

QUARKS TPSC

PREMIUM MAINS COMPANION

Opposite SDM Office, Office Lane, Agartala • 7628954476

TCS / TPS — General Studies Paper-I

Complete Theory | Solved PYQs (2019–2021) | Model Answers
TikZ Diagrams | Tripura Focus | IPCC / NDMA / ISFR Data
3 Mock Papers | Practice Sets | Last-Minute Revision

EDITION 2026

Aligned with the Latest TPSC Syllabus

Quarks TPSC Mains Companion

Environment & Disaster Management

TCS/TPS General Studies Paper-I — Section-E & Section-F

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Disclaimer

While every care has been taken to ensure factual accuracy, students must always cross-verify the latest data (forest cover, emission figures, scheme outlays, organisational chairpersons) before the examination, as such figures revise annually. The publisher accepts feedback at the institute office for incorporation in subsequent editions.

Preface

The Tripura Public Service Commission (TPSC), through its Combined Competitive (TCS/TPS) Mains examination, devotes **50 of the 250 marks in General Studies Paper-I** — a full one-fifth — to Sections E (*Environmental Conservation & Degradation*) and F (*Security & Disaster Management*). Yet, in our years of mentoring aspirants in Agartala, we have repeatedly observed that these two sections receive disproportionately *less* preparation time than they deserve. The reasons are familiar: aspirants are overwhelmed by the bulk of standard works such as Shankar IAS or P.D. Sharma; existing notes scarcely speak to the Tripura context; and the question pattern — five objective questions of one mark each, five very-short answers of two marks each, and two short answers of five marks each — needs a very different writing discipline from the descriptive 200-mark essays of UPSC.

This book was written to close that gap.

Inside, you will find every micro-topic of the prescribed TPSC syllabus broken down into examination-ready prose, fortified with **original TikZ diagrams** (the carbon cycle, the disaster-management cycle, ecological pyramids, the EIA flowchart, the seismic-zone map of Tripura, and many more), **tabulated comparisons** that the examiner expects in short-answer space, **Tripura linkage boxes** that translate global concepts to local terrain (the Gomati flood-plain, Baramura–Atharamura faults, the Trishna and Sepahijala sanctuaries), and **current-update boxes** carrying the most recent figures from IPCC AR6 (2023), ISFR 2023, COP28 (Dubai) and COP29 (Baku), the NDMA framework as updated for 2024, and the Tripura State Disaster Management Plan 2024–25 that followed the catastrophic August 2024 floods.

Every chapter ends with the same five-fold drill:

- **Previous Year Questions** with model answers, mark-wise, written exactly to the word length the examiner rewards.
- **An Examiner's Corner** that warns where candidates routinely lose marks.
- **Mains Enrichment Keywords** — the vocabulary that distinguishes a 5/5 answer from a 3/5 answer.
- **Practice Sets** — objective, very-short and short-answer — calibrated to TPSC difficulty.
- **A Quick Revision Capsule** for the final 48 hours.

The back of the book carries **three full-length mock papers** reproducing the exact pattern (1+2+5 marks × 5+5+2 questions = 25 marks per section), a *Last-Minute Revision* pamphlet, a curated list of **100 Most Important Facts**, the **Top 50 terms** for each section, and an extensive **glossary** so that no acronym — from NDMA to SEIAA, BNHS to UNDRR, CBD to TDMA — remains opaque.

If a student studies this volume *cover-to-cover*, attempts the practice sets honestly, and writes the three mock papers in timed conditions, we believe she or he need not refer to any other source for Sections E and F.

We dedicate this work to every TPSC aspirant from Tripura — from Sabroom to Dharmanagar, from Khowai to Kanchanpur — who chooses public service in a region where *climate*, *forest*, and *disaster* are not abstract examination words but the lived rhythm of everyday life.

— *The Editorial Team, Quarks TPSC*

Agartala, 2026

How to Use This Book

The Anatomy of a Chapter

Every chapter in this book follows the same eight-part architecture so that you never have to relearn the navigation:

1. **Syllabus Pointer & Marks Map** — what TPSC explicitly asks, and how many marks it has historically extracted from this micro-topic.
2. **Conceptual Theory** — written in compact, examination-grade prose. Every **key term** is rendered in colour the first time it appears so that you can build a vocabulary list as you read.
3. **Diagrams & Tables** — original TikZ illustrations of cycles, flow-charts and pyramids; tabular comparisons that should be *reproduced verbatim* in the answer book.
4. **Tripura Linkage Boxes** — the same concept seen through a Tripura lens. The examiner consistently rewards aspirants who localise their answers.
5. **Current Update Boxes** — the latest figure, the latest scheme, the latest committee report. These boxes are dated wherever possible.
6. **Solved PYQs** — the actual TCS/TPS questions of 2019 and 2021 (and earlier where available), each answered to the precise word-length the marks dictate.
7. **Practice Sets** — graded MCQs (basic / moderate / advanced / assertion-reason), very-short and short answers, with explanations.
8. **Quick Revision Capsule** — the one box you re-read in the final 48 hours.

Reading the Coloured Box System

	Concept box — definition, key facts, baseline theory
	Examiner's Corner — common mistakes, scoring patterns
	Tripura Linkage — district / river / sanctuary specifics
	Current Update — latest data & reports
	PYQ — Previous Year Questions of TCS/TPS
	Model Answer — examiner-approved framework
	Quick Revision Capsule — last-mile recall
	Common Mistake — the trap to avoid
	Mains Enrichment Keywords — vocabulary that earns marks

A Recommended 60-Day Schedule

The book is calibrated for a sixty-day Mains revision window, but is equally usable in compressed mode.

Days	Section-E Topic	Section-F Topic
1–6	Biodiversity (Ch. 1)	Hazards & Disasters (Ch. 8)
7–12	Ecology (Ch. 2)	DM Cycle & NDMA (Ch. 9)
13–18	Resources & Energy (Ch. 3)	Tripura Hazards (Ch. 10)
19–26	Pollution (Ch. 4)	Practice Set F (full)
27–34	Global Issues (Ch. 5)	Mock Paper 1 & 2
35–42	Legislation (Ch. 6)	Cross-revision
43–48	Organisations (Ch. 7)	Mock Paper 3
49–54	Section-E PYQ marathon	Section-F PYQ marathon
55–60	Last-Minute Revision (App. B)	100 Important Facts (App. C)

The 25-Mark Writing Discipline

- Objective (1 mark each)** — Encircle the chosen letter clearly. Negative marking exists in Section-I only; Sections-II and III have no penalty, so attempt all six and choose the best five at the very end.
- Very Short Answer (2 marks each)** — Two well-formed sentences or a 3–4 line bullet list. Do not exceed 40 words. Use the key term as the opening word of your answer.
- Short Answer (5 marks each)** — A 120–150 word answer with a one-line definition, three to four substantive points, and a one-line linkage (preferably Tripura-specific). A neat captioned diagram earns half a mark on its own.

Syllabus Mapping

The TPSC GS Paper-I syllabus, as notified for the Combined Competitive (TCS/TPS) Mains, devotes 25 marks each to Sections E and F. The grid below maps every syllabus head to the chapter that addresses it and to the kind of question that has historically been set.

Section-E: Environmental Conservation & Degradation (25 marks)

Syllabus Head	Sub-topics	Chapter
Biodiversity & Conservation	Types (genetic/species/ecosystem); hotspots; mega-diversity countries; rare, endangered, threatened, endemic; Red Data Book; in-situ & ex-situ.	Ch. 1
Ecological Concepts	Ecosystem structure & function; types; energy flow; food chains & webs; ecological pyramids.	Ch. 2
Environmental Resources	Renewable / non-renewable; resource management & conservation; rainwater harvesting; conventional & non-conventional energy.	Ch. 3
Environmental Pollution	Air, water, soil, noise, thermal, nuclear; causes, effects, control; solid waste management.	Ch. 4
Global Environmental Issues	Global warming & climate change; GHGs; CO ₂ emission; carbon reservoirs & cycling; ozone depletion; acid rain.	Ch. 5
Environmental Management & Legislation	EIA; Air, Water, Wildlife, Biodiversity, Forest Conservation Acts; PCBs; lake & river action programmes.	Ch. 6
Environmental Organisations	UNEP, IUCN, IPCC, Earth Summit, CBD, WWF; National: MAB, MoEFCC, MoES, NGOs.	Ch. 7

Section-F: Security & Disaster Management (25 marks)

Syllabus Head	Sub-topics	Chapter
Types of Hazards & Disasters	Natural: volcanic, earthquake, tsunami, cyclone, flood, drought, wildfire, landslide. Man-made: industrial, nuclear, biological, engineering, terrorism.	Ch. 8

Syllabus Head	Sub-topics	Chapter
Management & Planning for Disasters	Preparedness, adaptation, mitigation, relief, rehabilitation; role of administrators, scientists, planners, volunteers, NGOs; early-warning systems & forecasting.	Ch. 9
Hazards & Disaster in Tripura	Earthquake vulnerability of NE India; flood hazards; river-bank erosion; tropical storms; role of Government & NGOs.	Ch. 10

Reference Books prescribed by TPSC (with chapter mapping)

- *Environmental Biology* — P.D. Sharma — Ch. 1, 2, 5
- *A Text Book of Environment* — K.M. Agarwal, P.K. Sikdar, S.C. Deb — Ch. 3, 4, 6
- *Environmental Chemistry* — A.K. De — Ch. 4, 5
- *Environmental Studies: From Crisis to Cure* — R. Rajagopalan — All Section-E chapters
- *Disaster Science and Management* — Tushar Bhattacharya — Ch. 8, 9
- *IGNOU Disaster Management* — Ch. 8, 9, 10
- *Tripura University DM Soft-Skill Material* — Ch. 10
- *Perspectives in Environmental Studies* — Kaushik & Kaushik — Ch. 2, 4, 6, 7

PYQ Trend Analysis (Section-E & F)

Below is an integrated trend reading of the actual TCS/TPS GS-I papers of 2019 and 2021 (the most recent papers in the public domain at the time of going to press). The frequency of each theme indicates the *minimum* times the topic has been touched in 1+2+5-mark questions; many themes appear repeatedly within the same paper.

Section-E — Topic Frequency Matrix

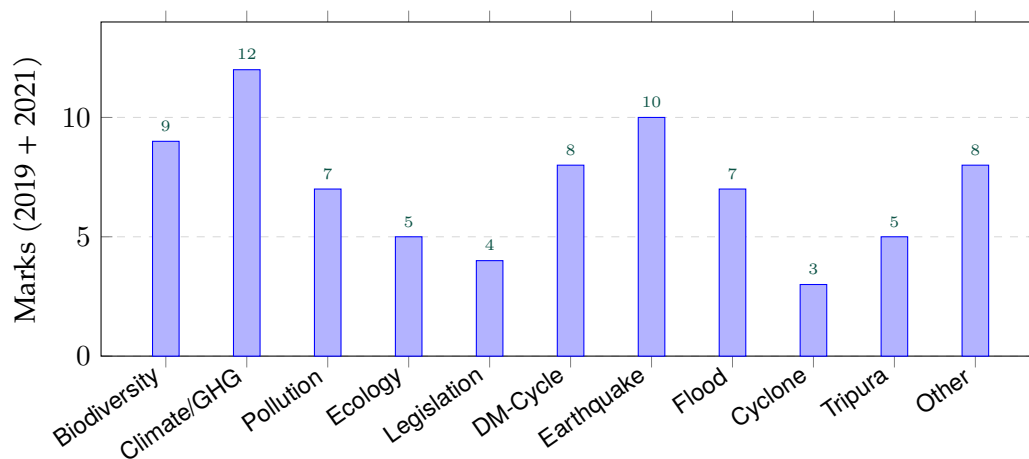
Theme	2019	2021	Total Marks	Trend
Biodiversity hotspots / MAB / IUCN	✓	✓	4	High
Climate change / GHGs / CO ₂	✓	✓	7	Very High
Ozone depletion / Montreal Protocol	✓	✓	4	High
Pollution standards (BS-IV / VI)	✓	✓	2	Moderate
International conventions (CBD, Cartagena, Ramsar)	—	✓	1	Moderate
Pyramid of number / energy / biomass	✓	✓	3	High
Solid & E-waste management	—	✓	5	High
Mitigation & Adaptation	—	✓	5	High
EIA / SEIAA / SEAC	—	✓	2	Moderate
Bio-magnification / BOD	—	✓	4	Moderate
Endangered vs threatened species	✓	—	5	High
Health impacts of climate change	✓	—	5	High

Section-F — Topic Frequency Matrix

Theme	2019	2021	Total Marks	Trend
Tripura's vulnerability (Zone-V / floods)	✓	✓	3	Very High
DM Cycle — 4 phases	✓	✓	4	Very High
NDMA / SDMA / DDMA	✓	✓	10	Very High
Earthquake — Focus/Epi-centre/Magnitude/Intensity/Retrofitting	✓	✓	10	Very High
Flood causes & mitigation (structural/non-structural)	✓	✓	7	Very High
Cyclone classification & mitigation (IMD)	—	✓	3	High
Bhopal / industrial / nuclear disaster	✓	✓	3	High
Community-based DM	—	✓	2	Moderate
Vulnerability & climate change linkage	—	✓	2	Moderate
Forecasting & Early Warning	—	✓	5	High

Trend Reading

A TikZ bar chart of the cumulative weightage tells the story at a glance:



What the data tells us:

1. **Climate change is the single highest-weighted theme** across both sections combined — every aspirant must master IPCC AR6 vocabulary, GWP, carbon cycle, mitigation vs adaptation, and India's NDC trajectory.
2. **Earthquake and NDMA/SDMA/DDMA dominate Section-F.** Together they have accounted for over 20 marks in just two paper cycles.
3. **Tripura-specific questions are guaranteed** in Section-F, and increasingly so in Section-E (e.g.

Tripura's biodiversity, Trishna sanctuary, river-bank erosion).

4. **Cyclone vocabulary** has been newly introduced in 2021 and should be expected in 2026 papers given the rising frequency of Bay of Bengal cyclones.
5. **New themes likely to be set** — based on news cycle and syllabus drift — include: ISFR 2023 findings, Net-Zero by 2070, COP28 fossil-fuel transition, Sendai Framework progress, August 2024 Tripura floods, Green Hydrogen Mission, plastic waste management amendment rules.

Most-Expected Themes for Forthcoming Papers

Section-E

- IPCC AR6 — 1.5°C pathway
- COP28 outcomes — Loss & Damage Fund
- Carbon credits & Article 6 of Paris
- Green Hydrogen Mission, 2023
- ISFR 2023 — Tripura forest decline
- Plastic Waste & EPR Rules, 2022
- Bio-Diversity (Amendment) Act, 2023

Section-F

- Tripura Floods 2024 (Aug–Sep)
- Sendai Framework mid-term review
- PM-CARES & SDRF financing
- Cyclones *Remal*, *Mocha*, *Biparjoy*
- NDMP 2019 — revised priorities
- NE Earthquake of 2023 (Doyang)
- School DM Plan — NDMA guideline

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SECTION-E

Environmental Conservation & Degradation

Biodiversity & Its Conservation

Syllabus Pointer (TPSC)

Section-E (A) — Biodiversity & Its Conservation: Types of Biodiversity; Genetic, Species, Ecosystem Biodiversity; Importance of Biodiversity; Hotspots of Biodiversity; Mega Diversity Countries; Threats to Biodiversity; Rare, Endangered, Threatened and Endemic Species; Red Data Book; Conservation — In-Situ and Ex-Situ Conservation.

Historical PYQ weight: 9 marks across 2019 & 2021 cycles. Expected weight in 2026 papers: **6–10 marks** (objective + 5-mark short answer almost certain).

1.1 Defining Biodiversity

The word **biodiversity**, coined by entomologist W. G. Rosen in 1985 and popularised by biologist E. O. Wilson, is a contraction of "biological diversity". The **Convention on Biological Diversity (CBD), Rio 1992** provides the legally binding international definition: "*the variability among living organisms from all sources ...and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.*" The Indian **Biological Diversity Act, 2002**, drawing from the CBD, repeats this three-tier formulation in Section 2(b).

Biodiversity, in other words, is not merely a count of species. It captures *life's variety* at three nested levels — within a species, between species, and across the ecosystems that house them.

Three-Level Architecture of Biodiversity

Level	What it measures
Genetic diversity	Variability in the gene pool <i>within</i> a species (e.g. over 50,000 varieties of rice in India).
Species diversity	Variability <i>between</i> species in a given area, measured by richness (<i>number</i>) and evenness (<i>relative abundance</i>).
Ecosystem diversity	Variety of habitats, biotic communities and ecological processes (forests, wetlands, grasslands, coral reefs).

1.1.1 Genetic Diversity

Genetic diversity is the variation of *alleles and genotypes* present in a species. It is the raw material on which natural selection operates and the substrate of adaptive evolution. High genetic diversity within a species buffers it against disease outbreaks, climate shifts and habitat loss. India hosts a remarkable agro-biodiversity: 167 cultivated species, more than 320 species of wild relatives, and over 50,000 rice landraces — varieties such as *tilakachari* of Tripura, *basmati* of Punjab, and salt-tolerant *pokkali* of Kerala. The 1845 **Irish Potato Famine** — caused by a single fungal strain wiping out a genetically uniform potato crop — is the textbook example of why genetic diversity matters.

1.1.2 Species Diversity

Species diversity has two parts:

- **Species richness** — the number of species in a defined area.
- **Species evenness** — how equally individuals are distributed among those species.

A forest with 50 trees of equal species count is more “even” than one where 99% are sal and 1% scattered among others. Both richness and evenness together define **alpha diversity**. **Beta diversity** measures change in species composition across habitats, and **gamma diversity** the total species diversity over a large landscape.

1.1.3 Ecosystem Diversity

Ecosystem diversity refers to the variety of habitats and ecological processes within a region. India, on account of being a meeting ground of three biogeographic realms (Palearctic, Afrotropical, Indo-Malayan), houses ten distinct biogeographic zones — from the Trans-Himalayan cold desert to the mangrove-rich coasts — making it ecologically the most varied country of comparable size.

Tripura’s Three-Level Profile

Genetic: Native rice landraces (*tilakachari*, *khawai dhan*); local pineapple cultivar *Queen* (GI tag, 2015); indigenous bamboo varieties (over 21 species of *Bambusa*, *Dendrocalamus*, *Melocanna baccifera/muli*).

Species: Approximately 1,546 angiosperms, 90 mammals, 300 birds, 65 reptiles, 24 amphibians documented. Flagship species include hoolock gibbon, capped langur, Phayre’s leaf monkey (state animal), green imperial pigeon (state bird).

Ecosystem: Tropical semi-evergreen forest (Sepahijala, Trishna), tropical moist deciduous (Gomati), bamboo brakes, freshwater lakes (Rudrasagar/Twijilikma, Dumboor), and riverine ecosystems.

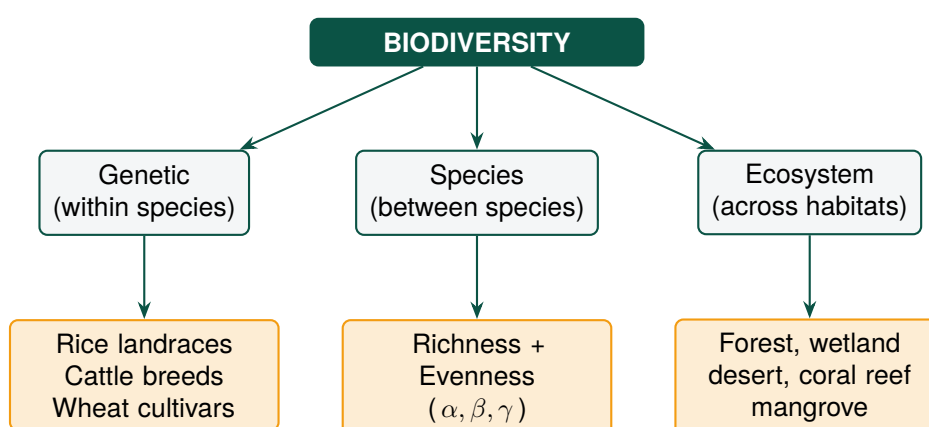


Figure 1.1: Three-level architecture of biodiversity.

1.2 Importance of Biodiversity

The *Millennium Ecosystem Assessment* (2005) categorised the value of biodiversity under four heads. We list them here in TPSC-answer format.

Values of Biodiversity (MEA, 2005)

Provisioning	Food (rice, fish), medicine (quinine, taxol), fibre (cotton, jute), timber, fuelwood — directly extracted from biota.
Regulating	Pollination, pest control, climate regulation, flood moderation, water purification, soil fertility maintenance.
Cultural	Spiritual values (sacred groves), recreation (ecotourism — Sepahijala, Trishna), aesthetic and educational value.
Supporting	Underpinning services — primary production, nutrient cycling, soil formation, oxygen production.

Other classifications used in TPSC short-answers:

- **Consumptive use value** — direct extraction for personal use (firewood, NTFPs).
- **Productive use value** — commercial extraction (timber, fish, honey).
- **Social value** — local cultural and religious significance (sacred groves like *Sarana* in Tripura).
- **Ethical value** — intrinsic right of every species to exist (Robert Macarthur's "ethic of existence").
- **Aesthetic value** — scenic beauty fuelling ecotourism (Twijilikma lake floating market).
- **Option value** — yet-undiscovered economic uses (the rosy periwinkle of Madagascar yielded vincristine for childhood leukaemia).

1.3 Measurement of Biodiversity

Two indices dominate examination questions:

- **Shannon–Wiener index (H)** — accounts for both richness and evenness. Higher H means greater diversity.
- **Simpson's index (D)** — probability that two randomly chosen individuals belong to the same species; closer to 0 means greater diversity.

Tropical rainforests show H values 4–5; temperate forests 3–4; agro-ecosystems below 2.

1.4 Biodiversity Hotspots

Conservation biologist **Norman Myers** introduced the hotspot concept in 1988 and refined it in 2000 with Conservation International. A **biodiversity hotspot** must satisfy *two strict criteria*:

1. It must contain at least **1,500 endemic vascular plant species**, and
2. It must have lost **at least 70% of its primary vegetation**.

The number of recognised hotspots has grown from 25 in Myers' original list (1999) to **36 today** (the latest addition, the North American Coastal Plain, was included in 2016). Together these 36 hotspots cover only 2.5% of Earth's land surface yet support more than 50% of all endemic plants and over 43% of endemic terrestrial vertebrates.

Memorise

Hotspots in the world today: **36**. India's share: **four**.

1.4.1 India's Four Biodiversity Hotspots

India's 4 Biodiversity Hotspots		
Hotspot	Extent in India	Key endemic species
Himalaya	J&K, HP, Uttarakhand, Sikkim, Arunachal	Snow leopard, red panda, musk deer
Indo-Burma	North-East India (incl. Tripura), Andaman & Nicobar	Hoolock gibbon, Phayre's langur, sun bear
Western Ghats & Sri Lanka	Maharashtra to Kerala	Lion-tailed macaque, Nilgiri tahr, purple frog
Sundaland	Nicobar Islands only	Nicobar megapode, Nicobar pigeon

The **Indo-Burma hotspot** is of particular interest to Tripura aspirants: the state lies squarely within it. Indo-Burma is one of the world's most biologically rich and most threatened hotspots, harbouring more endemic bird species (66) than any other Asian hotspot, and over 7,000 endemic vascular plants.

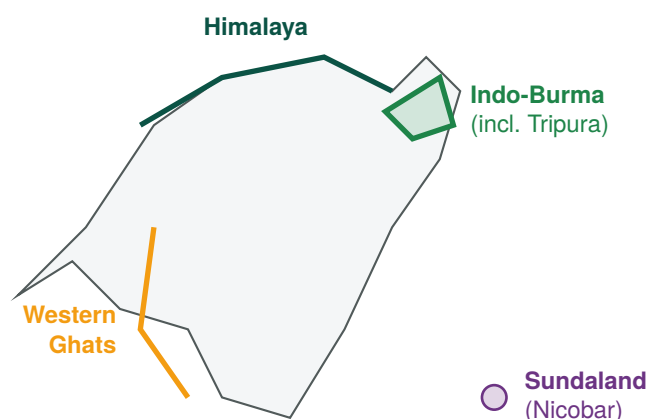


Figure 1.2: India's four biodiversity hotspots (schematic).

1.4.2 Mega-Diversity Countries

A **mega-diversity country** is one that harbours an exceptional concentration of biodiversity, especially endemic species. The concept was developed by **Russell Mittermeier** and Conservation International. Of the **17 mega-diversity countries** of the world, India is one. Together they host over 70% of Earth's species on only 10% of land surface. The list (alphabetical): Australia, Brazil, China, Colombia, DR Congo, Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Papua New Guinea, Peru, Philippines, South Africa, USA, Venezuela.

India occupies 2.4% of world land area but accounts for 7–8% of recorded species — about 91,200 animal species and 45,500 plant species.

1.5 Threats to Biodiversity

The most-cited acronym in mains-grade answers is **HIPPO**, given by E. O. Wilson. The expanded form should be reproduced in every short answer.

HIPPO — Drivers of Biodiversity Loss

H — Habitat destruction: deforestation, wetland reclamation, urbanisation. The single largest cause; e.g. shifting jhum cultivation in the NE.

I — Invasive alien species: *Lantana camara*, *Mikania micrantha*, water hyacinth (*Eichhornia*) clogging Rudrasagar lake.

P — Pollution: industrial effluents, plastic, oil spills, light & noise.

P — Population growth & over-consumption: more humans, more demand.

O — Over-exploitation: poaching (rhino, tiger), over-fishing, illegal timber.

A sixth driver — **climate change** — has overtaken habitat destruction in importance for many ecosystems. IPCC AR6 (2023) confirms that one in six species globally faces extinction risk under 4°C warming.

1.5.1 Additional Threats

- **Co-extinctions** (loss of a host species drags down its parasites/symbionts);
- **Genetic erosion** (loss of landraces to high-yield varieties);
- **Biopiracy** (unauthorised commercial use of biological resources — the neem and turmeric patent battles);
- **Wildlife trade** (pangolin scales, elephant ivory, rhino horn);
- **Forest fires** (Uttarakhand 2016, Bandipur 2019);
- **Linear infrastructure** (roads, railways, transmission lines fragmenting habitats).

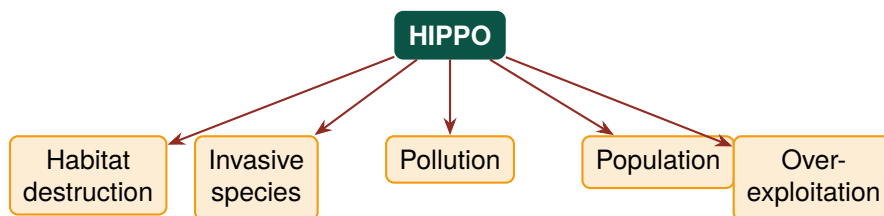


Figure 1.3: Wilson's HIPPO drivers of biodiversity loss.

1.6 Categorisation of Species — Rare, Endangered, Threatened, Endemic

The IUCN **Red List of Threatened Species** (1964; revised criteria 2001 & periodically) classifies organisms into nine categories based on quantitative thresholds of population size, range, and rate of decline.

IUCN Red List Categories

Code	Category	Indicative example
EX	Extinct	Dodo, Cheetah (in India, 1952)
EW	Extinct in the Wild	Père David's deer
CR	Critically Endangered	Great Indian Bustard, Gharial
EN	Endangered	Tiger, Asian elephant
VU	Vulnerable	Sloth bear, dugong
NT	Near Threatened	Striped hyena, Indian skimmer
LC	Least Concern	Common myna, house sparrow
DD	Data Deficient	Many cave-dwelling species
NE	Not Evaluated	Newly described species

Threatened is an umbrella category covering CR, EN and VU.

1.6.1 Key Terms

- **Rare** — small population that is not at immediate risk but vulnerable to chance events.
- **Endangered** — likely to become extinct in the foreseeable future if threats continue.
- **Critically Endangered** — facing extremely high risk of extinction in the wild.
- **Vulnerable** — likely to become endangered unless circumstances improve.
- **Endemic** — found naturally only in a specified geographical region (e.g. Phayre's leaf monkey is endemic to Indo-Burma and exists in Tripura's Sepahijala).
- **Indicator species** — a species whose health reflects the overall health of an ecosystem (e.g. frogs for wetland health).
- **Keystone species** — disproportionately important to an ecosystem relative to abundance (e.g. elephant, tiger).
- **Flagship species** — charismatic species used to leverage conservation funding (e.g. tiger for Project Tiger).
- **Umbrella species** — wide-ranging species whose protection automatically protects many co-habitants (e.g. Bengal tiger).

1.7 The Red Data Book

The **Red Data Book** (or Red List) is the global inventory of conservation status maintained by the **International Union for Conservation of Nature (IUCN)**. First published in 1964, it now lists over 1,57,000 species, of which more than 44,000 are classified as threatened (IUCN, 2024). **Sir Peter Scott** is credited as its founding architect.

The book is updated annually; data are drawn from a global network of specialist groups (the Species Survival Commission, SSC). India's parallel inventory is the **Wildlife Institute of India (WII) Red List** and the **Zoological Survey of India / Botanical Survey of India** compilations.

