

UPPSC PRELIMS

QRS

**QUICK
REVISION
SERIES**

Last-Minute Revision Notes

ENVIRONMENT & ECOLOGY

01 Ecology & Sustainable Development

02 Ecosystem & Biodiversity

03 Endangered Species & Ramsar

04 Greenhouse Effect & Climate Change

05 Climate Conferences

06 Ozone Layer

07 Forests, Parks & Wildlife Laws

08 Energy, Pollution & Water

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Facts reviewed and updated to October 2026

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CHAPTER 01

Environment & Sustainable Development, Ecology, Food Chain, Flow of Energy

Environment and Ecology: Core Concepts

Environment, Ecology, Ecosystem

- "Environment" comes from the French 'environ' = around; sum total of biotic and abiotic factors that surround and influence organisms.
- Environment (Protection) Act, 1986: environment includes water, air and land and the inter-relationship among them and with human beings, other living creatures, plants, micro-organisms and property.
- **Silent Spring** (1962) by **Rachel Carson** set the tone for the modern environmental movement.
- **Natural capital** = renewable and non-renewable resources created by nature (air, water, land, forests, minerals); roads are NOT natural capital.
- **Ecology**: term 'oekologie' coined by German zoologist **Ernst Haeckel (1866)**; Greek Oikos (home) + Logos (study); **Eugene Odum**: study of structure and function of nature.
- **Ecosystem**: term coined by **Sir Arthur Tansley (1935)**; structural and functional unit of the biosphere; self-regulating and self-sustaining; pond is the classic example.
- Ecosystem is an **OPEN system** (continuous input/output of energy and matter), NOT closed; it is the basic functional unit of nature.
- Four components of an ecosystem: abiotic materials, producers, consumers, decomposers.
- **Biosphere is the largest ecosystem**; term given by Austrian geologist **Eduard Suess (1875)**; open system (energy flows, matter recycled).
- Five major terrestrial ecosystems: desert, forest, grassland, taiga, tundra.
- Marine ecosystem covers about 71% of Earth's surface and holds about 97% of its water.

Ecological Hierarchy (Smallest to Largest)

Levels of Ecological Organisation

Level	Key point
Organism	Basic unit of study in ecology
Population	Same species, interbreeding, same area at a given time
Community	Assemblage of different populations in an area; named after dominant plant species
Ecosystem	Community + physical environment
Biome	Large regional unit with major vegetation type + fauna in a climate zone; terrestrial; boundaries set by climate
Biosphere	Part of earth where life exists; atmosphere + hydrosphere + lithosphere

- Order: organism → population → community → ecosystem → landscape → biome → biosphere.
- Aquatic systems are divided into life zones (by salinity, nutrients, temperature, light depth), not biomes.

Largest and Most Stable Ecosystem

Largest ecosystem = **Biosphere**; if options are only land/water types, largest = **Ocean / Marine** (71% of surface).

Most stable ecosystem = **Marine / Ocean** - not forest, mountain or desert.

Air is abiotic; plants, bacteria, animals are biotic.

Habitat, Niche, Home Range

Habitat vs Niche

Point	Habitat	Niche
Analogy	"Address" of the organism	"Profession" of the organism
Meaning	Place where an organism lives	Sum of activities and relationships by which a species uses resources
Sharing	Many species can share a habitat	Unique to a species
Basis	Physical place	Physical space + functional role (trophic position) + position in gradients

Types of Niche

Niche type	Describes
Habitat niche	Where it resides
Food (trophic) niche	What it eats and whom it competes with

- Term 'niche' first used by **Joseph Grinnell (1917)**.
- **Competitive Exclusion Principle** (Gause): no two species can occupy the same niche in a habitat.

Niche

Term describing both the physical space occupied and the functional role in the community = **Ecological niche** (not ecotone, habitat or home range).

Habitat = actual place where an organism lives; environment may have no life, habitat always has.

Key Species Terminology

Species Categories

Term	Meaning	Examples
Endemic species	Found only in one defined region	Galapagos tortoises, lemurs of Madagascar
Keystone species	Removal causes major change in abundance of other species	Top predators: lion, tiger, crocodile, elephant
Flagship species	Icon for a habitat or cause; need not be keystone	Indian tiger, giant panda, elephant
Indicator species	Proxy for the state of an ecosystem	Lichens (SO ₂ / air quality), crayfish (freshwater quality), corals, frogs
Umbrella species	Conserving it protects many other species	Tiger
Invasive / alien species	Occur outside natural range and threaten natives	Water hyacinth, Calotropis (Madar), Prickly poppy, Alternanthera

Ecological Terms Frequently Asked

Ecotope, Ecad, Ecotype, Ecocline

Term	Meaning
Ecad	Same genetic stock differing in vegetative traits; variations REVERSIBLE
Ecotype	Genetically different population of a species; variations PERMANENT
Ecocline	Gradual change from one ecosystem to another along an environmental gradient

- **Deep ecology**: values all living beings regardless of use to humans; coined by Norwegian philosopher **Arne Naess** (early 1970s).
- **Pycnocline** = density gradient; **Halocline** = salinity gradient; **Thermocline** = temperature change with depth.
- **Ecological footprint**: biologically productive area required to sustain a person/population; unit = **global hectares**.
- **Greenwashing**: false impression that a company's products are eco-friendly. **Eco-mark** (BIS, 1991) labels environment-friendly products.

Evolution and Ecological Principles

Evolutionary Concepts

Concept	Key point
Evolution	Theory by Charles Darwin and Alfred Wallace (joint paper 1858; Origin of Species 1859)
Adaptation	Inherited attribute enabling survival and reproduction
Natural selection	Favourable genes reproduced more
Extinction	End of a species; death of the last individual

Five Mass Extinctions and the Sixth

Event	Time	Impact
Ordovician-Silurian	~445 mya	Mostly small marine species
Devonian	~372 mya	Many tropical marine species
Permian-Triassic	~252 mya	Biggest ever ("Great Dying")
Triassic-Jurassic	~201 mya	Many land vertebrates lost; dinosaurs thrived afterwards
Cretaceous-Tertiary (K-T)	~66 mya	Dinosaurs wiped out
Anthropocene / Holocene (sixth)	Ongoing	Human-caused; over-exploitation, habitat loss, pollution, climate change

- The five mass extinctions destroyed 70-95% of species then existing.

Ecological Adaptation Rules

Biological Rules

Rule	Statement
Allen's rule	Cold-climate animals have shorter limbs/ears/appendages
Bergmann's rule	Larger-bodied populations in colder regions; overall body size
Shelford's law of tolerance	Each factor has minimum, maximum and optimum range
Liebig's law of minimum	Yield is proportional to the most limiting nutrient

Allen vs Bergmann

Allen = APPENDAGES (ears, limbs) shorter in cold. Bergmann = overall BODY SIZE larger in cold.

Gloger = PIGMENT (dark in humid). Shelford = TOLERANCE range. Liebig = LIMITING nutrient.

Types of Adaptation

Type	Example
Morphological	Desert plants: thick cuticle, sunken stomata; cold-region mammals: small ears and limbs
Physiological	Internal body functions: camel conserves water (concentrated urine, tolerates dehydration); people at high altitude have more red blood cells and haemoglobin
Behavioural	Actions of the organism: migration (Siberian crane), hibernation (bear), aestivation (lungfish), burrowing by desert rodents, nocturnal habit to avoid heat

Ecosystem: Structure and Components

Functions and Components

- Four functions: energy flow, nutrient cycling (biogeochemical cycles), ecological succession, homeostasis (cybernetic control).
- Abiotic: physical factors (temperature, humidity, light, pressure), inorganic substances (water, O₂, CO₂, N), organic substances. Biotic: producers, consumers, decomposers.

Abiotic Factors

Factor	Key facts
Air	Nitrogen + oxygen make up about 99% of Earth's air
Soil	Edaphic factor; layers = horizons; series of horizons = soil profile
Temperature	Eurythermal = wide tolerance (few species); Stenothermal = narrow tolerance (most species)
Light	Only red and blue light are useful in photosynthesis; UV is harmful
Water	Defines plant types: hydrophytes, mesophytes, xerophytes, halophytes

Light and Plants/Animals

Term	Meaning
Heliophytes	Sun-loving plants (e.g. banyan); form canopy
Sciophytes	Shade-loving plants (herbs); form understory

Water-Related Terms

Term	Meaning
Hydrophytes	Aquatic plants; have aerenchyma
Xerophytes	Dry-area plants; reduce transpiration
Halophytes	Salt-tolerant plants (mangroves); pneumatophores
Catadromous	Born in sea, live in freshwater, return to sea to spawn (eel)
Anadromous	Born in freshwater, live in sea, return to freshwater to spawn (salmon, hilsa)

Organism Responses to Abiotic Stress

Category	Mechanism	Meaning
Regulate	Osmoregulation	Maintain salt and water balance
Regulate	Thermoregulation	Keep body temperature in limits
Migrate	Migration	Move for food/warmth (Siberian birds at Keoladeo, Bharatpur)
Suspend	Hibernation	Winter dormancy
Suspend	Aestivation	Summer dormancy to avoid desiccation
Suspend	Brumation	Hibernation-like dormancy in reptiles
Suspend	Diapause	Delayed development during adverse periods

Biotic Components

Component	Role	Examples
Producers (autotrophs)	Make food; base of ecosystem	Green plants; phytoplankton
Herbivores (primary consumers)	Eat plants	Sheep, cow, goat
Carnivores	Eat other animals	Wolf, snake
Omnivores	Eat plants and animals	Man, bear, pig
Decomposers (saprotrophs)	Break down dead matter; return nutrients	Bacteria, fungi

- **Detritivores** feed on detritus (earthworms, millipedes, woodlice); decomposers = fungi and bacteria (viruses are NOT).
- Decomposers do NOT convert inorganic matter into organic matter.
- Main primary producers in the ocean: phytoplankton (cyanobacteria and diatoms); copepods and foraminifera are consumers.

Productivity of an Ecosystem

Productivity Terms

Term	Meaning
GPP	Total rate of photosynthetic capture of energy
NPP	$NPP = GPP - \text{Respiration (R)}$; energy available to consumers

- Tropical rainforests are the most productive terrestrial ecosystem; estuaries and coral reefs the most productive aquatic ones; mangroves comparable to rainforests.
- Decreasing productivity: Mangroves > Grasslands > Lakes > Oceans.
- Upwelling**: deep, cold, nutrient-rich water rises to surface; it increases productivity by bringing NUTRIENTS up. **Downwelling**: surface water sinks.

Energy Flow and Trophic Levels

Energy Flow

- Energy flow is **unidirectional**: producers to herbivores to carnivores; declines at each level due to heat loss; follows the laws of thermodynamics.
- Solar energy is the primary source; green plants capture only about 1% of solar energy falling on leaves.
- 10 percent law** (Lindeman, early 1940s): only about 10% of energy passes to the next trophic level; rest lost as heat.
- Tertiary consumers / top carnivores show the highest DDT concentration.

Food Chain

- Food chain = series of transfers of matter and energy as food from organism to organism; shows the ORDER of feeding, not numbers eaten, and does not occur within a single species.
- Two types: grazing and detritus food chain.

Grazing vs Detritus Food Chain

Point	Grazing food chain (GFC)	Detritus food chain (DFC)
Starts from	Producers (green plants)	Dead organic matter / detritus
First consumer	Herbivore	Detritivore / decomposer microorganisms
Energy flow	Less energy flows	More energy flows
Major channel in	Aquatic ecosystem	Terrestrial ecosystem
Land example	Grass → Grasshopper → Frog → Snake → Eagle	Litter → Earthworm → Snake → Eagle

Consumer Levels in Food Chains

Man = primary AND secondary consumer (omnivore). Deer = primary consumer; tiger = carnivore; fox = omnivore; ants = primary consumers / scavengers.

Correct chains: Grass → Grasshopper → Frog → Snake; Grass → Goat → Human; marine: Diatoms → Crustaceans → Herring.

If ocean phytoplankton were destroyed: carbon-sink role AND ocean food chains hit; ocean water density NOT drastically reduced.

Food Web

- Food web = network of interconnected food chains in an ecosystem; most organisms eat more than one kind of food and are eaten by more than one predator.
- A food web is more stable than a single food chain: if one food source fails, alternative links exist. More links = greater stability and resilience.
- Grazing food chain starts with green plants (producers) and is the major energy channel in aquatic ecosystems; detritus food chain starts with dead organic matter and is the major channel in terrestrial ecosystems.
- Only about 10% of energy passes from one trophic level to the next (Lindeman 10% law), so food chains rarely have more than 4-5 trophic levels; a top carnivore gets the least energy.

Interactions Among Organisms

Species Interactions

Interaction	Sp. 1	Sp. 2	Meaning	Examples
Mutualism	+	+	Favourable to both, obligatory	Coral and zooxanthellae; lichen (alga + fungus)
Commensalism	+	0	One benefits, other unaffected	Remora with shark; epiphytes on trees
Predation	+	-	Predator kills and eats prey	Tiger, leopard
Parasitism	+	-	Parasite lives on host and harms it	Tapeworm, malarial parasite
Competition	-	-	Both harmed for same resource	Any resource
Amensalism	-	0	One inhibited, other unaffected	Penicillium vs bacteria

- Symbiosis = intense, close mutualism; cnidarians (corals), fungi and protozoa have symbiotic species.
- Predators maintain species diversity by reducing competition among prey; female mosquito is NOT a parasite.

Ecological Pyramids

- Introduced by British ecologist **Charles Elton**; three types: numbers, biomass, energy.

Types of Ecological Pyramids

Pyramid	Measures	Usual shape	Inverted when
Numbers	Individuals per level	Upright (grassland)	Tree ecosystem; parasitic food chain
Biomass	Standing crop per level	Upright (most terrestrial)	Pond / marine ecosystems
Energy	Energy per area per time	ALWAYS upright	Never inverted

- Limitations: do not accommodate food webs; decomposers find no place; same species at two trophic levels not considered.

Pollutants in the Food Chain

Bioaccumulation vs Biomagnification

Point	Bioaccumulation	Biomagnification
Meaning	Build-up of a toxin in an individual organism	Increase in toxin concentration from one trophic level to the next
Level	Within an organism	Along the food chain
Highest concentration	-	At top trophic level

- Non-degradable, fat-soluble pollutants (DDT, heavy metals) biomagnify; DDT thinned egg shells of fish-eating birds; mercury caused Minamata disease (Japan).

Ecosystem Services and Valuation

Ecosystem Services (Millennium Ecosystem Assessment)

Category	Examples
Provisioning	Food, drinking water, genetic resources, medicinal herbs, timber
Regulating	Carbon sequestration, climate regulation, flood and disease control
Cultural	Spiritual values, tourism, recreation
Supporting	Nutrient cycling, soil formation, primary production, pollination

- **Millennium Ecosystem Assessment:** launched by the UN in 2001; four categories above.
- **Ecosystem valuation:** monetary value to ecosystem services for cost-benefit analysis.

Carrying Capacity

- Carrying capacity = maximum population an ecosystem can sustain indefinitely; beyond it competition, death and decline follow.
- Sustainable use: extraction rate must stay BELOW regeneration rate; waste within absorption capacity.

Sustainable Development

Concept

- **Brundtland Commission** (WCED) report **Our Common Future (1987)** defined sustainable development: meeting present needs without compromising the ability of future generations to meet theirs.
- It is INTER-GENERATIONAL; covers poverty reduction, biodiversity conservation, pollution control; balances economic development with environment.
- Sustainable agriculture: techniques protecting environment, public health, animal welfare; NMSA is part of NAPCC.
- **Conservation agriculture** (FAO): minimum tillage, permanent soil cover, crop rotation and inter-cropping.
- Three pillars: Economic, Social, Environmental.

Path to the SDGs

Year	Event
1972	Stockholm Conference - first world environment conference; UNEP created; 5 June = World Environment Day

Year	Event
1987	Brundtland Report; Montreal Protocol adopted (in force Jan 1989)
1992	Earth Summit, Rio (UNCED): Agenda 21, Rio Declaration, Forest Principles, UNFCCC, CBD
2000	Millennium Summit -> MDGs (2000-2015)
2002	World Summit on Sustainable Development (Rio+10), Johannesburg; reaffirmed Agenda 21
2012	Rio+20 (UN Conference on Sustainable Development); outcome "The Future We Want"; Open Working Group on SDGs
2015	UN adopts "Transforming Our World: the 2030 Agenda for Sustainable Development"

- SDGs: non-binding, universal; 17 goals, 169 targets, 232 unique indicators; built on the '5 Ps': People, Planet, Prosperity, Peace, Partnership.

Rio, Agenda 21 and SDG Traps

SDGs were NOT proposed in 1972 by the Club of Rome; proposed at Rio+20 (2012), to be achieved by 2030. Agenda 21 = non-binding UN action plan from the 1992 Rio Earth Summit; NOT from Johannesburg 2002. Chronology: Limits to Growth (1972) -> Brundtland Report (1987) -> Montreal Protocol enforced (1989) -> Rio Earth Summit (1992).

MDG vs SDG

Millennium Development Goals (2000-2015)

No.	MDG
1	Eradicate extreme poverty and hunger
2	Achieve universal primary education
3	Promote gender equality and empower women
4	Reduce child mortality
5	Improve maternal health
6	Combat HIV/AIDS, malaria and other diseases
7	Ensure environmental sustainability
8	Develop a global partnership for development

MDG vs SDG

Point	MDG	SDG
Period	2000-2015	2015-2030
Size	8 goals, 21 targets, 60 indicators	17 goals, 169 targets, 232 indicators
Coverage	Mainly developing countries	Universal
Scope	Narrow; missed peace and governance	Holistic; includes peace, justice, climate, inequality

The 17 Sustainable Development Goals

SDGs

SDG	Goal
1	No Poverty
2	Zero Hunger
3	Good Health and Well-being
4	Quality Education
5	Gender Equality
6	Clean Water and Sanitation
7	Affordable and Clean Energy
8	Decent Work and Economic Growth
9	Industry, Innovation and Infrastructure
10	Reduced Inequalities
11	Sustainable Cities and Communities
12	Responsible Consumption and Production
13	Climate Action
14	Life Below Water
15	Life on Land
16	Peace, Justice and Strong Institutions
17	Partnerships for the Goals

- "Space research" is NOT an SDG.

Five Ps of the 2030 Agenda

P	Goals
People	1-5
Planet	6, 12, 13, 14, 15
Prosperity	7, 8, 9, 10, 11
Peace	16
Partnership	17

World Environment Day (5 June)

Year	Theme / Host
2022	Only One Earth (50 years of Stockholm); Sweden
2025	Ending Plastic Pollution; Republic of Korea
2026	Climate action; Azerbaijan

Institutions and Indices

- **SDSN** (launched 2012 by Ban Ki-moon) publishes the annual Sustainable Development Report (global SDG Index).

Sustainable Development Report - India's Rank

Year	India rank	Note
2022	121 of 163	Finland topped
2025	99 of 167	First time in top 100
2026	94 of 167 (score 68.3)	Best ever; Finland, Sweden, Denmark lead

NITI Aayog SDG India Index - Editions

Edition	Released	India score	Top state(s)	Lowest
1st	Dec 2018	57	Kerala, Himachal Pradesh (69)	-
2nd	Dec 2019	60	Kerala (70)	Bihar (50)
3rd	May 2021	66	Kerala (75)	Bihar (52)
4th (latest)	July 2024	71	Kerala and Uttarakhand (79, joint)	Bihar (57), Jharkhand (62)

- 4th edition: 113 indicators; 32 states/UTs are Front-Runners; Tamil Nadu 78, Goa and Himachal 77; fastest movers: Uttar Pradesh (+25), J&K (+21), Uttarakhand (+19).

India's Efforts**India's Initiatives by SDG**

SDG	Initiative
7	International Solar Alliance
13	BS-VI norms; Panchamrit goals (COP26 Glasgow)

Gross Environment Product (GEP) and Green Accounting

- GEP = economic valuation of ecosystem goods and services; component of **Green GDP**; concept by **Robert Costanza (1997)**.
- Uttarakhand** announced valuation of natural resources through GEP.
- Green GDP** = Net Domestic Product further reduced by depletion of natural resources and ecosystem degradation.
- Global accounting tools: SEEA (UN standard for natural capital); Happy Planet Index (NEF, UK); Gross National Happiness (Bhutan).
- Himalayan ecosystem: over 41.5% forest cover; National Mission for Sustaining the Himalayan Ecosystem is under NAPCC.

CHAPTER 02

Ecosystem: Miscellaneous; Biodiversity, Causes of Loss & Conservation

Biogeochemical Cycles

- Biogeochemical cycle = cyclic exchange of elements between organisms and environment. C, H, O, N, P make up about 97% of body mass.

Types of nutrient cycles

Type	Reservoir	Examples
Gaseous	Atmosphere / hydrosphere	Carbon, nitrogen, oxygen
Sedimentary	Earth's crust (rocks)	Phosphorus, sulphur

Colours of carbon

Type	Meaning
Blue carbon	Ocean and coastal ecosystems (mangroves, seagrasses, tidal marshes); stores carbon faster than forests
Green carbon	Carbon in natural forests
Black carbon	Soot from incomplete combustion; part of PM2.5; melts Himalayan glaciers
Brown carbon	Brown smoke from burning organic matter

- Carbon cycle: oceans hold about 71% of carbon, atmosphere 1%. CO₂ is removed by photosynthesis and added by respiration, decay, fossil fuels, volcanoes.

Nitrogen cycle

Step	What happens	Agent
Fixation	N ₂ to ammonia/nitrates	Lightning, Haber process, bacteria
Ammonification	Dead matter to ammonia	Decomposers
Nitrification 1	Ammonia to nitrite	Nitrosomonas
Nitrification 2	Nitrite to nitrate	Nitrobacter
Denitrification	Nitrate to N ₂	Pseudomonas, Thiobacillus

- N₂ is 78% of atmosphere but inert. Symbiotic fixer: Rhizobium (legume nodules); free-living: Azotobacter, Nostoc, cyanobacteria.
- Excess nitrate causes eutrophication and blue-baby syndrome; NO_x causes acid rain.
- Oxygen is about 21% of atmosphere; released by photosynthesis.
- Water cycle: about 97.3% of water in oceans, 2.1% in ice caps; driven by solar energy and gravity.
- Phosphorus: no atmospheric phase; rock weathering is the source; slowest cycle; component of DNA, ATP, bones; limiting nutrient in freshwater.
- Sulphur: mostly sedimentary (gaseous H₂S, SO₂); in cysteine and methionine; SO₂ and NO_x cause acid rain.

Cycle quick-check

Gaseous: carbon, nitrogen, oxygen. Sedimentary: phosphorus, sulphur.

Rock weathering is the main source for phosphorus, not carbon or nitrogen.

Biodiversity: Concepts and Patterns

- Biodiversity (Earth Summit 1992): variability among organisms within species, between species and of ecosystems.
- "Biological diversity" coined by Raymond Dasmann (1968); "biodiversity" by Walter G. Rosen (1985).
- Alpha, beta, gamma diversity: R. H. Whittaker.
- International Day for Biological Diversity: 22 May. UN Decade on Biodiversity: 2011-2020.
- Insects are the most species-rich group; Amazon has the greatest biodiversity; diversity falls from equator to poles and with altitude.
- Tropical rainforest has maximum biodiversity; coral reefs are richest marine system. Higher productivity, intermediate disturbance and older age raise diversity.
- Biodiversity underpins soil formation, erosion prevention, waste recycling and pollination; its most significant aspect is maintenance of the ecosystem.
- Western Ghats is the most biodiversity-rich region of India. Silent Valley (Kerala) became a National Park in 1984 after a people's movement.
- National Centre for Marine Biodiversity is at Jamnagar; National Biodiversity Authority is at Chennai.

Levels and measures of biodiversity

Term	Meaning
Genetic	Variation within a species (rice, mango varieties)
Species	Variety of species (richness + evenness)
Ecological	Variety of ecosystems
Alpha	Diversity within a habitat
Beta	Change in composition between habitats
Gamma	Overall diversity across a region

- Endemism = restricted to one region; opposite is cosmopolitan.

India's biodiversity

- India has 2.4% of world land, about 7-8% of species and 17% of population. Ranks 7th in mammals, 9th in birds, 5th in reptiles.
- India has 2 realms, 5 biomes, 10 biogeographic zones, 25 provinces. Himalaya is in the Palearctic realm; rest in Indomalayan.
- World realms: Nearctic, Palearctic, Afrotropical, Indomalayan, Oceania, Australian, Antarctic, Neotropical.

Megadiverse countries

17 countries hold about 70% of the world's species on under 10% of land.

List: Australia, Brazil, China, Colombia, DR Congo, Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Papua New Guinea, Peru, Philippines, South Africa, USA, Venezuela.

Bio-terms

Term	Meaning
Bioaccumulation	Toxin build-up in a single organism
Biomagnification	Toxin concentration rising along trophic levels (DDT, PCBs, mercury); top carnivores worst hit; DDT thins raptor eggshells
Bioprospecting	Search for commercially valuable biological resources

Term	Meaning
Biopiracy	Exploitation of biological material/traditional knowledge without fair sharing (neem patent)
Bioassay	Testing potency of a substance on living organisms
Biomining	Extracting metals from ore using microbes

Biodiversity Hotspots and Special Areas

- Hotspot concept: Norman Myers (1988); adopted by Conservation International (1989). There are 36 hotspots covering 2.4% of land; North American Coastal Plain (2016) is the 36th.
- Hotspots hold over half of world's endemic plants. Not only tropical: California, Mediterranean Basin, Japan, SW Australia.
- Criteria for recognition: species richness, endemism, threat perception.

Two criteria of a hotspot

- At least 1,500 endemic vascular plant species.
- Lost 70% or more of original habitat.

Hotspots of India (4)

Hotspot	Extent	Key facts
Himalaya	Nepal, Bhutan, NE India	One-horned rhino, wild buffalo
Indo-Burma	NE India (south of Brahmaputra), Myanmar, SE Asia	Orchids; Andaman group included
Western Ghats and Sri Lanka	Western Ghats	62% reptiles, 77% amphibians endemic
Sundaland	Nicobar Islands, Malaysia, Indonesia	Great Nicobar BR

Commonly Confused - hotspots

Not hotspots: Eastern Ghats, Vindhyas, Aravallis, Sundarbans, Gangetic plains, Thar, Deccan Plateau, Cherrapunji, Manas.
Sikkim lies in the Eastern Himalaya hotspot.

- Cool spots = last refuges with threatened species (Amazon, Andes, boreal forests). Hope spots (Mission Blue) = ocean areas needing protection; Andaman and Nicobar, Lakshadweep named in 2013.

Biodiversity Heritage Sites (BHS)

- BHS notified by State Government under Section 37 of the Biological Diversity Act, 2002.
- India's first BHS: Nallur Tamarind Grove, Bengaluru (2007).
- Examples: Majuli (Assam), Hoglekan (Chikmagalur), Dialong (Manipur), Naro Hills (MP), Ameenpur Lake (Telangana), Gupteswar Forest (Odisha), Gharial Rehabilitation Centre (UP).

Causes of Biodiversity Loss

"HIPPO" - major threats

Habitat loss/fragmentation is the biggest threat; invasive alien species are second.
Others: Pollution, Population, Over-exploitation, climate change.

Factors causing biodiversity loss

Factor	Detail
Habitat loss and fragmentation	Deforestation, dams, mining; single most important cause
Over-exploitation	Hunting, poaching, overfishing (passenger pigeon, Steller's sea cow)
Invasive alien species	Out-compete natives
Co-extinction	Dependent species vanish with host
Climate change	GLOFs, extreme weather
Pollution	Pesticides, acid rain
Illegal wildlife trade	Pangolin scales

- Jhum cultivation degrades biodiversity; afforestation is NOT a cause of loss.
- Extinction risk is higher for narrow-niche (koala), large-bodied and genetically uniform species.
- Birds decline due to habitat loss and pesticides.
- Earth Overshoot Day = date when demand exceeds yearly regeneration.
- IAS = non-native species that spread and harm; second greatest threat after habitat loss. CBD Article 8(h) deals with alien species. ICFRE set up Forest Invasive Species Cell (2009).

Important invasive species in India

Species	Native to	Note
Water hyacinth	Tropical America	Chokes water bodies
Lantana camara	Tropical America	Forest weed
Parthenium (Congress grass)	N. America	Fields, wastelands
Prosopis juliflora	Mexico	Banni grassland
African apple snail	East Africa	Andaman and Nicobar
Eucalyptus / Black wattle	Australia	Afforestation, Western Ghats

Biodiversity Conservation**In-situ vs ex-situ conservation**

Point	In-situ	Ex-situ
Meaning	In natural habitat	Outside natural habitat
Examples	National parks, sanctuaries, biosphere reserves, sacred groves, conservation reserves	Zoos, botanical gardens, seed/gene banks, aquaria, cryopreservation
Best for	Maintains evolution and ecosystem	Critically endangered species

- Cryobank uses liquid nitrogen. Biosphere reserves conserve genetic variation with traditional human life.
- Gulf of Mannar BR (21 islands) is a region of exceptional marine biodiversity.

Protected area network (India)

- National Parks and Sanctuaries are declared by State Governments under the Wildlife (Protection) Act, 1972. NBWL is chaired by the Prime Minister.
- About 107 National Parks, 573 Wildlife Sanctuaries, 115 Conservation Reserves, 220 Community Reserves; protected areas cover about 5.32% of India's area; sanctuaries cover the largest share.
- NWAP 2017-2031 is the third National Wildlife Action Plan.

Eco-sensitive zones (ESZ)

- ESZ notified by MoEFCC under the Environment (Protection) Act, 1986 (NOT Wildlife Act); "shock absorbers" around protected areas; general principle up to 10 km; Supreme Court (2022) ordered minimum 1 km, later modified.
- Prohibited: commercial mining, polluting industries, flying over PAs. Regulated: tree felling, hotels, road widening. Permitted: ongoing agriculture, rainwater harvesting, organic farming.

Biosphere reserves

- BR: UNESCO designation under Man and Biosphere (MAB) Programme (1971). Zones: core, buffer, transition. Functions: conservation, development, logistic support.
- India has 18 BRs; 13 are in the UNESCO World Network (Cold Desert added 2025). First BR: Nilgiri (1986); largest: Kachchh; smallest: Dibru-Saikhowa.

Biosphere reserves of India

BR	Year	State	Key feature
Nilgiri	1986	TN, Kerala, Karnataka	First BR; Nilgiri tahr, lion-tailed macaque
Nanda Devi	1988	Uttarakhand	Snow leopard, musk deer
Nokrek	1988	Meghalaya	Hoolock gibbon, red panda
Gulf of Mannar	1989	Tamil Nadu	First marine BR; dugong
Sundarbans	1989	West Bengal	Tiger, estuarine crocodile
Manas	1989	Assam	Pygmy hog, golden langur
Great Nicobar	1989	A&N Islands	Nicobar megapode
Simlipal	1994	Odisha	Largest sal zone
Dibru-Saikhowa	1997	Assam	Smallest BR; feral horses
Dehang-Dibang	1998	Arunachal Pradesh	Mishmi takin, Siang valley forests
Pachmarhi	1999	Madhya Pradesh	Giant squirrel
Achanakmar-Amarkantak	2005	MP / Chhattisgarh	Source of Narmada, Son, Johilla
Khangchendzonga	2000	Sikkim	First Mixed Heritage Site
Agasthyamalai	2001	Kerala / TN	Nilgiri tahr, elephant
Kachchh	2008	Gujarat	Largest BR; wild ass
Cold Desert	2009	Himachal Pradesh	Snow leopard, ibex
Seshachalam	2010	Andhra Pradesh	Red sanders, Seshachalam hills
Panna	2011	Madhya Pradesh	Tiger

Tiger reserves and Project Tiger

- Project Tiger launched 1973; managed by NTCA. Jim Corbett (Uttarakhand) was the first tiger reserve; India has 58 tiger reserves (Madhav, MP, is the 58th).
- Largest: Nagarjunsagar-Srisailem; smallest: Bor. Tiger census every four years; camera traps and M-STripes now used (pugmark earlier).

India tiger estimates

Year	Tigers
2006	1,411
2010	1,706
2014	2,226
2018	2,967
2022	3,682

- India holds about 75% of world's wild tigers; Madhya Pradesh has most (785), then Karnataka, Uttarakhand; Corbett has the highest count.

