ENVIRONMENTAL STUDIES

Environmental Issues, Energy Conservation & Renewable Energy

Chapter: Environmental Studies

Complete Study Notes with Diagrams and 50 Practice MCQs

These notes are prepared for students of West Bengal who are preparing for government job examinations. Every topic is explained in simple English with definitions, lists, tables and diagrams, followed by a box of key points that are frequently asked in competitive examinations. At the end of the chapter, 50 multiple-choice questions with an answer key are given for practice.

Topics Covered

No.	Topic	No.	Topic
1	Environment and Ecosystem	7	Global Warming
2	Components of Environment	8	Climate Change
3	Food Chain and Food Web	9	Greenhouse Effect
4	Biodiversity	10	Ozone Layer Depletion
5	Natural Resources	11	Acid Rain
6	Deforestation	12	Sustainable Development
	50 MCQs		Answer Key

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1. Environment and Ecosystem

Environment

The word *environment* comes from the French word *environner*, meaning "to surround". Environment is the sum total of all living (biotic) and non-living (abiotic) things, conditions and influences that surround an organism and affect its life, growth and survival. It includes air, water, soil, climate, plants, animals, microorganisms and human society.

Scope and Importance

- It supports life by providing air, water, food, shelter and energy.
- It regulates climate, rainfall and the water cycle.
- Its balance decides the health of humans and all other species.
- Environmental studies is a multidisciplinary subject combining biology, chemistry, geography, geology, economics and sociology.

Ecology and Ecosystem

Ecology is the scientific study of the relationship between organisms and their environment. The term was coined by the German biologist **Ernst Haeckel** in **1866**. An **ecosystem** is a structural and functional unit of nature in which living organisms interact with each other and with the physical environment. The term was coined by the British ecologist **A. G. Tansley** in **1935**.

Structure of an Ecosystem

- **Abiotic components:** sunlight, temperature, water, air, soil, minerals and nutrients.
- **Biotic components:** producers (autotrophs), consumers (heterotrophs) and decomposers.

Functions of an Ecosystem

- **Energy flow:** energy enters as sunlight, is captured by producers and moves in one direction only.
- **Nutrient (biogeochemical) cycling:** carbon, nitrogen, water, phosphorus and other materials move repeatedly between living and non-living parts.
- **Ecological succession:** gradual, orderly change in the species composition of a community over time.
- **Homeostasis:** the ability of an ecosystem to maintain its balance.

Types of Ecosystem

Category	Type	Examples
Natural	Terrestrial	Forest, grassland, desert, tundra
Natural	Aquatic (freshwater)	Pond, lake, river, wetland
Natural	Aquatic (marine)	Ocean, sea, coral reef, estuary, mangrove (Sundarbans)
Artificial (man-made)	Created by humans	Crop field, garden, aquarium, reservoir, urban park

Key Points for Competitive Exams

- Ecology: Ernst Haeckel (1866). Ecosystem: A. G. Tansley (1935).
- World Environment Day: 5 June. Earth Day: 22 April. World Wildlife Day: 3 March.
- India's umbrella law: Environment (Protection) Act, 1986, passed after the Bhopal gas tragedy (1984).
- The Ministry of Environment, Forest and Climate Change (MoEFCC) is the nodal ministry in India.
- The largest ecosystem on earth is the biosphere; the largest natural ecosystem by area is the ocean.

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2. Components of Environment

The environment has two major groups of components: **abiotic** (non-living) and **biotic** (living). The zone of earth where life exists, where the lithosphere, hydrosphere and atmosphere meet, is called the **biosphere**.

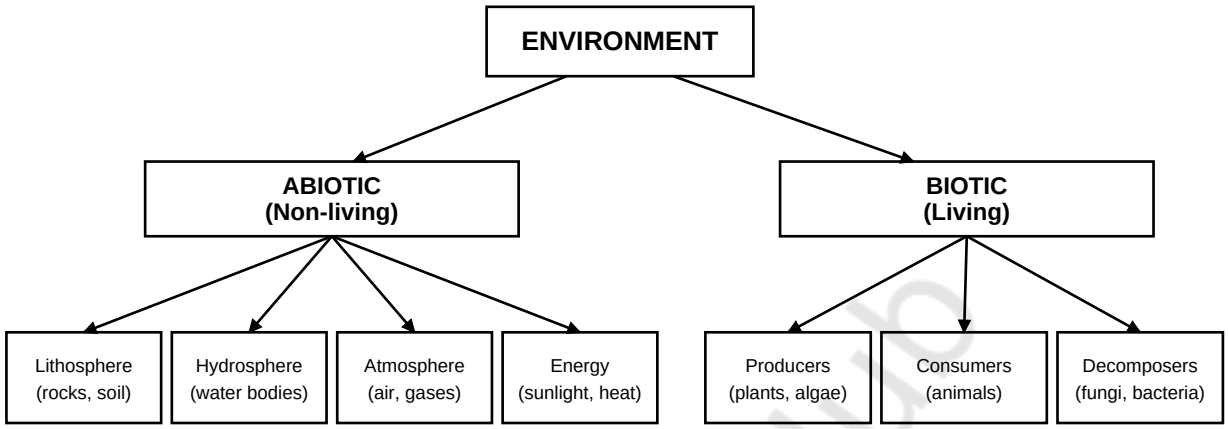


Fig. 1: Components of the environment

A. Abiotic Components

Component	Description	Key facts
Lithosphere	Solid outer crust of the earth: rocks, minerals and soil	Source of minerals, fossil fuels and soil for agriculture
Hydrosphere	All water on earth: oceans, rivers, lakes, ice and groundwater	About 71% of earth's surface is water; about 97% of it is saline; only about 2.5-3% is freshwater, most of it frozen in glaciers and ice caps
Atmosphere	Envelope of gases around the earth	Nitrogen about 78%, oxygen about 21%, argon about 0.93%, carbon dioxide about 0.04%
Energy	Solar energy, heat	The Sun is the ultimate source of energy for almost all ecosystems

Layers of the Atmosphere

Layer	Height (approx.)	Important features
Troposphere	0 - 12 km	Contains most of the air and water vapour; all weather happens here; temperature falls with height
Stratosphere	12 - 50 km	Contains the ozone layer; temperature rises with height; jet planes fly here
Mesosphere	50 - 80 km	Coldest layer; meteors burn up here
Thermosphere	80 - 600 km	Very hot; contains the ionosphere which reflects radio waves; aurora occurs here
Exosphere	Above 600 km	Outermost layer; gradually merges with outer space

