities. They can be categorized on the basis of their origin, recovery rate and utility. To sustain the Earth and its components, it's important to use the non-renewable resources judiciously and to try and use the renewable resources extensively. Land and forest resources are important for our sustainable living. Most of the land use takes place to cater to the food demand for the ever-increasing population. While deforestation has led to clearing of land for agriculture, urbanization etc., the land itself is getting degraded and on the verge of desertification. There are ways to reverse this process before it is not too late. We need sustainable management practices at all levels to do so. Besides, due to the changes in land use and the over-exploitation of forest resources, the green-house gas emissions have increased. This in turn, has made it impossible to limit temperature rise to safe levels without fundamentally altering the way the world produces food and manages land. A new special report from the Intergovernmental Panel on Climate Change (IPCC) states unequivocally that land is critically important both as a source of greenhouse gas emissions and as a climate change solution. Land with forest cover acts as a major sink for CO_2 but with deforestation and land degradation, we are losing the easiest way to reduce the greenhouse emissions.

2.10 Self-Test Questions

1) Multiple Choice Questions

1. How are the natural resources classified on the basis of their origin?
   a) Biotic and Abiotic Natural resources
   b) Renewable and Non-Renewable Natural resources
   c) Conventional Energy Sources and Non-conventional Energy Sources
   d) Stock and Non-Stock resources

2. The main factors responsible for desertification of agricultural land in India are
   a) the extension of cultivation in marginal lands
   b) inadequate soil and water conservation measures
   c) poor irrigation management and overexploitation of groundwater
   d) All of the above

3. Desertification is
   a) Expansion of Natural Desert
   b) Degradation of grassland and forests
   c) Degradation of land in semi-arid and arid areas leading to permanent loss of land
   d) Agricultural land using its nutrient capacity

4. The renewable source of energy is
   a) Minerals
   b) Petroleum
   c) Coal
   d) Solar Energy

5. What if rain falls on the soil without vegetation cover
   a) Soil will be eroded
   b) Soil will become more fertile
   c) No change on the soil
   d) Chemical properties of soil will change

2) State True or False

1. Conventional Energy Sources are renewable natural resources
2. Non-Conventional Energy Sources are environment-friendly, do not pollute the environment.
3. Managing soil erosion by adopting area specific surface land and water conservation practices can be done to reduce severity of desertification.
4. Managing forests sustainably will make negative impact on both people and planet.
5. The practice of Shift cultivation results in Afforestation.

3) Fill in the blanks

1. The Land covers …… percentage of earth's surface.
2. Excessive land degradation where fertile land gradually gets deteriorated into a wasteland is called ……..
3. The long term permanent loss of forest cover is known as …….
4. The actions that are collectively undertaken for recovery of forest structure, ecological functioning and biodiversity levels to those of natural forests before any human disturbance is known as …….

5. ……. is described as a combination of traditional agriculture with the use of trees, shrubs and other forest products.

4) Match the following

a) Nitrogen fixing bacteria	1) Deforestation
b) Soil Erosion	2) Radio Active Metals
c) Non Renewable source	3) Root nodules of leguminous plants
d) Green House Gas	4) Forest
e) Biotic Natural Resources	5) Carbon dioxide

5) Briefly describe how Sustainable forest management can benefit the present and future generation.

2.11 Answers to Self-Test Questions

1) Multiple Choice Questions

1. How are the natural resources classified on the basis of their origin?

a. Biotic and Abiotic Natural resources

b. Renewable and Non-Renewable Natural resources

c. Conventional Energy Sources and Non-conventional Energy Sources

d. Stock and Non-stock Resources

2. The main factors responsible for desertification in India are Extensive cultivation
   a. the extension of cultivation in marginal lands
   b. inadequate soil and water conservation measures
   c. poor irrigation management and overexploitation of groundwater
   d. All of the above

3. Desertification is
   a. Expansion of Natural Desert
   b. Degradation of grassland and forests
   c. Degradation of land in semi-arid and arid areas leading to permanent loss of land
   d. Agricultural land using its nutrient capacity

4. The renewable source of energy is
   a. Minerals
   b. Petroleum

c. Coal
d. **Solar Energy**

5. What is rain falls on the soil without vegetation cover
   a. Soil will be eroded
   b. Soil will become more fertile
   c. No change on the soil
   d. Chemical properties of soil will change

2) State True or False

a) Conventional Energy Sources are renewable natural resources. **False**
b) Non-Conventional Energy Sources are environment-friendly, do not pollute the environment. **True**
c) Manage soil erosion by adopting area specific surface land and water conservation practices can be done to reduce severity of desertification. **True**
d) Managing forests sustainably will make negative impact on both people and planet. **False**
e) The Practice of Shift cultivation results in Afforestation. **False**

3) Fill in the blanks

1. The Land covers **30** percent of Earth's surface.
2. Excessive land degradation where fertile land gradually gets deteriorated into a wasteland is called **Desertification.**
3. The long term of permanent loss of forest cover is referred as **Deforestation.**
4. The actions that are collectively undertaken for recovery of forest structure, ecological functioning and biodiversity levels to those of natural forests before any human disturbance is known as **Forest restoration.**
5. **Agroforestry** is described as a combination of traditional agriculture with the use of trees, shrubs and other forest products

4) Match the following

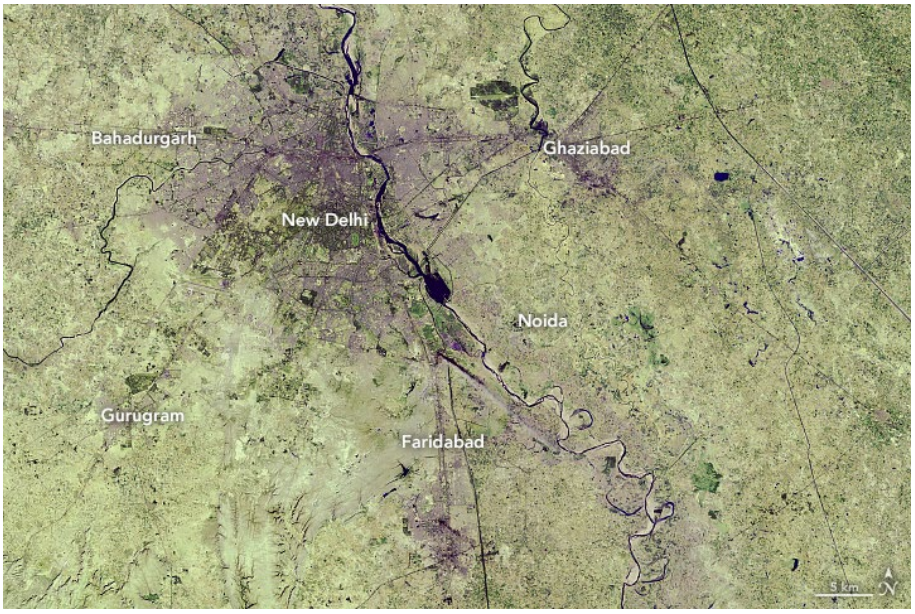
a) Nitrogen fixing bacteria	3) Root nodules of leguminous plants
b) Soil Erosion	1) Deforestation
c) Non Renewable source	2) Radio Active Metals
d) Green House Gas	5) Carbon dioxide
e) Biotic Natural Resources	4) Forest

2.12 Question based on Case Study: From Green to Grey

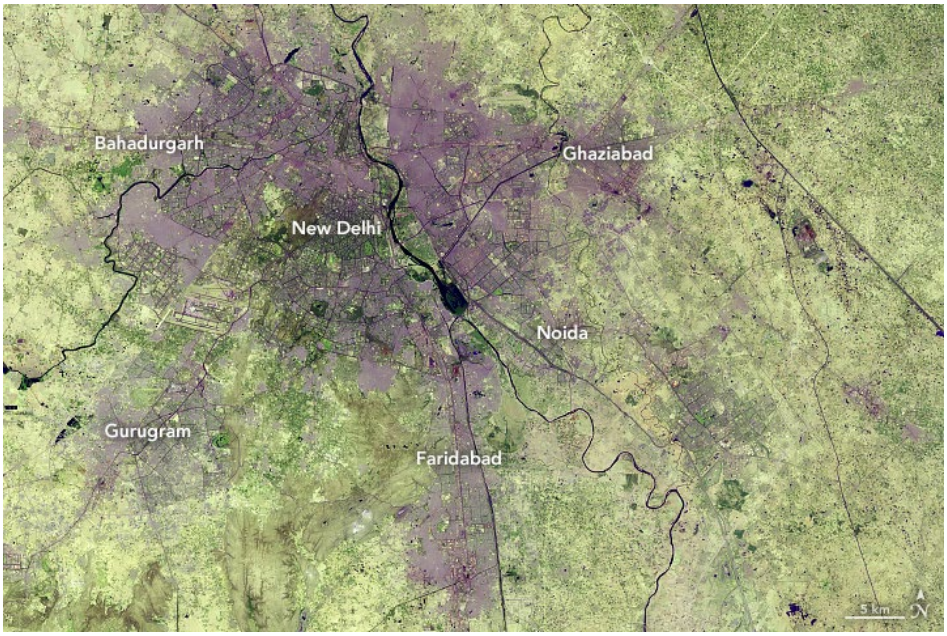
Read the following real case about the urbanization in Delhi region. Analyse and answer the questions given at its end.

