LOTUSARISE IAS

MAINS 2027 EDITION

FREE SAMPLE

UPSC CSE MAINS

GEOGRAPHY OPTIONAL

PAPER I

Environmental Geography Notes

The complete Environmental Geography section of Paper I — ecology, human adaptation and impact, degradation and management, biodiversity, policy, hazards and legislation, with previous year questions.

Compiled by Arvind KrS

ECOLOGY AND ECOSYSTEMS

HUMAN–ENVIRONMENT THOUGHT

DEGRADATION AND MANAGEMENT

BIODIVERSITY

POLICY AND LEGISLATION

34 Chapters

10 Units

118 Previous year questions

190 Diagrams and figures

IN THIS BOOK

01 Environmental Geography and Human–Environment Thought

02 Principles of Ecology

03 Human Ecological Adaptations

04 Human Impact and Ecological Change

05 Environmental Degradation

06 Ecosystem and Environmental Management and Conservation

07 Biodiversity and Sustainable Development

08 Environmental Policy

09 Environmental Hazards and Remedial Measures

10 Environmental Education and Legislation

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

LOTUSARISE IAS

Geography Optional — Environmental Geography

Paper I · Physical Geography: Environmental Geography

Mains 2027 Edition · Compiled October 2026

© 2026 LotusArise IAS. All rights reserved. This PDF is licensed to the purchaser for personal study only. Copying, sharing, reselling or uploading it to any website, drive or group, in whole or in part, is not permitted.

Questions or corrections: support@lotusarise.com

How to read these notes

Every chapter is marked against the questions UPSC has actually asked on it, so the points that matter most stand out on the first read and are quick to find at revision.

Energy flows one way through an ecosystem, while nutrients cycle within it.

Yellow marker: key point. A point that carries the ideas UPSC has asked about in this chapter. Read these first, and make sure each one is in your answer.

Ecology is the study of the relationships between organisms and their environment.

Blue marker: definition. The cleanest definition of a term, ready to open an answer with.

Before a large project is approved, its likely effects are studied through **environmental impact assessment**.

Saffron underline: PYQ term. A key term or phrase that appears in this chapter's previous year questions.

Air Pollution PYQ 2022 · 2020 · 2019 +4

PYQ tag on a heading. The years in which UPSC asked about this section. Sections without a tag are background or linking material.

PYQ RADAR **13** questions Last asked **2022**

PYQ radar. At the start of each chapter: how many times the topic has been asked, and how recently. The contents page shows the same count for every chapter.

Suggested method. First read: the whole chapter. Revision: the yellow and blue marks, the tagged headings and the PYQ list at the end of the chapter. Last week before Mains: the PYQ list alone, answering each question in your head from the marked points.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

Contents

UNIT 01 **Environmental Geography and Human–Environment Thought** 6

01 Environmental Geography: Nature, Scope, and Human-Environment Paradigms 2 PYQs IN THIS SAMPLE 7
02 Man–Environment Relationship in Environmental Geography 2 PYQs 22
03 Determinism, Possibilism & Neo-determinism 3 PYQs 40
04 Marxian View on the Environment 61
05 Social Production of Nature: Beyond the Nature-Society Dualism 80
06 Deep Ecology vs Shallow Ecology: Environmental Ethics in Geography 1 PYQ 93

UNIT 02 **Principles of Ecology** 112

07 Fundamental Concepts and Principles of Ecology 4 PYQs 113
08 Ecosystem: Structure, Functions, Energy Flow and Biogeochemical Cycles 8 PYQs 137

UNIT 03 **Human Ecological Adaptations** 169

09 Human Ecological Adaptations 2 PYQs 170
10 Ecological Adaptive Processes – Kinds of Adaptations 2 PYQs 198
11 Cultural Adaptation of Humans: An Evolutionary Overview of Human Sensibility 1 PYQ 223

UNIT 04 **Human Impact and Ecological Change** 241

12 Influence of Man on Ecology and Environment 9 PYQs 242
13 Environmental Impacts of Large Dams and Mining 6 PYQs 268
14 Global and Regional Ecological Changes and Imbalances 7 PYQs 289
15 Mountain Ecosystems: Fragility, Himalayan Ecosystem Services and High-Altitude Hazards 12 PYQs 321

UNIT 05 **Environmental Degradation** 343

16 Environmental Degradation and its Effects 4 PYQs 344
17 Environmental Pollution: Types, Sources, Effects and Control 13 PYQs ..... IN THIS SAMPLE 370
18 Environment and Human Health: Ecological Change, Climate Change and Disease 4 PYQs 396

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

UNIT 06 **Ecosystem and Environmental Management and Conservation** 415

19 Ecosystem Management and Conservation 3 PYQs 416
20 Environmental Management 1 PYQ 441
21 PAVE Theory: Perception, Attitude, Value and Emotion in Environmental Management 2 PYQs 464
22 Environmental Impact Assessment: Methods and Techniques 481
23 Social Impact Assessment: Methods and Techniques 1 PYQ 509
24 Environmental Conservation 2 PYQs 535

UNIT 07 **Biodiversity and Sustainable Development** 559

25 Biodiversity and Sustainable Development 6 PYQs 560
26 Conservation Measures of Biodiversity 5 PYQs 591
27 Gender and Biodiversity in India 620
28 Human–Wildlife Conflict: Causes, Consequences and Remedial Measures 1 PYQ 639

UNIT 08 **Environmental Policy** 658

29 Environmental Policy in India 1 PYQ 659
30 Carbon Neutrality and Net Zero: Concepts, Carbon-Negative Nations and Global Efforts 4 PYQs .. 689

UNIT 09 **Environmental Hazards and Remedial Measures** 707

31 Environmental Hazards and Remedial Measures 8 PYQs 708

UNIT 10 **Environmental Education and Legislation** 737

32 Environmental Education in India 2 PYQs 738
33 Environmental Legislations in India 2 PYQs 765
34 Environmental Legislation in India 794

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

UNIT 01 | 6 CHAPTERS

Environmental Geography and Human–Environment Thought

Environmental geography: nature and scope; man–environment relationship; determinism, possibilism and neo-determinism; environmental ethics.

CHAPTERS

01	Environmental Geography: Nature, Scope, and Human-Environment Paradigms	7
02	Man–Environment Relationship in Environmental Geography	22
03	Determinism, Possibilism & Neo-determinism	40
04	Marxian View on the Environment	61
05	Social Production of Nature: Beyond the Nature-Society Dualism	80
06	Deep Ecology vs Shallow Ecology: Environmental Ethics in Geography	93

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

GEOGRAPHY OPTIONAL | PAPER I · ENVIRONMENTAL GEOGRAPHY

Environmental Geography: Nature, Scope, and Human–Environment Paradigms

PYQ RADAR **2** questions Last asked **2020** 2020 · 2015

CONTENTS

01	Meaning and Definitions	02	Nature and Scope
03	Components and Types of Environment	04	Evolution and Approaches
05	Human–Environment Paradigms: An Overview	06	Previous Year Questions

- **Environmental geography** studies the **relationship between human beings and their environment** in its spatial and temporal setting. It is the part of geography that bridges the physical sciences (climatology, geomorphology, hydrology, biogeography) and the social sciences (economics, sociology, anthropology, policy studies).
- **Peter Haggett**, in *Geography: A Modern Synthesis* (1972), saw geography as concerned with **two interacting systems**:
  - the **ecological system**, which links people with their environment;
  - the **spatial system**, which links one region with another through flows of people, goods and ideas.
  - Environmental geography works mainly on the first, without losing sight of the second.
- It has **three analytical foci**: the **environment** itself, the human agent, and the interactions between the two.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

01 Meaning and Definitions

Meaning of environment

- The word comes from the Old French *environner*, **"to surround"**. In English, "environment" first meant simply the state of being surrounded.
  - **Thomas Carlyle** gave it its modern sense in 1827, using it to translate the German *Umgebung*, the conditions in which a person or thing lives.
  - In biology, **Jakob von Uexküll** (1864–1944) developed the idea of the *Umwelt* (1909): each organism lives in its own perceived surrounding world. His work gave ecology a working concept of environment.
- In the wider sense, environment is **every condition, force and influence that surrounds an organism and affects its life**: abiotic and biotic, climatic, social and economic.
- **Indian law** takes the same broad, relational view. The **Environment (Protection) Act, 1986** defines environment to include **water, air and land**, and the inter-relationship among them and human beings, other living creatures, plants, micro-organisms and property.

Definitions compared

SCHOLAR OR SOURCE	DEFINITION OR EMPHASIS
Chris C. Park (1980)	The **sum total of conditions surrounding man** at a given point in space and time
Douglas and Holland	The **aggregate of all external forces**, influences and conditions that affect the life, behaviour, growth and development of organisms
P. Gisbert	**Anything immediately surrounding an object** and exerting a direct influence on it
US National Environmental Policy Act (1969)	The **natural and man-made surroundings** and the interrelations of their components with human activity
Environment (Protection) Act, India (1986)	Water, air and land and their **inter-relationship with living beings and property**

Defining environmental geography

- Environmental geography is the **study of the spatial attributes of interrelationships** between living organisms and the natural environment in general.
  - Above all, it studies the relationship between **technologically advanced "economic man"** and his natural environment, within a temporal and spatial framework.
- **Kenneth Hewitt and F. Kenneth Hare** (*Man and Environment: Conceptual Frameworks*, 1973) defined it as the **systematic description of the components of the environment** and of human interaction with those components.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

- The current view treats environmental geography as the **integrative "third" field** between physical and human geography. It studies **coupled human–natural systems**, from local resource use to global environmental change.

Why geography is suited to the task

- **Arthur N. Strahler and Alan H. Strahler**, in *Geography and Man's Environment* (1977), placed **man and land** at the heart of geography. No other discipline joins the spatial, temporal, biotic and abiotic dimensions as fully:
  - It studies the **spatial attributes of all phenomena**, human and natural, at every scale from local to global.
  - As an **integrating science**, it brings the lithosphere, hydrosphere, atmosphere and biosphere together as one interacting system and links social with natural science.
  - Geographers can **identify environmental regions, locate and map them**, and explain the causes of their variation.
  - It **bridges physical processes** and the demographic, cultural and economic processes that drive environmental change.

02 Nature and Scope

Nature of environmental geography

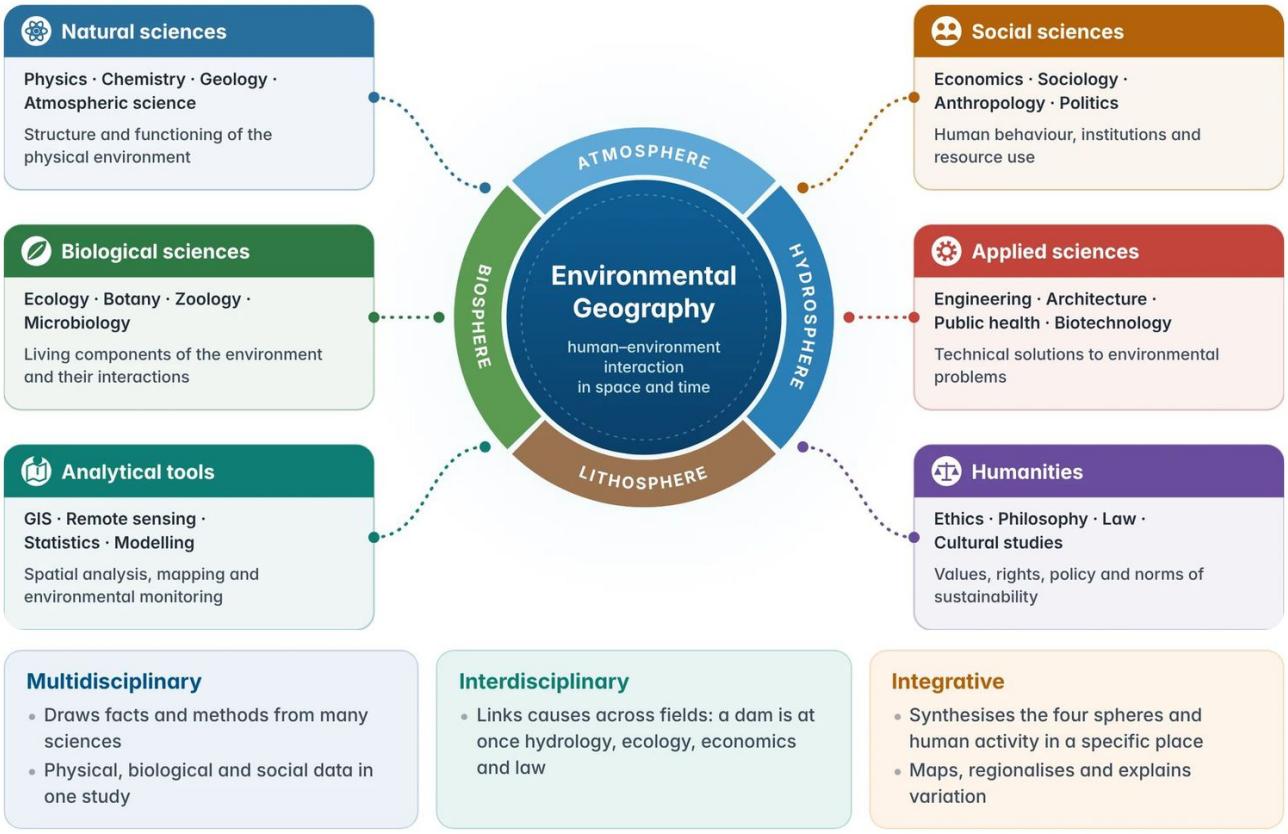
- **Multidisciplinary, interdisciplinary and integrative:**
  - It **borrows** facts and methods from physics, chemistry, biology, geology, economics, sociology, law and policy studies.
  - It **links** causes across these fields; a dam is at once a question of hydrology, ecology, economics and law.
  - It **synthesises** them in a specific place.
- **Holistic and systemic:** the environment is treated as a system of interacting parts, so a change in one sphere ripples through the others.
- **Spatial and temporal:** it asks where environmental conditions and problems occur, why there, and how they change over time.
- **Multi-scalar:** from a village watershed to the global climate system.
- **Applied and problem-solving:** it supplies the knowledge base for resource management, hazard reduction, planning and policy.
- **Value-laden:** questions of equity, ethics and justice (who pollutes, who suffers) are part of the subject, not outside it.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

ENVIRONMENTAL GEOGRAPHY · THOUGHT

The Multidisciplinary Character of Environmental Geography

Six families of knowledge feed one integrating discipline, which studies the four spheres of the Earth and human activity together, in space and over time.