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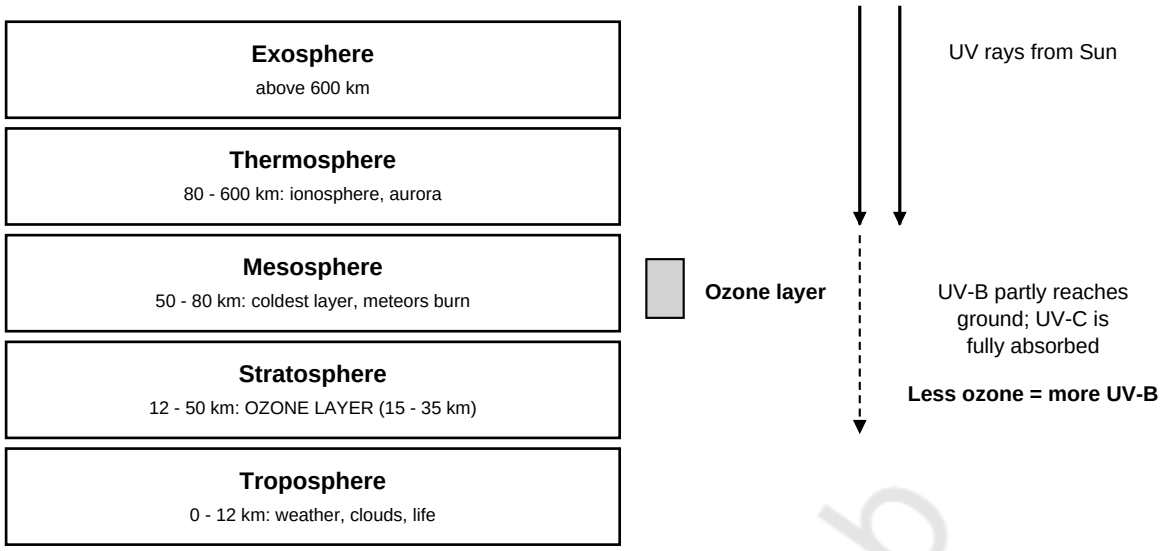


Fig. 2: Layers of the atmosphere and the ozone layer

B. Biotic Components

Group	Role	Examples
Producers (autotrophs)	Make their own food by photosynthesis or chemosynthesis	Green plants, algae, phytoplankton, some bacteria
Consumers (heterotrophs)	Depend on other organisms for food. Herbivores (primary), carnivores (secondary/tertiary), omnivores	Deer, cow, frog, snake, tiger, humans
Decomposers (saprotrophs)	Break down dead organic matter and return nutrients to the soil	Bacteria, fungi, earthworms (detritivores)

Natural and Man-made Environment

The **natural environment** consists of things not made by humans (forests, rivers, mountains, climate). The **man-made (built) environment** consists of things created by humans such as cities, roads, industries, dams and buildings. Human activities increasingly change the natural environment.

Key Points for Competitive Exams

- Nitrogen is the most abundant gas; oxygen is second. Carbon dioxide is about 0.04%.
- Ozone layer is in the stratosphere. Weather occurs in the troposphere.
- Producers form the first trophic level in every ecosystem.
- Biosphere = lithosphere + hydrosphere + atmosphere + living organisms.

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3. Food Chain and Food Web

Food Chain

A **food chain** is a linear sequence of organisms in which each organism is food for the next. It shows the path of energy flow from producers to top consumers. Each step in a food chain is called a **trophic level**.

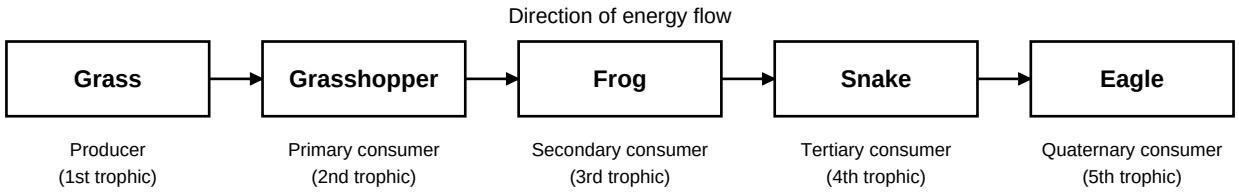


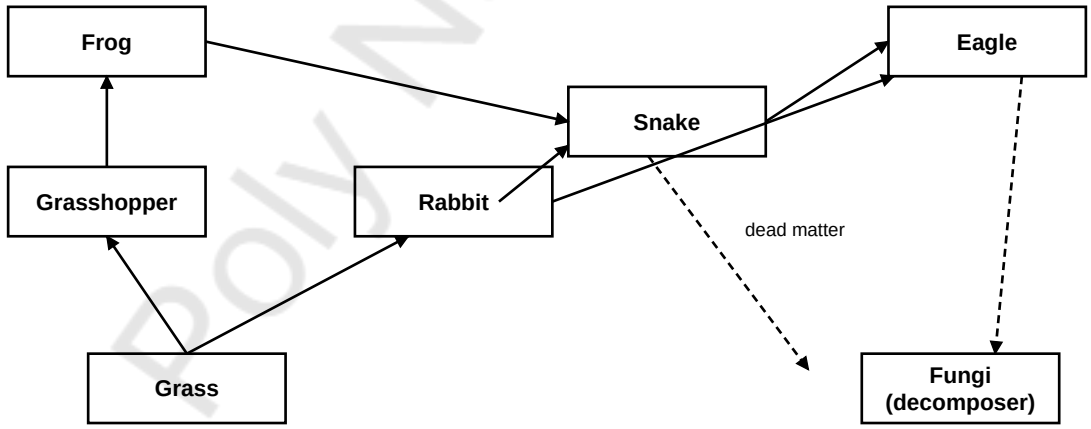
Fig. 3: A grassland food chain

Types of Food Chain

Type	Starts with	Example
Grazing food chain	Green plants (producers)	Grass, grasshopper, frog, snake, eagle
Detritus food chain	Dead organic matter (detritus)	Dead leaves, earthworm, bird, hawk
Parasitic food chain	A large host	Tree, bird, lice, bacteria

Food Web

In nature, one organism usually feeds on several kinds of food and is eaten by several predators. Many interconnected food chains therefore form a network called a **food web**. A food web is more stable than a single food chain because if one species declines, the consumers can switch to another food source.



Arrows point from the food to the eater; dashed arrows show dead matter going to decomposers

Fig. 4: A simple food web

Ten Percent Law of Energy Transfer

Proposed by **Raymond Lindeman (1942)**. Only about **10%** of the energy of one trophic level is transferred to the next level; the remaining 90% is lost as heat in respiration, movement and other life processes. For this reason, food chains are short (usually 4 to 5 levels) and there are fewer organisms at higher levels.