Critical Wildlife Habitat, sacred groves, ex-situ

- CWH is defined in the Forest Rights Act, 2006: inviolate areas of NPs and sanctuaries; Gram Sabha consent required. Baigas were the first PVTG given habitat rights (MP, 2016).
- Sacred groves: forest patches protected by religious tradition; legally community reserves (Wildlife Amendment Act, 2002).
- Svalbard Global Seed Vault (Norway) is the "doomsday vault"; India's high-altitude seed vault is at Chang La, Ladakh.
- IDWH scheme: centrally sponsored, with recovery programme for critically endangered species.

Local names of sacred groves

State	Name
Rajasthan	Orans, Vani, Kenkri
Meghalaya	Ki Law Lyngdoh, Ki Law Kyntang

Environmental movements

Movement	Year	Place	Leader	Key point
Bishnoi (Khejarli)	1730	Jodhpur	Amrita Devi	363 Bishnois died protecting Khejri trees
Chipko	1973	Chamoli, Uttarakhand	Sunderlal Bahuguna, Chandi Prasad Bhatt, Gaura Devi	Hugging trees; "Ecology is permanent economy"
Appiko	1983	Karnataka	Pandurang Hegde	Western Ghats; inspired by Chipko
Narmada Bachao Andolan	1985	Narmada valley	Medha Patkar	Against Sardar Sarovar dam

International Efforts for Biodiversity**Key biodiversity treaties**

Instrument	Year / fact	Key point
CBD	Rio Earth Summit 1992; in force 1993	Conservation, sustainable use, fair benefit sharing; USA has not ratified
Cartagena Protocol	2000 (in force 2003)	Biosafety; living modified organisms

Instrument	Year / fact	Key point
Nagoya Protocol	COP10, 2010 (in force 2014)	Access and Benefit Sharing
Aichi Targets	COP10, 2010 (2011-2020)	20 targets, 5 strategic goals
Kunming-Montreal GBF	COP15, Dec 2022	23 targets for 2030, including 30x30
ITPGRFA	2001	International Seed Treaty; farmers' rights
TEEB	2007 (G8+5), Pavan Sukhdev	Economic value of biodiversity; hosted by UNEP

CBD Conferences of the Parties

COP	Year	Venue
COP10	2010	Nagoya, Japan
COP11	2012	Hyderabad, India
COP12	2014	Pyeongchang, South Korea
COP13	2016	Cancun, Mexico
COP14	2018	Sharm El-Sheikh, Egypt
COP15	2021-22	Kunming; Montreal (Dec 2022)
COP16	2024	Cali, Colombia (Cali Fund for DSI)
COP17	2026	Yerevan, Armenia

- Biological Diversity Act 2002 created the National Biodiversity Authority (NBA, 2003, Chennai); GM-crop research is supervised by GEAC, not NBA.
- Biodiversity Management Committees (BMCs) implement Nagoya Protocol locally and can levy collection fees.

Environmental Degradation

- India's forest cover is 21.76% and forest plus tree cover 25.17% (ISFR 2023); National Forest Policy 1988 target is 33%.
- India targets net zero by 2070. CFCs were phased out by 2010; HFCs are being phased down under Kigali Amendment.

Government initiatives

Initiative	Detail
Compensatory Afforestation Act 2016	Equal non-forest land or twice degraded forest area
National Clean Air Programme	Air pollution abatement
National Green Tribunal	Established 2010
Environmental laws	Water Act 1974, Air Act 1981, EP Act 1986
Constitution	Art 48A (DPSP), Art 51A(g) (duty), Art 21

- Act years: Wildlife (Protection) 1972; Forest (Conservation) 1980 (renamed Van Adhiniyam, 2023); Environment (Protection) 1986; Biological Diversity 2002; Forest Rights 2006.
- SDG 14 = life below water; SDG 15 = life on land. Agenda 21 = Rio 1992 roadmap.

Land Degradation and Desertification

- Land degradation = long-term loss of productivity; desertification = degradation of dry lands (arid, semi-arid, dry sub-humid) from human activity and climate.

Land degradation in India (ISRO Atlas 2021)

Indicator	Figure
Degraded land (2018-19)	About 97.85 million ha = 29.77% of area
Water erosion	11.01% of area
Vegetation degradation	9.15%
Wind erosion	5.46%
Top states	Rajasthan, Maharashtra, Gujarat, Karnataka, Ladakh, Jharkhand, Odisha, MP, Telangana

Causes and remedies

Causes	Remedies
Deforestation, overgrazing, wrong ploughing	Terracing, windbreaks / shelter belts
Shifting cultivation, urbanisation, mining	Dune stabilisation, cover crops, crop rotation
Excess pesticides, drought, climate change	Rotational grazing, watershed management

UNCCD and Land Degradation Neutrality

- UNCCD: adopted 1994 (Paris), in force 1996; secretariat in Bonn. World Day to Combat Desertification and Drought: 17 June.
- LDN: stable or growing land resources; SDG target 15.3 by 2030; hierarchy Avoid, Reduce, Reverse.
- India's target: restore 26 million ha of degraded land by 2030 (announced at UNCCD COP14, New Delhi, 2019).
- UNCCD COP16: Riyadh (2024), on drought. COP17: Ulaanbaatar, Mongolia (August 2026), "Restoring Land. Restoring Hope."; binding drought framework deferred to COP18 (Egypt, 2028).
- Glasgow Leaders' Declaration on Forests and Land Use (COP26): stop forest loss and land degradation by 2030.

Indian schemes against desertification

Scheme	Detail
Desert Development Programme	Since 1977-78
National Action Programme to Combat Desertification	2001
Green India Mission	Part of NAPCC
Green Wall (Aravalli)	1,400 km belt, Porbandar to Panipat; inspired by Africa's Great Green Wall
Soil Health Card	Launched 19 February 2015 (Suratgarh, Rajasthan); 12 parameters

Sea buckthorn

Shrub of cold deserts (Ladakh, Spiti, Lahaul); soil-binding, controls erosion, fixes nitrogen.
Rich in vitamins; not a source of biodiesel or commercial timber.

Remember - land and soil

High organic matter increases water holding capacity.

Irrigation can cause salinisation; deforestation causes erosion, terracing reduces it.

Aral Sea shrank due to human activities. Soils are the largest terrestrial carbon sink.



CHAPTER 03

Endangered Species, Ramsar Convention; Biodiversity: Miscellaneous

Wildlife Status, Threats and Human-Wildlife Conflict

Status of Wildlife in India

- India: ~2.4% of world land area but ~8% of known biodiversity; one of 17 megadiverse countries.
- Living Planet Report 2024 (WWF): ~73% average decline in monitored wildlife populations (1970–2020).
- World Wildlife Day: 3 March (anniversary of CITES signing, 1973); proposed at CITES CoP16 (Bangkok, 2013), adopted by UNGA 20 Dec 2013.
- Wildlife Week: 1–7 October; World Environment Day 5 June; International Day of Forests 21 March.
- WWF: founded 1961; logo = Giant Panda (*Ailuropoda melanoleuca*).
- Bombay Natural History Society (BNHS): NGO (since 1883); NOT a government/autonomous body under MoEFCC.
- Awards: Rajiv Gandhi Wildlife Conservation Award (MoEFCC); Amrita Devi Bishnoi Award (Rajasthan).
- SDG 15 = Life on Land; SDG 14 = Life Below Water.

Threats to Wildlife in India

Threat	Key point
Habitat loss	Primary cause of species extinction (mining, infrastructure, agriculture)
Illegal wildlife trade	Second only to habitat loss in driving endangerment
Invasive alien species	Displace natives

Commonly Confused - Causes of Biodiversity Loss

Single most important cause = destruction of natural habitat.

Five main drivers (IPBES): habitat change, overexploitation, climate change, pollution/nutrient loading, invasive alien species.

Extinction of one species can drag down dependent species (Dodo and Tambalacoque tree, Mauritius).

NOT causes: afforestation of barren land, promotion of vegetarianism, creation of biosphere reserves.

Traits raising extinction risk: narrow niche (specialist), large body size, low genetic variability.

DDT and pesticides thin bird eggshells; jhum cultivation causes barren hills in Nagaland.

Human-Wildlife Conflict (HWC)

- IUCN (2020): negative interactions between humans and wildlife with undesirable results for people, resources, wildlife and habitats.
- Causes: habitat destruction, agricultural expansion, competition for land/food/water, humans moving close to habitats.
- Impacts: crop loss, food insecurity, costs borne by local communities, top predators and keystone species most at risk.

Conflict Data (2018–19 to 2020–21)

Item	Figure
Elephants killed by electrocution	222

Item	Figure
Humans killed by elephants (3 years)	1,579 (Odisha highest)

Solutions and Models

- **Sonitpur Model** (Assam): WWF-India, 2003-04; trained locals plus low-cost non-lethal single-strand electric fence.
- Odisha: seed balls in reserve forests to improve elephant food; Uttarakhand: bio-fence (2019).
- Surveillance: sensors, SMS-chip elephant collars, early warning; community participation; more protected areas.

HWC Advisory (SC-NBWL)

Component	Content
Gram Panchayats	Empowered to deal with problem animals under Sec 11(1)(b) of WPA 1972
Insurance	PMFBY add-on cover for crop damage by wildlife

- National Wildlife Action Plan (NWAP) 2017-2031 has a dedicated chapter on managing conflict.
- Section 62 of WPA: protected species can be declared vermin for a limited period (monkeys in Himachal Pradesh; nilgai and wild boar in Bihar).

Eco-bridges

- Eco-ducts restore connectivity broken by highways: canopy bridges (arboreal species), underpasses/overpasses (large animals), amphibian tunnels.
- Best example: NH-44 through Pench-Navegaon-Nagzira and Kanha-Pench corridors (5 animal underpasses, 4 small bridges in 6.6 km).

Constitutional and Legal Hooks

- Article 48A (DPSP): State to protect environment, forests and wildlife (42nd Amendment, 1976).
- Article 51A(g) (Fundamental Duty): protect and improve natural environment including forests, lakes, rivers, wildlife.
- 42nd Amendment moved "protection of wild animals and birds" to Concurrent List (Entry 17B).
- Wildlife (Protection) Act 1972: first comprehensive wildlife law; originally 66 sections, 6 schedules.
- Section 39: every wild animal is State property.
- A protected animal may be captured/killed only if dangerous to human life or disabled beyond recovery, by Chief Wildlife Warden's order - mere apprehension is not enough.
- Pre-2022 Schedule I = tiger-level protection (gharial, Indian wild ass, wild buffalo cannot be hunted).
- Community Reserve (Sec 36C/36D): private/community land declared by State; Community Reserve Management Committee chairman = Honorary Wildlife Warden; hunting and jhum barred, NTFP collection allowed.
- Forest Rights Act 2006 defines "Critical Wildlife Habitat"; Baigas got first-ever Habitat Rights.
- Chronology: WPA 1972 -> Project Tiger 1973 -> Project Elephant 1992 -> Biological Diversity Act 2002.

Wildlife (Protection) Amendment Act 2022 - Key Changes

Schedules cut from 6 to 4: Sch I and II (animals), Sch III (plants), Sch IV (CITES-listed specimens).
 Old Schedule V (vermin) deleted; plants moved from old Schedule VI to Schedule III.
 Centre can regulate or prohibit import, trade, possession and spread of invasive alien species.
 Centre designates a CITES Management Authority and Scientific Authority.
 Centre can notify Conservation Reserves (earlier only States).

Red List, CITES, CMS and International Wildlife Bodies

IUCN and the Red List

- IUCN: founded 1948 (Fontainebleau, France); HQ Gland, Switzerland; members are governments and NGOs.
- Earlier names: International Union for the Protection of Nature (1948-56); World Conservation Union (1990-2008).
- Not a UN organ; has observer status at the UN. Helped found WWF.
- Red List began 1964; called "Barometer of Life"; Red Data Book lists threatened species.
- Red List 2026-1 (July 2026): 175,909 species assessed; 49,505 threatened (~28%).
- Asian elephant = EN, mugger crocodile = VU, gharial = CR.

IUCN Red List Categories

Category	Code	Meaning / quantitative cue
Extinct	EX	No individual remains
Extinct in the Wild	EW	Survives only in captivity or outside range
Critically Endangered	CR	Extremely high risk; $\geq 50\%$ chance of extinction in 10 years or 3 generations
Endangered	EN	Very high risk; $\geq 20\%$ in 20 years or 5 generations
Vulnerable	VU	High risk; $\geq 10\%$ in 100 years
Near Threatened	NT	Close to qualifying for threatened
Least Concern	LC	Widespread and abundant
Data Deficient	DD	Inadequate information
Not Evaluated	NE	Not yet assessed

- Threatened = CR + EN + VU. Criteria A to E: population reduction, geographic range, small population, very small population, quantitative analysis.

Commonly Mixed-up IUCN Statuses

Indian (one-horned) rhino = VU; Javan and Sumatran rhinos = CR.
 Snow leopard = VU; fishing cat = VU; dugong = VU; olive ridley = VU.
 Asiatic cheetah = CR; African cheetah = VU.
 Asian elephant, tiger, Asiatic lion, Gangetic dolphin, red panda, golden langur, hoolock gibbon, dhole, whale shark = EN.
 Hawksbill turtle, Great Indian Bustard, Siberian crane, sociable lapwing = CR; Indian wild ass (khur) = NT.

CITES (Washington Convention)

CITES Basic Facts

Item	Detail
Signed / in force	1973 at Washington / 1 July 1975
Secretariat	Geneva; administered by UNEP
Aim	International trade must not threaten survival of wild animals and plants
Nature	Legally binding on parties but does not replace national laws

Item	Detail
CoP	Every 2-3 years
India	Party since 1976; hosted CoP3 at New Delhi (1981)
Parties	185
Recent CoPs	CoP18 Geneva (2019); CoP19 Panama (2022); CoP20 Samarkand, Uzbekistan (Nov-Dec 2025)
Coverage	~41,000 species; 1,000+ in App I, ~39,000 in App II
Other	TRAFFIC monitors trade; all Indian pangolins App I since CoP17 (2016)

CITES Appendices

Appendix	Covers	Trade rule	Examples
I	Species threatened with extinction	Commercial trade banned; import and export permits needed	Sea turtles, gorillas, tiger, Asian elephant
II	Not yet threatened but trade must be controlled	Export permit if trade not detrimental	Paddlefish, mahogany, corals
III	Protected in at least one country that seeks others' help	Export permit from listing country; certificate of origin from others	Walrus, map turtles

CITES CoP20 (Samarkand, 2025) Outcomes

Item	Outcome
Proposals	77 species added to appendices
Sharks and rays	Oceanic whitetip shark, whale shark, manta and devil rays moved to Appendix I
Elephants and rhinos	Bid to ease African elephant trade protection rejected; rhino downlisting rejected
Other	Saiga protection eased; giraffe delisting failed

CMS (Bonn Convention)

Convention on Migratory Species

Item	Detail
Adopted / in force	1979, Bonn / 1983; under UNEP
India	Party since 1983
Parties	132 states plus the EU
Uniqueness	Only global UN-based body for terrestrial, aquatic and avian migratory species
Appendix I	Migratory species threatened with extinction; strict protection
Appendix II	Species needing or benefiting from international cooperation

Item	Detail
COP13	Gandhinagar, India, Feb 2020; mascot Great Indian Bustard; Gandhinagar Declaration on ecological connectivity
COP13 Indian additions (App I)	Asian elephant, Great Indian Bustard, Bengal florican
COP14 / COP15	Samarkand (2024) / Campo Grande, Brazil (March 2026)
COP16	Bonn, 2029

- India's non-binding CMS MoUs: Siberian Crane (1998), Marine Turtles (2007), Dugong (2008), Raptors (2016).
- Central Asian Flyway (CAF): Siberia to West/South Asia and Maldives; India's National Action Plan for CAF 2018-23.

Anti-trafficking and Trade Bodies

Wildlife Trade and Crime Bodies

Body	Key facts
TRAFFIC	Wildlife Trade Monitoring Network; est. 1976; joint programme of WWF and IUCN (NOT a UNEP bureau); HQ Cambridge, UK; works with CITES
WCCB	Wildlife Crime Control Bureau (statutory body under WPA)
BirdLife International	NGO partnership; identifies Important Bird and Biodiversity Areas (IBAs)
Wetlands International	Independent NGO (not intergovernmental); HQ Netherlands; waterbird census, peatlands
National Biodiversity Authority (NBA)	Statutory body under Biological Diversity Act 2002; HQ Chennai; checks biopiracy (GEAC supervises GM crops)

Remember - IUCN vs CITES

IUCN is NOT a UN organ; CITES is an agreement between governments.

IUCN compiles the Red List; CITES regulates trade.

TRAFFIC is a WWF-IUCN programme, not a UNEP bureau.

Tiger-linked International Arrangements

Tiger and Snow Leopard Initiatives

Initiative	Key facts
Global Tiger Forum (GTF)	Only intergovernmental body focused on tigers; founded 1994; HQ New Delhi
Global Tiger Initiative (GTI)	Launched 2008 (World Bank-led); widened to snow leopards 2013
St Petersburg Declaration	Nov 2010; Global Tiger Recovery Programme "T x 2" (double wild tigers by 2022)
Tiger Range Countries	13
Global Tiger Day	29 July
Bishkek Declaration	"Secure 20 by 2020": 20 snow leopard landscapes

Initiative	Key facts
M-STrIPES	Monitoring System for Tigers - Intensive Protection and Ecological Status; NTCA + WII, 2010
TX2 Award	Sathyamangalam Tiger Reserve

- Tigers in India: 3,682 (2022); 2,967 (2018).
- Pugmark technique = census from footprints; replaced by camera trapping and M-STrIPES.

Invasive Alien Species (IAS)

- Alien (exotic) species: introduced outside natural range; invasive: spreads and harms native biodiversity, economy or health.
- IPBES 2023: >37,000 alien species worldwide; ~3,500 harmful invasive ones.
- Kunming-Montreal GBF (2022) Target 6: cut introduction and establishment of IAS by at least 50% by 2030.
- CBD COP17: Yerevan, Armenia, 19-30 October 2026.
- IUCN Invasive Species Specialist Group maintains the Global Invasive Species Database.

Major Invasive Species in India

Species	Type	Origin / note
Lantana camara	Shrub	Tropical America; chokes forest undergrowth
Water hyacinth (Eichhornia crassipes)	Aquatic weed	South America; "Terror of Bengal"; eutrophication
Prosopis juliflora	Tree	Mexico/Central America; invades grasslands
Parthenium hysterophorus	Weed	Congress/carrot grass; came with imported wheat
Mikania micrantha	Climber	"Mile-a-minute"; Kerala and north-east

Endangered Species: Species-wise Status Tables

Key Species - Status and Habitat

Species	IUCN	WPA	CITES	Habitat / note
Great Indian Bustard	CR	Sch I	App I	Rajasthan (Desert NP), Gujarat; Rajasthan state bird
Siberian crane	CR	Sch I	App I	Winter visitor; Keoladeo
Gharial	CR	Sch I	App I	Chambal and Himalayan rivers
Vultures (red-headed, white-rumped, Indian, slender-billed)	CR	Sch I	-	Diclofenac poisoning
Hangul (Kashmir stag)	CR	Sch I	-	Dachigam NP; J&K state animal
Asiatic cheetah	CR	-	App I	Only Iran now; extinct in India

Species	IUCN	WPA	CITES	Habitat / note
Asian elephant	EN	Sch I	App I	National Heritage Animal
Tiger	EN	Sch I	App I	Royal Bengal tiger
Asiatic lion	EN	Sch I	App I	Gir (Gujarat) only
Lion-tailed macaque	EN	Sch I	App I	Endemic to Western Ghats (Kerala, Karnataka, Tamil Nadu)
Nilgiri tahr	EN	Sch I	-	Western Ghats grasslands; Tamil Nadu state animal
Gangetic dolphin	EN	Sch I	App I	National aquatic animal
Red panda	EN	Sch I	App I	Eastern Himalaya
Sangai (brow-antlered deer)	EN	Sch I	App I	Keibul Lamjao NP, Loktak; Manipur state animal
Hoolock gibbon	EN	Sch I	App I	North-east India; India's only ape
Indian (one-horned) rhino	VU	Sch I	App I	Assam, West Bengal, UP
Snow leopard	VU	Sch I	App I	High Himalaya
Dugong	VU	Sch I	App I	Gulf of Mannar, Palk Bay, A&N, Kutch
Olive ridley turtle	VU	Sch I	App I	Odisha (Gahirmatha) mass nesting
Fishing cat	VU	Sch I	App II	Wetlands, mangroves
Indian wild ass (khur)	NT	Sch I	App II	Little Rann of Kachchh

- Hornbills: India has 9 species; Hornbill Festival (Nagaland) is named after the Great Hornbill.

Species Facts Frequently Asked

Lion-tailed macaque is found in Tamil Nadu, Kerala, Karnataka (NOT Andhra Pradesh).

Only floating national park in the world: Keibul Lamjao (Manipur).

Gahirmatha (Odisha) = world's largest olive ridley nesting beach.

Black-necked crane, flying squirrels and snow leopard are naturally found in India; spider monkey, bonobo, elk, indri are not.

Indian flying fox is a bat; slow loris lives in north-east forests; red panda is also found in Sikkim, West Bengal, Arunachal, Meghalaya.

Gharial best seen in Chambal (National Chambal Sanctuary); dugong feeds on seagrass.

Scientific Names Tested

Animal	Scientific name
Indian wild ass	Equus hemionus khur

Animal	Scientific name
Gharial	Gavialis gangeticus
Indian elephant	Elephas maximus indicus

Species Conservation Programmes

Project Elephant (1992)

- Centrally sponsored scheme launched February 1992; elephant declared National Heritage Animal (2010).
- Aims: protect elephants, habitat and corridors; mitigate human-elephant conflict; welfare of captive elephants.
- Elephant census every 5 years (direct sighting; indirect dung-decay). Matriarchal herds; gestation ~22 months.

Elephant Data

Item	Fact
2025 DNA-based census (SAIEE, WII)	22,446 elephants (27,312 in 2017; method differs)
Top states	Karnataka 6,013; Assam 4,159; Tamil Nadu 3,136; Kerala 2,785
Corridors	150 identified (2023 report); West Bengal has most (26)

Indian Rhino Vision (IRV) 2020

- Assam Forest Department with WWF-India, International Rhino Foundation; goal: raise Assam's rhinos to 3,000 by 2020 across 7 PAs via translocation (Kaziranga, Pobitora to Manas etc.).
- Rhinos in Assam: Kaziranga, Orang, Pobitora, Manas; Kaziranga holds about two-thirds of the world's one-horned rhinos.
- Dudhwa (UP): rhinos reintroduced 1984 from Assam.
- New Delhi Declaration on Asian Rhinos (2019): five range countries - India, Bhutan, Nepal, Indonesia, Malaysia; Chitwan Declaration (2023).

Rhino Species of the World

Species	Region	Horns	IUCN
Indian (greater one-horned)	India, Nepal	1	VU
Javan	Java	1	CR
Sumatran (smallest)	Sumatra/Borneo	2	CR

Project Cheetah (Reintroduction)

- Cheetah declared extinct in India in 1952; last three shot in 1947 in Koriya (Chhattisgarh).
- India-Namibia MoU (July 2022); first 8 cheetahs flown to Kuno National Park (MP) on 17 September 2022; 12 from South Africa in February 2023.
- Gandhi Sagar Sanctuary (MP) is the second site; 9 from Botswana arrived Feb 2026.
- Population: 60 on 5 October 2026 (MoEFCC), about 41 India-born. Implemented by NTCA.

Asiatic vs African Cheetah

Feature	Asiatic	African
Scientific name	Acinonyx jubatus venaticus	Acinonyx jubatus

Feature	Asiatic	African
Range	Iran only (fewer than 100)	Across Africa
IUCN	CR	VU

Other Recovery and Species Projects

Species Projects

Project	Key facts
Recovery of Critically Endangered Species	Component of Integrated Development of Wildlife Habitats (IDWH); 100% central assistance; species include snow leopard, bustards, dolphin, hangul, Nilgiri tahr, marine turtles, dugong, Asian wild buffalo, vultures, Malabar civet, Indian rhino, Asiatic lion, swamp deer, Jerdon's courser
SAVE (vultures)	Diclofenac identified as cause (2003-04); veterinary diclofenac banned 2006
Vulture Action Plan 2020-25	All 9 Indian species; ban aceclofenac and ketoprofen for vet use; Vulture Safety Zones
Project Snow Leopard	Snow leopards in India: 718 (SPAI 2019-23 report); Ladakh ~477
Project Dolphin	Announced 2020; Gangetic dolphin = National Aquatic Animal (5 October 2009) and Ganga indicator species

- Great Indian Bustard: ~130 individuals; Desert National Park (Jaisalmer) last viable habitat; breeding centre at Sam (Jaisalmer); main threat = collision with overhead power lines.

Western Ghats

Overview

Western Ghats at a Glance

Item	Fact
Other names	Sahyadri (Maharashtra), Sahya Parvatham (Kerala)
Extent / States	Tapi to Kanyakumari; 6 states - Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu
Area	~1.6 lakh sq km (about 5% of India)
Highest peak	Anamudi (2,695 m), Kerala - highest in India outside the Himalaya
Hotspot	Western Ghats-Sri Lanka hotspot
Plants	~5,000 vascular plants; ~34% endemic
UNESCO	World Heritage Site (2012) - 39 sites in 7 clusters
Coastal strips	Konkan (north), Kanara (central), Malabar (south)

- UNESCO clusters: Agasthyamalai, Periyar, Anamalai, Nilgiri, Talakaveri, Kudremukh, Sahyadri.
- Eastern Ghats are not a hotspot. India's hotspots: Himalaya (Eastern Himalaya in exam usage, but the CI hotspot spans the whole Himalayan arc incl. parts of the Western Himalaya), Indo-Burma, Western Ghats-Sri Lanka, Sundaland (Nicobar).

- Silent Valley (Palakkad, Kerala): last tropical rainforest of Kerala; saved by people's movement from hydel project; National Park 1984; Kuntipuzha river.
- Eravikulam NP (Idukki) holds largest Nilgiri tahr population; Nilgiri BR = Nagarahole, Bandipur, Wayanad, Mudumalai.
- Sathyamangalam Tiger Reserve links Western and Eastern Ghats.

Rivers and Passes of Western Ghats

Item	Details
East-flowing rivers	Godavari, Krishna, Kaveri, Tunga, Bhadra, Bhima
West-flowing rivers	Periyar, Bharathappuzha, Netravati, Sharavathi, Mandovi
Palakkad Gap	Coimbatore (TN) - Palakkad (Kerala)

- Western slopes: moist evergreen forests; eastern slopes: deciduous forests (teak, sal, sandalwood); Shola = montane forest with grasslands.
- Neelakurinji (Strobilanthes) flowers in shola forests. Only ~10% of Western Ghats is under protected areas.
- Threats: plantations, mining (iron ore in Goa), hydropower dams, grazing, human-wildlife conflict, encroachment.

Committees on the Western Ghats

Gadgil vs Kasturirangan

Feature	Gadgil (WGEEP)	Kasturirangan (HLWG)
Year	Report 2011	Report 2013
Approach	Whole Western Ghats as Ecologically Sensitive Area (ESA); 3 zones ESZ-1 to ESZ-3	Natural (~41%) vs cultural (~59%) landscape
ESA extent	Entire region	Only 37% of Western Ghats
Mining	No new mining in ESZ-1 and ESZ-2	Ban on mining, quarrying, sand mining in ESA
Governance	Bottom-up from Gram Sabhas; statutory Western Ghats Ecology Authority	Strengthened clearance framework

- ESA draft prohibitions: mining, quarrying, sand mining, new thermal power, Red-category industries, large buildings (20,000 sq m+) and area development projects (50 ha+).

Eco-Sensitive Zones (ESZ)

- ESZ notified around National Parks and Wildlife Sanctuaries under the Environment (Protection) Act 1986; "shock absorber" between highly and less protected areas.
- Wildlife Conservation Strategy 2002: ESZ may extend up to 10 km.
- Supreme Court (June 2022): mandatory 1 km ESZ around every national park and sanctuary (later modified 2023 to exempt PAs with notified/proposed ESZ).
- In ESZ: commercial mining, sawmills and commercial use of wood barred; agriculture not affected.

Wetlands and the Ramsar Convention

Wetland Basics

- Ramsar definition: marsh, fen, peatland or water, natural or artificial, permanent or temporary, fresh, brackish or salt, including marine water not deeper than 6 m at low tide.
- Wetlands are ecotones between terrestrial and aquatic ecosystems; "Nature's kidneys".
- Peatlands: ~3% of land but store twice as much carbon as forests.

- India's wetlands: ~4.6% of area (National Wetland Atlas 2011); inland > coastal; Gujarat has largest wetland area.

Lakes vs Wetlands

Feature	Lakes	Wetlands
Depth	Minimum 3 m	Less than 3 m
Productivity and biodiversity	Lower	Higher
Trophic status	Oligotrophic	Eutrophic
Dominant producer	Phytoplankton	Macrophytes
Thermal stratification	Present	Absent
Flood control	Limited	Very significant

Ramsar Convention

Ramsar Convention Facts

Item	Detail
Signed	2 Feb 1971, Ramsar, Iran (World Wetlands Day)
Nature	Intergovernmental treaty, legally binding on Parties (no sanctions); each Party designates at least one site and promotes wise use of all wetlands; UNESCO is depositary
Secretariat	Gland, Switzerland
Objectives	Conservation and wise use of wetlands
India	Ratified 1 Feb 1982
In force	21 December 1975
First site worldwide	Cobourg Peninsula, Australia (1974)
Most sites	UK, Mexico, then India (3rd)
Largest area	Bolivia
COP14 / COP15	Wuhan/Geneva (2022) / Victoria Falls, Zimbabwe (July 2025)
World Wetlands Day theme 2026	"Wetlands and Traditional Knowledge: Celebrating Cultural Heritage"

- India is obliged to protect only designated Ramsar sites, not every wetland.
- Wetlands (Conservation and Management) Rules 2010 were based on National Environment Policy 2006 expert panel, not Ramsar; Rules 2017 shifted management to State bodies.
- Wetland plants with aerenchyma thrive where water level fluctuates.

Nine Ramsar Site Criteria

No.	Criterion
1	Representative, rare or unique wetland type
2	Supports threatened species or ecological communities
3	Supports species important for biological diversity
4	Species at a critical life stage or refuge
5	Regularly supports 20,000 or more waterbirds

No.	Criterion
6	Supports 1% of a waterbird population
7	Significant proportion of indigenous fish subspecies/families
8	Fish food source, spawning ground, nursery, migration path
9	Supports 1% of non-bird wetland-dependent animal species

Montreux Record

- Register of Ramsar sites where ecological character has changed or is likely to change due to technology, pollution or human interference; named after Montreux, Switzerland (1990).
- Indian sites on the Record: Keoladeo National Park (Rajasthan) and Loktak Lake (Manipur).
- Chilika was listed in 1993 and removed in 2002; Chilika Development Authority got Ramsar Wetland Conservation Award 2002.
- Montreux Record is not a heritage status and not a law banning activity.

Wetlands International

- Founded 1937 (International Wildfowl Inquiry); renamed Wetlands International 1995; independent NGO; runs International Waterbird Census.