2024 Red List Snapshot — India

Critically endangered Indian species (selected): Great Indian Bustard, Bengal Florican, Forest Owlet, Gangetic dolphin (EN), Gharial, Hawksbill turtle, Hangul (Kashmir stag), Pygmy hog, Nicobar Megapode, Kondana soft-furred rat.

Recent uplisting (worse status): Indian Vulture, White-rumped Vulture, Slender-billed Vulture — all CR due to diclofenac poisoning.

1.8 Conservation of Biodiversity

Conservation strategies are broadly classified as **in-situ** (*within* natural habitat) and **ex-situ** (*outside* natural habitat).

1.8.1 In-Situ Conservation

The most ecologically sound approach; species are conserved where they evolved and continue to interact with their environment. Mechanisms in India:

In-Situ Conservation Tools	
Tool	Features and Indian numbers (2024)
Biosphere Reserves (BR)	UNESCO MAB designation; 18 in India; 12 of these on UNESCO World Network. Tripura has none, but adjoining Nokrek (Meghalaya) and Dehang-Dibang (Arunachal) are nearby.
National Parks (NP)	Strict protection; no human activity; 106 NPs in India.
Wildlife Sanctuaries (WLS)	Less strict than NP; regulated activities allowed; 573 WLS.
Tiger Reserves (TR)	Under Project Tiger (1973); managed by NTCA; 55 TRs.
Elephant Reserves (ER)	Under Project Elephant (1992); 33 ERs.
Conservation & Community Reserves	Buffer/connectivity areas; community-led.
Sacred Groves	Traditional protected forest patches; e.g. <i>Sarana</i> groves of Tripura, <i>Devarakadu</i> of Coorg, <i>Orans</i> of Rajasthan.

Biosphere Reserves

A biosphere reserve is organised into three concentric zones:

1. **Core zone** — no human activity, full legal protection.
2. **Buffer zone** — limited activities (research, education, ecotourism).
3. **Transition (manipulation) zone** — agriculture, settlements, sustainable use.

1.8.2 Ex-Situ Conservation

When in-situ protection is inadequate — small populations, habitat permanently lost, breeding-failures — species are conserved *outside* their natural habitat.

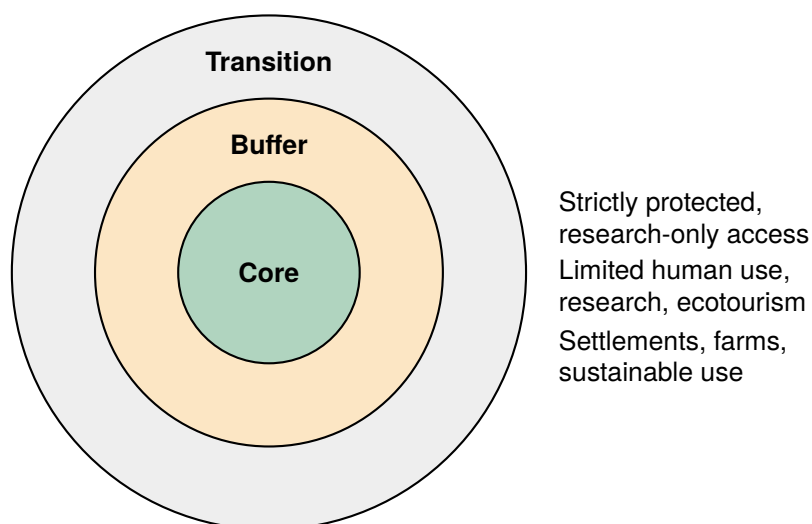


Figure 1.4: Three-zone architecture of a UNESCO Biosphere Reserve (MAB).

Ex-Situ Conservation Tools

Tool	Description / Indian examples
Zoological parks (Zoos)	Captive maintenance & display; Sepahijala Zoological Park (Tripura), National Zoological Park (Delhi).
Botanical gardens	Plant collections for research & propagation; Indian Botanic Garden (Howrah).
Aquaria & Lagoonaria	Aquatic species conservation & research.
Seed banks	Long-term storage at -18°C ; ICAR-NBPGR (Delhi); Svalbard Global Seed Vault (Norway).
Gene banks / Cryobanks	Cryogenic storage of germplasm, semen, embryos; LaCONES, Hyderabad.
Tissue culture & DNA banks	Plant tissue culture labs; DNA bank at NBPGR.
Captive breeding programmes	Gharial breeding (Lucknow), Manipur Sangai deer (Keibul Lamjao).

1.8.3 Comparing In-Situ and Ex-Situ

In-Situ vs Ex-Situ — Tabular Comparison

Aspect	In-Situ	Ex-Situ
Habitat	Natural	Artificial
Scale	Entire ecosystem	Few individuals
Cost	Lower per unit area	Higher per individual
Genetic integrity	Maintained	Risk of inbreeding
Adaptive evolution	Continues	Halted/altered
Examples	NP, WLS, BR, TR, Sacred Groves	Zoo, Botanical garden, Seed bank, Cryobank
Best for	Wide-ranging, habitat-dependent species	Critically endangered, breeding-failing species

1.8.4 India's Biological Diversity Act, 2002 — at a Glance

Enacted to give effect to the CBD (1992), the Act establishes a three-tier institutional structure:

- **National Biodiversity Authority (NBA)** at the national level — Chennai, statutory body.
- **State Biodiversity Boards (SBBs)** at the state level — Tripura SBB, Agartala.
- **Biodiversity Management Committees (BMCs)** at village/panchayat level.

BMCs prepare **People's Biodiversity Registers (PBRs)** documenting local biological resources and traditional knowledge — a tool against biopiracy.

Latest Amendment — Biological Diversity (Amendment) Act, 2023

- Exempts AYUSH practitioners from prior approval for accessing biological resources.
 - Decriminalises offences; replaces imprisonment with monetary penalties.
 - Encourages cultivation of medicinal plants and benefit-sharing arrangements.
 - Recognises codified traditional knowledge separately from non-codified.
- Criticism: weakens the safeguard against biopiracy; reduces deterrent value.

1.9 Solved Previous Year Questions

TCS/TPS 2019 — Q.101 — Objective (1 mark each)

- (i) The 8th International Conference on Biodiversity Conservation & Ecosystem Management was held in: (a) New Delhi (b) Tokyo (c) Paris (d) Geneva
Ans: (a) New Delhi.
- (ii) How many hotspots of biodiversity have been identified on earth? (a) 23 (b) 34 (c) 36 (d) 42
Ans: (c) 36 (Conservation International, latest count).

TCS/TPS 2019 — Q.102 — Very Short (2 marks)

- (i) **Who initiated the 'Man and Biosphere' Programme?**

Model Answer

The **Man and Biosphere (MAB) Programme** was initiated by **UNESCO** in 1971 at the 16th session of its General Conference. It establishes a global network of biosphere reserves that combine biodiversity conservation with sustainable human use, organised into core, buffer and transition zones. India joined the programme in 1986; the Nilgiri Biosphere Reserve was the first to be notified.

TCS/TPS 2019 — Q.102 — Very Short (2 marks)

- (vi) **Biological diversity is relatively greater in tropics. Give two reasons.**

Model Answer

Two reasons for higher tropical biodiversity: (i) *Climatic stability and high solar input* — tropics have remained climatically stable over evolutionary time, allowing speciation to accumulate; high incident solar energy supports greater net primary productivity, thus more energy at every trophic level. (ii) *Longer evolutionary time* — tropical ecosystems were not disturbed by recent glaciations as temperate regions were; species had millions of years to diversify and specialise into narrow niches.

TCS/TPS 2019 — Q.103(ii) — Short (5 marks)**Differentiate between endangered and threatened species.****Model Answer**

Introduction: The IUCN Red List classifies species into nine categories. "Threatened" is an umbrella category for three Red List grades, of which "Endangered" is one.

	Parameter	Threatened	Endangered
Comparison:	Scope	Umbrella category including CR, EN, VU	A specific Red List grade
	IUCN definition	Faces high risk of extinction	Faces very high risk of extinction
	Quantitative criterion	General term	Population reduction $\geq 50\%$ in 10 yrs / 3 generations
	Examples	Snow leopard, sloth bear, Asian elephant	Bengal tiger, Asian lion, Lion-tailed macaque
	Indian status	Used loosely in WLPA Schedule I	Specific status under IUCN

Conclusion: All endangered species are threatened, but not all threatened species are endangered. Tripura's hoolock gibbon and Phayre's langur are both classified as Endangered.

TCS/TPS 2021 — Q.102(vi) — Very Short (2 marks)**Define 'Biomagnification'.****Model Answer**

Biomagnification (also *biological magnification*) is the progressive increase in concentration of a persistent, non-biodegradable substance — typically a heavy metal or lipid-soluble pesticide (DDT, mercury, PCBs) — in the tissues of organisms at *successively higher* trophic levels of a food chain. A classic example is the magnification of DDT from 0.000003 ppm in water to 25 ppm in fish-eating birds in Long Island estuary, leading to eggshell thinning and population collapse of bald eagle, pelican and osprey.

1.10 Examiner's Corner**Examiner's Corner**

1. Confusing **Mega-diversity countries (17)** with **Biodiversity hotspots (36)** is the single most common error. Memorise both numbers cold.
2. Aspirants forget to mention that India has **four** hotspots (not three): students routinely miss the Sundaland (Nicobar) component.
3. In short-answer comparisons of **in-situ vs ex-situ**, draw the table; the examiner is trained to award full marks for tabulated answers.
4. Always cite the **Indo-Burma hotspot** when writing about Tripura — it is the single value-addition that distinguishes a 4/5 answer from a 5/5.
5. **HIPPO** is mandatory vocabulary. Even in a 2-mark answer on threats, the acronym alone earns full marks.
6. Do not mix up **Endangered (IUCN)** with **Schedule-I (WLPA)** — they are different legal frameworks.

Frequent Errors to Avoid

- Writing "biodiversity" when "biological diversity" is the legally correct term in the CBD/BD Act.
- Stating "all biosphere reserves are UNESCO-listed". Only **12 of 18** Indian BRs are on the UNESCO Network.
- Mentioning Sunderbans Hotspot — it is a *biosphere reserve*, not a hotspot.
- Confusing the Red Data Book (IUCN, global) with the State of Forest Report (FSI, Indian).

1.11 Mains Enrichment Keywords

Mains Enrichment Keywords

- | | |
|--|---------------------------------------|
| • HIPPO drivers (Wilson) | • People's Biodiversity Register |
| • Norman Myers, 1988 | • NBA, SBB, BMC |
| • 36 hotspots, 17 mega-diversity | • Cartagena, Nagoya Protocols |
| • Alpha-, Beta-, Gamma-diversity | • ABS, Bonn Guidelines |
| • Shannon–Wiener, Simpson index | • GBO-5 (2020 targets missed) |
| • Endemic, indicator, keystone, flagship, umbrella | • Kunming–Montreal GBF (2022) |
| • In-situ, ex-situ, on-farm | • 30×30 target (CBD COP-15) |
| • Core / buffer / transition (MAB) | • Sacred groves (Sarana, Orans) |
| • Red Data Book, IUCN Red List | • Translocation & reintroduction |
| • Biopiracy, neem, turmeric, basmati cases | • Cheetah reintroduction (Kuno, 2022) |

1.12 Practice Set — Chapter 1

A. Objective MCQs (1 mark each)

Practice Set

- The term "biodiversity" was coined by:
(a) E.O. Wilson (b) W.G. Rosen (c) Norman Myers (d) Sir Peter Scott
- Which of the following is **not** a criterion for a biodiversity hotspot?
(a) ≥ 1500 endemic vascular plants (b) $\geq 70\%$ habitat loss
(c) ≥ 500 mammal species (d) Both (a) and (b) are criteria
- The Indo-Burma hotspot does **not** include:
(a) Tripura (b) Mizoram (c) Andaman & Nicobar (d) Manipur
- The number of biodiversity hotspots in India is:
(a) 2 (b) 3 (c) 4 (d) 5
- Phayre's leaf monkey is the state animal of:
(a) Assam (b) Meghalaya (c) Tripura (d) Mizoram
- HIPPO acronym was given by:
(a) Norman Myers (b) Russell Mittermeier (c) E.O. Wilson (d) Peter Scott
- The People's Biodiversity Register is prepared by:
(a) National Biodiversity Authority (b) Biodiversity Management Committee
(c) State Biodiversity Board (d) MoEFCC
- Which is the legally binding international agreement on biodiversity?
(a) CITES (b) Ramsar (c) CBD (d) Bonn
- The total number of mega-diversity countries is:
(a) 12 (b) 15 (c) 17 (d) 21

10. Sepahijala Wildlife Sanctuary is famous for:
 (a) One-horned rhino (b) Spectacled langur & clouded leopard
 (c) Lion-tailed macaque (d) Snow leopard

Answers: 1-b, 2-c, 3-c, 4-c, 5-c, 6-c, 7-b, 8-c, 9-c, 10-b.

B. Assertion–Reason

Practice Set

Q. Assertion (A): The Indo-Burma hotspot is among the most threatened hotspots in the world. **Reason (R):** It has more than 7,000 endemic vascular plant species but has lost over 95% of its primary vegetation.

- (a) Both A & R are true, R is the correct explanation of A.
 (b) Both A & R are true, R is *not* the correct explanation of A.
 (c) A is true, R is false.
 (d) A is false, R is true.

Ans: (a). The high endemism combined with extreme habitat loss is precisely what makes Indo-Burma critically threatened.

C. Match the Following

Practice Set

List-I (Species)	List-II (Status)
A. Great Indian Bustard	1. Vulnerable
B. Snow leopard	2. Critically Endangered
C. Hoolock gibbon	3. Endangered
D. Indian elephant	4. Endangered

Codes: (a) A-2 B-1 C-3 D-4 (b) A-2 B-3 C-4 D-1

Ans: (a).

D. Very Short (2 marks each)

Practice Set

1. Differentiate alpha, beta and gamma diversity.
2. Define keystone species with an Indian example.
3. What are the two criteria for declaring a biodiversity hotspot?
4. Why is Tripura's hoolock gibbon classified as Endangered?
5. What is the difference between a National Park and a Wildlife Sanctuary?

E. Short Answer (5 marks each)

Practice Set

1. Discuss the importance of biodiversity under the Millennium Ecosystem Assessment framework.
2. Distinguish between in-situ and ex-situ conservation with examples. Which is more sustainable and why?
3. Explain the HIPPO drivers of biodiversity loss with emphasis on the North-East Indian context.
4. Describe the three-tier institutional structure of the Biological Diversity Act, 2002.
5. "Tripura, despite being within the Indo-Burma hotspot, is losing biodiversity rapidly." Discuss with reasons and remedies.

F. Predicted Questions for 2026

Practice Set

1. Discuss the salient features and criticism of the Biological Diversity (Amendment) Act, 2023.
2. Comment on the Kunming–Montreal Global Biodiversity Framework's 30×30 target.
3. What is the rationale behind India's Cheetah Reintroduction Project at Kuno?
4. How does ISFR 2023 portray the state of forests in Tripura and other NE states?

1.13 Quick Revision Capsule — Chapter 1

Quick Revision Capsule

Definition: CBD (Rio, 1992) — variability among living organisms at three levels: gene, species, ecosystem.

Three levels: Genetic (within species), Species (between species), Ecosystem (across habitats).

Hotspots: 36 globally; criteria — ≥ 1500 endemic plants & $\geq 70\%$ habitat loss; coined by **Norman Myers, 1988**; India has 4 (Himalaya, Indo-Burma incl. Tripura, Western Ghats, Sundaland).

Mega-diversity countries: 17 (India is one); concept by Mittermeier.

Threats: HIPPO (Wilson) — Habitat loss, Invasive species, Pollution, Population, Over-exploitation; plus climate change.

Red List: IUCN; 9 categories — EX, EW, CR, EN, VU, NT, LC, DD, NE.

Conservation: *In-situ* — NP (106), WLS (573), BR (18), TR (55), ER (33), Sacred groves. *Ex-situ* — zoo, botanical garden, seed bank, gene bank, cryo, captive breeding.

BR zonation: Core / Buffer / Transition.

Legal framework: BD Act 2002 — NBA, SBB, BMC; BD (Amendment) Act 2023.

Tripura keystones: Phayre's langur (state animal), Green Imperial Pigeon (state bird), Sepahijala WLS, Trishna WLS, Rudrasagar (Ramsar wetland).

2

Ecological Concepts

Syllabus Pointer (TPSC)

Section-E (B): Ecosystem definition, structure & function; types of ecosystem; energy flow; food chain & food web; ecological pyramids.

Historical PYQ weight: 5+ marks; 2021's energy-pyramid 2-marker is recurring vocabulary.

2.1 Ecosystem — Definition and Architecture

The term **ecosystem** was coined by British botanist **Sir A.G. Tansley** in **1935**. An ecosystem is a *self-regulating, self-sustaining, functional unit* of nature comprising **biotic** (living) and **abiotic** (non-living) components linked by the continuous flow of energy and cycling of matter. **Eugene Odum**, the "father of modern ecology", described it as a "biotic community plus its abiotic environment".

2.1.1 Structural Components

Two Pillars of Ecosystem Structure

Abiotic	Climatic (sunlight, temperature, humidity, wind), edaphic (soil), topographic (slope, altitude), chemical (water, gases, nutrients).
Biotic	<i>Producers</i> (autotrophs — green plants, algae, photosynthetic bacteria), <i>Consumers</i> (heterotrophs — primary, secondary, tertiary, quaternary, omnivores), <i>Decomposers</i> (saprotrophs — bacteria, fungi).

2.1.2 Functional Components

The four functions performed continuously by every ecosystem are:

1. **Productivity** — rate of biomass production. *Gross Primary Productivity (GPP)* is total energy fixed by producers; *Net Primary Productivity (NPP)* is GPP minus respiration; *Secondary productivity* is the rate at which consumers store energy.
2. **Decomposition** — breakdown of dead organic matter by saprotrophs; involves **fragmentation, leaching, catabolism, humification** and **mineralisation**.
3. **Energy flow** — unidirectional flow following Lindeman's 10% law.
4. **Nutrient cycling** — biogeochemical cycles (C, N, P, S, water) that return matter from decomposers back to producers.

2.2 Types of Ecosystems

Major Ecosystem Types

Aquatic	<i>Freshwater</i> : lentic (lakes, ponds — Rudrasagar in Tripura), lotic (rivers, streams — Gomati, Manu, Khowai). <i>Marine</i> : oceanic, estuarine, coral reef, mangrove. <i>Brackish</i> : lagoons, salt marshes.
Terrestrial	<i>Forest</i> : tropical (Sepahijala), temperate, boreal, mangrove. <i>Grassland</i> : tropical savanna, temperate steppe. <i>Desert</i> : hot (Thar), cold (Ladakh). <i>Tundra</i> — Arctic, Alpine.
Artificial	Agro-ecosystems, urban ecosystems, aquaculture ponds.

2.2.1 Tripura's Ecosystem Types — A Snapshot

Tripura Linkage

- 1. Tropical Semi-Evergreen Forest** — dominant in West Tripura (Sepahijala, Atharamura).
- 2. Tropical Moist Deciduous Forest** — South Tripura (Trishna, Gomati basin).
- 3. Sal Forest** — North Tripura.
- 4. Bamboo Brakes** — extensive *muli* bamboo (*Melocanna baccifera*); flowered in 2007–09 (mautam cycle) causing crop damage.
- 5. Freshwater Lakes & Wetlands** — Rudrasagar / Twijilikma (Ramsar site, 2005); Dumboor.
- 6. Riverine/Riparian** — Gomati, Howrah, Khowai, Manu, Juri, Feni, Muhuri.
- 7. Agro-ecosystems** — wet paddy in Khowai valley, rubber plantations, pineapple, jhum-fallow mosaic.

2.3 Energy Flow in Ecosystems

2.3.1 Source and Direction

The Sun is the ultimate source. Only 0.02–1% of incident solar radiation is captured by photosynthesis; the rest is reflected or used in transpiration. Once captured, energy flows **unidirectionally** from producer → herbivore → carnivore → top carnivore, with substantial loss as heat at every transfer. This makes energy flow obey the Second Law of Thermodynamics — every transformation increases entropy.

2.3.2 Lindeman's 10% Law (1942)

American limnologist **Raymond Lindeman** proposed that, on average, only **10%** of the energy at one trophic level is transferred to the next; **90%** is lost as heat through respiration and incomplete digestion. This is why food chains rarely exceed four to five trophic levels.

2.4 Food Chain and Food Web

2.4.1 Food Chain

A linear sequence of organisms in which each is eaten by the next. Two basic kinds:

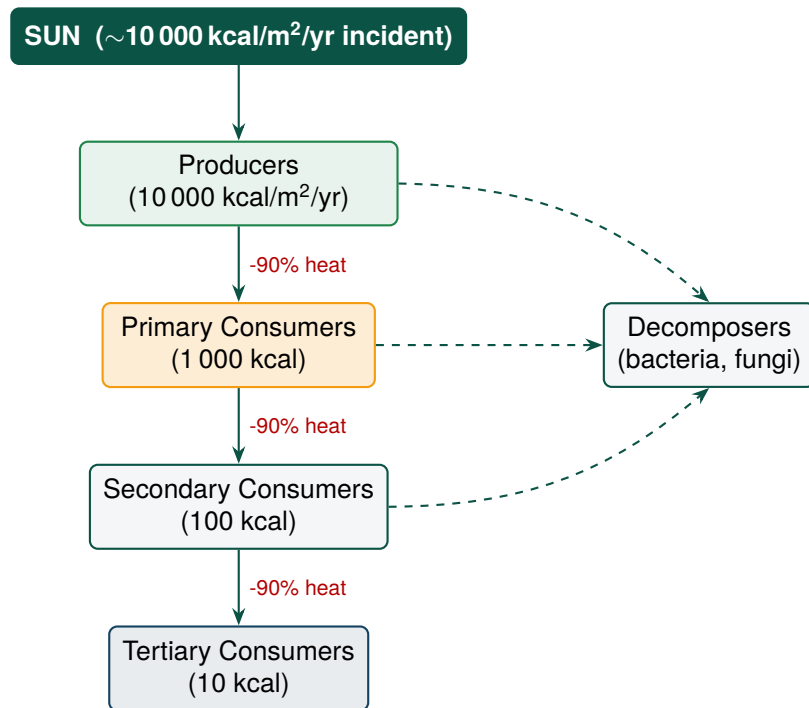


Figure 2.1: Lindeman's 10% Law — energy flow and the role of decomposers.

Two Types of Food Chain

Grazing food chain (GFC)	Starts with green plants ; energy from sunlight. Example: grass → grasshopper → frog → snake → hawk. Dominant in terrestrial & shallow aquatic ecosystems.
Detritus food chain (DFC)	Starts with dead organic matter . Example: leaf litter → earthworm → frog → snake. Dominant in deep aquatic & soil ecosystems. Greater energy flows through DFC than GFC in many forests.

2.4.2 Food Web

In reality, organisms feed on multiple prey and are eaten by multiple predators. A **food web** is the interconnected network of grazing and detritus food chains. Webs are inherently more *stable* than linear chains because the loss of one species can be compensated by alternative pathways.

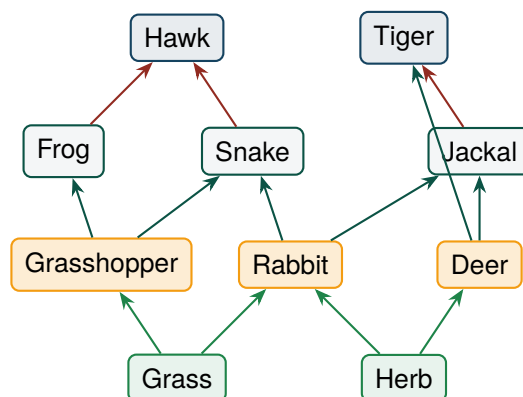


Figure 2.2: A simplified terrestrial food web — note the multiple pathways between trophic levels.

2.5 Ecological Pyramids

Ecological pyramids, introduced by **Charles Elton (1927)**, are graphical representations of the relative *number*, *biomass* or *energy* at successive trophic levels.

Three Ecological Pyramids		
Type	Description / Shape	Always erect?
Pyramid of Number	Number of individuals per trophic level. Erect in grassland, inverted in a tree-based ecosystem (one tree feeds thousands of insects).	No
Pyramid of Biomass	Dry mass of organisms per unit area. Inverted in marine ecosystems (small phytoplankton support a larger zooplankton biomass).	No
Pyramid of Energy	Rate of energy flow per unit area per unit time. Always erect owing to Lindeman's 10% law — energy is irrevocably lost at each transfer.	Yes

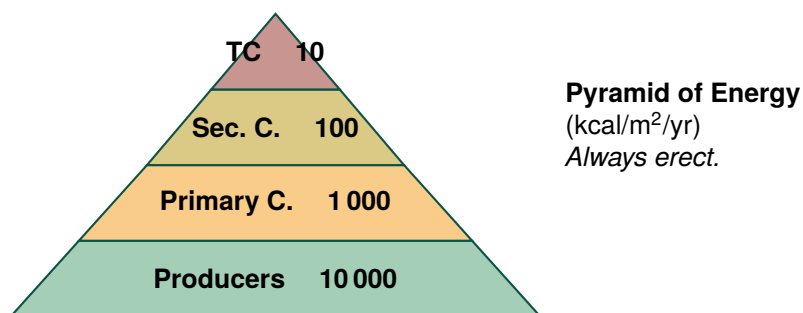


Figure 2.3: Pyramid of Energy — always erect per Lindeman's 10% law.

2.6 Biogeochemical Cycles

Matter, unlike energy, is cycled. The four major cycles set in TPSC questions are the **carbon, nitrogen, phosphorus and water cycles**.

Biogeochemical Cycles — One-Line Each	
Carbon	Atmospheric CO ₂ ↔ producers (photosynthesis) ↔ consumers ↔ decomposers ↔ fossil fuels. Anthropogenic combustion is the major perturbation.
Nitrogen	N ₂ fixation → ammonification → nitrification → assimilation → denitrification. Industrial Haber–Bosch process supplements natural fixation.
Phosphorus	Sedimentary cycle, lacks an atmospheric phase. Major source: phosphate rock weathering. Run-off causes eutrophication.
Water (Hydrological)	Evaporation, transpiration, condensation, precipitation, run-off, infiltration. Driven by solar energy.

2.7 Ecological Succession

The orderly process by which a community gradually changes the environment so that it becomes habitable for another community, which in turn replaces it, eventually reaching a stable **climax**.

community.

- **Primary succession** — on bare substrate without any prior community (e.g. cooled lava after volcanic eruption).
- **Secondary succession** — on substrate where a community previously existed (e.g. abandoned jhum field).
- **Xerosere** (dry rock → forest) and **Hydrosere** (pond → forest) are sequential names.

2.8 Solved Previous Year Questions

TCS/TPS 2019 — Q.101(ii) — Objective

The number of individuals decreases from producer level to consumer level in: (a) Pyramid of number (b) Pyramid of biomass (c) Pyramid of energy (d) None.

Ans: (a) Pyramid of number (in most terrestrial ecosystems — though see exception of a single tree).

TCS/TPS 2019 — Q.101(iii) — Objective

The driving force for an ecosystem is: (a) producers (b) consumers (c) biomass (d) **solar energy**.

TCS/TPS 2021 — Q.102(iv) — Very Short (2 marks)

Why is the energy pyramid always erect?

Model Answer

The pyramid of **energy** is always erect because energy flow in ecosystems is governed by Lindeman's **10% law**: at each trophic transfer, only ~10% of the available energy is incorporated into the next level; the remaining 90% is dissipated as heat through respiration. Consequently, the producer level always carries the highest energy and successive consumer levels carry progressively smaller energy stocks — yielding an upward-tapering, always-erect pyramid. By contrast, pyramids of number or biomass can be inverted (e.g. marine phytoplankton supporting a larger zooplankton biomass) but the energy pyramid never can be.

Predicted 5-mark

What would happen if there were no producers in an ecosystem? Discuss with a diagram.

Model Answer

Introduction: Producers (green plants, algae, cyanobacteria) are autotrophs that fix solar energy into chemical energy and form the foundational trophic level of every ecosystem.

Consequences of absence of producers:

1. **Collapse of energy flow** — without solar energy capture, no chemical energy enters the system; consumers and decomposers, lacking food, would die out within weeks.
2. **Carbon cycle disruption** — atmospheric CO₂ would not be drawn down by photosynthesis; the gas would accumulate, accelerating climate change.
3. **Oxygen depletion** — producers generate ~50% of atmospheric O₂; without them, aerobic respiration would halt.
4. **Loss of food chains & webs** — herbivores starve first, followed by carnivores; food webs unravel.
5. **Sterile soils** — without root systems and litter input, soil structure degrades and erosion accelerates.

Conclusion: Producers are the *sine qua non* of ecosystems; their loss would terminate life-supporting biosphere processes. Conservation of phytoplankton, forests and grasslands is therefore non-negotiable for sustaining the carbon-oxygen balance and the food chain.

2.9 Examiner's Corner

Examiner's Corner

- Always credit **Tansley (1935)** for the term "ecosystem" and **Lindeman (1942)** for the 10% law.
- In any pyramid question, mention the **single exception** for biomass (oceans) and number (single tree).
- Use **GFC vs DFC** distinction even when not directly asked — examiners reward it.
- Distinguish productivity types: **GPP, NPP, NEP, secondary productivity**.