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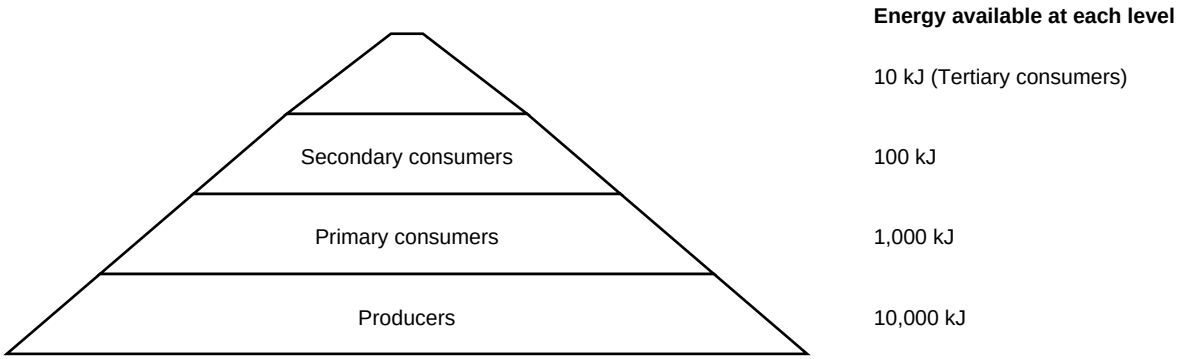


Fig. 5: Pyramid of energy (always upright)

Ecological Pyramids

Pyramid	Shape	Remark
Pyramid of numbers	Upright in grassland and pond; inverted in a tree ecosystem	Shows number of individuals at each level
Pyramid of biomass	Upright in land; inverted in ponds/oceans	Shows dry weight of living matter
Pyramid of energy	Always upright	Shows energy at each level; never inverted

Bioaccumulation and Biomagnification

Bioaccumulation is the build-up of a harmful, non-degradable chemical inside the body of an organism. **Biomagnification** is the increase in the concentration of that chemical at each higher trophic level. Top carnivores therefore carry the highest concentration. Examples: DDT (thinning of eggshells in eagles and pelicans) and mercury (Minamata disease in Japan).

Key Points for Competitive Exams

- Energy flow is one-way (unidirectional); nutrients move in cycles.
- Lindeman's 10% law: only 10% of energy passes to the next trophic level.
- Pyramid of energy is always upright.
- Biomagnification: concentration of pollutants is highest in top carnivores.
- In an aquatic ecosystem, the producers are mainly phytoplankton.

4. Biodiversity

Biodiversity (biological diversity) means the variety of all life forms on earth: plants, animals, microorganisms, their genes and the ecosystems they form. The term was coined by **Walter G. Rosen in 1985**. The Convention on Biological Diversity (CBD) was adopted at the Rio Earth Summit in 1992.

Levels of Biodiversity

Level	Meaning	Example
Genetic diversity	Variation of genes within a species	Thousands of rice varieties; many mango varieties
Species diversity	Variety of species in a region	Tropical rainforests have the highest species diversity
Ecosystem diversity	Variety of habitats and ecosystems	Forests, deserts, wetlands, coasts, mountains

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Diversity Measures (Whittaker)

- **Alpha diversity:** diversity within a community or habitat.
- **Beta diversity:** change in diversity between habitats.
- **Gamma diversity:** total diversity of a large region or landscape.

Value of Biodiversity

- **Direct use:** food, medicine, timber, fibre, fuel.
- **Indirect use:** pollination, soil formation, climate regulation, water purification, nutrient cycling.
- **Ethical and aesthetic:** cultural, spiritual and recreational value.

India's Biodiversity

India is one of the **17 mega-diverse countries** of the world. It has only about 2.4% of the world's land area but supports roughly 7-8% of all recorded species.

Biodiversity Hotspots

The concept was introduced by **Norman Myers (1988)**. A region is a hotspot if it has at least **1,500 species of endemic vascular plants** and has lost at least **70%** of its original habitat. There are 36 hotspots in the world and **4 in India**.

Hotspot in India	Region covered
Himalaya	Eastern Himalaya including Darjeeling and Sikkim, Bhutan, Nepal
Indo-Burma	North-East India (except Brahmaputra valley floor), Myanmar, Thailand etc.
Western Ghats and Sri Lanka	Western Ghats of India and Sri Lanka
Sundaland	Includes the Nicobar Islands of India

Threats to Biodiversity

- Habitat loss and fragmentation (the biggest threat), deforestation and urbanisation.
- Poaching and illegal wildlife trade.
- Pollution and climate change.
- Invasive alien species (such as water hyacinth and Lantana).
- Over-exploitation of resources; man-animal conflict.

Conservation of Biodiversity

Method	Meaning	Examples
In-situ (on site)	Protecting species in their natural habitat	National parks, wildlife sanctuaries, biosphere reserves, tiger reserves, sacred groves
Ex-situ (off site)	Protecting species outside their natural habitat	Zoos, botanical gardens, gene banks, seed banks, cryopreservation, tissue culture

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West Bengal at a Glance

Protected area	Key feature
Sundarbans (South 24 Parganas)	World's largest mangrove forest and delta; Royal Bengal Tiger; UNESCO World Heritage Site (1987); Biosphere Reserve (1989); Ramsar site
Jaldapara National Park	Indian one-horned rhinoceros
Gorumara National Park	Rhino, elephants, Indian bison (gaur)
Buxa Tiger Reserve	Tiger reserve in Alipurduar district
Singalila National Park	Red panda; trekking route to Sandakphu
Neora Valley National Park	Rich Eastern Himalayan biodiversity
Padmaja Naidu Himalayan Zoological Park, Darjeeling	Known for red panda and snow leopard conservation breeding

IUCN Red List Categories (high to low risk)

Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), Not Evaluated (NE). The IUCN is headquartered in Gland, Switzerland.

Important Laws and Programmes

Year	Law / programme
1972	Wildlife (Protection) Act, 1972
1973	Project Tiger launched
1980	Forest (Conservation) Act
1992	Convention on Biological Diversity (Rio)
2002	Biological Diversity Act, 2002 (National Biodiversity Authority, Chennai)

Key Points for Competitive Exams

- Biodiversity term: Walter G. Rosen (1985). Hotspot concept: Norman Myers (1988).
- India has 4 hotspots: Himalaya, Indo-Burma, Western Ghats and Sri Lanka, Sundaland.
- Tropical regions, especially rainforests, have the highest biodiversity; diversity decreases from equator to poles.
- In-situ: national parks, sanctuaries, biosphere reserves. Ex-situ: zoos, botanical gardens, gene banks.
- Sundarbans is the only mangrove tiger habitat in the world.

5. Natural Resources

A **natural resource** is any material or energy source provided by nature that humans use to meet their needs. Examples include air, water, soil, forests, minerals, fossil fuels, sunlight and wind.

