VISIONIAS
INSPIRING INNOVATION

Environment

Classroom Study Material 2025

JUNE 2024 TO MAY 2025

MAINS 365

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ENVIRONMENT

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Preface

To the Aspirant Who Dares to Dream

In the quiet corners of libraries across India, in the solitude of late-night study sessions, and in the hearts of millions who dare to dream of serving the nation, lies an unwavering determination to crack one of the world's most challenging examinations – the UPSC Civil Services Examination.

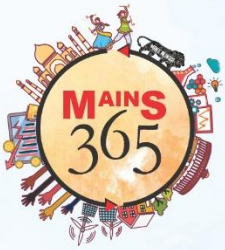
Mains 365 was born from that very spirit of determination and the recognition that success in UPSC CSE Mains 2025 demands more than just hard work; it requires strategic preparation, comprehensive understanding, and the ability to connect diverse streams of knowledge into coherent, impactful answers.

Q.1 Why most of the aspirants fail to crack mains?

- **Scattered Information:** Jumping between multiple sources creates confusion
- **Outdated Content:** Using materials that don't reflect current developments
- **Lack of Integration:** Inability to connect static knowledge with current affairs
- **Poor Answer Structure:** Not knowing how to present knowledge effectively
- **Missing the UPSC Mindset:** Failing to understand what UPSC actually want

But what if you could overcome ALL these challenges with ONE comprehensive resource?

Q2. Why Mains 365 Environment?



It is a one-stop annual compendium that distils every high-stakes current-affairs theme—Climate Change Conferences, Recent Disasters, Alternative Energy Resources—into exam-ready notes mapped topic-by-topic to the UPSC CSE Mains syllabus.

Also, Environment Mains 365 document enriches multiple GS papers—e.g., Environment links with GS-I (Geophysical Phenomena), GS-II (Climate Policy), and GS-IV (Environmental Ethics).

Q3. How does it mirror the General Studies papers?

Chapters are mapped after syllabus topics and recurring themes in the UPSC exam like Climate Change, Environmental Pollution and Degradation, Disaster Management, Conservation Efforts, etc., so you can easily match your reading with the syllabus and PYQ checklist.

Q4. I already have static books. Why do I need this?

Static concepts fetch marks only when linked to real examples. Mains 365 does this by connecting the year's key trends, data, committee reports, examples, etc.,—making your answers sharper, richer, and more analytical.

Q5. Will it actually save me time in the exam hall?

Yes. Infographics, Definition, Targets and "Why in News" blocks act like visual flashcards; you recall a picture, not a paragraph. That saves minutes off every 10- or 15-marker.

4.7.1. ETHANOL BLENDING

Why in the News? → Can be used as Introduction

India is gearing up to set a new target of 30% ethanol blending in petrol by 2030, having already achieved a 20% blend (March 2025).

What is Ethanol Blending?

- **Ethanol Blending**: Involves a **blended motor fuel containing ethyl alcohol** that is at least 99% pure, derived from agricultural products
  - **Ethanol is a biofuel** naturally produced by the **fermentation of sugars by yeasts** or via **petrochemical processes such as ethylene hydration.**
- **Key Targets:** Targets of 20% ethanol blending in petrol by 2025 (Updated) and 5% biodiesel blending in diesel by 2030. (National Policy on Biofuels, 2018)

Definition and India's Targets

Significance

Reduce Pollution: Use of **E20 leads** to reduction of **carbon monoxide** emissions by about **50 per cent** in two-wheelers and about **30 per cent** in four-wheelers compared to petrol.

Reduce Import: help in lowering India's energy import dependency.

Boost farmer income and help in **achieving international commitment** of the government.

Can be used as Value addition

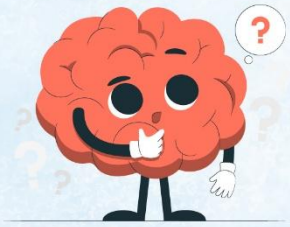
Q6. What gives my answers extra credibility?