Multidisciplinary

- Draws facts and methods from many sciences
- Physical, biological and social data in one study

Interdisciplinary

- Links causes across fields: a dam is at once hydrology, ecology, economics and law

Integrative

- Synthesises the four spheres and human activity in a specific place
- Maps, regionalises and explains variation

Schematic.

lotusarise.com

Scope of environmental geography

- **Resources:** creates awareness of renewable and non-renewable resource endowments, their patterns of use and their sustainability.
- **Ecological systems:** gives knowledge of ecosystems and the cause-and-effect relationships within them.
- **Biodiversity:** records the richness of plant, animal and microbial life and the threats to it.
- **Hazards and disasters:** explains natural and human-induced **hazards**, such as floods, earthquakes, cyclones and landslides, and their mitigation.
- **Policy choices:** evaluates alternative responses to an environmental problem before action is taken.
- **Citizenship:** builds environmentally literate citizens aware of environmental laws, rights and duties.
- **Population and health:** exposes the links between population growth, health, hygiene and environmental quality, and the role of technology in reducing damage.
- **Indigenous knowledge:** identifies eco-friendly traditional skills and technologies, such as tank irrigation, sacred groves and terrace farming.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

- **Sustainability:** promotes the sustainable use of inherited resources for future generations, linking theory to the practice of sustainable development.

Sub-fields within the scope

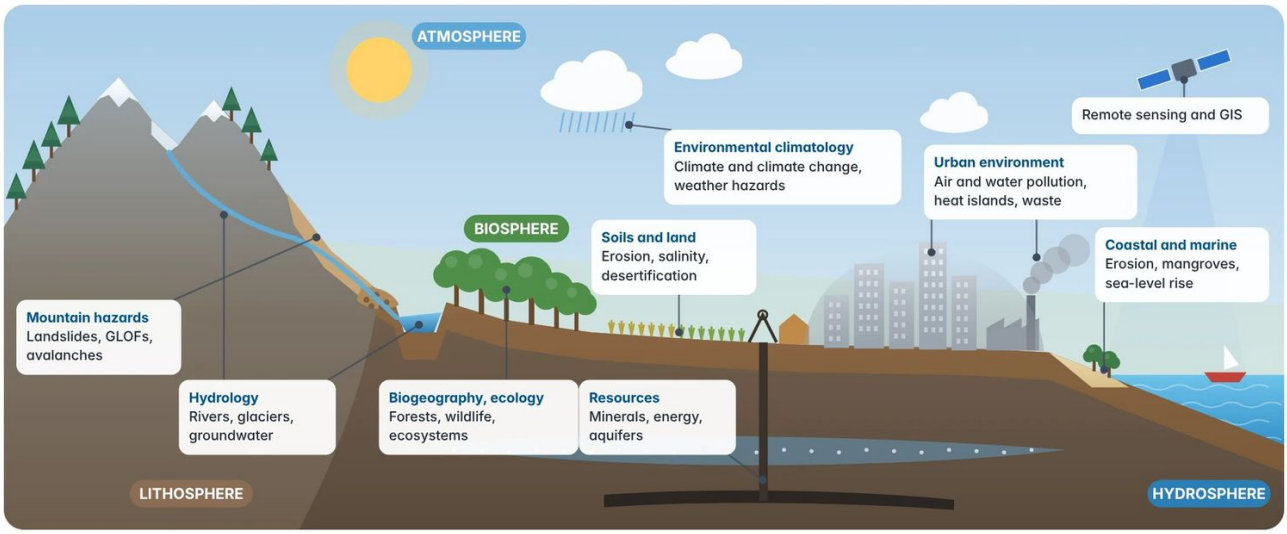
SUB-FIELD	FOCUS	EXAMPLE
Environmental geomorphology	Landforms and processes as resources and hazards	Landslide zoning in the Himalaya
Environmental climatology	Climate as a resource, a hazard and a changing system	Urban heat islands; heat waves
Hydrology and water resources	Rivers, glaciers, groundwater and their use	Groundwater depletion in Punjab
Biogeography and ecology	Ecosystems, biodiversity and conservation	Western Ghats biodiversity
Soils and land	Erosion, salinity, desertification	Chambal ravines
Environmental pollution	Air, water, soil, noise and waste	Winter smog in Delhi NCR
Hazards and disasters	Vulnerability, risk and response	Floodplain zoning
Environmental management and planning	Policy, law, EIA, restoration	**Environmental impact assessment** of projects
Environmental perception	How people see, value and respond to nature	**Perception, attitude, value and emotion** in conservation
Geospatial analysis	GIS, remote sensing and modelling	Satellite atlases of land degradation

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

ENVIRONMENTAL GEOGRAPHY · THOUGHT

The Scope of Environmental Geography

From mountain to coast, every part of the landscape is a field of study: each sub-field joins a sphere of the Earth to the human activity that alters it.



Physical environment
- The four spheres and their processes: climate, landforms, water, soils, life

Human environment
- Land use, settlements, economy and technology that transform the spheres

Applied fields
- Hazards, conservation, EIA, policy and planning; GIS and remote sensing as tools

Schematic cross-section; not to scale.

lotusarise.com

Core concepts of the field

- **Environment as a system:** the four spheres exchange **energy and matter** through inputs, stores and outputs, held in balance by **feedbacks**.
  - Negative feedback restores balance; positive feedback, as when melting ice lowers albedo and speeds warming, amplifies change.
- **Carrying capacity:** the largest population an area can support **without degrading** its resource base.
- **Ecological footprint:** the land and water area needed to supply a population's consumption and absorb its waste; it lets **environmental degradation** be compared across places.
- **Vulnerability and resilience:** how exposed a community is to harm, and how well it **absorbs a shock and recovers**.
- **Scale:** a process looks different at the scale of a field, a river basin and the globe, and so do its remedies.
- **Sustainability:** meeting present needs **without compromising future generations**, the organising goal of the whole field.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

Relevance in India

- **Constitutional base:**
  - The **42nd Amendment (1976)** added **Article 48A** (a duty of the State to protect and improve the environment) and **Article 51A(g)** (a fundamental duty of citizens to protect nature).
  - The courts have read the **right to a clean environment** into Article 21.
- **Institutions and policy:**
  - The National Green Tribunal (2010) hears environmental disputes.
  - The **National Action Plan on Climate Change (2008)** runs through eight national missions.
  - **Mission LiFE** (Lifestyle for Environment, October 2022) carries the subject into everyday behaviour. These form the core of **environmental policy in India**.
- **Climate commitments:**
  - India pledged **net zero by 2070** at COP26 in Glasgow (2021).
  - Its updated NDC (2022) aims to cut the **emissions intensity of GDP by 45%** from 2005 levels and to draw about **50% of installed power capacity** from non-fossil sources, both by 2030.
- **The geographer's agenda in India:**
  - It spans **Himalayan hazards**, winter smog over the Indo-Gangetic Plain, groundwater depletion in the north-west, coastal erosion and the loss of forests and wetlands.
  - Each joins a physical process to a human cause in a specific region.

Environmental geography, ecology and environmental science

BASIS	ECOLOGY	ENVIRONMENTAL SCIENCE	ENVIRONMENTAL GEOGRAPHY
Core question	How organisms relate to each other and their surroundings	How the environment works and how to fix its problems	**Where and why** human–environment relations vary
Centre of attention	Organisms, populations, ecosystems	Physical, chemical and biological processes	**People in place**, across scales
Human role	Often one species among many	A source of impacts	**An active agent and a variable**
Distinctive tool	Field experiment, energy and nutrient budgets	Laboratory and monitoring	**Mapping, regionalisation, spatial analysis**

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

03 Components and Types of Environment PYQ 2020

The four spheres

- The **physical environment** is made of the **four spheres of the Earth**:
  - **Lithosphere:** the solid Earth, with rocks, landforms, minerals and soils.
  - **Hydrosphere:** oceans, rivers, lakes, ice and groundwater.
  - **Atmosphere:** the gaseous envelope with its weather and climate.
  - **Biosphere:** the zone of life, where the other three meet and interact.
- **Energy** drives them: **solar radiation** from outside and internal heat from within the Earth. Matter cycles between them.

Types of environment

Physical (natural) environment

- The terrestrial and atmospheric conditions that **exist independently of human agency**, shaped over geological time by natural processes.
  - **Components:** rivers, mountains, plains, deserts, oceans, volcanoes, weather systems, seasons, soils, minerals.
  - **Key feature:** humans have limited or no control over these conditions.
  - **Also includes** the biological environment: natural vegetation and wildlife that evolve through ecological processes.

Social (human-made) environment

- Humans cannot live directly in the raw physical environment, so they **modify it through technology, knowledge and capital**. The result has **two interlinked layers**:
  1. **Outer environment:**
     - The physical environment **as modified by technology**: cities, transport networks, industries, dams, agricultural landscapes and communication systems.
     - It reflects humanity's **technical capacity to adapt nature** to human needs.
  2. **Inner environment:**
     - The **socio-cultural sphere**: customs, traditions, religious beliefs, social organisation, economic systems and moral codes, often called "social heritage".
     - It shapes **how people behave and decide** within the physical environment.
     - **Indian example:** sacred groves (*devrais* in Maharashtra, *kavus* in Kerala, *orans* in Rajasthan) are a religious tradition that conserves biodiversity.
- Environments are also classed by scale, as **micro-environment** (a field, a house, a city block) and **macro-environment** (a biome, the global climate).

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

The ecological basis

- **Ecology**, from the Greek *oikos* (house) and *logos* (study), was named by **Ernst Haeckel in 1866**. It is the science of the relationships between organisms and their surroundings; its levels, factors, niches and population interactions are set out in the **principles of ecology**.
- The **ecosystem**, a term coined by **Arthur George Tansley (1935)**, is ecology's working unit. Its structure, productivity, **energy flow and biogeochemical cycles** give environmental geography its functional base.
- **Energy flows one way** through an ecosystem and is lost as heat at each step, while **nutrients cycle**. Human interference with either, by clearing forests or adding fertiliser and carbon, is the root of most environmental problems.

Humans as an environmental agent

- Humans act on the environment in **three roles**:
  - as a **biological organism**: a consumer in food chains, dependent on air, water and food;
  - as a **social being**: organised in cultures and institutions that decide how nature is used;
  - as a **technological "economic man"**: the most powerful agent of change on the planet.
- **Scale of human impact today:**
  - The term **Anthropocene**, popularised by **Paul J.** Crutzen and Eugene F. Stoermer (2000), names an age in which human activity rivals natural forces. Geologists rejected it as a formal epoch in March 2024, but it remains a widely used concept for the **influence of man on the environment**.
  - The Planetary Health Check of **September 2025** found seven of nine planetary boundaries breached, with ocean acidification the latest to cross into the danger zone. These are among the **global ecological changes and imbalances** that now define the field's agenda.