Classification of Natural Resources

Type	Meaning	Examples
Inexhaustible	Never get used up by human use	Sunlight, wind, tides
Renewable	Can be replenished naturally in a reasonable time if used wisely	Forests, water, soil, fish, biomass, solar and wind energy
Non-renewable	Limited stock; form over millions of years	Coal, petroleum, natural gas, minerals, metals

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Major Natural Resources

Resource	Uses	Problems and conservation
Forest	Timber, fuel wood, medicine, oxygen, rainfall, soil protection	Deforestation, forest fires, overgrazing. Afforestation, social forestry, protected areas
Water	Drinking, irrigation, industry, hydro power	Over-use of groundwater, pollution, floods and droughts. Rainwater harvesting, drip irrigation, recycling
Mineral	Industry, construction, electronics	Mining damages land and water. Recycling, substitutes, efficient use
Energy	Transport, industry, electricity, cooking	Fossil-fuel pollution. Energy conservation and renewable energy
Land	Agriculture, housing, industry	Soil erosion, desertification, salinisation. Contour farming, terracing, crop rotation
Food	Cereals, vegetables, fish, livestock	Over-fishing, overgrazing, monoculture. Sustainable agriculture, organic farming

Over-utilisation of Resources

Rapid population growth, urbanisation and industrialisation have increased demand for resources. Over-use leads to depletion of resources, pollution, loss of biodiversity and conflict over resources (for example, river water disputes).

Resource Conservation: The 3Rs

- **Reduce** the use of resources.
- **Reuse** items again and again.
- **Recycle** waste into new products.

Resources in West Bengal and India

- Coal: the Raniganj coalfield in West Bengal is among the oldest coalfields in India (mining began in 1774).
- Jharia (Jharkhand) is famous for coking coal.
- Water: India has about 4% of the world's freshwater but about 16-18% of the world's population.
- Hooghly and Ganga-Brahmaputra systems are vital water resources for West Bengal.

Key Points for Competitive Exams

- Coal, petroleum and natural gas are fossil fuels (non-renewable).
- Forests, water and soil are renewable if managed properly.
- Water conservation methods: rainwater harvesting, drip and sprinkler irrigation, watershed management.
- Jal Shakti Abhiyan, Namami Gange and Atal Bhujal Yojana are major water-related initiatives of India.

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6. Deforestation

Deforestation is the permanent removal or clearing of forests for non-forest uses such as agriculture, mining, construction and industry. Forests act as the "lungs of the earth" and are the largest carbon store on land.

Causes of Deforestation

Natural causes	Human (anthropogenic) causes
Forest fires, cyclones and storms, floods and landslides, drought, insect and disease attack	Agricultural expansion and shifting cultivation (jhum); urbanisation and housing; mining and quarrying; dams and roads; industrial and fuel wood demand; overgrazing; commercial logging; forest fires set by humans

Effects of Deforestation

Area affected	Effect
Climate	Less carbon dioxide absorbed, so global warming increases; local rainfall decreases
Soil	Soil erosion, loss of fertility, landslides and floods; desertification
Water	Lower groundwater recharge; siltation of rivers and dams
Biodiversity	Loss of habitat; extinction of species; man-animal conflict
Humans	Loss of livelihood of forest-dwelling communities; shortage of wood and medicines

Measures to Control Deforestation

- Afforestation (planting trees on land that had no forest) and reforestation (replanting in cut forests).
- Social forestry and agroforestry; use of alternative fuels such as LPG and biogas.
- Strict implementation of the Forest (Conservation) Act, 1980.
- Controlled grazing, fire prevention and sustainable timber use.
- Public awareness and community participation (Joint Forest Management).

Important Forest Movements and Policies in India

Event	Details
Chipko Movement (1973)	Started in Chamoli district, Uttarakhand; associated with Sunderlal Bahuguna and Gaura Devi; villagers hugged trees to stop felling
Appiko Movement (1983)	Karnataka (Western Ghats); led by Pandurang Hegde; "appiko" means to hug
Joint Forest Management (JFM)	First started at Arabari, Midnapore district, West Bengal (1971-72) under forest officer A. K. Banerjee
Van Mahotsava (1950)	Tree-planting festival started by K. M. Munshi; celebrated in July
National Forest Policy (1988)	Target of 33% of total land area under forest; 66% in hilly areas
Forest Rights Act (2006)	Recognises the rights of forest-dwelling Scheduled Tribes and other traditional forest dwellers

Forest Cover of India

The **Forest Survey of India (FSI)**, Dehradun, publishes the **India State of Forest Report (ISFR)** every two years. According to ISFR 2023, forest cover is about 21.76% of the country's area and forest plus tree cover is about 25.17%. Madhya Pradesh has the largest forest area, while Mizoram has the highest percentage of forest cover. *Figures change with each report, so check the latest edition before the examination.*

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Key Points for Competitive Exams

- Chipko (1973, Uttarakhand), Appiko (1983, Karnataka), JFM (Arabari, West Bengal).
- National Forest Policy 1988: 33% forest cover target.
- FSI is headquartered at Dehradun; ISFR is published every two years.
- Afforestation = planting where there was no forest; reforestation = replanting where forest was lost.

7. Global Warming

Global warming is the long-term increase in the average temperature of the earth's surface, lower atmosphere and oceans, mainly caused by the increase of greenhouse gases from human activities. According to the IPCC, the global surface temperature in 2011-2020 was about **1.1 °C** higher than in 1850-1900.

Causes of Global Warming

Cause	Explanation
Burning of fossil fuels	Coal, oil and gas in power plants, industry and vehicles release carbon dioxide
Deforestation	Fewer trees to absorb carbon dioxide; burning forests releases stored carbon
Agriculture and livestock	Methane from paddy fields and cattle; nitrous oxide from fertilisers
Industrial gases	CFCs, HFCs and other synthetic gases trap heat strongly
Landfills and waste	Decomposing waste releases methane

Global Warming Potential (GWP) of Gases

Gas	GWP over 100 years (approx.)	Main source
Carbon dioxide (CO_2)	1 (reference)	Fossil fuels, deforestation
Methane (CH_4)	About 28-30	Paddy fields, cattle, landfills, natural gas
Nitrous oxide (N_2O)	About 265-298	Fertilisers, burning of biomass
Sulphur hexafluoride (SF_6)	About 23,500	Electrical equipment
CFCs / HFCs	Thousands of times CO_2	Refrigerators, air conditioners, aerosols

Effects of Global Warming

- **Melting of glaciers and ice caps** (Himalayan glaciers, Arctic and Antarctic).
- **Sea-level rise** from melting ice and thermal expansion of water; threatens coastal areas and islands.
- **Extreme weather:** more intense cyclones, floods, heat waves and droughts.
- **Ocean warming and acidification;** coral bleaching.
- **Loss of biodiversity** and shifting of habitats.
- **Effect on agriculture and health:** lower crop yield, spread of diseases such as malaria and dengue.

Impact on West Bengal

The Sundarbans delta is highly vulnerable to sea-level rise, coastal erosion and cyclones (such as Aila in 2009 and Amphan in 2020). Islands like Ghoramara and parts of Sagar island have lost land to the sea.