FROM GREEN TO GREY

Turning of croplands into streets, residential complexes, roads, malls etc. is a very common sight these days, especially in the NCR region. As per the study conducted by United Nations in 2018 India is expected to add about 400 million urban dwellers.



Shot on 5th DEC 1989



Shot on 5th June 2018

The above images, one shot in 1989 and the other in 2018, are of the Delhi (NCR) region. The combination of visible and short-wave infrared light is used to take these false-coloured images so that urban areas can be easily located. As the images show, there is a considerable increase in urban areas, mainly towards the outskirts of Delhi.

Central and New Delhi were already inhabited in 1989, so the major urbanisation has taken place in the adjacent areas, towards the Haryana and UP border. The population as well as geographical boundaries of Delhi have almost doubled since 1991 to 2011, the main expansion being of urban households whereas the rural houses have been reduced to almost half the numbers. These images clearly show the rapid increase of the urban households in the areas of Ghaziabad, Faridabad, Bahadurgarh, Gurugram and Noida.

Delhi's per capita income is the highest in India, hence people migrated to the city for employment putting great pressure on the entire ecosystem. The 'Times of India' in 2016 reported that almost 1000 people were added to the capital's population every day, of which, 300 completely migrated.

This unbridled urbanisation not only reduced the cropland but also affected other parameters of the environment like surface temperature, air pressure and water pollution. The increasing concrete structures absorb more heat, reduces moisture and hence, also radiate greater heat making the thickly populated area warmer by almost 7 to 9 degrees centigrade than the surrounding hinterland.

Also, this unplanned spreading of urban area calls for more industries, more products, resulting in, more traffic congestion and greater greenhouse gas emission into the environment.

The rising temperatures lead to reduction in wind speed, thereby reducing the speed to flush out heat and harmful gases from the environment. NASA scientists have observed decreasing air quality in many Indian cities, including the Capital, which is way more poisonous than the standards.

The damage doesn't end here, this fast-pace urbanisation also leads to about 40% reduction in water bodies of the region. From being 221 sq.km in 1971 to 136 Sq.Km in 2014. Further, riverbeds were encroached upon by dwellers.

Though this study portrays the picture of Delhi NCR region, the situation in other metros and B-class towns is similar, with just a slight difference in the magnitude. It is indeed an alarming situation and calls for immediate action by the government and common people.

Q1. What is the main reason of people migrating to the capital region?

Q2. List down the three most important issues arising due to rapid urbanisation.

Q3. What are the possible steps government need to take to reduce or at least stop further damages?

2.13 References

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LESSON 3. NATURAL RESOURCES: OTHER RESOURCES

TABLE OF CONTENTS:

3. NATURAL RESOURCES: OTHER RESOURCES

3.0 Objectives

This lesson aims to

- Explain briefly the various water resources.
- Apprise about the status of water scarcity problem in India.
- Discuss the types of water disasters and their impacts
- Discuss other important natural resources
- Emphasize the importance of conservation efforts of natural resources

3.1 Introduction

Water is the one of the primary requirements of living beings. Historically, all the civilizations developed along the major rivers because fresh water brought together the required ecosystem (animals, food and water) services required for the evolution of human settlements. Owing to population and industrialization, the demand for fresh water has increased more than the supply. To add to this, human activity is unmindfully destroying the green cover and in turn disrupting the natural rain cycle, besides polluting the available freshwater resources. Minerals and fishery resources are important natural resources from an economic point of view, but they are also being overexploited and disrupting the natural ecosystems and causing pollution. Flora and Fauna are living creatures that directly and indirectly impact human lives. There is an increasing trend in understanding the importance of conservation of natural resources and sustainable use of resources is very important for the future generations to lead a normal life.

3.2 Water Resources

3.2.1 Distribution of Water on Planet Earth

Water is perhaps the most vital substance among the components of the environment. Water resource is unique. It is the most abundant and most widely distributed element in the world and occupies about three fourths (70%) of the Earth's surface. Yet, a mammoth **97.4% of water** contained in the world's oceans and seas being saline, is unfit for human consumption.

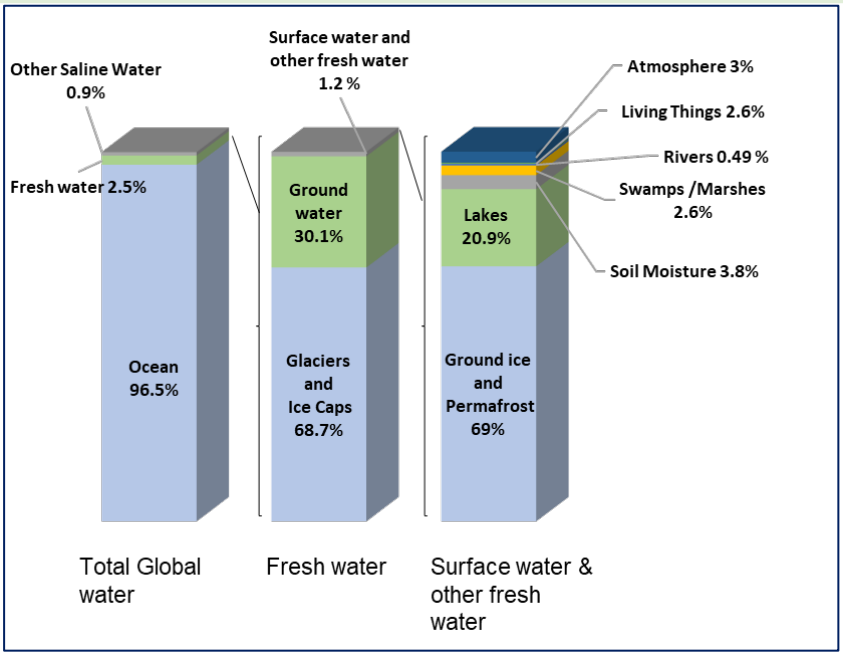


Fig. 3.1 Distribution of Global Water

Adapted from Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources (Oxford University Press, New York).

3.2.2 How much water for human consumption?

Humans, as all living creatures, require fresh water to survive. And **fresh water** constitutes a miserly **2.5 %** of the total amount of water on Earth. Of this, about 68.7% lies inaccessible in ice fields and glaciers and another 30.1% is present as groundwater. **In reality, only one–hundredth of one percent (0.03 percent) of the world's entire supply, which totals around 14 billion cubic metres,** is deemed readily available for human consumption on a regular basis. This water can be found in salty and freshwater lakes and reservoirs; as soil moisture; as water stored in living creatures; as vapour, droplets, and microscopic ice crystals in the sky; in swamps and marshes; and in rivers and streams, in decreasing order of abundance.

3.2.3 Fresh Water Distribution around the Globe

The problem wouldn't have been so acute had freshwater been evenly distributed around the globe, throughout the seasons or from year to year. But it is not so. The replenishment of the fresh water sources depends on the annual rainfall in a region. However, while around two-third or 67% of the world's population (around 5.8 billion people) live in areas receiving only one-fourth or 25% of the world's annual rainfall, while one-third or 33% of the population receives three-fourth or 75% of total annual rainfall. The map in figure 3 shows the distribution of easily available fresh water through rainfall around the world.

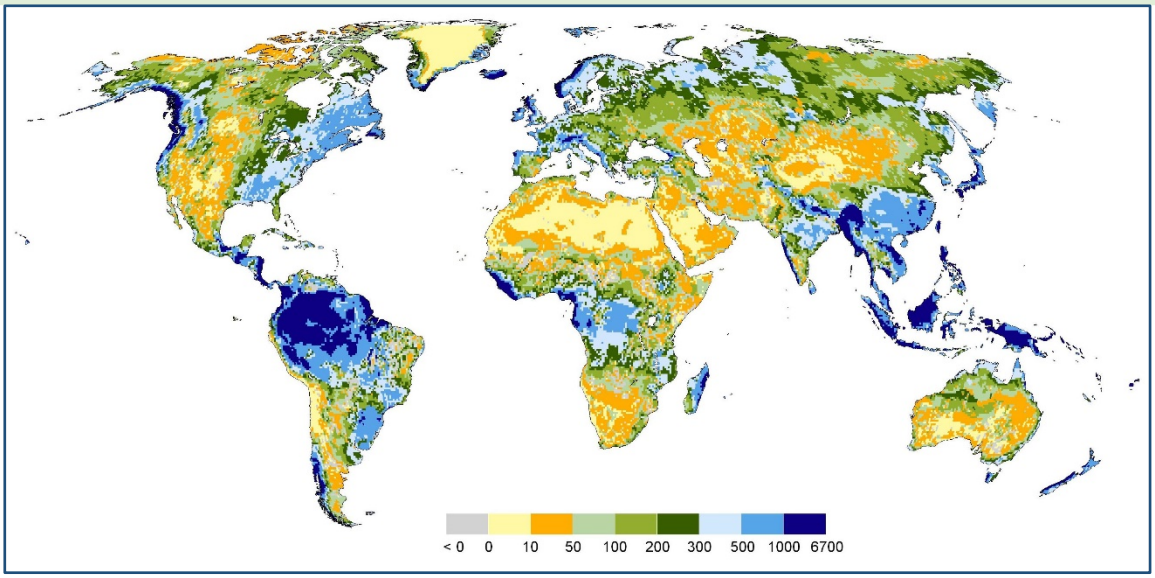


Fig. 3.2 Distribution of Annual Rain around the Globe

Total renewable freshwater resources of the world, in mm/yr (**1 mm is equivalent to 1 L of water per m²**) (long-term average for the years 1961-1990). Resolution is 0.5° longitude x 0.5° latitude (equivalent to 55 km x 55 km at the equator). Computed by the global freshwater model WaterGAP.