2.10 Practice Set — Chapter 2

A. Objective MCQs

Practice Set

1. The term "ecosystem" was coined by:
(a) Eugene Odum (b) A.G. Tansley (c) Raymond Lindeman (d) Charles Elton
2. NPP = GPP minus:
(a) Plant respiration (b) Decomposer activity (c) Herbivory (d) Solar input
3. The 10% law of energy transfer was proposed by:
(a) Lindeman (b) Tansley (c) Odum (d) Wilson
4. Which of the following is *always* erect?
(a) Pyramid of number (b) Pyramid of biomass (c) Pyramid of energy (d) All
5. A pyramid of biomass is inverted in:
(a) Forest (b) Grassland (c) Marine (d) Desert
6. In Tripura, Rudrasagar (Twijilikma) is an example of:
(a) Lotic ecosystem (b) Lentic ecosystem (c) Estuarine (d) Marine
7. DFC stands for:
(a) Detritus Food Chain (b) Deep Forest Cycle (c) Direct Feeding Channel (d) Dynamic Flow Cycle
8. Photosynthetic efficiency on Earth is approximately:
(a) 50% (b) 25% (c) 10% (d) 1%

Ans: 1-b, 2-a, 3-a, 4-c, 5-c, 6-b, 7-a, 8-d.

B. Very Short (2 marks)

Practice Set

1. Differentiate GPP and NPP.
2. Why is the pyramid of biomass inverted in marine ecosystems?
3. Define ecological succession with examples.
4. State Lindeman's 10% law.

C. Short (5 marks)**Practice Set**

1. Explain the structure and function of an ecosystem with diagram.
2. Discuss the biogeochemical cycles with emphasis on the carbon cycle.
3. Differentiate food chain and food web; why is a food web more stable?

2.11 Quick Revision Capsule — Chapter 2**Quick Revision Capsule**

Coined by: Ecosystem — Tansley (1935); 10% law — Lindeman (1942); pyramids — Elton (1927).

Structure: Abiotic (climate, soil, water) + Biotic (producers, consumers, decomposers).

Function: Productivity, decomposition, energy flow, nutrient cycling.

Energy: Unidirectional, lost as heat at each transfer.

Pyramids: Number (erect/inverted), Biomass (erect/inverted), Energy (**always erect**).

Food chain: GFC (green plants) & DFC (dead matter).

Tripura ecosystems: Semi-evergreen, moist deciduous, sal, bamboo, Rudrasagar wetland, riverine.

3

Environmental Resources & Energy

Syllabus Pointer (TPSC)

Section-E (C): Renewable & Non-Renewable Natural Resources, Resource Management & Conservation; Rainwater Harvesting; Conventional & Non-Conventional Energy Resources.

PYQ weight: 2021 set the 2-marker "Rainwater Harvesting + Artificial Recharge" and the 5-marker on *biogas* (production, barriers).

3.1 Defining Natural Resources

Natural resources are any forms or aspects of nature — animate or inanimate — that satisfy human wants. The classification scheme used most often in TPSC questions is:

Classification of Resources

By origin	Biotic (plants, animals, microbes) vs Abiotic (water, air, minerals).
By stage of development	Potential, developed, stock, reserve.
By distribution	Ubiquitous (everywhere) vs localised (concentrated).
By renewability	Renewable (solar, wind, water, biomass) vs Non-renewable (coal, oil, gas, minerals).

3.1.1 Renewable vs Non-Renewable

A **renewable** resource is one whose stock is replenished by natural processes at a rate at least as fast as the rate of human use. A **non-renewable** resource has a finite stock, accumulated over geological time, and is depleted by use. Some renewables — soil, forests, fisheries — are renewable *only if* the harvest rate does not exceed the regeneration rate; otherwise they become functionally non-renewable.

Renewable vs Non-Renewable — Quick Compare

Aspect	Renewable	Non-Renewable
Replenishment	Within human time-scale	Geological time-scale
Stock	Effectively unlimited if used wisely	Finite & depletable
Pollution	Generally low	Generally high (CO ₂ , SO _x , ash)
Examples	Solar, wind, hydel, biomass, tidal, geothermal	Coal, petroleum, natural gas, uranium, metallic ores
Cost trend	Falling rapidly	Rising as deposits deplete

3.2 The Major Natural Resources

3.2.1 Water Resources

India holds about 4% of world's freshwater on 2.4% of land but supports 18% of the world's population. India is officially water-stressed (per-capita availability below 1700 m³/yr). Major issues: over-extraction of groundwater (NITI Aayog's CGWB shows 17% of blocks "over-exploited"), pollution, glacial-melt anomalies, inter-state river disputes (Cauvery, Krishna), and trans-boundary issues (Indus, Teesta).

3.2.2 Forest Resources

ISFR 2023 reports India's total forest & tree cover at **25.17%** of geographical area (target: 33%, per the National Forest Policy 1988). Tripura, with over 75% forest cover, is in the top tier of forest-rich states — but ISFR 2023 also flagged the maximum decrease inside Recorded Forest Area in Tripura, against the 2021 baseline.

3.2.3 Soil Resources

Soil takes centuries to form (1 cm in 100–400 years) and is therefore renewable only over geological time. Major degradation processes: water and wind erosion, salinisation, water-logging, acidification, nutrient depletion. India loses 5.3 billion tonnes of topsoil annually (ICAR estimate). Tripura's red-loam and lateritic soils are intrinsically acidic and require lime and organic amendments.

3.2.4 Mineral Resources

India is rich in coal (4th globally), iron ore, bauxite, manganese, mica, but lean in crude oil and natural gas. Tripura sits on substantial **natural gas reserves** — about 30 BCM — and the ONGC Tripura Power Project at Palatana produces 726 MW from indigenous gas, exporting power to Bangladesh under a 2013 agreement.

3.2.5 Biological Resources

Covered in Chapter 1.

3.2.6 Land Resources

India's geographical area is 3.29 million km². Of this, 46% is agricultural, 21% forest, 7% non-agricultural built-up. Land degradation neutrality (LDN) is now a Sustainable Development Goal (SDG 15.3).

3.3 Resource Management & Conservation

The 3R hierarchy — **Reduce, Reuse, Recycle** — has been extended in recent UN frameworks to 5R (*Refuse, Reduce, Reuse, Recycle, Rot*) and 7R (adding Repair and Rethink).

3.3.1 Principles of Resource Conservation

1. **Carrying capacity** — limit extraction to what the ecosystem can regenerate.
2. **Precautionary principle** — when in doubt, avoid action that may cause harm.
3. **Polluter Pays Principle (PPP)** — internalise externalities.
4. **Inter-generational equity** — present use should not foreclose options for future generations (Brundtland definition of sustainable development, 1987).
5. **Stewardship** — humans as custodians, not owners, of nature.

3.3.2 Indian Schemes for Resource Conservation

- **Jal Jeevan Mission** (2019) — tap water to every rural household by 2024.
- **Atal Bhujal Yojana** (2019) — community-led groundwater management in 7 stressed states.
- **PM Krishi Sinchai Yojana** (*Har Khet Ko Paani*) — micro-irrigation, watershed development.
- **Compensatory Afforestation Fund Act (CAMPA)** 2016 — funds for afforestation.
- **National Mission for a Green India** (NMGI) — under NAPCC.
- **Nagar Van Yojana** (2020) — urban forests in 200 cities.

3.4 Rainwater Harvesting (RWH) and Artificial Recharge

A 2021 TPSC PYQ asked exactly this — the model answer below should be memorised.

Rainwater Harvesting — Defined

Rainwater Harvesting (RWH) is the deliberate collection, conveyance and storage of rainwater from rooftops, paved or natural surfaces for direct domestic use or for groundwater recharge.

Artificial Recharge to Groundwater is the planned augmentation of aquifer storage by routing runoff or harvested rainwater into the subsurface through engineered structures.

3.4.1 Types of RWH Structures

- **Rooftop harvesting** — gutters & downpipes lead rain into storage tanks (*kund/khattin*) or recharge pits.
- **Surface runoff harvesting** — check-dams, percolation tanks, contour bunds, terraces.
- **Recharge structures** — recharge wells, recharge shafts, recharge trenches, dug-well recharge, sub-surface dykes.

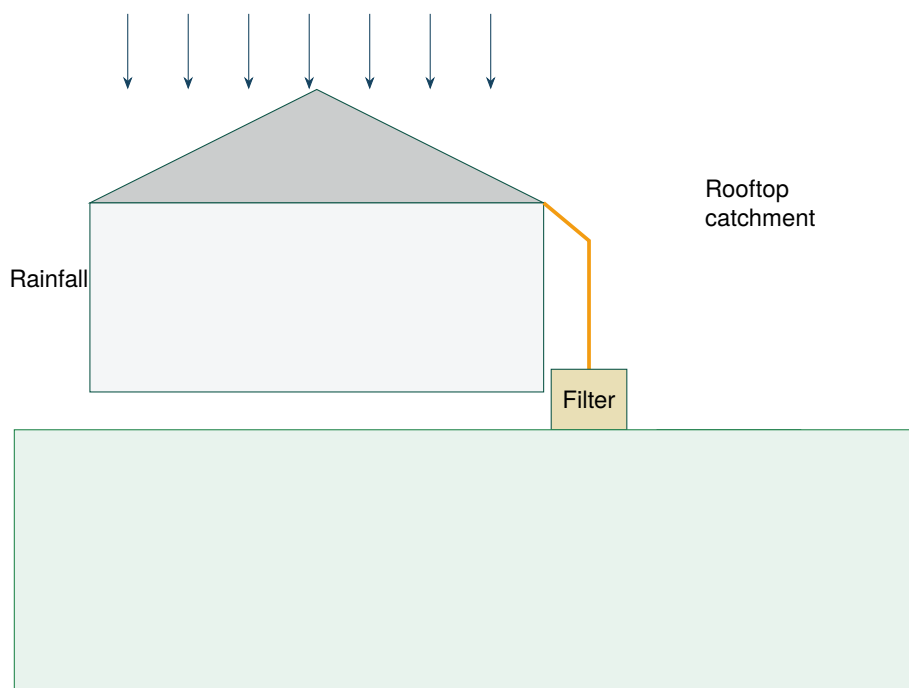


Figure 3.1: Schematic of a rooftop rainwater harvesting system.

3.4.2 Benefits of RWH

- Raises groundwater table; mitigates urban flooding.

- Reduces dependence on municipal supply; lowers electricity bill on pumping.
- Lower TDS and softer water than groundwater in many basins.
- Cost-effective: rooftop system pays back in 3–5 years for a typical household.

RWH in Tripura

Tripura receives 2,100–2,400 mm annual rainfall, yet faces winter water shortage due to high run-off on undulating terrain. The Tripura State Water Mission promotes *khattin*-style rooftop tanks in hilly tribal villages of Dhalai and North Tripura. ATMA schemes integrate RWH with pisciculture in farm ponds.

3.5 Energy Resources

3.5.1 Conventional vs Non-Conventional

Energy Classification		
Aspect	Conventional	Non-Conventional
Origin	Used for many decades	Newer, alternative sources
Renewability	Mostly non-renewable	Mostly renewable
Examples	Coal, oil, gas, nuclear (in some definitions), large hydro	Solar, wind, small hydro, biomass, biogas, geothermal, tidal, wave, hydrogen
Pollution	High (except large hydro)	Low to zero
Cost trend	Rising	Falling (solar PV has fallen 89% since 2010)

3.5.2 Conventional Sources

- **Coal** — India's energy backbone (54% of installed capacity until recently). Major fields: Jharia, Raniganj, Talcher.
- **Petroleum** — Mumbai High, Bombay High, Krishna-Godavari Basin; India imports 88% of crude.
- **Natural Gas** — Bombay High, KG basin, **Tripura's Gas fields** (Konaban, Baramura, Rokhia).
- **Hydroelectric** — large dams (Bhakra, Sardar Sarovar, Tehri). Gumti HEP in Tripura (8.6 MW) is the state's oldest.
- **Nuclear** — Tarapur, Kudankulam, Kakrapar; uses U-235; carbon-free but with waste-management issues.

3.5.3 Non-Conventional Sources

Solar

India targets 500 GW renewable capacity by 2030 (COP26 Glasgow). The **International Solar Alliance (ISA)**, headquartered at Gurugram, was India–France joint initiative (2015). The **PM-KUSUM** scheme solarises agriculture. India's installed solar capacity crossed 90 GW in 2024.

Wind

India is the 4th-largest wind power producer (45 GW+). Largest wind farms in Tamil Nadu, Gujarat, Rajasthan, Maharashtra. Offshore wind potential being explored off Gujarat.

Biomass and Biogas

Biogas, a mixture of methane (50–75%), CO_2 (25–50%) and traces of H_2S , NH_3 , is produced by anaerobic digestion of organic matter (cattle dung, agricultural waste, kitchen waste) in a digester. The **GOBAR-Dhan** (Galvanising Organic Bio-Agro Resources Dhan) scheme and the **SATAT initiative** (Sustainable Alternative Towards Affordable Transportation) for compressed biogas (CBG) are the major government interventions.

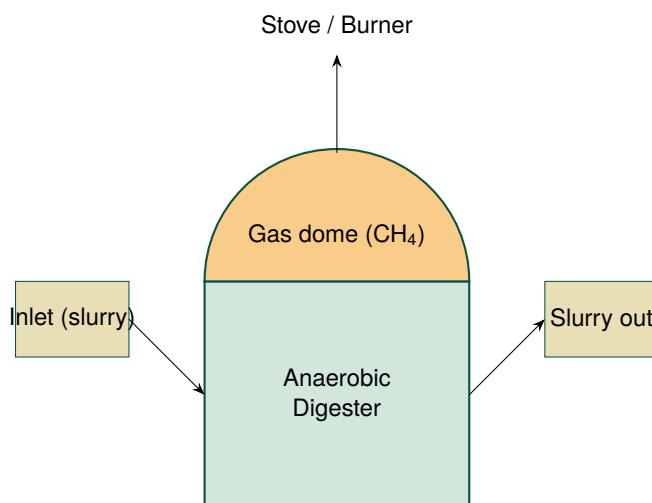


Figure 3.2: Conceptual schematic of a household biogas plant (KVIC/Janata model).

Geothermal, Tidal, Wave

Geothermal — Puga valley (Ladakh), Manikaran (HP). Tidal — Gulf of Khambhat and Kutch (3000+ MW potential). Wave — Vizhinjam (Kerala) experimental plant.

Green Hydrogen

The **National Green Hydrogen Mission** (Jan 2023, outlay Rs. 19,744 crore) targets 5 MMT of green hydrogen by 2030, positioning India as a global hub for production and export.

Latest Numbers — India's Energy Transition (2024-25)

- Installed renewable capacity: ~203 GW (incl. large hydro).
- Solar: 90+ GW; wind: 45+ GW; bio-power: 11 GW; small hydro: 5 GW.
- Target: 500 GW non-fossil by 2030 (COP26).
- Net-zero by 2070 — India's NDC commitment.
- Per-capita CO_2 : ~1.9 t/yr (one-third world average).

3.6 Solved Previous Year Questions

TCS/TPS 2021 — Q.103(ii) — Short (5 marks)

What is biogas? How is it produced? What are the barriers to increase the production and use?

Model Answer

Definition: Biogas is a combustible gas mixture (~60% CH₄, ~40% CO₂, traces of H₂S, NH₃) produced by anaerobic digestion of organic matter under controlled conditions.

Production: Cattle dung, kitchen waste, agricultural residue, sewage sludge — mixed with water as slurry — fed into an air-tight *digester*. Methanogenic bacteria break down the organic matter in four stages — *hydrolysis* → *acidogenesis* → *acetogenesis* → *methanogenesis* — over 30–40 days at 30–40°C. The gas collected in a dome is piped to a burner; the residual slurry is a nutrient-rich bio-fertiliser. Common designs: KVIC floating-drum (1962) and *Janata* fixed-dome (1978).

Barriers:

1. *High upfront cost* — Rs. 25,000–Rs. 50,000 per household plant; subsidy is uneven across states.
2. *Feedstock scarcity in landless families* who lack cattle.
3. *Maintenance burden* — gas leakage, dome cracks, low-temperature stalling in winter.
4. *Low public awareness* compared to LPG / PNG.
5. *Distribution gaps* for compressed biogas (CBG) under SATAT.
6. *Policy fragmentation* — central and state schemes do not always converge.

Way forward: GOBAR-Dhan and SATAT schemes; community plants; bundling with PMUY/Ujjwala; capacity-building of village-level technicians; carbon-credit linkage.

TCS/TPS 2021 — Q.105(iii) — Very Short (2 marks)

What is Rainwater Harvesting and Artificial Recharge to Groundwater? Name any two types of groundwater recharging structures.

Model Answer

Rainwater Harvesting is the planned collection, conveyance and storage of rainwater from rooftops or paved surfaces for direct use or aquifer recharge.

Artificial Recharge is the engineered augmentation of groundwater storage by routing surface water into the aquifer.

Two recharge structures: (i) Recharge well/borewell, and (ii) Percolation tank/recharge pit. (Other examples: sub-surface dyke, recharge trench, dug-well recharge.)

3.7 Examiner's Corner**Examiner's Corner**

- Mention the **Brundtland definition** of sustainable development (1987) whenever discussing conservation.
- For energy questions, always close with a current-affairs hook — **Green Hydrogen Mission, ISA, 500 GW target.**
- In RWH questions, name at least two structures with one line each.
- Add a *Tripura linkage* — Palatana gas-based plant, Twijilikma wetland, Khowai check-dams.

A. Objective MCQs

Practice Set

- Which is non-renewable?
(a) Wind (b) Solar (c) Coal (d) Tidal
- ISA headquarters:
(a) New Delhi (b) Gurugram (c) Hyderabad (d) Paris
- GOBAR-Dhan scheme deals with:
(a) Cattle insurance (b) Biogas from cattle dung (c) Sterilising of stray cattle (d) Milk pricing
- Tripura's largest gas-based power plant is at:
(a) Rokhia (b) Baramura (c) Palatana (d) Monarchak
- Per-capita CO₂ emission of India (2024) is approximately:
(a) 1.9 t/yr (b) 5.0 t/yr (c) 9.0 t/yr (d) 14 t/yr
- Net-Zero target year of India:
(a) 2050 (b) 2060 (c) 2070 (d) 2100
- Brundtland Commission was constituted in:
(a) 1972 (b) 1980 (c) 1983 (d) 1992

Ans: 1-c, 2-b, 3-b, 4-c, 5-a, 6-c, 7-c.

B. Very Short (2 marks)

Practice Set

- Name any four non-conventional energy sources.
- Differentiate conventional and non-conventional energy.
- State two benefits of rainwater harvesting in hilly Tripura.
- Define carrying capacity.

C. Short (5 marks)

Practice Set

- Discuss the principles of resource conservation with examples.
- Evaluate India's progress in non-conventional energy under the 500 GW target.
- Explain RWH and artificial recharge as tools for water security in Tripura.

3.9 Quick Revision Capsule — Chapter 3

Quick Revision Capsule

Resources: Biotic/abiotic; renewable/non-renewable; potential/developed.

Forest cover (ISFR 2023): 25.17% of India; Tripura >75%.

RWH structures: rooftop tank, percolation pit, recharge well, sub-surface dyke.

Conventional energy: coal, oil, gas, nuclear, large hydro.

Non-conventional: solar (90 GW), wind (45 GW), bio-power, geothermal, tidal, green H₂.

Schemes: JJM, Atal Bhujal, PMKSY, GOBAR-Dhan, SATAT, KUSUM, ISA, GHM.

Targets: 500 GW non-fossil by 2030; Net-Zero by 2070.

4

Environmental Pollution

Syllabus Pointer (TPSC)

Section-E (D): Types of pollution; causes & major pollutants — Air, Water, Soil, Noise, Thermal, Nuclear; effects & control measures; Solid Waste Management.

PYQ history: BS-IV/VI standards (2019, 2021), BOD (2021), aerobic-degradation product (2021), E-waste Rules 2016 (2021).

4.1 Defining Pollution

Pollution is the undesirable change in the physical, chemical or biological characteristics of air, water, soil or other environmental components, which has an adverse effect on living organisms, materials, or amenity. The Indian **Environment (Protection) Act, 1986** defines an *environmental pollutant* as any solid, liquid or gaseous substance present in such concentration as may be, or tend to be, injurious to the environment.

4.1.1 Classification of Pollutants

Pollutants — Classifications

Source	<i>Point</i> (single identifiable source — chimney, drain) vs <i>Non-point</i> (diffuse — agricultural run-off).
Persistence	<i>Biodegradable</i> (sewage, plant waste) vs <i>Non-biodegradable</i> (DDT, plastic, heavy metals).
Form	Primary (emitted directly — CO, SO ₂) vs Secondary (formed in atmosphere — O ₃ , PAN).
Phase	Gaseous, particulate, liquid, solid.

4.2 Air Pollution

The 2019 **State of Global Air** report ranked India among the world's worst air polluted regions. The **World Air Quality Report 2023** listed 9 of the 10 most polluted cities in India.

4.2.1 Major Air Pollutants

The Criteria Air Pollutants — NAAQS, India

Pollutant	Major sources & effects
PM ₁₀ , PM _{2.5}	Vehicular exhaust, construction, biomass burning, fly-ash; lung & cardiovascular disease.
SO ₂	Coal combustion (thermal plants), petroleum refining; acid rain, respiratory illness.
NO _x	Vehicles, thermal plants; smog, acid rain, ozone formation.
CO	Incomplete combustion; binds haemoglobin (carboxy-Hb) reducing O ₂ carriage.
O ₃ (tropospheric)	Secondary photochemical pollutant (NO _x + VOCs + sunlight); pulmonary irritant, crop damage.
Pb	Leaded petrol (phased out 2000), battery manufacture; neurotoxicity (esp. children).
NH ₃	Agriculture (fertiliser), livestock; eutrophication, particulate precursor.
Benzene, BaP	Vehicle exhaust, incomplete combustion; carcinogenic.

4.2.2 Indoor Air Pollution

WHO estimates 3.2 million deaths/yr globally from household air pollution, predominantly in low-income households burning *solid biomass* (firewood, dung-cake) on inefficient stoves. India's **PM Ujjwala Yojana** (2016) has provided over 9 crore LPG connections to BPL women to mitigate indoor combustion smoke.

4.2.3 Smog — Two Types

- **London (sulphurous/classical) smog** — cool, humid mornings; SO₂ & soot; example: London 1952 (4,000 deaths in five days).
- **Los Angeles (photochemical) smog** — sunny afternoons; NO_x, VOCs, O₃, PAN; eye-irritating brown haze.

4.2.4 Control of Air Pollution

- **Source control** — better fuel quality (BS-VI, 2020), CNG conversion, EVs.
- **Stack-end devices** — electrostatic precipitators, bag filters, scrubbers, cyclonic separators.
- **Catalytic converters** in vehicles to oxidise CO & HC, reduce NO_x.
- **National Clean Air Programme (NCAP), 2019** — 40% reduction in PM₁₀/PM_{2.5} by 2026 (revised target) in 131 non-attainment cities.
- **Graded Response Action Plan (GRAP)** — Delhi-NCR emergency response.

BS-VI Norms (1 April 2020)

Sulphur in petrol/diesel reduced to 10 ppm (from 50 ppm in BS-IV); particulate matter limits for diesel cars reduced by 82%; NO_x for diesel cars by 68%. India leapfrogged BS-V to BS-VI globally.

4.3 Water Pollution

4.3.1 Types and Indicators

Water pollution comes from *point sources* (industrial outfalls, sewage) and *non-point sources* (farm run-off, urban storm water). Key indicators:

Water Quality Indicators

BOD	Biochemical Oxygen Demand — O ₂ required by aerobic microbes to decompose organic matter over 5 days at 20°C; high BOD indicates heavy organic load (sewage).
COD	Chemical Oxygen Demand — O ₂ needed to chemically oxidise organic + inorganic load; COD > BOD.
DO	Dissolved Oxygen — fish need >5 mg/L; fall below 2 mg/L is hypoxic.
pH	6.5–8.5 acceptable; acidified water harms aquatic life.
TDS, TSS	Total dissolved & suspended solids.
Coliforms	MPN of <i>E. coli</i> indicates faecal contamination.

4.3.2 Eutrophication

Excess nutrients (N, P) from fertilisers/sewage cause algal blooms; algae die, decompose, deplete O₂, killing fish. Process is termed **cultural eutrophication** when human-driven. Famous Indian examples: Dal Lake (Srinagar), Sukhna (Chandigarh), Vembanad. The “dead zone” of the Gulf of Mexico is a global benchmark.

4.3.3 Biomagnification & Bioaccumulation

Bioaccumulation — gradual build-up of a persistent pollutant within a single organism over time. **Biomagnification** — increase in tissue concentration as the pollutant moves up trophic levels. Famous case: DDT in birds of prey (Rachel Carson, *Silent Spring*, 1962).

4.3.4 Marine Pollution

- **Oil spills** — Exxon Valdez (1989), Deepwater Horizon (2010); Indian: Chennai Ennore (2017).
- **Plastic** — 11 million tonnes enter oceans annually; microplastics in fish, salt, drinking water.
- **Thermal discharge**, sewage, agricultural run-off.

4.3.5 Control

Effluent Treatment Plants (ETP), Sewage Treatment Plants (STP), Common Effluent Treatment Plants (CETP) in industrial clusters, riverfront development plans (Namami Gange, NRCP), Polluter Pays Principle enforced through CPCB & SPCBs.

4.4 Soil Pollution

4.4.1 Major Causes

Industrial effluents and sludge, agro-chemicals (urea, DAP, pesticides), heavy metals (Cd, Pb, Hg, As), e-waste leachate, plastic, fly-ash, mining over-burden, untreated sewage.

4.4.2 Effects

- Loss of soil fertility (salinisation in canal-irrigated NW India).
- Heavy-metal accumulation in crops → human exposure.
- Groundwater contamination by leachate.
- Microbial diversity collapse.
- **Itai-itai disease** (Cd, Japan) and **Minamata disease** (Hg, Japan) — landmark cases.

4.4.3 Control

Crop rotation, biofertilisers, vermicomposting, integrated nutrient & pest management, phytoremediation (e.g. sunflower for Pb, mustard for Cd), bioremediation (microbes), *Soil Health Card* scheme (2015).

4.5 Noise Pollution

Noise above ambient standards causes hearing damage, hypertension, sleep disturbance and reduced cognitive performance.

Ambient Noise Standards (CPCB, India)		
Area	Day (06–22 h)	Night (22–06 h)
Industrial	75 dB(A)	70 dB(A)
Commercial	65 dB(A)	55 dB(A)
Residential	55 dB(A)	45 dB(A)
Silence zone (near hospital, school)	50 dB(A)	40 dB(A)

Control: silence zones, vehicular horns/silencers, building insulation, green buffers, public-awareness campaigns.

4.6 Thermal Pollution

Discharge of warm water from power plants/industries into rivers reduces DO (warm water holds less O₂), shifts species composition, encourages disease, kills cold-water fish (mahseer). Coastal nuclear plants are major sources. **Control:** cooling towers, cooling ponds, recycled cooling water.

4.7 Nuclear / Radiation Pollution

Ionising radiations — alpha (α), beta (β), gamma (γ), X-rays — from radioactive decay damage DNA, cause cancers, mutations and acute radiation sickness. **Sources:** Atmospheric nuclear tests, accidents (Chernobyl 1986, Fukushima 2011), nuclear-power waste, medical isotopes, mining of uranium. **Control:** containment, IAEA safeguards, deep-geological repositories, decommissioning of obsolete reactors, AERB oversight in India.

4.8 Solid Waste Management (SWM)

India generates approximately 1.5 lakh tonnes/day of MSW (CPCB 2023). Composition (avg.): 50% organic, 17% recyclables (paper, plastic, metal, glass), 5% inert, balance C&D and others.

Quarks TPSC • Opp. SDM Agartala • 7628954476

4.8.1 Waste Hierarchy (5R)

4.8.2 Key Rules in India

India's Waste-Management Rule Set (2016, updated)	
Solid Waste Management Rules, 2016	Segregation at source (wet/dry/hazardous); user fees; spot fines; coverage of slums & rural areas.
Plastic Waste Management Rules, 2016 (amend. 2021, 2022)	Phased ban on identified single-use plastics (1 July 2022); Extended Producer Responsibility (EPR).
E-Waste (Management) Rules, 2016 (amend. 2022)	EPR for producers; deposit-refund scheme; CPCB registration of recyclers.
Bio-Medical Waste Rules, 2016	Colour-coded segregation (yellow/red/blue/white); barcoded bags; CBWTF.
Construction & Demolition Waste Rules, 2016	Bulk-generator responsibility; recycling facilities in cities >1 million.
Hazardous Waste (M&TBM) Rules, 2016	Inventorisation, manifest system, ban on import without permit.

4.8.3 Disposal Methods

- **Sanitary landfilling** — engineered with liners, leachate & gas-management.
- **Incineration** (waste-to-energy) — used for hazardous and BMW.
- **Composting** — aerobic (Bangalore method, Indore method) or vermi-composting.
- **Anaerobic digestion** — produces biogas & digestate.
- **Recycling & upcycling** via informal and formal sectors.

4.8.4 Swachh Bharat Mission

SBM-Urban (2014) achieved ODF status in 4,372 cities; **SBM-Gramin** declared rural India ODF in October 2019. **SBM 2.0** (2021–26) focuses on faecal sludge management, plastic waste & urban infrastructure.