Ready-to-use definitions, latest data from recent reports (e.g., India's BUR-4: Fourth Biennial Update Report to UNFCCC) and recommendations from official sources (e.g., NDMA Guidelines), key words plus facts (e.g., **$300 billion** per year by 2035 is the **New Collective Quantified Goal on Climate Finance (NCQG)** adopted at CoP29) embed instant authority. UPSC love precise references.

Q7. How is it structured for the 3-hour examination?

Every sub-topic follows the golden sequence—Context→Analysis→Way Forward—so you can lift the framework, plug in your insights, and write at full speed while others are still outlining.

Q8. Can you demonstrate with an actual question?



PYQ: "What is oil pollution? What are its impacts on the marine ecosystem? In what way is oil pollution particularly harmful for a country like India? (GS-III 2023, 10 marks)"

Quick extract from Mains 365 → Oil Spills at a Glance

- Definition of Oil spill (Meaning)
- Impacts of Oil Spill (Impacts)
- Way Forward (Solution)

Plug these into Intro–Body–Conclusion:

Start by defining Oil Spills, illustrate through examples, list out the major Environmental and Socio-Economic impacts of oil pollution and conclude by stating the potential solutions.

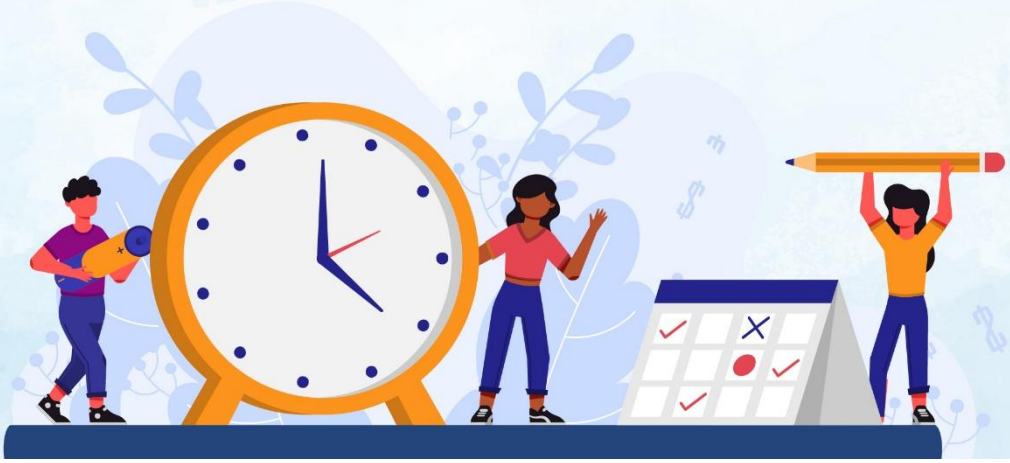
Result will be a focused, 150-word answer that links recent examples and standard guidelines to theory—just what UPSC looks for in a 10-mark question.

Q9. What's the recommended micro-structure for each 15-marker?

- Intro (≤30 sec): Why in the News, or data/facts.
- Body (≤6 min): 2–3 dimensions, each with evidence & analysis.
- Way forward (≤1 min): 3–4 actionable reforms.
- Conclusion (1 line): Memorable, visionary sentence.

Q10. Any final pro tip?

Think of Mains365 as a ready answer bank: it's pre-curated—your job is just to pick, organise, and add your own insight. Use it wisely, and find questions becoming easier to answer and higher marks becoming more achievable.



1. CLIMATE CHANGE

1.1. INDIA AND CLIMATE ACTION AT A GLANCE

India and climate Action

India's Nationally Determined Contributions (NDCs) Targets for 2030 submitted to UNFCCC

Reduce Emissions Intensity of its GDP by 45%, from 2005 level.	Achieve **~50% cumulative electric power** installed capacity **from non-fossil fuel**-based resources.	**Additional carbon sink of 2.5-3 billion tonnes of CO_2** through additional forest and tree cover.