04 Evolution and Approaches

Evolution of environmental geography

- **Classical roots:**
  - **Hippocrates**, in *Airs, Waters, Places* (about 400 BCE), and **Aristotle** linked climate to the body and temperament of peoples.
  - **Ibn Khaldun** (*Muqaddimah*, 1377) related the character of societies to climatic zones.
- **Modern foundations:**
  - **Alexander von Humboldt** (1769–1859) saw nature as one interconnected web, a view set out in his **contributions to geographical thought**.
  - **George Perkins Marsh**, in *Man and Nature* (1864), gave the first systematic account of human destruction of the environment: deforestation, soil loss and changes to rivers.
- **Age of environmentalism (1880s–1920s):**
  - **Friedrich Ratzel**, **Ellen Churchill Semple** and **Ellsworth Huntington** made the environment the controlling factor in human affairs. This **environmentalism** dominated early academic geography.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

- **Reaction and middle paths (1900s–1950s):**
  - Possibilism grew in France.
  - **Harlan H. Barrows** (*Geography as Human Ecology*, 1923) redefined the subject as the study of human adjustment to environment.
  - **Carl Ortwin Sauer** studied the cultural landscape and attacked determinism's premature generalisations.
  - The Princeton symposium ***Man's Role in Changing the Face of the Earth*** (1955, published 1956) reversed the question: it asked what humans do to nature.
- **Eclipse (1950s–1960s):** the **quantitative revolution** turned geography towards spatial science, and human–environment questions were pushed to the margins.
- **Rejuvenation (1960s onwards):** an environmental crisis brought the theme back with new tools.
  - **Rachel Carson's** *Silent Spring* (1962), **Garrett Hardin's** "tragedy of the commons" (1968) and ***The Limits to Growth*** (1972) set the tone, and the Stockholm Conference (1972) put the environment on the global agenda.
  - **David R. Stoddart** (1965) proposed the ecosystem as a geographic principle. **Richard J. Chorley and Barbara A. Kennedy** (1971) built physical geography on systems analysis.
  - **Gilbert F. White** (*Human Adjustment to Floods*, 1945) and later **Ian Burton, Robert W. Kates** and White (*The Environment as Hazard*, 1978) founded hazards research.
  - **Radical, Marxian and political-ecology** geographers asked who controls nature and who bears the costs.
  - The **Brundtland Report (1987)**, the IPCC (1988) and the Rio Earth Summit (1992) made sustainable development and climate change central themes.
- **Contemporary phase:**
  - The field now covers **global environmental change, earth system science, climate justice** and the Anthropocene.
  - It relies on GIS and remote sensing. **Noel Castree, David Demeritt, Diana Liverman and Bruce Rhoads** (*A Companion to Environmental Geography*, 2009) consolidated it as a recognised sub-discipline.

Approaches to the study of environmental geography

- The approaches below are **ways of studying** the environment. The history of ideas behind each, from Darwin's influence to political ecology, is traced in the **man–environment relationship**.

APPROACH	FOCUS	KEY PROPONENTS
Ecosystem (systems) approach	Inputs, flows and feedbacks among the spheres; humans as one component	Tansley (1935), Stoddart (1965), Chorley and Kennedy (1971)
Human ecological approach	Human adjustment to the natural and social environment	Barrows (1923)

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

APPROACH	FOCUS	KEY PROPONENTS
Cultural ecological approach	How the "culture core" adapts to the environment	**Julian Steward** (1955)
Spatial and regional approach	Patterns, regions and areal differentiation of environmental conditions	Ecological and agro-ecological regions
Behavioural and perception approach	How people perceive and respond to hazards and resources	White, Kates; **behavioural geography**
Political ecology approach	Power, markets and the state in resource use and degradation	**Piers Blaikie and Harold Brookfield** (1987)
Historical approach	Change in environment and land use over time	Marsh (1864), Sauer
Geospatial approach	Mapping and monitoring with GIS, remote sensing and models	Satellite-based land-use and land-cover change

05 Human–Environment Paradigms: An Overview PYQ 2020

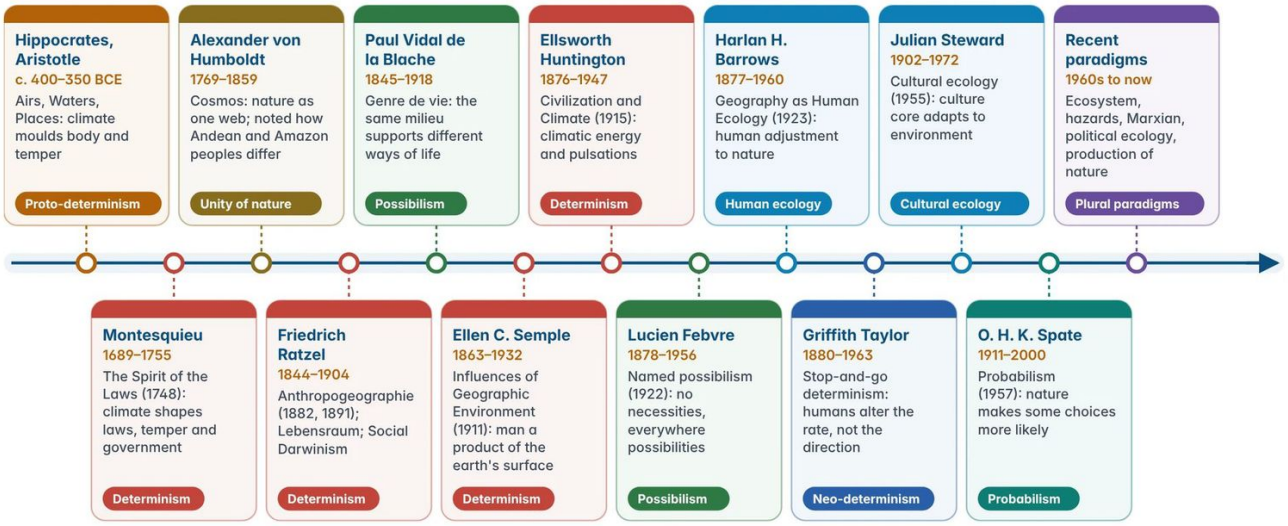
- The **central question** of environmental geography is how far the **physical environment decides human life and culture.** Over two centuries it has produced a sequence of paradigms, each re-drawing the balance between nature and human choice.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

ENVIRONMENTAL GEOGRAPHY · THOUGHT

Human–Environment Paradigms: Key Thinkers Through Time

From the classical idea that climate shapes people to the plural, critical views of today, each generation has re-drawn the balance between nature and human choice.



Environmental determinism

- **Environmental determinism** holds that the **physical environment controls human life**: culture, social organisation, politics and economy are **products of nature**, and humans are passive agents.
- **Lineage:** the idea runs from Aristotle through **Montesquieu** (*The Spirit of the Laws*, 1748) to Friedrich Ratzel's "new determinism", which added Social Darwinism.
  - Ratzel (*Anthropogeographie*, 1882 and 1891) applied **"struggle for existence"** and "survival of the fittest" to states through the concept of *Lebensraum* (living space).
  - **Ellen Churchill Semple** (*Influences of Geographic Environment*, 1911) carried it to the United States, arguing that plains peoples and mountain peoples differ because of their environments.
  - **Ellsworth Huntington** (*Civilization and Climate*, 1915) went furthest: temperate, changeable climates stimulate achievement, while tropical heat and humidity breed lethargy.
- **Criticism:**
  - It **ignores human agency, culture and technology**.
  - It cannot explain why **similar environments produce different cultures**: the pastoral Gujjar-Bakarwals and the settled Kashmiri farmers live in the same mountain setting.
  - It was **used to justify racism and imperialism**.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

- **Carl Ortwin Sauer** faulted it for premature generalisation without observation, and Barrows for overstating environmental influence.

Possibilism

- **Possibilism** arose in France as a **reaction against German determinism**.
  - **Paul Vidal de la Blache** (1845–1918) argued that nature offers possibilities, not necessities, and that humans, as active agents with culture and free will, choose among them.
  - His concept of ***genre de vie*** (way of life) showed that the same environment can support different lifestyles, depending on cultural heritage and accumulated knowledge.
- **Lucien Febvre**, who **named the school** (1922), summed it up: there are no necessities, but everywhere possibilities, and man, as master of these possibilities, is the judge of their use.
  - **Jean Brunhes** extended it to the study of human imprints on the land.
- **Indian example:** terrace farming in the Himalaya and canal irrigation turning parts of the Thar into cropland show human choice reworking natural limits.

Neo-determinism (stop-and-go determinism)

- **Griffith Taylor** (1880–1963) took a **middle course**: neither absolute determinism nor unlimited possibilism fits reality.
  - In extreme environments, such as the **Australian deserts** or the Arctic, nature sets firm limits that cannot be crossed without severe cost.
- His metaphor: man is like a **traffic controller in a large city**, who can **alter the rate but not the direction** of progress. Humans can speed up, slow down or pause, but nature fixes the route.
- **Indian example:** Joshimath (2023) was built on old landslide debris, and a 1976 committee had warned against heavy construction there. Its subsidence shows the limits nature sets when they are ignored.

Probabilism

- **Oskar Hermann Khristian Spate** (1957) proposed **probabilism** as a further middle ground.
  - The environment does not decide outcomes, but it makes **some human responses more probable** than others.
  - Statistical generalisations about **land use, population density and crop yields** are therefore possible, but they always admit exceptions.

Comparing the classical paradigms

CRITERION	DETERMINISM	POSSIBILISM	NEO-DETERMINISM	PROBABILISM
Human role	Passive agent	Active agent	Conditional agent within limits	Chooser weighing the odds

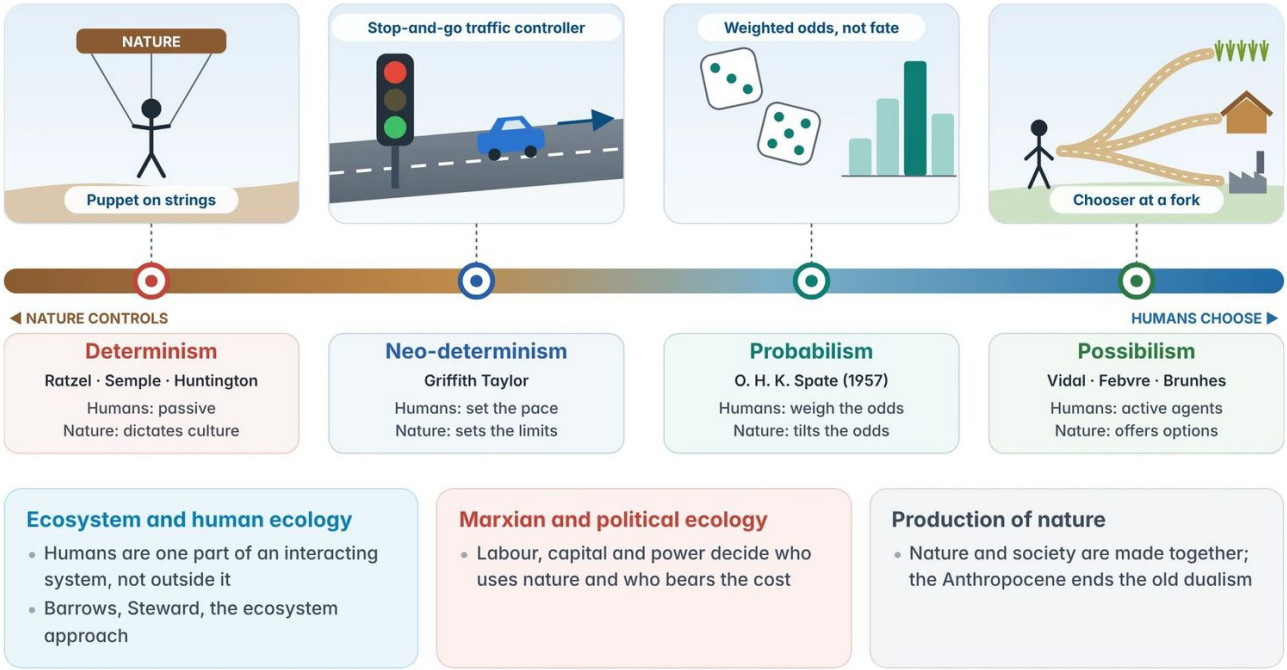
FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

CRITERION	DETERMINISM	POSSIBILISM	NEO-DETERMINISM	PROBABILISM
Environment's role	Controls and decides	Offers options	Sets ultimate limits	Tilts the probabilities
Key scholars	Ratzel, Semple, Huntington	Vidal de la Blache, Febvre, Brunhes	Griffith Taylor	Spate
Metaphor	Puppet on strings	Player choosing a role	Traffic controller	Weighted dice
Standing today	Rejected in its extreme form	Widely accepted	Revived by climate limits	Used in quantitative work
Indian example	Monsoon-bound rainfed farming	Himalayan terraces	Joshimath subsidence	Kharif yield odds with rainfall

ENVIRONMENTAL GEOGRAPHY · THOUGHT

From Nature's Control to Human Choice

The four classical paradigms sit on one spectrum of how much the environment decides; later views reject the either-or framing altogether.



Ecosystem and human ecology
- Humans are one part of an interacting system, not outside it
- Barrows, Steward, the ecosystem approach

Marxian and political ecology
- Labour, capital and power decide who uses nature and who bears the cost

Production of nature
- Nature and society are made together; the Anthropocene ends the old dualism

Schematic. Metaphors are teaching devices; Taylor's own image was the traffic controller.

lotusarise.com

Beyond the classical debate

- **Human and cultural ecology:** Barrows and Julian Steward treated people as one part of an adapting system, not as puppets or masters.