Pollution & Waste in Tripura

Air: Agartala's PM_{2.5} typically 60–90 µg/m³ in winter — moderate but rising; vehicular and brick-kiln emissions principal sources.

Water: Howrah and Haora rivers polluted by Agartala sewage; pisciculture ponds suffering eutrophication.

Solid Waste: Agartala Municipal Corporation generates ~170 tonnes/day; the Debendra Chandra Nagar landfill site under reform; plastic carry-bag ban implemented since 2019.

E-waste: Tripura SPCB-registered recyclers in Agartala; need to scale.

4.9 Solved Previous Year Questions

TCS/TPS 2019 — Q.101(v) — Objective

Which BS emission standard did the government propose to implement from April 2020? (a) BS-IV (b) BS-V (c) **BS-VI** (d) BS-VII.

TCS/TPS 2019 — Q.102(ii) — Very Short (2 marks)

Nitrogen and hydrocarbons react in the presence of sunlight. Name the secondary pollutants produced.

Model Answer

When nitrogen oxides (NO_x) and volatile hydrocarbons (VOCs) react in sunlight, they generate **photochemical secondary pollutants** — chiefly **tropospheric ozone (O_3)**, **peroxyacetyl nitrate (PAN)** and aldehydes. This mixture constitutes the *Los Angeles-type photochemical smog*, irritating to eyes and the respiratory tract.

TCS/TPS 2021 — Q.101(i) — Objective

Sulphur permissible in BS-IV petrol and diesel: (a) 40 ppm (b) **50 ppm** (c) 45 ppm (d) 60 ppm.

TCS/TPS 2021 — Q.101(vi) — Objective

Aerobic degradation of organic matter by bacteria releases: (a) chlorine (b) hydrogen (c) hydrogen sulphide (d) **carbon dioxide**.

TCS/TPS 2021 — Q.102(iii) — Very Short (2 marks)

Write the full form of BOD and define it.

Model Answer

BOD = Biochemical Oxygen Demand. It is the amount of dissolved oxygen, in mg/L, consumed by aerobic micro-organisms in decomposing organic matter in a water sample, measured at 20°C over five days (BOD_5). A high BOD indicates a heavy load of biodegradable organic pollution (sewage); the river-quality criterion for "fit for bathing" is $\text{BOD} < 3 \text{ mg/L}$.

TCS/TPS 2021 — Q.103(i) — Short (5 marks)

Write a short note on E-waste Management Rules enacted in 2016.

Model Answer

Context: India generated about 1.6 million tonnes of e-waste in 2022 (3rd largest globally), and 95% is processed in the informal sector under hazardous conditions.

Key Features of E-Waste (Management) Rules, 2016 (amended 2018, 2022):

1. **Coverage** — extended to producers, consumers, bulk consumers, dealers, refurbishers, dismantlers, recyclers and CFCs of EEE, including CFL/mercury-containing lamps.
2. **Extended Producer Responsibility (EPR)** — every producer must take back, recycle and ensure environmentally sound management of its branded e-waste, with annual collection targets ramping up from 30% to 70% (2022 amendment).
3. **Deposit-Refund Scheme** — manufacturer collects a deposit at the time of sale and refunds upon return of end-of-life product.
4. **CPCB Registration** — mandatory for dismantlers and recyclers, with manifest tracking.
5. **Reduction in Hazardous Substances (RoHS)** — restrictions on Pb, Hg, Cd, Cr-VI, PBBs, PBDEs

in EEE.

6. **State Pollution Control Boards** — monitoring and enforcement.

7. **Liability for damage** — under Sections 14 & 16 of the Environment (Protection) Act, 1986.

Way forward: Formalising informal sector, awareness drives like *e-Waste Jagrukta Diwas*, expansion of authorised collection centres.

4.10 Examiner's Corner

Examiner's Corner

- Always cite **BOD₅ at 20°C** — the temperature & duration are markers of mastery.
- Distinguish **eutrophication (lake)** from **biomagnification (food chain)** — they are different concepts often confused.
- In SWM answers, name at least **three** sets of 2016 rules — SWM, PWM, EWM.
- For air-pollution control questions, write **source control + end-of-pipe + regulatory** as three pillars.

4.11 Practice Set — Chapter 4

A. Objective MCQs

Practice Set

1. BS-VI was implemented in India from:
(a) 2018 (b) 2019 (c) 2020 (d) 2021
2. Itai-itai disease is caused by:
(a) Mercury (b) Lead (c) Arsenic (d) Cadmium
3. NAAQS in India is fixed by:
(a) MoEFCC (b) CPCB (c) WHO (d) NDMA
4. Minamata disease was caused by:
(a) Cd (b) As (c) Hg (d) Pb
5. Day-time noise limit in a silence zone:
(a) 40 (b) 45 (c) 50 (d) 55 dB(A)
6. NCAP target for PM-reduction by 2026:
(a) 20% (b) 30% (c) 40% (d) 50%
7. Plastic Waste Management Rules ban single-use plastic from:
(a) 1 Jan 2022 (b) 1 July 2022 (c) 2 Oct 2022 (d) 26 Jan 2022

Ans: 1-c, 2-d, 3-b, 4-c, 5-c, 6-c, 7-b.

B. Very Short (2 marks)

Practice Set

1. Differentiate primary and secondary air pollutants with examples.
2. State the four-stage process of anaerobic digestion.
3. Define eutrophication.
4. Name any four diseases associated with heavy-metal pollution.

C. Short (5 marks)

Practice Set

1. Discuss the sources, effects & control of urban air pollution in India.
2. Explain the Solid Waste Management Rules 2016 and their implementation in Tripura.
3. "Plastic pollution is a slow-motion catastrophe." Discuss with reference to PWM Rules.
4. Compare classical and photochemical smog with examples.

4.12 Quick Revision Capsule — Chapter 4

Quick Revision Capsule

Types: Air, water, soil, noise, thermal, nuclear, marine.

Primary vs Secondary — O_3 , PAN are secondary.

Smog: London (sulphurous) vs Los Angeles (photochemical).

BOD: O_2 for microbes, 5 days, $20^\circ C$; **COD** chemical.

Eutrophication — algal bloom from N/P.

Biomagnification — DDT in food chain.

Noise standards — Industrial 75/70, Comm. 65/55, Res. 55/45, Silence 50/40 dB(A).

Diseases: Itai-itai (Cd), Minamata (Hg), Black-foot (As), Plumbism (Pb).

Rules 2016: SWM, PWM, EWM, BMW, C&D, HW.

Schemes: NCAP, GRAP, Namami Gange, SBM 1.0 & 2.0, Ujjwala, Soil Health Card.

5

Global Environmental Issues

Syllabus Pointer (TPSC)

Section-E (E): Global warming & climate change; greenhouse gases — CO₂ emissions, carbon reservoirs, carbon cycling; ozone depletion; acid rain.

Highest PYQ weight in Section-E. 2019 set the health-impact 5-marker; 2021 set the mitigation-adaptation 5-marker, GWP question, Montreal Protocol objective, and CO₂-global-warming linkage.

5.1 The Climate System and the Greenhouse Effect

The Earth's mean surface temperature is set by a delicate balance between incoming *short-wave* solar radiation and outgoing *long-wave* infrared radiation. The atmosphere is largely transparent to incoming sunlight but partially opaque to outgoing infrared, owing to certain **greenhouse gases (GHGs)** that absorb and re-radiate infrared back to the surface. This natural greenhouse effect keeps the planet $\sim 33^\circ\text{C}$ warmer than it would otherwise be — without it, Earth would average -18°C .

Human activities, however, have raised atmospheric GHG concentrations substantially since the Industrial Revolution, intensifying the greenhouse effect. The IPCC AR6 (2021–23) confirms with high confidence that human-induced warming has already reached $1.1\text{--}1.2^\circ\text{C}$ above the 1850–1900 baseline, and is on track to exceed 1.5°C within the next decade.

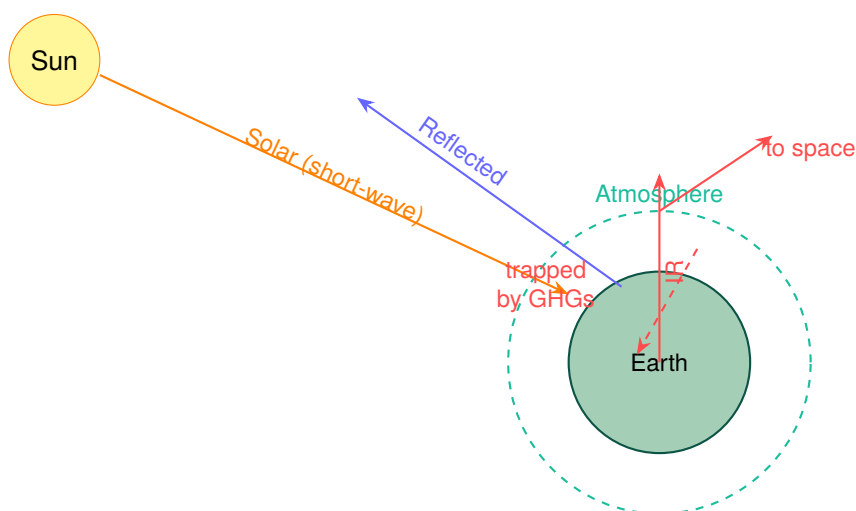


Figure 5.1: The greenhouse effect — short-wave incoming, infrared re-emission, partial trapping by GHGs.

5.2 The Greenhouse Gases

GHGs are classified by lifetime, source and *Global Warming Potential (GWP)* — a 100-year mass-weighted comparison with CO₂.

Major GHGs — TPSC Cheat-sheet

Gas	Major sources	GWP-100	Life (yr)
CO ₂	Combustion, deforestation, cement	1	100–1000
CH ₄	Rice paddies, cattle, oil/gas leaks	28–34	12
N ₂ O	Fertiliser, biomass burning	273	109
HFCs	Refrigeration, AC	1000s	1–40
PFCs	Aluminium production, electronics	~7400	2600–50000
SF ₆	Electrical insulation	23,500	3200
CFCs (legacy)	Refrigeration (banned, Montreal)	5000+	50–100

Descending order of GWP — 2021 PYQ answer: SF₆ > CFCs > N₂O > CH₄.

5.2.1 Why CO₂ Dominates the Climate Conversation

Although individual gases like SF₆ have much higher GWP, **CO₂ is the largest absolute emitter** (75–80% of total GHG forcing) and remains the longest-lived; emissions today linger for centuries. Pre-industrial CO₂ was 280 ppm; in 2024 it crossed **422 ppm** (Mauna Loa).

5.3 The Carbon Cycle and Reservoirs

Carbon moves among four major reservoirs.

Earth's Carbon Reservoirs

Reservoir	Description	Size (GtC)
Lithosphere (rocks, sediments, fossil fuels)	Largest by far — limestone, kerogen, fossil deposits	100,000,000+
Oceans (DIC, DOC)	Surface + deep ocean carbon	38,000–40,000
Terrestrial biosphere & soils	Plants + soil organic carbon	2,000–2,500
Atmosphere (CO ₂ , CH ₄)	Rapid exchange	~870 (rising)

5.3.1 Major Fluxes

- **Photosynthesis:** atmospheric CO₂ → biomass (~120 GtC/yr).
- **Respiration & decomposition:** biomass → atmosphere (~120 GtC/yr).
- **Ocean–atmosphere exchange:** ~90 GtC/yr each way.
- **Anthropogenic** (combustion + deforestation): ~11 GtC/yr; about half taken up by ocean and land, the rest accumulates in atmosphere.

5.4 Climate Change Impacts

- **Sea-level rise** — averaged 3.4 mm/yr in 2013–2022; projected 0.4–0.8 m by 2100. Sundarbans, Lakshadweep, low-lying coasts in jeopardy.
- **Heat waves** — frequency & severity rising; 2022 India heat-wave reached 49°C in NW.
- **Glacier retreat** — Himalayan glaciers losing 1 m water-equivalent per year; impacts Ganga-Brahmaputra

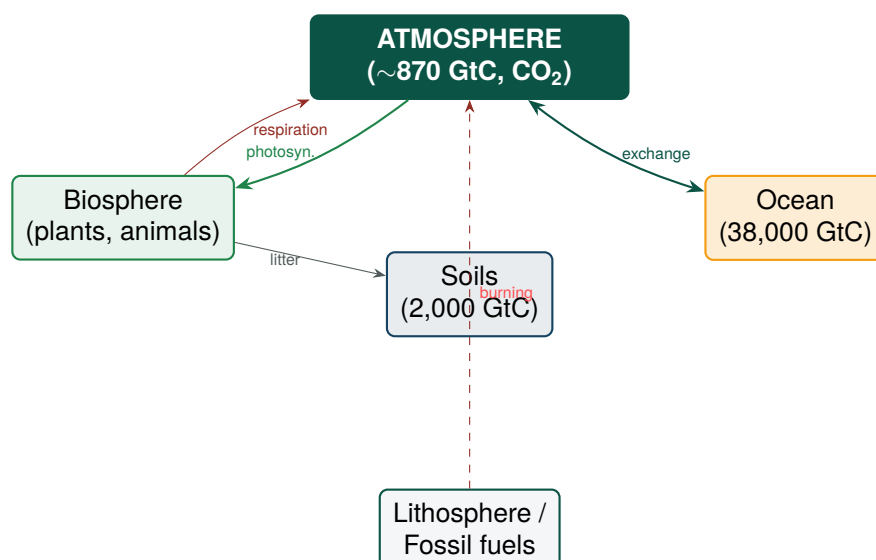


Figure 5.2: Schematic of the global carbon cycle.

flow.

- **Cyclone intensification** — Bay of Bengal warming feeding storms like *Amphan* (2020), *Yaas* (2021), *Mocha* (2023), *Remal* (2024).
- **Crop yields** — wheat in NW India projected to drop 6–23% by 2050; rice yields vulnerable.
- **Biodiversity** — coral bleaching, range shifts, phenological mismatch.
- **Health** — heat stroke, vector-borne disease expansion (dengue, malaria, kala-azar), respiratory disease.
- **Climate migration** — IPCC AR6 projects hundreds of millions displaced by 2050.

5.4.1 Mitigation vs Adaptation

Mitigation vs Adaptation — TPSC's favourite distinction		
Aspect	Mitigation	Adaptation
Goal	Reduce/avoid GHG emissions	Adjust to existing/expected impacts
Time-scale	Long-term (decades-century)	Immediate & continuous
Beneficiary	Global community	Local/regional community
Examples	RE deployment, EVs, afforestation, CCS	Drought-resistant crops, sea-walls, early-warning systems, crop insurance
India schemes	NSM, NMEEE, FAME, ISA, NMSH ²	NAFCC, NAPCC's NMSA, NWM, NMSHE

5.5 Ozone Depletion

The **ozone layer** in the stratosphere (15–35 km altitude) absorbs harmful UV-B (280–315 nm), protecting life from skin cancer, cataracts and DNA damage. **Chlorofluorocarbons (CFCs)**, halons, methyl bromide, HCFCs — used in refrigeration, foam blowing, fire-extinguishers, fumigants — release Cl/Br radicals in the stratosphere via UV-photolysis. A single Cl atom can destroy ~100,000 O₃ molecules.

The **Antarctic ozone hole**, discovered in 1985 by Farman, Gardiner & Shanklin, recurs each Austral

spring (Sep–Nov) when polar stratospheric clouds catalyse the Cl-radical reaction.

5.5.1 Montreal Protocol (1987)

Hailed as the most successful environmental treaty ever signed: universally ratified (197 parties), phased out 99% of ODS. **Kigali Amendment (2016)** extended it to HFCs (potent GHGs); India ratified in 2021. Ozone layer expected to recover to 1980 levels by mid-21st century (over Antarctica by 2066).

Ozone Hole 2024 Update

WMO/Copernicus reports show the Antarctic ozone hole peaking smaller than the 1990s average — a signal of recovery. India phased out CFCs by 2010 and HCFCs by 2025 under the HCFC Phase-out Management Plan (HPMP-III).

5.6 Acid Rain

Acid rain (pH <5.6) is precipitation acidified by SO₂ and NO_x converted to H₂SO₄ and HNO₃ in the atmosphere. Sources: coal-fired power plants, smelters, vehicles. Effects:

- Acidification of lakes & streams; fish mortality (perch, salmon).
- Leaching of Al from soils — toxic to roots.
- Corrosion of monuments — *Taj Mahal yellowing* attributed partly to acid rain from Mathura refinery.
- Damage to forests (Black Forest, Germany).

Control: flue-gas desulphurisation (FGD), low-S coal, catalytic converters, lime treatment of acidified lakes.

5.7 Other Global Concerns

- **Ocean acidification** — CO₂ dissolved in seawater lowers pH; coral and shellfish lose calcification capacity.
- **Coral bleaching** — symbiotic zooxanthellae expelled under heat stress; Great Barrier Reef, Lakshadweep, A&N affected.
- **Desertification** — UNCCD (1994); India committed to LDN by 2030.
- **Black carbon** — short-lived climate pollutant (SLCP); contributes to glacial melt by darkening snow surface.

5.8 India's Climate Action Architecture

- **NAPCC (2008)** — National Action Plan on Climate Change; 8 missions.
- **State Action Plans on Climate Change (SAPCCs)** — Tripura's SAPCC notified.
- **NDCs (updated 2022)** — 45% reduction in emissions intensity of GDP by 2030 (vs 2005); 50% non-fossil installed capacity by 2030; create additional carbon sink of 2.5–3.0 Gt CO₂-eq. through forests by 2030; **Net-Zero by 2070** (COP26, Glasgow).
- **International Solar Alliance, Coalition for Disaster Resilient Infrastructure (CDRI), LiFE Mission (Lifestyle for Environment)** — India's signature initiatives.
- **Green Hydrogen Mission, 2023; PAT scheme** for industrial efficiency; **FAME-II** for EVs.

5.8.1 NAPCC — Eight National Missions

1. National Solar Mission
2. National Mission for Enhanced Energy Efficiency (NMEEE)
3. National Mission on Sustainable Habitat
4. National Water Mission
5. National Mission for Sustaining the Himalayan Ecosystem (NMSHE)
6. National Mission for a Green India (Green India Mission)
7. National Mission for Sustainable Agriculture (NMSA)
8. National Mission on Strategic Knowledge for Climate Change

Post-COP29 Snapshot (Baku, Nov 2024)

- NCQG: at least **USD 300 billion/yr** by 2035 for developing countries — far short of the USD 1.3 trillion sought.
- Loss & Damage Fund: pledges crossed USD 12.5 billion.
- Carbon Markets: Article 6.2 & 6.4 rules finalised.
- COP28's "transition away from fossil fuels" language was *not* explicitly reaffirmed.
- India's stance: equity, CBDR-RC, just transition, climate finance for adaptation.

Climate Change & Tripura

Observed trends: Average temperature in Tripura rose by 0.8–1.2°C since 1950; monsoon increasingly erratic (excess and deficit cycles).

Vulnerabilities: Rain-fed agriculture (jhum, paddy); forest fires; river-bank erosion; vector-borne disease shift to higher altitudes; pineapple flowering timing disrupted.

Adaptation: SAPCC priorities — agro-forestry, climate-resilient seed varieties, soil-water conservation in jhum-fallow, decentralised solar, micro-irrigation.

Mitigation: Forest carbon stock improvement; Palatana gas-fired plant (lower emissions vs coal); rooftop solar in Agartala.

5.9 Solved Previous Year Questions

TCS/TPS 2019 — Q.101(iv) — Objective

The so-called good ozone is present in: (a) Troposphere (b) **Stratosphere** (c) Over Antarctica (d) Everywhere.

TCS/TPS 2019 — Q.102(iv) — Very Short (2 marks)

What do jet airplanes and refrigerators have in common that has contributed to pollution?

Model Answer

Both jet aeroplanes and refrigerators historically used (and in some cases continue to use) **chlorofluorocarbons (CFCs) and their substitutes (HCFCs/HFCs)** — as refrigerants in refrigerators/air-conditioners, and as exhaust components / cleaning solvents in jet aviation. CFCs deplete stratospheric ozone while HFCs are potent greenhouse gases. The Montreal Protocol (1987) and its Kigali Amendment (2016) regulate them.

TCS/TPS 2019 — Q.103(iii) — Short (5 marks)**Give a brief account of the impact of global climate change on human health.****Model Answer**

Introduction: The WHO recognises climate change as the single biggest health threat facing humanity, projected to cause 2,50,000 additional deaths annually between 2030–2050 from heat, undernutrition and disease.

Impacts:

1. **Heat-related morbidity** — heat strokes, dehydration, cardiovascular mortality (India 2022: >250 heat deaths; Europe 2003 heatwave 70,000 deaths).
2. **Vector-borne disease expansion** — rising temperatures expand the range of dengue, malaria, kala-azar, Zika; mosquito habitats shifting to higher altitudes in the NE.
3. **Water-borne disease** — flood- & storm-displacement, contaminated water → cholera, typhoid, hepatitis-A.
4. **Respiratory illness** — wildfire smoke, particulate aggravation of asthma, COPD; pollen-season shifts.
5. **Food insecurity & undernutrition** — crop yield decline, fishery collapse → stunting, wasting.
6. **Mental health** — eco-anxiety, PTSD post-disaster, displacement stress.
7. **Health systems strain** — climate disasters disrupt hospitals, vaccine cold chains.

Conclusion: A whole-of-government, One-Health approach — building heat-action plans (Ahmedabad model), strengthening vector surveillance, climate-resilient hospital infrastructure, nutrition-sensitive agriculture — is imperative. Tripura's CHC network must build heat & disease surveillance protocols.

TCS/TPS 2021 — Q.102(i) — Very Short (2 marks)**Mention the main objective of the Montreal Protocol.****Model Answer**

The **Montreal Protocol (1987)**, ratified universally by 197 parties, aims to **protect the stratospheric ozone layer** by phasing out the production and consumption of ozone-depleting substances (ODS) — CFCs, HCFCs, halons, methyl bromide, methyl chloroform — on a time-bound schedule with differentiated responsibility for developed and developing countries. Its **Kigali Amendment (2016)** additionally targets HFCs to mitigate global warming.

TCS/TPS 2021 — Q.102(v) — Very Short (2 marks)**Why does an increase in atmospheric CO₂ concentration cause global warming?****Model Answer**

CO₂ is a **greenhouse gas**: its molecular structure absorbs outgoing terrestrial infrared radiation (peak absorption near 15 μm) and re-emits part of it back toward the surface. As atmospheric CO₂ concentration rises from the pre-industrial 280 ppm to over 422 ppm today, more long-wave radiation is trapped, enhancing the natural greenhouse effect and raising mean global surface temperature. CO₂ is also long-lived (centuries), so its warming is cumulative.

TCS/TPS 2021 — Q.103(iii) — Short (5 marks)**Explain with examples the Mitigation and Adaptation measures relating to climate change.**

Model Answer

Introduction: The UNFCCC distinguishes two complementary responses to climate change: *mitigation* (reduce sources/enhance sinks of GHGs) and *adaptation* (adjust to actual or expected climatic effects).

Mitigation measures (illustrative):

1. *Renewable energy* — India's 500 GW target by 2030; ISA; solar pumps under PM-KUSUM.
2. *Energy efficiency* — PAT scheme, LED Ujala (37 crore LEDs distributed).
3. *Electric mobility* — FAME-II, EV30@30, FAME-incentivised buses.
4. *Sustainable land use* — Green India Mission, agro-forestry, conservation agriculture.
5. *Carbon sinks* — Compensatory Afforestation Fund; "additional 2.5–3.0 Gt CO₂-eq sink by 2030" (NDC).
6. *Industrial decarbonisation* — Green Hydrogen Mission 2023, CCS pilots.

Adaptation measures (illustrative):

1. *Climate-resilient agriculture* — drought-resistant seeds (DRR42, SambaMahsuri), zero-tillage, crop insurance (PMFBY).
2. *Water security* — Atal Bhujal Yojana, watershed development, rainwater harvesting.
3. *Coastal protection* — Integrated Coastal Zone Management Plan, mangrove restoration, sea-walls in Sundarbans.
4. *Heat action plans* — Ahmedabad (since 2013); now 23 city HAPs.
5. *Early-warning systems* — IMD's impact-based forecast for cyclones; NDMA SoP.
6. *Health adaptation* — vector-disease surveillance, climate-resilient hospitals.

Conclusion: Mitigation tackles the cause; adaptation tackles the consequence. The two are complementary, not substitutable. India's NAPCC houses both; for Tripura, agro-forestry, decentralised solar and flood-adaptation in the Gomati basin are immediate priorities.

5.10 Examiner's Corner**Examiner's Corner**

- **GWP ranking** is asked frequently — memorise: SF₆ > CFCs > N₂O > CH₄ > CO₂.
- Distinguish **good ozone (stratosphere)** from **bad ozone (troposphere)** — never confuse.
- In mitigation/adaptation questions, write **schemes & targets**, not generic phrases — examiner-credit attaches to specifics like "ISA, PAT, PMFBY, NAFCC".
- For climate health questions, mention **WHO numbers, heat-action plans, vector range shift**.
- For carbon-cycle questions, name **four reservoirs** and their relative sizes.

5.11 Practice Set — Chapter 5**A. Objective MCQs****Practice Set**

1. Pre-industrial atmospheric CO₂ concentration was approximately:
(a) 180 ppm (b) 280 ppm (c) 320 ppm (d) 380 ppm
2. The Kigali Amendment targets:
(a) CFCs (b) HCFCs (c) HFCs (d) N₂O
3. NAPCC has how many national missions?
(a) 5 (b) 7 (c) 8 (d) 10
4. India's Net-Zero target year:

- (a) 2030 (b) 2050 (c) 2070 (d) 2100
5. "Good ozone" is found in:
(a) Troposphere (b) Stratosphere (c) Mesosphere (d) Exosphere
6. Acid rain is mainly caused by:
(a) CO₂ & CH₄ (b) SO₂ & NO_x (c) CO & Pb (d) O₃ & PAN
7. Largest carbon reservoir is:
(a) Atmosphere (b) Ocean (c) Biosphere (d) Lithosphere
8. Article 6 of the Paris Agreement deals with:
(a) Climate finance (b) Carbon markets (c) Adaptation (d) Loss & damage
- Ans:** 1-b, 2-c, 3-c, 4-c, 5-b, 6-b, 7-d, 8-b.

B. Very Short (2 marks)

Practice Set

1. Name the four major carbon reservoirs.
2. State two consequences of ocean acidification.
3. Differentiate mitigation and adaptation in one sentence each.
4. What is GWP and how does it rank N₂O vs CH₄?
5. Define carbon sink with an Indian example.

C. Short (5 marks)

Practice Set

1. Discuss the impact of climate change on the agriculture of Tripura.
2. Explain ozone depletion: causes, effects, and the Montreal Protocol.
3. Evaluate the success of NAPCC and its eight missions.
4. "COP29 was a finance COP that failed to deliver." Critically examine.

5.12 Quick Revision Capsule — Chapter 5

Quick Revision Capsule

Warming: 1.1–1.2°C above pre-industrial (IPCC AR6).

CO₂: 422 ppm in 2024 vs 280 pre-industrial.

GWP order: SF₆ > CFCs > N₂O > CH₄ > CO₂.

Carbon reservoirs: Lithosphere (largest) > Ocean > Soil/biosphere > Atmosphere.

Good O₃: Stratosphere (UV shield); **Bad O₃:** Troposphere (smog).

Montreal Protocol 1987, Kigali Amendment 2016.

Acid rain pH < 5.6; SO₂+NO_x → H₂SO₄, HNO₃.

India NDC: 45% intensity cut, 50% non-fossil, 2.5–3 Gt CO₂-eq sink; Net-Zero 2070.

NAPCC missions (8): Solar, Energy Eff., Habitat, Water, Himalayan, Green India, Agriculture, Knowledge.

COP28 Dubai: "transition away from fossil fuels"; Loss & Damage Fund.

COP29 Baku: NCQG \$300 bn/yr by 2035.

6

Environmental Management & Legislation

Syllabus Pointer (TPSC)

Section-E (F): EIA; Environmental Protection Acts in India — Air, Water, Bio-Diversity, Wildlife, Forest; Lake & River Action Programmes; role of Pollution Control Boards.

PYQ trace: SEIAA/SEAC full forms (2021); recurring objective questions on Acts, river programmes, NGT.

6.1 Constitutional Mandate

India's environmental jurisprudence is anchored in the Constitution.

Constitutional Provisions for Environment

Art. 48A	Directive Principle: "The State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country." (Added by 42nd Amendment, 1976)
Art. 51A(g)	Fundamental Duty: "to protect and improve the natural environment...and to have compassion for living creatures."
Art. 21	Right to Life — interpreted by SC to include the <i>right to a clean and healthy environment</i> (Subhash Kumar v. State of Bihar, 1991; Vellore Citizens' Welfare Forum, 1996).
Concurrent List	Forests (Entry 17A) and Wildlife (Entry 17B) moved from State to Concurrent list by 42nd Amendment.

6.2 Major Environmental Acts

6.2.1 Water (Prevention & Control of Pollution) Act, 1974

- First comprehensive environmental statute; set up **CPCB** (Centre) and **SPCBs** (States).
- Prohibits discharge of pollutants beyond standards into water bodies without "consent".
- **Water Cess Act, 1977** levied cess on local bodies/industries; subsumed under GST in 2017.