India's Ramsar Sites

Ramsar Sites in India - Key Numbers

Item	Fact
Total sites	103 (as of 15 October 2026); only 26 in 2014
101st site	Glaw Lake, Arunachal Pradesh (state's first)
Rank	3rd in world (after UK and Mexico); 1st in Asia
First Indian sites	Chilika Lake (Odisha) and Keoladeo NP (Rajasthan), 1981
Largest site	Sundarban Wetland, West Bengal (4,230 sq km; 2019)
State with most sites	Tamil Nadu (20); Uttar Pradesh second (14)
Montreux Record	Keoladeo + Loktak

Ramsar Sites in India - State-wise List

State / UT	No.	Sites
Tamil Nadu	20	Point Calimere; Pichavaram Mangrove; Pallikaranai Marsh; Gulf of Mannar Marine BR; Vedanthangal; Vembannur; Koonthankulam; Longwood Shola; others
Uttar Pradesh	14	Upper Ganga; Sur Sarovar; Haiderpur; Bakhira; Saman; Samaspur; Sandi; Sarsai Nawar; Nawabganj; Parvati Arga; Patna BS; Shekha Jheel; Surha Tal; Sauj Jheel (2026)

State / UT	No.	Sites
Punjab	6	Harike; Kanjli; Ropar; Beas Conservation Reserve; Keshopur-Miani; Nangal
Odisha	6	Chilika; Bhitarkanika Mangroves; Satkosia Gorge; Ansupa; Hirakud Reservoir; Tampara
Bihar	6	Kanwar Taal; Nagi; Nakti; Udaipur; Gokul Jalashay; Gogabeel
Rajasthan	5	Keoladeo NP; Sambhar Lake; Siliserh; Khichan; Menar
Gujarat	5	Nalsarovar; Thol; Wadhvana; Khijadiya; Chhari-Dhand
Madhya Pradesh	5	Bhoj Wetland; Sakhya Sagar; Sirpur; Yashwant Sagar; Tawa Reservoir
Jammu and Kashmir	5	Wular; Hokera; Surinsar-Mansar; Hygam; Shallabugh
Karnataka	4	Ranganathittu; Ankasamudra; Aghanashini Estuary; Magadi Kere
Kerala	3	Ashtamudi; Sasthamkotta; Vembanad-Kol
Himachal Pradesh	3	Pong Dam; Chandertal; Renuka
Maharashtra	3	Nandur Madhameshwar; Lonar Lake; Thane Creek
West Bengal	2	Sundarban Wetland; East Kolkata Wetlands
Haryana	2	Bhindawas Wildlife Sanctuary; Sultanpur National Park
Chandigarh (UT)	1	Sukhna Wetland (2026)
Ladakh	2	Tso Kar Wetland Complex; Tsomoriri
Others (1 each)	11	Andhra Pradesh - Kolleru; Assam - Deepor Beel; Arunachal - Glaw Lake; Chhattisgarh - Kopra; Goa - Nanda Lake; Jharkhand - Udhwa; Manipur - Loktak; Mizoram - Pala; Sikkim - Khecheopalri; Tripura - Rudrasagar; Uttarakhand - Asan Barrage

High-yield Ramsar Site Facts

Site	Fact
Loktak (Manipur)	Largest freshwater lake in North-East; floating biomass "phumdis"; Keibul Lamjao NP - only floating NP, home of sangai
Chilika	Largest brackish lagoon in Asia; Irrawaddy dolphin
Sambhar	Largest inland saline lake in India (Rajasthan)

Site	Fact
Renuka	Smallest Ramsar site (with Vembannur); Himachal Pradesh
Hokera	Jammu and Kashmir (NOT Punjab)
East Kolkata Wetlands	Sewage-fed fisheries; wise use model
Bhitarkanika	Mangrove; saltwater crocodile; Brahmani-Baitarani delta, Kendrapara (Odisha)
Keoladeo (Bharatpur)	World Heritage Site 1985; Gambhir-Banganga confluence; wintering ground of Siberian crane; Montreux Record

Functions and Depletion

- Functions: biodiversity, flood control, groundwater recharge, sediment and nutrient retention, carbon sink, livelihoods, migratory bird habitat.
- Depletion causes: agriculture conversion, eutrophication, urbanisation, overgrazing, pollution, climate change.
- Aral Sea (Central Asia) lost over 90% of its area due to irrigation diversion.

Wetland Programmes and Rules

Wetland Conservation Programmes in India

Programme	Key points
National Wetlands Conservation Programme (NWCP)	Started 1985-86
NPCA	2013; merger of National Lake Conservation Plan and NWCP; Wetland Mitras; Wetland Health Card
Amrit Dharohar	Budget 2023-24; optimal use of wetlands, ecotourism

Wetlands (Conservation and Management) Rules, 2017

Feature	Provision
Legal basis	Environment (Protection) Act 1986; replaced 2010 Rules
Applies to	Ramsar sites; wetlands notified by Centre, State or UT
Excluded	River channels, paddy fields, human-made water bodies, wetlands under Forest Act, WPA, CRZ
Authority	State Wetlands Authority in each State/UT
National body	National Wetland Committee - only advisory
Prohibited	Encroachment, solid waste dumping, untreated effluents, reclamation, industrial discharge
Inventory	Digital inventory updated every 10 years

Estuarine Ecosystem

- Estuary: partially enclosed coastal brackish water body with river(s) and free connection to open sea; ecotone between river and marine ecosystems.
- Adaptation to salinity change is osmoregulation.

- Tidal bore: leading edge of incoming tide moving up a river against its current.

Classification of Estuaries

Basis	Type	Key point
Environment	Open	Never cut off from ocean (Hooghly)
Environment	Blind	Small; summer sandbar closes the mouth
Salinity	Positive	Freshwater inflow exceeds evaporation
Geomorphology	Bar-built	Lagoon sheltered by sandbar (Coromandel coast)
Geomorphology	Tectonic	Faulting of land (San Francisco Bay)

Estuary vs Delta vs Lagoon

Feature	Estuary	Delta	Lagoon
Origin	Freshwater meets sea; sea-level rise	River deposition of silt; triangular	Sandbank separates sea water
Indian examples	Narmada, Tapi, Mandovi, Zuari	Ganga, Mahanadi, Godavari, Krishna, Cauvery	Kerala backwaters

- West-flowing rivers form estuaries; east-coast rivers form deltas.
- Krishna delta: "Granary of South India".
- Estuaries are among the most productive ecosystems; low species richness but many endemic species.

Mangrove Ecosystem

Basics

- Mangroves: salt-tolerant (halophytic) trees of tropical/subtropical coasts, roughly 25 degrees N to 25 degrees S; cannot survive freezing.
- "Mangroves are nurseries, seagrasses secondary schools, coral reefs the colleges" of fishes.

Mangrove Adaptations

Adaptation	Detail
Pneumatophores	Breathing roots in anoxic mud (Avicennia)
Prop / stilt roots	Aerial roots from trunk (Rhizophora)
Succulent leaves	Store fresh water; cut transpiration
Vivipary	Seed germinates on parent tree; propagule drops and roots
Salt excretion	Handle high salinity

Mangrove Cover and Distribution

Mangrove Cover Data

Item	Fact
India (ISFR 2023)	4,991.68 sq km (~0.15% of area); net fall of 7.43 sq km from 2021

Item	Fact
Largest share (sq km)	1 West Bengal 2,119.16 (Sundarbans); 2 Gujarat 1,164.06; 3 Andaman and Nicobar 608.29; 4 Andhra Pradesh 421.43
Largest rises	Andhra Pradesh +13.01, Maharashtra +12.39, Karnataka +2.54
World	~14.79 million ha in 113 countries; Asia top continent

Major Mangrove Sites of India

Site	Key facts
Sundarbans (West Bengal)	World's largest mangrove block; only mangrove with tigers; Sundari tree (<i>Heritiera fomes</i>)
Bhitarkanika (Odisha)	Second largest mangrove ecosystem in India; saltwater crocodile
Andaman and Nicobar	Pristine, varied mangroves

- Kharai camel (Kutch): swims in sea up to ~3 km, feeds on mangroves.
- Chorao Island (Goa) has protected mangroves.

Commonly Confused - Mangroves

Second largest mangrove area by State = Gujarat (ISFR 2023); Bhitarkanika is the second largest mangrove ecosystem (Odisha).

Bhitarkanika is in Kendrapara, Odisha, NOT West Bengal; not a World Heritage Site.

Mangroves resist storms because of extensive roots that do not get uprooted.

MISHTI announced in Union Budget 2023-24, launched 5 June 2023; aim = restore and promote mangroves.

Significance and Threats

- Carbon sinks (blue carbon): store 3-5 times more carbon per area than tropical forests.
- Coastal protection from cyclones, storm surges, tsunamis; nursery for >75% of fish species.
- Threats: sea-level rise (greatest), shrimp farms (at least 35% of loss), aquaculture, dams, coastal development.

Mangrove Conservation Initiatives

Initiative	Key facts
Mangroves for the Future (MFF)	IUCN + UNDP; 2006, after 2004 tsunami; India a member
MISHTI	Mangrove Initiative for Shoreline Habitats and Tangible Incomes; 5 June 2023
Regulation	CRZ Notification 2019, WPA 1972, Indian Forest Act 1927

Coral Reefs

- Cover ~0.2% of ocean floor but host ~25% of marine species; built by coral polyps with zooxanthellae algae.
- Need clear, warm, shallow, sunlit water.
- Coral bleaching: expulsion of zooxanthellae under heat stress; reefs turn white; ocean acidification weakens skeletons.

- Reef types: fringing, barrier, atoll.

Coral Reef Areas of India

Area	Note
Gulf of Mannar (Tamil Nadu)	First marine biosphere reserve of Asia (1989; Kachchh is the largest BR) and Ramsar site; 21 islands
Gulf of Kutch (Gujarat)	India's first Marine National Park (Jamnagar; 1982)
Lakshadweep	Atolls (only atolls in India)
Andaman and Nicobar	Fringing reefs; richest diversity

Commonly Confused - Coral Bleaching

Single most significant cause = rise in sea-water temperature / global warming, not salinity or disease.

Corals expel zooxanthellae and turn white; may recover if stress ends.

Corals are in CRZ-I and protected under WPA; Sundarbans has mangroves, NOT corals.

Coastal Conservation

Coastline Data

India's coastline by State / UT (revised 2025)

Rank	State / UT	Coastline, 2025 revision (km)
1	Andaman and Nicobar Islands (UT)	3,083.50 (was 1,962)
2	Gujarat	2,340.62 (was 1,214.7)
3	Tamil Nadu	1,068.69 (was 906.9)
4	Andhra Pradesh	1,053.07 (was 973.7)
5	Maharashtra	877.97 (was 652.6)
6	West Bengal	721.02 (was 157.5)
7	Kerala	600.15 (was 569.7)
8	Odisha	574.71 (was 476.4)
9	Karnataka	343.30 (was 280)
10	Goa	193.95 (was 101)
11	Lakshadweep (UT)	144.80 (was 132)
12	Daman and Diu (UT)	54.38 (was 42.5)
13	Puducherry (UT)	42.65 (was 47.6)

- Revised in 2025 (new methodology): total coastline 11,098.81 km (mainland 7,870.51 km + islands 3,228.30 km), up from 7,516.6 km. Among States: Gujarat > Tamil Nadu > Andhra Pradesh; Andaman and Nicobar (3,083.50 km) is longest overall. Old figures (7,516.6 km; Gujarat 1,214.7 km) are outdated.
- Nine coastal states and four UTs (Puducherry, Lakshadweep, Andaman and Nicobar, Dadra and Nagar Haveli and Daman and Diu). EEZ: 2.02 million sq km (200 nautical miles).

Regional Names of the Coast

Coast	Name	Extent / feature
East	Utkal	Chilika to Kolleru
East	Andhra	Kolleru to Pulicat
East	Coromandel	Pulicat to Kanyakumari; winter rain

Coast	Name	Extent / feature
West	Konkan	Daman to Goa
West	Kannada	Marmagao to Mangalore
West	Malabar	Mangalore to Kanyakumari; lagoons and backwaters

- Kerala coast sands are rich in monazite (thorium).

Key Coastal Lakes and Beaches

Feature	Fact
Chilika Lake (Odisha)	Asia's largest brackish lagoon
Pulicat Lake	Second-largest brackish lagoon in India; Andhra Pradesh and Tamil Nadu; Sriharikota barrier island
Gahirmatha (Odisha)	World's largest olive ridley nesting beach

Degradation and Threats

- Coastal erosion (1990-2018): eroding 34%, accreting 26%, stable 40%; worst in West Bengal, Kerala, Tamil Nadu.
- Threats: marine plastic, oil spills, destructive fishing, eutrophication, sea-level rise, coastal sand mining (saltwater ingress, loss of dunes).

CRZ Rules

Coastal Regulation Zone (CRZ) Notification 2019

Zone	Coverage
CRZ-I	Ecologically sensitive areas (mangroves, corals, etc.)
CRZ-II	Developed areas
CRZ-III	Rural/urban areas not substantially developed
CRZ-IV	Up to 12 nautical miles seaward from Low Tide Line and tidal water bodies

- CRZ first framed 1991 under EPA 1986; CRZ 2019 replaced CRZ 2011; Shailesh Nayak Committee (2014).
- CRZ-III A: density above 2,161 per sq km, NDZ 50 m from HTL; CRZ-III B: below 2,161, NDZ 200 m.
- Critically Vulnerable Coastal Areas (CVCA): Sundarbans, Gulf of Khambhat, Gulf of Kutch, Achra-Ratnagiri, Gulf of Mannar, Bhitarkanika.

Government Initiatives and Blue Flag

Coastal Management Institutions and Schemes

Initiative	Key facts
NCSCM	National Centre for Sustainable Coastal Management; MoEFCC
ICZMP	Integrated Coastal Zone Management Plan; pilot in Gujarat, Odisha, West Bengal
BEAMS	Beach Environment and Aesthetics Management Services; India's eco-label modelled on Blue Flag

Blue Flag in India

Item	Fact
Awarded by	Foundation for Environmental Education (FEE), Denmark-based NGO; origin France 1985
Criteria	33 criteria in 4 groups
India's first batch	Oct 2020 - 8 beaches: Shivrajpur (Gujarat), Ghoghla (Diu), Kasarkod and Padubidri (Karnataka), Kappad (Kerala), Rushikonda (Andhra), Golden Beach (Puri, Odisha), Radhanagar (Andaman)
Total now	18 beaches
National operator	SICOM (MoEFCC)

- Blue Carbon Initiative: protect mangroves, tidal marshes, seagrasses for climate mitigation.

CHAPTER 04

Greenhouse Effect and Climate Change

Weather, Climate, Climate Change, Global Warming

- Weather = state of atmosphere at a point of time; climate = long-term average of weather (typically 30 years).
- Elements: temperature, pressure, wind, humidity, precipitation.
- Global warming = gradual rise in Earth's average surface temperature, mainly due to enhanced greenhouse effect.

Climate Change vs Global Warming

Point	Climate Change	Global Warming
Meaning	Long-term change in climate of globe/region	Rise in average temperature of Earth
Causes	Natural + human	Mainly human (GHG emissions)
Natural factors	Volcanoes, plate tectonics, ocean currents, orbital changes	Not natural-driven in current phase

Greenhouse Effect

- Natural phenomenon: gases in lower atmosphere trap heat and keep Earth habitable.
- Without it Earth's average surface temperature would be about -18 deg C instead of about 15 deg C.
- Concept of the greenhouse effect given by Joseph Fourier (1820s).
- Enhanced greenhouse effect (extra human GHGs) = global warming; raises temperature and humidity.
- Ozone layer absorbs harmful UV; visible light reaches Earth and is re-emitted as infrared.

Greenhouse (building) vs Greenhouse effect

Glass greenhouse warms mainly by stopping convection (trapping warm air).

Atmospheric greenhouse effect works by GHGs absorbing outgoing infrared radiation.

CO₂ raises temperature because it absorbs the infrared part of radiation (not UV).

Greenhouse Gases (GHGs)

- Main GHGs: water vapour, CO₂, CH₄, N₂O, CFCs/HFCs, PFCs, SF₆, NF₃ (also ozone).
- CO₂ is the main GHG responsible for global warming (highest concentration among long-lived anthropogenic GHGs).

Relative contribution of GHGs to global warming

Gas	Share
CO ₂	66%
CH ₄	16%
N ₂ O	6%
CFCs and others	12%

- Global Warming Potential (GWP) = heat a gas traps relative to CO₂ over 100 years; CO₂ = 1.

GWP and lifetime of GHGs (traditional values)

Gas	GWP (100 yr)	Lifetime (yrs)	Main natural source	Main human source
CO ₂	1	50-100	Respiration, volcanoes, forest fires	Fossil fuels, vehicles, industry
CH ₄	21	10-15	Wetlands (largest natural), oceans, termites	Paddy fields, cattle, waste, coal mining
N ₂ O	310	120	Nitrogen cycle	Fertilisers, vehicles, nitric acid production
CFC-11 / CFC-12	5,000 / 8,500	50-500	None	Refrigeration, solvents, foams
HFCs	150 to 11,700	1.5 to 209	None	Refrigerants
PFCs	6,500 to 9,200	2,600 to 50,000	None	Aluminium smelting, semiconductors
SF ₆	23,900	3,200	None	Circuit breakers, electrical insulation

- CH₄ over 20 years is about 80 times CO₂; short-lived but strongly potent.
- Fluorinated gases (HFCs, PFCs, SF₆) have the highest GWP.

Methane and rice

Sources of CH₄: rice fields, coal mining, domestic animals (enteric fermentation), wetlands - all four.

Burning crop residue releases CO, CH₄, ozone precursors and SO₂.

Rice is the major anthropogenic source of BOTH CH₄ (anaerobic paddies) and N₂O (nitrogen fertiliser).

Methane - extra facts

- CH₄ = Marsh Gas; main component of natural gas and biogas.
- Natural sources: wetlands (largest), termites, oceans, methane hydrates, volcanoes, wildfires.
- Human sources: rice paddies, cattle, manure, coal mines, landfills, oil and gas; agriculture is the largest anthropogenic sector.
- Methane hydrate: warming may trigger release; deposits in Arctic tundra and under seafloor; CH₄ oxidises to CO₂ in a decade or two.
- Human CO₂ is absorbed by phytoplankton in oceans and plants on land.

Which is NOT a greenhouse gas?

NOT GHGs: Argon, Hydrogen, Oxygen, Nitrogen, Propane, Ammonia, Radon, Butane; SO₂ and oxides of nitrogen are not direct GHGs.

Indirect GHGs (influence ozone/CH₄ chemistry): NO_x, CO, NMVOCs, SO₂.

Direct GHGs: CO₂, CH₄, N₂O, CFCs, SF₆, NF₃, water vapour, ozone.

Climate change causes: GHGs, ozone depletion and pollution; solar flares are NOT a major cause.

Aerosols and carbon terms

- Black carbon: soot from incomplete combustion; short life (days) but strong warming; lowers albedo of snow/ice.
- Brown carbon: light-absorbing organic carbon from combustion of organic matter.
- Warming aerosols: black and brown carbon; cooling aerosols: sulphate droplets (volcanoes, coal/oil burning).
- Aerosol concentration is about 3 times higher in the Northern Hemisphere.

Greenhouse Gas Protocol and carbon terms

Term	Meaning
GHG Protocol	International accounting tool to measure GHG emissions; framed by WRI + WBCSD
Carbon footprint	Total CO ₂ (equivalent) emitted by an individual, organisation, product or activity
Social cost of carbon	Monetary value of long-term damage from emitting 1 extra tonne of CO ₂

Causes of Climate Change**Natural vs anthropogenic causes**

Type	Factor	Effect
Natural	Plate tectonics	Changes position of water bodies, currents, winds
Natural	Volcanoes	SO ₂ , ash, CO ₂ ; short-term cooling by sulphate aerosols
Natural	Ocean currents	Heat redistribution
Natural	Orbital variation (Milankovitch)	Changes solar distribution across seasons and latitudes
Natural	Permafrost melt	Releases CO ₂ and CH ₄ (positive feedback)
Anthropogenic	GHG emissions	Enhanced greenhouse effect
Anthropogenic	Aerosols	Warm (black carbon) or cool (sulphates)
Anthropogenic	Land cover change	Deforestation reduces CO ₂ uptake and albedo

Milankovitch cycles

- Milutin Milankovitch = Serbian astronomer; astronomical theory proposed in the 1920s.
- Three components: eccentricity of orbit, obliquity (axial tilt), precession of the equinoxes.
- Solar output is NOT part of it; cycles drive glacial-interglacial periods.

Albedo

- Albedo = fraction of solar radiation reflected; scale 0 (absorbs all) to 1 (perfect reflection).
- Fresh snow and sea ice have highest albedo; open ocean and dark surfaces are low.
- Earth's average albedo is about 0.3; sea ice reflects about 80%.
- Ice-albedo feedback: ice melts → darker surface → more absorption → more melting.

Evidence and Methods to Study Past Climate**Proxy methods (paleoclimate)**

Method	What it records
Tree rings (dendroclimatology)	Wide rings = wet years; narrow = dry years
Ice cores (cryosphere)	Trapped air bubbles (GHGs), dust, ash, volcanic eruptions; climate of hundreds of thousands of years

- Ice core = the cryogenic indicator of climate change; fossil pollen, tree rings are other proxies.
- Cryosphere = Earth's frozen water (snow, ice caps, glaciers, permafrost).

Global Climate Records and Indicators

Key global figures (latest)

Indicator	Value
CO ₂ , 2024 (WMO GHG Bulletin)	423.9 ppm (about 152% of pre-industrial)
CH ₄ , 2024	1942 ppb (about 266% of pre-industrial)
N ₂ O, 2024	338 ppb (about 125% of pre-industrial)
Mauna Loa (Hawaii) peak CO ₂	May 2026: about 432 ppm; May 2025: about 430 ppm; May 2021: 419 ppm
2023-24 increase	CO ₂ +3.5 ppm (largest one-year rise in modern record)
Warmest year on record	2024 (about 1.55 deg C above 1850-1900); first calendar year above 1.5 deg C
2025	1.44 deg C above pre-industrial
2015-2025	The eleven warmest years on record
Sea-level rise rate	4.75 mm/yr (2012-2025) vs 2.65 mm/yr (1993-2011)

- Warming since 1900: about 1 deg C, with over half since mid-1970s.
- Largest CO₂ emitters: China > USA > India > Russia > Japan.
- Paris 1.5 deg C limit refers to a long-term (about 20-year) average; one year above 1.5 deg C is not a breach.

IPCC and Assessment Reports

- IPCC set up in 1988 by WMO and UNEP; HQ Geneva.
- It does not do research; it assesses published science; policy-relevant, not policy-prescriptive.
- Nobel Peace Prize 2007 (shared with Al Gore).

IPCC Assessment Reports

Report	Year	Key point
AR1	1990	Led to UNFCCC
AR2	1995	Basis for Kyoto Protocol
AR3	2001	"New and stronger evidence" that most warming in past 50 years is due to human activity
AR4	2007	"Warming unequivocal"; Nobel year
AR5	2014	Human activity main cause (95%+ likely); basis for Paris Agreement
AR6	2021-23	Human influence "unequivocal"; WG1 Aug 2021, WG2 Feb 2022, WG3 Apr 2022, Synthesis Mar 2023
AR7	2023-2030 (ongoing)	Chair Jim Skea

Updated IPCC AR6 GWP-100 values

Gas	AR6 GWP-100	AR6 lifetime
CH ₄ (fossil)	about 30	about 12 yrs
N ₂ O	about 273	about 109 yrs
SF ₆	about 25,200	about 3,200 yrs

AR6 key numbers

Item	Figure
Warming 2011-2020 vs 1850-1900	1.09 deg C (land 1.59, ocean 0.88)
Sea-level rise 1901-2018	About 0.20 m
Sea-level rise rate	1.3 mm/yr (1901-71), 1.9 (1971-2006), 3.7 mm/yr (2006-2018)
CO2 in 2019	410 ppm (highest in at least 2 million years)
Remaining carbon budget from 2020 for 1.5 deg C	About 500 GtCO2 (50% chance)
WG3: cuts needed for 1.5 deg C	GHG peak before 2025; about 43% cut by 2030; net zero CO2 by about 2050
WG2	3.3-3.6 billion people highly vulnerable
Synthesis Report	March 2023 (Interlaken)

Climate Sensitivity, Feedbacks, Carbon Budget

- Climate sensitivity = rise in global temperature after doubling of CO2 (about 280 to 560 ppm); AR6 best estimate = 3 deg C (likely 2.5-4).
- Positive feedback amplifies warming; negative feedback reduces it.
- Carbon budget = cap on total future CO2 emissions to stay within a temperature limit.

Clouds and climate

Cloud type	Effect	Feedback type
Thick, low, water-droplet clouds	Reflect sunlight, cool	Negative
Thin, high cirrus (ice crystal) clouds	Trap outgoing heat, warm	Positive

- CO2 fertilisation: higher CO2 speeds photosynthesis and global greening; benefit fades with time.

Carbon fertilisation

Carbon fertilisation = increased plant growth due to increased atmospheric CO2.

It is NOT the greenhouse effect and NOT ocean acidification.

Sea-Level Rise (SLR)

- Global mean SLR is about 23 cm between 1880 and 2015; rate rose from 1.3 mm/yr to 3.7 mm/yr (2006-2018) and now about 4.75 mm/yr.

Three main drivers of SLR

Driver	Detail
Thermal expansion	Warm water expands; about half of SLR
Melting glaciers	Mountain glaciers melt more
Ice-sheet loss	Greenland and Antarctica melting faster

India-specific

- Coastal Regulation Zone (CRZ) established 1991 under Environment Protection Act; regulates up to 500 m from High Tide Line.
- Indonesia is moving its capital Jakarta -> Nusantara (Borneo); Rotterdam uses "water squares".

Cryosphere, Glaciers and the Arctic

- Cryosphere = snow, glaciers, ice sheets, sea ice, permafrost; holds the largest freshwater store.
- Greenland is losing mass about twice as fast as Antarctica.
- Himalayan glaciers feed major rivers including Ganga, Indus, Brahmaputra, Yangtze.
- Hindu Kush Himalaya (HKH) = "Third Pole"; spans 8 countries.
- IPCC SROCC (2019) is the key report on ocean and cryosphere.

Arctic Amplification

- Arctic warms 3-4 times faster than the global average in recent decades (older texts: "twice") (ice-albedo loss, water vapour, cloud changes).
- Arctic likely ice-free in summer before end of century.

India and the Arctic

- Himadri station at Ny-Alesund (Svalbard) opened 2008.
- Observer status in Arctic Council since 2013.
- Arctic Council members (8): Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden, USA.
- India's Arctic Policy (2022, MoES) has six pillars.

Extreme Events

Tropical cyclones

- Need SST of about 26.5 deg C to form.
- Warming raises cyclone intensity; Arabian Sea warming now producing more cyclones.

Heat waves

- IMD declares a heatwave when max temp is at least 40 deg C (plains) or 30 deg C (hills) AND departure from normal is 4.5 deg C or more.
- Severe heatwave: departure 6.5 deg C or more.
- Absolute criterion: 45 deg C or more (heatwave), 47 deg C or more (severe).
- First Heat Action Plan: Ahmedabad, 2013; NDMA heatwave guidelines 2016.

Blocking and heat dome terms

Term	Meaning
Heat dome	High-pressure area acting like a lid trapping heat; record 49.6 deg C at Lytton (British Columbia), July 2021
Omega block	Stationary high flanked by two lows; blocks jet stream
Rex block	Dipole block: high pole-ward of a low
Pyrocumulonimbus	"Fire clouds" from intense bushfires

Urban Heat Island (UHI)

- Cities are 3-5 deg C hotter than surrounding rural areas.
- Causes: concrete and asphalt, lack of evapotranspiration, air-conditioning waste heat, loss of green cover.
- Remedies: urban greening, cool/white roofs, green building codes.

Marine heatwaves (MHW)

- MHW = extremely warm SST lasting at least 5 consecutive days.
- Impacts: coral bleaching, harmful algal blooms, fishery losses.
- Antarctic Circumpolar Current (ACC) is the strongest ocean current and the only one that flows completely around the Earth (no land barrier in the Southern Ocean).

Impacts of Climate Change

Impact summary

Sector	Impact
Health	Malnutrition, malaria, diarrhoea, heat stress
Water	More people in water-scarce regions
Ecosystems	Shifting biomes, coral bleaching, ocean acidification, species loss
Gender	Women hit harder: food insecurity, water-collection distances

- Ocean acidification: CO₂ dissolves in seawater lowering pH; harms corals and shell-forming organisms.
- Direct effects of global warming: melting glaciers, sea-level rise, coral bleaching, spread of diseases, earlier flowering (e.g. mango), more severe cyclones.
- Arctic and Greenland ice sheet = most fragile ecosystem, first affected.
- Agriculture is the human activity most affected by climate.
- Andaman and Nicobar mass coral bleaching: cause = about 2 deg C rise in Indian Ocean temperature.

2 deg C vs 3 deg C above pre-industrial

Beyond 2 deg C: widespread coral mortality; about 1/6 of ecosystems transformed; about 1/4 of known species at risk.

Beyond 3 deg C: terrestrial biosphere tends toward a NET CARBON SOURCE; about 30% of species at risk.

Wrong options: "all global wetlands permanently disappear", "cereal cultivation impossible anywhere".

India and Climate Change

- India is the world's 3rd largest GHG emitter after China and USA (very low per capita).
- Net-zero target year: 2070 (announced at COP26, "Panchamrit"); China targets 2060.
- Net zero does NOT mean zero emissions: remaining emissions are balanced by sinks and removal; a country can go carbon negative.
- Bhutan = world's top carbon-negative country.
- India's non-fossil capacity crossed 300 GW (about 54% of installed capacity); target 500 GW by 2030.

Climate risk indices on India

Index	Latest India position
Germanwatch Climate Risk Index 2026 (1995-2024)	India 9th most affected long-term; top three Dominica, Myanmar, Honduras
Climate Change Performance Index 2026	India 23rd (fell from 10th); ranks 1-3 vacant; 4 categories: GHG emissions, renewable energy, energy use, climate policy
UNICEF Children's Climate Risk Index	India 26th of 163
World Risk Report (UNU-EHS)	Philippines highest risk (WorldRiskReport 2025; Vanuatu topped earlier editions)

Projected impacts on India

Area	Projection
Heat	Hotter, longer heatwaves
Monsoon	Erratic and unpredictable
Water	Per capita water 5,178 m ³ (1951) -> 1,544 m ³ (2011)

Area	Projection
Glaciers	Northern rivers (Indus, Brahmaputra) threatened
Food	Wheat yield hurt above 34 deg C

NAPCC (2008)

Released 30 June 2008 by PM Manmohan Singh; India's first National Action Plan on Climate Change.

8 Missions: Solar, Enhanced Energy Efficiency, Sustainable Habitat, Water, Sustaining Himalayan Ecosystem, Green India, Sustainable Agriculture, Strategic Knowledge on Climate Change.

NOT among the 8 missions: nuclear/atomic energy.

Green India Mission aims to add 5 Mha tree cover and improve quality of another 5 Mha.

Mitigation Strategies**Clean Coal Technologies**

- Coal burning emits CO₂, CO, NO_x, SO_x.
- Syngas = mixture of CO and H₂ (gasification).

Coal-cleaning technologies

Technology	What it does
Coal beneficiation / washing	Removes ash before burning
Low-NO _x burners	Reduce nitrogen-oxide formation
Fluidised bed combustion	More complete combustion
Coal gasification	Converts coal to gas in absence of oxygen
Supercritical / ultra-supercritical plants	Higher efficiency
Flue gas desulphurisation (FGD)	Limestone + water removes SO ₂
Electrostatic precipitator (ESP)	Captures particulates

Carbon sinks and sequestration

- Natural sinks: forests, soils, oceans; artificial sinks: unmineable coal seams, depleted oil and gas reservoirs, deep saline formations.
- Carbon sequestration = capture and long-term storage of CO₂.

Green carbon vs Blue carbon

Type	Meaning	Key fact
Green carbon	Carbon in terrestrial plants and soil	Forests = largest reservoir
Blue carbon	Carbon in coastal/marine ecosystems (mangroves, seagrass, salt marsh)	Stores more per unit area than forests

Sequestration methods

Abandoned coal seams, depleted oil and gas reservoirs, deep saline formations - ALL are potential sites. Enhanced rock weathering (ground basalt on farmland), ocean alkalinity enhancement and carbonated water into mines all count.

Contour bunding, relay cropping and zero tillage help store carbon in soil.

Types of sequestration

Type	Mechanism
Terrestrial	Soil and vegetation; photosynthesis
Geological	Depleted oil/gas reservoirs, saline aquifers, coal seams
Artificial (CCS)	Capture at source and bury

Geo-engineering**Solar vs Carbon geo-engineering**

Category	Techniques
Solar Radiation Management (SRM)	Space mirrors; stratospheric sulphate aerosol injection; marine cloud brightening; cirrus cloud thinning
Carbon dioxide removal	Afforestation (Great Green Wall); biochar; BECCS; direct air capture; ocean fertilisation; artificial trees

Climate-smart cities

- CSCAF = Climate Smart Cities Assessment Framework (MoHUA), 28 indicators in 5 categories.
- Madrid wind garden; China's Sponge Cities; Cooling Singapore.
- India Cooling Action Plan: 20-year view to 2037-38.

Carbon credits, offsets, markets

- 1 carbon credit = right to emit 1 tonne of CO₂ (or equivalent); concept originated from Kyoto Protocol.
- CER (Certified Emission Reduction) = tradable CDM unit = 1 t CO₂; prices set by market, not UNEP.
- China and India are the biggest sellers; Europe the biggest buyer.
- MCX was the first exchange in Asia to trade carbon credits.
- Carbon tax = tax on energy resources emitting CO₂ (Sweden, Finland, Netherlands, Norway); Singapore from 2019.