- **Ecosystem and systems approach:** humans became a component inside the ecosystem, linked by flows of energy and matter.
- **Behavioural approach:** decisions follow the environment as perceived, not as it objectively is; hence hazard perception and resource appraisal.
- **Marxian and radical views:** nature is shaped by labour, capital and class, and degradation follows from how production is organised; this is the **Marxian view on the environment**.
- **Political ecology:** degradation is traced to power, markets and the state, as in the work of Piers Blaikie and Harold Brookfield (1987).
- **Production of nature: Neil Smith (1984)** argued that capitalism produces nature itself, so the **social production of nature** dissolves the nature–society dualism.
- **Environmental ethics: Arne Næss (1973)** contrasted **deep ecology with shallow ecology**, giving nature value of its own beyond human use.
- **The current view:** human–environment relations are a two-way, co-evolving system.
  - Nature sets limits, which climate change, sea-level rise and Himalayan hazards make plain. Human choices, technology and power decide how those limits are met.
  - This **synthesis of limits and choice**, with sustainability as its goal, is why environmentalism has returned as a paradigm in geography.

Previous Year Questions

2020	"Human ecology is the study of mutual relationship of people and their environment both natural and social." Discuss in detail using ecological concepts.
2015	"There is a rejuvenation of environmentalism as a paradigm in geographical studies." Comment.

LOTUSARISE IAS

COMPLETE NOTES

Get the full Geography Optional notes, Paper I and II

₹1,180 ~~₹1,600~~

Get the Complete Notes →

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

UNIT 05 | 3 CHAPTERS

Environmental Degradation

Environmental degradation.

CHAPTERS

16 Environmental Degradation and its Effects 344
17 Environmental Pollution: Types, Sources, Effects and Control 370
18 Environment and Human Health: Ecological Change, Climate Change and Disease 396

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

GEOGRAPHY OPTIONAL | PAPER I · ENVIRONMENTAL GEOGRAPHY

Environmental Pollution: Types, Sources, Effects and Control

PYQ RADAR **13** questions Last asked **2024**
2024 · 2023 · 2022 ×2 · 2020 · 2019 · 2017 · 2013 ×4 · 2005 · 2003

CONTENTS

01 Pollution: Concepts and Classification
02 Air Pollution
03 Water Pollution
04 Soil, Noise, Thermal and Radioactive Pollution
05 Persistent Toxins and Wastes
06 Controlling Pollution
07 Previous Year Questions

- **Pollution** is an **undesirable change in the physical, chemical or biological characteristics** of air, water or land that harms human health, living organisms, property or the processes of nature.
  - India's Environment (Protection) Act, 1986 calls an **environmental pollutant** any solid, liquid or gaseous substance present in a concentration that **may be, or tends to be, injurious** to the environment. **Environmental pollution** is simply the presence of such a pollutant.
- The test is **harm, not mere presence**. Every environment can dilute, disperse and break down some waste. Pollution begins where the input **exceeds this assimilative capacity**.
- Pollution is the most visible form of **compositional degradation**: the constituents of air, water and soil change, while **environmental degradation** also includes the structural loss of forests, land and species.
- Geographically, pollution is a problem of **sources, pathways and receptors**: where pollutants are released, how wind, water and food chains carry them, and who or what receives the dose. That makes it local (a drain), regional (the Indo-Gangetic smog) and global (persistent pesticides in Arctic seals) at once.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

01 Pollution: Concepts and Classification

PYQ 2022 · 2020 · 2019 +4

Pollutant, contaminant and the dose

- A **contaminant** is a substance present where it does not belong; it becomes a **pollutant** only when it causes harm.
- **Concentration and exposure decide harm.** Nitrogen and phosphorus are nutrients in a field but pollutants in a lake; ozone protects life in the stratosphere but injures lungs and crops at ground level.
- **Threshold and non-threshold pollutants:**
  - most have a **threshold** below which no measurable harm occurs, the basis of air and water standards;
  - carcinogens and fine particles show **no safe threshold**, which is why the WHO keeps lowering its guideline values.

Classification of pollutants

BASIS	CLASSES	EXAMPLES
Origin	Natural; anthropogenic	Volcanic SO_2, pollen; vehicle exhaust
Formation	Primary (emitted directly); secondary (formed in the environment)	SO_2, CO, soot; ozone, sulphate aerosol, PAN
Persistence	Biodegradable; slowly degradable; non-degradable	Sewage; DDT, plastics; lead, mercury
Source geometry	Point; line; area (non-point)	Chimney, outfall; highway; farm runoff, city dust
Medium	Air, water, soil, noise, thermal, radioactive	

- **Eugene P. Odum** grouped pollutants by how ecosystems handle them:
  - **biodegradable** pollutants (domestic sewage, food waste) are broken down by decomposers, so the remedy is **treatment and dilution**;
  - **non-degradable** pollutants (heavy metals, many synthetic organics) are not, so they **accumulate**, and the remedy is **control at source**.
- **Point sources** are easy to locate, license and monitor. **Non-point sources** are diffuse, weather-driven and the hardest to control.

Pollution at the global scale

PYQ 2005

- Many pollutants **cross borders**, so a local discharge becomes a regional or planetary problem:
  - **acid deposition** downwind of industrial belts (Scandinavia from Britain and Central Europe in the 1970s);

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

  - **ozone-depleting substances** and **greenhouse gases**, part of the **global ecological changes** of the Anthropocene;
  - **persistent organic pollutants and mercury**, carried by air to the poles;
  - **plastics and nutrients** reaching the oceans, as in **marine pollution**;
  - **winter haze** spread over the whole Indo-Gangetic Plain and across national borders.
- **Global measures** therefore rest on treaties: Montreal (1987), Basel (1989), Rotterdam (1998), Stockholm (2001), Minamata (2013) and the climate regime, together with technology transfer, finance and national laws that tackle sources.

02 Air Pollution

PYQ 2022 · 2020 · 2019 +4

Sources

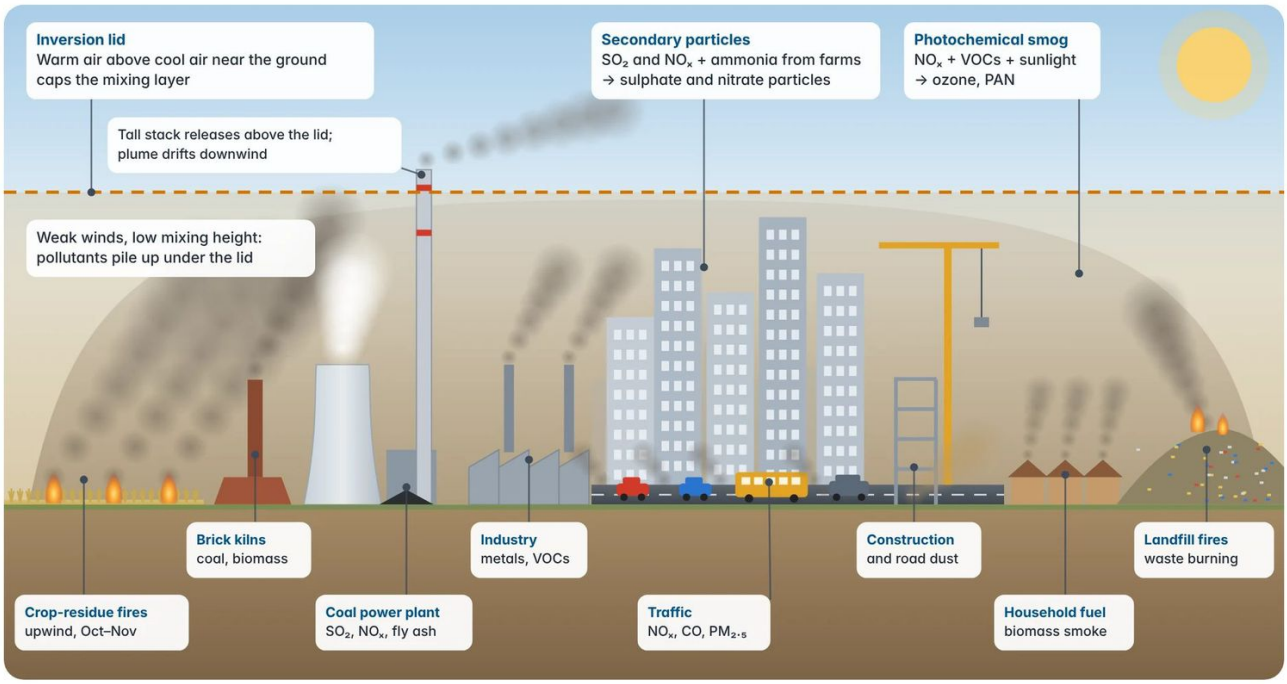
- **Natural:** volcanoes, dust storms, forest fires, sea spray, pollen, and methane from wetlands.
- **Anthropogenic:**
  - **Stationary sources:** coal-fired power stations, smelters, refineries, cement, brick kilns;
  - **Mobile sources:** vehicles, diesel generators, ships and aircraft;
  - **Area sources:** road and construction dust, open waste burning, crop-residue fires, household fuels;
  - **Indoor sources:** biomass and coal stoves, kerosene lamps, tobacco smoke, building materials.
- **Household air pollution** from solid cooking fuel remains a leading exposure in rural India; it falls hardest on women and children who spend hours beside the chulha.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

ENVIRONMENTAL GEOGRAPHY · POLLUTION

Sources of Air Pollution in an Indian City

Local and regional sources release primary pollutants; under a winter inversion they pile up and react into secondary particles and ozone.



Primary pollutants

- PM_{10} and $PM_{2.5}$, black carbon
- SO_2 and NO_x from coal and fuel
- CO and VOCs from traffic and waste

Secondary pollutants

- Sulphate, nitrate, ammonium particles
- Ozone and PAN in sunlight
- Often half or more of winter $PM_{2.5}$

Why winter is worst

- Long, calm nights and inversions
- Low mixing height; little rain
- Farm smoke and festival fireworks

Schematic; not to scale. Typical winter conditions in the Indo-Gangetic Plain.

lotusarise.com

Major air pollutants and their effects

POLLUTANT	MAIN SOURCES	EFFECTS
PM_{10} and $PM_{2.5}$	Combustion, dust, secondary aerosols	Penetrate lungs ($PM_{2.5}$ reaches the blood); heart and lung disease, cancer; haze
Sulphur dioxide (SO_2)	Coal and oil burning, smelters	Respiratory irritation; acid rain; sulphate aerosol
Nitrogen oxides (NO_x)	Vehicles, power plants	Lung damage; ozone and nitrate formation; acid rain
Carbon monoxide (CO)	Incomplete combustion	Binds haemoglobin; headache, death in closed rooms

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

POLLUTANT	MAIN SOURCES	EFFECTS
Ground-level ozone (O_3)	Secondary: NO_x + VOCs + sunlight	Lung inflammation; crop yield loss
Lead (Pb)	Formerly leaded petrol; smelters, batteries	Neurotoxic, especially to children
Ammonia (NH_3)	Fertiliser, livestock	Forms ammonium sulphate and nitrate particles
Benzene, benzo(a)pyrene	Fuel evaporation, incomplete combustion	Carcinogenic

- **Fine particles ($PM_{2.5}$)** carry the largest **health burden.** Air pollution was linked to about **7.9 million deaths worldwide in 2023**, and to **more than 2 million in India** (State of Global Air, 2025).
- **Secondary pollutants** form in the air:
  - SO_2 and NO_x oxidise to **sulphate and nitrate** particles, which combine with ammonia from farms;
  - nitrogen oxides and **volatile organic compounds (VOCs)** react in sunlight to form **ozone**, peroxyacetyl nitrate (PAN) and aldehydes.
  - Hence a large share of a city's $PM_{2.5}$ is **formed regionally** and not emitted inside it.

Smog, acid deposition and the urban atmosphere

BASIS	CLASSICAL (LONDON) SMOG	PHOTOCHEMICAL (LOS ANGELES) SMOG
Ingredients	Smoke, SO_2, fog	NO_x, VOCs, ozone, PAN
Conditions	Cold, damp, calm winter; inversion	Warm, sunny, still; inversion
Chemistry	Reducing	Oxidising
Classic case	London, December 1952	Los Angeles basin, from the 1940s
Indian parallel	Delhi winter haze	Summer ozone peaks in large cities

- **The Great Smog of London (December 1952)** killed about 4,000 people within days; later estimates are far higher. It led to Britain's Clean Air Act of 1956.
- **Temperature inversions** decide whether pollutants disperse or pile up. A **temperature inversion** caps the mixing layer, so emissions accumulate in a shallow layer near the ground.
- Cities build their own **pollution dome** under the heat island, and a regional wind stretches it into an **urban plume** many kilometres downwind.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

- **Acid deposition:**
  - rain is naturally slightly acidic (about **pH 5.6**) from dissolved CO_2; rain below that is **acid rain**, from sulphuric and nitric acids;
  - it reaches the ground as **wet deposition** (rain, snow, fog) or **dry deposition** (gases and particles);
  - it acidifies lakes and forest soils, mobilises toxic aluminium and **corrodes buildings**; the marble of the **Taj Mahal** is protected by the **Taj Trapezium Zone**.
- **Ozone depletion** (from CFCs and halons) and **global warming** (from greenhouse gases) are air pollution at the planetary scale.