As water-short societies have done for centuries, many countries attempt to move water from where it occurs in nature, to where it is required by people, and also try to store water for future use. Dams are built for this purpose. Worldwide, there are 40,000 dams higher than 15 meters, most of them built in the last 50 years. Although dams help ensure a steady water supply, they often endanger aquatic systems by blocking river channels, altering water flows of rivers, food plains, deltas, and other natural wetlands, as well as imperiling plant and animal life and sometimes resulting in floods.

3.2.4 How a country uses its water?

The amount of water that is actually used by the people in a country depends not only on minimum needs and the availability of water for use, but also on the level of economic development and the extent of urbanization.

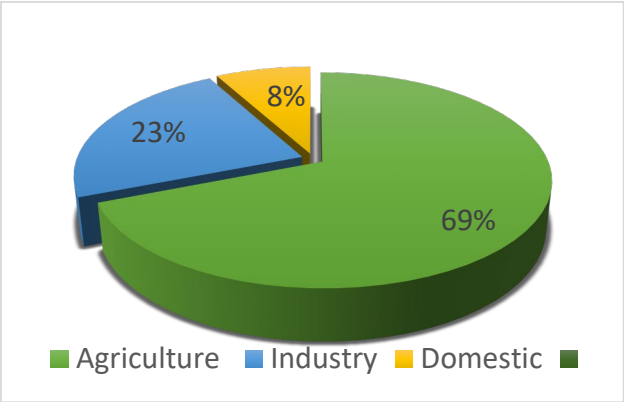


Fig. 3.3 How a Country Uses its Water Resources

Globally, there are three main categories of freshwater use: **agriculture, industry** and **domestic**. On a global basis, agriculture accounts for maximum use, about 69%, of the annual water withdrawals; industry, about 23% and domestic use, about 8%.

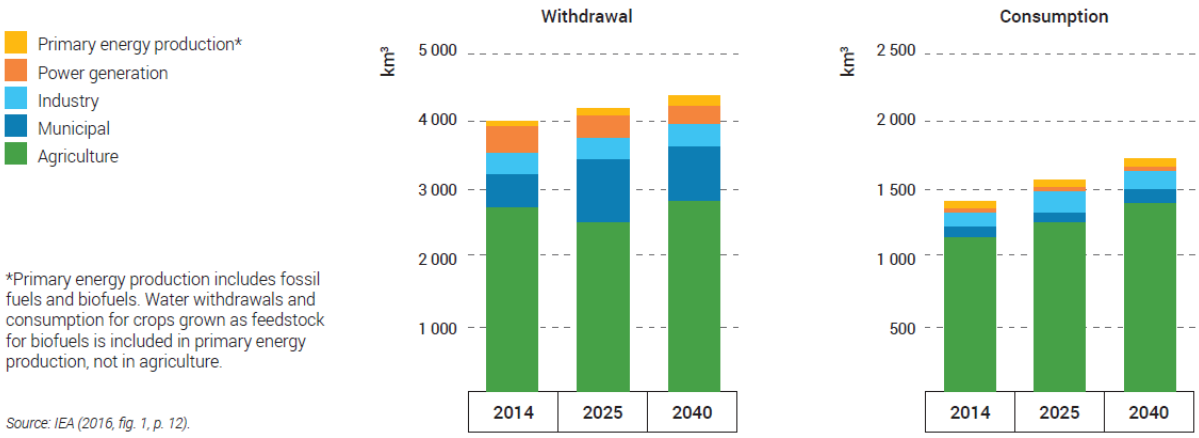


Fig. 3.4 Trend of Withdrawal and Consumption of Water Through the Years

https://www.bt-projects.com/wp-content/uploads/documents-public/Environment/IEA-2017-Water-Energy-Nexus.pdf

The above figure (Fig.3.4) shows the overall global increase in withdrawal and consumption of water in various sectors. Water withdrawal is the total volume of water withdrawn from a groundwater or surface water source. Water consumption represents the portion of withdrawn water permanently lost from its source i.e. the water that is no longer available because it got evaporated, used, transported etc.

3.2.5 Water Scarcity and Water Stress

The world's freshwater resources have been stressed by years of increasing population and rising water usage. Water demand has already surpassed natural availability in some locations, and an increasing number of countries are anticipated to experience water shortages in the near future. The world's population is growing by about 81 million people each year. This number implies an increased demand for freshwater of about 64 billion cubic meters (m^3) a year. When annual water resources **fall below 1700 m^3 per person**, a country is said to be experiencing **water stress**. The country faces **water scarcity** if water resources fall **below 1000 m^3 per person**. Once a country faces water scarcity, it can expect persistent freshwater shortages that endanger food production, impede economic growth and development, and harm the environment.

In 1995, 31 countries with a population of 458 million people faced water scarcity or stress. According to Population Action International's forecasts, more than 2.8 billion people in 48 countries would face water stress or scarcity by 2025.

The map in Fig. 3.5 shows the levels of physical water stress in different parts of the world.

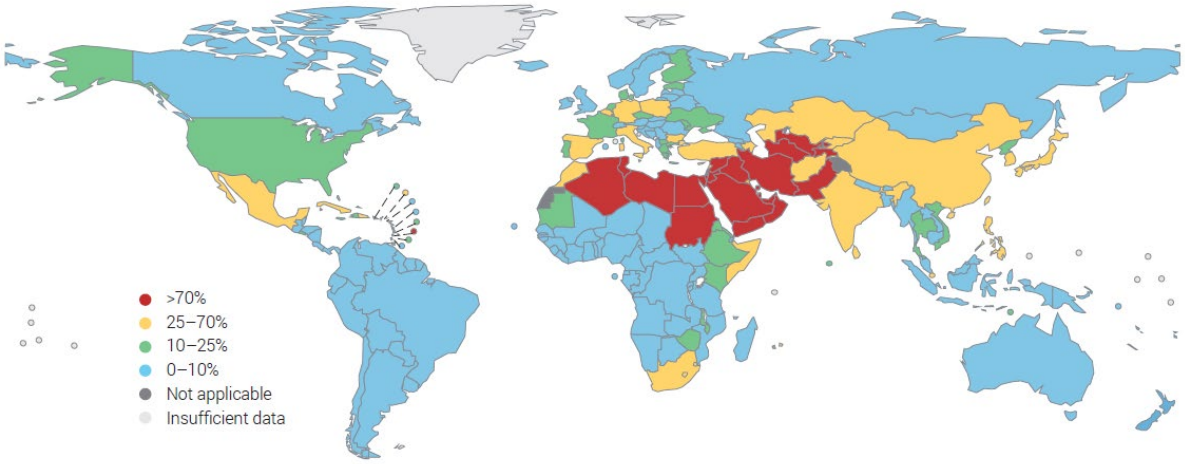


Fig. 3.5 Level of Physical Water Stress (2015)

Physical water stress is defined here as the ratio of total freshwater withdrawn annually by all major sectors, including environmental water requirements, to the total amount of renewable freshwater resources, expressed as a percentage. (UN, 2018)

3.3 India's Water Resources Potential

India is a water rich country with 4% of world's water resources.

3.3.1 Rivers

Fig. 3.6 Map of Rivers of India

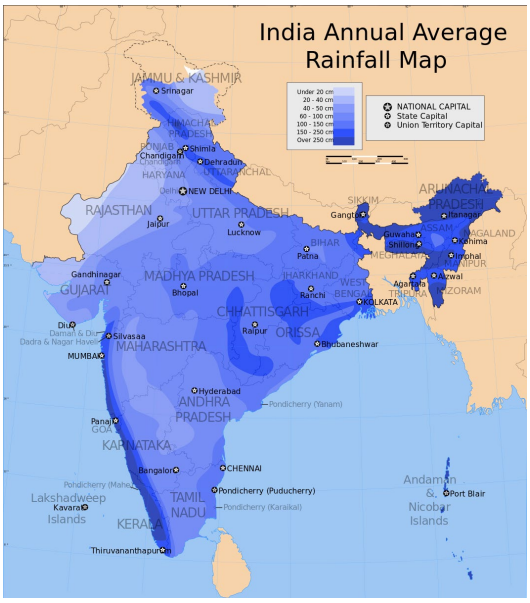
The rivers have been instrumental in India's growth as well as culture. Many ancient civilizations developed on the banks of rivers, and most of today's big cities are located along them. Twelve rivers are categorized as large rivers, serving a catchment area of

around 253 million hectares (mha), and 46 as medium rivers, serving a catchment area of 24.6 mha. Many of the river systems and their tributaries are perennial, while others are active only during certain times of the year. With a catchment area of over 110 million hectares, the Ganga-Brahmaputra-Meghana system is India's largest river system.

It also provides about 60% of the total amount of freshwater amongst rivers. (When it rains, water collects in an area called a *catchment*, from where it finds its way into streams, soil and river.)