India's Carbon Credit Trading Scheme (CCTS)

Feature	Detail
Legal base	Energy Conservation (Amendment) Act 2022; scheme notified June 2023
Administrator	Bureau of Energy Efficiency (BEE)
Credit unit	Carbon Credit Certificate (CCC) = 1 tonne CO ₂ e
Built on	PAT (Perform, Achieve and Trade) scheme

Climate finance and reports**Climate bodies and initiatives**

Body	Key point
Climate Action Tracker	Independent analysis by Climate Analytics + NewClimate Institute; tracks pledges
The Climate Group	Non-profit founded 2003; runs EP100; secretariat of Under2 Coalition

Body	Key point
Under2 Coalition	Network of states/regions committed to net zero by 2050
Asia-Pacific Partnership on Clean Development and Climate (2005)	Australia, India, Japan, China, South Korea, USA; voluntary, non-binding

Reports and indices (climate)

Report	Publisher	Key point
Global Climate Risk Index	Germanwatch	Countries most hit by extreme weather
CCPI	Germanwatch	Climate performance of top emitters
Production Gap Report	UNEP	Planned fossil production vs Paris limits
Emissions Gap Report	UNEP	Pledges vs 1.5 deg C needs
State of Global Climate	WMO	Annual climate indicators

- Sendai Framework 2015-30: adopted at Sendai (Japan), 2015; successor to Hyogo Framework 2005-15.

Climate Change and Agriculture

- About 46% of India's workforce is engaged in agriculture (PLFS 2023-24); about two-thirds of output depends on monsoon.
- Livestock (enteric fermentation) is the largest source of agricultural emissions (about 54.6%).
- Flooded paddy fields release CH₄ and N₂O; fertilisers release N₂O.
- Every 1 deg C rise could cut farm incomes in unirrigated areas by about 6%.

Excess nitrogenous fertiliser

Causes soil acidification and nitrate leaching to groundwater.

Reduces need for nitrogen-fixing bacteria (does NOT proliferate them).

Climate Smart Agriculture (CSA)

- CSA developed by FAO; presented at Hague Conference, 2010.
- Three pillars: increase productivity and income; enhance resilience; reduce emissions.
- Global Alliance for Climate-Smart Agriculture (GACSA): launched 2014 (UN Climate Summit, New York), not outcome of Paris 2015; membership voluntary with no binding obligations.

Sustainable Agriculture

Sustainable farming methods

Method	Key point
Crop rotation	Breaks pest cycle, restores soil
Cover crops	Prevent erosion; green manure
Agroforestry	Trees integrated in farmland
Permaculture	Bill Mollison and David Holmgren; discourages monoculture; mulching essential
Conservation agriculture	Minimum tillage + permanent soil cover + crop rotation

Method	Key point
Biodynamic agriculture	Rudolf Steiner
LEISA	Low External Input Sustainable Agriculture
Zero tillage	Seeds placed in slits; residue retained; saves water and carbon

Zero tillage and water saving

Zero tillage + crop residue on field + gypsum application help conserve water.

Zero tillage allows wheat sowing without burning residue and soil carbon sequestration.

Organic and Natural Farming

- India: 1st in number of organic farmers.
- Sikkim: first fully organic state in the world (2016); Lakshadweep: first UT 100% organic (2020).

Organic farming schemes

Scheme	Note
Paramparagat Krishi Vikas Yojana (2015)	Cluster approach, PGS certification
NPOP	Third-party certification for export
PGS-India	Participatory certification
National Mission on Natural Farming	Approved Nov 2024; outlay Rs 2,481 crore; targets 1 crore farmers

Nutrients, Pests, Biotechnology**Biofertilisers**

Type	Example
Bacterial	Rhizobium, Azotobacter, Azospirillum
Fungal	Mycorrhiza
Algal	Blue-green algae, Azolla

Protected / emerging agriculture

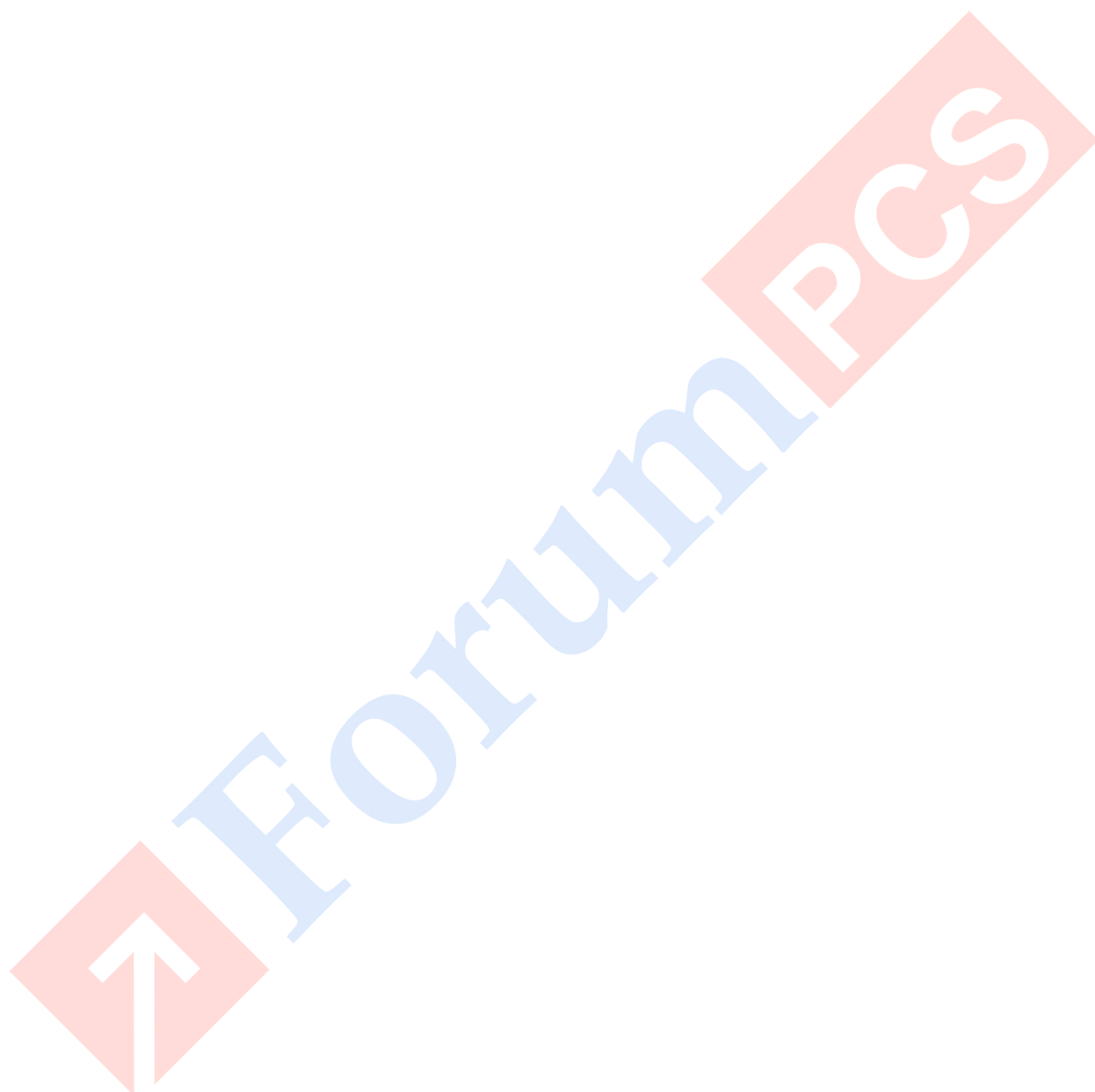
Method	Key point
Vertical farming	Stacked layers; urban
Hydroponics	Plants in nutrient solution, no soil
Aeroponics	Roots in air, sprayed with nutrient mist
Aquaponics	Hydroponics + aquaculture

- Bt cotton: introduced in India in 2002; only GM crop commercially cultivated in India.
- Bt Brinjal moratorium in 2010; DMH-11 mustard developed by Deepak Pental.
- GEAC: nodal body for GM release; under MoEFCC.

Green Revolution

Point	Detail
Father (global)	Norman Borlaug

Point	Detail
India	M S Swaminathan; Third Five Year Plan
Elements	HYV seeds, fertilisers, irrigation, mechanisation
Negative	Groundwater depletion, soil salinity, loss of crop diversity
BGREI	Bringing Green Revolution to Eastern India



CHAPTER 05

Climate Change Conferences, Climate Change: Miscellaneous

UN Environmental Conferences: Master Timeline

Landmark global environmental conferences

Year	Event	Place	Key outcome
1972	UN Conference on the Human Environment	Stockholm, Sweden	Stockholm Declaration; UNEP created
1987	Brundtland Commission report "Our Common Future"	UN (WCED)	Defined sustainable development
1992	UNCED (Earth / Rio Summit)	Rio de Janeiro, Brazil	Rio Declaration, Agenda 21, Forest Principles; UNFCCC, CBD, UNCCD
1997	Kyoto Protocol adopted	Kyoto, Japan (COP3)	First binding GHG targets
2002	Rio+10 (WSSD)	Johannesburg, South Africa	Johannesburg Plan of Implementation
2012	Rio+20 (UNCSD)	Rio de Janeiro, Brazil	"The Future We Want"; SDG process; UNEA created
2015	Paris Agreement	Paris (COP21)	1.5/2 degree C goal, NDCs

Commonly Confused - Years

Agenda 21 originated at Rio 1992, NOT Johannesburg 2002.

Rio+20 = UN Conference on Sustainable Development, 2012.

Chronology: Limits to Growth (1972) -> Brundtland Report (1987) -> Montreal Protocol (adopted Sept 1987, in force Jan 1989) -> Rio Earth Summit (June 1992).

Stockholm Conference 1972

- Held 5-16 June 1972; first major UN conference on the global environment; linked environment with development.
- Outcome: Stockholm Declaration with 26 principles, and an Action Plan.
- UNEP was established by the UNGA in pursuance of it.
- World Environment Day (5 June) commemorates its opening day; first WED 1973.
- Environment (Protection) Act 1986 (Article 253) implements Stockholm decisions.

Rio Earth Summit 1992 (UNCED)

- Held in Rio de Janeiro, 3-14 June 1992 (20th anniversary of Stockholm); also called Earth Summit.
- Agenda 21, Rio Declaration and Forest Principles adopted.
- Commission on Sustainable Development (CSD) created to monitor implementation.

Outcomes of Rio 1992

Outcome	Nature	Key facts
UNFCCC	Binding treaty	Climate change
CBD	Binding treaty	Biodiversity
UNCCD	Binding treaty	Desertification (from Agenda 21 recommendation)
Rio Declaration	Non-binding	27 principles; includes Polluter Pays and Precautionary principles
Agenda 21	Non-binding action plan	"21" = 21st century; 40 chapters in 4 sections
Forest Principles	Non-binding	All types of forests; led to Montreal Process (1994)

- The three Rio Conventions: UNFCCC, CBD, UNCCD.
- Agenda 21 is about sustainable development, NOT ozone layer or environmental education; Local Agenda 21 = implementation by local governments.

UNFCCC (United Nations Framework Convention on Climate Change)**UNFCCC fact file**

Item	Fact
Adopted	New York, 9 May 1992; opened for signature at Rio
Entered into force	21 March 1994
Parties	198 (197 countries plus the EU)
Supreme body	Conference of the Parties (COP); COP1 Berlin 1995
India ratified	1993 (nodal agency MoEF&CC)

- First international legal instrument on climate change; ultimate objective: stabilise GHG concentrations.
- Contains the principle of Common But Differentiated Responsibilities (CBDR).
- Climate Neutral Now (UNFCCC secretariat, 2015): measure, reduce, compensate with CERs.
- US ordered exit from the UNFCCC and IPCC in January 2026 (withdrawal takes effect one year after notification).

Classification of Parties

Group	Meaning	Obligation
Annex I	Industrialised countries and economies in transition	Binding GHG reduction targets (Kyoto)
Annex II	Subset of Annex I (OECD members)	Give finance and technology to developing countries
Non-Annex I	Developing countries (India, China, Brazil)	No binding targets
LDCs	Least developed countries	No binding targets; special support

Commonly Confused - CBDR and Annexes

CBDR comes from Rio 1992 / UNFCCC, not from Kyoto or Paris.

India is Non-Annex I; Kyoto targets did not apply to India.

CDM goes with Kyoto; CER does NOT go with Nagoya; Annex I does NOT go with Cartagena.

Kyoto Protocol

Kyoto Protocol fact file

Item	Fact
Adopted	11 December 1997, Kyoto, Japan (COP3)
In force	16 February 2005 (55 Parties covering 55% of Annex I CO ₂ ; Russia's ratification triggered it)
Target	5.2% cut below 1990 levels by Annex I countries
First commitment period	2008–2012
India ratified	2002
Second period	2013–2020 (Doha Amendment, COP18, 2012; in force 31 Dec 2020)
Not in	USA (signed, never ratified); Canada withdrew (2011)

- Only treaty with legally binding GHG limits (on developed countries); a protocol to the UNFCCC, NOT about ozone depletion or wetlands.
- Carbon credit / carbon trading originated from the Kyoto Protocol, NOT Rio, Montreal Protocol or G8.
- Covers 6 GHGs: CO₂, CH₄, N₂O, HFCs, PFCs, SF₆.

Kyoto flexibility mechanisms

Mechanism	Article	Meaning
International Emissions Trading	Art 17	Annex I countries trade assigned units
Clean Development Mechanism (CDM)	Art 12	Annex I invests in projects in developing countries; earns CERs
Joint Implementation (JI)	Art 6	Projects between Annex I countries earn ERUs

- 1 CER = 1 tonne CO₂ equivalent; CERs can also be earned by afforestation (carbon sinks).
- CDM is in sunset phase; transitioning to Paris Article 6.4 mechanism.
- Adaptation Fund financed by a 2% levy on CDM CERs.

COP Timeline (Post-Kyoto to Paris)

Key UNFCCC COPs 2007–2019

COP	Year and place	Key outcome
COP13	2007 Bali	Bali Action Plan; NAMAs; REDD+
COP15	2009 Copenhagen	Copenhagen Accord; 2 degree C goal; USD 100 bn per year pledge by 2020
COP16	2010 Cancun	Cancun Agreements; GCF created; Technology Mechanism; Adaptation Framework
COP17	2011 Durban	GCF instrument adopted; Durban Platform leads to Paris
COP18	2012 Doha	Doha Amendment (Kyoto second period)

COP	Year and place	Key outcome
COP19	2013 Warsaw	INDCs; Warsaw Mechanism on Loss and Damage; Warsaw Framework for REDD+
COP20	2014 Lima	Lima Call for Climate Action
COP21	2015 Paris	Paris Agreement (also CMP11 of Kyoto)
COP22	2016 Marrakech	"Action COP"; first CMA meeting
COP23	2017 Bonn (Fiji presidency)	Talanoa Dialogue
COP24	2018 Katowice, Poland	Katowice Rulebook for Paris
COP25	2019 Madrid	Santiago Network on Loss and Damage

- Copenhagen Accord was only "taken note of", not formally adopted.
- Katowice Rulebook: transparency, global stocktake, NDC features, finance reporting.
- Talanoa Dialogue: first COP presided by a small island state (Fiji).

Paris Agreement (2015)

Paris Agreement fact file

Item	Fact
Adopted	12 December 2015, COP21 Paris
In force	4 November 2016
Entry trigger	55 Parties covering 55% of global emissions
Parties	194 (193 states plus EU)
India ratified	2 October 2016
US	Exit effective 27 January 2026

- Goal: well below 2 degrees C above pre-industrial; pursue 1.5 degrees C; net-zero in second half of century.
- NDCs: nationally determined, not legally binding (procedural duties binding); updated every 5 years with higher ambition.
- Global Stocktake every 5 years; first concluded at COP28 (2023); next 2028.
- Enhanced Transparency Framework: Biennial Transparency Reports.
- Finance floor: USD 100 bn per year till 2025; replaced by NCQG.
- Articles: 2 temperature goal; 4 NDCs; 6 carbon markets; 7 adaptation; 8 Loss and Damage; 9 finance; 14 Global Stocktake.

Commonly Confused - Paris Agreement

Not signed by all UN members; entered into force 2016, not 2017.

Developed countries pledged USD 100 billion a year (NOT 1000 billion).

The "20/20/20" target is the EU 2020 package, not Paris.

Carbon markets under Paris Article 6

Provision	What it is
Article 6.2	Bilateral trading of ITMOs (Internationally Transferred Mitigation Outcomes)

Provision	What it is
Article 6.4	UN-supervised Paris Agreement Crediting Mechanism (earlier Sustainable Development Mechanism); replaces CDM
Article 6.8	Non-market approaches

COP26 to COP32

Recent COPs

COP	Dates and place	Highlights
COP26	Nov 2021, Glasgow, UK	Glasgow Climate Pact; coal "phase-down"; Article 6 rulebook; Global Methane Pledge
COP27	Nov 2022, Sharm el-Sheikh, Egypt	Loss and Damage Fund agreed
COP28	30 Nov-13 Dec 2023, Dubai, UAE	First Global Stocktake; "UAE Consensus"; L&D Fund operationalised
COP29	11-22 Nov 2024, Baku, Azerbaijan	NCQG (USD 300 bn by 2035)
COP30	10-22 Nov 2025, Belem, Brazil	Global Mutirao; adaptation finance tripling; TFFF launched
COP31	9-20 Nov 2026, Antalya, Turkiye	Turkiye President; Australia (Chris Bowen) President of Negotiations
COP32	2027, Addis Ababa, Ethiopia	Next in line

COP26 Glasgow (2021)

- Glasgow Climate Pact: first climate decision to name coal; phase-down of unabated coal power and phase-out of inefficient fossil-fuel subsidies.
- Global Methane Pledge: cut methane 30% by 2030 from 2020 levels.
- Declaration on Forests and Land Use: halt and reverse forest loss by 2030; India was among the G20 countries not signing.
- India's announcements: LiFE idea and Panchamrit; target is 50% of energy requirements from renewables by 2030 (not 60%).

COP27 to COP29

- COP27: Loss and Damage fund agreed (historic first); India submitted its Long-Term Low Emission Development Strategy (net-zero 2070); International Drought Resilience Alliance (IDRA) launched.
- COP28: first Global Stocktake concluded; "UAE Consensus": transition away from fossil fuels, net zero by 2050.
- COP28: triple renewable capacity to at least 11,000 GW and double energy-efficiency rate by 2030; L&D Fund operational; India did not sign the renewables tripling pledge.
- COP29 ("Finance COP"): NCQG - developed countries to lead mobilising at least USD 300 bn per year by 2035; wider call for USD 1.3 trillion per year by 2035; replaces USD 100 bn goal; India rejected USD 300 bn as too low.

COP30 Belem (2025)

- First COP in the Amazon region; President Andre Correa do Lago; main decision "Global Mutirao".
- Call to triple adaptation finance by 2035; 59 Belem Adaptation Indicators adopted; new just-transition mechanism.

- Tropical Forest Forever Facility (TFFF) launched by Brazil; pays tropical countries for standing forest; World Bank hosts secretariat.

COP31 Antalya (2026)

- 9-20 November 2026; first split presidency: Türkiye (Murat Kurum) COP President, Australia's Chris Bowen President of Negotiations.

Latest COP chain

COP26 Glasgow (coal) - COP27 Sharm (L&D fund) - COP28 Dubai (transition away from fossil fuels, GST) - COP29 Baku (NCQG) - COP30 Belem - COP31 Antalya (2026) - COP32 Ethiopia (2027).

India's Climate Commitments

India's NDC evolution

Stage	Emissions intensity (vs 2005)	Non-fossil power	Carbon sink
INDC / first NDC (2015)	33-35% cut by 2030	40% of installed capacity by 2030	2.5-3 bn t CO ₂ e extra by 2030
Updated NDC (Aug 2022)	45% cut by 2030	50% of installed capacity by 2030	2.5-3 bn t CO ₂ e by 2030
NDC 3.0 (2035; submitted April 2026)	47% cut by 2035	About 60% by 2035	3.5-4 bn t CO ₂ e by 2035

- India met 40% non-fossil capacity in 2021 and 50% in July 2025, ahead of schedule.
- 2035 NDC: 47% intensity cut is unconditional; 60% non-fossil target conditional on international finance and technology.
- Net zero by 2070 (India) vs 2060 (China); Bhutan is carbon-negative.
- Net zero does NOT mean zero emissions: residual emissions balanced by sinks and removals such as CCS.
- Panchamrit (COP26, 2021): 500 GW non-fossil capacity by 2030; 50% of energy requirements from renewables by 2030; 1 billion tonnes projected emissions cut by 2030; 45% carbon-intensity cut (vs 2005) by 2030; net zero 2070.
- LiFE (Lifestyle for Environment): proposed at COP26 (NOT COP25), launched 5 June 2022; builds 'Pro-Planet People' (P3).
- CCPI 2026 (Germanwatch): India fell from 10th to 23rd; CCPI scores GHG emissions, renewable energy, energy use, climate policy.
- SDR 2026 (UN SDSN): India 94th of 167 (99th in 2025); NITI Aayog is nodal body for SDGs in India.
- NAPCC (2008) 8 Missions: Solar; Enhanced Energy Efficiency; Sustainable Habitat; Water; Sustaining the Himalayan Ecosystem; Green India; Sustainable Agriculture; Strategic Knowledge for Climate Change.
- NAPCC released 30 June 2008; nuclear energy is NOT among the 8 missions.
- Green India Mission protects, restores and enhances forest cover; it does NOT incorporate green accounting.

Climate Finance

Major climate funds

Fund	Created	Key facts
Green Climate Fund (GCF)	Cancun COP16 (2010); instrument at Durban (2011)	HQ Songdo, South Korea; mitigation and adaptation; World Bank trustee; 24-member Board; not under UNEP, OECD, ADB or World Bank aegis

Fund	Created	Key facts
Global Environment Facility (GEF)	1991, before Rio	HQ Washington DC; UNDP, UNEP, World Bank
Adaptation Fund	Kyoto Protocol	Funded by 2% levy on CDM CERs; now serves Paris Agreement
Fund for responding to Loss and Damage (FRLD)	Agreed COP27; operational COP28	Interim secretariat at World Bank

Global Environment Facility (GEF)

- Financial mechanism for UNFCCC, CBD, UNCCD, Stockholm POPs Convention, Minamata Convention; NOT an OECD agency and does not conduct research.

Loss and Damage

- Warsaw International Mechanism (WIM): COP19 (2013); Santiago Network: COP25 (2019).

Climate finance sequence

USD 100 bn/yr by 2020 (Copenhagen 2009, extended to 2025) -> NCQG USD 300 bn/yr by 2035 (Baku 2024) -> USD 1.3 trillion aspiration.

Adaptation finance to triple by 2035 (Belem 2025).

Carbon Markets, Carbon Credit and CBAM

- Carbon credit: permit to emit 1 tonne of CO₂ or equivalent; originated under Kyoto Protocol; prices set by market, NOT fixed by UNEP.
- India and China are biggest sellers; Europe biggest buyer; MCX first Asian exchange to trade carbon credits.
- India's Carbon Credit Trading Scheme (CCTS) rests on Energy Conservation (Amendment) Act 2022; BEE is administrator.
- Blue carbon: carbon captured by mangroves, seagrass, salt marshes; sequesters faster than forests.
- EU CBAM (Carbon Border Adjustment Mechanism): tax on embedded carbon in imports to prevent carbon leakage; definitive phase from 1 January 2026; covers cement, iron and steel, aluminium, fertilisers, electricity, hydrogen; India argues it violates CBDR.

Global Initiatives and Alliances

COP26 initiatives

Initiative	Key facts
IRIS (Infrastructure for Resilient Island States)	Launched by India with Australia, UK, Fiji, Jamaica; under CDRI; supports SIDS
GGI-OSOWOG	One Sun One World One Grid (India/UK/ISA); phases: Asia, Asia plus Africa, global

International Solar Alliance (ISA)

- Launched 30 November 2015 at COP21 Paris by India (Modi) and France (Hollande); HQ Gurugram, Haryana.
- Focus: "sunshine countries" between Tropics of Cancer and Capricorn.
- India is President, France Co-President; Director General Ashish Khanna.

Other alliances

- Climate and Clean Air Coalition (CCAC): launched 2012; secretariat UNEP; targets short-lived pollutants (methane, black carbon, HFCs, tropospheric ozone); India joined 2019; NOT a G20 initiative.

- Global Climate Change Alliance (GCCA): EU initiative (2007) supporting LDCs and SIDS; coordinated by European Commission, not WRI/WBCSD.
- Under2 Coalition: subnational governments, net zero by 2050; EP100: energy productivity (Climate Group).

IPCC, UNEP and Climate Reports

IPCC

- Established 1988 by WMO and UNEP; HQ Geneva; shared 2007 Nobel Peace Prize with Al Gore.
- Warming above 2 degrees C: widespread coral mortality, about 1/4 species at risk; above 3 degrees C: terrestrial biosphere tends to net carbon source.
- IPCC Working Groups: WG I physical science basis; WG II impacts, adaptation, vulnerability; WG III mitigation.
- AR6 WG I (2021): CO2 main driver; Special Report 1.5 degree C (2018); SRCCL (2019) Land; SROCC (2019) Ocean and Cryosphere.

UNEP

- Established December 1972 (UNGA resolution 2997) after the Stockholm Conference; HQ Nairobi, Kenya; Executive Director Inger Andersen.
- Governing body: UN Environment Assembly (UNEA), created at Rio+20 (2012); UNEA-7 held Nairobi, Dec 2025.
- Global 500 Roll of Honour (1987) replaced by Champions of the Earth (2005); PM Modi won Champions of the Earth 2018.
- Reports: Emissions Gap and Adaptation Gap (UNEP); Greenhouse Gas Bulletin (WMO); Climate Change Performance Index and Global Climate Risk Index (Germanwatch); Groundswell (World Bank).
- WMO GHG Bulletin 2024: CO2 423.9 ppm, CH4 1942 ppb, N2O 338 ppb; pre-industrial CO2 278.3 ppm.
- Contribution to warming: CO2 66%, CH4 16%, N2O 6%, CFCs and others 12%.

Forests and Land: UNFF, REDD+, UNCCD

- UNFF: established 2000 by ECOSOC; Global Forest Goals 2017–2030.

REDD+

- Developed under UNFCCC; roots in Bali Action Plan (COP13, 2007); Warsaw Framework for REDD+ (COP19).
- Covers reducing deforestation and degradation, conservation, sustainable management, enhancing forest carbon stocks; results-based payments.
- Forest Carbon Partnership Facility (FCPF): World Bank (2008); Readiness Fund and Carbon Fund.

UNCCD (UN Convention to Combat Desertification)

UNCCD fact file

Item	Fact
Adopted	1994 (Paris); in force 1996
Secretariat	Bonn, Germany
Origin	Only convention from a direct Agenda 21 recommendation
Legally binding	Yes; links environment and development to land management
Focus	Drylands: arid, semi-arid, dry sub-humid; special focus on Africa
Approach	Bottom-up, local community participation
COP14	Greater Noida, India, Sept 2019

Item	Fact
COP17	Ulaanbaatar, Mongolia, Aug 2026

- COP14 Delhi Declaration; Peace Forest Initiative (South Korea-led); India's restoration goal raised to 26 million ha by 2030.
- Great Green Wall of Aravalli: 1,400 km by 5 km green belt, Gujarat to Delhi-Haryana border.

UNCCD-linked initiatives

Initiative	Key facts
LDN Target Setting Programme	Land Degradation Neutrality by 2030 (SDG 15.3)
Bonn Challenge	2011, Germany and IUCN; 350 mn ha by 2030; India 21 mn ha
Great Green Wall (Africa)	11 Sahel-Saharan countries

Biodiversity and Wildlife Conventions

Key conventions at a glance

Convention	Adopted / in force	Secretariat	Latest status
CBD	1992 Rio; in force 1993	Montreal	196 Parties; COP17 Yerevan, Armenia, Oct 2026
CITES	1973 Washington; in force 1975	Geneva	CoP20 Samarkand, 2025
CMS (Bonn Convention)	1979; in force 1983	Bonn	COP15 Campo Grande, Brazil, 2026
Ramsar Convention	1971 Ramsar, Iran; in force 1975	Gland	2,526 sites; COP15 Victoria Falls, 2025
BBNJ (High Seas Treaty)	Adopted June 2023	To be set up	In force 17 January 2026

CBD and Kunming-Montreal GBF

- CBD objectives: conservation, sustainable use, fair sharing of genetic resources benefits.
- Cartagena Protocol: adopted 2000, in force 2003; biosafety of living modified organisms.
- Nagoya Protocol: adopted 2010, in force 2014; access and benefit sharing. Both are protocols to the CBD, NOT UNFCCC.
- Aichi Targets (2010-2020) preceded the Kunming-Montreal GBF (COP15, Montreal, Dec 2022).
- GBF: 4 goals for 2050 and 23 targets for 2030; Target 3 (30x30): protect 30% of land and sea; Target 2: restore 30% of degraded ecosystems; Target 19: USD 200 bn per year.

CITES and CMS

- CITES regulates international trade in endangered species via Appendices I, II, III; Appendix I bans commercial trade.
- CoP20 moved oceanic whitetip shark, whale shark and manta and devil rays to Appendix I.
- CMS: migratory species; Appendix I (endangered) and II (needs cooperation).

Ramsar Convention

- Wetlands of international importance; World Wetlands Day 2 February.
- Montreux Record: sites with adverse ecological change; India has Keoladeo and Loktak.

- India has 103 Ramsar sites (Oct 2026; Sukhna Wetland, Chandigarh and Sauj Jheel, Uttar Pradesh added); Tamil Nadu has the most, followed by Uttar Pradesh.
- Chilika (Odisha) was India's first Ramsar site (1981); Sundarban is the largest.

BBNJ (High Seas Treaty)

- Covers marine biodiversity beyond national jurisdiction; entered into force 17 January 2026.
- Four pillars: marine protected areas, environmental impact assessments, marine genetic resources benefit sharing, capacity building and technology transfer.

Global Plastics Treaty

- Launched by UNEA-5.2 resolution (2022); Intergovernmental Negotiating Committee (INC).

Other international environmental agreements

Agreement	Year	Subject
World Heritage Convention (UNESCO)	1972	Natural and cultural heritage
MARPOL	1973/78	Ship pollution
UNCLOS	1982	Law of the sea
Basel Convention	1989	Hazardous waste movement
Rotterdam Convention	1998	Prior Informed Consent for chemicals
Stockholm Convention	2001	Persistent Organic Pollutants
Minamata Convention	2013	Mercury

Sustainable Development Goals and Allied Bodies

- Sustainable development (Brundtland, 1987): meeting present needs without compromising future generations.
- MDGs: 8 goals, 2000–2015; SDGs: 17 goals, adopted 2015 (UNGA Resolution 70/1), process initiated at Rio+20.
- Environment-linked SDGs: 11.6 urban environmental impact; 12.c fossil-fuel subsidies; 13 Climate action; 14 Life below water; 15 Life on land.

Other organisations and campaigns

- PAGE: five UN agencies (UNEP, UNDP, ILO, UNIDO, UNITAR); emerged from Rio+20.
- Club of Rome (1968): "The Limits to Growth" (1972); did NOT propose SDGs. 'Silent Spring' (1962) by Rachel Carson.
- WWF: founded 1961; HQ Gland, Switzerland. Earth Hour: WWF initiative, 2007 Sydney, last Saturday of March; NOT a UNEP initiative.
- New Delhi Declaration on Asian Rhinos (2019): India, Nepal, Malaysia, Indonesia, Bhutan.
- Indian schemes: MISHTI (mangroves, 2023), NCAP (2019, clean air), PAT (2012, BEE, energy efficiency).

CHAPTER 06

Ozone Layer

Ozone Layer: Basics

Stratospheric Ozone ("Good Ozone")

- Ozone (O₃) is a triatomic form of oxygen; about 90% lies in the **stratosphere**, about 10% in the troposphere.
- The ozone layer lies roughly 15-35 km above Earth (lower stratosphere); peak concentration is around 20-25 km.
- In the stratosphere, ozone level is naturally regulated by **nitrogen dioxide (NO₂)**.
- It absorbs harmful UV (mainly UV-B and all UV-C) and is why temperature rises with height in the stratosphere.
- Natural formation (Chapman cycle): UV splits O₂ into O atoms; each O atom combines with an O₂ to give O₃.
- An 'ozone halo' over the Tibetan Plateau was reported in 2005 by **G.W. Kent Moore** (Univ. of Toronto).