Air quality standards and the AQI

- India's **National Ambient Air Quality Standards (NAAQS), 2009** cover **12 pollutants**. They are still the legal benchmark, and they are far looser than the **WHO Air Quality Guidelines (2021)**.

POLLUTANT	NAAQS ANNUAL	NAAQS 24-HOUR	WHO 2021 ANNUAL
$PM_{2.5}$ (µg/m³)	40	60	5
PM_{10} (µg/m³)	60	100	15
NO_2 (µg/m³)	40 (30 in ecologically sensitive areas)	80	10
SO_2 (µg/m³)	50 (20 in ecologically sensitive areas)	80	40 (24-hour only)
O_3 (µg/m³)	100 (8-hour)	180 (1-hour)	100 (8-hour)
CO (mg/m³)	2 (8-hour)	4 (1-hour)	
Lead (µg/m³)	0.5	1.0	
NH_3 (µg/m³)	100	400	

- The other four NAAQS parameters are annual limits for **benzene** (5 µg/m³), **benzo(a)pyrene** (1 ng/m³), **arsenic** (6 ng/m³) and **nickel** (20 ng/m³).
- The **National Air Quality Index (AQI)**, launched in **2014**, turns eight pollutants into one number and colour band:

AQI	CATEGORY	LIKELY HEALTH IMPACT
0–50	Good	Minimal
51–100	Satisfactory	Minor discomfort to sensitive people
101–200	Moderate	Discomfort to people with lung or heart disease

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

AQI	CATEGORY	LIKELY HEALTH IMPACT
201–300	Poor	Discomfort to most on prolonged exposure
301–400	Very poor	Respiratory illness on prolonged exposure
401–500	Severe	Affects healthy people; serious for the ill

Air pollution in India PYQ 2013

- India is among the **most polluted countries**. In 2025 its average $PM_{2.5}$ was **48.9 µg/m³**, almost ten times the WHO guideline. **Loni** (Ghaziabad) was the world's most polluted city, and New Delhi the most polluted capital for the **eighth year running** (IQAir, 2025).
- **Urbanisation** creates air pollution through:
  - rising vehicle numbers and congestion;
  - construction and road dust;
  - industry and power plants on the urban fringe;
  - open burning of garbage and **landfill fires**;
  - the heat island and **built-up canyons** that trap emissions.

Why North Indian cities are more polluted than South Indian cities

FACTOR	NORTH INDIA (INDO-GANGETIC PLAIN)	SOUTH INDIA (PENINSULA)
Location	Landlocked plain enclosed by the Himalaya; air stagnates	Narrow peninsula; sea breezes ventilate coastal cities
Winter weather	Cold, calm nights; strong inversions; mixing height falls to a few hundred metres	Warm; deeper mixing layer; little inversion
Winds	Weak north-westerlies carry farm smoke and Thar dust down the plain	Steady monsoon and trade winds disperse pollutants
Rain	Dry October–February; little washout	North-east monsoon rain over Tamil Nadu in winter
Emissions	Crop-residue fires, coal plants, brick kilns, dense traffic, biomass fuel	Fewer farm fires; cleaner fuel mix
Soil and dust	Fine alluvial and desert dust	Rocky, vegetated surfaces

- Winter **western disturbances** bring calm, moist, foggy spells behind them. Fog droplets absorb gases and grow into **secondary particles**, which turns haze into smog.
- **The contrast is meteorological as much as emission-driven.** Bengaluru, Chennai and Hyderabad emit heavily too, but ventilation keeps their annual $PM_{2.5}$ far lower.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

Delhi NCR's particulate problem

- Delhi's winter AQI regularly enters the **"severe"** band in November, and $PM_{2.5}$ stays above the NAAQS for most of the year.
- **Why it persists:**
  - **Geography and season:** a landlocked basin with the Aravallis to the south-west, cold calm air, inversions and low mixing heights;
  - **Local sources:** vehicles, road and construction dust, industry, diesel generators, waste burning and landfill fires (Ghazipur, Bhalswa, Okhla);
  - **Regional sources:** power plants, brick kilns and industries across the NCR, and **paddy-stubble smoke** from Punjab and Haryana in October–November;
  - **Festive spikes:** firecrackers around Diwali;
  - **Governance:** a single airshed split across Delhi, Uttar Pradesh, Haryana and Rajasthan, weak enforcement, and measures that react to emergencies rather than run all year.
- **Responses:**
  - the **Commission for Air Quality Management in NCR and Adjoining Areas Act, 2021** gives one statutory body power over the whole airshed;
  - the **Graded Response Action Plan (GRAP)** tightens curbs in four stages as the AQI rises from "poor" to "severe+";
  - cleaner fuels (CNG, piped gas), the Eastern and Western Peripheral Expressways that divert trucks, the metro and electric buses, and a ban on unapproved fuels in industry.

Crop residue burning and its management

- Combine harvesting leaves loose paddy stubble, and only **two to three weeks** separate the paddy harvest from wheat sowing. Burning is the cheapest way to clear the field.
- The smoke adds $PM_{2.5}$, CO and black carbon, and **destroys soil organic matter**, nitrogen and soil microbes.
- **Fire counts are falling:** Punjab's farm fires fell from about **71,300 in 2021 to 5,114 in 2025**, and Haryana's to **662** (CAQM). Yet Delhi's winter air did not improve in proportion, which shows how much of the load is local.
- **Management:**
  - **In-situ:** Happy Seeder and Super Seeder sowing into stubble, mulching, and the **PUSA bio-decomposer** that rots stubble in the field;
  - **Ex-situ:** baling straw for **biomass power**, **compressed biogas**, co-firing pellets in thermal plants (now mandated), 2G ethanol, cardboard and fodder;
  - **Crop shift:** diversifying away from water-hungry paddy, delayed transplanting under Punjab's groundwater law (2009), and support prices for alternatives;
  - **Incentives:** subsidised crop-residue machinery, custom hiring centres, and cash support per acre not burnt.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

Control of air pollution PYQ 2013

- **At the source:**
  - cleaner fuels (LPG under **Pradhan Mantri Ujjwala Yojana**, CNG, electricity) and fuel switching in industry;
  - **Bharat Stage VI** vehicle and fuel norms, adopted nationwide on 1 April 2020 by skipping BS-V;
  - renewable power, efficient kilns (zig-zag brick kilns), and dust control on construction sites.
- **End-of-pipe equipment:**

DEVICE	REMOVES	PRINCIPLE
Electrostatic precipitator	Fly ash, dust	Charged plates attract particles
Bag (fabric) filter	Fine dust	Filtration through cloth
Cyclone separator	Coarse particles	Centrifugal settling
Wet scrubber, flue-gas desulphurisation	SO_2, acid gases	Absorption in limestone slurry
Catalytic converter	CO, hydrocarbons, NO_x	Oxidation and reduction on a catalyst

- **Planning:** green belts, siting of industry downwind and outside inversion-prone valleys, and transport-oriented urban design.
- **Law and programmes:** the **Air (Prevention and Control of Pollution) Act, 1981**, the NAAQS, and the **National Clean Air Programme (NCAP)**.
  - NCAP, launched in **January 2019**, covers **131 non-attainment and million-plus cities**. Its first target was a 20–30% cut in particulate levels by 2024 over 2017 levels.
  - The target was revised to a **40% cut in PM_{10}, or meeting the national standard of 60 µg/m³, by 2025–26**. City funds are tied to measured improvement.
  - **Results are uneven:** of 100 cities with adequate data, **51 met the original target** but only **23 the revised one**, and most still exceed the PM_{10} standard (2026 assessment). Dust control dominates spending, while industrial, vehicle and regional sources get less.

03 Water Pollution PYQ 2022 · 2020 · 2019 +4

Sources

- **Domestic sewage:** organic matter, nutrients, pathogens, detergents. It is the **largest single source** in India.
- **Industrial effluents:** heavy metals (chromium from tanneries, mercury from chlor-alkali plants), dyes, acids, oils, and organic chemicals from pulp, sugar, distillery and pharmaceutical units.
- **Agricultural runoff:** nitrate and phosphate from fertilisers, pesticides, and animal waste; a classic **non-point source**.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

- **Mining:** acid mine drainage, metals and silt; the effects of **mining and large dams** extend far downstream.
- **Thermal discharge** from power plants, **landfill leachate**, and **religious and cultural loads** such as idol immersion.

Measuring water quality

- **Dissolved oxygen (DO):** the oxygen available to aquatic life. Fish suffer below about **4–5 mg/L**; water below **2 mg/L** is **hypoxic**.
- **Biochemical oxygen demand (BOD):** the oxygen microbes need to decompose the organic matter in a sample. It is measured over five days at 20 °C, or three days at 27 °C in Indian practice.
  - High BOD means heavy organic pollution. Untreated sewage runs to a few hundred mg/L, while clean river water stays below 3 mg/L.
- **Chemical oxygen demand (COD):** the oxygen needed to oxidise all organic matter chemically. It is always higher than BOD, and the **COD:BOD ratio** shows how much is non-biodegradable, typical of industrial waste.
- **Faecal coliform:** an indicator of sewage and pathogens.
- **CPCB criteria for outdoor bathing:** DO at least **5 mg/L**, BOD at most **3 mg/L**, faecal coliform below **2,500 MPN per 100 mL**, and pH 6.5–8.5.

Eutrophication

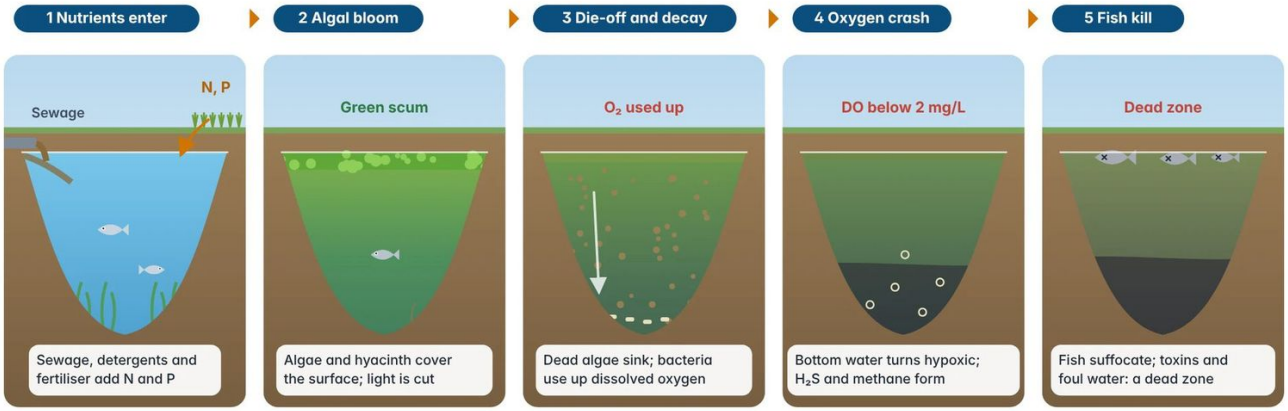
- **Eutrophication** is the **over-enrichment of a water body with nutrients**, chiefly nitrogen and phosphorus, which drives excessive plant and algal growth.
  - **Natural eutrophication** is the slow ageing of a lake over centuries as sediment and nutrients fill it.
  - **Cultural (anthropogenic) eutrophication** compresses this into years through sewage, detergents and fertiliser runoff.
- **The sequence:**
  1. Nutrients enter from sewage and farms;
  2. **Algal blooms** and floating weeds (water hyacinth) cover the surface and shade out submerged plants;
  3. The bloom dies, and **bacterial decomposition** consumes dissolved oxygen;
  4. Bottom water becomes **hypoxic or anoxic**; hydrogen sulphide and methane form;
  5. **Fish kills**, loss of species and foul water follow. Some blooms (cyanobacteria) release **toxins**.
- **Indian cases:**
  - **Bellandur Lake**, Bengaluru, frothed and caught fire repeatedly in 2015–2018 under untreated sewage and detergents;
  - **Hussain Sagar** (Hyderabad), **Dal Lake** (Srinagar) and the **Yamuna's toxic foam** at Kalindi Kunj every winter;
  - nutrient loads also feed the **coastal dead zones** described under marine pollution.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

ENVIRONMENTAL GEOGRAPHY · POLLUTION

Eutrophication: From Nutrients to a Dead Zone

Extra nitrogen and phosphorus feed an algal bloom whose decay strips oxygen from the water, ending in fish kills.