Panchamrita targets announced at COP 26-Glasgow

Achieve target of **net zero by 2070.**	Increase **non fossil energy** capacity **to 500 GW by 2030.**	Meet **50% energy requirements from renewable sources** by 2030.	Reduce **carbon intensity** of economy by **less than 45% by 2030.**	Reduce total projected carbon emissions by **one billion tonnes by 2030.**

Achievements/Progress (India's Fourth Biennial Update Report (BUR-4) to UNFCCC)

Reduced Emission Intensity of GDP: by 36% (Between 2005 to 2020)	**Share of non-fossil sources:** 46.52% of installed capacity (Oct 2024).	**Additional carbon sink of 2.29 billion tonnes of CO_2** created through forest and tree cover **(2005 to 2021)**

Challenges in achieving climate targets

GHG Emissions India is currently **world's 3rd largest GHG emitter** (growing at 32% in past decade) (Environmental Performance Index, 2024).	**NDCs:** India has **8% implementation gap between Current Policies and NDC pledges.**	**Constraints in increasing share of renewable energy:** Intermittent supply, high dependence on import for components, high cost of storage, etc.	**Pace of decommissioning coal-based plants does not match** with rise of renewable energy.

Schemes/ Policies/initiatives

National level

National Action plan on Climate Change (NAPCC), National Adaptation Fund on Climate Change, etc.	**Policies:** National Wind Solar hybrid policy, National biofuel Policy, Green Hydrogen/ Green Ammonia policy etc.	**Schemes:** PM-KUSUM, PM Surya Ghar, Perform Achieve and Trade (PAT) scheme, Ujjwala, FAME India, etc.	**International:** International Solar Alliances (ISA), Coalition for Disaster Resilient Infrastructure (CDRI), LiFE Mission etc.

Way Forward

Local Financing E.g., Climate Chapter in **Ahmedabad Municipal Corporation (AMC)'s budget,** 1st Green Municipal Bond by **Ghaziabad Nagar Nigam.**	**Reduce Reliance on Fossil Fuels** E.g., Investing in **Biofuels** and **Green Ammonia;** phasing out of coal power (FAME India Mission etc.).	**Balancing Long term renewable energy goals and short-term demands** E.g., Increased Investment in **Battery Energy Storage Systems.**	**Localised Actions** E.g., **Pachathuruthu Initiative** in **Kerala** for mini forests; **Swaniti development planning,** Jharkhand.	**Supportive Policies** Fostering **international collaboration** for transitioning towards **net-zero.**

1.2. UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC) COP29

Why in the News?

COP29, **held in Baku, Azerbaijan,** concluded with **Baku Climate Unity Pact** and several significant agreements.

Key Outcomes of COP29

Themes	Details
New Collective Quantified Goal on Climate Finance (NCQG) or **Baku Finance Goal**	• NCQG was proposed in COP21 for setting **post-2025 climate finance goal** under **Article 9** (developed countries to finance developing) of **Paris Agreement.** • **Target: Triple finance** to **USD 300 billion annually by 2035** (previous goal: **USD 100 billion decided in 2009 till 2020, extended to 2025**).
Carbon Markets and Article 6	• **Finalized the rules for Article 6** of **Paris Agreement,** which provides for international **carbon markets**.
Transparency	• Concluded all **transparency negotiating items**: ○ **Enhanced Transparency Framework (ETF):** For countries to report their climate actions. ○ **1st submissions of Biennial Transparency Reports (BTRs)** (regular reports submitted under ETF by countries). ○ **Baku Declaration on Global Climate Transparency** and **Baku Global Climate Transparency Platform.**
Adaptation	• Launched the **Baku Adaptation Road Map** and **Baku High-Level Dialogue on Adaptation** to enhance **UAE Framework for Global Climate Resilience** implementation.
Mitigation	• **Sharm el-Sheikh mitigation ambition and implementation work programme**
Indigenous Peoples and Local Communities	• Adopted the **Baku Workplan** and renewed the **mandate of Facilitative Working Group (FWG)** of the Local Communities and Indigenous Peoples Platform (LCIPP). ○ FWG was established at **COP24 in Katowice** to **operationalize LCIPP.**
Gender and climate change	• **Lima Work Programme on Gender and Climate Change** (established in COP 20,in 2014) extended for 10 years.