Ozone Measurement and Key Discoveries

Item	Fact
Unit of measurement	Dobson Unit (DU); 1 DU = 0.01 mm pure ozone at STP
Normal global average	About 300 DU
Ozone hole threshold	Total column ozone below 220 DU
Ground instrument	Dobson spectrophotometer (Gordon Dobson)
Hole discovered	1985: Joe Farman, Brian Gardiner, Jonathan Shanklin (British Antarctic Survey, Halley Bay)
CFC damage hypothesis	1974: Mario Molina and F. Sherwood Rowland
Nobel Prize in Chemistry	1995: Paul Crutzen, Mario Molina, F. Sherwood Rowland

Ozone Depletion and the Antarctic Hole

- CFCs are inert in the troposphere, rise to the stratosphere, and strong UV releases free chlorine (Cl) atoms.
- Cl + O₃ gives ClO + O₂; ClO + O gives Cl + O₂; chlorine is regenerated (catalytic); one Cl atom destroys about 1,00,000 ozone molecules.
- Bromine (halons, methyl bromide) is about 40-100 times more destructive than chlorine per atom.
- The Antarctic hole is a seasonal thinning forming each Southern Hemisphere spring (August to October), maximum in September-October.
- Winter darkness and extreme cold (below -78 deg C) form **Polar Stratospheric Clouds (PSCs)** (Type I nitric acid trihydrate; Type II water ice).
- PSC surfaces convert inactive chlorine (HCl, ClONO₂) into active chlorine (Cl₂); the **polar vortex** keeps cold and chemicals trapped.
- Returning spring sunlight splits Cl₂ into Cl atoms, starting rapid destruction.
- Antarctic loss is greater than Arctic (colder, stable vortex); Arctic loss is occasional (record in 2011 and 2020).

Why Antarctica, not the Equator?

Ozone is made mostly over the tropics, but the hole forms over the poles.

Reason: extreme cold, PSCs and the polar vortex, not the amount of CFC emitted there.

CFCs are emitted mainly in the Northern Hemisphere, yet the biggest hole is in the south.

Radiation, Gases and Effects

UV Radiation and Effects

Types of Ultraviolet Radiation

Type	Wavelength	Absorbed by ozone?	Effect
UV-A	315-400 nm	Almost not absorbed	Skin ageing, tanning
UV-B	280-315 nm	Mostly absorbed	Skin cancer, cataract, DNA damage
UV-C	100-280 nm	Fully absorbed by O ₂ and O ₃	Most harmful, never reaches surface

- UV-B is the radiation most affected by ozone depletion.
- Increased UV-B causes skin cancer, cataract, snow blindness, weakened immunity, reduced crop yield, and lower phytoplankton productivity (disrupting aquatic food chains).
- Ozone depletion is not the main cause of global warming; the two are separate problems.

Ozone Depleting Substances (ODS)

- ODS are halogen gases containing **chlorine and/or bromine**, with very long atmospheric lifetimes.
- **ODP (Ozone Depletion Potential)**: relative to CFC-11 (= 1.0). **GWP**: warming power relative to CO₂ (= 1) over 100 years.

Major ODS and Alternatives (Approximate Values)

Substance	Common use	ODP	GWP (100 yr)
CFC-11	Foam blowing, old refrigerators	1.0 (reference)	About 4,750
CFC-12	Refrigerant, aerosols	About 1.0	About 10,900
Halon-1301	Fire extinguishers	About 10 (highest)	About 7,100
Carbon tetrachloride (CTC)	Solvent, cleaning	About 1.1	About 1,400
Methyl bromide	Fumigant (soil, grain)	About 0.6	Very low
HCFC-22	Air conditioners	About 0.055	About 1,800
HFC-134a	Car AC refrigerant	0	About 1,400
HFC-23	By-product of HCFC-22 manufacture	0	About 14,800

- Halons have the highest ODP because they contain bromine.
- CFCs are non-toxic, non-flammable, highly stable (life about 80-100 years); sold as 'Freon/Mafron'; they are also potent greenhouse gases.
- Chlorine-releasing ODS: CFCs, HCFCs, CTC, methyl chloroform; bromine-releasing: halons, methyl bromide.
- CO, CO₂, SO₂ and methane are NOT ODS.
- Nitrous oxide (N₂O) is now the largest ozone-depleting emission, but is not controlled under the Montreal Protocol.
- Uses of CFCs: plastic foams, tubeless tyres, cleaning electronic components, aerosol propellants.
- Refrigerant generations: 2nd = CFCs/HCFCs (ozone depletion); 3rd = HFCs (zero ODP, high GWP); 4th = HFOs and natural refrigerants (low GWP).

HFCs = ozone friendly, climate unfriendly

HFCs do NOT deplete ozone (no chlorine or bromine).
 They are potent greenhouse gases (short-lived climate pollutants).
 HFCs are covered by the Montreal Protocol via the **Kigali Amendment** because of climate, not ozone.

Commonly Confused - Ozone

Ozone layer: stratosphere (not troposphere/ionosphere); absorbs UV (not IR/cosmic rays).
 Unit = Dobson Unit (not decibel/ppb); regulated by NO₂ (not N₂O/CFC).
 Montreal Protocol = ozone (not Kyoto/Nagoya, not carbon trade, not acid rain).
 World Ozone Day = 16 September (not 5 June, 22 April).

Global Efforts: Treaties and Protocols

Vienna Convention (1985)

- Vienna Convention for the Protection of the Ozone Layer: adopted 22 March 1985; in force 1988.
- A framework convention with NO legally binding targets; Vienna COP meets every three years, Montreal MOP yearly.
- On 16 September 2009 the Vienna Convention and Montreal Protocol became the **first UN treaties with universal ratification**.

Montreal Protocol (1987)

- Agreed 16 September 1987; in force 1 January 1989; legally binding protocol under the Vienna Convention with time-bound ODS phase-out.
- Follows **Common But Differentiated Responsibilities (CBDR)**: Article 5 countries (developing) get a grace period.
- Trade in controlled substances with non-parties is restricted.
- The **Multilateral Fund (MLF)** helps developing countries; implementing agencies: UNEP, UNDP, UNIDO, World Bank.
- It has phased out over 99% of controlled ODS; often called the most successful environmental treaty.
- 16 September is **World Ozone Day**, proclaimed by the UN General Assembly on 19 December 1994 (first observed 1995).
- World Ozone Day 2026 theme: "Global Action for a Cooler Planet" (10 years of the Kigali Amendment).

Amendments and Adjustments to the Montreal Protocol

Year	Meeting / Place	Key change
1990	London Amendment	CFC and halon phase-out by 2000; added CTC, methyl chloroform; created Multilateral Fund
1992	Copenhagen Amendment	Accelerated phase-out; added HCFCs, HBFCs, methyl bromide
1995	Vienna Adjustment	HCFC phase-out schedule fixed
1997	Montreal Amendment	Licensing system for ODS import and export
1999	Beijing Amendment	Controlled bromochloromethane
2016	Kigali Amendment (Rwanda)	Phase-down of HFCs; in force 1 January 2019

- Developed countries phased out CFCs by 1996 and halons by 1994; developing countries phased out CFCs, halons and CTC by 1 January 2010.

- HCFC phase-out, developing countries: 35% by 2020, 67.5% by 2025, 97.5% by 2030, 100% by 2040; developed countries: 100% by 2030.

Kigali Amendment (2016)

- Adopted 15 October 2016 at the 28th Meeting of the Parties, Kigali (Rwanda); in force 1 January 2019.
- Aim: cut HFC production and consumption by roughly **80–85%** of baseline by the late 2040s; avoids up to **0.5 deg C** warming by 2100.
- Legally binding with penalties and trade restrictions; 18 HFCs listed; 174 countries have ratified; India ratified on 27 September 2021.

Kigali HFC Phase-down Groups

Group	Countries	Baseline	Freeze	Final reduction
Group 1 (Non-Article 5)	US, EU, Japan, other developed	2011-13	Cuts start 2019	85% by 2036
Group 2 (Article 5)	China, Brazil, most of Africa, ASEAN	2020-22	2024	80% by 2045
Group 3 (Article 5)	India, Pakistan, Iran, Iraq, Saudi Arabia, Gulf states	2024-26	2028	85% by 2047

India and the Ozone Layer

India's Role and Actions

- India is a party to the Vienna Convention and Montreal Protocol (since 1992), an Article 5 country; ratified all amendments and Kigali (2021).
- Nodal agency: **MoEF&CC**; the **Ozone Cell** is the National Ozone Unit.
- Legal framework: **Ozone Depleting Substances (Regulation and Control) Rules, 2000** under the Environment (Protection) Act, 1986.
- The 2019 Amendment Rules prohibited import licences for **HCFC-141b** (foam blowing) from 1 January 2020.
- India phased out CFCs, CTC and halons by 1 January 2010, and methyl chloroform by 2015.
- **HCFC Phase-out Management Plan (HPMP)**: Stage I 2012-16, Stage II 2017-24, Stage III aims at complete HCFC phase-out by 2030.
- India's **Cooling Action Plan (ICAP, 2019)** was the world's first; it aims to cut cooling demand by 20–25% by 2037–38.

Recovery Status and Latest Assessments

- The quadrennial **Scientific Assessment of Ozone Depletion** is by the Montreal Protocol's Scientific Assessment Panel (WMO, UNEP, NOAA, NASA, EC); the latest is the 2022 assessment.
- The ozone layer has been recovering since about 2000.

Projected Ozone Recovery to 1980 Level

Region	Year
Most of the world	About 2040
Arctic	About 2045
Antarctic	About 2066

- Without the Protocol, the world would have faced far more UV and about 2.5 deg C more warming by 2100.
- Unexpected **CFC-11** emissions detected in 2018 were traced mainly to eastern China.

Ground-Level (Tropospheric) Ozone ("Bad Ozone")

- It is a **secondary pollutant**, formed when NO_x and VOCs react in sunlight; a key component of **photochemical smog**.
- Effects: asthma, lung irritation, reduced crop yield; it is also a short-lived greenhouse gas.
- Good vs bad: stratospheric ozone protects (blocks UV-B); tropospheric ozone is a pollutant not regulated by the Montreal Protocol.



CHAPTER 07

Forests & Types, ISFR, Conservation, National Parks, Biosphere Reserves, Sanctuaries, Project Tiger

Forest: Definition, Legal Status and Terminology

Forest definition - Kyoto Protocol vs India

Parameter	Kyoto Protocol range	India uses
Crown (canopy) cover	10 to 30%	10%
Minimum area of stand	0.05 to 1 ha	1 ha
Minimum tree height at maturity	2 to 5 m	2 m

- FSI "forest cover": all land over 1 ha with tree canopy density above 10%, irrespective of ownership, legal status, land use and species.
- Orchards, plantations and agroforestry count only if they meet the 1 ha and 10% norms.

Forest terminology (ISFR)

Term	Meaning
Recorded Forest Area (RFA) / Green Wash (GW)	Legal status: land recorded as forest in government records
RFA composition	Reserved and Protected Forests (Indian Forest Act 1927) plus Unclassed forests
Green Wash area	Area shown green on Survey of India maps; may not reflect ground reality
Forest cover	Presence of trees: over 1 ha, canopy over 10%
Tree cover	Tree patches under 1 ha outside RFA; a subset of Trees Outside Forests (TOF)
Trees Outside Forests (TOF)	All trees growing outside RFA irrespective of patch size
Forest and Tree Cover	Forest cover plus tree cover; basis of the 33% national target

Forest area vs forest cover

Forest AREA = legal status (records). Forest COVER = actual presence of trees (satellite).

Godavarman case 1996: "forest" under FCA means dictionary meaning plus any area recorded as forest, irrespective of ownership.

- Constitutional hooks: Article 48A (DPSP), Article 51A(g) (Fundamental Duty), Article 21 (clean environment).
- 42nd Amendment 1976 moved "Forests" and "Protection of wild animals and birds" from State List to Concurrent List.

Champion and Seth Classification of Forests

- Classification by H.G. Champion (1936) and S.K. Seth (revised 1968), based on climate, rainfall and vegetation.

- 5 major groups, 16 type groups, over 200 sub-types.
- Largest area: tropical dry deciduous (about 38%), then tropical moist deciduous (about 30%).

Champion and Seth 16 type groups

Group	Forest type	Rainfall	Key trees	Where found
I Moist Tropical	1 Tropical Wet Evergreen	Over 250 cm	Mahogany, ebony, rosewood, rubber, cinchona	Western Ghats slopes, Assam, Meghalaya, Arunachal, A&N
I	2 Tropical Semi-evergreen	200-250 cm	Mixed evergreen and deciduous	Western Ghats, Assam, Odisha coast
I	3 Tropical Moist Deciduous	100-200 cm	Teak, sal, shisham, sandalwood, arjun	Himalayan foothills, NE, Jharkhand, Odisha, Chhattisgarh
I	4 Littoral and Swamp	Tidal areas	Sundari, mangroves	Sundarbans, Bhitarkanika, deltas, A&N
II Dry Tropical	5 Tropical Dry Deciduous	70-100 cm	Teak, sal, peepal, neem	Peninsular plateau, UP plains, Bihar
II	6 Tropical Thorn	Under 70 cm	Babul, kikar, khejri, cacti	Rajasthan, Gujarat, Punjab, Haryana, Deccan interior
II	7 Tropical Dry Evergreen	About 100 cm	Hard-leaved evergreens	Coromandel coast
III Montane Subtropical	8 Broad-leaved hill forest	-	Oak, chestnut, laurel	NE hills, Nilgiris
III	9 Subtropical Pine	-	Chir pine	Western Himalaya (1,500-1,750 m)
III	10 Subtropical Dry Evergreen	-	Olive, acacia	Punjab and Himachal Shivaliks
IV Montane Temperate	11 Montane Wet Temperate	-	Oak, rhododendron, magnolia	Nilgiris (Shola), NE hills
IV	12 Himalayan Moist Temperate	-	Deodar, oak, blue pine, spruce, silver fir	Western Himalaya 1,500-3,300 m
IV	13 Himalayan Dry Temperate	-	Chilgoza, deodar, juniper	Lahaul-Spiti, Kinnaur, Ladakh
V Sub-Alpine and Alpine	14 Sub-Alpine	3,000-4,000 m	Silver fir, juniper, birch, rhododendron	High Himalaya below snowline
V	15 Moist Alpine Scrub	-	Birch, rhododendron	Eastern Himalaya
V	16 Dry Alpine Scrub	-	Juniper, dwarf willow	Trans-Himalaya, Ladakh

Himalayan vegetation by altitude

Foothills: tropical deciduous. 1,000-2,000 m: wet temperate evergreen (oak, chestnut).
1,500-1,750 m: chir pine. 2,225-3,048 m: blue pine and spruce.

3,000–4,000 m: silver fir, juniper, birch, rhododendron, then alpine pastures.
Sandalwood and red sanders are NOT Himalayan; oak and rhododendron are.

Forest-type facts

Fact	Detail
Evergreen forests	Western Ghats, North-East India, Andaman and Nicobar
Tropical wet evergreen in	Arunachal Pradesh and Mizoram (not Himachal Pradesh)
Maximum plant diversity	Tropical evergreen (rain) forest
Teak dominant in	Tropical moist deciduous forest; largest teak area in Madhya Pradesh
Red Sanders	Tropical dry deciduous; Seshachalam hills (Eastern Ghats); not a rainforest tree
Taxus (yew)	Himalayas; source of taxol (anti-cancer)
Largest mangrove delta	Sundarbans (Sundari tree)
A&N Islands	Only region with mangrove, evergreen and deciduous forests together
Valley of Flowers NP	Entirely in temperate-alpine zone
Namdapha NP	Climate varies from tropical to subtropical, temperate and arctic

- Shola forests: tropical montane forests of Western Ghats (Nilgiris, Anamalais, Palni hills) separated by grasslands; Southern Montane Wet Temperate type; "overhead water tanks", source of Bhavani.

India State of Forest Report (ISFR)

- Published every two years by Forest Survey of India (FSI), Dehradun, under MoEFCC. FSI founded 1981; first ISFR 1987.
- Latest: ISFR 2023 (18th report, released December 2024). ISFR 2021 was the 17th.
- Mapping on 1:50,000 scale using satellite data (Resourcesat-2 LISS III).

Canopy density classes (FSI)

Class	Canopy density
Very Dense Forest (VDF)	70% and above
Moderately Dense Forest (MDF)	40% to under 70%
Open Forest (OF)	10% to under 40%
Scrub	Under 10%

ISFR 2023 headline numbers

Item	Value
Forest cover	7,15,342.61 sq km = 21.76% of geographical area
Tree cover	1,12,014.34 sq km = 3.41%
Total forest and tree cover	8,27,356.95 sq km = 25.17%
Change in forest cover (vs 2021)	+156.41 sq km
VDF	1,02,502.20 sq km (3.12%)

Item	Value
MDF	3,07,673.28 sq km (9.36%)
Open forest	3,05,167.13 sq km
Scrub	43,622.64 sq km
Recorded Forest Area	About 23.59% of geographical area
Mangrove cover	4,991.68 sq km (down 7.43 sq km)
Bamboo bearing area	1,54,670 sq km
Carbon stock in forests	7,285.5 million tonnes (up 81.5 Mt)

State-wise forest cover (ISFR 2023)

Rank	By area	Area (sq km)	By % of own area	Percent
1	Madhya Pradesh	77,073.44	Mizoram	85.34
2	Arunachal Pradesh	65,881.57	Arunachal Pradesh	78.67
3	Chhattisgarh	55,811.75	Meghalaya	75.65
4	Odisha	52,433.56	Manipur	74.29
5	Maharashtra	50,858.53	Nagaland	73.72

- Over 75% forest cover: Lakshadweep (91.33%), Mizoram, Andaman and Nicobar (81.62%), Arunachal Pradesh, Meghalaya.
- Lowest forest percentage among States: Haryana (3.65%) and Punjab (3.67%).
- Very dense forest, largest area: Arunachal Pradesh. Largest tree cover: Maharashtra.
- Highest forest carbon stock: Arunachal Pradesh, then Madhya Pradesh, then Chhattisgarh.
- Dry deciduous forests are most fire-prone; evergreen and montane temperate least.

ISFR 2023 gainers and losers

Category	States
Biggest gain in forest cover	Mizoram (+241.73), Gujarat (+180.07), Odisha (+151.89), Karnataka, Kerala
Biggest loss in forest cover	Madhya Pradesh (-371.54), Telangana, Tripura, Arunachal Pradesh, Rajasthan
Mangrove: top States	West Bengal (2,119.16), Gujarat (1,164.06), A&N (608.29), Andhra Pradesh
Most fire incidents	Uttarakhand, Odisha, Chhattisgarh

- Earlier editions: 2015 = 24.16% forest and tree cover; 2017 = 21.54% forest cover; 2019 = 21.67%; 2021 = 21.71%.

Global Forest Facts

Global forest assessments and days

Item	Detail
FAO Global Forest Resources Assessment (FRA)	Every 5 years since 1990; FRA 2025 is latest
India in FRA 2025	9th in total forest area; 3rd in annual net gain
Top forest countries (FRA 2020)	Russia, Brazil, Canada, USA, China
Global forest area	About 4.1 billion ha (about 31-32% of land)
Bhutan	Constitution mandates at least 60% forest cover

Item	Detail
International Day of Forests	21 March
World Wildlife Day	3 March
Wildlife Week (India)	1 to 7 October
International Tiger Day	29 July
World Forestry Congress	Every 6 years; 2022 Seoul

New York Declaration on Forests

Voluntary, NOT legally binding. Endorsed at UN Climate Summit 2014.

Goal: halve natural forest loss by 2020 and end it by 2030.

India did NOT sign.

- Bonn Challenge: restore 350 million ha of degraded land by 2030 (IUCN-led).
- Miyawaki method: Japanese botanist Akira Miyawaki; dense native mini-forests in urban areas.

Deforestation and Social Forestry

- Agriculture causes about 80% of global deforestation (FAO).
- Nagaland hills turn barren mainly due to shifting (jhum) cultivation.

Social forestry (National Commission on Agriculture, 1976)

Type	Meaning
Farm forestry	Farmers grow trees on own land
Community forestry	Trees on community land; community protects, government gives seedlings
Agroforestry	Trees or shrubs with crops or pasture
Urban forestry	Parks, avenues, green belts in and around cities

- Term "social forestry" first used by the National Commission on Agriculture, 1976.

Forest Policies and Laws

Timeline of forest policy and legislation

Year	Event	Key point
1865	Indian Forest Act 1865	First forest law
1894	Forest Policy	First policy; timber-oriented
1906	Forest Research Institute (Dehradun)	Imperial Forest Research Institute
1927	Indian Forest Act 1927	Still in force; basis of Reserved/Protected forests
1952	National Forest Policy	First post-independence policy; 33% target
1972	Wild Life (Protection) Act	Assented 9 Sept 1972
1976	42nd Amendment	Forests to Concurrent List
1980	Forest (Conservation) Act	Came into force 25 Oct 1980
1988	National Forest Policy	Present policy
1990	Joint Forest Management	MoEF circular

Year	Event	Key point
1992	NAEB set up	National Afforestation and Eco-Development Board
1996	Godavarman judgment	Dictionary meaning of forest
2000	National Afforestation Programme	Merged four schemes; JFMCs
2006	Forest Rights Act	Passed Dec 2006; notified Jan 2008
2014	Green India Mission	One of 8 NAPCC missions
2016	CAMPA Act	Compensatory Afforestation Fund Act
2017	Indian Forest (Amendment) Act	Bamboo grown on non-forest land is not a "tree"
2023	Van (Sanrakshan Evam Samvardhan) Adhiniyam	Renamed FCA 1980

Indian Forest Act, 1927

Forest categories under IFA 1927

Category	Section	Features
Reserved Forest (RF)	Section 20	Highest restriction; local access banned unless allowed by Forest Officer
Protected Forest (PF)	Section 29	Government has proprietary rights; control over timber and produce
Village Forest	Section 28	Reserved forest assigned to village community

- 2017 amendment: bamboo on non-forest land is no longer "tree" or "timber"; no felling or transit permit needed.
- Under FRA 2006 bamboo is Minor Forest Produce (MFP); forest dwellers do NOT get right to fell bamboo from forest areas under the 2017 amendment.
- Forest Research Institute: Dehradun; 1906; deemed university 1991.

National Forest Policies

National Forest Policy 1952 vs 1988

Feature	1952	1988
Target	33% of land (60% hills, 20% plains)	33% of land; 66% in hills and mountains
Priority	Productive, protective and bio-aesthetic roles; revenue	Ecological balance, conservation, local needs; least priority to industrial timber
Forest classes	Protection, National, Village forests, Tree lands	Conservation as prime aim
People	Wean people from shifting cultivation	People's participation; JFM (1990); women's involvement

- National Parks are NOT a forest category under the 1952 policy.

- 1988 policy covers afforestation, wasteland development, reforestation, wood substitutes; it does NOT include promotion of pesticides.

Forest (Conservation) Act, 1980 and Van Adhiniyam 2023

- Effective 25 October 1980; prior Central approval needed to de-reserve forest or divert forest land for non-forest use.
- Forest Advisory Committee advises Centre on diversions; compensatory afforestation and Net Present Value (NPV) are charged.
- Tarun Bharat Singh v UoI (1993): State cannot grant mining lease in protected forest without Centre's approval.
- T.N. Godavarman Thirumulpad v UoI (1996-97): wide meaning of "forest"; introduced NPV; CAMPA fund.

Van (Sanrakshan Evam Samvardhan) Adhiniyam 1980 (amended 2023)

Renamed from Forest (Conservation) Act 1980 by 2023 amendment.

Applies to land notified as forest or recorded as forest in government records after 25 Oct 1980.

Exempts: forest land up to 0.10 ha along roads/railways; up to 10 ha for security infrastructure; up to 5 ha in Left Wing Extremism districts; strategic linear projects within 100 km of borders and LoC/LAC.

Allows zoos, safaris and ecotourism outside Protected Areas.

Criticism: weakens Godavarman 1996 definition.

NPV and CAMPA

- NPV: one-time payment by user agency for diverting forest land; introduced by Supreme Court in Godavarman case.
- Compensatory Afforestation: equal area of non-forest land, or twice the area of degraded forest land.
- CAF Act 2016 created National CAF and State CAFs; 90% to States, 10% retained by the Centre.
- CAMPA = Compensatory Afforestation Fund Management and Planning Authority.

Forest Rights Act, 2006

- Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006; nodal ministry: Ministry of Tribal Affairs; rules in force 1 January 2008.
- Eligibility: Forest-dwelling STs or Other Traditional Forest Dwellers living in forest for three generations (75 years) before 13 December 2005.
- Gram Sabha initiates claims, then Sub-Divisional Level Committee, then District Level Committee (final).

Four categories of rights under FRA

Right	Content
Title rights	Ownership of land actually cultivated, up to 4 ha
Use rights	Minor forest produce, grazing, water bodies, nomadic routes
Relief and development rights	Rehabilitation on illegal eviction; basic amenities
Forest management rights	Protect, regenerate and manage Community Forest Resources

- Defines "Critical Wildlife Habitat" (only FRA contains this term).
- Baiga tribe got first Habitat Rights (Madhya Pradesh).
- NGT has no jurisdiction over FRA, Wildlife Act, Indian Forest Act.

Forest Schemes and Campaigns

Forest conservation schemes

Scheme	Year	Key facts
National Afforestation Programme (NAP)	2000	Merged four schemes; degraded forest lands; SFDA, FDA, JFMC tiers; run by NAEB
Joint Forest Management (JFM)	1990	Community shares usufruct and protects forests; pioneered at Arabari (West Bengal)
National Mission for a Green India (GIM)	2014	One of 8 NAPCC missions; 10 million ha improved
Nagar Van Yojana	2020	One City Forest in each city; target 200 city forests
MISHTI	2023	Mangrove Initiative for Shoreline Habitats and Tangible Incomes; launched 5 June 2023
Ek Ped Maa Ke Naam	2024	Tree planting campaign (5 June 2024)
Van Mahotsav	1950	Started by K.M. Munshi; first week of July

- India pledged an additional carbon sink of 2.5 to 3 billion tonnes CO₂e by 2030.

Forest movements and institutions

Item	Detail
Chipko	Raini village, Chamoli, 1973-74; Gaura Devi; Chandni Prasad Bhatt (Magsaysay 1982); Sundarlal Bahuguna
Amrita Devi Bishnoi Smriti Award	Rajasthan, wildlife protection (Khejarli, Bishnoi)
ICFRE	Dehradun; apex forestry research body
IIFM	Bhopal, 1982
CAFRI	Jhansi; Central Agroforestry Research Institute
Wildlife Institute of India	Dehradun

Wildlife Protection Act, 1972 (WPA)

- Assented 9 September 1972; amended 1991, 2002, 2006, 2013 and 2022; extends to whole of India.
- Before it, India had only five national parks.
- Protects wild animals, birds and plants; wild animals are property of the State Government (Section 39).
- Killing of a protected animal allowed only if it endangers human life or is disabled/diseased beyond recovery, with Chief Wildlife Warden permission.
- Gharial, Indian wild ass and wild buffalo cannot be hunted.

Key sections of the WPA

Section	Subject
5A	National Board for Wildlife (2002)
6	State Board for Wildlife (Chair: Chief Minister)
9	Prohibition of hunting

Section	Subject
18	Declaration of Wildlife Sanctuary
35	Declaration of National Park
36A	Conservation Reserve (2002)
36C	Community Reserve (2002)
38L	National Tiger Conservation Authority
38V	Tiger Reserve
38Y	Wildlife Crime Control Bureau

Schedules of WPA before and after 2022

Schedule	Before 2022 (6)	After 2022 amendment (4)
I	Highest protection; tiger, elephant, rhino, lion	Highest protection, strictest penalty
II	High protection	Lesser protection
III	Lesser protection	Specified plants (old Schedule VI)
IV	Lesser protection	Species listed under CITES Appendices
V	Vermin	Removed
VI	Specified plants	Merged into Schedule III

- 2022 amendment: Management Authority and Scientific Authority for CITES; Centre can regulate invasive alien species.
- Penalty: general violations up to Rs 1 lakh; specially protected animals minimum Rs 25,000.

Wildlife bodies

National Board for Wildlife: statutory (Sec 5A, 2002); Chair: Prime Minister; clears projects near protected areas.

Central Zoo Authority (1992): recognition of zoos.

NTCA: statutory from 2006 (Tiger Task Force 2005).

WCCB: set up 2007; nodal agency for wildlife crime and CITES enforcement.

Protected Areas: National Parks, Sanctuaries, Reserves

Protected Area Network of India

Category	Number	Legal basis
National Parks	107	WPA 1972, Sec 35
Wildlife Sanctuaries	573	WPA 1972, Sec 26A
Conservation Reserves	115	WPA, Sec 36A (2002)
Community Reserves	220	WPA, Sec 36C (2002)
Tiger Reserves	58	WPA, Sec 38V
Biosphere Reserves	18	Non-statutory (MAB)

National Park vs Wildlife Sanctuary

Feature	National Park	Wildlife Sanctuary
Rights of people	Totally extinguished	Allowed to continue
Grazing	Prohibited	Allowed with permission
Boundary change	Needs NBWL and legislature	Needs NBWL recommendation
Upgrade	Cannot be downgraded to WLS	WLS can be upgraded to NP

Conservation vs Community Reserve

Conservation Reserve: government land adjoining NP or WLS, acts as buffer or corridor (2002).

Community Reserve: private or community land, no change in ownership (2002).

First Conservation Reserve: Tiruppudaimaruthur (Tamil Nadu, 2005).

National Parks (key facts)

National Park	State	Known for
Jim Corbett	Uttarakhand	First NP (1936 as Hailey NP), Project Tiger launch
Kaziranga	Assam	One-horned rhino, UNESCO WHS
Manas	Assam	Tiger and elephant reserve, WHS, Biosphere Reserve
Keoladeo	Rajasthan	Bird sanctuary, Ramsar, WHS
Sundarbans	West Bengal	Royal Bengal Tiger, mangroves, WHS
Silent Valley	Kerala	Lion-tailed macaque, saved from Kunthipuzha dam
Kanha	Madhya Pradesh	Barasingha, Jungle Book setting
Gir	Gujarat	Only home of wild Asiatic lion
Marine NP (Kutch)	Gujarat	First marine NP (1980)
Hemis	Ladakh	Largest NP, snow leopard
Namdapha	Arunachal Pradesh	Tiger, leopard, snow leopard, clouded leopard
Dachigam	J&K	Hangul (Kashmir stag)
Eravikulam	Kerala	Nilgiri tahr, Anamudi peak
Simlipal	Odisha	Melanistic tiger, Biosphere
Bhitarkanika	Odisha	Saltwater crocodile, Ramsar
Keibul Lamjao	Manipur	Only floating NP in world (Loktak Lake), sangai
Dudhwa	Uttar Pradesh	Swamp deer, Terai, tiger

- Smallest National Park: South Button Island NP (Andaman). Madhya Pradesh (Tiger State) has the most national parks among states.
- Gahirmatha (Odisha) is the world's largest nesting site of olive ridleys.
- Vedanthangal (Tamil Nadu): oldest bird sanctuary. Nal Sarovar (Gujarat): largest wetland bird sanctuary. Rann of Kutch WLS: largest sanctuary.
- Chambal WLS (MP, Rajasthan, UP): gharial, dolphins. Kuno (MP): cheetah.

Natural World Heritage Sites in India (UNESCO)

Site	State	Year
Kaziranga NP	Assam	1985
Manas WLS	Assam	1985
Keoladeo NP	Rajasthan	1985
Sundarbans NP	West Bengal	1987
Nanda Devi and Valley of Flowers	Uttarakhand	1988, 2005
Western Ghats	KA, KL, TN, MH, GA	2012
Great Himalayan NP	Himachal Pradesh	2014
Khangchendzonga NP	Sikkim	2016 (mixed)

Biosphere Reserves

- International designation by UNESCO under the Man and Biosphere (MAB) Programme of 1971; not statutory in India.
- First in India: Nilgiri (1986). India has 18 notified BRs.
- Three zones: Core (legally protected), Buffer (research, education, tourism), Transition (settlements, agriculture).