3.3.2 Monsoon

Along with rivers, monsoon precipitation has been the lifeline of India with respect to agriculture, as well as recharging its water resources. India receives about 4000 bcm (billion cubic meters) of average annual precipitation along with snowfall, of which 3000 bcm is received in the monsoon season (June-September). The spatial distribution of precipitation widely varies over the country (<100 mm in Rajasthan to >2500mm in Assam - Central Ground Water Board, 2014).



3.7 Map showing Annual Average Precipitation in India.

Less than 50% of the total monsoon precipitation flows to the rivers and is estimated at 1869 bcm. However, only 690 billion cubic metres of surface water may be used (Central Water Commission, 2015).

3.3.3 Groundwater

In India groundwater has been used for irrigation and domestic water supply since times immemorial. The South Asian Network on Dams, River and People estimates that ground water is vital for two-thirds of irrigated area, 85% of rural population and more than half of urban and industry. India's annual utilisable ground water resources are estimated to be 433 billion cubic metres. The main source of replenishing ground water is monsoon precipitation (67%), while other sources like seepage from canals, tanks, ponds, other water structures and irrigation account for about 33%.

Groundwater extraction is expanding to suit agricultural demands, particularly for the production of water-intensive crops like sugarcane. Today, more than 8.5 million electric and diesel pumps are used to withdraw groundwater leading to falling water tables in most states.

3.4 Water Stress and Scarcity in India

India is highly dependent on the monsoon precipitation to replenish its abundant water sources including ground water, rivers, lakes and reservoirs. However, in some states, such as Delhi, Punjab, Haryana, and Uttar Pradesh, excessive groundwater exploitation has resulted in water scarcity. Arid climates cause water scarcity in areas like Rajasthan and Gujarat, while poor aquifer qualities cause water scarcity in Tamil Nadu, Karnataka, and Andhra Pradesh.

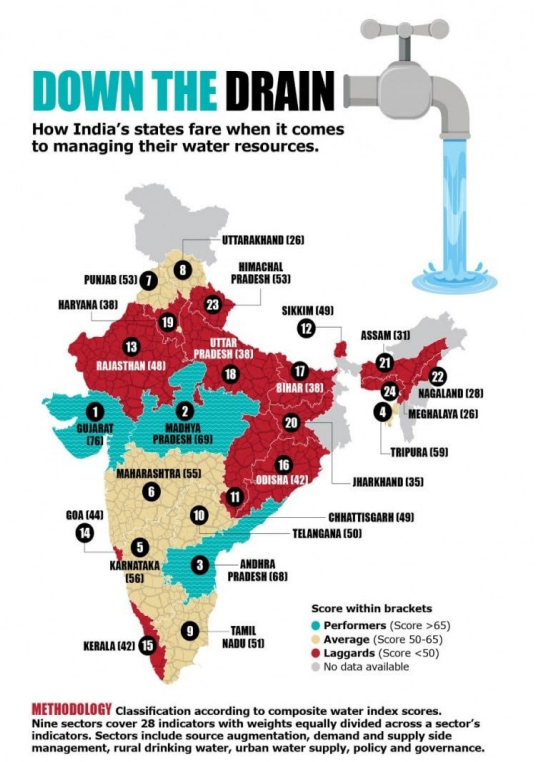


Fig. 3.8 How States Manage their Water Resources

https://www.indiatoday.in/india-today-insight/story/india-water-crisis-new-ministry-1541181-2019-06-03

This map indicates how our states manage and distribute their water supplies across various sectors. The states in sea green are the best performers followed by average performers in light brown and poor performers in maroon.

Increasing population, industrial growth, and an unparalleled speed of urbanization has put high stress on ground water. Ground water is being extracted from lower and lower levels at a much faster rate than rainfall can ever replenish. The decline in ground water is 54%. The per capita water has decreased from 2208 to 1700 m^3 in a decade. Besides, the decreasing water resources, 70% the surface water in India is

highly unusable due to water pollution and dumping of sewage and industrial effluents in rivers and other water bodies. We will be studying about it in detail in a later Unit.

Around 600 million people, almost half the country face severe water scarcity each year. Water scarcity is becoming the single greatest threat to food production, since groundwater levels are falling and rivers are receding, leaving less water available for cultivation. According to UNEP, India will be water stressed before 2025. According to a report by Niti Ayog (June 2018), water demand will be twice the current supply, causing India to lose up to 6% of its GDP.

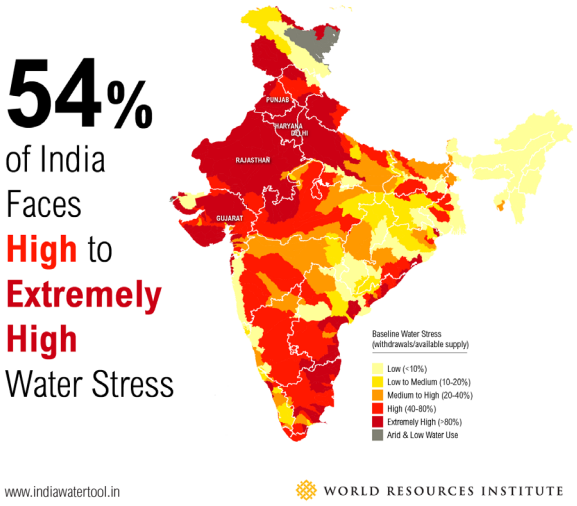
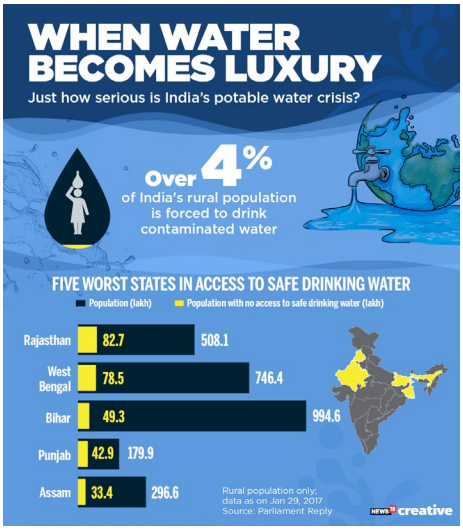


Fig. 3.9 Water Stress Map of India

https://theglobepost.com/2018/07/13/india-water-scarcity/

Time to Ponder: Every Drop Counts

While we Waste, Others don't even have Access to Safe Drinking Water



https://www.news18.com/news/opinion/opinion-the-ticking-time-bomb-indias-water-crisis-about-to-blow-up-in-our-face-1696839.html

Whenever we open the tap, we must realize the importance of saving water. There are villages all over India where ladies still need to travel miles on foot with heavy pots on their heads, to fetch water for their daily use. Strangely, there are villages in Maharashtra where in spite of having water reservoirs and good annual rainfall, they are unable to use that water, as it is being directed for use in metro cities like Mumbai. Read about it in detail and how uninformed and ignorant people of urban cities are in this article,

https://www.firstpost.com/india/mumbais-burgeoning-water-needs-leave-nearby-villages-parched-citys-wasted-and-free-supply-more-than-nagpurs-daily-need-8127461.html

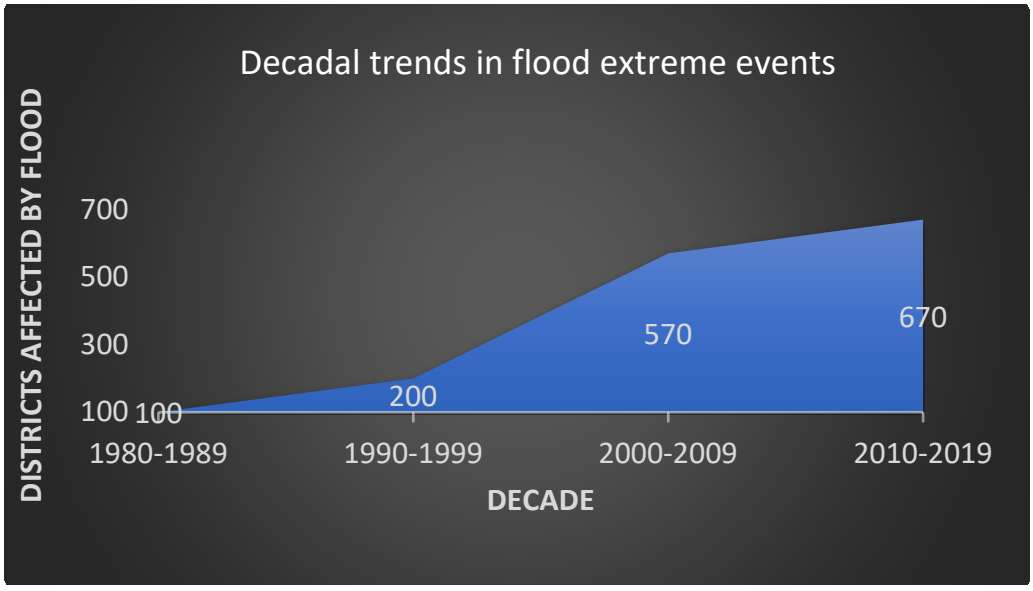
We all must pledge to continuously and consciously take simple steps as an individual to save as much water as we can.

3.5 Water Disasters

India is highly vulnerable to water related disasters such as floods, droughts and cyclones.