Key Initiatives/Declarations launched at COP29

- **Reducing Methane from Organic Waste Declaration:** Sets sectoral **targets** (India not a signatory).
- **Global Energy Storage and Grids Pledge: 1,500 GW of energy storage** in power sector globally (>six times the 2022 level) by **2030.**
- **Hydrogen Declaration: Non-binding** and aims to accelerate the production and use of Clean hydrogen.
- **Climate Finance Action Fund (CFAF) (Hq: Baku, Azerbaijan):** Support climate projects in developing countries.
- **Global Matchmaking Platform (GMP): Decarbonizing heavy-emitting industries** in emerging/developing economies through technical/financial solutions.

About UNFCCC (Hq: Bonn, Germany)

- **Genesis:** 1992 **Earth Summit** in **Rio de Janeiro**, adopted in **1994.**
  - Sister Convention to the other **two Rio Conventions,** namely, **Convention on Biological Diversity (CBD)** and **United Nations Convention to Combat Desertification (UNCCD).**
- **Parent convention** for **Kyoto Protocol (1997)** and **Paris Agreement (2015)**

Issues persisting in climate negotiations

- **NCQG falls short of Global Investment Required** for climate action i.e., **$6.3–6.7 trillion per year by 2030** (Raising Ambition and Accelerating Delivery of Climate Finance' Report)

- **Deadlock on Mitigation Work Programme (MWP)** due to diverging views on **fossil fuels' role in future energy mix** and contention on Global Stocktake.
- **Other Issues:** Slow operationalization and inadequate funding in **Loss and Damage Fund (LDF)**; **postponing next round of NDCs** ahead of COP30; influence of **fossil fuel lobbyists in negotiations; etc.**

Conclusion

Emission cuts of **42% (by 2030) and 57% (by 2035) below 2019 levels are** needed for 1.5°C. Hence countries should enhance their NDCs, backed by **sectoral commitments, strong and effective policies, investment**, and **society-wide efforts.** Further, negotiations can be progressed through **Climate Diplomacy** in adherence to the principle of CBDR-RC, and a strong commitment to climate equity.

1.2.1. INDIA AT COP29

Why in the News?

India clarified its stance regarding climate negotiation at the Plenary Session of the **UNFCCC-COP29.**

India's stance on various aspects

Parameters	India's Stance
NCQG	• **Proposed a goal of $1.3 trillion annually**, with $600 billion coming from grants or equivalent resources
Mitigation	• **Opposed changes** to the scope of the **Mitigation Work Programme (MWP)** and attempts **to alter temperature goals** in the Paris Agreement. • **Urged recognition of the pre-2020 mitigation gap** by developed countries (Annex I Parties).
Just Transition	• Asserted that **developed countries should provide financial/technological support** to developing. • **Respect the right to development** and sustainable priorities of developing countries.
Global Stock Take (GST)	• **Opposed follow-up mechanisms for GST outcomes,** citing the Paris Agreement's framework. • **Criticized UAE dialogue** text for its lack of connection to finance, imbalance, and mitigation-centric language.
Adaptation	• Called **for clear indicators to measure progress** on adaptation. • **Opposed the use of third-party databases** for reporting indicators, advocating for Party-submitted data only.
Voice of Global South	• **Integrating Disaster Resilient Infrastructure into the Adaptation Strategies:** Organised by **India** and **Coalition for Disaster Resilient Infrastructure (CDRI).** • **Energy Transitions for the Global South:** Organised by India and International Solar Alliance (ISA).