Causes

- Untreated sewage and detergents (phosphate)
- Fertiliser runoff; livestock waste
- Warm, still, stratified water

Effects

- Fish kills; loss of species
- Toxic cyanobacteria; foul drinking water
- Weeds choke boating and fishing

Control

- Treat sewage; remove phosphorus
- Buffer strips; balanced fertiliser
- Desilting, aeration, wetland filters

Schematic; oxygen values are indicative. Indian cases: Bellandur Lake (Bengaluru), Hussain Sagar (Hyderabad), Dal Lake (Srinagar).

lotusarise.com

Groundwater contamination PYQ 2022

- Groundwater supplies most of India's drinking water and irrigation, and it is polluted from two directions:
  - **geogenic** contaminants dissolved from rocks and sediments: **arsenic, fluoride, uranium, iron, salinity**;
  - **anthropogenic** contaminants leached from the surface: **nitrate**, pesticides, heavy metals and pathogens.
- **Extent:** in 2025, **28.3%** of samples tested by the Central Ground Water Board exceeded at least one drinking-water limit.

CONTAMINANT	SHARE OF SAMPLES ABOVE LIMIT	MAIN BELTS	HEALTH EFFECT
Nitrate (above 45 mg/L)	About 20%	Rajasthan, Tamil Nadu, Maharashtra, Telangana, Andhra Pradesh, Madhya Pradesh, Punjab	Methaemoglobinaemia ("blue baby syndrome")

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

CONTAMINANT	SHARE OF SAMPLES ABOVE LIMIT	MAIN BELTS	HEALTH EFFECT
Fluoride (above 1.5 mg/L)	About 8%	Rajasthan, Gujarat, Haryana, Telangana, Andhra Pradesh, Karnataka	Dental and skeletal fluorosis
Salinity (EC)	About 7%	Rajasthan, Delhi, Haryana, Gujarat	Unfit for drinking and irrigation
Uranium (above 30 ppb)	About 7–8%	Punjab, Haryana, Delhi, Rajasthan	Kidney damage
Arsenic (above 0.01 mg/L)	Patchy but severe	Ganga–Brahmaputra plain: West Bengal, Bihar, Uttar Pradesh, Jharkhand, Assam; parts of Punjab	Skin lesions, cancer

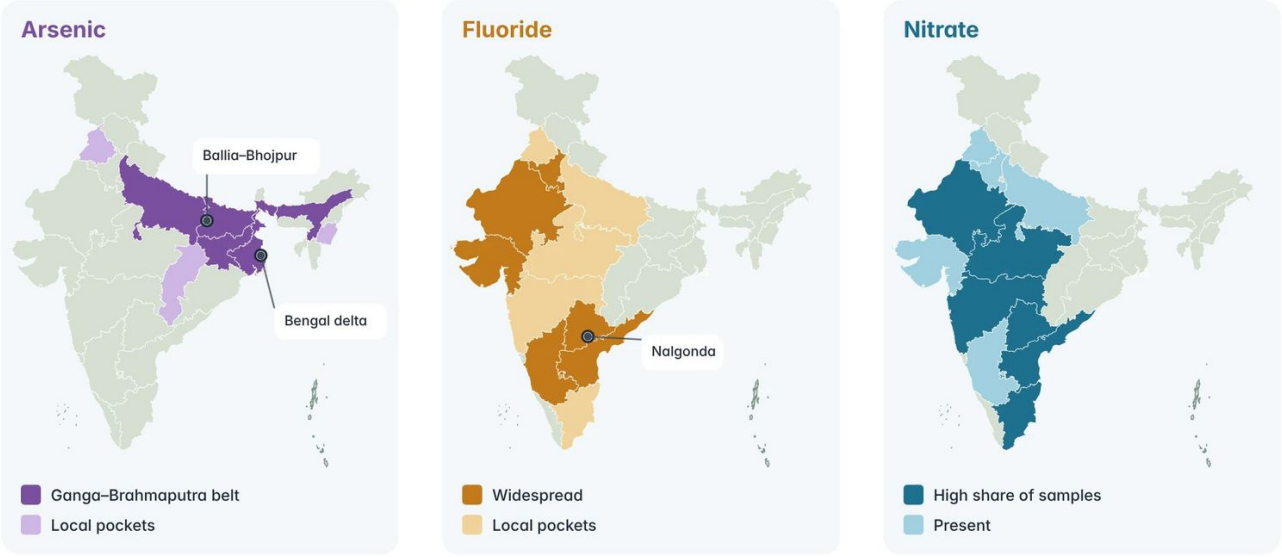
- **Arsenic** is released from **Holocene alluvium** when iron oxides dissolve under reducing conditions, so it is worst in young deltaic and floodplain aquifers. It was first identified in West Bengal in the early 1980s.
- **Fluoride** comes from granite and gneiss and is concentrated by evaporation in **semi-arid hard-rock areas**. Nalgonda in Telangana is the classic fluorosis district.
- **Nitrate** marks intensive farming and sewage. Heavy urea use in the **Green Revolution** belt and septic tanks in cities both raise it.
- **Urban groundwater** is a fast-growing public-health problem:
  - septic tanks, leaking sewers and unlined drains seep into shallow aquifers;
  - **landfill leachate** carries metals and organics (Ghazipur in Delhi, Deonar in Mumbai);
  - industrial units inject effluent into **borewells** to evade inspection;
  - **over-pumping** draws in saline or deeper contaminated water, and coastal cities such as Chennai face **seawater intrusion**;
  - the result: diarrhoeal disease, hepatitis, fluorosis, and higher costs for treatment and tanker water.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

ENVIRONMENTAL GEOGRAPHY · POLLUTION

Groundwater Contamination Belts of India

Arsenic follows the young alluvium of the Ganga–Brahmaputra plain, fluoride the dry hard-rock lands, and nitrate the intensively farmed and urbanised states.



Arsenic (limit 0.01 mg/L)

- Geogenic: released from young alluvium when iron oxides dissolve
- Skin lesions, cancers
- Worst in shallow floodplain and deltaic aquifers

Fluoride (limit 1.5 mg/L)

- Geogenic: granite and gneiss of hard-rock dry regions
- Dental and skeletal fluorosis
- About 8% of samples above limit (2025)

Nitrate (limit 45 mg/L)

- Anthropogenic: fertiliser, sewage, septic tanks
- Blue baby syndrome in infants
- About 20% of samples above limit (2025)

Schematic: shading marks states where the Central Ground Water Board reports contamination, not that the whole state is affected. Data: CGWB Annual Ground Water Quality Reports, 2024 and 2025; limits: BIS 10500.

lotusarise.com

Water pollution in India PYQ 2013

- **The sewage gap:** India generated about **72,368 million litres a day (MLD)** of sewage against an installed treatment capacity of **31,841 MLD**; only about **28%** was actually treated (CPCB, 2021).
- **Polluted river stretches: 296** stretches failed the bathing criteria in 2025, down from **311** in 2022. Maharashtra had the most (54). Priority I stretches carry BOD above 30 mg/L.
- **Hotspots:** the Yamuna below Delhi, the Ganga at Kanpur (tanneries), the Sabarmati below Ahmedabad, the Mithi in Mumbai, and the Musi in Hyderabad.
- **Responses:** the **Water (Prevention and Control of Pollution) Act, 1974**, which an amendment in 2024 shifted from jail terms to penalties for many offences; the **Namami Gange** programme (2014); and the **AMRUT** sewerage component in cities.
- **Marine pollution** has its own pathways and law. About 80% of it comes from land, through rivers, outfalls and the air, so cleaning rivers is the main step towards cleaner seas.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

Control of water pollution PYQ 2013

- **Treat sewage** in sewage treatment plants: primary (settling), secondary (biological: activated sludge, trickling filters), tertiary (nutrient removal, disinfection). Reuse the treated water for industry and parks.
- **Industrial effluents:** effluent treatment plants, **common effluent treatment plants (CETPs)** for small-unit clusters, and **zero liquid discharge** in water-hungry sectors such as textiles and distilleries.
- **Low-cost options:** waste-stabilisation ponds, **constructed wetlands**, and bioremediation of drains. The East Kolkata Wetlands, a Ramsar site, treat much of the city's sewage through fisheries.
- **Non-point control:** balanced fertiliser use, buffer strips along streams, and integrated pest management.
- **Groundwater:** community arsenic and fluoride removal plants, a shift to safe surface sources (the Jal Jeevan Mission), recharge, and regulation of over-extraction.

04 Soil, Noise, Thermal and Radioactive Pollution PYQ 2017 · 2013

Soil pollution PYQ 2017

- **Soil pollution** is a form of chemical **land degradation**: the build-up of **toxic substances in soil** to levels that harm organisms, crops and people through the food chain or groundwater.
- **Sources:** industrial effluents and sludge, mining waste, fly ash, municipal and electronic waste, **pesticides and excess fertiliser**, and irrigation with untreated sewage.
- **Effects:** loss of soil microbes and fertility, toxic metals in crops (cadmium in rice, lead in vegetables), groundwater contamination, and **salinisation** from poor-quality water.
- **Areas vulnerable to soil pollution in India:**

TYPE OF AREA	EXAMPLES	MAIN POLLUTANTS
Industrial clusters	Vapi and Ankleshwar (Gujarat), Patancheru (Telangana), Kanpur tanneries, Ratlam	Chromium, solvents, dyes
Mining belts	Sukinda chromite (Odisha), Jharia coalfield, Singrauli, Bellary	Hexavalent chromium, mercury, fly ash, acid drainage
Intensive farming belts	Punjab's Malwa region, Haryana, western Uttar Pradesh	Pesticide residues, nitrate, cadmium from phosphate fertiliser
Peri-urban sewage-farmed land	Around Delhi, Kanpur, Hyderabad (Musi)	Pathogens, heavy metals
Waste and e-waste sites	Landfills of big cities; Seelampur (Delhi), Moradabad	Lead, cadmium, mercury, dioxins

- The Central Pollution Control Board's **Comprehensive Environmental Pollution Index (2009)** rated **43 of 88 industrial clusters** critically polluted, most with combined air, water and land contamination.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

- **Remedies:** treatment at source, secure landfills, **phytoremediation** (plants that take up metals), bioremediation, liming of acid sites, soil testing and balanced fertilisation.

Noise pollution PYQ 2013

- **Noise** is **unwanted or harmful sound**. It is measured in **decibels (dB)**, usually A-weighted, dB(A), to match the ear's sensitivity.
  - The scale is **logarithmic**: a rise of **10 dB** is a tenfold rise in sound intensity and sounds roughly **twice as loud**.
  - Standards use **Leq**, the equivalent continuous sound level averaged over a period.
- **Levels of noise:**

LEVEL DB(A)	TYPICAL SOURCE	EFFECT
0–30	Threshold of hearing; rustling leaves, whisper	Quiet
40–60	Library, normal conversation	Comfortable
70–85	Busy traffic, vacuum cleaner, heavy truck	Annoyance; hearing risk with long exposure above 85
90–110	Pneumatic drill, factory floor, loud music	Hearing damage within hours
120–140	Firecrackers at close range, jet take-off	Pain threshold; immediate damage

- **Effects:**
  - **Auditory:** temporary threshold shift, then permanent **noise-induced hearing loss**, and tinnitus;
  - **Non-auditory:** disturbed sleep, stress, high blood pressure and heart disease, poor concentration and learning in children;
  - **Wildlife:** masking of bird calls and of the acoustic signals whales use at sea.
- **Ambient noise standards** under the **Noise Pollution (Regulation and Control) Rules, 2000**:

AREA	DAY (6 AM–10 PM), DB(A) LEQ	NIGHT (10 PM–6 AM), DB(A) LEQ
Industrial	75	70
Commercial	65	55
Residential	55	45

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

AREA	DAY (6 AM–10 PM), DB(A) LEQ	NIGHT (10 PM–6 AM), DB(A) LEQ
Silence zone	50	40