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Control Measures

- Shift to renewable energy (solar, wind, hydro) and improve energy efficiency.
- Afforestation and forest protection.
- Public transport, electric vehicles and cleaner fuels.
- Reduce methane from waste and agriculture; carbon capture technologies.
- International cooperation: UNFCCC, Kyoto Protocol, Paris Agreement.

Key Points for Competitive Exams

- Carbon dioxide is the main greenhouse gas by quantity; methane and nitrous oxide are more potent per molecule.
- Sea-level rise is caused by melting land ice and thermal expansion of seawater.
- Sundarbans is highly vulnerable to sea-level rise.
- Global warming is a result of the enhanced greenhouse effect.

8. Climate Change

Climate change is a long-term change (decades or longer) in average weather patterns such as temperature, rainfall and wind of a region or of the whole earth. **Weather** is the day-to-day state of the atmosphere, whereas **climate** is the average weather of a place over at least 30 years.

Causes of Climate Change

Natural causes	Anthropogenic (human) causes
Volcanic eruptions; variation in solar output; changes in earth's orbit (Milankovitch cycles); ocean currents (El Nino and La Nina); natural changes in greenhouse gas levels	Fossil-fuel burning; deforestation; industrial and agricultural emissions; urbanisation; waste

Effects of Climate Change in India

- Irregular monsoon, more floods and droughts; changes in crop patterns.
- Glacier retreat in the Himalayas, affecting rivers like the Ganga and Brahmaputra.
- Rising sea level threatening coastal cities and delta regions.
- Increase in heat waves and extreme cyclones; health risks.

International Efforts

Year	Event	Key point
1972	Stockholm Conference	First major UN conference on the human environment
1985 / 1987	Vienna Convention / Montreal Protocol	Protection of the ozone layer
1988	IPCC established	By WMO and UNEP; provides scientific assessments on climate change
1992	UNFCCC (Rio Earth Summit)	Framework treaty on climate change; entered into force in 1994; COP meets yearly
1997	Kyoto Protocol	Binding emission targets for developed countries; came into force in 2005
2015	Paris Agreement (COP21)	Hold warming well below 2 °C and pursue 1.5 °C; Nationally Determined Contributions (NDCs); in force 2016
2021	COP26, Glasgow	India announced net-zero target by 2070 and "Panchamrit" goals

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India's Climate Initiatives

- National Action Plan on Climate Change (NAPCC), 2008, with eight national missions (including the National Solar Mission).
- West Bengal and other states have State Action Plans on Climate Change.
- International Solar Alliance (ISA), launched by India and France in 2015.
- Mission LiFE (Lifestyle for Environment), launched in 2022.
- Goal of net-zero emissions by 2070.

Key Points for Competitive Exams

- IPCC: 1988. UNFCCC: 1992. Kyoto: 1997. Paris: 2015.
- Paris Agreement goal: well below 2 °C, efforts towards 1.5 °C.
- NAPCC was launched in 2008 and has 8 missions.
- Weather is short-term; climate is the long-term average (30 years or more).

9. Greenhouse Effect

The **greenhouse effect** is the natural process by which certain gases in the atmosphere trap part of the heat radiated by the earth and keep the planet warm. Without it, the average surface temperature would be about **-18 °C** instead of the present **about 15 °C**, and life as we know it would not be possible. The problem arises when human activities increase these gases and enhance the effect, leading to global warming.

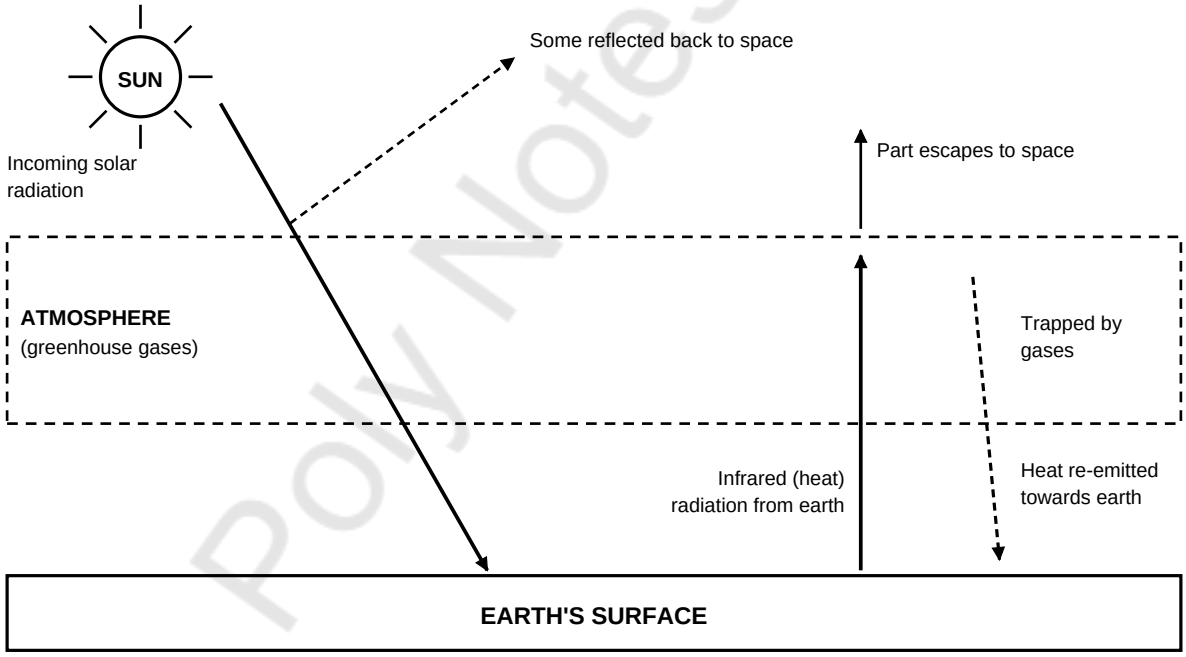


Fig. 6: Working of the greenhouse effect

How It Works

- Short-wave solar radiation passes through the atmosphere and warms the earth's surface.
- The earth re-radiates this energy as long-wave infrared (heat) radiation.
- Greenhouse gases absorb part of this infrared radiation and re-emit it in all directions, including back towards the earth.
- This trapped heat raises the temperature of the lower atmosphere.