Conclusion

India plays a critical leadership role for other emerging markets and developing economies (EMDEs) in climate diplomacy hence India's stance seeks to reverse the impact of climate change through **fair and non-discriminatory policies.**

1.3. CLIMATE CHANGE IMPACTS

1.3.1. IMPACT ON VULNERABLE SECTIONS AT A GLANCE

Impact of Climate Change on Vulnerable Sections

Climate Change Impacts on Women

Displacement **80% of people displaced** by climate change are women. (UN figures)	**Adaptation** Only **2% of gender-tagged international adaptation finance** is gender-responsive. (Adaptation Gap Report)	**Disaster Impacts** Women and children are **14 times** more likely than men to die during a disaster. (UNDP)	**Threat to Livelihood** Women make up **43% of the agricultural labor force** (vulnerable to climate change) in developing countries. (FAO)

Climate Change Impacts on Indigenous Communities

Displacement and Forced Relocations Causing the erosion of **traditional governance,** subjecting them to abuse and discrimination.	**Spiritual and Cultural Disruptions** **Habitat loss** and **species extinction** affect traditional medicine, rituals and spiritual beliefs.	**Livelihood Risks:** **40%** of land occupied by Indigenous peoples lies in areas of **high biodiversity** affected by Climate Change.	**Health Impacts** **Heat-related illnesses, vector-borne diseases** and **malnutrition** exacerbated by limited access to healthcare.

Climate Change Impacts on Marginal Farmers (Forum of Enterprises for Equitable Development)

Vulnerability Over 1/3rd of marginal farmers had to cope with **extreme weather events at least twice in five years.**	**Reduction in agriculture income** By average 15-18% and by 20-25% in un-irrigated areas (Economic Survey of 2017- 18).	**Altered Livelihood** Over 86% of farmers altered their occupations to **temporal migration.**	**Hurdles in adoption of Climate Resilient Agricultural practices** High up-front cost, small land holdings, lack of physical resources, etc.

1.3.2. IMPACT ON SMALL ISLAND DEVELOPING STATES (SIDS) AT A GLANCE

Climate change Impacts on Small Island Developing States (SIDS)

SIDS

Countries and territories sharing **similar sustainable development challenges** and facing similar social, economic and environmental vulnerabilities. **E.g. of SIDS:** Maldives, Seychelles, Marshall Islands, Solomon Islands etc.	**Located in 3 geographic regions:** Caribbean, Pacific, and Atlantic, Indian Ocean and South China Sea (AIS).	Recognized as **special case at the 1992 United Nations Conference on Environment and Development** for their environment and development.

Impact of Climate Change on SIDS

Forceful displacement **Panama** became first nation to **evacuate** island community over climate impact.	**Economic impact** SIDS lost **US$153 billion** due to weather extremes (from 1970-2020).	**Lack of Financial Access** SIDS had access to a mere **US$1.5 billion out of the US$100 billion pledged** in 2019.	**Climate injustice** Least responsible for the **climate crisis (1% of Global emissions).**

Initiatives

Alliance of Small Island States (AOSIS): intergovernmental organization advocating for SIDS.	**Global Conference on the Sustainable Development of Small Island Developing States (1994)** (Barbados Programme of Action)	**Coalition for Disaster Resilient Infrastructure (CDRI):** Announced **$8 Million funding** through its **Infrastructure for Resilient Island States (IRIS) programme.**	**Infrastructure Resilience Accelerator Fund (IRAF) (2022): US$50 Million Trust Fund** established with the support of **UNDP and UNDRR.**

Way Forward

Improve data collection and technical capacity through **climate change impact and vulnerability assessments.**	**International Financing:** E.g., **Bridgetown Initiative (2022)** proposed SDG Stimulus package to invest in SDGs.	**Nature-based solutions:** E.g. **Blue Carbon projects,** restoring degraded ecosystems etc.	**Promote renewable energy:** E.g., **SIDS Lighthouses Initiative-** targets 10GW renewable energy installed capacity in SIDS by 2030.