6.2.2 Air (Prevention & Control of Pollution) Act, 1981

- Enacted following the 1972 Stockholm Conference commitments.
- Empowers CPCB/SPCBs to set National Ambient Air Quality Standards (NAAQS).
- Designates "air pollution control areas"; "consent to operate" mandatory for industries.

6.2.3 Environment (Protection) Act, 1986 — the umbrella legislation

- Enacted after the 1984 Bhopal Gas Tragedy and following the 1985 Rio commitments.

- Empowers the Central Government to lay down standards, regulate hazardous substances, restrict industries in ecologically sensitive areas.
- All subordinate rules — EIA Notification (1994, revised 2006), Hazardous Waste Rules, Plastic Waste Rules, E-Waste Rules, Biomedical Waste Rules, Noise Pollution Rules — are framed under it.

6.2.4 Wildlife (Protection) Act, 1972

- Provides for protection of wild animals, birds and plants; framework for National Parks, Wildlife Sanctuaries, Conservation & Community Reserves, Tiger Reserves.
- Schedules categorise species by level of protection (Sch. I-IV after 2022 amendment).
- Set up **National Board for Wild Life (NBWL)** chaired by PM and **State Boards for Wild Life (SBWLs)**.
- **WLPA Amendment 2022** streamlined schedules, increased penalties, and added new species (e.g. Indian Pangolin).

6.2.5 Forest Conservation Act, 1980

- Restricts use of forest land for non-forest purposes without prior approval of the Centre.
- **Compensatory Afforestation Fund Act (CAMPA), 2016** operationalises afforestation funds.
- **Van (Sanrakshan Evam Samvardhan) Adhiniyam, 2023** renamed the FCA; introduced exemptions for security/strategic/linear projects.

6.2.6 Biological Diversity Act, 2002

- Implements the CBD (1992); three-tier institutional structure (NBA, SBB, BMC).
- Regulates access to biological resources, equitable benefit-sharing, intellectual property.
- **BD Amendment Act, 2023** eased compliance for AYUSH practitioners; decriminalised many offences.

6.2.7 Scheduled Tribes & Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 — FRA

Grants individual and community forest rights to tribals and OTFDs; particularly relevant to Tripura's tribal communities (Reang/Bru, Tripuri, Jamatia, Halam, Lushai, Kuki). Gram Sabha is the deciding authority.

6.2.8 National Green Tribunal Act, 2010 — NGT

Specialised tribunal for environmental disputes; principal bench in New Delhi, zonal benches in Pune, Bhopal, Kolkata, Chennai. Power: damages, restoration orders, closure of polluting units. Disposes cases within 6 months.

6.3 Pollution Control Boards

Institutional Architecture of Pollution Control

Central Pollution Control Board (CPCB)	Constituted 1974; under MoEFCC; sets standards, coordinates SPCBs, runs National Air Quality Monitoring Programme.
State Pollution Control Boards (SPCBs)	In each state & UT; consent management, monitoring, enforcement.
Tripura SPCB	Headquartered Agartala; monitors air quality at 4 stations (Agartala, Udaipur, Dharmanagar, Ambassa).
State Environment Impact Assessment Authority (SEIAA)	Category-B project clearance under EIA 2006.
State Expert Appraisal Committee (SEAC)	Provides technical recommendations to SEIAA.
Pollution Control Committees (PCCs)	In UTs.

6.4 Environmental Impact Assessment (EIA)

EIA is the formal process for predicting and evaluating the likely environmental consequences of a proposed project, plan or programme *before* a decision is taken. India's EIA Notification of 1994 (revised 2006) is the primary instrument under the EP Act 1986.

6.4.1 EIA Process Flow

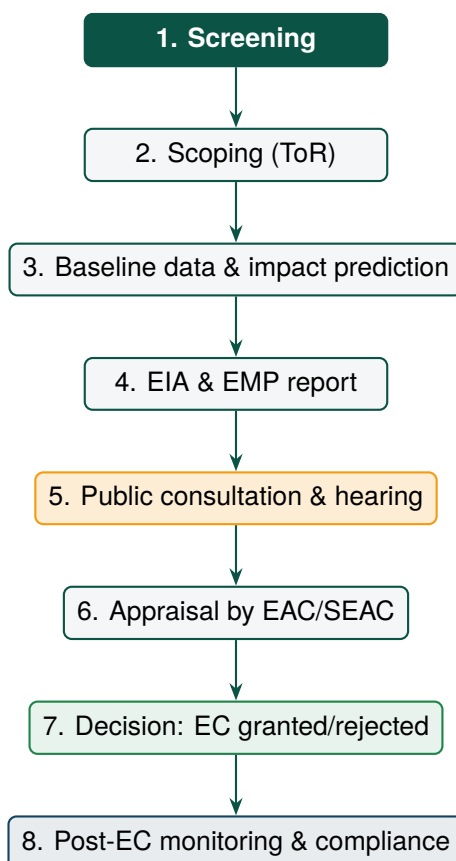


Figure 6.1: The eight-stage EIA process under the 2006 Notification.

6.4.2 Project Categorisation

- **Category A** — large projects requiring clearance from the **Centre (MoEFCC)** via the EAC.
- **Category B** — medium projects requiring clearance from the **State (SEIAA/SEAC)**, sub-divided into B1 (requires EIA) and B2 (no EIA needed).

6.4.3 Critiques of EIA

- Limited public consultation for Cat-B2 projects.
- EIA Draft Notification 2020 — proposed weakening of public consultation, ex-post-facto clearance — faced wide criticism.
- Quality of EIA consultants and reports is uneven.

6.5 Lake & River Action Programmes

6.5.1 National River Conservation Plan (NRCP)

Launched 1995; covers 34 rivers in 16 states. Funds STPs, riverfront development, low-cost sanitation, public awareness.

6.5.2 Ganga Action Plan (GAP) & Namami Gange

GAP Phase I (1986) and **Phase II** (1993) sought to clean the Ganga; results were patchy. **Namami Gange Mission** (2014) is a Rs. 20,000 crore integrated effort under **National Mission for Clean Ganga (NMCG)**, with five pillars: (i) Sewerage Treatment Infrastructure, (ii) River-Front Development, (iii) River Surface Cleaning, (iv) Bio-Diversity, (v) Afforestation.

6.5.3 Yamuna Action Plan, Brahmaputra Action Plan

similar models in respective basins.

6.5.4 National Lake Conservation Plan (NLCP)

Launched 2001; merged with NRCP in 2013. Covers 65+ lakes (Dal, Sukhna, Powai, Vembanad, etc.).

6.5.5 Wetlands (Conservation & Management) Rules, 2017

Implements the Ramsar Convention (1971); 80+ Ramsar sites in India as of 2024. **Rudrasagar (Twijilikma)** in Tripura is a Ramsar site since 2005.

6.6 Major International Environmental Agreements

International Agreements — One-Liners

Agreement	Year	Subject
Ramsar	1971	Wetlands of international importance
Stockholm Conference	1972	First major UN environment conference
CITES	1973	Trade in endangered species
Bonn (CMS)	1979	Migratory species
Vienna Convention	1985	Ozone layer protection
Montreal Protocol	1987	Phase-out of ODS
Basel Convention	1989	Trans-boundary hazardous waste
Earth Summit, Rio	1992	UNCED, Agenda 21
UNFCCC	1992	Climate change framework
CBD	1992	Biodiversity
UNCCD	1994	Desertification
Kyoto Protocol	1997	First binding emission cuts
Cartagena Protocol	2000	Biosafety / LMOs
WSSD, Johannesburg	2002	World Summit on Sustainable Development
Stockholm Convention	2001	Persistent Organic Pollutants
Nagoya Protocol	2010	Access & Benefit-Sharing (ABS)
Minamata Convention	2013	Mercury
Paris Agreement	2015	NDC-based climate framework
Sendai Framework	2015	DRR (2015–2030)
Kigali Amendment	2016	HFCs
Kunming–Montreal GBF	2022	30×30 target for biodiversity

Tripura's Legal & Institutional Stack

SPCB: Tripura State Pollution Control Board (Agartala) since 1989.

SBB: Tripura State Biodiversity Board notified under BD Act 2002.

SEIAA/SEAC: Functional, processing Cat-B projects (cement, mining, irrigation).

Ramsar Site: Rudrasagar (Twijilikma) — 240 ha, since 2005.

Forest Rights Act: Substantial CFR titles to Reang, Tripuri, Jamatia, Halam communities.

Sanctuaries: Sepahijala WLS, Trishna WLS, Gomati WLS, Rowa WLS.

6.7 Solved Previous Year Questions

TCS/TPS 2021 — Q.102(ii) — Very Short (2 marks)

Write the full form of SEIAA and SEAC as per Environment (Protection) Rules, 1986.

Model Answer

SEIAA = *State Environment Impact Assessment Authority* — the State-level authority that grants environmental clearance to Category-B projects under the EIA Notification, 2006.

SEAC = *State Expert Appraisal Committee* — provides technical scrutiny and recommendations to SEIAA on Cat-B project applications.

TCS/TPS 2021 — Q.101(v) — Objective

Which of the following pairs is correctly matched? (A) **Cartagena Protocol — Biosafety to CBD** (B) Ramsar — Chemicals (C) Vienna — Wetlands (D) Bonn — Ozone.

Ans: (A).

Predicted 5-mark

Describe the EIA process in India. Critically evaluate the EIA Notification, 2006.

Model Answer

Introduction: EIA is a regulatory tool, formalised in India by the EIA Notification 1994 (revised 2006) under the Environment (Protection) Act 1986, designed to assess likely environmental consequences of development projects *before* approval.

Process (8 stages): Screening → Scoping (ToR) → Baseline studies → EIA & Environmental Management Plan (EMP) report → Public consultation → Appraisal by EAC/SEAC → Decision (EC) → Post-EC compliance.

Category A (large) goes to MoEFCC–EAC; **Category B** (medium) goes to SEIAA–SEAC, split into B1 (with EIA) and B2 (without).

Critique:

1. Public consultation often perfunctory; tight timelines.
2. EIA reports outsourced to consultants paid by project proponents — conflict of interest.
3. Cumulative impact assessment of multiple projects in same region inadequate.
4. Post-EC monitoring weak; many violations escape penalty.
5. Draft 2020 amendment proposed ex-post-facto clearance & narrow public consultation — widely opposed.

Reforms: An independent EIA Authority, registered & accredited consultants, mandatory cumulative assessment, strict post-EC audit, digital monitoring (PARIVESH portal).

Conclusion: A well-implemented EIA balances development with conservation — central to India's NDC and SDG commitments.

6.8 Examiner's Corner**Examiner's Corner**

- Always cite the **Article 21 jurisprudence** when discussing environmental rights.
- For EIA questions, draw the eight-step flow-chart — instant marks.
- Distinguish **NGT (judicial)** from **CPCB (regulatory)** from **MoEFCC (policy)**.
- For river-cleaning questions, name **NMCG** as nodal body, not just MoEFCC.

6.9 Practice Set — Chapter 6**A. Objective MCQs****Practice Set**

1. The first environmental Act of India:
(a) Air Act (b) Water Act (c) EP Act (d) FC Act
2. NGT was established in:
(a) 1986 (b) 1995 (c) 2010 (d) 2016
3. CAMPA full form:

- (a) Central Afforestation Management Project (b) Compensatory Afforestation Fund Management & Planning Authority (c) Central Action for Mountainous & Polar Areas (d) None
4. Tripura's Ramsar site:
(a) Dumboor (b) Twijilikma/Rudrasagar (c) Gomati (d) Sepahijala
5. "Polluter Pays Principle" was enshrined by SC in:
(a) MC Mehta v. UoI (b) Vellore Citizens v. UoI (c) Indian Council for Enviro-Legal Action v. UoI (d) All
6. The latest amendment to the WLPA was in:
(a) 2002 (b) 2006 (c) 2017 (d) 2022

Ans: 1-b, 2-c, 3-b, 4-b, 5-d, 6-d.

B. Very Short (2 marks)

Practice Set

1. Differentiate EAC and SEAC.
2. Name any four major international conventions related to environment.
3. State the three-tier structure under the BD Act 2002.
4. What is the National Mission for Clean Ganga (NMCG)?

C. Short (5 marks)

Practice Set

1. Discuss the constitutional framework for environmental protection in India.
2. Explain the role and powers of NGT with case examples.
3. Critically examine the Forest (Conservation) Amendment Act, 2023.
4. Evaluate the success of Namami Gange Mission.

6.10 Quick Revision Capsule — Chapter 6

Quick Revision Capsule

Constitution: Art. 48A (DPSP), 51A(g) (FD), 21 (FR — clean env).

Acts: Water 1974, Air 1981, EP 1986, WLPA 1972 (amend 2022), FCA 1980 (amend 2023), BDA 2002 (amend 2023), FRA 2006, NGT 2010.

Bodies: MoEFCC (policy), CPCB/SPCB (pollution), NBA/SBB/BMC (biodiversity), NBWL/SBWL (wildlife), NMCG (rivers), NGT (tribunal).

EIA: 1994/2006 Notification; 8 stages; Cat A (EAC) & Cat B (SEAC).

River programmes: NRCP, Namami Gange, YAP, BAP, NLCP.

Ramsar sites in India: 80+; Tripura has Rudrasagar (since 2005).

International: Ramsar 1971, Stockholm 1972, CITES 1973, Vienna 1985, Montreal 1987, Basel 1989, Rio 1992, Kyoto 1997, Cartagena 2000, Stockholm 2001, Nagoya 2010, Minamata 2013, Paris 2015, Sendai 2015, Kigali 2016, GBF 2022.

Environmental Organisations & Conventions

Syllabus Pointer (TPSC)

Section-E (G): International — UNEP, IUCN, IPCC, Earth Summit, CBD, WWF. National — MAB Programme, MoEFCC, MoES, NGOs.

PYQ trace: UNEP HQ (2019), MAB initiation (2019), IUCN Red List terms (recurring), CBD/Cartagena (2021).

7.1 International Organisations

7.1.1 United Nations Environment Programme (UNEP)

- Established 1972 at the Stockholm Conference; HQ **Nairobi, Kenya** (the first UN HQ in the Global South).
- Mandate: set the global environmental agenda; lead the implementation of the environmental dimension of sustainable development.
- Flagship reports: *Global Environment Outlook (GEO)*, *Emissions Gap Report*, *Adaptation Gap Report*, *Frontiers, Inclusive Wealth Report*.
- **Champions of the Earth** award (PM Modi in 2018 for Solar Alliance leadership).

7.1.2 International Union for Conservation of Nature (IUCN)

- Founded 1948 in France; HQ **Gland, Switzerland**; first global environmental union.
- Members: governments + NGOs (over 1,400).
- Maintains the *IUCN Red List of Threatened Species* — the world's most comprehensive inventory of conservation status.
- Six Commissions, including the Species Survival Commission (SSC) and the World Commission on Protected Areas (WCPA).

7.1.3 Intergovernmental Panel on Climate Change (IPCC)

- Established 1988 by WMO and UNEP; HQ **Geneva**.
- Provides comprehensive scientific Assessment Reports (ARs) every 6–7 years; AR6 cycle completed 2023.
- Three working groups: WG-I (physical science), WG-II (impacts & adaptation), WG-III (mitigation).
- Nobel Peace Prize 2007 (jointly with Al Gore).
- AR6 SYR (2023): Human-induced warming reached 1.1°C; 1.5°C likely to be exceeded this cen-

tury without rapid action.

7.1.4 The Earth Summit Series

The "Summit" Family		
Summit	Year	Key outcomes
Stockholm	1972	UNEP; Stockholm Declaration
Rio Earth Summit (UNCED)	1992	Agenda 21; UNFCCC; CBD; Rio Declaration
Rio+5, New York	1997	Mid-term review
WSSD, Johannesburg	2002	Johannesburg Plan of Implementation
Rio+20, Rio	2012	"The Future We Want"; SDG process
UN Sustainable Dev. Summit	2015	17 SDGs (2030 Agenda)
Stockholm+50	2022	Renewed commitment

7.1.5 Convention on Biological Diversity (CBD)

- Opened for signature at Rio 1992; entered into force 1993; secretariat in Montreal.
- Three objectives: *conservation, sustainable use, access & fair benefit-sharing* (ABS).
- Protocols: **Cartagena Protocol (2000)** — biosafety/LMOs; **Nagoya Protocol (2010)** — ABS.
- **Aichi Targets (2010–2020)** largely missed; replaced by **Kunming–Montreal Global Biodiversity Framework (Dec 2022, COP-15)**.
- Headline: 30×30 — protect 30% of land & sea by 2030.

7.1.6 World Wide Fund for Nature (WWF)

- Founded 1961 (originally World Wildlife Fund); HQ **Gland, Switzerland**.
- Logo: giant panda — iconic since 1961.
- Publishes the biennial *Living Planet Report* (2024 edition shows 73% average decline in monitored wildlife populations since 1970).
- Initiatives: WWF-India, Earth Hour (since 2007), TRAFFIC (with IUCN).

7.1.7 Other Significant Bodies

- **UNDP** — sustainable development programmes; Human Development Report.
- **WMO** — meteorology, weather, climate science.
- **FAO** — food, agriculture; sustainable land use.
- **UNESCO** — Man & Biosphere (MAB) Programme; World Heritage Sites.
- **UNDRR** — UN Office for Disaster Risk Reduction (Sendai Framework custodian).
- **IRENA** — International Renewable Energy Agency; HQ Abu Dhabi.
- **Green Climate Fund (GCF)** — funding mechanism for climate action under UNFCCC.
- **Global Environment Facility (GEF)** — multi-donor fund for environment projects.
- **International Solar Alliance (ISA)** — HQ Gurugram, India–France joint initiative 2015.
- **Coalition for Disaster Resilient Infrastructure (CDRI)** — India-led, launched 2019.

7.2 National Environmental Organisations

7.2.1 Ministry of Environment, Forest & Climate Change (MoEFCC)

- Nodal Central Government ministry; established 1985 (then MoEF; rebranded MoEFCC in 2014).
- Implements EP Act, Air Act, Water Act, WLPA, FCA, BDA, ozone-layer protection.
- Houses: National CAMPA Authority, NMCG, Animal Welfare Board, NTCA, NBA-coordination.

7.2.2 Ministry of Earth Sciences (MoES)

- Established 2006; consolidates IMD, IITM (Pune), INCOIS (Hyderabad), NCAOR (Goa), NCM-RWF, ICMAM.
- Functions: weather, climate, seismology, oceanography, polar research, tsunami warning.

7.2.3 Key National Institutions

Indian Environmental Institutions	
Body	Role
ZSI (1916)	Zoological Survey of India — animal taxonomy & Red List inputs
BSI (1890)	Botanical Survey of India — plant taxonomy
FSI (1981)	Forest Survey of India — ISFR biennial
WII (1982)	Wildlife Institute of India — research, training
ICFRE	Indian Council of Forestry Research & Education
SACON	Salim Ali Centre for Ornithology & Natural History
NCSCM	National Centre for Sustainable Coastal Management
NTCA	National Tiger Conservation Authority
WTI	Wildlife Trust of India (NGO)

7.2.4 Major Indian NGOs

- **BNHS** (Bombay Natural History Society, 1883) — Asia's oldest natural history society; ornithology research.
- **WWF-India** (1969) — conservation projects, environmental education.
- **Centre for Science & Environment (CSE)** — policy research, *Down To Earth* magazine.
- **TERI** (The Energy and Resources Institute) — climate & energy policy.
- **ATREE, FERAL, Dakshin, WTI, WPSI, SankalpTaru** — conservation NGOs.
- **Chipko Movement** (1973), **Narmada Bachao Andolan** (1985), **Silent Valley Movement** (1970s), **Appiko** (1983) — landmark people's movements.

7.2.5 Sustainable Development Goals (SDGs) — environmental cluster

- SDG 6 — Clean Water & Sanitation
- SDG 7 — Affordable & Clean Energy
- SDG 11 — Sustainable Cities & Communities
- SDG 12 — Responsible Consumption & Production
- SDG 13 — Climate Action
- SDG 14 — Life Below Water
- SDG 15 — Life on Land

7.3 Solved Previous Year Questions

TCS/TPS 2019 — Q.102(v) — Very Short (2 marks)**Where is the headquarters of the United Nations Environment Programme?****Model Answer**

The **UNEP headquarters is in Nairobi, Kenya**, established 1972 in the wake of the Stockholm Conference. It was the first major UN body headquartered in the Global South. Eight regional offices coordinate global delivery.

TCS/TPS 2019 — Q.102(i) — Very Short (2 marks)**Who initiated the 'Man and Biosphere' Programme?****Model Answer**

The **Man and the Biosphere (MAB) Programme** was launched by UNESCO at its 16th General Conference in 1971. It established the World Network of Biosphere Reserves combining biodiversity conservation with sustainable human use, organised into core, buffer and transition zones.

Predicted 5-mark**Discuss the role of IPCC in shaping global climate policy.****Model Answer**

Introduction: The IPCC, set up in 1988 by WMO & UNEP and headquartered in Geneva, is the UN body for assessing the science of climate change. Awarded the Nobel Peace Prize in 2007, it has authored six assessment cycles, the latest being AR6 (2021–23).

Role in policy-making:

1. **Science-policy interface** — supplies governments with peer-reviewed, consensus-driven assessments.
2. **Three working groups** — WG-I (physical), WG-II (impacts/adaptation), WG-III (mitigation) — provide a 360-degree view.
3. **Anchored UNFCCC negotiations** — IPCC SR-15 (2018) led to the 1.5°C ambition adopted at Glasgow; AR6 underpinned the Global Stocktake at COP28.
4. **Standardised methodologies** — IPCC inventory guidelines for national GHG accounting.
5. **Capacity-building** — TGICA, expert nominations, support for developing-country researchers.

Critique: consensus process is slow; pace lags emission realities; representation of developing-country authors needs deepening.

Conclusion: The IPCC remains the gold standard of climate science; India must continue to engage proactively, contribute authors and benefit from its assessments to inform its own NDCs.

7.4 Examiner's Corner

Examiner's Corner

- Memorise HQ locations: **UNEP Nairobi, IUCN & WWF Gland, IPCC Geneva, CBD Montreal, ISA Gurugram, IRENA Abu Dhabi, GCF Songdo, UNDRR Geneva.**
- Distinguish **IUCN (1948, members)** from **IPCC (1988, scientific assessment)** — frequent confusion.
- For "Earth Summit" questions, list **Rio 1992 + 3 outcomes (Agenda 21, UNFCCC, CBD).**
- For Indian NGOs, name **BNHS, CSE, TERI, WWF-India.**

7.5 Practice Set — Chapter 7

A. Objective MCQs

Practice Set

1. UNEP HQ: (a) Geneva (b) Nairobi (c) New York (d) Vienna
2. IPCC was established in: (a) 1972 (b) 1988 (c) 1992 (d) 1997
3. CBD secretariat is in: (a) New York (b) Bonn (c) Montreal (d) Geneva
4. ISA HQ: (a) New Delhi (b) Gurugram (c) Hyderabad (d) Paris
5. BNHS was founded in: (a) 1869 (b) 1883 (c) 1908 (d) 1947
6. Earth Hour is initiated by: (a) UNEP (b) WWF (c) UNESCO (d) CITES

Ans: 1-b, 2-b, 3-c, 4-b, 5-b, 6-b.

B. Very Short (2 marks)

Practice Set

1. Differentiate UNEP and IPCC.
2. State two functions of MoEFCC.
3. Name any four Indian environmental research institutions.
4. What are the three objectives of CBD?

C. Short (5 marks)

Practice Set

1. Trace the evolution of global environmental governance from Stockholm 1972 to COP29.
2. Discuss India's leadership in global climate diplomacy (ISA, CDRI, LiFE).
3. Evaluate the role of NGOs and people's movements in shaping India's environmental policy.

7.6 Quick Revision Capsule — Chapter 7

Quick Revision Capsule

UNEP 1972 — Nairobi. **IUCN** 1948 — Gland. **IPCC** 1988 — Geneva.

WWF 1961 — Gland. **CBD** 1992 — Montreal. **ISA** 2015 — Gurugram.

Summits: Stockholm 1972, Rio 1992, WSSD 2002, Rio+20 2012, SDG 2015.

Indian: MoEFCC, MoES, ZSI, BSI, FSI, WII, NTCA, NMCG.

NGOs: BNHS, WWF-India, CSE, TERI, WTI; movements — Chipko, NBA, Silent Valley.

India's flag initiatives: ISA, CDRI, LiFE, IBCA (Big Cats), Global Biofuel Alliance.

SECTION-F

Security & Disaster Management

8

Types of Hazards & Disasters

Syllabus Pointer (TPSC)

Section-F (A): Natural Disasters — volcanic eruption, earthquake, tsunami, cyclone, flood, drought, wild-fire, landslide. Man-made Disasters — industrial, nuclear, biological, engineering hazards, terrorism.

PYQ history: Hazard vs disaster (2019), Bhopal (2019, 2021), earthquake mechanism (2019), cyclone wind-speed (2021), magnitude vs intensity (2021), nuclear disaster (2019).

8.1 Foundational Definitions — UNDRR & NDMA

Core Vocabulary

Hazard	A potentially damaging physical event, phenomenon or human activity that may cause loss of life, injury, property damage, social/economic disruption or environmental degradation.
Disaster	A serious disruption of the functioning of a community involving widespread human, material, economic or environmental losses that exceed the ability of the affected community to cope using its own resources.
Vulnerability	The conditions determined by physical, social, economic and environmental factors which increase the susceptibility of a community to the impact of hazards.
Capacity	The combination of strengths, attributes and resources available within a community to manage and reduce disaster risk.
Risk	The probability of harmful consequences. Disaster Risk = Hazard × Vulnerability / Capacity.
Resilience	The ability of a system or community to resist, absorb, accommodate and recover from a hazard.

8.1.1 The Risk Equation

$$\text{Disaster Risk} = \frac{\text{Hazard} \times \text{Exposure} \times \text{Vulnerability}}{\text{Capacity}}$$

All four parameters are manageable. *Hazard* (physical event) can be partly reduced (anti-erosion bunds), *exposure* reduced by land-use planning, *vulnerability* reduced by building codes & social safety nets, and *capacity* built through training, early warning, drills.

8.2 Classification of Disasters

The High Powered Committee (HPC) on Disaster Management (2001, JC Pant) classified Indian disasters into **five major sub-groups**: water & climate, geological, biological, chemical/industrial/nuclear, and accident-related.

High Powered Committee Classification — 31 Disasters

Water & Climate	Floods, droughts, cyclones, tornadoes, hailstorms, cloudbursts, heat & cold waves, snow avalanches, sea erosion, thunderstorms, lightning.
Geological	Earthquakes, tsunamis, landslides, mudflows, volcanic eruptions.
Biological	Epidemics, pest attacks, cattle epidemics, food poisoning.
Chemical/Industrial/Nuclear	Industrial gas leaks, oil spills, mine fires, chemical & nuclear disasters.
Accidents	Road, rail, air, water; building collapse; bomb blast; serial; festival stampedes.

8.3 Natural Disasters — Detailed

8.3.1 Earthquakes

Sudden release of accumulated stress along a fault produces seismic waves that shake the ground. India lies in the seismically active Alpine-Himalayan belt.

Mechanism

Plate tectonics: the Indian plate is moving north at ~5 cm/yr, colliding with the Eurasian plate. Convergent boundary stresses accumulate on faults until brittle failure releases them as earthquakes.

Key Terms

- **Focus / Hypocentre** — point within the Earth where rupture begins.
- **Epicentre** — point on the surface directly above the focus.
- **Magnitude** — *quantitative* measure of energy released; Richter scale (M_L), Moment Magnitude (M_w).
- **Intensity** — *qualitative* measure of effects at a location; Modified Mercalli scale (I–XII).
- **Seismic waves** — Primary (P, longitudinal, fastest), Secondary (S, transverse), Surface (L, R) waves.

Magnitude vs Intensity

Aspect	Magnitude	Intensity
What it measures	Energy released at source	Effects at a location
Type	Quantitative, single value	Qualitative, varies with distance & site
Scale	Richter (M_L), Moment (M_w)	Modified Mercalli (I–XII)
Determined by	Seismograph	Field survey, damage observation

Seismic Zonation of India

Bureau of Indian Standards (IS 1893) divides India into **four zones** (II–V) by expected MMI.

- **Zone V** (highest risk) — entire NE India (**Tripura, Assam, Manipur, Nagaland, Meghalaya, Mizoram, Arunachal**), J&K, Uttarakhand, N. Bihar, Kutch.
- **Zone IV** — Delhi, Mumbai (parts), J&K (parts), Himachal foothills.

- **Zone III, II** — central & peninsular India.

Major Indian Earthquakes

- **Assam** 1897 (M 8.7), 1950 (M 8.6 — strongest in India).
- **Kangra** 1905 (M 7.8); **Bihar-Nepal** 1934 (M 8.4).
- **Latur (Killari)** 1993 — Stable Continental Region surprise (M 6.4).
- **Bhuj** 26 Jan 2001 (M 7.7); 20,000+ dead.
- **Indian Ocean** 2004 (M 9.1) tsunami; 2.3 lakh deaths regionally.
- **Sikkim** 2011 (M 6.9); **Nepal-Gorkha** 2015 (M 7.8).
- **Doyang (Nagaland)** 2023 (M 5.9) — felt across NE.