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Major Greenhouse Gases

Gas	Natural sources	Human sources
Water vapour	Evaporation from oceans and water bodies	Indirect (more warming gives more vapour)
Carbon dioxide (CO_2)	Respiration, volcanoes, decay	Fossil fuels, cement, deforestation
Methane (CH_4)	Wetlands, termites	Rice fields, cattle, landfills, coal mining
Nitrous oxide (N_2O)	Soil and ocean processes	Fertilisers, burning of biomass
Ozone (O_3) (lower atmosphere)	Lightning	Vehicle and industrial pollution
CFCs, HFCs, PFCs, SF_6	None (synthetic)	Refrigeration, air conditioning, aerosols, electrical industry

Natural vs Enhanced Greenhouse Effect

Natural greenhouse effect	Enhanced greenhouse effect
Essential for life; keeps earth warm	Caused by extra gases from human activity
Maintains average temperature of about 15 °C	Raises global temperature (global warming)
Balanced and stable	Disturbs climate and weather patterns

Key Points for Competitive Exams

- Without the greenhouse effect, earth's average temperature would be about -18 °C.
- Water vapour is the most abundant greenhouse gas; carbon dioxide contributes the most to human-caused warming.
- Carbon dioxide level in the atmosphere is now above 420 ppm (parts per million).
- CFCs damage the ozone layer and also act as greenhouse gases.

10. Ozone Layer Depletion

Ozone (O_3) is a pale blue gas made of three oxygen atoms. About 90% of atmospheric ozone lies in the **stratosphere**, in a region about 15 to 35 km above the earth called the **ozone layer**. It absorbs most of the Sun's harmful **ultraviolet (UV) radiation**, especially UV-B and all UV-C. Ozone is measured in **Dobson Units (DU)**. (See Fig. 2.) Ozone in the stratosphere is "good ozone"; ozone near the ground is "bad ozone" (a pollutant).

Ozone Depleting Substances (ODS)

Substance	Uses
Chlorofluorocarbons (CFCs)	Refrigerators, air conditioners, aerosol sprays, foam
Halons	Fire extinguishers
Carbon tetrachloride, methyl chloroform	Solvents, cleaning agents
Methyl bromide	Pesticide / fumigant
HCFCs	Temporary substitutes for CFCs

Mechanism of Depletion

In the stratosphere, UV rays break CFC molecules and release chlorine atoms. One chlorine atom can destroy about **100,000 ozone molecules** before it is removed from the stratosphere.

$Cl + O_3$ gives $ClO + O_2$; then $ClO + O$ gives $Cl + O_2$. The chlorine atom is released again and the cycle repeats.

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Antarctic Ozone Hole

The ozone hole over Antarctica was discovered in **1985** by British scientists **Joseph Farman, Brian Gardiner and Jonathan Shanklin**. It forms every year in September-October because of extremely cold temperatures, polar stratospheric clouds and returning sunlight, which speed up chlorine reactions.

Effects of Ozone Depletion

- **Human health:** skin cancer, cataract and other eye disease, weaker immune system.
- **Plants:** reduced photosynthesis and crop yield.
- **Aquatic life:** damage to phytoplankton, the base of the marine food chain.
- **Materials:** faster damage to plastic, paint and rubber.

Control Measures and International Agreements

Year	Agreement	Purpose
1985	Vienna Convention	Framework for protecting the ozone layer
1987	Montreal Protocol	Phase-out of ODS; considered the most successful environmental treaty; came into force in 1989
2016	Kigali Amendment	Phase-down of HFCs (strong greenhouse gases)

India and the ozone layer: India joined the Montreal Protocol in 1992 and has an Ozone Cell in the MoEFCC. **International Ozone Day** (World Ozone Day) is observed on **16 September**. The ozone layer is expected to recover to 1980 levels around the middle of this century (Antarctic region around 2066).

Key Points for Competitive Exams

- Ozone layer lies in the stratosphere and absorbs UV-B and UV-C rays.
- Montreal Protocol: 1987. Vienna Convention: 1985. Kigali Amendment: 2016. Ozone Day: 16 September.
- Ozone hole was discovered over Antarctica in 1985 by Farman, Gardiner and Shanklin.
- Ozone is measured in Dobson units.
- CFCs were invented by Thomas Midgley Jr. and were widely used before the ban.

11. Acid Rain

Acid rain is rain, snow, fog or dust with a pH lower than **5.6**. Normal rain is slightly acidic (pH about 5.6) because carbon dioxide dissolves in rainwater to form weak carbonic acid. The term "acid rain" was first used by **Robert Angus Smith** in **1872** in Manchester, England. The pH scale runs from 0 to 14; a pH below 7 is acidic.

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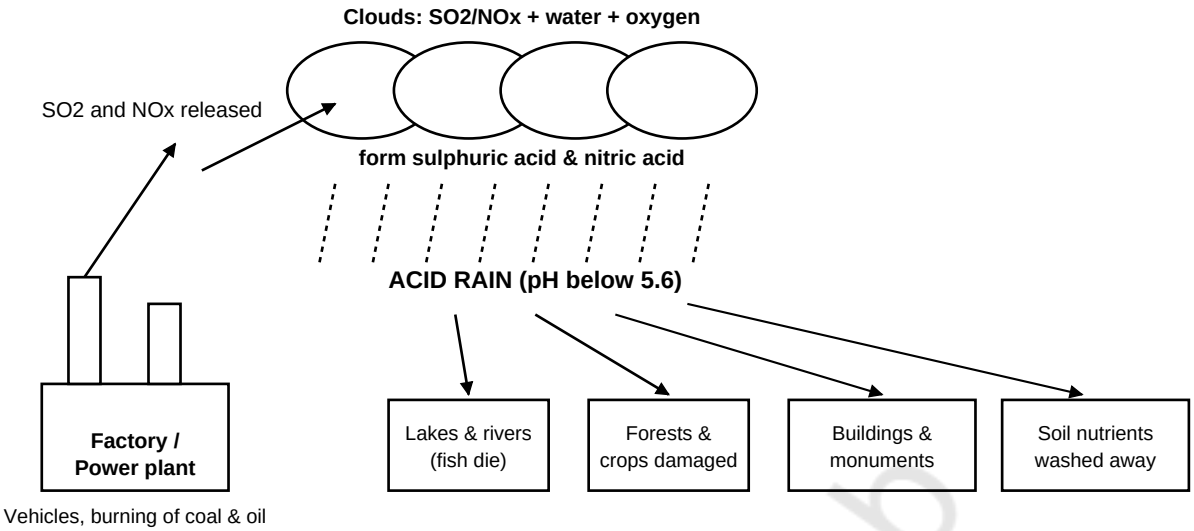


Fig. 7: Formation and effects of acid rain

Causes

Source	Pollutant	Acid formed
Coal-based power plants, smelters, refineries	Sulphur dioxide (SO_2)	Sulphuric acid (H_2SO_4)
Vehicles, industries, high-temperature combustion	Nitrogen oxides (NO_x)	Nitric acid (HNO_3)
Natural: volcanoes, lightning, forest fires	SO_2, NO_x	Small amounts

Chemical reactions (in words, balanced): $2SO_2 + O_2 + 2H_2O$ gives $2H_2SO_4$; $4NO_2 + O_2 + 2H_2O$ gives $4HNO_3$.