3.5.1 Floods

More than 12% of India's geographical area is flood prone (Ministry of Home Affairs, 2015). Floods are a common occurrence can result in significant loss of life and property. The marginalized population suffers the most. It is a cause for concern that flood related damages show an increasingly upward trend. While the number of flood incidents was lower than 20 between 1965 and 1975, it jumped to 100 between 2005 and 2015. From 1915 to 2015, India saw 649 disasters, 302 of which were caused by floods, with an average of three floods each year. This accounted for approximately 47% of total disasters that took place in India in the last 100 years. The following graph shows the increase in floods and the districts affected.



3.10 Increase in Districts Affected by Floods through the Decade

Causes of floods

Floods are caused by a combination of two factors:

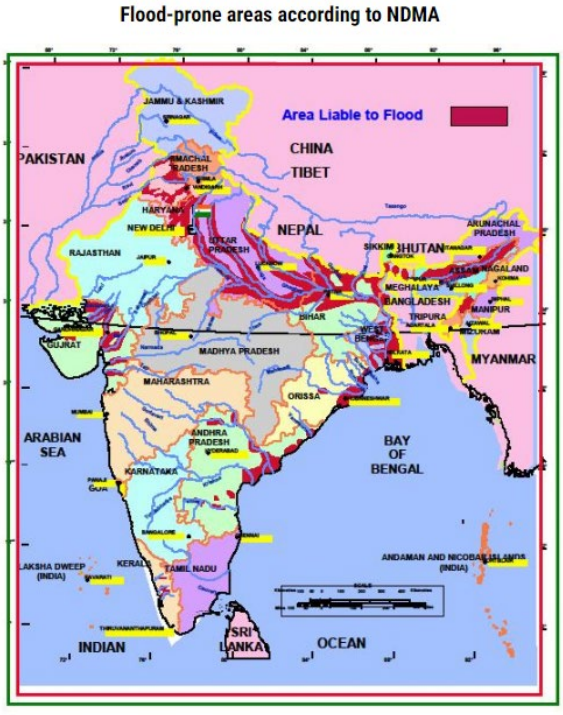
1) Heavier-than-normal rainfall and

2) Limited capacity of rivers, drainage and water harvesting structures to withstand and discharge the excess rainwater. Or, in an urban context, the choked drainage systems with plastic and other sludge, limits the discharge of excess water into drainages.

In many recent heavy rainfall events, it is observed that floods followed a period of unusually heavy rain, like equivalent to a month's or week's rainfall being dumped in a day or a couple of days overwhelming the drainage systems to discharge the water.

Floods – then and now

According to National Disaster Management Authority (NDMA), regions most susceptible to floods lie mostly along the Ganga-Brahmaputra river basin, from the northern states of Himachal Pradesh and Punjab, covering Uttar Pradesh and Bihar and stretching to Assam and Arunachal Pradesh in the northeast along with Odisha and Andhra Pradesh. This report (and the map below) was based on estimates made in 1980 that ascribed floods to purely anthropogenic factors and not heavy rainfall.



3.11 Flood prone areas according to NDMA (1980)

However, since then, in the last four decades, India has experienced the effects of climate change and global rise in temperatures along with extreme weather events. Flash floods and cloud bursts in Uttarakhand, devastating flooding in Kerala with just two weeks of rain after a normal monsoon in 2019, flooding in Maharashtra in July

2021 with just one day of heavy rain are some examples of these extreme flood events. Floods were reported in 256 districts across 13 states in 2020 due to excessive rainfall. Besides, the frequency of thunder storms and lightening events throughout the year have increased dramatically. Intense rainstorms are expected to be more frequent due to global warming as warmer air holds more moisture. Indian economy is dependent on the monsoon system for water and agriculture and as such, the climate change is making the monsoon system more chaotic and unpredictable.

3.12 Floods in Uttarkashi, 2013; Submerged Kolhapur, Maharashtra, India, 2021

3.5.2 Drought

Droughts can be caused by a variety of factors, including rainfall variability, monsoon delay or early withdrawal, break in monsoon duration, geographical differences in monsoon and human activities. Droughts can be classified as meteorological, hydrological, soil--moisture, agricultural, socio-economic, famine, or ecological, depending on their physical characteristics. The map depicts the areas of India that are prone to drought.

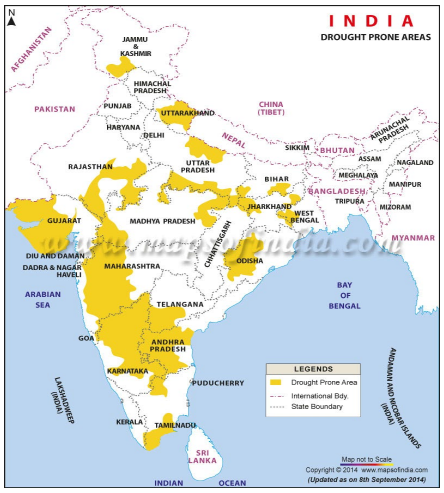


Fig. 3.13 Drought Map of India

https://www.mapsofindia.com/maps/india/drought-prone-areas.html

According to Mishra et al. (2019), India had seven major soil moisture droughts or agricultural drought episodes between 1870 and 2016, based on their analysis of

severity, area, and length. Three droughts in 1877, 1896, and 1899 were linked to El Nino when warm temperatures in the Pacific Ocean cause below-normal rains. Except for the Bengal famine of 1943, five major famines during 19th century were caused by large-scale and severe soil moisture droughts driven by June-September monsoon failures.

Historically, ground water has been the saviour in times of droughts in most regions of India. However, due to rising demand, India - the world's largest user of groundwater, extracts 250 cubic kilometres each year, accounting for more than a quarter of the global total. According to the study, groundwater has depleted due to overexploitation and shifting rainfall patterns. In the last 30-40 years, India's lean-density rain, which is good for recharging groundwater, has decreased, while high-intensity rainfall has increased.

Combating drought

Planning for drought includes:

- Introduction of proper cropping pattern.
- Development of irrigation facilities.
- Development of existing irrigation potential.
- Water losses can be reduced by lining canals and distributaries.
- Use of drip irrigation/trickle irrigation in saline locations.
- The expeditious completion of ongoing projects to be prioritised in planning.
- Construction of new irrigation projects.

3.5.3 Dams

Around the world, there are more than 45,000 big dams that play a vital role in

communities that use water resources for economic growth. Dams irrigate around 30-40% of the world's irrigated area, according to current estimates. China and India, the world's two most populous countries, have built over 57 percent of the world's big dams.

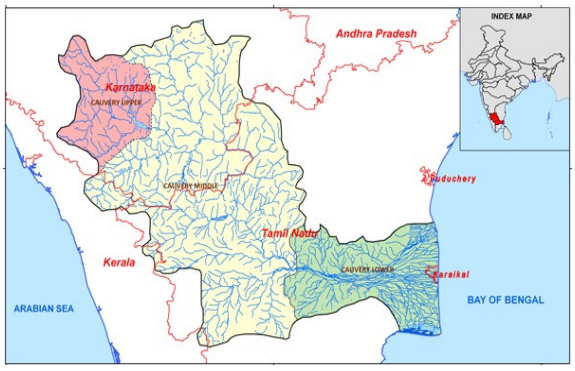
Dams store water, provide renewable energy (hydroelectricity) and help to prevent floods. Ironically though, recent events have proven that rather than preventing flooding, they have been acting as triggers of floods. There may be several advantages of dams, but there are many disadvantages too. Let us enlist them.

- Dams cause weakening and fragmentation of the physical structure of the area where they are built. Scientists have attributed over 100 earthquakes globally to the dams and reservoirs, a phenomenon known as Reservoir Induced Seismicity.
- The riverine ecosystem i.e. ecology of the river and its bank gets seriously affected.
- There are social implications too. To make dams, people and their homes have to be displaced. In India, of the 16-18 million people displaced by dams, 40-50% were tribal people.
- Dams affect the animal populations, by damaging their habitats and disrupting their migratory routes.
- Fishing and waterway traffic is also disrupted.
- Dams also worsen the impact of climate change. Reservoirs and man-made lakes built by dams typically have a larger surface area than the rivers and canals that feed them. Larger surface area of exposed water leads to more evaporation of water. The evaporation affects local climatic conditions of the surrounding areas, causing fluctuations in the natural temperature. Emission of greenhouse gases from reservoirs due to rotting vegetation also increases.
- Recent floods especially in China in 2021 and some in India have been shown to be triggered by dams.

Case Study: The Tragic Tale of the Magestic Cauvery

Adapted from: *Let Cauvery be, Down to Earth, 15 Aug 2019, pp 21-27*

Cauvery – Floods and Droughts



Barely a trickle now remains in the 805-km river that flows through Karnataka and Tamil Nadu. There's not more than knee-deep water in Talakaveri, the source of the river in Karnataka's Kodagu district. Water here is so still that it has turned green with algae. It is mind boggling how this is possible in the Western Ghats, one of India's highest rainfall zones. Last year, the Cauvery basin received 4 per cent above

normal rainfall. By August, all the dams were overflowing and soon both the states were drowning in floods. This year, the two states are reeling under a severe and unprecedented water crisis. The situation has befuddled experts: **Why is rainfall in the Cauvery river basin inconsistent, causing floods as well as droughts**?