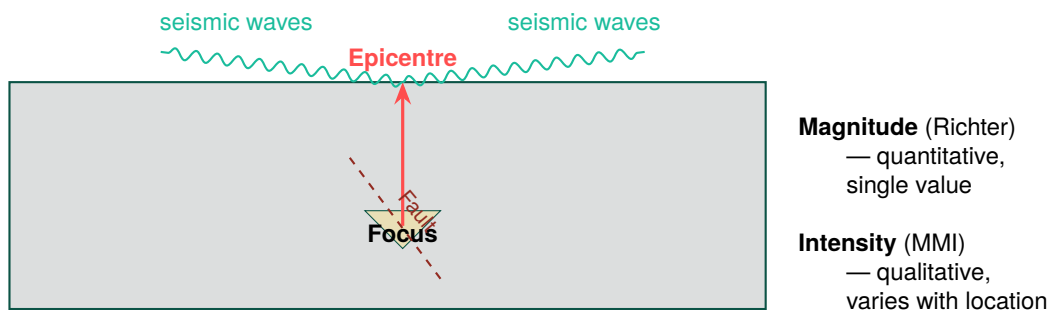


Figure 8.1: Earthquake mechanism — focus, epicentre, fault, seismic waves.

8.3.2 Tsunamis

A **tsunami** is a series of giant ocean waves triggered by sudden vertical displacement of seawater — usually by undersea earthquakes ($>M\ 7$), submarine landslides, volcanic eruptions, or rarely meteorite impacts. Speed in deep ocean: 700+ km/h; height: under 1 m in open sea, but >10 m near shore.

Indian Ocean Tsunami, 26 Dec 2004 — triggered by M 9.1 Sumatra–Andaman earthquake; 14 countries affected; over 230,000 deaths (10,749 in India: TN, Kerala, A&N, Pondicherry, AP).

Indian Tsunami Early Warning System (ITEWS) — operational since 2007 at INCOIS, Hyderabad; tsunami bulletins issued within 10 minutes of a major undersea earthquake.

8.3.3 Cyclones

A **cyclone** is a closed atmospheric circulation moving counter-clockwise (NH) around a low-pressure centre. India faces tropical cyclones in the Bay of Bengal (more frequent) and Arabian Sea (less frequent but intensifying).

IMD Classification of Cyclonic Disturbances

IMD Tropical Cyclone Categories (3-min sustained wind speed)

Category	Wind speed
Low Pressure Area	up to 31 km/h
Depression	31–49 km/h
Deep Depression	50–61 km/h
Cyclonic Storm	62–88 km/h
Severe Cyclonic Storm (SCS)	89–117 km/h
Very Severe Cyclonic Storm (VSCS)	118–165 km/h
Extremely Severe Cyclonic Storm (ESCS)	166–220 km/h
Super Cyclonic Storm	> 221 km/h

Naming Convention

Cyclones in the North Indian Ocean are named by the 13 member-countries of WMO/ESCAP Panel: each contributes a list of 13 names. Recent names: *Amphan*, *Nisarga*, *Yaas*, *Tauktae*, *Asani*, *Mocha*, *Biparjoy*, *Hamoon*, *Midhili*, *Remal* (2024).

Major Recent Cyclones

- **Amphan** (May 2020) — Super Cyclone; West Bengal, Odisha; \$13 billion damage.
- **Tauktae** (May 2021) — VSCS; Gujarat.
- **Yaas** (May 2021) — VSCS; Odisha–West Bengal.
- **Mocha** (May 2023) — ESCS; Myanmar coast, NE India winds.
- **Biparjoy** (June 2023) — VSCS; Gujarat.
- **Remal** (May 2024) — SCS; West Bengal, Bangladesh, NE India backflow.

8.3.4 Floods

A **flood** is the temporary inundation of normally dry land by overflow from rivers, intense rainfall, dam-failure, storm-surge, or melt. India's flood-prone area is ~40 million ha (12% of land); annual flood damage ~Rs. 1,800 crore.

Types: riverine, flash, urban, coastal, glacial-lake outburst (GLOF), dam-burst.

Causes: heavy rain (Western Disturbance, monsoon, cyclone), siltation, deforestation, encroachment of floodplains, bad land-use planning, inadequate drainage, climate change.

Recent floods: Kerala 2018; Bihar/Assam regular; Chennai 2015; Mumbai 2005; Uttarakhand 2013 (Kedarnath); Hyderabad 2020; **Tripura 2024** (Aug–Sep, 32 deaths, 1.47 lakh displaced).

8.3.5 Droughts

Drought is a prolonged shortage of water below normal — meteorological (rainfall), hydrological (water bodies), agricultural (soil moisture), socio-economic (livelihood). India Drought Management Manual (2009, revised) classifies droughts by SPI, NDVI, etc.

Drought-prone: Rajasthan, Gujarat (Kutch, Saurashtra), Maharashtra (Marathwada, Vidarbha), Karnataka, Andhra Pradesh, Telangana, Bundelkhand region. **Tripura**, with 2,100–2,400 mm rainfall, is largely *not* drought-prone but faces seasonal water shortage in February–April.

Mitigation: watershed development, drought-tolerant crops, drip irrigation, MGNREGA water-conservation works, crop insurance (PMFBY), water budgeting.

8.3.6 Landslides

Sudden mass downslope movement of rock, soil, debris. Triggers: heavy rainfall, earthquake, slope-cutting, deforestation. India's landslide vulnerability map: Himalayas, NE hills (incl. Tripura), Western Ghats, Nilgiris.

Tripura context: hilly terrain in West, Dhalai, North, South districts; 2024 floods triggered numerous landslides in Khowai & Gomati.

Mitigation: slope stabilisation (gabion walls, geotextiles), early warning, hazard mapping (NDMA's National Landslide Risk Management Strategy 2019), forest conservation.

8.3.7 Wildfires

Uncontrolled spread of fire in forests/grasslands. Causes: lightning, agricultural burning, jhum, accidental, arson. Frequency rising with climate change.

India's worst affected: Uttarakhand, HP, MP, AP, Odisha, NE. **Tripura** fire incidence in dry months (Feb–Apr); jhum cycle drives some forest fires in Dhalai & North.

8.3.8 Volcanic Eruptions

India's only active volcano: **Barren Island** (Andamans, last erupted 2017, 2022). **Narcondam** is dormant. Eruptions can cause pyroclastic flows, ashfall, lahars, climate cooling.

8.3.9 Other Natural Hazards

Cloudburst (>100 mm/hr) — Leh 2010, Uttarakhand 2013, Amarnath 2022. **Avalanches** — Siachen 2016, Uttarakhand 2023 (Joshimath). **Hailstorms, lightning, heatwaves.**

8.4 Man-Made (Anthropogenic) Disasters

8.4.1 Industrial Disasters

- **Bhopal Gas Tragedy (2–3 Dec 1984)** — methyl isocyanate (MIC) leak from Union Carbide India Limited, Bhopal; 3,787 official deaths (estimates up to 20,000); 500,000 affected. Legacy: **Public Liability Insurance Act 1991, Environment Protection Act 1986, Chemical Accidents Rules 1996, NDMA Guidelines for Chemical Disasters.**
- **Visakhapatnam LG Polymers (May 2020)** — styrene leak; 12 deaths.
- **Mumbai port blast (2020)** — fire-cargo explosion.

8.4.2 Nuclear Disasters

Three Mile Island (USA, 1979), **Chernobyl** (USSR, 1986) — INES Level 7; **Fukushima Daiichi** (Japan, 2011) — INES Level 7; **Tokaimura** (Japan, 1999). India's regulatory framework: **Atomic Energy Regulatory Board (AERB), 1983, IAEA safeguards, NDMA Nuclear Disaster Guidelines 2009.**

Definition for TPSC: A nuclear disaster is an event involving the release of significant amounts of radioactive material into the environment from a nuclear facility, weapon, or transportation accident, causing harm to human health and ecosystem.

8.4.3 Biological Disasters & Epidemics

- Plague (Surat 1994), SARS (2003), Avian Flu, H1N1 (2009), Ebola (2014), Nipah (Kerala 2018, 2021, 2023), **COVID-19 (2020–23)**.
- Bioterrorism risks (anthrax, smallpox).
- NDMA Guidelines on Biological Disasters (2008); IDSP under MoHFW.

8.4.4 Engineering Hazards

Building collapse, dam burst (Machhu 1979, Idukki concerns), bridge collapse (Morbi 2022), road & rail accidents (Balasore train tragedy June 2023, ~290 deaths).

8.4.5 Terrorism

Mumbai 26/11 (2008), Parliament attack (2001), Pulwama (2019), Pahalgam (2025). National-security architecture: NSG, NIA, MAC, NCTC concept, UAPA.

8.4.6 Oil Spills

Marine: Exxon Valdez 1989, Deepwater Horizon 2010; Indian: Chennai-Ennore Jan 2017 (200+ tonnes), MV Wakashio Mauritius 2020.

8.5 Disaster Management Cycle (Overview)

The four-phase cycle is treated fully in Chapter 9 but introduced here as foundational vocabulary.

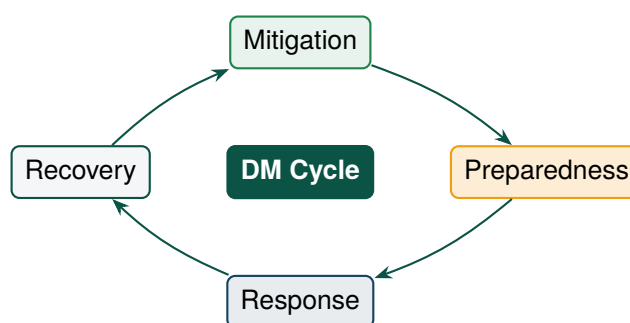


Figure 8.2: The four-phase Disaster Management Cycle.

8.6 Solved Previous Year Questions

TCS/TPS 2019 — Q.105(v) — Very Short (2 marks)

What is the difference between a hazard and a disaster?

Model Answer

A **hazard** is a potentially damaging physical or human event (e.g. a tropical cyclone over the Bay of Bengal). A **disaster** is the realised event that causes serious disruption beyond the affected community's coping capacity (e.g. Cyclone Amphan striking inhabited West Bengal and killing 128 people). All disasters originate as hazards, but not all hazards become disasters — exposure, vulnerability and capacity determine whether the conversion happens.

TCS/TPS 2019 — Q.106(i) — Short (5 marks)

How does an earthquake occur? What are its effects? Explain Focus, Epicentre and Magnitude.

Model Answer

Mechanism: Earth's lithosphere is broken into rigid plates that move at a few cm/yr. At plate boundaries — convergent (Himalayas), divergent (Mid-Atlantic Ridge), or transform (San Andreas) — stress accumulates along faults. When the accumulated stress exceeds the rock's strength, brittle failure releases energy as *seismic waves* (P, S, surface). The Indian plate's northward push beneath the Eurasian plate is the master driver behind earthquakes in NE India (incl. Tripura), Himalayas, Kutch and Andaman trench.

Key terms:

- **Focus (hypocentre)** — the point within the Earth where rupture begins, where seismic waves originate.
- **Epicentre** — the point on the Earth's surface directly above the focus; reported in news bulletins.
- **Magnitude** — quantitative measure of energy released; Richter scale (M_L) or Moment Magnitude (M_w).

Effects: ground shaking, surface rupture, liquefaction (Bhuj 2001), landslides, tsunamis (if submarine), structural collapse, loss of life and property, secondary fires, epidemics, displacement, economic disruption.

Conclusion: For Tripura, lying in Seismic Zone-V, an awareness of focus/epicentre/magnitude is more than academic — building bylaws, retrofitting and community drills are urgent.

TCS/TPS 2019 — Q.105(vi) — Very Short (2 marks)

Explain what is a Nuclear Disaster.

Model Answer

A **nuclear disaster** is an event involving the unintended release of significant quantities of radioactive material from a nuclear facility (reactor, fuel-cycle plant, waste store), nuclear weapon detonation, or radioactive-source transport accident, causing immediate (acute radiation syndrome) and long-term (cancer, genetic damage) harm to humans and lasting ecological contamination. Severity is graded on the IAEA's INES scale (Level 0–7); Chernobyl 1986 and Fukushima 2011 are the only Level-7 events.

TCS/TPS 2021 — Q.105(i) — Very Short (2 marks)

Define magnitude and intensity of earthquake disaster.

Model Answer

Magnitude is the *quantitative* measure of energy released at the focus of an earthquake; it is a single number derived from seismograph readings (Richter scale M_L or Moment Magnitude M_w).

Intensity is the *qualitative* measure of effects observed at a location — felt vibrations, damage to structures, surface effects — graded on the Modified Mercalli Intensity (MMI) scale from I (not felt) to XII (total destruction). Intensity varies with distance from epicentre, depth, soil type and building quality.

TCS/TPS 2021 — Q.104(v) — Objective

What is the wind speed of a Super Cyclone as classified by IMD?

(A) >220 km/h (B) >250 km/h (C) >200 km/h (D) 119–220 km/h.

Ans: (A) >220 km/h (strict IMD threshold is ≥ 221 km/h).

TCS/TPS 2019 & 2021 — Bhopal Gas Tragedy

Bhopal Gas Tragedy is an **industrial disaster**. It occurred in **1984** (2–3 Dec). Cause: leak of methyl isocyanate (MIC) from Union Carbide India Limited plant. Aftermath shaped India's chemical & environmental law (EP Act 1986, PLI Act 1991).

8.7 Examiner's Corner**Examiner's Corner**

- Hazard $\neq$ Disaster — make this distinction the very first sentence of any 5-marker.
- Memorise the **Risk = Hazard $\times$ Vulnerability / Capacity** formula; it impresses examiners.
- For earthquake questions, draw **focus-epicentre** diagram — adds 0.5 marks.
- For cyclone questions, recall **IMD wind-speed table**; quote **>221 km/h for Super Cyclonic Storm**.
- Use **Bhopal as the standard industrial-disaster case study** — date, location, gas (MIC), legal aftermath.
- Always link Tripura to Seismic Zone-V, August 2024 floods, and Indo-Burma seismicity.

8.8 Practice Set — Chapter 8**A. Objective MCQs****Practice Set**

- Highest seismic zone in India is:
(a) II (b) III (c) IV (d) V
- Earthquake magnitude is measured by:
(a) Richter (b) Mercalli (c) Seismograph (d) Both (a) & (c)
- Cyclone Amphan struck in:
(a) 2018 (b) 2019 (c) 2020 (d) 2021
- India's only active volcano is at:
(a) Narcondam (b) Barren Island (c) Krakatoa (d) Mauna Loa
- INCOIS, Hyderabad operates:
(a) Tsunami EWS (b) Cyclone EWS (c) Earthquake EWS (d) Wildfire EWS
- Indian Ocean Tsunami year:
(a) 1998 (b) 2001 (c) 2004 (d) 2011
- Highest INES level for nuclear disasters:
(a) 5 (b) 6 (c) 7 (d) 8
- The Bhopal Gas Tragedy involved:
(a) Chlorine (b) Methyl isocyanate (c) Phosgene (d) Ammonia
- Mocha Cyclone (May 2023) was named by:
(a) Yemen (b) Myanmar (c) Maldives (d) Saudi Arabia
- Drought classified by SPI is:
(a) Meteorological (b) Hydrological (c) Agricultural (d) Socio-economic

Ans: 1-d, 2-d, 3-c, 4-b, 5-a, 6-c, 7-c, 8-b, 9-a, 10-a.

B. Very Short (2 marks)

Practice Set

1. State two differences between magnitude and intensity of earthquake.
2. Define a tsunami; what triggers it?
3. Name any four IMD cyclone categories with wind-speed ranges.
4. Differentiate hazard, disaster, vulnerability and risk.
5. Mention any two effects of nuclear disasters.

C. Short (5 marks)

Practice Set

1. Discuss the causes, effects and mitigation of urban floods in India.
2. Explain the genesis and impact of the Indian Ocean Tsunami 2004.
3. Compare and contrast natural and man-made disasters with examples.
4. Describe the seismic zonation of India and its implications for the North-East.
5. Critically evaluate India's chemical-disaster preparedness with reference to Bhopal.

8.9 Quick Revision Capsule — Chapter 8

Quick Revision Capsule

Risk formula: Hazard × Exposure × Vulnerability / Capacity.

HPC classification (31 disasters): water/climate, geological, biological, chemical/industrial/nuclear, accidents.

Earthquake: Focus (inside) — Epicentre (surface) — Fault — P/S/Surface waves; Magnitude (Richter, M_w) vs Intensity (MMI I–XII); India zones II–V; NE = V.

Tsunami: Sumatra 2004 (M 9.1, 230k deaths); ITEWS at INCOIS.

IMD cyclone: LP → Dep → DD → CS → SCS → VSCS → ESCS → Super (>221 km/h).

Recent cyclones: Amphan 2020, Tauktae & Yaas 2021, Mocha & Biparjoy 2023, Remal 2024.

Flood: riverine, flash, urban, coastal, GLOF, dam-burst; Tripura 2024 floods.

Drought: meteorological/hydrological/agricultural/socio-economic.

Volcano: Barren Island.

Industrial: Bhopal 1984 (MIC); Vishakhapatnam 2020 (styrene).

Nuclear: INES Level 7 — Chernobyl 1986, Fukushima 2011; AERB regulates India.

Biological: COVID-19 (2020–23), Nipah, H1N1, plague Surat 1994.

Terrorism: Mumbai 26/11 (2008), Parliament 2001, Pulwama 2019.

9

Disaster Management — Cycle, Institutions & Frameworks

Syllabus Pointer (TPSC)

Section-F (B): Preparedness, adaptation to hazards, mitigation strategies, relief, rehabilitation; role of administrators, scientists, planners, volunteers, NGOs; early-warning systems & forecasting.

Highest weight in Section-F. The DM-cycle 2-marker has been set in *both* 2019 and 2021; NDMA/SDMA/DDMA 5-marker is recurring; DRR 5-marker set in 2021.

9.1 Disaster Management Defined

The Disaster Management Act, 2005 (Sec. 2(e)) defines **disaster management** as a continuous and integrated process of planning, organising, coordinating and implementing measures necessary or expedient for:

- Prevention of danger or threat of any disaster;
- Mitigation or reduction of risk;
- Capacity-building;
- Preparedness to deal with any disaster;
- Prompt response;
- Assessment of severity or magnitude;
- Evacuation, rescue & relief;
- Rehabilitation & reconstruction.

The DM Act 2005 thus codifies the modern, life-cycle approach.

9.2 The Four-Phase Disaster Management Cycle

The DM Cycle — Phases

Phase	What it does
1. Mitigation	Pre-disaster, long-term: actions to eliminate or reduce risk (structural & non-structural).
2. Preparedness	Pre-disaster, short-term: plans, drills, stockpiles, early-warning systems.
3. Response	At/just after disaster: search, rescue, evacuation, relief, medical aid.
4. Recovery (Rehabilitation & Reconstruction)	Post-disaster: restore livelihoods, rebuild "Build Back Better".

9.2.1 Mitigation — Structural and Non-Structural

Mitigation Measures

Disaster	Structural	Non-Structural
Flood	Embankments, reservoirs, channels, raised platforms, drainage	Land-use zoning, floodplain regulation, insurance (PMFBY), forecasting, community drills
Cyclone	Cyclone shelters, sea-walls, mangrove plantation, retrofitted houses	Coastal building codes, evacuation plans, IMD warnings, community awareness
Earthquake	Earthquake-resistant designs (IS 1893), retrofitting, base isolation	Building bye-laws, hazard zonation, awareness, mock drills, school-DM-plans
Drought	Watershed development, check dams, micro-irrigation, lift schemes	Crop insurance, drought-tolerant seeds, water budgeting, MGNREGA
Landslide	Gabion walls, slope stabilisation, retaining structures	Hazard mapping, land-use control, afforestation, slope-cutting regulation

9.2.2 Preparedness — From Plan to Drill

- **Comprehensive Disaster Management Plans (DMP)** at national, state, district, block and village levels.
- **Early Warning Systems (EWS)** — IMD cyclone, INCOIS tsunami, CWC flood forecasting, GSI landslide alerts, FSI fire alerts.
- **Stockpiles & logistics** — pre-positioned relief, fuel, medicines, satellite phones, food.
- **Training & drills** — NIDM, ATIs, school DM plans, NDRF mock exercises.
- **Community capacity-building** — Aapda Mitra, Civil Defence, Home Guards, NCC, NSS, Red Cross.

9.2.3 Response — Saving Lives in the Golden Hour

- **Incident Response System (IRS)** — adopted from US ICS, NDMA Guideline 2010.
- **Search & Rescue** — NDRF (12 battalions, ~15,000 personnel), SDRF, Army, Navy, Air Force, Coast Guard.
- **Emergency medical response** — National Health Mission, AYUSH, blood-banks.
- **Relief** — Sphere standards: 15 L water/person/day, 2,100 kcal food.
- **Communication** — VSAT, satellite phones, HAM radio.

9.2.4 Recovery — Build Back Better

- Damage & Loss Assessment (PDNA) — UN-EU-WB toolkit.
- Rehabilitation — temporary shelter, livelihood support, psychosocial care.
- Reconstruction — permanent housing, public infrastructure with disaster-resilient design.
- Financing — SDRF, NDRF (Centre), PM-CARES, PMNRF; private CSR; insurance.
- “Build Back Better” — Sendai Framework principle (2015).

9.3 Institutional Architecture in India — DM Act 2005

The Disaster Management Act, 2005 created a three-tier statutory structure.

DM Architecture in India	
Tier	Body & Composition
National	NDMA — Chaired by Prime Minister ; up to 9 members; based in New Delhi. Apex body; lays down policies, plans, guidelines.
	NEC — National Executive Committee, chaired by Union Home Secretary; coordinates implementation.
	NIDM — National Institute of Disaster Management; training, research, documentation.
	NDRF — National Disaster Response Force; 16 battalions; specialised SAR.
State	SDMA — Chaired by Chief Minister ; State Executive Committee chaired by Chief Secretary.
	SDRF — State response force.
District	DDMA — Chaired by District Magistrate/Collector; co-chair: elected representative of district panchayat/ZP.

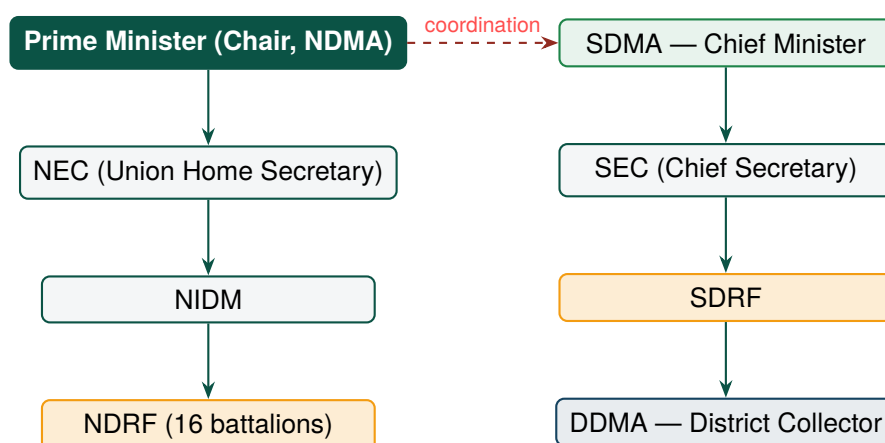


Figure 9.1: Institutional architecture under the DM Act, 2005.

9.3.1 Key Powers & Functions of NDMA, SDMA, DDMA

- **NDMA** — issue national policy, plan, guidelines; recommend funds; lay down standards.
- **SDMA** — state policy, plan, guidelines; coordinate; financial assistance.
- **DDMA** — district plan; lay down standards & procedures locally; coordinate response; ensure inter-agency working.

9.3.2 Disaster Response Funds

- **NDRF (financial)** — National Disaster Response Fund, statutory under Sec. 46 of DM Act.
- **SDRF (financial)** — State Disaster Response Fund, Sec. 48.
- **Mitigation Funds** — NDMF, SDMF, DDMF (added 2021 by 15th Finance Commission).
- PM-CARES (registered Trust 2020) and PMNRF for special contingencies.

9.4 Disaster Risk Reduction (DRR)

The **Disaster Risk Reduction** approach was endorsed in the Hyogo Framework for Action (2005–2015) and substantially upgraded in the **Sendai Framework for DRR, 2015–2030**.

9.4.1 Sendai Framework — Four Priorities, Seven Targets

Sendai Framework 2015–2030

Priorities: (1) Understanding disaster risk; (2) Strengthening DRR governance; (3) Investing in DRR for resilience; (4) Enhancing preparedness for effective response, and to “Build Back Better” in recovery, rehabilitation and reconstruction.

Seven Global Targets:

- Substantially reduce global disaster mortality by 2030.
- Substantially reduce the number of affected people.
- Reduce direct economic loss.
- Reduce damage to critical infrastructure and disruption of basic services.
- Increase the number of countries with national & local DRR strategies.
- Substantially enhance international cooperation.
- Substantially increase availability of multi-hazard early-warning systems.

9.4.2 India’s DRR Initiatives

- **Prime Minister’s 10-Point Agenda on DRR** (2016, Asian Ministerial Conference).
- **Coalition for Disaster Resilient Infrastructure (CDRI)** — India-led, 2019.
- **National Disaster Management Plan (NDMP), 2016 (rev. 2019)** — first plan aligned with Sendai.
- **National Cyclone Risk Mitigation Project (NCRMP)** — World Bank-funded cyclone shelters along east coast.
- **School Safety Programme (NDMA)**.
- **India Disaster Resource Network (IDRN)** — online inventory of resources.

9.5 Adaptation to Hazards

Adaptation is the process of adjusting to actual or expected hazards (including climate change-driven ones). Differs from mitigation: adaptation accepts the risk & reduces consequences; mitigation reduces the hazard itself.

Examples of adaptation for disasters:

- Building stilt houses in flood-prone Brahmaputra basin.
- Drought-tolerant pulses for Marathwada.
- Mangrove plantations for cyclone-coast (Odisha).
- Early-warning SMS, community sirens.
- Diversified livelihoods to reduce dependency on one sector.

- Insurance products — PMFBY, crop insurance, livestock insurance, parametric coverage.

9.6 Early Warning Systems & Forecasting

Indian EWS Landscape	
Hazard	Nodal agency / system
Cyclone, monsoon, heat-wave	IMD (impact-based forecasting since 2019, dynamical models)
Tsunami	ITEWS, INCOIS-Hyderabad
Flood	CWC (Central Water Commission), 332 forecasting stations
Glacial Lake Outburst Flood (GLOF)	NRSC, ISRO, NIH
Landslide	GSI (Landslide Hazard Zonation Atlas)
Forest fire	FSI Forest Fire Alert System (FFAS) v3.0
Drought	IMD + Mahalanobis Centre + DAC&FW (DAMU)
Earthquake	National Centre for Seismology (MoES)
Avalanche	DRDO-SASE (Snow & Avalanche Study Establishment)

9.6.1 Recent Developments in Flood Forecasting (asked 2021)

- **Dynamic flood forecasting** using Google's flood-forecasting AI partnered with CWC (operational since 2019; covers Ganga, Brahmaputra).
- **Doppler weather radars** expanded from 15 (2015) to 39 (2024); plans to reach 56 with full coverage.
- **IMD's Impact-Based Forecast (IBF)** system, 2019 onwards.
- **e-SMS alerts** via NDMA SACHET platform.
- **SMS push** to mobile users in vulnerable zones via SACHET-EWDS.
- **Common Alerting Protocol (CAP)** for unified alerts.
- **Hydromet modernisation** — Bhuvan satellite imagery, ISRO satellites (INSAT-3D/3DR, RISAT, EOS).

9.7 Role of Stakeholders

9.7.1 Administrators

The **District Magistrate (DM)** is the cornerstone of disaster response at field level. Functions: chair DDMA; coordinate police, fire, health, PWD; issue declarations; manage relief camps; oversee compensation. Sub-Divisional Magistrate (SDM) and Block Development Officer (BDO) extend the chain.

9.7.2 Scientists & Planners

Hazard mapping (GSI, NRSC), structural design (CBRI, NCSDP), risk modelling (IIT/NIDM), early warning (IMD, INCOIS, CWC), retrofitting (BMTPC), epidemiology (NCDC).

9.7.3 Volunteers & Community

Aapda Mitra (NDMA, 2017) — trained community volunteers in 350 districts; **NCC, NSS, Bharat Scouts & Guides, Civil Defence, Home Guards, Indian Red Cross Society (1920)**.

9.7.4 NGOs

SEEDS, Sphere India, Doctors For You, Goonj, Habitat For Humanity, ActionAid, Caritas, Oxfam, Hindu Spiritual & Service Foundation.

9.7.5 Community-Based Disaster Management (CBDM)

CBDM is a bottom-up approach where the community is the primary actor — identifying risks, planning, mitigating, responding. Asked in TPSC 2021 as a 2-marker. Examples:

- Village DM Plans under **Gram Panchayat DM Plan** mandate of 15th FC.
- Pre-monsoon community drills in flood-prone Tripura villages.
- Cyclone-warning volunteer corps along Odisha-Andhra coast.

9.8 Solved Previous Year Questions

TCS/TPS 2019 & 2021 — DM Cycle (4 phases)

Name any four phases of the Disaster Management cycle.