Biosphere Reserves of India

Biosphere Reserve	State(s)	Year	UNESCO WNBR
Nilgiri	TN, KL, KA	1986	Yes (2000)
Nanda Devi	Uttarakhand	1988	Yes (2004)
Nokrek	Meghalaya	1988	Yes (2009)
Gulf of Mannar	Tamil Nadu	1989	Yes (2001)
Sundarbans	West Bengal	1989	Yes (2001)
Manas	Assam	1989	No
Great Nicobar	A and N	1989	Yes (2013)
Simlipal	Odisha	1994	Yes (2009)
Dibru-Saikhowa	Assam	1997	No
Dehang-Dibang	Arunachal	1998	No
Pachmarhi	Madhya Pradesh	1999	Yes (2009)
Khangchendzonga	Sikkim	2000	Yes (2018)
Agasthyamala	KL, TN	2001	Yes (2016)
Achanakmar-Amarkantak	MP, Chhattisgarh	2005	Yes (2012)
Kachchh	Gujarat	2008	No
Cold Desert	Himachal Pradesh	2009	Yes (2025)
Seshachalam	Andhra Pradesh	2010	No
Panna	Madhya Pradesh	2011	Yes (2020)

- Largest BR: Kachchh. Smallest: Dibru-Saikhowa.
- Gulf of Mannar: first marine BR in Asia. Nokrek: wild citrus gene pool.
- Not in UNESCO network: Manas, Dibru-Saikhowa, Dehang-Dibang, Kachchh, Seshachalam.

Project Tiger

- Launched 1 April 1973 from Jim Corbett NP under Indira Gandhi with 9 tiger reserves.
- Original nine: Corbett, Manas, Palamau, Simlipal, Sundarbans, Ranthambore, Bandipur, Kanha, Melghat.
- Run by NTCA under MoEFCC; Tiger Task Force 2005 (after Sariska lost all tigers); NTCA statutory 2006.
- Tiger reserve notified by State on NTCA advice (Sec 38V); has core (critical tiger habitat) and buffer zone.
- M-STripes monitoring system launched 2010. Global Tiger Forum (1994) HQ New Delhi.
- Tx2: double global tigers by 2022 (St Petersburg Declaration, 2010).
- International Big Cat Alliance (IBCA): launched April 2023 at Mysuru; covers seven big cats.
- India has 58 tiger reserves and about 75% of world's tigers.

Tiger Census (All India Tiger Estimation)

Year	Tigers	Note
2006	1,411	Camera trap introduced
2010	1,706	
2014	2,226	
2018	2,967	Guinness record camera trap survey
2022	3,682	Released April 2023

- Census every 4 years by NTCA with WII.
- Most tigers (2022): Madhya Pradesh (785), Karnataka (563), Uttarakhand (560), Maharashtra (444).
- Largest tiger reserve: Nagarjunsagar-Srisailem. Smallest: Bor (Maharashtra). Sundarbans is the only mangrove tiger reserve.

Tiger Facts for Prelims

Panna lost all tigers in 2009; reintroduced from Kanha and Bandhavgarh.
 Sariska lost all tigers in 2004-05; reintroduced from Ranthambore (2008).
 First inter-state translocation: Kanha and Bandhavgarh to Satkosia (2018).

Project Elephant

- Launched 1992 by MoEFCC. Elephant is National Heritage Animal (2010); Schedule I; IUCN Endangered; CITES Appendix I.
- Elephant census (SEPE) every 5 years; 2017: 27,312; Karnataka highest (6,049). 2025 DNA-based estimate: 22,446.
- India has 33 Elephant Reserves; first: Singhbhum (Jharkhand); most in Assam and Arunachal Pradesh.
- 150 elephant corridors identified (2023). World Elephant Day: 12 August.
- MIKE (Monitoring the Illegal Killing of Elephants) is a CITES programme; ETIS monitors ivory trade.

Other Species Projects

Species Conservation Projects

Project	Year	Species	Key facts
Project Tiger	1973	Tiger	NTCA, 58 reserves
Project Elephant	1992	Elephant	33 reserves
Project Crocodile	1975	Gharial, mugger, saltwater croc	Led to Bhitarkanika
Indian Rhino Vision 2020	2005	One-horned rhino	Assam translocation
Project Snow Leopard	2009	Snow leopard	Himalayan landscape

Project	Year	Species	Key facts
Project Dolphin	2020	Gangetic dolphin	Announced 15 Aug 2020
Project Lion	2020	Asiatic lion	Gujarat
Project Cheetah	2022	Cheetah	Kuno NP
Project Hangul	1970	Kashmir stag	Dachigam
Project Sea Turtle	1999	Olive ridley	Gahirmatha
Project Vulture	2006	Vultures	Diclofenac ban

- Cheetah: declared extinct in India 1952; first 8 from Namibia (17 September 2022) at Kuno NP; 12 more from South Africa in February 2023; Gandhi Sagar WLS is second site.
- Asiatic lion: only in Gir (Gujarat); Endangered; Schedule I; 2015 = 523, 2020 = 674; 2025 = 891 (16th census, May 2025); International Lion Day 10 August.
- One-horned rhino: Vulnerable; Assam (Kaziranga 2,613 in 2022, Pobitora, Orang, Manas), West Bengal, UP; World Rhino Day 22 September.
- Gharial: Critically Endangered; National Chambal Sanctuary is the largest habitat.
- Gangetic river dolphin: National Aquatic Animal (5 October 2009); Vikramshila Sanctuary (Bihar) is the only dolphin sanctuary; Irrawaddy dolphin in Chilika.
- Snow leopard: State Animal of Ladakh and Himachal Pradesh; SPAI 2019-23: 718, Ladakh highest.
- Hangul: Critically Endangered; State Animal of J&K. Sangai: State Animal of Manipur.
- Great Indian Bustard: Critically Endangered; State Bird of Rajasthan.
- Olive Ridley: Gahirmatha, Rushikulya (Odisha); mass nesting called arribada.
- Nilgiri Tahr: State Animal of Tamil Nadu. Barasingha: State Animal of MP.

National Symbols

Tiger: National Animal. Peacock: National Bird. Ganga dolphin: National Aquatic Animal.
Indian elephant: National Heritage Animal.

CHAPTER 08

Non-Conventional Energy, Pollution, Water Conservation

Non-Conventional (Clean) Energy: Overview and India Status

- Conventional sources: coal, petroleum, natural gas, nuclear; non-conventional: solar, wind, hydro, biomass, geothermal, tidal, wave, OTEC, fuel cell, co-generation.
- Uranium is not a fossil fuel; nuclear energy is non-renewable, not biomass, and produces no air pollution but has radioactive waste problems.
- Fossil fuels store the Sun's energy; the Sun is the ultimate source of energy.
- Solar (photovoltaic) cell is the most eco-friendly option; no atmospheric pollution during conversion.
- UNGA declared 2014-2024 the Decade of Sustainable Energy for All; SDG 7 = affordable and clean energy by 2030.

India's non-fossil installed capacity (30 September 2026)

Source	Capacity (GW)	Note
Solar	171.05	Largest share of non-fossil capacity
Wind	59.20	Mostly onshore; no offshore wind commissioned yet
Hydro (large + small)	57.25	Large hydro 52.06 GW (incl. 7.43 GW pumped storage) + small hydro 5.18 GW; large hydro counted renewable since 2019
Bio-power	11.76	Biomass/bagasse cogeneration ~10.87 GW + waste-to-energy ~0.9 GW
Nuclear	8.78	Non-fossil but not "renewable"
Total non-fossil	308.03	Crossed 300 GW in 2026; over 54% of ~552 GW total installed capacity

- Total renewable capacity (including large hydro) is 299.25 GW (247.18 GW excluding large hydro); it was 76.38 GW in 2014.
- India added 24.56 GW renewable capacity in April-September 2026: solar 20.79 GW, wind 3.11 GW, large hydro 0.65 GW.
- In March 2015 wind (about 23 GW) was the largest renewable source and solar only about 3.7 GW; by 2026 solar (171 GW) is the largest.
- Rajasthan has the highest installed solar capacity, then Gujarat; Gujarat now has the highest installed wind capacity (about 16 GW), ahead of Tamil Nadu (Muppandal wind farm).
- Highest estimated renewable potential: Rajasthan (15%), Gujarat (11%), Maharashtra, Jammu and Kashmir.
- India ranks 3rd globally in renewable energy capacity; solar has the greatest renewable potential in India.
- Old target: 175 GW renewable by 2022 (100 solar + 60 wind + 10 bio + 5 small hydro) was missed; now subsumed in the 500 GW non-fossil target for 2030.
- India has about 300 sunny days and about 3000 hours of sunshine per year.

India's climate and clean energy commitments

Commitment	Target	Status
Original NDC (2015)	40% of installed power capacity non-fossil by 2030	Achieved in 2021, nine years early
Updated NDC (2022)	50% of installed power capacity non-fossil by 2030	Achieved around mid-2025
Updated NDC (2022)	Emission intensity of GDP down 45% from 2005 by 2030	Original target was 33-35%
Panchamrit (COP26, Glasgow 2021)	500 GW non-fossil capacity by 2030	308 GW by September 2026
Panchamrit	50% of energy requirement from renewables by 2030	In progress
Panchamrit	Cut projected emissions by 1 billion tonnes by 2030	In progress
Panchamrit	Net zero by 2070	Long-term

Targets that are easy to confuse

175 GW renewable by 2022 = old target; 500 GW non-fossil by 2030 = Glasgow COP26 pledge (includes large hydro and nuclear).

40% non-fossil capacity = 2015 NDC; 50% = 2022 updated NDC.

Conventional = coal, petroleum, gas, nuclear; non-conventional = solar, wind, hydro, biomass, geothermal.

Solar tariff regulator = CERC (not SECI); ISA HQ = Gurugram; first ISA Summit = New Delhi 2018.

IREDA

- Indian Renewable Energy Development Agency Limited; under MNRE; Mini Ratna (Category-I); founded 1987; motto "Energy Forever".
- Finances renewable energy and energy efficiency projects.

Net metering

- Billing system for grid-connected rooftop solar; bi-directional meter records power drawn and fed; consumer pays only the net difference.
- On-grid solar is connected to the grid (backup); off-grid is not connected; hybrid combines two or more sources with a common connection point.

Solar Energy

- Conversion devices: photovoltaic (PV) cells, solar heaters, cookers.
- Solar parks mostly in Rajasthan, Gujarat, Karnataka, Tamil Nadu, Andhra Pradesh, Madhya Pradesh.

Solar schemes and initiatives in India

Scheme / initiative	Year	Key facts
National Solar Mission (JNNSM)	Jan 2010	Brand 'Solar India'; one of 8 NAPCC missions (2008); target 20 GW by 2022 raised to 100 GW in 2015 (40 GW rooftop + 60 GW large/medium scale)
Solar Park / Ultra Mega Solar Park Scheme	2014	Plug-and-play model; land and connectivity provided

Scheme / initiative	Year	Key facts
Atal Jyoti Yojana (AJAY)	2016	Solar street lights where under 50% households have grid power
PM-KUSUM	2019	Solar pumps and feeder solarisation for farmers
PM Surya Ghar: Muft Bijli Yojana	Feb 2024	Rooftop solar for 1 crore households
ALMM	-	Approved List of Models and Manufacturers for solar modules

- Domestic Content Requirement (DCR): solar cells/modules must be made in India under certain schemes; the US took India to the WTO over it.
- Solar tariffs are determined by CERC, not SECI; India's panels are mostly assembled from imported cells.
- Solar can supply hot water, run irrigation pumps and street lighting.
- Largest solar parks: Bhadla (Rajasthan; about 2.25 GW, among the world's largest solar parks), Khavda (Gujarat; 30 GW renewable energy park under development), Pavagada (Karnataka), Kurnool (Andhra Pradesh), Rewa (Madhya Pradesh), Kamuthi (Tamil Nadu; one of the largest at a single location).

Solar firsts

First	Place
First fully solar-powered airport in the world	Cochin International Airport (Kochi, Kerala; first airport under PPP)
First UT / city 100% solar by day	Diu (2018)
First district with 100% solar-powered PHCs	Surat, Gujarat (52 PHCs, 2018)
India's first solar-powered village	Modhera (Gujarat)
Largest floating solar project	Ramagundam (Telangana), 100 MW, NTPC with BHEL as EPC; bigger projects such as Omkareshwar (MP) are under development (not Goa)

PM-KUSUM

- Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan; launched 2019 by MNRE.
- Original aim: add 30.8 GW solar capacity by 2022; about 13.11 GW installed by March 2026; deadline extended to 31 March 2027.

PM-KUSUM components

Component	Content
A	10,000 MW decentralised grid-connected renewable plants (up to 2 MW) on barren land
B	20 lakh standalone solar agriculture pumps
C	Solarisation of 15 lakh grid-connected agriculture pumps (also feeder level)

- Benefits: farmers sell surplus power and replace diesel pumps; DISCOMs get lower subsidy burden. Criticism: small and marginal farmers left out.

PM Surya Ghar: Muft Bijli Yojana

- Launched 13 February 2024; outlay about Rs 75,021 crore; rooftop solar on 1 crore households; up to 300 units free electricity per month.
- Central subsidy: Rs 30,000 per kW for first 2 kW, Rs 18,000 for the third kW; capped at Rs 78,000.

- Crossed 50 lakh household installations (~14.8 GW) by August 2026; target 75 lakh by December 2026.

International Solar Alliance (ISA)

- Joint initiative of India and France, launched on 30 November 2015 at COP21 Paris by PM Modi and President Hollande.
- Headquarters: Gurugram, Haryana (NISE campus); first treaty-based inter-governmental organisation headquartered in India (December 2017).
- Open to all UN members; originally for sun-rich countries between the Tropics; about 126 countries.
- First ISA Summit: New Delhi, 11 March 2018; second Summit: 31 October 2019; Eighth Assembly: 27–30 October 2025, New Delhi.
- Target: mobilise USD 1000 billion by 2030; supports SDG 7; UNGA granted ISA observer status.
- Delhi Solar Agenda (2018); ISTAR-C is a network of training and R&D centres.

One Sun One World One Grid (OSOWOG)

- Idea mooted by PM Modi at the first ISA Assembly (2018); launched by India and UK at COP26 Glasgow (2021) with the Green Grids Initiative.
- Vision "The Sun Never Sets"; global grid sharing solar power across borders; World Bank supports technically.

Challenges and solutions for solar

- Challenges: land need, T&D losses, DISCOM stress, intermittency, imports from China, funding gaps.
- Solutions: wasteland use, decentralised plants, manufacturing and R&D support, hybrid plants, REC, viability gap funding, anti-dumping duties.

Wind Energy

- Converts kinetic energy of wind to mechanical then electrical energy.
- Potential ~300 GW at 100 m mast height; over 95% of exploitable potential lies in seven states: Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Gujarat, Rajasthan, Madhya Pradesh.
- Wind capacity is 59.20 GW; National Institute of Wind Energy (NIWE) is at Chennai.

Offshore wind

- India's long coastline (11,098.81 km, revised 2025) offers potential mainly off Gujarat and Tamil Nadu.
- National Offshore Wind Energy Policy, 2015: allows offshore wind in the EEZ; MNRE nodal ministry, NIWE nodal agency.
- Target: 30 GW offshore by 2030; VGF scheme Rs 7,453 crore (June 2024) for 1 GW (500 MW each off Gujarat and Tamil Nadu).
- First tenders drew no bids (cancelled August 2025); no offshore wind commissioned yet.

Wind policies and support

Policy	Key content
Generation Based Incentive (GBI), 2009-10 (wind; reintroduced 2013)	Reward per unit generated
Wind Repowering Policy, 2016	Replace old turbines with higher capacity ones
Reverse bidding, 2017	Lowest-tariff bidder wins
Wind-Solar Hybrid Policy, 2018	Framework for large grid-connected hybrid systems
National Clean Energy Fund (2010)	Clean energy cess on coal and lignite per tonne; "polluter pays"; funds clean energy R&D

- Hybrid types: solar-wind, solar-biomass, hydro-wind, solar-hydro; both sources intermittent so storage/backup needed.
- Wind challenges: land, cost, bird habitat impact, noise.

Hydel (Hydro) Energy

- Kinetic energy of flowing/falling water turns turbines; first hydro project in India: Darjeeling, 1898.
- India imports hydropower from Bhutan (Tala, Chukha).
- Potential ~145-150 GW; Brahmaputra basin has highest potential, then Indus and Ganga; Arunachal Pradesh has highest state potential; east-flowing rivers have greater potential than west-flowing.

Large hydro versus small hydro

Feature	Large hydro	Small hydro (SHP)
Capacity	Above 25 MW	Up to 25 MW
Ministry	Ministry of Power	MNRE
Status	Declared renewable in 2019	Always renewable
Potential	-	~21,000 MW at 7000 sites (IIT Roorkee)

- Hydel challenges: capital cost, forest clearance, displacement, siltation, inter-state disputes.
- Small hydro downsides: affects stream flow, landslides in hills.

Biomass and Biofuels

- Biomass: crop residue, biodegradable waste, animal manure burnt or converted for energy; biofuel made from biomass in short time, unlike fossil fuels.
- USA is the largest ethanol producer; 2G ethanol technology developed by Department of Biotechnology; India's first 2G ethanol refinery: IOCL Panipat (2022).
- World Biofuel Day: 10 August.
- Biodiesel crops: Jatropha, Pongamia (Karanja), Mahua, Neem, sunflower; ethanol crops: maize, sugarcane.
- First Indian biofuel-powered flight: SpiceJet, Dehradun-Delhi, 27 August 2018.
- Bio-asphalt is made from non-petroleum renewable organic material (sugar, molasses, starch, vegetable oil); eco-friendly.
- Microbial fuel cells use microbes as catalysts on organic substrates; can run in wastewater plants.
- Global Biofuels Alliance launched by India at G20 Delhi Summit, 2023.

Generations of biofuels

Generation	Feedstock	Key point
1G	Food crops: corn, sugarcane, soybean, sunflower	Food-versus-fuel concern
2G	Agricultural waste, wood chips, grasses, MSW	No food competition; lower yield
3G	Algae	Needs far less arable land than crops (grown in ponds/photobioreactors, still needs area, water and infrastructure); high yield; not yet widely viable

Major types of biofuel

Type	Source / process	Key fact
Bioethanol	Fermented sugarcane, corn	Lowers CO and SO ₂
Biodiesel	Transesterification of vegetable, palm, soya oil, animal fat	Near-zero harmful gases

Type	Source / process	Key fact
Biogas	Anaerobic digestion	Mostly methane and CO ₂ ; traces of H ₂ S
Biohydrogen	Pyrolysis, biogasification, fermentation	Alternative to fossil fuel
Biobutanol	Fermentation of starch	Highest energy content; can be added to diesel

- Pyrolysis: heating organic matter without air gives syngas; gasification: partial burning with limited air gives producer gas (CO, hydrogen, methane) that can run engines (coconut shells, rice husk usable).
- Plasma gasification converts municipal solid waste into syngas (hydrogen + CO).

National Policy on Biofuels, 2018

- Aim: 20% ethanol blending in petrol and 5% biodiesel in diesel by 2030; E20 target advanced to 2025-26.
- Categories: 1G, 2G (ethanol, MSW), 3G (bio-CNG etc.).
- Allowed feedstock: sugarcane juice, beet, sorghum, cassava, corn, damaged food grains (wheat, broken rice), rotten potatoes; surplus foodgrains only with approval of National Biofuel Coordination Committee.
- Viability Gap Funding Rs 5000 crore for 2G ethanol; GST on blending ethanol cut from 18% to 5%.

Ethanol blending status

Blending rose from under 1.5% in 2013-14 to about 19.2% in ESY 2024-25 and 20% (E20) from November 2025, about five years ahead of the 2030 target.

Ethanol production capacity is about 19.9 billion litres (about 2.2 billion litres in 2014); maize is the largest feedstock.

BIS standards for E22, E25, E27 and E30 notified in May 2026; no decision yet to go beyond E20.

Biofuel and bioenergy schemes

Scheme	Year	Aim
GOBAR-Dhan	2018	Convert dung and farm waste into compost, biogas, bio-CNG
SATAT	2018	Compressed Biogas (CBG) plants and vehicle fuel use
PM JI-VAN Yojana	2019	Support 2G ethanol sector
RUCO	-	FSSAI-led collection of used cooking oil for biodiesel

Methanol economy

- Concept proposed in 1994 by Nobel laureate George Olah; methanol (CH₃OH) made from high-ash coal, CO₂, agri residue, natural gas.
- NITI Aayog Methanol Economy programme targets 10% cut in crude imports by 2030; BIS notified 20% DME blending with LPG.
- Burns without particulates or soot; corrosive, lower mileage.

Hydrogen and Fuel Cells

- Hydrogen has the highest calorific value among common fuels; burns to water; fuel cells convert chemical energy directly into DC electricity with water and heat as by-products.
- Delhi ran a pilot H-CNG bus in 2020 (first Indian city); H-CNG has hydrogen up to 18-20% by volume and cuts CO, CO₂ and hydrocarbons.

- Green hydrogen can be used in internal combustion engines, blended with natural gas, and in fuel cell vehicles.
- National Hydrogen Energy Board (2003) is superseded by the National Green Hydrogen Mission.

Colours of hydrogen

Colour	Production route
Green	Electrolysis of water using renewable power
Grey	Steam methane reforming of natural gas
Black / Brown	Coal gasification (black: bituminous, brown: lignite)
Blue	Grey hydrogen with carbon capture and storage
Turquoise	Methane pyrolysis (solid carbon by-product)
Pink	Electrolysis using nuclear power

National Green Hydrogen Mission (NGHM)

- Approved January 2023; outlay Rs 19,744 crore; nodal ministry MNRE.
- Target: 5 million metric tonnes green hydrogen per year by 2030; linked renewable capacity ~125 GW; ~50 MMT CO₂ abatement per year.
- Main programme SIGHT (Strategic Interventions for Green Hydrogen Transition); Green Hydrogen Hubs planned at ports.
- Hydrogen Valley Innovation Clusters: Jodhpur, Odisha, Pune, Kerala; green methanol bunkering at VOC Port.

Geothermal Energy

- Natural heat of the earth (hot springs, geysers, magma, hot dry rocks); steady source unlike solar and wind.
- GSI identified ~350 geothermal sites; seven provinces: Himalayas, Sohana, West Coast, Cambay, Son-Narmada-Tapi (SONATA), Godavari, Mahanadi (Ganga delta is not one).
- Most promising site: Puga Valley, Ladakh; others: Tatta Pani (Chhattisgarh), Manikaran (Himachal), Chumathang (Ladakh).

Ocean Energy

- Types: tidal, wave, ocean thermal (OTEC), ocean current, osmotic; MNRE has declared all as renewable; R&D by NIOT, Chennai (Ministry of Earth Sciences).

Ocean energy potential in India

Type	Potential	Notes
Tidal	~9,000-12,500 MW	Gulf of Khambhat, Gulf of Kutch (Gujarat highest), Sundarbans
Wave	~40,000 MW	East and west coasts
OTEC	~180,000 MW	Needs temperature difference of ~20 degrees C

- Closed-cycle OTEC: ammonia vaporised in heat exchanger; open-cycle: warm surface water flashed into steam.

Nuclear Energy (Brief)

- Installed nuclear capacity 8.78 GW from 24 operating reactors; 9 units under construction.
- Three-stage programme (Homi Bhabha): PHWR using natural uranium; fast breeder reactors using plutonium; thorium-U233 reactors. Large thorium reserves in monazite sands of Kerala and Odisha.
- First nuclear plant: Tarapur (Maharashtra), 1969; Kudankulam (Tamil Nadu) has Russian reactors.

- SHANTI Act, 2025 opens nuclear power to private participation; replaces Atomic Energy Act 1962 and Civil Liability for Nuclear Damage Act 2010; aim 100 GW nuclear by 2047.
- Environmental issues: radioactive contamination of air, soil, water; waste disposal; thermal pollution.

Co-generation

- Generation of heat and electricity from one fuel; waste steam reused; used in sugar mills, distilleries, fertiliser units.

Energy Conservation

Key institutions and laws for energy efficiency

Item	Facts
Energy Conservation Act	2001; amended 2010 and 2022
Bureau of Energy Efficiency (BEE)	Statutory body under Ministry of Power, set up 1 March 2002
NMEEE	One of 8 NAPCC missions; includes PAT
Perform, Achieve and Trade (PAT)	Market-based scheme for energy-intensive Designated Consumers; trade in Energy Saving Certificates
Star rating	1 to 5 stars; more stars = more efficient
ECBC	Launched 2007; revised 2017; large commercial buildings (100 kW or 120 kVA and above)
Eco-Niwas Samhita	2018; energy code for residential buildings
UJALA	2015; LED bulb distribution by EESL (Energy Efficiency Services Limited)

- Energy Conservation (Amendment) Act, 2022 enables the Carbon Credit Trading Scheme (Indian Carbon Market, under BEE) and mandates non-fossil energy use by designated consumers.

Air Pollution

Basics and Classification

- Air composition: nitrogen ~78%, oxygen ~21%; rest water vapour, argon, CO₂, ozone, methane.
- Indoor air pollution: main cause is solid-fuel (firewood, dung) cooking.
- Biodegradable pollutants: sewage, dung, garbage, agricultural residues; non-biodegradable: plastic, mercury, asbestos, DDT, lead.
- Human-made pollutants = xenobiotics.

Primary vs secondary pollutants

Type	Meaning	Examples
Primary	Enter atmosphere directly from source	CO ₂ , CO, SO ₂ , NO, soot, fly ash
Secondary	Formed by reactions of primary pollutants	Ozone (O ₃), acid rain, PAN, photochemical smog

Key air-pollution numbers

WHO: ambient + household air pollution linked to ~6.7 million premature deaths a year; State of Global Air 2025: 7.9 million deaths worldwide in 2023, India over 2 million.

Household air pollution: ~3.8 million premature deaths/year globally, ~60% in women and children.

Gaseous pollutants - sources and effects

Pollutant	Main sources	Main effects
Carbon monoxide (CO)	Incomplete combustion; vehicle exhaust (main pollutant), cigarettes	Binds haemoglobin 200-300 times more strongly than O ₂ (carboxyhaemoglobin)
Carbon dioxide (CO₂)	Fossil fuel burning	Principal greenhouse gas
CFCs	AC and refrigeration	Deplete ozone layer; phased out under Montreal Protocol
Ozone (O₃)	Vehicles, industries (CO and NO ₂ help form it)	"Good" in stratosphere, "bad" at ground level; eye irritation, crop damage
Nitrogen oxides (NO_x)	Petrol, diesel, coal; lightning; fertilisers	Smog, acid rain; bronchitis, asthma
Sulphur dioxide (SO₂)	Coal burning, smelting, volcanoes	Smog, acid rain; respiratory problems
VOCs	Perfumes, glues, air fresheners	Eye/nose/throat irritation
Ammonia (NH₃)	Fertilisers, livestock, decaying matter	Secondary PM _{2.5} ; eutrophication; raises BOD

- CNG is mainly methane (CH₄).
- Radon: most important indoor air pollutant; radioactive noble gas from radium decay in soil/rock; causes lung cancer.
- PAN (peroxyacetyl nitrate): powerful eye irritant; damages chloroplasts.
- Benzene sources: automobile exhaust, tobacco smoke, wood burning, varnished furniture, polyurethane products.
- Mercury: gold mining and coal power plants are sources; humans exposed mainly to methylmercury via fish.
- Steel industry emits SO_x, NO_x, CO and CO₂.

Particulate pollutants

Pollutant	Key facts
PM₁₀	Inhalable particles of 10 micrometres or less
PM_{2.5}	Fine particles of 2.5 micrometres or less; more harmful; can cross lung barrier into blood
Fly ash	By-product of coal burning in thermal plants
Lead	In petrol, batteries, paints; Tetraethyl lead (TEL) = anti-knock agent; cumulative poison, lowers IQ in children
Soot / black carbon	Incomplete combustion; short-lived; lowers albedo, melts Himalayan glaciers
Magnetite	Magnetic iron oxide; sources: vehicle brakes and engines, power plants; linked to neurodegeneration

- Soot and aerosols form Asian brown clouds over South and East Asia (UNEP 2002).
- Rain cannot clear particles below 2.5 micrometres.
- Brominated flame retardants (mattresses): persistent, bioaccumulative, endocrine disruptors; some are POPs.

Air-pollution control devices and indicators

Device / tool	Use
Bag filter	Removes particles below 50 micrometres
Cyclone separator, wet scrubber	Remove particles above 50 micrometres
Electrostatic precipitator	Removes fly ash in thermal plants
Catalytic converter	Pt-Pd-Rh catalyst: CO to CO ₂ , NO _x to N ₂ , hydrocarbons to CO ₂ + water
Ringelmann scale	Grades smoke density
Lichens	Bioindicator of air pollution, especially SO ₂

Commonly confused - pollutants and organs

Asbestos: lung (asbestosis, mesothelioma). Lead: brain and nervous system. Mercury: stomach/kidney. CO: bloodstream.

Fluoride causes fluorosis/knock-knee syndrome. Eutrophication is water pollution, not air pollution.

Acid rain - SO₂; photochemical smog - unsaturated hydrocarbons; Hb binding - CO; ozone depletion - CFC.

Aflatoxins are produced by moulds; argemone seeds adulterate mustard and cause epidemic dropsy.

Causes and Impacts of Air Pollution**Natural vs anthropogenic causes**

Natural	Anthropogenic
Forest fires	Fossil-fuel combustion (power, steel, cement, fertiliser)
Volcanic eruptions	Vehicular emissions (CO, NO _x , benzene)
Dust storms	Mining and smelting
Radon, pollen	Agriculture: NH ₃ , CH ₄ , N ₂ O; stubble burning
Enteric fermentation (cattle methane)	Open waste burning, firecrackers, construction dust

- Rice cultivation (anaerobic paddy fields) is the most important agricultural source of methane and nitrous oxide.
- India's agricultural emissions: livestock 54.6%, nitrogenous fertilisers 19%, rice cultivation 17.5%.
- Agriculture soils release NO_x; cattle release ammonia; poultry release reactive nitrogen compounds.
- NGT banned open burning of used tyres (2014).
- Health effects: lung cancer, heart disease, asthma; ground-level ozone reduces crop yield; Taj Mahal marble turning yellow.
- Rankings: WHO 2018 named Kanpur the world's most polluted city (PM_{2.5}); IQAir 2024 named Byrnihat (Meghalaya).
- World Air Quality Report 2025 (IQAir): India 6th most polluted country, average PM_{2.5} 48.9 ug/m³; Loni (UP) most polluted city; New Delhi most polluted capital for eighth consecutive year.

WHO Global Air Quality Guidelines (2021) - revised from 2005

Pollutant	Averaging	2005 value	2021 value
PM _{2.5}	Annual	10 ug/m ³	5 ug/m ³
PM _{2.5}	24-hour	25 ug/m ³	15 ug/m ³
PM ₁₀	Annual	20 ug/m ³	15 ug/m ³
PM ₁₀	24-hour	50 ug/m ³	45 ug/m ³

Acid Rain

- Rain with pH below 5.6 (normal rain ~5.6 due to dissolved CO₂); caused by SO₂ and NO_x forming H₂SO₄ and HNO₃; CO, CO₂ and ozone do not cause it.
- Effects: soil and water acidification, kills aquatic life, leaches aluminium into lakes, corrodes marble.
- "Lake killer": Norway and Canada worst hit. Helsinki Protocol 1985: at least 30% cut in sulphur emissions.

Taj Mahal and air pollution

Acid rain corrodes marble ("marble cancer"); soot from Mathura refinery turns marble yellow.

Taj Trapezium Zone (TTZ): 10,400 sq km protected area; Supreme Court (M.C. Mehta case) ordered industries to shift to CNG/LPG.

Sulphur Dioxide, Coal and Fly Ash

- India is the world's largest SO₂ emitter (over 15% of anthropogenic emissions); main source is coal power plants, most without Flue Gas Desulphurisation (FGD).
- Furnace oil: dark viscous residual product of crude distillation; releases sulphur oxides.

Classification of coal

Type	Carbon content	Features	Occurrence
Anthracite	80-95%	Best quality; highest calorific value	Small amounts in J&K
Bituminous	60-80%	High calorific value	Jharkhand, West Bengal, Odisha, Chhattisgarh, MP
Lignite	40-55%	Brown, high moisture	Tamil Nadu, Rajasthan, Lakhimpur (Assam)
Peat	Below 40%	First stage of coal formation	Marshes

- Indian coal has high ash content (25-45%); coal ash contains arsenic, lead and mercury.