The reasons unfold:

1. Land use change:

During monsoons, rainwater flows downstream the Kurubara Matte mountain range to natural paddy fields where water is held for four months during the kharif season, from July to November. When the crop is ready, it is released to the many natural streams that fall into the Cauvery. Farmers here have been traditionally practising this method for centuries as it recharges groundwater and also acts as a natural feeder to the river.

But now, tourist resorts have replaced natural paddy fields that recharge groundwater, drastically changing the land use. Paddy fields have shrunk, while plantations of silver oak, areca nut and oil palm trees that fetch quick money have increased.

Now, farmers no longer need the huge amount of water they once required to irrigate paddy. When it rains, they let the water flow down directly to the natural streams.

Result: In November-December when the river is water-starved, it barely gets any water from the paddy fields. And when it is bulging during monsoons, the river gets huge amounts of water, creating floods.

So although ample profits are being earned from the resorts and plantations, the farmers realise that they have added to an environmental problem.

2. Excessive coffee plantations

The story of the water crisis in the Cauvery's basin was scripted decades ago. In the 1980s, people cut down traditional trees and replaced them with coffee plantations. As land here is ideal for its growth, coffee proved to be a huge success. From 2007 to 2017, land under coffee plantation increased by 4,000 ha in Kodagu. Now, Kodagu has 43 per cent of India's coffee plantations, and 80 per cent of India's total coffee comes from Karnataka.

"But coffee plants cannot hold water or soil as they have small roots. They neither conserve nor restore rainwater," says S Janakarajan, former professor at Madras Institute of Development Studies, Chennai. Growing coffee excessively on steep slopes that have loose soil and are heavy with water result in landslides. Small wonder, Kodagu witnessed a land-slide last year, destroying coffee plantations, nearby houses, and also choking river streams.

Also, the new coffee plantations have blocked the forest corridor which elephants used earlier. In the past few years, incidences of human conflict with wild boars, porcupines, anteaters, leopards, elephants, monkeys and peacocks have increased, but the government, it seems, is not bothered that land use changes have deeply

impacted the environment, and thus people's lives, since government documents categorise coffee estates and the new trees as forest area, so according to them there has been no loss of green cover.

3. Indiscriminate Mining

At Kushalnagar, near Mysuru, the Cauvery is bone dry. Illegal sand miners work fearlessly on the riverbed, digging beyond permissible levels severely depleting the water table. The permissible mining limit is 1 metre, but illegal miners excavate the riverbeds up to 6 metres creating huge pits this also adversely impacts aquatic life. The river had 148 species of fish, of which 17 are endemic to the river, but many species have either disappeared or are under threat of extinction. The hump- backed mahseer, once a common Cauvery fish, has now been categorised critically endangered by the International Union for Conservation of Nature.

4. Industrial effluents and Urbanisation

As the Cauvery enters Tamil Nadu, Mettur, a small town in Salem district, dumps untreated effluent from tannery, paper and textile units, increasing toxicity. And by the time it reaches Erode district, the Cauvery is nothing but a sewer. Pollution levels here are the highest in the country, shows a government funded study conducted in December 2017 by the Anna University in Tamil Nadu. In Mettur and Erode, TDS level is an astounding 1,750 and 1,450 mg per litre. The average TDS level in the Cauvery is 753 mg per litre.

As the Cauvery enters the plains of Tamil Nadu, it widens and forms a delta. Large scale groundwater extraction for farming and sand mining have sealed the river's fate. The basin is already starved of sediments. As many as 96 dams, 10 barrages and 16 anicuts, besides 54 irrigation projects and 15 major hydroelectric projects upstream, have blocked silt from flowing downstream. Silt helps create delta at an elevation, which differentiates river water from that of the sea. But absence of enough silt has shrunk the Cauvery's mouth. Now, the river's flow has reversed: instead of the river water flowing into the sea, the Bay of Bengal has entered 17 km into the delta and turned the water saline.

3.6 Other Resources

3.6.1 Mineral resources

Mineral resources are those resources that are potentially valuable material and of economic interest to humankind, found in Earth's crust. We need metals for machines, sand and gravel for roads and buildings, quartz for computer chips, limestone and gypsum for concrete, clay for ceramics, gold, silver, copper, and Aluminium for electric circuits and innumerable other uses, diamonds and corundum (sapphire, ruby, emerald) for abrasives and jewellery. Due to its diverse geological structure, India is blessed with a diverse range of mineral resources. India's major mineral resources include coal, iron ore, manganese, mica, bauxite, etc.

Types of Mineral Resources

Mineral resources can be divided into two major categories - **Metallic** and **Nonmetallic**. Metallic resources include metals like copper, mercury, tin, silver, gold, silver, lead, aluminum, iron, zinc etc. Non-metallic resources include sand, gravel, gypsum, granite etc.

Finding and exploiting mineral resources requires the application of the principles of geology. Some minerals are used as they are found in the ground, i.e. they require **no further processing or very little processing**. For example - gemstones, sand, gravel, and salt (halite). Most minerals **must be processed** before they are used. As extraction of mineral costs, labor costs, and energy costs vary with time and from country to country, what constitutes an economically viable deposit of minerals varies considerably in time and place.

Impact of Extraction and Processing of Minerals on the Environment

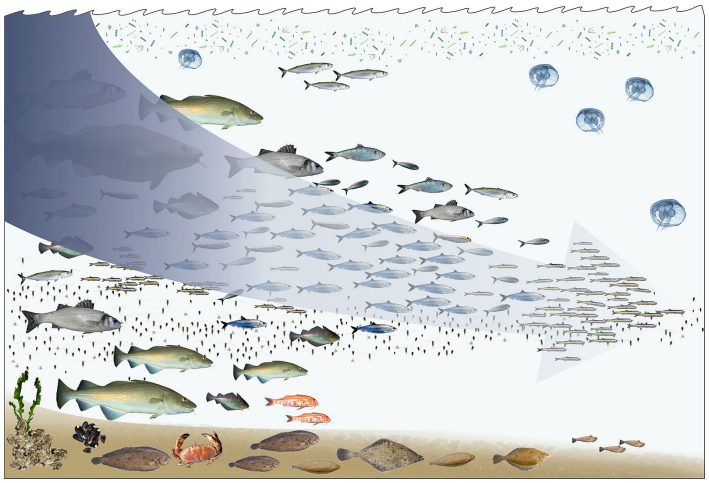
Severe land degradation happens when mineral exploration and mining are not done sustainably. Extraction and processing have large environmental impacts in terms of deterioration of air quality, surface water quality, groundwater quality, soils, vegetation, and aesthetics. One example of direct impact on the environment is **acid mine drainage.** Sulfide minerals exposed to oxygen and water near the surface produce sulfuric acid. Rainwater that falls on mine tailings becomes acidified, potentially causing harmful discharge. This can mobilize potentially dangerous heavy metals and kill organisms in the streams draining the tailings. Unregulated and excessive mining for minerals and ores lead to desertification in parts of Karnataka, Andhra Pradesh and Orissa, Jharkhand to some extent.

The most valuable mineral resources are fundamentally nonrenewable since the processes that generate ores operate on geologic time periods (millions of years). New deposits cannot be generated in human timescales (hundreds of years). But, as mentioned previously, as the reserves of materials become depleted it is possible to find other sources that are more expensive to exploit. Furthermore, mineral resources are not evenly distributed. How long current mineral resources will last depend on consumption rates and reserve amounts.

3.6.2 Fishery resources

Fisheries refer to the collection and harvesting of aquatic animals and plants, as well as the industries that support them, such as processing and distribution. Fisheries

resources are the aquatic resources available, for legally fishing in present as well as future times. These resources include oceans, seas, backwaters, rivers, canals, ponds, lakes, reservoirs etc.



Importance of Fishery Resources

- Fish resources play an essential role as a source of food for a country's population.
- Fish and fish products is one of the most widely traded foods.
- Fisheries and industries related to it provide employment opportunities and contribute to substantial incomes.
- The trade and transport industry associated with fisheries is huge.
- Fishing is also a recreation activity for many.
- Many medicines and potential drugs especially vitamins are extracted from aquatic animals and plants.
- They contribute to the marine biodiversity.
- Sea beds are an important source of fossil fuels like petroleum and related products.

Exploitation of Fishery Resources and Impact on Environment

If not controlled, fishing leads to excessive fishing known as overfishing. Sometimes if rules and regulations are not in place, illegal fishing i.e. fishing at places where it has been banned or fishing for restricted species. These greatly affect the biodiversity and ecosystems and also have social and econmic implications.

It not only directly affects the species being fished directly in terms of reducing their numbers, modifications in their structure, reproduction, age, size etc. but also affect the dependent and other associated species.

Overfishing highly degrades and stresses a stable and efficient ecosystem. This is done by altering the population of the various species whether it is the big fish that eats, or the small fish and organisms being eaten. It greatly disturbs their food pattern and might lead to a collapse of the ecosystem.

Besides overfishing and physical factors like leaving the fishing gear and associated material on the bottom of the sea bed, alters and destroys the habitats of the marine creatures. Even plants like algae, seaweed etc. and coral reefs get affected.

Various anthropogenic (caused by man) activities like building artifical structures like oil rig platforms, aquaculture installations, fish processing plants, fish nurseries etc., pollution which may be disposal of city waste or different chemicals, oil spills all affect the ecology and stability of the marine systems. Dumping of plastic waste has terrible consequences as these are either ingested by the sea animals or they get entangled in them.