Model Answer

The four phases are:

1. **Mitigation** — pre-disaster measures to eliminate or reduce risk through structural (embankments, retrofitting) and non-structural (land-use planning, insurance) means.
2. **Preparedness** — pre-disaster planning: DMPs, EWS, drills, stockpiles, capacity-building of NDRF/SDRF.
3. **Response** — immediate at/post-event: search, rescue, evacuation, medical aid, relief.
4. **Recovery (Rehabilitation & Reconstruction)** — long-term restoration; "Build Back Better"; psychosocial care; livelihood support.

TCS/TPS 2019 — Q.106(ii) — Short (5 marks)

What is Disaster Risk Reduction (DRR)? What are NDMA, SDMA and DDMA under DM Act 2005, and their roles in disaster management in India?

Model Answer

Definition: *Disaster Risk Reduction (DRR)* is a systematic approach to identify, assess and reduce the risks of disaster. It aims to reduce socio-economic vulnerabilities and address environmental and other hazards that trigger them; embodied globally in the **Sendai Framework 2015–2030**.

Institutional Structure under DM Act 2005:

1. **NDMA — National Disaster Management Authority** — Chaired by the **Prime Minister**, headquartered in New Delhi. Functions: lay down national policy, approve NDMP, recommend funding, issue guidelines, oversee mitigation & preparedness, coordinate inter-state aid.
2. **SDMA — State Disaster Management Authority** — Chaired by the **Chief Minister** of the State. Functions: formulate state DM policy and plan, ensure coordination across departments, approve district plans, recommend state mitigation & response funds.
3. **DDMA — District Disaster Management Authority** — Chaired by the **District Magistrate/Collector**, co-chaired by the elected head of district panchayat. Functions: prepare District DM Plan; coordinate departments, NDRF, SDRF, NGOs; declare emergencies; manage evacuation, relief camps, compensation; conduct drills.

Conclusion: The three-tier structure ensures vertical coordination (Centre→State→District) and horizontal integration (across sectors). For Tripura, the TSDMA and eight DDMA operationalise man-

dates under the National DM Plan 2019.

TCS/TPS 2021 — Q.105(vi) — Very Short (2 marks)

Explain Community-Based Disaster Management (CBDM).

Model Answer

Community-Based Disaster Management is a participatory, bottom-up approach in which local communities are the primary actors in identifying their hazards, assessing vulnerabilities, planning mitigation actions and responding to disasters. It complements formal NDMA/SDMA/DDMA structures by mobilising indigenous knowledge, volunteer networks (Aapda Mitra, Civil Defence) and panchayat-level DM plans — making first response faster and recovery more sustainable.

TCS/TPS 2021 — Q.106(iii) — Short (5 marks)

Discuss the recent developments in forecasting, warning and monitoring system during floods in India.

Model Answer

Introduction: India loses Rs. 1,800 crore on average annually to floods, and 40 million ha of land is flood-prone. Recent decade has seen significant upgradation of forecasting, warning and monitoring infrastructure.

Forecasting:

1. **CWC's flood-forecasting network** now operates 332 stations (197 inflow + 135 level) across 23 states; 7-day medium-range outlooks since 2019.
2. **Google-CWC AI partnership** (2018) uses hydrological models for the Ganga & Brahmaputra; alerts pushed via Google Maps.
3. **Doppler Radar network** expanded from 15 (2015) to 39 (2024); aim of 56 stations for full coverage.
4. **Numerical Weather Prediction** — IITM-Pune & NCMRWF run higher-resolution models (12 km global, 4 km regional).

Warning:

1. **SACHET** platform of NDMA — Common Alerting Protocol-based SMS push alerts.
2. **IMD's Impact-Based Forecast (IBF)** since 2019 — colour-coded green/yellow/orange/red.
3. **Cell Broadcast & Location-based SMS** from May 2024 — pinpointed alerts.

Monitoring:

1. **Bhuvan & INSAT-3D/3DR**, RISAT, EOS satellites for near-real-time flood mapping.
2. **Bhuvan-Ganga URL** for participatory pollution & flood reporting.
3. **Drones (UAV)** for damage assessment in inaccessible terrain.

Conclusion: The challenge is *last-mile dissemination* — ensuring warnings reach the right village in the right language at the right time. Investments in CAP-aligned multilingual SMS, IVRS, community radio, and Aapda Mitra networks will close that gap.

9.9 Examiner's Corner

Examiner's Corner

- Memorise the **four DM-cycle phases** — they are asked in some form every year.
- In NDMA/SDMA/DDMA answers, mention the **chairperson at each tier** (PM, CM, DM) — that is examiner gold.
- Mention **Sendai Framework 2015–2030** in every DRR answer.

- Distinguish **NDRF (response force)** from **NDRF (response fund)** — same acronym, different things.
- Cite Tripura's TSDMA, eight DDMA's, and the August 2024 floods for context.

9.10 Practice Set — Chapter 9

A. Objective MCQs

Practice Set

1. DM Act was passed in: (a) 1999 (b) 2002 (c) 2005 (d) 2009
2. NDMA is chaired by: (a) Home Minister (b) PM (c) President (d) HM Secretary
3. SDMA chaired by: (a) Chief Secretary (b) Governor (c) CM (d) Home Minister
4. DDMA chaired by: (a) DM/Collector (b) SP (c) BDO (d) Panchayat head
5. NDRF currently has battalions: (a) 8 (b) 12 (c) 16 (d) 20
6. Sendai Framework timeline: (a) 2005–15 (b) 2015–30 (c) 2010–25 (d) 2020–35
7. Aapda Mitra programme covers districts: (a) 200 (b) 250 (c) 350 (d) 500
8. “Build Back Better” is a principle of: (a) Hyogo (b) Sendai (c) Yokohama (d) Kyoto
9. NEC is chaired by: (a) PM (b) HM (c) HM Secretary (d) CDS
10. DM Mitigation Funds were introduced by: (a) 14th FC (b) 15th FC (c) NITI Aayog (d) MoF

Ans: 1-c, 2-b, 3-c, 4-a, 5-c, 6-b, 7-c, 8-b, 9-c, 10-b.

B. Very Short (2 marks)

Practice Set

1. Differentiate structural and non-structural mitigation.
2. Name any four members of India's EWS landscape with their hazard.
3. State four priorities of the Sendai Framework.
4. Define “Build Back Better”.

C. Short (5 marks)

Practice Set

1. Explain the Disaster Management Cycle with a diagram and Indian examples.
2. Describe India's institutional architecture for disaster management under the DM Act 2005.
3. Discuss the role of NDRF in disaster response.
4. “Community-based disaster management is the future of DRR.” Discuss.
5. Examine the implementation of the Sendai Framework in India with reference to NDMP 2019.

9.11 Quick Revision Capsule — Chapter 9

Quick Revision Capsule

DM Act 2005 — three-tier institutions; NDRF (response force) & NDRF (fund); NDMP 2019.

DM Cycle: Mitigation → Preparedness → Response → Recovery.

NDMA — PM chair; SDMA — CM; DDMA — DM/Collector.

Sendai 2015–30: 4 priorities, 7 targets, “Build Back Better”.

India's flagship: PM's 10-Point Agenda; CDRI 2019; NDMP 2019.

EWS: IMD (cyclone/heat); INCOIS (tsunami); CWC (flood); GSI (landslide); FSI (fire); NRSC/ISRO satellite.

NDRF: 16 battalions; specialised SAR (CBRN).

Volunteers: Aapda Mitra (350 districts), NCC, NSS, Civil Defence, Red Cross.

Funds: NDRF, SDRF (response); NDMF, SDMF, DDMF (mitigation — 15th FC).

10

Hazards & Disasters in Tripura

Syllabus Pointer (TPSC)

Section-F (C): Earthquake Vulnerability of North-East India; Flood Hazards in Tripura; River-bank Erosion; Tropical Storms; Role of Government and NGOs.

Guaranteed PYQ: Tripura-specific Q appeared in 2019 (*Tripura in Zone-V — T/F; Major natural hazards*) and 2021 (*Tripura most vulnerable to — earthquake*). One Tripura-specific question is virtually certain in 2026.

10.1 Tripura's Geographical Setting and Hazard Profile

Tripura, the third-smallest state of India (10,492 km²), is bordered on three sides by Bangladesh and on the fourth by Assam and Mizoram. Five north-south running hill ranges — Baramura, Atharamura, Longtarai, Sakbantlang and Jampui — alternate with valleys drained by 10 major rivers. Average annual rainfall: 2,100–2,400 mm. The state's eight districts (West, Khowai, Sepahijala, Gomati, South, North, Unakoti, Dhalai) display widely varying hazard profiles.

Tripura's Disaster Profile — Snapshot

Earthquake	Entire state in Seismic Zone-V (highest risk).
Flood	750 km ² flood-prone; rivers rain-fed; flash floods common in monsoon.
Landslide	Hilly districts (Dhalai, Khowai, North, Gomati); 2024 floods triggered numerous slides.
Cyclone (impact)	Tropical-storm backflow from Bay of Bengal cyclones; not direct landfall.
Forest fire	Dry season (Feb–Apr) in Dhalai, North, Khowai.
Drought	Localised, seasonal (Feb–Apr); not chronic.
River-bank erosion	Persistent on Manu, Khowai, Howrah, Gomati banks.
Industrial	Few major plants; gas-based projects at Palatana, Monarchak.
Health/Bio	Malaria & dengue endemic; COVID-19 impacts 2020–22.

10.2 Earthquake Vulnerability of North-East India

10.2.1 Tectonic Context

The NE region lies at the triple junction of the **Indian, Eurasian, and Burmese plates**. The Indian plate is subducting beneath the Burmese plate along the Indo-Burma Arc, while the Shillong Plateau lifts up between major thrust faults. This makes NE one of the world's most seismically active regions — comparable to Japan and Indonesia.

10.2.2 Why Tripura is in Zone-V

- Proximity to the **Indo-Burma Range** subduction zone (major source of >M 7 events).
- Major fault systems crossing the state: **Baramura, Atharamura, Longtarai, Sakhantlang, Jampui Anticlinoria** and the **Sylhet Fault** to the west.
- Thick alluvial cover in valleys → amplification of seismic waves (site effect).
- Liquefaction-prone soils along river plains (Howrah, Manu).

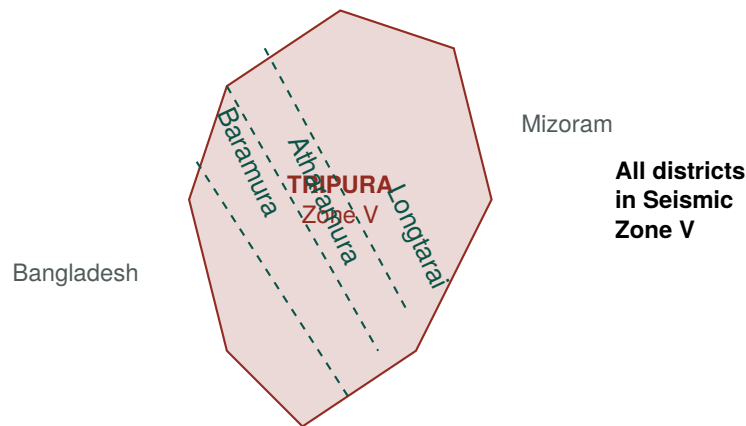


Figure 10.1: Tripura's anticlinal fault systems (schematic).

10.2.3 Notable Earthquakes Felt in/Around Tripura

- **Great Assam Earthquake 1897** (M 8.7) — felt destructively in Cachar and present-day Tripura.
- **Srimangal 1918** (M 7.6) — epicentre in Sylhet area, severe damage.
- **Cachar 1923** (M 7.1).
- **Assam 1950** (M 8.6) — strongest event in Indian seismic record; widely felt.
- **Indo-Bangladesh border 2003** (M 5.6).
- **Tripura 2017** (M 5.6, Bangladesh border); 2021 mild tremors.
- **Doyang/Nagaland 2023** (M 5.9); felt across NE incl. Tripura.

10.2.4 Earthquake Risk Mitigation in Tripura

- **Seismic micro-zonation of Agartala** completed by NCS (MoES) under the National Centre for Seismology programme.
- **Earthquake-resistant building codes** — IS 1893, IS 4326, IS 13920 incorporated in Tripura's PWD design manual.
- **Retrofitting** of government schools, hospitals — Sepahijala, Gomati districts under SDMA programmes.
- **Mock drills** by NDRF, SDRF & Aapda Mitra teams.
- **Seismic retrofitting** (asked in 2021 5-marker): strengthening existing buildings — column jacking, base isolation, FRP wrapping — to withstand expected ground motion without collapse.
- **Awareness campaigns** in schools (Hum Honge Kamyab, Bhuj earthquake anniversary observed each 26 Jan).

10.3 Flood Hazards in Tripura

10.3.1 Geomorphology of Floods

Tripura's rivers are short, steep & rain-fed, with high seasonal variability. Heavy monsoon down-pours and back-up from rivers in Bangladesh produce flash floods within hours. The Howrah river, which drains Agartala, is the most flood-prone urban stream.

10.3.2 Major Rivers & Flood-Prone Stretches

Tripura's Rivers & Flood Vulnerability	
River	Districts & flood profile
Howrah	West Tripura — passes through Agartala; severe urban flooding in 2017, 2018, 2022.
Khowai	Khowai, West — flash floods, mid-monsoon.
Manu	North Tripura — flooded Kailashahar 2018, 2022.
Juri	Unakoti — flash floods.
Dhalai	Dhalai — repeated flooding in Ambassa.
Gomati	Gomati, South — Udaipur and Amarpur affected; embankments breached 2024.
Muhuri	South — Sabroom region.
Feni	Border with Chittagong, Bangladesh.
Deo	North/Unakoti.
Longai	North.

10.3.3 The August 2024 Tripura Floods

Tripura Floods 2024 — Case Study

Period: 18 August – 5 September 2024.

Trigger: Sustained heavy rainfall (>400 mm in 48 hours in places), saturated soils, embankment breaches on Gomati & Howrah.

Impact: 32 deaths; over 38,606 families / 1.47 lakh persons displaced; 821 relief camps; severe damage to roads, bridges, agriculture, MSMEs.

Worst districts: South Tripura, Gomati, Khowai, West Tripura.

Response: NDRF, SDRF, Army, Air Force deployed; central relief sanctioned; TSDMA coordinated camps; NGOs (Goonj, Sphere India, Caritas, Red Cross) assisted.

Aftermath: Tripura SDMP 2024–25 released after 9-year gap; embankment-strengthening prioritised.

10.3.4 Flood Mitigation in Tripura — Structural & Non-Structural

Structural:

- Embankment-strengthening on Howrah, Khowai, Manu, Gomati.
- De-silting of urban drains in Agartala under AMRUT.
- Detention basins, pump stations.
- Diversion canals and floodway re-design.

Non-Structural:

- Flood plain zoning regulations (under draft).
- Real-time gauge data sharing with CWC.
- SMS-based community alerts via SACHET.

- Crop insurance (PMFBY) and livestock insurance.
- Awareness drives by SDMA in flood-vulnerable panchayats.

10.4 River-Bank Erosion

River-bank erosion — the lateral cutting of banks by river flow — is a chronic problem in Tripura along the Manu, Khowai, Howrah and Gomati.

10.4.1 Causes

- High monsoon discharge and steep gradient.
- Loose alluvial banks unable to resist shear.
- Deforestation in catchments; jhum on slopes.
- Sand mining in riverbeds disturbs equilibrium.
- Embankment failure shifts river course.

10.4.2 Consequences

- Loss of farmland, homes, infrastructure.
- Population displacement (notably along Manu in North Tripura).
- Sedimentation in downstream stretches.
- Aquatic habitat loss (fish breeding grounds).

10.4.3 Erosion Control

- **Bio-engineering** — bamboo *spurs* (*porcupines*), vetiver grass plantation.
- **Engineered structures** — concrete revetments, gabion walls, geo-textile bags, retaining walls.
- **Catchment treatment** — afforestation, watershed development, contour bunding.
- **Regulation of sand mining** under EIA Notification.
- **Resettlement** of displaced families with land tenure.

10.5 Tropical Storms in Tripura

Although Tripura is landlocked and does not face direct cyclone landfall, *tropical storm backflow* from Bay-of-Bengal cyclones brings high winds (60–100 km/h), heavy rain and landslides. Examples:

- **Cyclone Amphan** (May 2020) — tail-end winds in South Tripura, agriculture loss.
- **Cyclone Mocha** (May 2023) — heavy rain.
- **Cyclone Remal** (May 2024) — strong winds; ferocious gusts in West & South Tripura.
- Pre-monsoon **Nor'westers (Kalbaisakhi)** — March–May convective storms with damaging winds (60–80 km/h), hail & lightning; major source of crop damage & livestock mortality.
- **Lightning** — Tripura among NE leaders in lightning fatalities.

10.6 Role of Government and NGOs in Tripura's DM

10.6.1 State-Level Architecture

- **Tripura State Disaster Management Authority (TSDMA)** — chaired by Chief Minister; vice-chair: Revenue Minister; nodal department: Revenue Department.
- **State Executive Committee (SEC)** — Chief Secretary.
- **State Disaster Response Force (SDRF)** — under Tripura Police; specialised SAR.

- **Aapda Mitra** cadre — trained community volunteers across districts.
- **District-level DDMAs** — chaired by District Magistrate; one per district.
- **Tripura SDMP 2024–25** — aligns with NDMP 2019, Sendai 2015–30, Paris Agreement, SDGs.

10.6.2 Key NGOs Active in Tripura

- **Indian Red Cross Society (Tripura branch)** — first-aid, blood-bank, relief.
- **SEEDS India** — community-based DM, school safety.
- **Sphere India** — coordination of humanitarian agencies; led JRNA for Tripura floods 2024.
- **Goonj** — material relief.
- **Caritas India** — emergency response.
- **NEEDS, Caritas, ActionAid, Habitat for Humanity.**
- **Local Self-help Groups (SHGs)** — preparedness & livelihood recovery.

10.6.3 Schemes and Programmes

- **Tripura SDMP 2024–25** (released 2024).
- **NDMP 2019** (central).
- **Flood Management Programme (FMP)** of MoJS.
- **MGNREGA** water-conservation works.
- **Pradhan Mantri Awas Yojana** — resilient housing.
- **PMFBY** — crop insurance.
- **Atal Bhujal** (limited; Tripura is groundwater-rich).
- **North-Eastern Council (NEC)** — special infrastructure assistance.

10.7 Solved Previous Year Questions

TCS/TPS 2019 — Q.104(i) — Objective (True/False)

Tripura is situated in the most vulnerable earthquake zone — V of India. Ans: TRUE.

TCS/TPS 2019 — Q.104(iii) — Objective

Who is the Chairperson of Tripura Disaster Management Authority?

(A) Minister (Revenue & PWD) (B) **Chief Minister** (C) Chief Secretary (D) Minister (Health).

TCS/TPS 2019 — Q.105(iv) — Very Short (2 marks)

What are the major natural hazards in the state of Tripura?

Model Answer

Tripura's major natural hazards are (i) **earthquakes** — entire state in Seismic Zone-V, with the Indo-Burma subduction and intrastate faults (Baramura, Atharamura, Longtarai, Sakshantlang, Jampui) generating seismic risk; (ii) **floods** — 750 km² flood-prone, exemplified by the catastrophic August 2024 floods that killed 32 people; (iii) **landslides** — in hilly districts (Dhalai, Khowai, North) especially during monsoon; (iv) **river-bank erosion** — along Manu, Khowai, Howrah, Gomati; and (v) **tropical-storm winds, hailstorms, lightning** — Nor'westers and Bay-of-Bengal cyclone backflow.

TCS/TPS 2019 — Q.106(iii) — Short (5 marks)

What are floods? Explain briefly the causes and effects of floods in North-Eastern India.

Model Answer

Definition: A *flood* is the temporary inundation of land that is normally dry, caused by overflow of inland or tidal waters or by abnormal accumulation of run-off.

Causes of floods in NE India:

1. **Climatic** — high monsoon rainfall (Mawsynram, Cherrapunji record over 11,000 mm); cloudbursts.
2. **Geomorphic** — short, steep, rain-fed rivers (Brahmaputra, Barak, Manu, Gomati, Howrah) with high sediment load.
3. **Tectonic** — frequent seismicity alters river beds (1950 Assam quake raised Brahmaputra bed).
4. **Catchment degradation** — jhum cultivation, deforestation, mining.
5. **Embankment failures** — Tripura's August 2024 breaches on Gomati & Howrah.
6. **Trans-boundary discharge** — Bangladesh-Bhutan back-water effects.
7. **Climate change** — extreme rainfall events increasing per IPCC AR6.

Effects:

1. Loss of life (Tripura 2024: 32; Assam 2022: 200+).
2. Mass displacement (Tripura 2024: 1.47 lakh).
3. Crop & livestock damage; food-security stress.
4. Infrastructure collapse — roads, bridges, schools, hospitals.
5. Health emergencies — cholera, dengue, diarrhoea.
6. Long-term soil erosion & sedimentation.
7. Trans-boundary tensions (Indo-Bangladesh water sharing).

Way forward: Embankment-strengthening, watershed management, decentralised DM, transboundary cooperation under Sendai & Paris frameworks.

TCS/TPS 2021 — Q.104(i) — Objective

State of Tripura is most vulnerable to: (A) Flood (B) **Earthquake** (C) Cyclone (D) Landslide.

Rationale: While floods are recurrent, Tripura's location in Seismic Zone-V — the highest seismic-risk band — makes the catastrophic worst-case scenario an earthquake.

TCS/TPS 2021 — Q.106(i) — Short (5 marks)

Name the measures taken/to be taken in India to reduce the impact of Earthquake. What is seismic (Earthquake) retrofitting and how will it be useful?

Model Answer

Introduction: India has nearly 59% of its land area vulnerable to moderate-to-severe earthquakes (BMTPC); the entire NE, including Tripura, falls in Zone-V.

Mitigation measures in India:

1. **Seismic zonation** — IS 1893 (2002) divides India into Zones II-V.
2. **Building codes** — IS 1893 (design), IS 4326 (masonry), IS 13920 (RCC ductile detailing), IS 13935 (retrofitting).
3. **Town planning** — restrict construction in high-risk & liquefaction-prone areas.
4. **NDMA Earthquake Guideline** (2007) — national framework.
5. **National Centre for Seismology** (MoES) — 153 station network.
6. **Awareness** — *Hum Honge Kamyab*, mock drills.
7. **Insurance** — earthquake clause in property insurance.
8. **Micro-zonation** of major cities (Delhi, Kolkata, Guwahati, Agartala).
9. **Capacity-building** — NDRF specialised earthquake-rescue battalions; mason training programmes by BMTPC.

Seismic Retrofitting: Strengthening existing buildings (which were built without earthquake-resistant features) to enhance their capacity to withstand expected seismic motion without collapse. Methods include:

- **Column jacketing** — reinforcing existing RCC columns.
- **Steel/FRP wrapping** of weak members.
- **Base isolation** — installing flexible bearings to decouple foundation from superstructure.
- **Shear-wall addition** — to redistribute seismic forces.
- **Foundation strengthening** & bracing.

Usefulness: Retrofitting saves lives at a fraction of the cost of reconstruction; protects critical assets (hospitals, schools, command centres); and aligns with Sendai Priority-3 (investing in DRR). For Tripura's Zone-V context, retrofitting of government schools, hospitals, and the Agartala Secretariat is an existential priority.

TCS/TPS 2021 — Q.105(iv) — Very Short (2 marks)

Name any four structural and non-structural measures of Cyclone Risk Mitigation.

Model Answer

Structural: (i) cyclone shelters; (ii) sea-walls and groynes; (iii) mangrove plantation; (iv) wind-resistant building design and underground power cabling.

Non-structural: (i) IMD-led EWS and SACHET SMS; (ii) coastal land-use zoning (CRZ); (iii) community drills and evacuation plans; (iv) parametric/property insurance.

10.8 Examiner's Corner

Examiner's Corner

- Always cite the August 2024 Tripura Floods (32 deaths, 1.47 lakh displaced) — fresh, value-adding.
- Mention TSDMA, eight DDMA's, SDRF & Aapda Mitra in any Tripura DM answer.
- Distinguish the **TSDMA chairperson (CM)** from the **NDMA chairperson (PM)**.
- Cite specific rivers (Howrah, Manu, Gomati, Khowai) — not just "Tripura rivers".
- Mention specific faults (Baramura, Atharamura) — exam-grade detail.
- Refer to the **Tripura SDMP 2024–25** as the latest plan.

10.9 Practice Set — Chapter 10

A. Objective MCQs

Practice Set

1. Tripura's seismic zone: (a) II (b) III (c) IV (d) V
2. Worst-affected districts in Aug 2024 Tripura floods: (a) Dhalai & North (b) South, Gomati, Khowai, West (c) Unakoti (d) Sepahijala
3. TSDMA is chaired by: (a) Governor (b) Chief Minister (c) Chief Secretary (d) Revenue Minister
4. Tripura's only Ramsar site: (a) Sepahijala lake (b) Twijilikma/Rudrasagar (c) Dumboor (d) Gomati lake
5. Largest river entering Bangladesh from Tripura: (a) Gomati (b) Howrah (c) Manu (d) Feni
6. Year of Tripura SDMP (latest release): (a) 2017 (b) 2019 (c) 2022 (d) 2024
7. Tripura's flood-prone area is approximately: (a) 250 km² (b) 500 km² (c) 750 km² (d) 1,200 km²
8. Number of districts in Tripura currently: (a) 4 (b) 6 (c) 8 (d) 10

Ans: 1-d, 2-b, 3-b, 4-b, 5-a, 6-d, 7-c, 8-c.

B. Very Short (2 marks)

Practice Set

1. Name any four major rivers of Tripura and their flood-prone districts.
2. Why is the entire state of Tripura placed in Seismic Zone-V?
3. Define river-bank erosion and name two affected rivers in Tripura.
4. State four impacts of the August 2024 Tripura floods.
5. Name any four NGOs active in Tripura's disaster response.

C. Short (5 marks)

Practice Set

1. Discuss the earthquake vulnerability of North-East India with special reference to Tripura.
2. Analyse the causes and consequences of the August 2024 Tripura floods.
3. Examine the role of TSDMA and DDMA in Tripura's disaster management framework.
4. Discuss river-bank erosion in Tripura: causes, effects and mitigation.
5. "Climate change is multiplying Tripura's disaster risk." Discuss with examples.

10.10 Quick Revision Capsule — Chapter 10

Quick Revision Capsule

Geography: 10,492 km²; 8 districts; rain 2,100–2,400 mm; five hill-ranges; 10 major rivers.

Earthquake: Entire state Zone-V; Indo-Burma subduction; Baramura, Atharamura, Longtarai, Sakhsantlang, Jampui faults; 1897 & 1950 Assam quakes felt severely.

Floods: 750 km² flood-prone; rivers — Howrah, Khowai, Manu, Gomati, Juri, Muhuri, Feni, Deo, Dhalai, Longai; **Aug 2024 floods:** 32 deaths, 1.47 lakh displaced.

Erosion: Manu, Khowai, Howrah, Gomati banks.

Cyclones (impact): Amphan 2020, Mocha 2023, Remal 2024; Nor'westers Mar–May; lightning.

Architecture: TSDMA (CM-chair), SEC (CS), SDRF, 8 DDMA (DM-chair), Aapda Mitra.

Plans: Tripura SDMP 2024–25; aligned with NDMP 2019, Sendai, Paris, SDG.

Ramsar: Rudrasagar (Twijilikma) — 2005.

NGOs: Red Cross, SEEDS, Sphere India, Goonj, Caritas.

Model Test Papers

The three model papers below reproduce the exact TCS/TPS pattern for Sections E & F of GS Paper-I:

- **1 mark × 5 of 6 questions** (objective) = 5 marks
- **2 marks × 5 of 6 questions** (very-short) = 10 marks
- **5 marks × 2 of 3 questions** (short) = 10 marks
- **Total per section: 25 marks; both sections combined: 50 marks.**

Time-bench: 30 minutes per section.

Model Paper 1

Section-E (Environment) — 25 marks

1 mark × 5 of 6

1. Number of biodiversity hotspots globally is: (a) 25 (b) 32 (c) 36 (d) 42
2. The pyramid of ____ is always erect. (a) number (b) biomass (c) energy (d) all
3. "Good ozone" lies in: (a) troposphere (b) mesosphere (c) stratosphere (d) exosphere
4. ISA HQ: (a) Paris (b) Gurugram (c) Geneva (d) Hyderabad
5. BS-VI was implemented from: (a) 2018 (b) 2019 (c) 2020 (d) 2021
6. Which is NOT a Ramsar site in India? (a) Chilika (b) Rudrasagar (c) Vembanad (d) Sukhna

2 marks × 5 of 6

7. Differentiate genetic and species diversity.
8. State two reasons why CFCs are banned under the Montreal Protocol.
9. Define biomagnification with an example.
10. What are SEIAA & SEAC?
11. Why is India a mega-diversity country?
12. State two adaptation measures for Tripura's agriculture under climate stress.

5 marks × 2 of 3

13. Discuss the threats to biodiversity and India's institutional response.
14. Explain mitigation and adaptation in the climate-change context with Indian examples.
15. Critically evaluate the EIA Notification 2006.