By-products of coal ash

Product	Description
Fly ash	Very fine powder, mostly silica; captured by electrostatic precipitators
Bottom ash	Coarse particles settling at bottom of furnace
Boiler slag	Molten bottom ash solidified into glassy pellets
FGD material	Residue from SO ₂ removal

- Fly ash composition: SiO₂, Al₂O₃, Fe₂O₃, CaO; harms: heavy-metal poisoning, groundwater contamination; uses: cement, bricks, road sub-base, embankments.
- Fly ash policy: Maharashtra first state with fly-ash policy; ASHTRACK portal; plants below 80% ash utilisation fined Rs 1,000 per tonne; GST 5%.

Stubble (Crop Residue) Burning

- Most prevalent in Punjab, Haryana, western UP; paddy harvested October, wheat sown November; burning releases methane, CO, VOCs and PM_{2.5} (~40% of PM_{2.5} at peak).
- Reasons: combine harvesters leave residue; rice straw high in silica; short gap between crops; Punjab Preservation of Subsoil Water Act 2009 delayed transplanting.

Solutions to stubble burning

Solution	Detail
Happy Seeder / Turbo Happy Seeder	Sows wheat directly into residue
Zero tillage	Seeds drilled without disturbing residue
Central Sector Scheme	50% subsidy for in-situ machines; 80% for Custom Hiring Centres
PUSA Decomposer	Fungal capsules (IARI) speed up straw composting
Short-duration paddy	PAU Ludhiana varieties (e.g. Pusa-44)
Ex-situ use	Fodder, compost, bioethanol, biomass energy

- NGT banned crop residue burning in Rajasthan, UP, Haryana, Punjab (10 Dec 2015).
- CAQM environmental compensation for stubble burning: Rs 5,000 (under 2 acres), Rs 10,000 (2-5 acres), Rs 30,000 (over 5 acres) per incident.

Smog**Types of smog**

Feature	Photochemical (Los Angeles) smog	Sulphurous (London) smog
Also called	Oxidising smog	Classic / winter / reducing smog
Reactants	NO _x + VOCs + sunlight	Smoke + fog + SO ₂ (coal)
Secondary products	Ozone, PAN	Sulphuric acid aerosols
Weather	Sunny, warm	Cold, humid
Typical cause	Vehicles	Coal burning

- Smog tower (Connaught Place, Delhi): 24 m tall, 5,000 filters, 40 fans, ordered by Supreme Court (2019); China's tower (60 m) uses updraft.

Delhi Air Pollution, EPCA and CAQM

- Winter causes: north-westerly winds with dust, temperature inversion, low wind speed, landlocked geography, stubble burning, vehicles, road dust, Diwali firecrackers.
- Airshed: region sharing common pollutant distribution (Delhi NCR forms one).
- WAYU (Wind Augmentation Purifying Unit): installed 2018 at ITO and Mukarba Chowk; designed by NEERI and IIT Bombay.
- Pusa Bio-decomposer: ICAR-IARI fungal consortium converting stubble to compost.

EPCA vs CAQM

Feature	EPCA	CAQM
Created	1998 on SC order under Sec 3 of EPA 1986	Ordinance October 2020; Act 2021
Status	Non-statutory	Statutory, permanent
Area	NCR	NCR + adjoining areas of Punjab, Haryana, Rajasthan, UP
Powers	Directions, GRAP notification	Overrides CPCB, SPCBs; penalty up to Rs 1 crore and/or 5 years jail
Appeal	Supreme Court	National Green Tribunal
Fate	Dissolved 2020	Replaced EPCA

- M.C. Mehta vs Union of India (1988): landmark case on Delhi pollution.

Graded Response Action Plan (GRAP)

- Notified 2017 on SC direction; emergency measures by AQI; applies to Delhi-NCR.

GRAP stages (revised)

Stage	Air quality	AQI	Sample measures
I	Poor	201-300	Dust control, ban on waste burning
II	Very Poor	301-400	Ban diesel generators; more bus and Metro services
III	Severe	401-450	Ban BS-III petrol and BS-IV diesel LMVs; restrict construction
IV	Severe+	Above 450	Truck entry ban; halt construction; odd-even; school closure

National Air Quality Index (AQI)

- Launched 17 October 2014 under Swachh Bharat by MoEFCC; "One Number, One Colour, One Description"; developed by CPCB with IIT Kanpur.
- Eight pollutants: PM10, PM2.5, NO2, SO2, CO, O3, NH3, Pb; CO2 and methane are not included.
- Colours: Good (dark green), Satisfactory (light green), Moderate (yellow), Poor (orange), Very Poor (red), Severe (maroon).

AQI categories

AQI range	Category
0-50	Good
51-100	Satisfactory
101-200	Moderately polluted
201-300	Poor
301-400	Very Poor
401-500	Severe

National Clean Air Programme (NCAP)

NCAP at a glance

Item	Detail
Launched	January 2019 by MoEFCC; first national time-bound framework (non-statutory)
Original target	20-30% reduction in PM10 and PM2.5 by 2024 (baseline 2017)
Revised target	Up to 40% reduction in PM10 by 2025-26
Cities covered	130 non-attainment cities across 24 states/UTs
Portal	PRANA (launched 7 Sept 2021) tracks progress
NGT view	Right to clean air is part of Article 21; Public Trust Doctrine applies

Vehicular Pollution and Clean Fuels

Bharat Stage norms

Item	Detail
Started	2000 (Euro norms based); set by CPCB under MoEFCC
BS-IV	Nationwide 1 April 2017
BS-V	Skipped
BS-VI	From 1 April 2020; sulphur 10 ppm (50 ppm in BS-IV); DPF for diesel
BS-VI Stage II	Real-time emissions monitoring (OBD-II), April 2023

- Mashelkar Committee (2002): Euro norms phasing under National Auto Fuel Policy.
- India phased out leaded petrol in 2000; globally in 2021 (Algeria last).
- Vehicle Scrappage Policy: 20 years for personal and 15 years for commercial vehicles.
- FAME India launched 1 April 2015; FAME-II (2019, Rs 10,000 crore); replaced by PM E-DRIVE (2024, Rs 10,900 crore).
- LPG emits 20% less carbon than oil and 50% less than coal.

Policy Instruments for Air Quality

- **Air (Prevention and Control of Pollution) Act, 1981:** passed under Article 253 after Stockholm Conference; noise added as air pollutant in 1987 amendment.
- CPCB: statutory body created under Water Act 1974; also exercises Air Act powers; under MoEFCC.
- Pradhan Mantri Ujjwala Yojana (2016, MoPNG): deposit-free LPG connections to BPL women; Ujjwala 2.0 in 2021.
- Polluter Pays Principle: Principle 16 of Rio Declaration 1992.
- Industry categories by Pollution Index: Red (PI 60+), Orange (41-59), Green (21-40), White (non-polluting).
- Jan Vishwas Act 2023 replaced imprisonment in Air Act and EP Act with penalties up to Rs 15 lakh decided by adjudicating officers (appeal to NGT).

Water Pollution

Basics

- Four main causes: sewage, industrial operations, agricultural activities, urban runoff.
- SDG 6 = clean water and sanitation; SDG 14 = life below water; Water Action Decade 2018-2028.

Point vs non-point sources

Point source	Non-point source
Well-defined discharge point	Diffuse, spread over wide area
Domestic sewage, industrial effluent	Agricultural and construction runoff
Easier to regulate	Major share of toxins in streams and lakes

- Thermal pollution: hot cooling water; dissolved oxygen falls as temperature rises.
- Agricultural runoff carries nitrates, phosphates, DDT, endosulfan.

Water quality indicators

Indicator	Meaning	Interpretation
DO (Dissolved Oxygen)	Oxygen dissolved in water	Higher = cleaner; falls with temperature and organic load

Indicator	Meaning	Interpretation
BOD (Biochemical Oxygen Demand)	Oxygen used by microbes to decompose organic matter (5 days at 20 degrees C)	Higher = more organic pollution
COD (Chemical Oxygen Demand)	Oxygen to chemically oxidise all matter	Always greater than or equal to BOD

- CPCB Class A drinking-water source: DO 6 mg/L or more, BOD 2 mg/L or less.

Eutrophication

- Nutrient (nitrogen, phosphorus) enrichment leading to algal bloom; cultural eutrophication is human-caused (sewage, detergents, fertilisers).
- Sequence: nutrients, algal bloom, decomposition, oxygen depletion, fish kill, "dead zones"; blue-green algae dominate blooms.
- BOD is the key index of organic pollution; highest BOD in Ganga is between Kanpur and Prayagraj.
- Damodar is 'Sorrow of Bengal' and a 'biological desert'; Gomti (Lucknow-Jaunpur) declared 'biological disaster'.
- Untreated sewage is the largest source of water pollution in India; leather industry causes highest chemical pollution.

Facts and Figures (India)

- Polluted river stretches (CPCB): 351 (2018), 311 (2022), 296 (2023); Maharashtra has most (54), then Kerala (31).
- India treats about one-third of its wastewater; STP capacity 31,841 MLD versus 72,368 MLD sewage generated.

Water Pollution Laws and Institutions

Key laws

Law	Key points
Water (Prevention and Control of Pollution) Act, 1974 (amended 1988)	First environmental law; creates CPCB and SPCBs
Water Cess Act, 1977 (amended 2003)	Cess on water-using industries
Environment (Protection) Act, 1986	Umbrella Act
Water (Amendment) Act 2024	Decriminalises minor offences (Rs 10,000 to Rs 15 lakh); adjudicating officers
Article 51A(g)	Fundamental duty to protect lakes, rivers, forests, wildlife
Article 21	Right to clean water and environment

- BIS drinking water standard: IS 10500:2012.
- Atal Bhujal Yojana: groundwater management; AMRUT: urban water supply and sewerage.

Wastewater Treatment

- Primary: sedimentation; secondary: activated sludge, trickling filters; tertiary: advanced oxidation.

Water treatment steps

Step	What happens
Coagulation	Alum or ferric sulphate make dirt clump into flocs
Sedimentation	Heavy flocs settle
Filtration	Sand, gravel, anthracite remove suspended matter

Step	What happens
Disinfection	Chlorination kills germs; cannot remove dissolved salts/metals
Defluoridation	Using lime, sodium carbonate, alum

- Zero Liquid Discharge (ZLD): recycles all water; Tirupur knitwear hub first to adopt.
- Kolkata sewage-fed aquaculture: world's largest system of its kind.
- Water hyacinth treats chemical wastewater; desalination by reverse osmosis; Tamil Nadu first state to use it.
- Blue-baby syndrome (methemoglobinemia): nitrate in drinking water.

Bioremediation

- Microorganisms convert pollutants to less harmful forms; GM microbes (e.g. *Pseudomonas putida*) for oil spills; heavy metals like cadmium and lead cannot be readily treated.
- TERI 'Oilzapper': oil-degrading bacteria consortium; used in 2010 Mumbai port oil spill.

Bioremediation techniques

Type	Technique	Meaning
In-situ	Bioventing	Air and nutrients through wells to stimulate bacteria
In-situ	Bioaugmentation	Adding specialised microbes
Ex-situ	Landfarming	Excavated soil spread and tilled
Ex-situ	Biopiles	Hybrid of landfarming and composting
Fungal	Mycoremediation	Fungi clean up contaminants

Groundwater Pollution

- India is the largest groundwater user in the world (26% of global extraction); Punjab has the highest exploitation rate.
- Geogenic contaminants: arsenic and fluoride; overpumping causes inland salinity and seawater intrusion.
- Heavy sand mining lowers the water table and pollutes groundwater.

Groundwater contaminants and affected states

Contaminant	States	Health effect
Arsenic	West Bengal, Bihar, Chhattisgarh, Assam, UP	Skin lesions, cancers, black foot disease
Fluoride	Rajasthan, Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu, Punjab, Haryana	Dental and skeletal fluorosis, knock-knee
Nitrate	Rajasthan, Punjab, Haryana, Gujarat	Blue-baby syndrome
Iron	Assam, West Bengal, Odisha	Hemochromatosis
Uranium	Rajasthan, Andhra Pradesh, Punjab, Haryana	Kidney damage

- Arsenic WHO limit 0.01 mg/L; first Indian case West Bengal 1978; paddy absorbs arsenic.
- Uranium limit in drinking water 0.03 mg/L (WHO); NPPCF (fluorosis programme) started 2008-09.

Water-related diseases

Disease	Cause
Minamata	Mercury poisoning
Itai-itai	Cadmium poisoning
Blue-baby syndrome	Nitrate
Fluorosis (knock-knee)	Excess fluoride
Black foot disease	Arsenic

Groundwater institutions

Institution	Key fact
Central Ground Water Board (CGWB)	Under Ministry of Jal Shakti; NAQUIM aquifer mapping
Central Ground Water Authority (CGWA)	Constituted 1997 under Sec 3(3) of EPA 1986; regulates extraction

River Pollution, Ganga and Yamuna

- NRCP (National River Conservation Plan) started 1995; Ganga Action Plan 1985; Yamuna and Gomti Action Plans 1993.

Ganga governance

Body	Details
National Mission for Clean Ganga (NMCG)	Society registered 12 Aug 2011; implementation arm of National Ganga Council
NGRBA	Set up 2009 under EPA; replaced by National Ganga Council in 2016
National Ganga Council	Chaired by Prime Minister
Namami Gange	Approved June 2014; Rs 20,000 crore for 2015-2020; extended with Rs 22,500 crore to March 2026
Clean Ganga Fund	Donations qualify as CSR

- Pillars of Namami Gange: sewage treatment, riverfront development, river-surface cleaning, biodiversity, afforestation, awareness, effluent monitoring, Ganga Gram.
- Ganga Gram: gram panchayats on Ganga banks in five states (Uttarakhand, UP, Bihar, Jharkhand, West Bengal).
- Hybrid Annuity Model and One City One Operator: PPP models for STPs.

Ocean and Marine Pollution

- ~80% of marine pollution from land-based sources; 8-10 million tonnes of plastic enter oceans annually.
- Ocean acidification: oceans absorb CO₂ forming carbonic acid; harms calcareous phytoplankton and corals.
- India has National Oil Spill Disaster Contingency Plan (1996).
- India-SACEP MoU (2018) on oil and chemical pollution in South Asian Seas.

International marine conventions

Convention	Key facts
London Convention 1972	Prevention of marine pollution by dumping (Protocol 1996)
MARPOL 73/78	IMO convention on ship pollution; six annexes

Convention	Key facts
Annexes	I Oil; II Noxious liquids; III Packaged harmful substances; IV Sewage; V Garbage; VI Air pollution
IMO	UN agency; HQ London; convention adopted Geneva 1948
Honolulu Strategy	Framework on marine debris
Clean Seas Campaign	UNEP, 2017; targets single-use plastics
UN Decade of Ocean Science	2021-2030

Lake Pollution

- Causes: siltation, acid rain, agricultural runoff, untreated sewage, industrial heavy metals; impacts: eutrophication, fish kills, waterborne diseases.
- Bellandur lake (Bengaluru): untreated sewage, toxic froth and fires.

Plastic Pollution

- Single-use plastics: one-third of all plastic made; Delhi generates the most plastic waste among Indian cities.
- Only 9% of global plastic waste is recycled; polythene (polymer of ethylene) is non-biodegradable.
- Bisphenol A (BPA) in food-contact plastics is an endocrine disruptor; chewing gum base is plastic/synthetic rubber.
- World Environment Day 2018 theme "Beat Plastic Pollution" (host India); 2025 theme Ending Plastic Pollution (host Republic of Korea).
- Bangladesh was first country to ban thin plastic bags (2002).

Evolution of plastic rules in India

Year	Rule	Key point
1999	Recycled Plastics Rules	Ban on carry bags below 20 microns
2011	Plastic Waste (Management and Handling) Rules	Ban on plastic sachets for gutkha, tobacco
2016	Plastic Waste Management Rules	Polluter Pays and Extended Producer Responsibility (EPR); carry bag minimum 50 microns
2018	Amendment	Phase-out of multilayered non-recyclable plastics
Aug 2021	Amendment	Ban on identified single-use plastics from 1 July 2022
Sep 2021	Second Amendment	Carry bag thickness 75 microns (2021), 120 microns (Dec 2022)
Feb 2022	Amendment	EPR guidelines for plastic packaging with four categories
Mar 2026	Amendment Rules 2026	Mandatory recycled-content targets; reuse obligations for rigid packaging

EPR plastic packaging categories

Category	Type
1	Rigid plastic packaging

Category	Type
2	Flexible plastic packaging
3	Multilayered plastic packaging
4	Plastic sheets, carry bags of compostable plastics

Single-Use Plastic ban (from 1 July 2022)

Banned: earbuds with plastic sticks, balloon sticks, plastic flags, candy and ice-cream sticks, thermocol decoration, plates, cups, cutlery, straws, stirrers, PVC banners below 100 microns.

Penalty under EP Act 1986: up to 5 years jail or fine up to Rs 1 lakh or both.

- India Plastics Pact (2021; CII and WWF-India) is the first in Asia; first Plastics Pact was UK, 2018.
- Project REPLAN (KVIC): handmade paper with 20% plastic waste.
- Global plastics treaty: INC-5.2 (Geneva, August 2025) ended without agreement; UNEA-5 (2022) launched the treaty process.

Soil Pollution

- Soil pollution = hazardous compounds in soil endangering health/environment; World Soil Day: 5 December.
- Excess fertiliser causes soil, water (eutrophication, nitrate) and air pollution.
- Sita Ashok is effective against dust pollution.

Sources of soil pollution

Category	Examples
Industrial	Fly ash, mercury, lead, cadmium, cyanides, nuclear waste
Agricultural	Chemical fertilisers, DDT, endosulfan, heptachlor
Plastics	Non-biodegradable; block seed germination
Natural	Acid rain, flood deposition

- Permaculture: integrated design, multi-cropping, agroforestry, mulching; discourages monoculture; chemical farming raises salinity.
- Global Soil Partnership (FAO, 2012); International Code of Conduct on Pesticide Management (FAO/WHO, voluntary).
- Measures: organic farming, biofertilisers, IPM, contour ploughing, terracing, ban on DDT/BHC, phytoremediation.

Waste Management

Types and Data

- Types: solid, municipal, industrial, bio-medical, e-waste, agricultural.
- Delhi tops Indian cities in waste generation; Ghazipur landfill is huge.
- Copper smelting releases SO₂, HF, NO_x and heavy metals in slag (not CO).

Solid waste management methods

Method	Description	Issue
Open dump	Unregulated dumping	Breeds rats, flies, disease
Sanitary landfill	Engineered, lined, leachate-collected	Leachate pollutes groundwater; methane

Method	Description	Issue
Incineration	Burning in excess oxygen	Dioxins and furans
Pyrolysis	Heating without oxygen to give syngas	Waste-to-energy
Gasification	Partial combustion in limited oxygen	Waste-to-energy
Composting	Aerobic decomposition to humus	Improves water retention
Biomethanation	Anaerobic digestion for biogas	

Solid Waste Management Rules

SWM Rules 2016 vs 2026

SWM Rules 2016 replaced Municipal Solid Wastes Rules 2000; 2026 Rules (effective 1 April 2026) replace 2016 Rules and apply to urban and rural bodies.

2016: three-stream segregation (wet, dry, domestic hazardous). 2026: four streams (wet, dry, sanitary, special care).

SWM Rules 2016 highlights

Feature	Detail
Applicability	Beyond municipal areas: census towns, airports, railways, SEZs, pilgrimage sites
Waste-to-energy	Industries within 100 km of RDF plant to replace at least 5% fuel with RDF
Collect-back scheme	Brand owners with non-biodegradable packaging must collect it
Open burning	Prohibited
Informal sector	Integration of rag pickers

- SWM Rules 2026: bulk waste generators process wet waste on-site; landfills only for non-recyclable and inert waste; legacy dumpsites cleared by biomining.
- SWM Rules 2026 (effective 1 April 2026; replace 2016 Rules; apply to urban and rural areas): four-stream segregation (wet, dry, sanitary, special care); Extended Bulk Waste Generator Responsibility.
- Bulk waste generator = built-up area above 20,000 sq m, or water use above 40,000 L/day, or waste above 100 kg/day.
- Industrial RDF use to rise from 5% to 15% within six years; Environmental Compensation (Polluter Pays) for violations; central digital portal; annual landfill audits; higher tipping fee for unsegregated waste; time-bound biomining of legacy dumpsites.

Construction and Hazardous Waste

- C&D Waste Management Rules 2016 (MoEFCC).
- Hazardous waste: physical, chemical, reactive, toxic, flammable, explosive or corrosive; TSDF = Treatment, Storage and Disposal Facilities.
- Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016: added "other wastes"; 2019 amendment banned solid plastic waste import even in SEZ/EOU.

International conventions on chemicals and wastes

Convention	Key facts
Basel	Transboundary movement of hazardous waste; adopted 1989, in force 1992; radioactive waste not covered; Ban Amendment bars OECD to non-OECD export
Rotterdam	Prior Informed Consent (PIC) for hazardous chemicals/pesticides; adopted 1998, in force 2004
Stockholm	Persistent Organic Pollutants (POPs); adopted 2001, in force 2004; India ratified 2006
Minamata	Mercury; adopted Kumamoto, Japan, 2013; in force 2017; India ratified 2018

- Stockholm: Annex A (elimination), Annex B (restriction), Annex C (unintentional production).
- Original Dirty Dozen POPs: Aldrin, Chlordane, DDT, Dieldrin, Endrin, Heptachlor, Hexachlorobenzene, Mirex, Toxaphene; PCBs; dioxins and furans. Endosulfan added 2011.
- BRS COPs 2025: chlorpyrifos, MCCPs and long-chain PFCAs listed in Annex A of Stockholm.
- Nairobi Declaration (Basel COP-9) on environmentally sound e-waste management.

Bio-medical Waste

- BMW Rules 2016 (amended 2018); first rules 1998; barcoding and GPS in CBWTF; chlorinated plastic bags phased out.
- Colour codes: yellow (anatomical, soiled), red (contaminated recyclable plastics), white translucent (sharps), blue (glassware, metallic implants).
- Bio-toilets (Indian Railways-DRDO): anaerobic bacteria digest human waste into methane, CO₂ and water.

E-Waste

- India is the third largest e-waste generator after China and USA; informal sector handles ~90% of e-waste.
- Global e-waste: 62 million tonnes (2022); International E-Waste Day: 14 October.
- India's first e-waste clinic: Bhopal.

E-Waste rules

Rule	Features
E-Waste Rules, 2011	First e-waste law; introduced EPR
E-Waste Rules, 2016	CFL and mercury lamps included; PRO; Deposit Refund Scheme
E-Waste Rules, 2022	In force 1 April 2023; online registration; 106 EEE items; tradable EPR certificates; recycling targets 60% (2023-25), 70%, 80%

- PRO = Producer Responsibility Organisation; RoHS = Reduction of Hazardous Substances.
- Battery Waste Management Rules, 2022: EPR for all batteries.

Waste to Energy and Circular Economy

- RDF: refuse-derived fuel from inorganic waste (plastics, cloth); Bidadi (Karnataka) 11.5 MW WtE plant; Okhla and Timarpur (Delhi) WtE plants.
- Polycrack technology converts plastics to fuel; first government plant at Mancheswar (Odisha).
- Circular economy principles: design out waste and pollution; keep products in use; regenerate natural systems.
- 4 R: Reduce, Reuse, Recycle, Recover.

Other Pollution Types

Noise Pollution

- Noise Pollution (Regulation and Control) Rules, 2000 (under EPA 1986); unit decibel (dB), named after Alexander Graham Bell.

Ambient noise standards (dB(A) Leq)

Area	Day (6 am-10 pm)	Night (10 pm-6 am)
Industrial	75	70
Commercial	65	55
Residential	55	45
Silence zone	50	40

- Silence zone: within 100 m of hospitals, educational institutions, courts.
- Typical levels: whisper 30 dB, conversation 60 dB, truck 80-85 dB, jet engine 120 dB, rocket 180 dB.
- Green muffler: belts of trees (Ashoka, Neem) absorb noise and dust.

Other

- Bhopal gas tragedy: 2-3 December 1984, Union Carbide plant, methyl isocyanate (MIC) leak. Chernobyl: 26 April 1986; Fukushima: 2011.

Water: Global and Indian Situation

- Water covers ~71% of the earth; over 97% is saline. After ice caps and glaciers, groundwater is the largest freshwater store.
- World Water Day: 22 March (first observed 1993); 2026 theme: Water and Gender. UN 2026 Water Conference: 2-4 December 2026 (UAE and Senegal).
- Rajendra Singh ('Waterman of India', Tarun Bharat Sangh): Magsaysay Award 2001, Stockholm Water Prize 2015.
- India has ~4% of world freshwater but ~16-18% of population; utilisable resources 1,122 BCM (690 BCM surface + 432 BCM groundwater).
- India is the world's largest groundwater extractor; irrigation uses ~80% of freshwater. About 600 million Indians face high to extreme water stress (NITI Aayog).
- Water is a State subject (Entry 17, State List); regulation of inter-state rivers is Union List Entry 56.

Falkenmark indicator (per-capita annual renewable water)

Condition	m ³ /person/year
Water stress	Below 1,700
Water scarcity	Below 1,000
Absolute scarcity	Below 500

- Physical scarcity: demand exceeds supply (arid areas); economic scarcity: lack of infrastructure or poor management.
- Dynamic Groundwater Resource Assessment 2025: of 6,762 units, 730 (10.8%) over-exploited, 201 critical, 758 semi-critical, 4,946 safe; stage of extraction ~60.6%.
- Causes of scarcity: population growth, Green Revolution tube wells, paddy under MSP in Punjab/Haryana, flood irrigation, reduced recharge, pollution, droughts.

Water institutions

Central Water Commission (CWC): est. 1945, technical body under Ministry of Jal Shakti; Central Ground Water Board (CGWB): est. 1970 (grew out of the Exploratory Tubewells Organisation, 1954).

Central Ground Water Authority (CGWA): constituted 1997 under Environment (Protection) Act, 1986; CWC and CGWB are not under EPA.

Water Act 1974 (amended 1988) versus Water Cess Act 1977 (enforced 1978) versus EPA 1986.

- India has 20 river basins (12 major, 8 composite) per CWC.

Water Conservation Techniques

- Rainwater harvesting (RWH): Tamil Nadu first state to make it compulsory for every building.
- Aquifer recharge; sponge city; Zero Liquid Discharge; drip irrigation; desalination; coastal reservoirs.
- Virtual water: water embedded in traded goods.
- Watershed: area draining to a common point; boundary between two is the water divide.

Watershed classification by size

Class	Area
Macro	More than 50,000 ha
Sub-watershed	10,000 to 50,000 ha
Milli	1,000 to 10,000 ha
Micro	100 to 1,000 ha
Mini	1 to 100 ha

Government Schemes: Water

Water-related schemes and missions

Scheme	Year / level	Key facts
National Water Mission	2008, NAPCC	Goals include 20% rise in water use efficiency; river interlinking is not part of it
PMKSY	2015	"Har Khet Ko Pani" and "Per Drop More Crop"
Namami Gange	June 2014	Rs 20,000 crore flagship for Ganga rejuvenation
AMRUT	2015	Urban water supply, sewerage
Jal Shakti Abhiyan	2019	Water conservation in water-stressed districts; "Catch the Rain" campaign
Jal Jeevan Mission	2019	Tap water to every rural household; extended to December 2028
Atal Bhujal Yojana	April 2020	Community groundwater management in 7 states (Gujarat, Haryana, Karnataka, MP, Maharashtra, Rajasthan, UP)
Amrit Sarovar Mission	April 2022	75 water bodies in each district
Mission Kakatiya	Telangana	Restore minor irrigation tanks
Jalyukt Shivar	Maharashtra	Water-stress-free villages
Neeru Chettu	Andhra Pradesh	Water conservation

Scheme	Year / level	Key facts
Pani Bachao Paise Kamao	Punjab	Payment to farmers for electricity saved

- Jal Jeevan Mission: only 17% rural households had tap water in 2019; coverage now ~82%; "Har Ghar Nal se Jal".
- Namami Gange status: 219 sewerage projects sanctioned; 4,263 MLD treatment capacity created; Ganga declared National River on 4 November 2008.
- Central Ganga Authority 1985 became NRCA in 1995; NGRBA set up 20 February 2009 under EPA 1986 and dissolved 7 October 2016.
- Ganga Action Plan began 1985; Yamuna Action Plan (India-Japan project) and Gomti Action Plan 1993; Namami Gange announced in Budget 2014-15.
- Ganges river dolphin: National Aquatic Animal (2009); declines from dams, nets, agrochemicals. Gharial is Critically Endangered.
- NLCP (2001) covers Sukhna, Bhoj, Pichola, Dal but not Chilika; merged with National Wetlands Conservation Programme into NPCA (2013).
- Aral Sea shrank due to human activity (irrigation); NITI Aayog Composite Water Management Index (CWMI) ranks states.

Water Policy and Governance

- National Water Policies: 1987, 2002, 2012; Draft National Water Policy 2020 by Mihir Shah committee (National Water Commission merging CWC and CGWB, demand management, crop diversification).
- Disinfectants for drinking water: chlorine, chloramine, chlorine dioxide, ozone; UV kills microbes without altering taste but does not remove turbidity.

Interlinking of Rivers

- Transfers water from surplus to deficit basins; components: Himalayan (14 links), Peninsular (16 links), Inter-state links; managed by National Water Development Agency (NWDA).
- Early proposals: Sir Arthur Cotton; K.L. Rao's National Water Grid (1972, Ganga-Kaveri); Captain Dinshaw Dastur's Garland Canal (1977).
- Ken-Betwa Link: first project under National Perspective Plan; Daudhan Dam; cost ~Rs 44,605 crore (Union Cabinet approval 8 December 2021; foundation stone laid 25 December 2024); benefits Bundelkhand; submerges part of Panna Tiger Reserve.
- Challenges: cost, displacement, biodiversity loss, inter-state disputes.

Dams in India

- India ranks third (after China and USA) in large dams; issues: sedimentation, displacement, reservoir-induced seismicity (Koyna).
- Mullaperiyar Dam: Periyar river, Idukki (Kerala); built 1887-1895 by John Pennycuik.
- Dam Safety Act, 2021: passed 8 December 2021, in force 30 December 2021; covers dams above 15 m (and 10-15 m with conditions); National Committee on Dam Safety (NCDS) and National Dam Safety Authority (NDSA); State Dam Safety Organisations.
- DRIP (Dam Rehabilitation and Improvement Project): launched 2012 by CWC with World Bank help; Phase II and III with World Bank and AIIB help cover 736 dams in 19 States.