Usage of destructive fishing techniques which includes using dynamites or cyanides has a huge lasting impact.

Ghost fishing is another apalling consequence. Sometimes discarded or lost fishing gear remains dumped in the sea, known as "ghost gear,". This gear continues to catch, kill and marine life, suffocate their habitats, and pose a navigational danger.

3.6.3 Flora and Fauna

Flora and fauna refer to the plethora of living creatures on planet Earth but are specific terms used to refer to plants and animals respectively. All the living things on this Earth have a specific role to play which might not be evident to us but directly impacts us. Some of the roles include providing oxygen, absorbing and converting our waste carbon dioxide, into food for us, pollinating flowers to give us fruits, tilling and making our soil nutritious, acting as sources of medicines, providing beautiful aesthetics and calmness, besides the major role in precipitation, climate etc. Each species and the number is important on this Earth and if the balance is disturbed, it can create havoc. A simple example would be if the number of frogs reduces, it will have a direct impact on the number of snakes and birds as frogs form their food. Another interesting but indirect example is of alligators that create depressions in swamps and marshes. These "alligator holes" provide essential refuge to water-dependent life-forms during droughts. You will be learning all about the living creature, their relationships, balance and much more in the subsequent units.

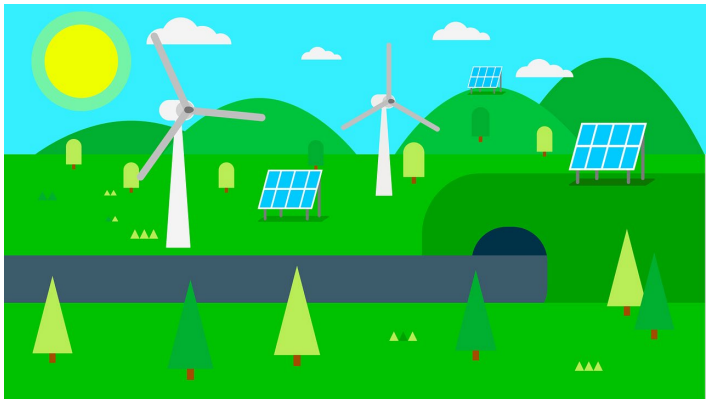
Another interesting aspect that needs mention is the inspiration from nature for some of the products that have been designed by humans for human use. The most famous is **Velcro** which was invented by George de Mestral, in 1941. It was inspired by the burrs (seeds/dry fruits of a plant) he found on himself and his dog. He examined the burr under a microscope and discovered that the burr's little hooks and the fur/loops fabric's allowed the burr to adhere extremely well. The other inventions include Speedo’s Fastskin Swimwear which has microscopic layers of scale and was inspired by a shark, a Woodpecker Ice Axe, a climbing tool that efficiently cuts ice and has the shape of a Woodpecker’s head, beak and chest created by Camp, airless tires for all terrain driving based on the structure and concept of a honeycomb by Polaris Industries.

You may visit the following sites to know more about them,

https://www.microphotonics.com/biomimicry-burr-invention-velcro/

https://99designs.com/blog/creative-inspiration/18-incredible-designs-inspired-nature/

3.6.4 Renewable Resources



Hydroelectric power or Hydro power

Hydro power is one of the oldest renewable source of energy. The mechanical energy of falling and flowing water is converted to electrical energy. In India, the Brahmaputra basin produces almost 30% of the country's electricity, followed by the Indus, Godavari and Ganga basins. Such projects also play a role in agricultural irrigation.

Wind Energy

Generation of electricity using the wind is gaining lot of poularity theses days. Wind mills can be seen in various places in Madhya pradesh, Maharashtra, Karnataka etc. The wind pushes the large blades of the wind turbines, and this mechanical energy is converted into electricity.

Solar Energy

The energy of the sun or solar power is widely being used these days to generate electricity. The Sun's radiation is absorbed by photovoltaic cells which convert the solar energy into electricity. The Dayalbagh Educational Institute uses solar energy efficiently to power its campus.

Bio-energy

Bio-energy is energy derived from plant or animal based organic products. One of the most significant and abundnantly availbale organic material is organic waste. These may be in the form of cow dungs or by products of sugarcane and other industries. Using biowaste is a two edged sword. It is a cheap source to produce fuel and a great way for the disposal of waste which decreases risk of emission of greenhouse gas emission and air pollution. Burning cow dung to produce biogas for cooking is an example of bioenergy.

Geothermal energy

The heat generated deep within the Earth's core is used to generate geothermal energy. Drilling wells pump hot water or steam from geothermal reservoirs (found along tectonic plate borders near volcanic activity or deep underground) to a power plant where geothermal energy is harvested.

3.6.5 Non-renewable source of energy: Atomic Power

When fossil fuels run out, atomic power appears to be the sole option for meeting large-scale energy demands. Atomic energy has been successfully used in the chemical and food processing industries, in addition to generating power. The expense of construction and maintenance of plants, as well as the disposal of radioactive wastes, are significant restraints in atomic energy generation.

3.7 Conservation of Natural Resources

3.7.1 What is Conservation of Natural Resources?

Earth’s natural resources include air, water, plants, animals, soil and minerals. Conservation of the natural resources is to undertake the care and protection of these resources so that they can persist and be used by future generations as well. It includes maintaining diversity of species and ecosystems, as well as all the functions of the environment. Conservation seeks the sustainable use of nature and its resources by humans. Growing human population has led to unsustainable rates of consumption of our natural resources, resulting in a loss of Earth’s biodiversity. Habitat destruction, climate change, invasive species, overexploitation, and pollution are the main drivers of biodiversity and ecosystem loss. Declining biodiversity is closely linked to species extinction. According to scientists, present extinction rates are nearly a thousand times higher than the fossil record would suggest.

3.7.2 Conservation is interlinked

In the context of ongoing poverty and continued environmental deterioration, the importance of water in food and livelihood security, for example, is a key source of worry. Despite the fact that there is a lot of knowledge about land and water management, an overarching picture of the land-water-food-livelihoods-environment nexus is needed to reduce uncertainties about management and economic decisions that will meet food, socioeconomic, and environmental security goals.

Water management is dependent on land and soil management, fertility, and degradation. Higher water productivity is facilitated by healthy soils. Soils that have been degraded demand more water and more intensive water management. Land-use practices are, in essence, water-use practices. Similarly, water management strategies have an impact on land management. Erosion is slowed by better water management. Inappropriate water application procedures can lead to nutrient deficiency. These are some of the reasons it is essential to consider land and water management practices as a whole.

3.7.3 Assessment of Natural Resources

Some United Nations bodies along with governments and researchers from across the world work together to address the global challenge of water and land use along with environmental and resource degradation. These groups aid in the understanding of the current situation of world resources. Global level assessments are done on:

- Climate Change (https://www.ipcc.ch/report/ar6/wg1/)
- Ecosystem and environmental degradation (https://www.millenniumassessment.org/en/Reports.html) and
- Natural resource degradation (https://www.unep.org/global-environment-outlook).

However, the processes underlying these measured impacts are poorly understood, and evaluations that link land and water resource degradation, as well as those that integrate socio-political and economic aspects with land and water degradation, are mostly unavailable.

3.7.4 A need for conservation efforts at all levels

The aim of conserving natural resources is to reduce the humanity's collective footprint and try to make sufficient natural resources available for future generations. Conservation of natural resources is to be done at various levels, from framing international and national policies and their enforcement to efforts at the regional and local level by communities and individuals.

Examples of national policy level efforts in environmental protection include:

- "Banning the manufacture, sale and use of identified single-use plastics" from July 1, 2022 as notified by the Government Plastic Waste Management Amendment Rules, 2021. This policy will affect how people will reuse plastic, and also discard more environmentally harmful plastics that have become a problem worldwide.
- Project Tiger adopted in 1973 to improve India's declining tiger population, has been the most successful environmental project by the Government of India. The scheme sponsored by the Ministry of Environment, Forest and Climate Change assists states to conserve their tigers in forests. The objectives of the projects are to protect and restore habitat, monitor them on a day-to-day basis, eco-development for local people, and relocation of the people from the habitats of tigers.

Example at regional and local level:

- One of the most recent success story is that of Indore Waste Management (https://www.smartcityindore.org/solid-waste/). Every morning, garbage vans in Indore play a celebratory song "Indore hua hai number one" as Indore was ranked the cleanest city in India by the Government's Swachhata Sarvekshan (cleanliness survey) rankings. Since 2016, the Municipal Corporation of Indore (IMC) has eliminated garbage dumps and ensured home waste segregation (dry

and wet rubbish) and separate collection. The waste is converted to usable products, such as compost and fuel. It collaborated with non-governmental organisations on an awareness campaign to encourage citizens to separate their trash at home, hired private companies to run some waste management operations, used technology, and increased municipal capacity to ensure that its waste management plan was implemented. Indore, is thus, easily managing its daily production of 1200 tons of waste sustainably. The success of Indore's urban solid waste management shows that urban India can clean up if municipal bodies, NGOs, private companies and citizens come together.

Steps at Individual Level:

There are several ways to conserve natural resources at individual level, in our homes and in our lives. Making simple lifestyle changes can make a lot of difference in contributing to the conservation efforts.