Effects of Acid Rain

- **Aquatic life:** lakes and rivers become acidic, fish and other organisms die (e.g. lakes in Scandinavia).
- **Forests and crops:** leaves damaged, nutrients washed out of soil, trees weakened (Black Forest, Germany).
- **Soil:** loss of calcium, magnesium and potassium; release of toxic aluminium.
- **Buildings and monuments:** marble, limestone and metals corrode. The Taj Mahal at Agra has shown yellowing and pitting ("marble cancer"); emissions from the Mathura refinery and nearby industries were a concern.
- **Human health:** respiratory problems, and toxic metals in drinking water.

Control Measures

- Install flue-gas desulphurisation (scrubbers) in power plants.
- Use low-sulphur fuel; shift to renewable energy and natural gas.
- Use catalytic converters in vehicles and follow emission norms (Bharat Stage standards).
- Add lime (liming) to acidified lakes and soil.
- Reduce energy use and promote public transport.

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Key Points for Competitive Exams

- Acid rain: pH below 5.6. Normal rain pH is about 5.6.
- Main causes: sulphur dioxide and nitrogen oxides.
- Term coined by Robert Angus Smith (1872).
- Taj Mahal is affected by acid rain and air pollution; Supreme Court has acted through the Taj Trapezium Zone (TTZ) orders.
- Acid rain is a transboundary pollution problem, as winds carry pollutants far away.

12. Sustainable Development

Sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. This definition was given by the **Brundtland Commission** (World Commission on Environment and Development, chaired by **Gro Harlem Brundtland**) in its 1987 report **"Our Common Future"**.

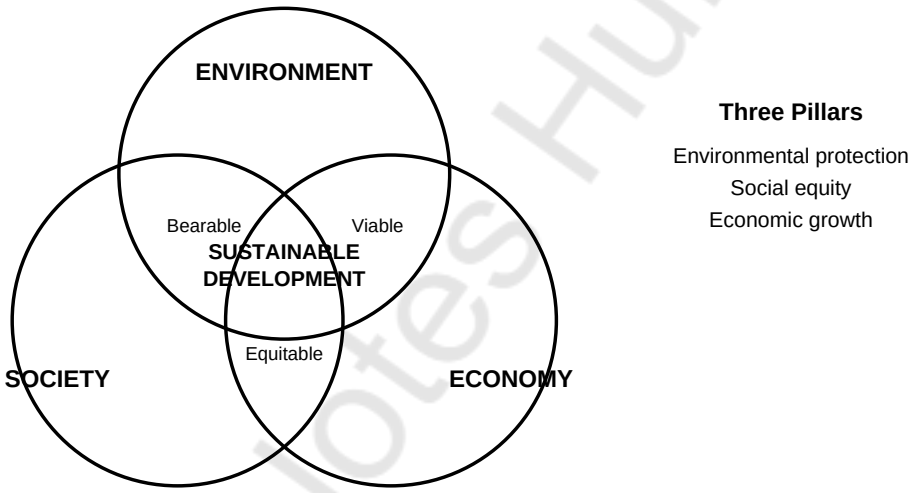


Fig. 8: Three pillars of sustainable development

Principles of Sustainable Development

- **Inter-generational equity:** fairness to future generations.
- **Intra-generational equity:** fair sharing of resources within the present generation.
- **Precautionary principle:** take preventive action even if scientific proof is not complete.
- **Polluter pays principle:** the one who pollutes bears the cost of cleaning.
- **Conservation of biodiversity and ecosystems;** carrying-capacity limits.

Milestones towards Sustainable Development

Year	Event	Outcome
1972	UN Conference on Human Environment, Stockholm	First global environment conference; UNEP created; World Environment Day started
1987	Brundtland Report	Popularised the term sustainable development
1992	Earth Summit, Rio de Janeiro	Agenda 21, UNFCCC, CBD, Rio Declaration
2002	World Summit, Johannesburg	Review of Agenda 21 and implementation targets
2012	Rio+20	Decision to create the Sustainable Development Goals
2015	UN adopts Agenda 2030	17 Sustainable Development Goals (SDGs) with 169 targets

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Selected Sustainable Development Goals

SDG	Goal
1	No poverty
2	Zero hunger
3	Good health and well-being
4	Quality education
6	Clean water and sanitation
7	Affordable and clean energy
11	Sustainable cities and communities
12	Responsible consumption and production
13	Climate action
14	Life below water
15	Life on land
17	Partnerships for the goals

Ways to Achieve Sustainable Development

- Use of renewable energy and energy-efficient technologies.
- Waste management: reduce, reuse, recycle; circular economy.
- Sustainable agriculture, organic farming and water conservation.
- Environmental education and public participation; green buildings and public transport.
- Strong environmental laws and their proper enforcement.

Indian Initiatives

Initiative	Key point
Environment (Protection) Act, 1986	Umbrella law to protect and improve the environment
National Green Tribunal (NGT), 2010	Specialised body for quick disposal of environmental cases; principal bench in Delhi, with zonal benches including Kolkata (Eastern Zone)
Swachh Bharat Mission (2014)	Sanitation and cleanliness
Mission LiFE (2022)	Environment-friendly lifestyle
National Solar Mission, International Solar Alliance	Promotion of solar energy

Ecological Footprint

The **ecological footprint** measures the amount of biologically productive land and water needed to produce the resources a person or population consumes and to absorb its waste. It is an indicator of sustainability.

Key Points for Competitive Exams

- Brundtland Report "Our Common Future" (1987) defined sustainable development.
- Three pillars: environment, society and economy.
- SDGs: 17 goals adopted in 2015 to be achieved by 2030.
- Stockholm 1972, Rio 1992, Johannesburg 2002, Rio+20 2012.
- NGT was established in 2010; it follows the polluter pays and precautionary principles.

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Practice Questions: 50 MCQs

Choose the correct option for each question. The answer key is given at the end.

1. The term 'ecosystem' was coined by:

(A) Ernst Haeckel
(B) A. G. Tansley
(C) Eugene Odum
(D) Raymond Lindeman

2. The term 'ecology' was coined by Ernst Haeckel in:

(A) 1859
(B) 1900
(C) 1866
(D) 1935

3. World Environment Day is celebrated on:

(A) 5 June
(B) 22 April
(C) 16 September
(D) 22 March

4. The ozone layer is present in which layer of the atmosphere?

(A) Troposphere
(B) Mesosphere
(C) Thermosphere
(D) Stratosphere

5. Which is the most abundant gas in the atmosphere?

(A) Oxygen
(B) Nitrogen
(C) Argon
(D) Carbon dioxide

6. Approximately what share of the world's water is freshwater?

(A) 10%
(B) 25%
(C) 2.5-3%
(D) 50%

7. Producers in an ecosystem are also called:

(A) Autotrophs
(B) Heterotrophs
(C) Saprotrophs
(D) Detritivores

8. Lindeman's ten percent law is related to:

(A) Number of species
(B) Biomass of plants
(C) Nutrient cycling
(D) Energy transfer between trophic levels

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9. Which ecological pyramid is always upright?