Section-F (Disaster Management) — 25 marks

1 mark × 5 of 6

1. NDMA is chaired by: (a) HM (b) PM (c) HS (d) President
2. Super Cyclone wind speed (IMD): (a) >200 (b) >220 (c) >250 (d) 119–220 km/h
3. DM Act passed in: (a) 2002 (b) 2005 (c) 2008 (d) 2009
4. Tripura's seismic zone: (a) II (b) III (c) IV (d) V
5. ITEWS is based at: (a) IMD Pune (b) INCOIS Hyderabad (c) NCS Delhi (d) ISRO Bengaluru
6. Sendai Framework runs: (a) 2005–15 (b) 2015–30 (c) 2010–25 (d) 2020–35

2 marks × 5 of 6

7. Differentiate hazard and disaster.
8. Define magnitude vs intensity of earthquake.
9. Name any four phases of the DM cycle.
10. State two structural & two non-structural cyclone mitigation measures.
11. What is seismic retrofitting?
12. Name four major rivers of Tripura and their flood-prone districts.

5 marks × 2 of 3

13. Explain the three-tier institutional structure of DM in India under the DM Act 2005.
14. Discuss the earthquake vulnerability of North-East India with special reference to Tripura.
15. Analyse the causes and consequences of the August 2024 Tripura floods.

Model Paper 2**Section-E — 25 marks****1 mark × 5 of 6**

1. Mega-diversity countries number: (a) 12 (b) 15 (c) 17 (d) 21
2. Coined “ecosystem”: (a) Odum (b) Tansley (c) Lindeman (d) Elton
3. GWP descending order:
(a) $\text{SF}_6 > \text{CFC} > \text{N}_2\text{O} > \text{CH}_4$ (b) $\text{CH}_4 > \text{N}_2\text{O} > \text{CFC} > \text{SF}_6$
(c) $\text{CO}_2 > \text{CH}_4 > \text{N}_2\text{O} > \text{SF}_6$ (d) $\text{N}_2\text{O} > \text{CFC} > \text{SF}_6 > \text{CH}_4$
4. CBD secretariat: (a) Geneva (b) Nairobi (c) Montreal (d) Bonn
5. Cartagena Protocol concerns: (a) climate (b) wetlands (c) biosafety (d) ozone
6. Net-Zero target year of India: (a) 2050 (b) 2060 (c) 2070 (d) 2100

2 marks × 5 of 6

7. State the criteria for a biodiversity hotspot.
8. Why is the pyramid of biomass inverted in marine ecosystems?
9. Full form of BOD; define it.
10. Define keystone species with an Indian example.
11. Name any four NAPCC missions.
12. State two impacts of climate change on Tripura.

5 marks × 2 of 3

13. Distinguish in-situ and ex-situ conservation with Indian examples.
14. Explain the carbon cycle and the role of human activities in disturbing it.
15. Discuss India's commitments at COP26, COP27, COP28, and COP29.

Section-F — 25 marks**1 mark × 5 of 6**

1. Bhopal Gas Tragedy involved: (a) MIC (b) Phosgene (c) Chlorine (d) Ammonia
2. Aapda Mitra covers districts: (a) 200 (b) 250 (c) 350 (d) 500
3. NDRF battalions: (a) 8 (b) 12 (c) 16 (d) 20
4. Latest Tripura SDMP year: (a) 2019 (b) 2021 (c) 2023 (d) 2024

5. DDMA is chaired by: (a) DM (b) SP (c) Panchayat head (d) BDO
6. Cyclone Remal struck in: (a) 2022 (b) 2023 (c) 2024 (d) 2025

2 marks × 5 of 6

7. Explain Community-Based Disaster Management.
8. State four priorities of the Sendai Framework.
9. Define “Build Back Better”.
10. What is vulnerability in the context of climate change?
11. Differentiate NDRF (force) and NDRF (fund).
12. Name any four NGOs active in disaster response in Tripura.

5 marks × 2 of 3

13. Discuss recent developments in flood forecasting, warning and monitoring in India.
14. Discuss the impact of climate change on disaster risk profile of NE India.
15. Critically examine India's chemical-disaster preparedness with reference to Bhopal.

Model Paper 3

Section-E — 25 marks

1 mark × 5 of 6

1. Indo-Burma hotspot does NOT include: (a) Tripura (b) Mizoram (c) A&N Islands (d) Manipur
2. Minamata disease is caused by: (a) Cd (b) Hg (c) As (d) Pb
3. Kigali Amendment targets: (a) CFC (b) HCFC (c) HFC (d) N₂O
4. MoEFCC was renamed (from MoEF) in: (a) 2010 (b) 2014 (c) 2016 (d) 2019
5. “Driving force” of an ecosystem is: (a) producers (b) consumers (c) biomass (d) solar energy
6. Stockholm Conference held in: (a) 1968 (b) 1972 (c) 1980 (d) 1992

2 marks × 5 of 6

7. Main objective of Montreal Protocol.
8. Name 4 major GHGs in descending GWP.
9. State Lindeman's 10% law.
10. Define ecological succession with example.
11. Two effects of acid rain on monuments.
12. Two reasons why biodiversity is greater in tropics.

5 marks × 2 of 3

13. Write a short note on E-waste Management Rules (2016, amended 2022).
14. Discuss the role of IPCC in shaping global climate policy.
15. Analyse the impact of climate change on human health.

Section-F — 25 marks**1 mark × 5 of 6**

1. Tripura is most vulnerable to: (a) Flood (b) Earthquake (c) Cyclone (d) Landslide
2. DM Mitigation Funds (NDMF/SDMF/DDMF) created by: (a) 14th FC (b) 15th FC (c) NITI Aayog (d) MoF
3. Indian Ocean Tsunami year: (a) 1998 (b) 2001 (c) 2004 (d) 2011
4. Latest NDMP year: (a) 2009 (b) 2016 (c) 2019 (d) 2024
5. India's only active volcano: (a) Narcondam (b) Barren Island (c) Saddle Peak (d) None
6. TSDMA is constituted under: (a) DM Act 2005 (b) EP Act 1986 (c) ND Act 1980 (d) WLPA 1972

2 marks × 5 of 6

7. Two structural and two non-structural flood mitigation measures.
8. Differentiate earthquake focus and epicentre.
9. What is rainwater harvesting + artificial recharge?
10. Define a tsunami; what triggers it?
11. Two NGOs active in Tripura's disaster relief.
12. Two recent developments in flood forecasting in India.

5 marks × 2 of 3

13. Discuss the river-bank erosion problem in Tripura and suggest mitigation strategies.
14. "Sendai Framework is more comprehensive than Hyogo Framework." Examine.
15. Explain the role of administrators, scientists and volunteers in disaster management.

Last-Minute Revision Notes

The 48-Hour Revision Sheet — Section-E

Environment — One-Page Recap

Biodiversity: 3 levels (Genetic/Species/Ecosystem); 36 hotspots, 17 mega-diversity; India 4 hotspots (Himalaya, Indo-Burma, W. Ghats, Sundaland); HIPPO threats (Wilson); Red List 9 cat. EX-EW-CR-EN-VU-NT-LC-DD-NE; in-situ: NP 106, WLS 573, BR 18, TR 55, ER 33; ex-situ: zoo, bot. garden, seed/gene bank.

Ecology: Tansley 1935; 10% law Lindeman 1942; Pyramids — Number/Biomass (can invert), Energy (always erect); GFC vs DFC; Carbon cycle reservoirs — lithosphere > ocean > soil > atmosphere (870 GtC).

Resources: ISFR 2023: 25.17% forest+tree cover; Tripura >75%; RWH: rooftop, percolation, recharge well, sub-surface dyke; energy targets: 500 GW non-fossil 2030; Net-Zero 2070; ISA HQ Gurugram.

Pollution: BS-VI (2020); NAAQS by CPCB; BOD₅ 20°C; Itai-itai (Cd), Minamata (Hg); SWM/P-WM/EWM 2016 rules; NCAP 40% PM cut by 2026.

Climate: 1.1°C warming; CO₂ 422 ppm; GWP: SF₆>CFC>N₂O>CH₄; Good O₃=stratosphere; Montreal 1987 + Kigali 2016; NDC: 45% intensity, 50% non-fossil, 2.5–3 Gt sink; NAPCC 8 missions.

Legislation: EP Act 1986 (umbrella); WLPA 1972 (amend 2022); FCA 1980 (amend 2023); BDA 2002 (amend 2023); FRA 2006; NGT 2010; EIA 2006 — 8 stages; SEIAA/SEAC.

Organisations: UNEP-Nairobi, IUCN & WWF-Gland, IPCC-Geneva, CBD-Montreal, ISA-Gurugram; CDRI 2019; LiFE; SDGs 6, 7, 11, 12, 13, 14, 15.

The 48-Hour Revision Sheet — Section-F

Disaster Management — One-Page Recap

Definitions: Hazard ≠ Disaster; Risk = Hazard × Exposure × Vulnerability / Capacity; HPC classification (31 disasters in 5 groups).

Earthquake: Focus (inside)/Epicentre (surface); Magnitude vs Intensity (MMI); India Zones II–V; NE = V; Bhuj 2001 (M 7.7); Sumatra 2004 (M 9.1); Nepal-Gorkha 2015.

Cyclone IMD ladder: LP → Dep → DD → CS → SCS → VSCS → ESCS → Super (>221 km/h); Recent: Amphan 2020, Tauktae & Yaas 2021, Mocha 2023, Remal 2024.

Flood/Drought/Landslide/Wildfire/Volcanic: Tripura 2024 floods (32 deaths); Kerala 2018; Kedar-nath 2013; Barren Is volcano.

Man-made: Bhopal 1984 (MIC, industrial); Chernobyl 1986 & Fukushima 2011 (nuclear, INES 7); COVID-19 (biological); Balasore train 2023; Morbi 2022.

DM cycle: Mitigation → Preparedness → Response → Recovery (Build Back Better).

Architecture: DM Act 2005; NDMA (PM), SEC (HS); NIDM; NDRF 16 batt.; SDMA (CM); DDMA (DM/Collector); NDRF/SDRF funds + NDMF/SDMF/DDMF (15th FC).

Sendai 2015–30: 4 priorities; 7 targets; “Build Back Better”.

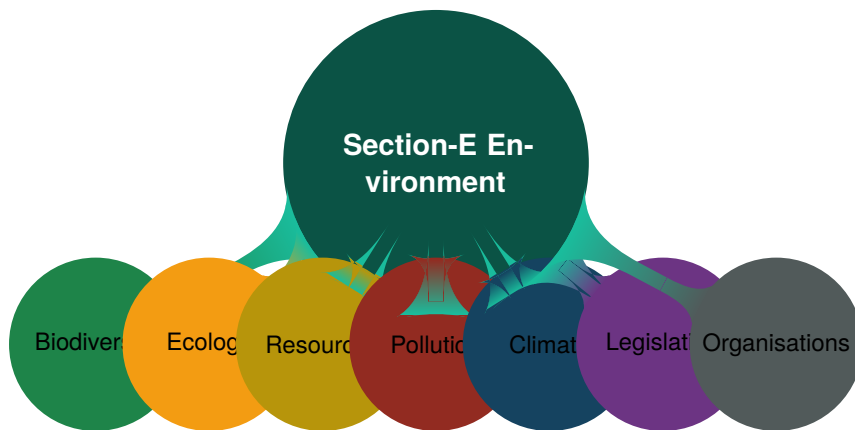
Indian flagship: PM’s 10-Point Agenda; CDRI 2019; NDMP 2019.

EWS: IMD (cyclone/heat); INCOIS (tsunami); CWC (flood); GSI (landslide); FSI (fire); NCS (seismic); DRDO-SASE (avalanche); FFAS v3.0; SACHET (CAP).

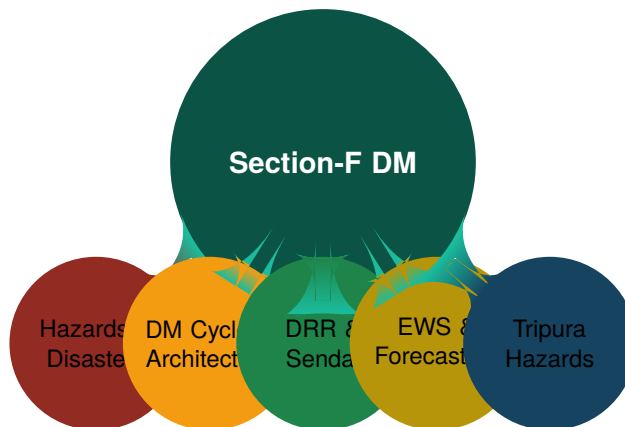
Tripura: Zone-V; Baramura, Atharamura, Longtarai, Sakbantlang, Jampui faults; rivers Howrah, Khowai, Manu, Gomati; Aug 2024 floods; TSDMA (CM), 8 DDMAAs; SDMP 2024–25; Rudrasagar Ramsar (2005).

Mind Maps for Final Recall

Section-E Mind Map



Section-F Mind Map



100 Most Important Facts & Top 50 Terms

100 Most Important Facts (50 Environment + 50 Disaster Management)

Environment — 50 Facts

1. Biodiversity coined by W.G. Rosen (1985), popularised by E.O. Wilson.
2. 36 biodiversity hotspots globally; 17 mega-diversity countries.
3. India has 4 hotspots: Himalaya, Indo-Burma, Western Ghats, Sundaland.
4. Tripura lies in the Indo-Burma hotspot.
5. Norman Myers introduced hotspot concept (1988).
6. Hotspot criteria: $\geq 1,500$ endemic plants + $\geq 70\%$ habitat loss.
7. HIPPO drivers: Habitat, Invasive, Pollution, Population, Over-exploitation.
8. IUCN Red List: 9 categories EX-EW-CR-EN-VU-NT-LC-DD-NE.
9. India: 106 National Parks, 573 Wildlife Sanctuaries.
10. Tiger Reserves: 55; Elephant Reserves: 33.
11. 18 Biosphere Reserves in India; 12 on UNESCO Network.
12. Biological Diversity Act passed in 2002; Amendment 2023.
13. NBA (Chennai), SBB (state), BMC (panchayat).
14. Ecosystem coined by Tansley (1935).
15. Lindeman's 10% law (1942).
16. Pyramids: Number, Biomass (can invert), Energy (always erect).
17. GFC: starts with green plants; DFC: starts with dead matter.
18. Eutrophication: N & P excess $\rightarrow$ algal bloom.
19. BOD: 5 days, 20°C; bathing-fit < 3 mg/L.
20. ISFR 2023: 25.17% forest+tree cover.
21. Tripura forest cover $> 75\%$ (one of top tier).
22. Net-Zero India target: 2070 (Glasgow COP26, 2021).
23. NDC: 45% emission intensity reduction by 2030.
24. NDC: 50% non-fossil installed capacity by 2030.
25. ISA HQ: Gurugram; CDRI launched 2019.
26. NAPCC 2008 — 8 missions.
27. BS-VI implemented 1 April 2020.
28. $PM_{2.5}$ & PM_{10} are criteria pollutants.
29. Itai-itai = Cd (Japan); Minamata = Hg.
30. Bhopal 2–3 Dec 1984 — MIC, Union Carbide.
31. NAAQS set by CPCB under Air Act 1981.
32. Water Act 1974, Air Act 1981, EP Act 1986 — three pillars.
33. Wildlife (Protection) Act 1972, amended 2022.
34. Forest Conservation Act 1980; renamed VSESA 2023.
35. NGT established 2010; PB Delhi.
36. EIA Notification 2006 under EP Act 1986.
37. EIA stages: Screening, Scoping, Baseline, EMP, PH, Appraisal, Decision, Compliance.
38. Cat-A: EAC (Centre); Cat-B: SEAC/SEIAA (state).
39. Rudrasagar (Tripura) — Ramsar site 2005.
40. Tropical ozone = bad (smog); stratospheric = good (UV shield).
41. Montreal 1987 phased out CFCs; Kigali 2016 added HFCs.

42. GWP descending: $\text{SF}_6 > \text{CFC} > \text{N}_2\text{O} > \text{CH}_4 > \text{CO}_2$.
43. CO_2 pre-industrial 280 ppm; 2024 = 422 ppm.
44. Acid rain: $\text{SO}_2 + \text{NO}_x \rightarrow \text{H}_2\text{SO}_4 \text{ \& \; } \text{HNO}_3$.
45. Black carbon = short-lived climate pollutant.
46. Phayre's langur — state animal of Tripura.
47. Green Imperial Pigeon — state bird of Tripura.
48. UNEP HQ Nairobi (1972); first UN body in Global South.
49. IUCN founded 1948, HQ Gland.
50. IPCC founded 1988, HQ Geneva, Nobel Peace Prize 2007.

Disaster Management — 50 Facts

1. Disaster Management Act passed 2005.
2. NDMA chaired by Prime Minister.
3. SDMA chaired by Chief Minister.
4. DDMA chaired by District Magistrate/Collector.
5. NEC chaired by Union Home Secretary.
6. NDRF has 16 battalions (operational).
7. NIDM under MoHA — training apex body.
8. HPC (Pant Committee) classified 31 disasters into 5 groups.
9. Bhopal Gas Tragedy: 2–3 Dec 1984, MIC, industrial.
10. Indian Ocean Tsunami: 26 Dec 2004, M 9.1 Sumatra.
11. ITEWS established 2007 at INCOIS Hyderabad.
12. India's 4 seismic zones: II–V (no Zone I).
13. Zone V = NE India (entire), Kutch, parts of J&K, Uttarakhand, N. Bihar.
14. Tripura in Zone V (highest risk).
15. Magnitude — quantitative (Richter/ M_w); Intensity — qualitative (MMI).
16. Focus inside Earth; Epicentre on surface.
17. Seismic waves: P (longitudinal), S (transverse), L & R (surface).
18. Bhuj 26 Jan 2001 — M 7.7, 20,000+ deaths.
19. Latur 1993 — Stable Continental Region surprise.
20. Assam 1950 — M 8.6, strongest in Indian record.
21. Nepal-Gorkha 2015 — M 7.8.
22. Doyang/Nagaland 2023 — M 5.9; felt across NE.
23. IMD cyclone ladder: LP-Dep-DD-CS-SCS-VSCS-ESCS-Super.
24. Super Cyclone IMD: >221 km/h (3-min sustained).
25. Cyclones named by 13 WMO/ESCAP NIO countries.
26. Amphan May 2020 — Super Cyclone, WB/Odisha.
27. Tauktae & Yaas — both May 2021.
28. Mocha May 2023 — ESCS, Myanmar coast.
29. Biparjoy June 2023 — VSCS, Gujarat.
30. Remal May 2024 — SCS, WB/Bangladesh; backflow into NE.
31. India's only active volcano: Barren Island.
32. Drought types: meteorological, hydrological, agricultural, socio-economic.
33. Sendai Framework 2015–2030; 4 priorities, 7 targets.
34. Hyogo Framework was 2005–2015.
35. PM's 10-Point Agenda on DRR (2016 AMCDRR).
36. CDRI launched at UNGA 2019.

37. DM Cycle: Mitigation → Preparedness → Response → Recovery.
38. “Build Back Better” is a Sendai principle.
39. Aapda Mitra (NDMA 2017) — community volunteer scheme.
40. NDRF (fund) is statutory under Sec. 46 DM Act.
41. NDMF/SDMF/DDMF created by 15th Finance Commission.
42. Tripura SDMP released 2024–25 (after 9-year gap).
43. Tripura Aug 2024 floods: 32 deaths, 1.47 lakh displaced.
44. Worst hit districts (Aug 2024): South, Gomati, Khowai, West.
45. TSDMA Chairperson: Chief Minister of Tripura.
46. Tripura faults: Baramura, Atharamura, Longtarai, Sakhsantlang, Jampui.
47. Major Tripura rivers: Howrah, Khowai, Manu, Gomati, Juri, Muhuri.
48. Tripura flood-prone area: 750 km².
49. Rudrasagar = Tripura’s only Ramsar site (2005).
50. Tripura’s eight districts: West, Khowai, Sepahijala, Gomati, South, North, Unakoti, Dhalai.

Top 50 Environment Terms

- | | |
|-------------------------------|--------------------------------|
| • Alpha/Beta/Gamma diversity | • Indicator species |
| • Anthropocene | • IUCN Red List |
| • Bioaccumulation | • Keystone species |
| • Biomagnification | • Loss & Damage |
| • Biopiracy | • Mega-diversity |
| • Biosphere reserve | • Mitigation vs Adaptation |
| • Carbon footprint | • Net-Zero |
| • Carbon sink & source | • NDC |
| • Carrying capacity | • NPP / GPP |
| • CBD | • Ocean acidification |
| • CFCs / HCFCs / HFCs | • PAR |
| • Climate justice | • Persistent Organic Pollutant |
| • Conservation reserve | • Photochemical smog |
| • COP (Conference of Parties) | • Precautionary principle |
| • Decomposition | • Polluter Pays Principle |
| • Ecological footprint | • Ramsar site |
| • Ecosystem services | • Resilience |
| • Endemic species | • Sustainable development |
| • EIA | • Stockholm Convention (POPs) |
| • Eutrophication | • Trophic level |
| • Flagship species | • Umbrella species |
| • GHG | • UNFCCC |
| • GWP | • Vulnerability |
| • Hotspot | • Wetland |
| • In-situ / Ex-situ | • Xerosere / Hydrosere |

Top 50 Disaster Management Terms

- Aapda Mitra
- AERB
- CAP (Common Alerting Protocol)
- CBDM
- CDRI
- Cyclone shelters
- DDMA
- Disaster Risk Reduction (DRR)
- DM Cycle
- Doppler radar
- Early warning system
- Epicentre
- Focus / Hypocentre
- Hazard
- Hyogo Framework
- IRS (Incident Response System)
- INES (nuclear scale)
- INCOIS
- Intensity (MMI)
- Magnitude (M_w)
- Mitigation (structural & non-structural)
- NCRMP
- NDMA
- NDMP
- NDRF (Force & Fund)
- NIDM
- Preparedness
- PMNRF
- PM-CARES
- Recovery
- Resilience
- Response
- Retrofitting
- Risk
- SACHET
- Sendai Framework
- Sphere standards
- SDMA
- SDRF (Force & Fund)
- Seismic micro-zonation
- Storm surge
- Tropical cyclone
- Tsunami
- TSDMA
- Vulnerability
- Volcanic eruption
- Wildfire
- Windward / leeward
- Vulnerability Atlas of India
- Build Back Better

Glossary of Key Terms & Acronyms

Environment & Climate

Term / Acronym	Expansion / Meaning
ABS	Access and Benefit-Sharing (Nagoya Protocol).
AR6	Sixth Assessment Report of IPCC (2021–23).
BDA	Biological Diversity Act, 2002.
BMC	Biodiversity Management Committee.
BOD	Biochemical Oxygen Demand.
CBD	Convention on Biological Diversity (1992).
CDRI	Coalition for Disaster Resilient Infrastructure (2019, India-led).
CFC	Chlorofluorocarbon — ozone-depleting refrigerant.
COP	Conference of Parties (UNFCCC, CBD, etc.).
CPCB	Central Pollution Control Board.
EAC	Expert Appraisal Committee (EIA, Centre).
EIA	Environmental Impact Assessment.
EP Act	Environment (Protection) Act, 1986.
FSI	Forest Survey of India (Dehradun).
GBF	Global Biodiversity Framework (Kunming–Montreal, 2022).
GEF	Global Environment Facility.
GHM	Green Hydrogen Mission (Jan 2023).
GWP	Global Warming Potential.
HIPPO	Habitat-Invasive-Pollution-Population-Overexploitation (Wilson).
IPCC	Intergovernmental Panel on Climate Change.
ISA	International Solar Alliance.
ISFR	India State of Forest Report.
IUCN	International Union for Conservation of Nature.
LDN	Land Degradation Neutrality (SDG 15.3).
MAB	Man and the Biosphere Programme (UNESCO, 1971).
MoEFCC	Ministry of Environment, Forest & Climate Change.
MoES	Ministry of Earth Sciences.
MEA	Millennium Ecosystem Assessment (2005).
NAAQS	National Ambient Air Quality Standards.
NAPCC	National Action Plan on Climate Change (2008).
NBA	National Biodiversity Authority (Chennai).
NCAP	National Clean Air Programme (2019).

Term / Acronym	Expansion / Meaning
NDC	Nationally Determined Contribution (Paris).
NGT	National Green Tribunal (2010).
NMCG	National Mission for Clean Ganga.
NPP / GPP	Net / Gross Primary Productivity.
PAT	Perform, Achieve and Trade (EE).
PFC	Perfluorocarbon.
POP	Persistent Organic Pollutant (Stockholm Conv. 2001).
SBB	State Biodiversity Board.
SDG	Sustainable Development Goal.
SEAC	State Expert Appraisal Committee.
SEIAA	State Environment Impact Assessment Authority.
SF ₆	Sulfur hexafluoride — most potent GHG (GWP 23,500).
SPCB	State Pollution Control Board.
UNEP	United Nations Environment Programme (Nairobi).
UNFCCC	UN Framework Convention on Climate Change (Rio 1992).
WLPA	Wildlife (Protection) Act, 1972.

Disaster Management

Term / Acronym	Expansion / Meaning
AERB	Atomic Energy Regulatory Board (India, 1983).
CAP	Common Alerting Protocol.
CBDM	Community-Based Disaster Management.
CWC	Central Water Commission — flood forecasting.
DDMA	District Disaster Management Authority (chaired by DM/Collector).
DM Act	Disaster Management Act, 2005.
DRR	Disaster Risk Reduction.
ESCS	Extremely Severe Cyclonic Storm.
EWS	Early Warning System.
FFAS	Forest Fire Alert System (FSI).
GLOF	Glacial Lake Outburst Flood.
GSI	Geological Survey of India.
HPC	High Powered Committee on DM (2001, Pant).
ICS / IRS	Incident Command/Response System.
IMD	India Meteorological Department.
INCOIS	Indian National Centre for Ocean Information Services.

Term / Acronym	Expansion / Meaning
INES	International Nuclear Event Scale.
ITEWS	Indian Tsunami Early Warning System.
MMI	Modified Mercalli Intensity scale.
NCS	National Centre for Seismology (MoES).
NDMA	National Disaster Management Authority (chaired by PM).
NDMF / SDMF / DDMF	National / State / District Disaster Mitigation Funds (15th FC).
NDMP	National Disaster Management Plan (2016, rev. 2019).
NDRF	National Disaster Response Force (16 battalions).
NEC	National Executive Committee (DM Act).
NIDM	National Institute of Disaster Management.
PMUY / PMFBY	Pradhan Mantri Ujjwala / Fasal Bima Yojana.
SACHET	NDMA's CAP-based SMS-alert platform.
SCS / VSCS	Severe / Very Severe Cyclonic Storm.
SDMA	State Disaster Management Authority (chaired by CM).
SDRF	State Disaster Response Force (also fund).
Sendai Framework	2015–2030 DRR Framework.
TSDMA	Tripura State Disaster Management Authority.
WMO	World Meteorological Organization.

Bibliography & Recommended Reading

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7. Kaushik, A. & Kaushik, C.P. *Perspectives in Environmental Studies*. New Delhi: New Age International Publishers.
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Supplementary Reading

1. NCERT Biology, Class XI–XII (Chapters on Ecology, Biodiversity, Environment).
2. Shankar IAS. *Environment* (latest edition).
3. Vision IAS Environment Compilation.
4. NDMA Guidelines (all hazards) — ndma.gov.in/Governance/Guidelines.
5. NIDM India Disaster Reports (annual).
6. IPCC AR6 — Synthesis Report (2023), WG-I, II, III contributions.
7. UNEP. *Emissions Gap Report 2024*.
8. UNEP. *Adaptation Gap Report 2024*.
9. Forest Survey of India. *India State of Forest Report 2023*.
10. Ministry of Earth Sciences & NCS. *Seismic Zoning Map of India* (IS 1893).
11. Tripura State Disaster Management Plan 2024–25.
12. Tripura State Action Plan on Climate Change (SAPCC).
13. Down To Earth magazine (Centre for Science & Environment).
14. Yojana & Kurukshetra (MoIB monthlies, environment specials).
15. PIB releases — MoEFCC, MoES, MoHA / NDMA.

Useful Web Resources

- moefcc.gov.in — Ministry of Environment, Forest & Climate Change.
- moes.gov.in — Ministry of Earth Sciences.
- ndma.gov.in — National Disaster Management Authority.
- tdma.tripura.gov.in — Tripura DM authority resources.
- ipcc.ch — IPCC reports.
- unep.org — UNEP publications.
- iucnredlist.org — IUCN Red List.
- cbd.int — Convention on Biological Diversity.
- nbaindia.org — National Biodiversity Authority.

- fsi.nic.in — Forest Survey of India.
- cpcb.nic.in — Central Pollution Control Board.
- tripura.gov.in — Government of Tripura.
- ndrf.gov.in — National Disaster Response Force.
- incois.gov.in — Indian National Centre for Ocean Information Services.
- cwc.gov.in — Central Water Commission.

A Final Word

This volume has been built around *exam-orientation, depth, and Tripura focus*. Aspirants are encouraged to:

1. Read each chapter in sequence; do not skip the Examiner's Corner, Common Mistakes, or Practice Sets.
2. Maintain a single *Vocabulary Notebook* listing every keyword in the Mains Enrichment boxes.
3. Practise all model papers in timed conditions.
4. Re-read the Quick Revision Capsules in the final 48 hours.
5. Update Tripura-specific data from official sources before the examination.

— **Quarks TPSC** —

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