1. Use less water and electricity**:** Use appliances like dishwasher and washing machine only with full load. All the electrical appliances should be energy saving appliances with highest energy efficiency rating. Higher the star rating, better the appliance in energy efficiency. LED light bulbs use significantly less energy than traditional bulbs, thus switching to this alternative lighting technique can help save money and the environment.

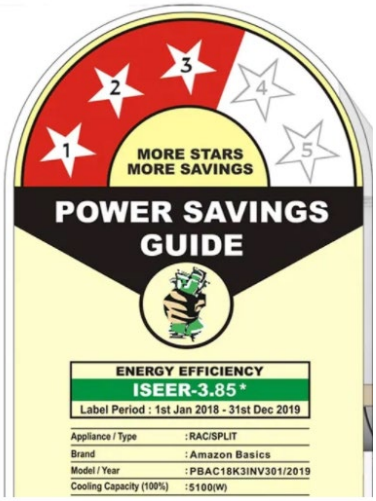


Fig. 3.14 Energy Efficiency ratings as per Bureau of Energy Efficiency (India)

2. Turn off the lights and electrical appliances when not in use. Use of motion sensor detectors can help in conserving power in public places.

3. Use renewable energy when possible. It is now possible for many homes to install solar panels and integrate with the grid so that if power generated by solar is more than required, it is supplied to the power grid and get an incentive on the power bill.

4. Recycle any product whenever possible. Find centers that accepts items like plastic bottles, cardboard, or aluminum for recycling. Using recycled paper and paperless billing would go a long way to save trees and prevent deforestation.

5. Compost: Compost from food scraps is a great way to enrich soil for gardens. It will reduce the kitchen waste that goes into the garbage dumpsites.

6. Manage temperature at home: Heating and air conditioning make up approximately half of household's energy bill. Raising the temperature of the room that is air conditioned by 1-2 degrees in the summer will also have energy-saving effects and help reduce your monthly bill.

7. Second hand shops: It can take over 2700 liters of water to make a single cotton t-shirt, which is enough water for one person to drink for 900 days. Buying second hand clothes and reusing the clothes, modifying the clothes to extend its lifecycle is a great way to decrease the need for more manufacturing. Recycled and up cycled clothing has inspired lots of new fashion labels (transforming old, worn out or damaged materials to brand new clothes). Most of the famous brands now have shoes and sports goods made from recycled plastic waste collected from coastal areas. Examples include
    - https://www.adidas.de/sustainability-parley-ocean-plastic
    - Refash
    - Doodlage
    - Pomogrenade and many more

Check out this article on how Tokyo Olympics used sustainable products from recycled medals to cardboard beds.

https://www.thenationalnews.com/lifestyle/2021/07/28/eight-ways-the-tokyo-2020-olympics-are-sustainable-from-cardboard-beds-to-recycled-medals/

3.8 Summary

Water is vital for life as well as the survival of the planet. Though 71% of the earth is covered with water, only 0.03% fresh water is available easily for human consumption. The replenishment of surface and fresh water is precipitation mostly as rain. However, the distribution of rain around the globe is skewed, with 25% of the population receiving 75% of the world's annual rainfall and vice versa. With increasing population and demand, the situation is leading to a water crisis with most countries facing either water stress or water scarcity. India's water resources include monsoon, rivers and ground water. The situation is grave as ground water is getting depleted and not being replenished at the same rate as its consumption by monsoons, rivers are highly polluted and monsoons are unpredictable. On one hand India faces a water crisis and droughts, on the other hand, the frequency and intensity of natural water disasters is increasing day by day. Moreover, deforestation, building of dams, urbanization etc. are

not only causing disruption of the water cycle but also increasing the green-house emissions. Fishery resources is another important natural resource. However, due to over fishing and illegal fishing, and pollution the marine biodiversity is at a grave threat and some aquatic species are on the brink of extinction. Flora and fauna are valuable resources that directly and indirectly impact humans. Mineral resources are important for the economic and well to do of man. It is important to understand and implement conservation of these natural resources, so that they are available for the future generations. Efforts have to be made at all levels and we must learn to live sustainably.

3.9 Self-Check Questions

1) Multiple Choice Questions

1. Reservoir Induced Seismicity is a phenomenon
   a) Earthquakes due to dams and water reservoirs
   b) Volcano eruption that are caused by earthquakes.
   c) Earthquakes that are creating water reservoirs.
   d) Earthquake zone with forest reservoir

2. Climate change raises the risk of extreme weather events like
   a) Draught
   b) Flooding
   c) Wildfires
   d) All of the above

3. A country is said to experience water stress when annual water supplies drop below
   a) 1,700 cubic meters per person.
   b) 500 cubic meters per person.
   c) 5000 cubic meters per person.
   d) 10000 cubic meters per person

4. What is the purpose of Dam Construction
   a) Storing water
   b) Generating electricity
   c) Prevent flood
   d) All of the above

5. What is project “Tiger”
   a) Hunting of tigers in Indian forests
   b) Feeding tigers in Indian zoological parks
   c) Protecting and restoring habitat of tigers
   d) Creating law against tiger hunting

2) State True or False

1. About 68.7% of total water present on the earth's surface is inaccessible to human.
2. Atomic Power is non-renewable natural resource.
3. Monsoon precipitation has been the lifeline of India with respect to agriculture as well as recharging its water resources.
4. Increasing population is not responsible for stress on groundwater level.
5. Overfishing and Illegal fishing is not depleting fishery resources.

3) Fill in the blanks

1. Mineral resources are classified as ……. and …….
2. An environmental impact of extraction and processing of sulphur ores is …….
3. …….. is a cheap renewable resource that can be used widely in rural India for cooking purposes.
4. The natural resources that include plants and animals are ……. and ……. respectively
5. Energy efficiency rating is given by …….. to electronic appliances in India.

3.10 Answers to Self-Check Questions

1) Multiple Choice Questions

1. Reservoir Induced Seismicity is a phenomenon
   a) Earthquakes due to dams and water reservoirs
   b) Volcano eruption that are caused by earthquakes.
   c) Earthquakes that are creating water reservoirs.
   d) Earthquake zone with forest reservoir

2. Climate change raises the risk of extreme weather events like
   a) Draught
   b) Flooding
   c) Wildfires
   d) All of the above

3. A country is said to experience water stress when annual water supplies drop below
   a) 1700 cubic meters per person
   b) 500 cubic meters per person.
   c) 5000 cubic meters per person.
   d) 10000 cubic meters per person

4. What is the purpose of Dam Construction
   a) Storing water

b) Generating electricity
c) Prevent flood
d) All of the above

6. What is project “Tiger”
   e) Hunting of tigers in Indian forests
   f) Feeding tigers in Indian zoological parks
   g) Protecting and restoring habitat of tigers
   h) Creating law against tiger hunting

2) True or False

1. About 68.7% of total water present on the earth’s surface is inaccessible to human. **True**
2. Atomic Power is renewable natural source of energy. **False**
3. Monsoon precipitation has been the lifeline of India with respect to agriculture as well as recharging its water resources. **True**
4. Increasing population is not responsible for stress on groundwater level. **False**
5. Overfishing and Illegal fishing is not depleting fishery resources. **False**

3) Fill in the blanks

1. Mineral resources are classified as **metallic** and **non-metallic**
2. An environmental impact of extraction and processing of sulphur ores is **acid mine drainage.**
3. **Bio-energy** is a cheap renewable resource that can be used widely in rural India for cooking purposes.
4. The natural resources that include plants and animals are **Flora** and **Fauna** respectively.
5. Energy efficiency rating is given by **Bureau of Energy Efficiency** to electronic appliances in India.

3.11 Case Study Based Question:

From Barren Land to Lush Forest, the Story of Dhun: Where there is a will there is a way

500 acres of dusty and dry in Phagi district, on the outskirts of Jaipur, which barely had 30 trees, has been converted to a lush green forest with 70 species of native trees, more than 120 species of birds, and 1000s of animals, by the vision, planning and extreme hard work and will of Manavendra Singh Shekhawat, and his team.

The land once, an agricultural land bubbling with life was destroyed and left to desertify. Its fate changed in 2013 and an ecosystem was created. The first step was to bring water to the land and harvest it, as water is life. **Watch the first video to find out how the team managed that**. The water not only helped revive the land, it drastically

transformed the lives and economies of the nearby villages. The next mission of the team was restore the ecology of the area which they successfully managed and created not only a grassland but also a forest land. **Watch the second part of the video to know how.** They managed to achieve the whole task by the help, advice, and knowledge of the local community. This story is truly a glimmer of hope in the time of despair. It is possible to reverse the damage done by us, if we have the will and determination to do so.

Watch both the inspiring videos carefully and answer the questions given below.

DHUN 1 https://youtu.be/415an1V0FxQ

DHUN 2 https://youtu.be/ATZAkFtVAsQ

1) Which event in the district led to the ruining of the top soil of Phagi in 1981?

2) Name two forms of water harvesting that were built in this region to retain water.

3) List a few native trees that were reintroduced in this area that fit into its vegetation pallet.

4) What role do traditional grasses play in improving the general ecology of the area? Name 3-4 benefits.

5) Name some future projects envisioned by the creators in this land that will not only keep nature intact but also create a sustainable living environment for the future settlement.

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3.13 Suggested readings and videos

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