CHAPTER 09

Organizations and Institutions

Constitutional and Legal Framework for Environment

Constitutional provisions on environment

Provision	Nature	Content
Article 21	Fundamental Right	Right to life includes right to clean and healthy environment
Article 48A	DPSP (non-binding)	State shall protect and improve environment, safeguard forests and wildlife
Article 51A(g)	Fundamental Duty	Protect and improve natural environment; compassion for living creatures
Article 253	Legislative power	Parliament can legislate to implement international treaties; basis of EPA 1986
42nd Amendment 1976	Seventh Schedule	Forests and Protection of Wild Animals and Birds moved from State List to Concurrent List

Landmark judgments on environment

Case	Year	Key holding
Subhash Kumar v. State of Bihar	1991	Right to pollution-free water and air is part of Article 21
M.C. Mehta v. Union of India (Ganga pollution)	1988	Environmental education compulsory in schools and colleges (order of 1991; Ganga case 1988)
Vellore Citizens Welfare Forum v. Union of India	1996	Precautionary principle and Polluter Pays principle part of Indian law
T.N. Godavarman Thirumulpad v. Union of India	1996-97	"Forest" = dictionary meaning plus any area recorded as forest; NPV concept; felling ban
Tarun Bharat Singh v. Union of India	1993	Protected forest comes under FCA 1980; no non-forest use without Centre's approval
Divya Pharmacy v. Union of India (Uttarakhand HC)	2018	Prior consent and benefit-sharing needed for access to biological resources

Environmental principles upheld by courts

Polluter Pays and Precautionary Principle: Vellore Citizens case (1996)

Both principles plus sustainable development guide NGT (Section 20, NGT Act 2010)

Rio Declaration (1992): Precautionary approach = Principle 15; Polluter Pays = Principle 16 (not Stockholm 1972, which has 26 principles)

Key Environmental Acts

Major environmental legislation of India

Act	Year	Key provision
Indian Forest Act	1927	Reserved, Protected, Village and Non-government forests; consolidated 1865 and 1878 Acts
Wildlife (Protection) Act	1972	Schedules, Protected Areas, NBWL, NTCA, CZA, WCCB; originally 6 schedules
Water (Prevention and Control of Pollution) Act	1974	India's first pollution-control law; created CPCB (statutory) and SPCBs
Forest (Conservation) Act	1980	Prior Central approval for diverting forest land; renamed Van (Sanrakshan Evam Samvardhan) Adhiniyam by 2023 Amendment
Air (Prevention and Control of Pollution) Act	1981	Air pollution control; noise added as pollutant 1987
Environment (Protection) Act	1986	"Umbrella Act"; after Bhopal Gas Tragedy 1984; Stockholm 1972 follow-up; Article 253; whole of India
Public Liability Insurance Act	1991	Mandatory insurance for handling hazardous substances
Biological Diversity Act	2002	NBA, SBB, BMC; Access and Benefit Sharing; follow-up of CBD 1992
Forest Rights Act (FRA)	2006	Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act; Gram Sabha central
National Green Tribunal Act	2010	NGT established 18 October 2010
Jan Vishwas (Amendment of Provisions) Act	2023	Decriminalised EPA, Air Act, IFA, PLI Act offences; jail replaced by penalties

Dates to remember

Water Act 1974 (first) -> Air Act 1981 -> EPA 1986 -> PLI Act 1991 -> NGT Act 2010

Forest Conservation Act = 1980; Wildlife Act = 1972; Biological Diversity Act = 2002; FRA = 2006

Chronology: Wildlife Act 1972 -> Project Tiger 1973 -> Project Elephant 1992 -> Biological Diversity Act 2002

NGT Act does NOT apply to Wildlife Act, Indian Forest Act 1927, FRA and state forest laws

Commonly confused - Acts and statutory bodies

NGT was created by an ACT (2010); CPCB is also STATUTORY (Water Act 1974), not an executive order

Animal Welfare Board of India = Section 4, Prevention of Cruelty to Animals Act 1960 (1962), NOT the EPA 1986

NTCA is statutory (WPA); National Ganga River Basin Authority (2009, chaired by PM) dissolved 7 Oct 2016
-> National Ganga Council

Central Ground Water Authority (CGWA) is constituted under Section 3(3) EPA 1986; CGWB and CWC are not

Critical Wildlife Habitat is defined only in FRA 2006; Baigas got first Habitat Rights; Ministry of Tribal Affairs decides

Key environmental policies and programmes

Policy / Programme	Year	Point
Forest Policy (first, colonial)	1894	Custodial, timber-oriented
National Forest Policy	1988	Current policy; conservation first, people's participation; least priority to industrial timber
National Action Plan on Climate Change (NAPCC)	2008	Eight missions
National Clean Air Programme (NCAP)	2019	PM10 cut target 20-30% by 2024, revised to 40% by 2025-26 (base 2017)

NAPCC: eight national missions

- National Solar Mission; National Mission for Enhanced Energy Efficiency
- National Mission on Sustainable Habitat; National Water Mission
- National Mission for Sustaining the Himalayan Ecosystem; National Mission for a Green India (GIM)
- National Mission for Sustainable Agriculture; National Mission on Strategic Knowledge for Climate Change

Indian Forest Act 1927

- Consolidated law on forests, transit of forest produce and duty on timber; superseded 1865 and 1878 Acts
- Prohibits quarrying, burning lime or charcoal, removal of forest produce from protected forests

Forest categories under IFA 1927

Category	Constituted by	Key feature
Reserved Forest	State government (Section 20)	Highest restriction; local people barred unless permitted
Protected Forest	State government	Government holds proprietary rights; rights of locals recorded
Non-government forest	Outside reserved and protected categories	Private or community-owned

- Amendment 2017: bamboo grown on non-forest land is not a "tree"; no felling or transit permit needed
- Reserved and State Forests are not Protected Areas unless part of a sanctuary or national park

Wildlife (Protection) Act 1972

- Applies to whole India (J&K brought in after 2019 reorganisation); before 1972 India had only five national parks
- Central Government appoints Director of Wildlife Preservation (Section 3); State appoints Chief Wildlife Warden (CWLW) and Wardens (Section 4)

- NBWL created by 2002 Amendment (Section 5A); State Board for Wild Life (Section 6) chaired by Chief Minister
- Section 2(24A): "Protected Area" = National Park, Sanctuary, Conservation Reserve, Community Reserve; Tiger Reserve is also a PA (Chapter IVB)
- Section 39: every wild animal is the property of the State Government; protection applies equally inside and outside Protected Areas
- Community Reserve (Sections 36C-36D): private/community land; Management Committee (elected Chairman is Honorary Wildlife Warden) manages it, not the CWLW; hunting prohibited, jhum not allowed, NTFP collection allowed
- Gharial, Indian wild ass and wild buffalo are Schedule I animals; a Schedule I tortoise gets the same protection as the tiger

Wild Life (Protection) Amendment 2022

Feature	Provision
Schedules	Six reduced to four; Schedule V (vermin) removed; new schedule for CITES-listed specimens
CITES	Centre designates Management Authority (permits) and Scientific Authority (advice)
Penalty	General violation: fine up to Rs 1 lakh (earlier Rs 25,000); specially protected animals: minimum fine Rs 25,000 (earlier Rs 10,000)

Schedule facts

Schedule I animals get tiger-level protection (gharial, Indian wild ass, wild water buffalo, Sch I tortoises)
 Old Schedule VI = specified plants; cultivation needs a licence
 After 2022: plants moved to Schedule III; Schedule IV = CITES specimens

Forest (Conservation) Act 1980 and Van Adhiniyam

- Enacted 27 December 1980; in force 25 October 1980; only Central Government can grant forest clearance
- Prior Central approval needed for de-reservation of reserved forest and non-forest use of forest land
- Godavarman (1996) widened "forest" to dictionary meaning and government records; NPV of diverted forest land introduced (1997-2002 orders)

Forest (Conservation) Amendment Act 2023

Feature	Provision
New name	Van (Sanrakshan Evam Samvardhan) Adhiniyam 1980
Land covered	Notified forests and areas recorded as forest on or after 25 Oct 1980
Exemption	Strategic linear projects within 100 km of international borders, LAC and LoC
Supreme Court interim order	19 Feb 2024: States/UTs must follow Godavarman 'dictionary meaning'; zoos/safaris outside Protected Areas need prior SC approval

Environment (Protection) Act 1986

- "Umbrella Act": framework for Central coordination of authorities under earlier laws such as Water Act and Air Act

- Enacted under Article 253 after Bhopal Gas Tragedy (1984); implements Stockholm Conference (1972) decisions
- Powers: set standards, restrict industrial locations, regulate hazardous substances, issue directions (Section 5); appoint officers (Section 4); constitute authorities (Section 3(3))
- Jan Vishwas 2023: imprisonment replaced by penalties up to Rs 15 lakh imposed by adjudicating officers; appeal to NGT

Biological Diversity Act 2002

- Passed December 2002, assent February 2003; outcome of CBD 1992
- Three tiers: National Biodiversity Authority (NBA, statutory autonomous, 2003, Chennai), State Biodiversity Boards (SBBs), Biodiversity Management Committees (BMCs) at local body level
- BMCs prepare People's Biodiversity Registers (PBR) and can levy collection fees
- Prior NBA approval required for IPR on Indian biological resources; NBA opposes foreign patents (anti-biopiracy); it does NOT supervise GM crops (GEAC does)
- 2023 Amendment: AYUSH practitioners and codified traditional knowledge users exempt from prior intimation; cultivated medicinal plants exempt; penalties Rs 1 lakh to Rs 50 lakh; Member Secretary post created

Forest Rights Act 2006

- Aim: undo "historical injustice"; land tenure, livelihood and food security, conservation
- Eligibility: Scheduled Tribes residing in forests; Other Traditional Forest Dwellers who lived there three generations (75 years) before 13 December 2005
- Minor Forest Produce (MFP) = all non-timber forest produce of plant origin, including bamboo, tendu leaves, cane; forest dwellers get ownership/collection/transit rights
- Bamboo on non-forest land is not a 'tree' (IFA 2017) but remains MFP under FRA
- FRA is the only law defining 'Critical Wildlife Habitat'; Baiga tribe (Madhya Pradesh) got India's first Habitat Rights

Four categories of rights under FRA

Right	Content
Title rights	Ownership of land actually cultivated by the household (up to 4 ha), as on 13 Dec 2005
Use rights	MFP, grazing, nistar
Relief and development rights	Rehabilitation on illegal eviction; basic amenities
Forest management rights	Protect, regenerate, conserve and manage Community Forest Resources

FRA facts

Individual Forest Rights (IFR) and Community Forest Rights (CFR)
 Linked with PESA 1996; expands Fifth and Sixth Schedule protection
 Ministry of Tribal Affairs is the nodal ministry (not MoEFCC)
 NGT has no jurisdiction over FRA matters

Compensatory Afforestation (CAMPA)

- Compensatory afforestation: planting on equal area of non-forest land, or twice the area of degraded forest land, when forest land is diverted
- National CAF and State CAF under Public Account; distribution 90% to states, 10% retained by Centre

National Green Tribunal (NGT)

- Established 18 October 2010 under NGT Act 2010 (Article 21 basis); first chairperson Justice Lokeshwar Singh Pant; present chairperson Prakash Shrivastava (since August 2023)
- India: third country (after Australia and New Zealand) and first developing country with a specialised environmental tribunal

NGT benches

Bench	Location
Principal Bench	New Delhi
Western Zone	Pune
Central Zone	Bhopal
Southern Zone	Chennai
Eastern Zone	Kolkata

Acts under NGT jurisdiction (Schedule I)

Included (seven Acts)	Excluded
Water Act 1974; Water Cess Act 1977	Wildlife (Protection) Act 1972; Indian Forest Act 1927
Forest (Conservation) Act 1980	State forest and tree preservation laws
Air Act 1981	Forest Rights Act 2006
Environment (Protection) Act 1986	
Public Liability Insurance Act 1991	
Biological Diversity Act 2002	

Indian Environmental Institutions

Nodal and regulatory bodies

Core regulatory and nodal institutions

Institution	Year / Act	HQ	Function
MoEFCC	MoEF 1985; renamed MoEFCC 2014	New Delhi	Nodal ministry for environment and forestry policy
Central Pollution Control Board (CPCB)	Sept 1974 (Water Act); Air Act powers 1981	Delhi	Statutory; monitoring, standards, NAMP, AQI, CEPI
National Biodiversity Authority (NBA)	2003 (BD Act 2002)	Chennai	ABS regulation; opposes foreign IPR on Indian resources
Genetic Engineering Appraisal Committee (GEAC)	1989 Rules under EPA	New Delhi	Apex body for approval of GM organisms and field trials
Central Zoo Authority (CZA)	1992 (WPA)	New Delhi	Recognises zoos; National Zoo Policy 1998
National Tiger Conservation Authority (NTCA)	2005 (WPA)	New Delhi	Statutory body for Project Tiger

Institution	Year / Act	HQ	Function
Wildlife Crime Control Bureau (WCCB)	2007 (WPA)	New Delhi	Wildlife crime intelligence; nodal agency for CITES enforcement
National Board for Wildlife (NBWL)	2002 (replaced Indian Board for Wildlife 1952)	New Delhi	Apex advisory body; chaired by Prime Minister

Scientific and research institutions

Forest, wildlife and biodiversity research institutions

Institution	Year	HQ	Function
Forest Survey of India (FSI)	1981	Dehradun	Forest mapping; India State of Forest Report (ISFR) biennially
Wildlife Institute of India (WII)	1982	Dehradun	Wildlife training and research
ICFRE	1986	Dehradun	Apex forestry research body
Forest Research Institute (FRI)	1906	Dehradun	Oldest forestry research institute
Indian Institute of Forest Management (IIFM)	1982	Bhopal	Forest management education
Zoological Survey of India (ZSI)	1916	Kolkata	Faunal survey
Botanical Survey of India (BSI)	1890	Kolkata	Floral survey; herbarium

Dehradun cluster

FSI (1981), WII (1982), ICFRE (1986), FRI (1906) are all in Dehradun
 ZSI (1916) and BSI (1890) are in Kolkata; IIFM is in Bhopal
 BNHS is an NGO, not an autonomous body under MoEFCC

Protected Areas and Forest Data

Protected Area network

Category	Number	Note
National Parks	106-107	First: Hailey (Jim Corbett) 1936; Largest: Hemis (Ladakh); Smallest: South Button (A&N)
Wildlife Sanctuaries	~573	Grazing may be permitted
Conservation Reserves	~115	Government land next to NP/WLS; first: Tiruppudaimaruthur (Tamil Nadu)
Community Reserves	~220	Private/community land
Total PAs	Over 1,000	About 5.3% of geographical area

- Tiger Reserves: 58 (latest added Madhav, Madhya Pradesh); 2022 All India Tiger Estimation: 3,682 tigers

Wildlife Sanctuary vs National Park

Feature	Wildlife Sanctuary	National Park
Boundary	Not fixed	Fixed; alteration needs State Legislature resolution + NBWL

Forest area terms (ISFR)

Term	Meaning
Forest Cover	All land more than 1 ha with tree canopy density above 10%, irrespective of ownership
Green Wash Area	Areas shown green on Survey of India maps; may not reflect actual forest

- ISFR 2023 (released Dec 2024): forest cover + tree cover about 25.17% of area

International Organisations and Reports**UN and treaty bodies**

Organisation	Year	HQ	Role
UNEP	1972	Nairobi	Environmental authority of UN; Executive Director Inger Andersen; UN Environment Assembly (UNEA-7 Nairobi Dec 2025); Emissions Gap, Global Environment Outlook, Food Waste Index
UNFCCC Secretariat	1992 (in force 1994)	Bonn	COP30 Belem 2025; COP31 Antalya, Turkiye (9-20 Nov 2026)
IPCC	1988 (WMO + UNEP)	Geneva	Assessment reports (AR6 2021-23); Nobel Peace Prize 2007 (with Al Gore)
Global Environment Facility (GEF)	1991	Washington DC	Financial mechanism for CBD, UNFCCC, UNCCD, POPs, Minamata; funds LDCF and SCCF; India is donor and recipient
CBD Secretariat	1992 (in force 1993)	Montreal	Kunming-Montreal Global Biodiversity Framework (2022); Nagoya Protocol
CITES Secretariat	1973 (in force 1975)	Geneva	Regulates wildlife trade; Appendices I, II, III; hosted by UNEP
Ramsar Secretariat	1971 (in force 1975)	Gland, Switzerland	Wetland convention; Montreux Record
International Solar Alliance (ISA)	2015	Gurugram, India	India-France initiative, launched at COP21

Non-governmental and scientific organisations

Organisation	Year	HQ	Role / flagship
IUCN	1948	Gland, Switzerland	Red List; both state and NGO members; President Razan Al Mubarak
WWF	1961	Gland, Switzerland	Living Planet Report (biennial, with ZSL); giant panda logo
TRAFFIC	1976	Cambridge, UK	Wildlife trade monitoring network of WWF and IUCN; NOT a bureau of UNEP
BirdLife International	1922	Cambridge, UK	IUCN's Red List authority for birds; identifies Important Bird and Biodiversity Areas (IBAs); hotspot concept is from Norman Myers, NOT BirdLife

Commonly confused organisations

IUCN (Gland) publishes Red List; CITES (Geneva) regulates trade; Ramsar (Gland) for wetlands
 UNFCCC and UNCCD secretariats are both in Bonn; CBD in Montreal; GEF in Washington; GCF in Songdo
 TRAFFIC = wildlife trade monitoring (WWF + IUCN); WCCB = Indian statutory nodal for CITES

Biodiversity-related terms

- International Day for Biological Diversity: 22 May; International Year of Biodiversity: 2010; Earth Day: 22 April
- Ramsar Convention does not make it mandatory to protect all wetlands; Wetlands (Conservation and Management) Rules 2010 were framed under National Environment Policy 2006 (not Ramsar); Rules 2017 shifted management to State authorities

CHAPTER 10

Awards, Days and Dates, Environment: Miscellaneous

Environmental Days and Dates Calendar

Date matching - Commonly Confused

World Wildlife Day = 3 March; World Water Day = 22 March; World Forestry Day = 21 March

World Environment Day = 5 June; World Ozone Day = 16 September; Earth Day = 22 April

World No Tobacco Day = 31 May; World Health Day = 7 April; World Population Day = 11 July

World Habitat Day = FIRST MONDAY of October (not fixed date); World Toilet Day = 19 November; World Cities Day = 31 October

January to June

Date	Day	Notes / latest theme
2 Feb	World Wetlands Day	Ramsar Convention signed 1971; 2026: "Wetlands and Traditional Knowledge: Celebrating Cultural Heritage"
3 Mar	World Wildlife Day	UNGA 2013; date = CITES signing (1973); 2026: "Medicinal and Aromatic Plants: Conserving Health, Heritage and Livelihoods"
21 Mar	International Day of Forests	2026: "Forests and Economies"; 2025: "Forests and Food"
22 Mar	World Water Day	UN-Water; 2026: "Water and Gender"; 2025: "Glacier Preservation"
22 Apr	Earth Day	First held 1970 (Gaylord Nelson, USA); 2024: "Planet vs. Plastics"
22 May	International Day for Biological Diversity	CBD text adopted 1992; 2026: "Acting locally for global impact"
31 May	World No Tobacco Day	WHO; 2022: "Tobacco: threat to our environment"
5 Jun	World Environment Day	UNEP; Stockholm 1972, first WED 1973 "Only One Earth"; 2026: "Climate action" (host Azerbaijan); 2025: "Ending Plastic Pollution" (#BeatPlasticPollution; host Republic of Korea)
17 Jun	World Day to Combat Desertification and Drought	UNCCD adopted 1994; 2026: "Rangelands: Recognize. Respect. Restore" (host Kenya); 2026 = International Year of Rangelands and Pastoralists

July to December

Date	Day	Notes
29 Jul	International Tiger Day	St Petersburg Tiger Summit 2010; Tx2 goal
16 Sep	World Ozone Day	Montreal Protocol signed 1987; 2026: "Global action for a cooler planet"
1st Mon of Oct	World Habitat Day	UN-Habitat; first 1986; 2026: "Adequate Housing for All"
19 Nov	World Toilet Day	UNGA resolution 2013; 2025: "Sanitation in a changing world"

- Earth Overshoot Day (Global Footprint Network): 2024 = 1 August; 2025 = 24 July; 2026 = 30 July; concept by Andrew Simms.

Environmental Awards and Prizes*International awards***Major international environmental awards**

Award	By / since	Key facts
Champions of the Earth	UNEP; 2005 (replaced Global 500)	UN's highest environmental honour; categories: Policy Leadership, Science and Innovation, Entrepreneurial Vision, Inspiration and Action, Lifetime Achievement
Earthshot Prize	Prince William; 2020	5 categories; GBP 1 million each, for 10 years
Goldman Environmental Prize	San Francisco; 1989	"Green Nobel"; 6 grassroots winners, one per region
John and Alice Tyler Prize	University of Southern California; 1973	"Nobel Prize for Environment"
Right Livelihood Award	Sweden; 1980	"Alternative Nobel": Chipko (1987), Narmada Bachao Andolan (1991), Vandana Shiva (1993)
Nobel Peace Prize	Norway	Wangari Maathai 2004 (Green Belt Movement); IPCC and Al Gore 2007; OPCW 2013
Norman Borlaug Award	World Food Prize Foundation	Agriculture; Borlaug won Nobel Peace Prize 1970; "Father of Green Revolution"

Champions of the Earth - recent laureates

Year	Laureates (category)
2016	Afroz Shah (Versova beach clean-up)
2018	PM Narendra Modi (Policy Leadership, for ISA and single-use plastic pledge); Cochin International Airport (Entrepreneurial Vision)

Year	Laureates (category)
2025	Pacific Islands Students Fighting Climate Change (Policy Leadership); Supriya Sahu, Tamil Nadu IAS (Inspiration and Action); Mariam Issoufou (Entrepreneurial Vision); Imazon, Brazil (Science and Innovation); Manfredi Caltagirone (Lifetime Achievement)

- Earthshot Prize winners: 2021 Costa Rica, Takachar (India), Coral Vita, Enapter, Milan; 2023 S4S Technologies (India); 2025 re.green, Bogota, High Seas Treaty, Lagos Fashion Week, Friendship (Bangladesh).
- Goldman 2026: Africa Irero Tanshi; Asia Borim Kim; Europe Sarah Finch; Islands Theonila Roka Matbob; N. America Alannah Acaq Hurley; S&C America Yuvelis Morales Blanco.
- India's Goldman winners: Medha Patkar (1992), M.C. Mehta (1996), Rashida Bee and Champa Devi Shukla (2004, Bhopal), Ramesh Agrawal (2014), Prafulla Samantara (2017).
- Tyler Prize: Madhav Gadgil (India) 2015; Partha Dasgupta 2016; Michael Mann 2019; Pavan Sukhdev 2020.

Indian awards

Indian environmental awards

Award	Instituted	Key facts
Indira Gandhi Paryavaran Puraskar (IGPP)	1987	MoEFCC; contribution to environment protection; silver lotus trophy
Rajiv Gandhi Environment Award for Clean Technology	-	MoEFCC; clean technologies in industry
Amrita Devi Bishnoi Wildlife Protection Award	First conferred 2001	MoEFCC; wildlife protection by individuals/communities in rural areas

Commonly Confused

Global 500 (UNEP, till 2003) replaced by Champions of the Earth (from 2005)

Tyler Prize = environment; Borlaug Award = agriculture; Goldman = grassroots activists

Rajiv Gandhi Environment Award = clean TECHNOLOGY; IGPP = overall environment protection

Environmental Impact Assessment (EIA)

EIA in India: timeline

- 1976-77: Department of Science and Technology asked to examine river-valley projects (first step).
- 27 January 1994: first EIA Notification under Environment (Protection) Act 1986 made Environmental Clearance (EC) mandatory.
- 14 September 2006: EIA Notification 2006 replaced the 1994 notification.
- 2020: Draft EIA Notification 2020 released; not notified in final form.
- Legal basis: Section 3 of EPA 1986 and Rule 5(3) of EP Rules 1986.
- Stages: Screening, Scoping (ToR), Impact prediction, Mitigation (EMP), Reporting (EIS), Public hearing, Appraisal (EAC/SEAC), Decision, Monitoring.

EIA Notification 2006 - categories and authorities

Category	Appraised at	Authority	Process
A	Centre	Expert Appraisal Committee (EAC), MoEFCC	Mandatory EC; no screening; EIA and public hearing

Category	Appraised at	Authority	Process
B1	State	SEIAA with State Expert Appraisal Committee (SEAC)	Mandatory EIA report
B2	State	SEIAA / SEAC	No EIA report needed; only Form 1

- Four stages in 2006 notification: Screening (only B), Scoping, Public Consultation, Appraisal.
- General Condition: Category B projects near protected areas, critically polluted areas, eco-sensitive areas or inter-state boundaries are treated as Category A.
- Public hearing conducted by State Pollution Control Board; notice 30 days (2006) vs 20 days (Draft 2020).
- Timelines: appraisal 60 days; decision 45 days.
- Validity of EC (originally 5 years most / 10 river valley / 30 mining; later extended): river valley 13 years; nuclear power 15 years; other projects 10 years; mining = life of mine or 30 years (extendable by 20 years, up to 50, with 5-yearly review). Check the latest notification for sector rules.
- Compliance report every six months (annual in Draft 2020).

Draft EIA Notification 2020 vs EIA 2006

Aspect	EIA 2006	Draft EIA 2020
Public hearing notice	30 days	20 days
Compliance report	Every 6 months	Annual
Violations (no EC)	Not regularised	Post-facto clearance with penalty
Who can report violations	Public could complain	Only promoter, government, committee or regulator
Exemptions	Fewer	Many (strategic projects, certain B2, inland waterways)
Criticism	-	Encourages "Pay and Pollute" over "Polluter Pays"

EIA vs SEA

EIA = project level, END of decision cycle, narrow and detailed; SEA = policy/plan/programme level, EARLY in cycle, broad
SEA considers broad alternatives and cumulative effects; SEA does not replace EIA - they are complementary

Related assessments and tools

Tool	Key points
Strategic Environmental Assessment (SEA)	For plans, programmes and policies; India has no statutory SEA
Social Impact Assessment (SIA)	Mandated by RFCTLARR (Land Acquisition) Act 2013
Environment Supplement Plan (ESP)	Beneficial activity by an alleged violator after paying penalty
PARIVESH	Single-window hub for Environment, Forest, Wildlife and CRZ clearances

Coal Mining and Thermal Power: Environmental Impacts

- Coal mining: acid mine drainage (pyrite), coal bed methane, subsidence and fires at Raniganj and Jharia; thermal plants emit fly ash, SO₂, NO_x, mercury.
- Top coal reserve states: Jharkhand > Odisha > Chhattisgarh > West Bengal > Madhya Pradesh.
- India is the 2nd largest coal producer after China.
- District Mineral Foundation (DMF) created by MMDR Amendment Act 2015 for welfare of mining-affected people.

Environmental Movements of India

Major environmental movements

Movement	Year	Place	Leader(s)	Key facts
Bishnoi (Khejarli)	1730	Khejarli, Jodhpur, Rajasthan	Amrita Devi	363 Bishnois died hugging Khejri trees; Guru Jambheshwar founded sect (1485); inspires Forest Martyrs Day (11 Sep)
Chipko	1973	Mandal / Reni, Chamoli (Uttarakhand)	Sunderlal Bahuguna, Chandi Prasad Bhatt, Gaura Devi	Tree-hugging by women; Bhatt: Magsaysay 1982; Right Livelihood Award 1987
Appiko	1983	Salkani, Uttara Kannada, Karnataka	Pandurang Hegde	Western Ghats; Karnataka's Chipko
Silent Valley	1973-1985	Palakkad, Kerala	KSSP; Salim Ali; Sugathakumari	Against Kunthipuzha hydro project; lion-tailed macaque; NP inaugurated 1985 by Rajiv Gandhi
Narmada Bachao Andolan	1985	Narmada valley	Medha Patkar, Baba Amte	Against Sardar Sarovar dam; "Rally for the Valley" 1989; Right Livelihood 1991
Navdanya	1987	Uttarakhand	Vandana Shiva	Seed saving, organic farming
Plachimada	2002	Palakkad, Kerala	Mayilamma	Against Coca-Cola groundwater extraction
Niyamgiri	2000s	Odisha	Dongria Kondh	Vedanta bauxite; Supreme Court 2013 gave Gram Sabhas the decision
Green Belt Movement	1977	Kenya	Wangari Maathai	Nobel Peace Prize 2004

Movement matching

Appiko = Pandurang Hegde; Chipko = Sunderlal Bahuguna; Narmada = Medha Patkar

Silent Valley is linked to Salim Ali, NOT Baba Amte (Narmada Bachao and wildlife protection)

Indices, Reports and Eco-Labels

Latest index ranks

Index	Publisher	Latest India status
Environmental Performance Index (EPI) 2026	Yale (biennial)	India 176th of 177, score 22.46; Estonia 1st
EPI 2024	Yale and Columbia	India 176th of 180, score 27.6; Estonia 1st
Climate Change Performance Index (CCPI) 2026	Germanwatch, NewClimate Institute, CAN	India 23rd (down from 10th); ranks 1-3 vacant
Living Planet Report 2026	WWF with ZSL (biennial)	73.2% fall in monitored vertebrate populations 1970-2022

Who publishes what

EPI = Yale + Columbia; CCPI and Climate Risk Index = Germanwatch

Emissions Gap, Global Environment Outlook, Food Waste Index = UNEP; State of Global Climate = WMO

Living Planet Report = WWF + ZSL; World Air Quality Report = IQAir; World Risk Index = UNU-EHS

CEPI = CPCB; SDG India Index = NITI Aayog; State Energy Efficiency Index = BEE + AEEE

Eco-labelling and green rating systems

System	Body	Key facts
Eco Mark	Govt of India, 1991; BIS	Voluntary labelling of eco-friendly products; logo earthen pot; NOT for drugs
ISI mark	Bureau of Indian Standards	Since 1947; BIS Act 2016 effective 2017; mandatory for automotive tyres and tubes
AGMARK	Directorate of Marketing and Inspection (1935)	Agricultural Produce (Grading and Marking) Act 1937
BEE Star Label	Bureau of Energy Efficiency	Appliance energy rating (1-5 stars)
GRIHA	TERI + MNRE	India's national green building rating
Blue Flag	FEE, Denmark	Beach eco-label; 33 criteria; India operator SICOM (MoEFCC)

- Blue Flag beaches (first 8 in 2020): Shivrajpur (Dwarka), Ghoghla (Diu), Kasarkod, Padubidri, Kappad, Rushikonda, Golden Beach (Puri), Radhanagar; later Kovalam, Eden, Minicoy Thundi, Kadmat; 18 total in 2025-26.

Footprint and carbon terms

Term	Meaning
Ecological footprint	Productive area needed to sustain a population; unit global hectare
Carbon footprint	Total GHG emissions in CO ₂ e

Term	Meaning
Carbon credit	Permit to emit 1 tonne CO ₂ e; market-determined price (not fixed by UN)
Green accounting	Economic activity together with environmental effects

Remember

Carbon credit system arose with the Kyoto Protocol; MCX was first exchange in Asia to trade carbon credits

Green India Mission is one of eight NAPCC missions: restore forest cover; it does NOT do "green accounting"

Disaster Management**Disaster management facts**

Item	Fact
Disaster Management Act	2005
NDMA	Notified 2006; headed by Prime Minister
INCOIS	Hyderabad (1999); tsunami early warning

- Floods are the most frequent natural disaster in India; tsunamis are mostly caused by submarine earthquakes.

Miscellaneous Facts**Conventions, treaties and agreements**

- OPCW: implements Chemical Weapons Convention (in force 1997); HQ The Hague; Nobel Peace Prize 2013.
- Mega-diverse countries (Conservation International, 1998): 17 – USA, Mexico, Colombia, Ecuador, Peru, Venezuela, Brazil, DR Congo, South Africa, Madagascar, India, Malaysia, Indonesia, Philippines, Papua New Guinea, China, Australia; Nepal, New Zealand and Austria are not.

Indian Antarctic stations

Station	Year	Notes
Dakshin Gangotri	1983	First Indian station; abandoned (buried in ice)
Maitri	1989	Operational
Bharati	2012	Operational

- Locations: Wildlife Institute of India and FRI – Dehradun; IIFM – Bhopal; CAZRI – Jodhpur; IGFR – Jhansi; GB Pant Institute – Almora; INCOIS – Hyderabad.

Government schemes

- Perform, Achieve and Trade (PAT): 2012; BEE; cuts specific energy consumption in energy-intensive industries.
- MISHTI (Mangrove Initiative for Shoreline Habitats and Tangible Incomes): launched 5 June 2023.
- LiFE (Lifestyle for Environment): presented by PM Modi at COP26 Glasgow, 1 November 2021.

UNESCO World Heritage (India)

Item	Fact
Total sites	45 (37 cultural, 7 natural, 1 mixed Khangchendzonga)

Item	Fact
Moidams of Ahom dynasty (Assam)	2024 (43rd site)
Maratha Military Landscapes	2025 (44th site)
Ancient Buddhist Site of Sarnath (Uttar Pradesh)	July 2026 (45th site; 48th WHC session, Busan)

Species, places and science one-liners

- Marine National Park, Gulf of Kachchh (Jamnagar, Gujarat): first marine NP of India.
- Bhitarkanika: Kendrapara, Odisha; Brahmani-Baitarani estuary.
- Geological heritage: National Fossil Wood Park - Tiruvakkarai (Villupuram, Tamil Nadu); Shivalik Fossil Park - Sirmaur; Stromatolite Park - Chittaurgarh; Lonar Lake - Buldhana.

UP-PSC 2026

PRELIMS

SIMULATOR TESTS

Write Your
Prelims before the
Actual Prelims



SCAN TO
REGISTER

ENGLISH &
हिंदी माध्यम

SIMULATOR - 0
25 OCT
2026

SIMULATOR - 1
01 NOV
2026

SIMULATOR - 2
11 NOV
2026

SIMULATOR - 3
22 NOV
2026

SIMULATOR - 4
29 NOV
2026

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