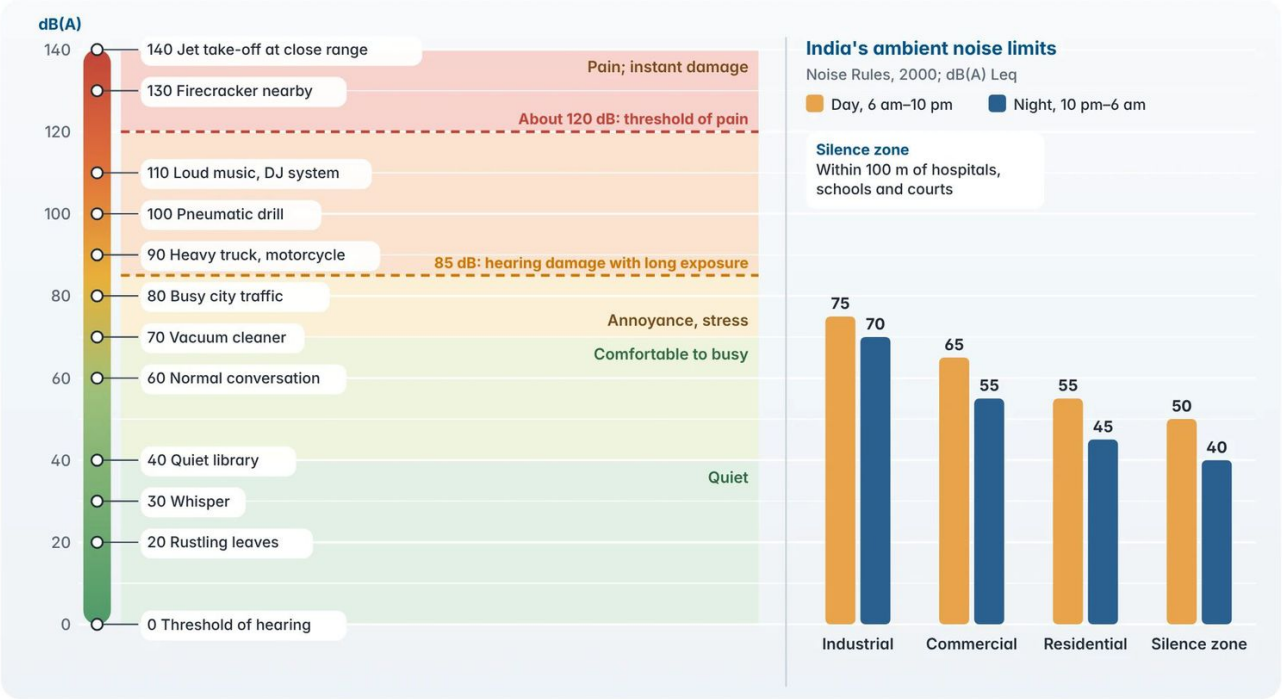
- **Legislative measures:**
  - The **Air (Prevention and Control of Pollution) Amendment Act, 1987** brought **noise** within the definition of an air pollutant.
  - The **Noise Rules, 2000**, framed under the Environment (Protection) Act, 1986:
    - make states classify industrial, commercial, residential and silence zones;
    - declare **silence zones** within **100 m** of hospitals, educational institutions and courts;
    - ban loudspeakers and public-address systems at night, except in closed premises; states may relax this until midnight on a limited number of festive days a year.
  - **Firecrackers** have noise limits at source under the Environment (Protection) Rules, and the **Supreme Court (2005)** barred bursting them between 10 pm and 6 am.
  - The **Motor Vehicles Act** and rules limit horn and engine noise, and factory law limits exposure at the workplace.
- **Control:** reduce noise at source (silencers, quieter machines, electric vehicles), block its path (noise barriers, tree belts, insulation), protect receivers (ear protection), and plan land use by keeping hospitals and schools away from highways and airports.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

ENVIRONMENTAL GEOGRAPHY · POLLUTION

Levels of Noise and India's Noise Standards

The decibel scale is logarithmic: every 10 dB means ten times the sound intensity. Long exposure above about 85 dB damages hearing.



Effects

- Hearing loss and tinnitus
- Sleep loss, stress, high blood pressure
- Poor concentration in children

Legislative measures

- Air Act amended 1987: noise is an air pollutant
- Noise Rules 2000: zoned limits, silence zones
- No loudspeakers or firecrackers 10 pm–6 am

Control

- Source: silencers, quieter machines, EVs
- Path: barriers, tree belts, insulation
- Receiver: ear protection, land-use zoning

Example levels are typical values at the listener. Limits: Noise Pollution (Regulation and Control) Rules, 2000, Schedule (Rule 3(1) and 4(1)).

lotusarise.com

Thermal pollution

- **Thermal pollution** is the **raising of water temperature** by heated discharge, mainly cooling water from thermal and nuclear power plants and industries.
- **Effects:**
  - warm water holds **less dissolved oxygen** while raising the metabolic demand of fish;
  - it alters spawning and migration, favours heat-tolerant algae, and causes **thermal shock** when plants start or stop;
  - near coastal outfalls it adds to **coral and seagrass stress**.
- **Control:** cooling towers and cooling ponds, reuse of waste heat (cogeneration), and discharge standards for temperature rise.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

Radioactive pollution

- **Radioactive pollution** is the release of ionising radiation from **radionuclides**.
  - **Natural sources:** cosmic rays, radon gas, and radioactive minerals such as the **monazite sands of the Kerala coast**, where Karunagappally has high background radiation.
  - **Human sources:** nuclear weapons testing, the nuclear fuel cycle (uranium mining, reactors, reprocessing), medical and industrial isotopes.
- **Effects:** cell and DNA damage, **cancers** (thyroid cancer from iodine-131, bone cancer from strontium-90), genetic effects, and long-term contamination of land.
- **Accidents: Chernobyl** (Ukraine, 26 April 1986) left an exclusion zone of about 30 km; **Fukushima Daiichi** (Japan, 11 March 2011) followed an earthquake and tsunami.
- **Control:** reactor safety and regulation (the Atomic Energy Regulatory Board in India), deep geological storage of high-level waste, and monitoring of mining areas such as Jaduguda in Jharkhand.

05 Persistent Toxins and Wastes

Chlorinated hydrocarbons and persistent organic pollutants

- **Chlorinated hydrocarbons (CHCs)** are synthetic organic compounds of carbon, hydrogen and **chlorine**. They include the organochlorine insecticides **DDT, aldrin, dieldrin, endrin, chlordane, heptachlor, endosulfan and lindane (BHC)**, and industrial chemicals such as **PCBs** and the by-products **dioxins and furans**.
- **Characteristics that make them a serious threat to ecosystems:**
  - **Persistence:** the carbon–chlorine bond resists breakdown by sunlight, water and microbes, so DDT lasts for years to decades in soil and sediment;
  - **Fat solubility, low water solubility:** they leave water for the **fatty tissues** of organisms and are excreted very slowly;
  - **Bioaccumulation:** the concentration in an organism rises over its lifetime as intake exceeds loss;
  - **Biomagnification:** the concentration **multiplies at each trophic level**, so top predators and humans receive the highest doses;
  - **Broad-spectrum toxicity:** they kill non-target insects, pollinators, fish and the natural enemies of pests, and pests evolve **resistance**;
  - **Long-range transport:** they evaporate in warm regions and condense in cold ones (the **"grasshopper effect"**), so they reach the Arctic and the Himalaya far from any use;
  - **Endocrine disruption:** they mimic hormones, causing reproductive failure, birth defects and cancers;
  - **Synergy:** mixtures act together, and residues in milk, eggs and human breast milk persist across generations.
- **Classic evidence:**
  - **Rachel Carson's *Silent Spring* (1962)** documented the death of birds and fish from DDT spraying and launched the modern environmental movement;

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

- DDE, a breakdown product of DDT, interferes with calcium deposition, causing **eggshell thinning** and the collapse of **peregrine falcon, bald eagle, osprey and brown pelican** populations;
- **Endosulfan in Kasaragod, Kerala:** aerial spraying of cashew plantations for over two decades was linked to birth defects and chronic illness in surrounding villages. The **Supreme Court** imposed a ban in **2011**, the year endosulfan was listed under the Stockholm Convention.

Bioaccumulation and biomagnification

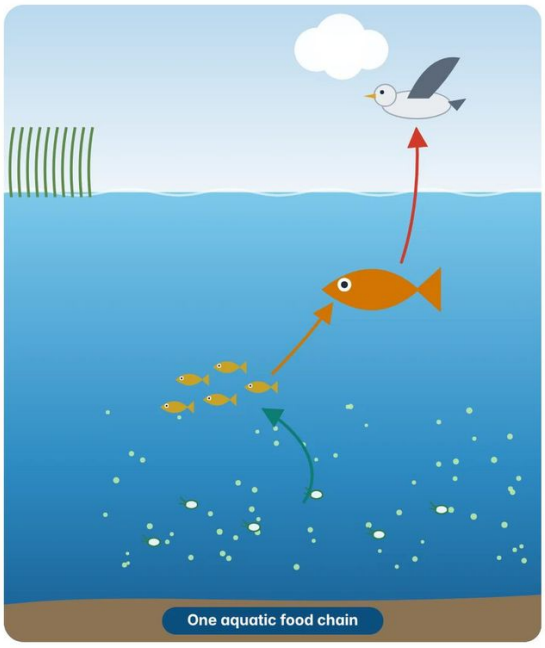
- **Bioaccumulation** is the build-up of a pollutant **within one organism**, from water and food, faster than the body can remove it.
- **Biomagnification (biological magnification)** is the **increase in concentration from one trophic level to the next** along a food chain, because each consumer eats many prey and stores the pollutant in its fat. Since most energy is lost between **trophic levels**, each level must eat many times its own mass, and the residue stays behind.
- **The classic case:** in a Long Island estuary, **George M. Woodwell, Charles F. Wurster and Peter A. Isaacson (1967)** found DDT at about **0.04 ppm in plankton**, a few tenths to about 2 ppm in fish, and **3–25 ppm in fish-eating birds**, with up to **75 ppm** in a ring-billed gull. Over the chain the concentration rises **millions of times** above that in the water.
- **Heavy metals biomagnify too:**
  - **mercury**, converted to methylmercury by bacteria, caused **Minamata disease** in Japan (identified 1956);
  - **cadmium** from mining waste in the Jinzu river basin caused **itai-itai disease**.

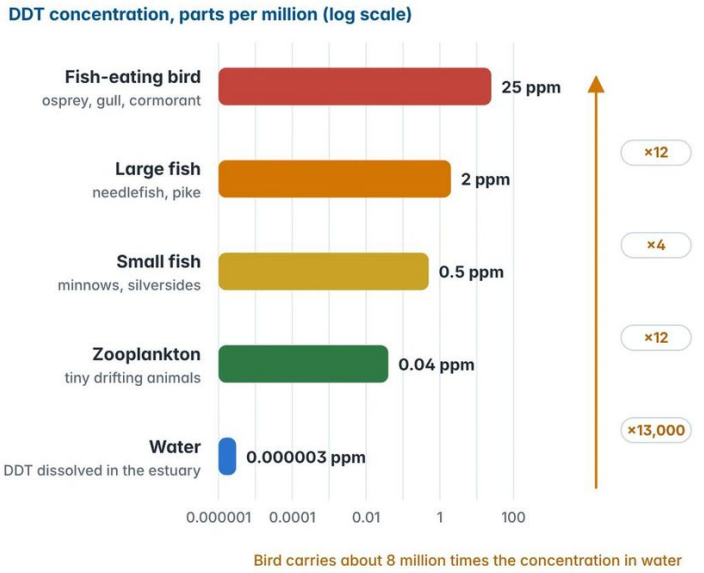
FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

ENVIRONMENTAL GEOGRAPHY · POLLUTION

Biomagnification of DDT in an Aquatic Food Chain

A trace of DDT in water is concentrated at every step of the food chain, so fish-eating birds carry millions of times more than the water around them.





Why DDT magnifies

- Persistent: decades in sediment
- Fat-soluble, excreted very slowly
- Each consumer eats many prey

Harm at the top

- DDE thins eggshells; eggs crack
- Falcons, eagles, ospreys, pelicans crashed
- Residues reach human breast milk

Response

- Rachel Carson's Silent Spring (1962)
- Stockholm Convention (2001): DDT only for disease-vector control

Classic textbook values derived from the Long Island estuary study of George M. Woodwell, Charles F. Wurster and Peter A. Isaacson (1967), which found about 0.04 ppm in plankton, 3–25 ppm in fish-eating birds and 75 ppm in one ring-billed gull. Logarithmic scale.

lotusarise.com

- **The Stockholm Convention on Persistent Organic Pollutants** (adopted 2001, in force 2004) targets these chemicals:
  - it began with the **"dirty dozen"**: eight pesticides (aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex, toxaphene), two industrial chemicals (PCBs, hexachlorobenzene) and two by-products (dioxins, furans);
  - **Annex A** lists chemicals for elimination, **Annex B** for restriction, and **Annex C** for unintentional releases;
  - **37 chemicals** are now listed, the latest being **chlorpyrifos**, medium-chain chlorinated paraffins and long-chain perfluorocarboxylic acids (2025);
  - **DDT** is still allowed for **disease-vector control**, which matters to India, a producer and user for malaria control;
  - **India ratified it in 2006**, choosing that new listings do not bind it until it ratifies each one.
- Three sister treaties govern **hazardous wastes and chemicals**: Basel (transboundary waste), Rotterdam (prior informed consent in trade) and Minamata (mercury).

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

Solid waste PYQ 2023 · 2013

- **Municipal solid waste (MSW)** is the everyday waste of homes, markets, offices and streets. India generates about **1.85 lakh tonnes a day** (CPCB, 2023–24).
  - About half is **wet, biodegradable** organic matter; the rest is paper, plastic, glass, metal, textiles and inert dust.
- **Environmental challenges in metropolitan regions:**
  - **Legacy landfills** that rise like hills: Ghazipur, Bhalswa and Okhla in Delhi; Deonar in Mumbai; Perungudi in Chennai;
  - **methane** emissions and spontaneous **landfill fires** that add to winter smog;
  - **leachate** that contaminates groundwater and soil;
  - **open burning** of waste, clogged drains that worsen urban floods, and plastics that reach rivers and the sea;
  - **land scarcity** for new sites, and the health risks borne by an informal workforce of waste pickers;
  - weak segregation, which spoils the organic fraction for compost and the dry fraction for recycling.
- The waste stream swells with rising incomes, packaging and **"use and throw" consumption**.
- **Rules:**
  - the **Solid Waste Management Rules, 2016** extended rules beyond municipalities to census towns, villages and bulk generators, and made **segregation at source** mandatory;
  - the **Solid Waste Management Rules, 2026**, in force from **1 April 2026**, replace them:
    - mandatory **four-stream segregation**: **wet, dry, sanitary and special-care** waste;
    - **bulk waste generators** (20,000 m² of floor area, 40,000 litres of water a day, or 100 kg of waste a day) must process wet waste on site or buy **Extended Bulk Waste Generator Responsibility** certificates;
    - landfills only for **non-recyclable and inert** residue, with higher fees for unsegregated waste;
    - **time-bound biomining** of legacy dumpsites;
  - the **Environment (Construction and Demolition) Waste Management Rules, 2025** also apply from April 2026.
- **Efforts:** the **Swachh Bharat Mission (Urban) 2.0** (2021) aims at **garbage-free cities**; materials recovery facilities, composting, biomethanation and waste-to-energy are spreading. **Indore**, with strict segregation and wet-waste biogas, is the model city.