(A) Pyramid of numbers
(B) Pyramid of biomass
(C) Pyramid of energy
(D) None of these

10. Biomagnification of DDT results in the highest concentration in:

(A) Producers
(B) Top carnivores
(C) Herbivores
(D) Decomposers

11. Which of the following is a decomposer?

(A) Fungi
(B) Grass
(C) Deer
(D) Frog

12. The term 'biodiversity' was coined by:

(A) Charles Darwin
(B) Norman Myers
(C) Walter G. Rosen
(D) Eugene Odum

13. The concept of biodiversity hotspots was given by:

(A) Norman Myers
(B) A. G. Tansley
(C) Ernst Haeckel
(D) Rachel Carson

14. How many biodiversity hotspots are found in India?

(A) 2
(B) 4
(C) 6
(D) 8

15. Which of these is NOT a biodiversity hotspot of India?

(A) Himalaya
(B) Indo-Burma
(C) Cape Floristic Region
(D) Western Ghats and Sri Lanka

16. The Sundarbans was declared a UNESCO World Heritage Site in:

(A) 1972
(B) 1980
(C) 1985
(D) 1987

17. Which of the following is an example of in-situ conservation?

(A) National park
(B) Zoo
(C) Seed bank
(D) Botanical garden

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18. Which of the following is an example of ex-situ conservation?

(A) Wildlife sanctuary
(B) Biosphere reserve
(C) Botanical garden
(D) Sacred grove

19. The Wildlife (Protection) Act in India was enacted in:

(A) 1962
(B) 1972
(C) 1982
(D) 1992

20. Project Tiger was launched in:

(A) 1952
(B) 1962
(C) 1982
(D) 1973

21. Which of the following is a non-renewable resource?

(A) Coal
(B) Wind
(C) Forest
(D) Solar energy

22. The Chipko Movement started in 1973 in which present-day state?

(A) Karnataka
(B) Uttarakhand
(C) Kerala
(D) Odisha

23. Joint Forest Management was first tried at Arabari in:

(A) Kerala
(B) Bihar
(C) West Bengal
(D) Assam

24. The National Forest Policy 1988 aims at forest cover of how much of the total land area?

(A) 10%
(B) 20%
(C) 25%
(D) 33%

25. Which state has the largest forest area in India?

(A) Madhya Pradesh
(B) Assam
(C) Odisha
(D) West Bengal

26. The headquarters of the Forest Survey of India is at:

(A) Kolkata
(B) Dehradun
(C) Nagpur
(D) Bhopal

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27. Which gas is the main anthropogenic contributor to global warming?

(A) Oxygen
(B) Nitrogen
(C) Carbon dioxide
(D) Argon

28. Which of the following has the highest Global Warming Potential?

(A) Carbon dioxide
(B) Methane
(C) Nitrous oxide
(D) Sulphur hexafluoride

29. Without the greenhouse effect, the earth's average temperature would be about:

(A) -18 °C
(B) 0 °C
(C) 15 °C
(D) 30 °C

30. The Paris Agreement was adopted in:

(A) 2009
(B) 2015
(C) 2020
(D) 1997

31. The Kyoto Protocol was adopted in:

(A) 1987
(B) 1992
(C) 1997
(D) 2015

32. The IPCC was established in:

(A) 1972
(B) 1985
(C) 1992
(D) 1988

33. The UNFCCC was adopted at:

(A) Rio Earth Summit, 1992
(B) Stockholm, 1972
(C) Kyoto, 1997
(D) Paris, 2015

34. India has set the target of net-zero emissions by:

(A) 2050
(B) 2070
(C) 2060
(D) 2100

35. The International Solar Alliance was launched by India and:

(A) Germany
(B) Japan
(C) France
(D) Russia

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36. The National Action Plan on Climate Change (NAPCC) was launched in:

(A) 2008
(B) 1998
(C) 2015
(D) 2020

37. The ozone layer protects life on earth by absorbing harmful:

(A) Infrared rays
(B) Ultraviolet rays
(C) Radio waves
(D) Gamma rays from earth

38. The ozone hole was first discovered over:

(A) Arctic
(B) India
(C) Antarctica
(D) Australia

39. The Montreal Protocol was signed in:

(A) 1987
(B) 1992
(C) 1997
(D) 2015

40. The Kigali Amendment to the Montreal Protocol deals with the phase-down of:

(A) CFCs
(B) Halons
(C) Methane
(D) HFCs

41. Ozone is measured in:

(A) Decibel
(B) Dobson unit
(C) Lux
(D) Pascal

42. Which chemical used in refrigerators damages the ozone layer?

(A) Carbon dioxide
(B) Ammonia
(C) CFC
(D) Nitrogen

43. International Ozone Day is observed on:

(A) 16 September
(B) 5 June
(C) 22 April
(D) 10 December

44. Acid rain has a pH below:

(A) 7.0
(B) 6.5
(C) 8.0
(D) 5.6

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45. The term 'acid rain' was coined by:

(A) Rachel Carson
(B) Robert Angus Smith
(C) Paul Crutzen
(D) Svante Arrhenius

46. The main gases responsible for acid rain are:

(A) SO_2 and NO_x
(B) CO_2 and CH_4
(C) O_3 and CFCs
(D) N_2 and O_2

47. The damage to the marble of the Taj Mahal is mainly attributed to:

(A) Floods
(B) Earthquakes
(C) Acid rain and air pollution
(D) Soil erosion

48. The report 'Our Common Future' (1987) is associated with:

(A) Club of Rome
(B) Rio Summit
(C) Stockholm Conference
(D) Brundtland Commission

49. How many Sustainable Development Goals (SDGs) are there?

(A) 10
(B) 17
(C) 20
(D) 25

50. The UN Conference on the Human Environment was held at Stockholm in:

(A) 1972
(B) 1982
(C) 1992
(D) 2002

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Answer Key

1. (B)	11. (A)	21. (A)	31. (C)	41. (B)
2. (C)	12. (C)	22. (B)	32. (D)	42. (C)
3. (A)	13. (A)	23. (C)	33. (A)	43. (A)
4. (D)	14. (B)	24. (D)	34. (B)	44. (D)
5. (B)	15. (C)	25. (A)	35. (C)	45. (B)
6. (C)	16. (D)	26. (B)	36. (A)	46. (A)
7. (A)	17. (A)	27. (C)	37. (B)	47. (C)
8. (D)	18. (C)	28. (D)	38. (C)	48. (D)
9. (C)	19. (B)	29. (A)	39. (A)	49. (B)
10. (B)	20. (D)	30. (B)	40. (D)	50. (A)

Tip: Revise the "Key Points for Competitive Exams" box at the end of each topic and attempt the MCQs again after a few days. Wrong answers show which topics need more revision.

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