Plastic waste

- India generated about **4.13 million tonnes** of plastic waste in 2022–23. Much of it is **single-use** packaging, which is light, cheap and hard to collect.
- **Problems:** clogged drains and urban flooding, cattle deaths, toxic smoke when burnt, **microplastics** in soil and water, and marine litter.
- **Plastic Waste Management Rules, 2016** and their amendments:
  - minimum carry-bag thickness raised to **75 microns** (September 2021) and **120 microns** (December 2022);
  - a ban on **identified single-use plastic items** from **1 July 2022**;

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

- **extended producer responsibility (EPR)** guidelines (2022), with collection, recycling and recycled-content targets tracked on a central portal;
- the **2026 amendment** sets recycled-content targets by category (rigid packaging from 30% in 2025–26 to 60% by 2028–29) and allows shortfalls to be carried forward. Critics say it weakens enforcement where **fake EPR certificates** are already a problem.

E-waste

- **E-waste** is discarded electrical and electronic equipment: phones, computers, appliances, solar panels and batteries.
  - It contains **lead, mercury, cadmium, brominated flame retardants**, and valuable metals such as gold, copper and rare earths.
- **Scale:** India generated about **1.75 million tonnes** in 2023–24, up about 73% in five years; about 43% was recycled through formal channels. The world generated about **62 million tonnes** in 2022, and only **22.3%** was documented as recycled (Global E-waste Monitor, 2024).
- **The informal sector** dismantles most of it by acid baths and open burning, in clusters such as **Seelampur** (Delhi) and **Moradabad** (Uttar Pradesh), poisoning workers, soil and water.
- **E-Waste (Management) Rules, 2022** (in force **1 April 2023**) put the burden on producers through **EPR targets** met by registered recyclers. They cover **106 equipment items** and bring in solar panels and cells.

Hazardous and industrial waste PYQ 2024

- **Industrial waste is diverse:** fly ash from coal power, slag from steel plants, **red mud** from alumina refineries, **phosphogypsum** from fertiliser plants, sludge, spent chemicals and hazardous residues.
- **Hazardous waste** is toxic, corrosive, flammable, reactive or infectious, and is governed by the **Hazardous and Other Wastes Rules, 2016**, the Bio-Medical Waste Management Rules, 2016 and the Battery Waste Management Rules, 2022.
- **Potentials:**
  - **fly ash** in cement, bricks, road embankments and mine filling, with power plants obliged to utilise it fully;
  - **slag** in cement and roads; **red mud** as a source of iron and rare earths; phosphogypsum for soil reclamation;
  - **industrial symbiosis**, where one firm's waste is another's raw material, as in Kalundborg (Denmark), and a **circular economy** supported by EPR.
- **Challenges:** huge volumes and low value, toxic content, illegal dumping, too few treatment, storage and disposal facilities, a weak informal recycling chain, and accidents. The **Bhopal gas tragedy** (December 1984, methyl isocyanate) remains the worst industrial disaster.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

06 Controlling Pollution

PYQ 2022 · 2020 · 2019 +4

The pollution control hierarchy

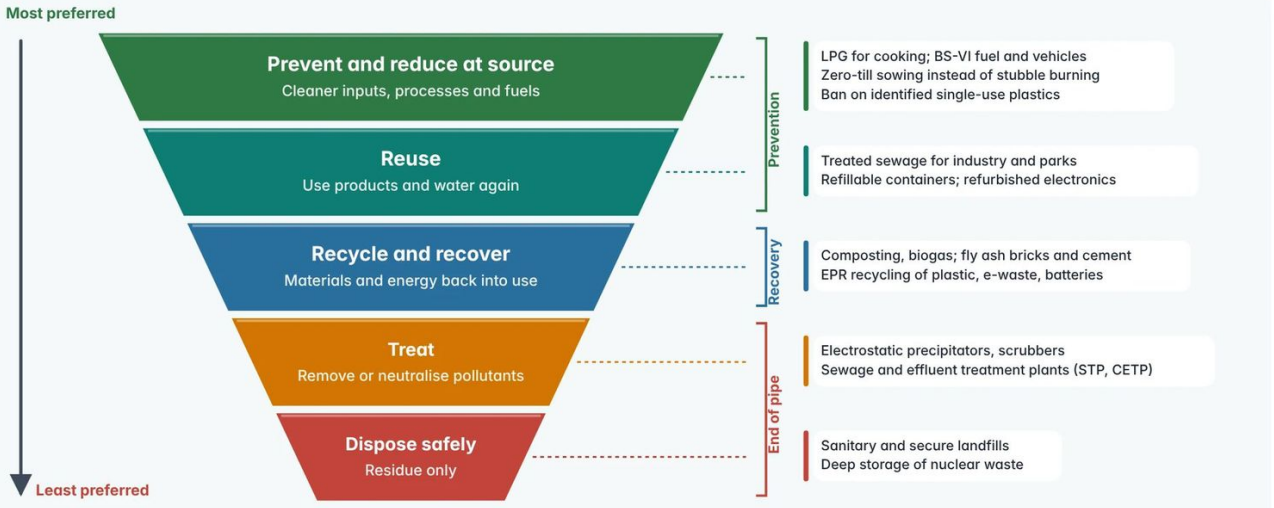
PYQ 2013

- Pollution control has moved from **dilution** ("the solution to pollution is dilution") to **end-of-pipe treatment**, and now to **prevention at source**.
- **The hierarchy, from most to least preferred:**
  1. **Prevent and reduce at source:** cleaner production, process change, substitution of toxic inputs, efficiency;
  2. **Reuse** products and materials;
  3. **Recycle and recover** materials and energy;
  4. **Treat** emissions and effluents to remove or neutralise pollutants;
  5. **Dispose** of the residue safely: secure landfill, controlled release.
- **Why prevention wins:** treatment shifts pollutants from one medium to another (scrubber sludge, incinerator ash), while prevention removes them.

ENVIRONMENTAL GEOGRAPHY · POLLUTION

The Pollution Control Hierarchy

Pollution control has moved from dilution and end-of-pipe treatment towards preventing pollution at its source.



Why prevention wins
- No pollutant, no treatment cost
- Saves energy and raw material
- Treatment only shifts pollutants: sludge, ash

Guiding principles
- Polluter pays
- Precautionary principle
- Extended producer responsibility

Indian instruments
- Water Act 1974, Air Act 1981, EP Act 1986
- Waste rules 2016–2026; NCAP 2019
- NGT 2010; CAQM 2021

Schematic; adapted from the waste-management hierarchy used in Indian waste rules and international practice. lotusarise.com

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

Principles and instruments

- **Polluter pays:** the polluter bears the cost of prevention and of restoring damage, a principle Indian courts have enforced since the 1990s.
- **Precautionary principle:** lack of full scientific certainty is no reason to delay action against serious harm.
- Indian **environmental policy** mixes three kinds of **instruments**:
  - **command and control:** emission and effluent standards, consent to establish and operate, closure orders;
  - **market-based:** pollution taxes, cess, **emissions trading** (Surat's particulate trading scheme, 2019), and EPR certificates;
  - **information:** the AQI, continuous emission monitoring, public disclosure and ratings.

The Indian framework

- India's **environmental legislation** rests on three framework Acts and a growing set of rules:

INSTRUMENT	YEAR	SCOPE
Water (Prevention and Control of Pollution) Act	1974 (amended 1988, 2024)	Pollution control boards; consent for discharge
Air (Prevention and Control of Pollution) Act	1981 (amended 1987)	Air quality, emission standards; noise added in 1987
Environment (Protection) Act	1986	Umbrella law; standards and rules for all media
Noise Pollution (Regulation and Control) Rules	2000	Zoned noise standards
National Green Tribunal Act	2010	Specialised environmental court
Waste rules (solid, plastic, e-waste, hazardous, bio-medical, battery, C&D)	2016–2026	Segregation, EPR, safe disposal
Commission for Air Quality Management Act	2021	One airshed authority for NCR
National Clean Air Programme	2019	City action plans for particulates

Critical evaluation and way forward

- **Weak enforcement:** pollution control boards are short of staff and money, and the 2023 decriminalisation of the Air Act and the Environment (Protection) Act relies on penalties that must actually be collected.
- **Standards lag science:** the NAAQS date from 2009 and are several times looser than the WHO guidelines.
- **Airsheds and river basins cross state lines**, while action is city- or state-wise. Regional sources such as stubble smoke and power plants need regional management.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

- **Data gaps:** sparse monitoring in small towns and villages, and self-reported compliance in EPR systems.
- **Way forward:**
  - airshed and basin-level planning, and enforcement of existing standards;
  - full sewage treatment and reuse, with nutrient control;
  - clean energy and electric mobility, and a circular economy for plastics, e-waste and industrial waste;
  - revision of standards towards WHO targets, wider monitoring, and public participation.

Previous Year Questions

2024	Industrial waste is diversified. Discuss the potentials and challenges associated with it.
2023	Examine the environmental challenges caused by the solid waste in metropolitan regions of India and discuss the efforts to overcome it.
2022	Why has extreme particulate pollution remained a festering issue in Delhi NCR region?
2022	Groundwater contamination in the fast expanding urban landscape of India appears to have become a major public health issue. Discuss.
2020	Discuss the methods of crop residue management in rural India to reduce pollution.
2019	Give a reasoned account of high level of pollution in North Indian cities as compared to South Indian cities.
2017	What do you understand by soil pollution? Delineate the areas vulnerable to it in India and suggest remedial measures.
2013	What are the characteristics that make CHC a serious threat to the ecosystem? Give examples.
2013	Explain the levels of Noise pollution and the legislative measures to control it.
2013	“Urban Solid Waste Management poses the greatest challenge in Metropolitan Planning”. Elaborate.
2013	Describe how urbanization creates air and water pollution in India.

FREE SAMPLE · COMPLETE NOTES AT LOTUSARISE.COM

2005	Bring out the major problems of environmental pollution at global scale and suggest measures to check it.
2003	Write short note: Environmental pollution.

LOTUSARISE IAS

COMPLETE NOTES

Get the full Geography Optional notes, Paper I and II

Syllabus-mapped, topic-wise notes for Physical, Human, Indian and World Geography, with mapping notes and topic-wise PYQs.

- ✓ Geomorphology, Climatology, Oceanography and Biogeography
- ✓ Human, Indian and World Geography with mapping notes
- ✓ Topic-wise PYQs for focused answer practice

SCAN TO OPEN

₹1,180 ~~₹1,600~~

Get the Complete Notes →

FREE SAMPLE

Liked the sample? Get the complete notes.

You have read 2 of 34 chapters of the Environmental Geography notes. The complete book covers every unit below in the same format: marked key points and definitions, PYQ tags on the sections UPSC has asked about, and the previous year questions after each chapter.

34	10	118	808
Chapters	Units	Previous year questions	Pages

IN THE COMPLETE BOOK

01 **Environmental Geography and Human–Environment Thought** 6 chapters · from page 6

02 **Principles of Ecology** 2 chapters · from page 112

03 **Human Ecological Adaptations** 3 chapters · from page 169

04 **Human Impact and Ecological Change** 4 chapters · from page 241

05 **Environmental Degradation** 3 chapters · from page 343

06 **Ecosystem and Environmental Management and Conservation** 6 chapters · from page 415

07 **Biodiversity and Sustainable Development** 4 chapters · from page 559

08 **Environmental Policy** 2 chapters · from page 658

09 **Environmental Hazards and Remedial Measures** 1 chapter · from page 707

10 **Environmental Education and Legislation** 3 chapters · from page 737

COMPLETE NOTES

Get the full Geography Optional notes, Paper I and II

Syllabus-mapped, topic-wise notes for Physical, Human, Indian and World Geography, with mapping notes and topic-wise PYQs.

- ✓ Geomorphology, Climatology, Oceanography and Biogeography
- ✓ Human, Indian and World Geography with mapping notes
- ✓ Topic-wise PYQs for focused answer practice

SCAN TO OPEN

₹1,180 ~~₹1,600~~

Get the Complete Notes →

Questions: support@lotusarise.com · lotusarise.com