1.3.3. IMPACT ON SOCIO-ECONOMIC INDICATORS AT A GLANCE

Climate Change Impacts on Health

Major Health risks › **Injury/Mortality** from Extreme Weather events. › **Heat related illness** (Heat stroke etc.). › Increase in **Vector borne** and **zoonotic diseases.** › **Mental Health** consequences.	**Health Threatening Heat** **50 more days of health threatening heat** (2023), due to climate change.	**Deaths due to Non – Communicable Diseases (NCD)** **85% of NCD deaths** caused by Climate Change and air pollution. (Special Report on Climate Change and Health in CoP 29)

Way Forward

'One health approach' recognizing the interconnection between people, animals, plants, and environment.	Building climate-resilient, **low-carbon sustainable health systems.**	**Tailored climate information** to support the health sector .	**Transition** from extractive economic systems towards circular economy.

Climate Change Impacts on Education (World Bank)

School Closures During 2005-2024, schools were **closed in at least 75% of extreme weather events.**	**Decline in Outcomes** Increase of **1°C in outdoor temperature** can result in a substantial decline in test scores.	**Gendered Impact** Climate-related events **prevent at least 4 million girls** in low- and lower-middle-income countries **from completing their education.**	**Cognitive Skills** Rainfall shocks negatively affecting vocabulary at age five and mathematics & non-cognitive skills at age 15 (UNESCO).

Way Forward

Early warning systems E.g. Indonesia's **InaRISK mobile app for disaster knowledge** for students and staff.	**Resilience of existing buildings** E.g. **Rwanda's Project** equips school with **Retaining walls** to mitigate floods and landslides.	**Learning Continuity Back-to-school campaign (Ghana)** resulting in nearly 100% re-enrollment after COVID-19.	**Others** › **Investment in education** under climate finance programs › **Integrate Climate change education into curriculum, etc.**

1.3.4. IMPACT ON GEOLOGICAL RESOURCES AT A GLANCE

Climate Change Impact On Geological Resources

Climate Change Impacts on Indian Subcontinent

Average temperature Rise ~ 0.7 deg. C during 1901-2018.	**Frequency of daily precipitation extremes (›150 mm per day):** Increased by about 75% during 1950-2015.	**Sea-level rise Occurred at a rate of 3.3 mm per year** (1993-2017) in Northern Indian Ocean.	**Extreme events** Marine heatwaves expected to increase from 20 days per year to **220-250** days per year.

Climate Change Impacts on Oceans/Water Resources (UNESCO State of Oceans Report, 2024)

Warming Ocean temperatures increased by an average of 1.45°C, with hotspots **above 2°C in the Mediterranean, Tropical Atlantic Ocean and Southern Oceans.**	**Acidification** Ocean absorbs around **25% of annual anthropogenic CO2.**	**Coastal blue carbon ecosystems 20–35%** of ecosystems including mangroves, seagrasses, and tidal marshes have been lost since 1970.	**Rivers 2023 was driest year for global rivers** in 33 years (WMO)

1.3.5. SEA LEVEL RISE AT A GLANCE

Sea Level Rise (SLR)

Global Trends
- From 2014-2023, **global mean sea level rose at a rate of 4.77 mm per year** (›double rate between 1993 and 2002). (State of Climate 2024)

Trends in India (Centre for Study of Science, Technology and Policy, CSTEP)
- **Maximum SLR (4.44 cm)** witnessed by Mumbai (1987-2021).
- **›10% of land in Mumbai, Yanam, and Thoothukudi** would be submerged by 2040.

Factors Responsible

Ocean Thermal Expansion Oceans absorb >90% of heat trapped by accumulating GHGs.	**Ice melting** From glaciers, ice caps, and ice sheets in Greenland and Antarctica.

Impacts of SLR

Loss of beaches and coastal habitats - **~32% of India's coastline underwent sea erosion between 1990 and 2018** (National Centre for Coastal Research (NCCR))	**Coastal community displacement** - **29% of India's population lives within 50 km of coastline,** making them vulnerable to displacement.	**Others** - **Freshwater salinization** - Loss of **coastal ecosystems** like mangroves, coral reefs, salt marshes impacting fisheries and biodiversity.

Mitigation Measures

Flood Barriers to Protect Infrastructure - **Ecosystem based** (Oyster beds along the coast); **Man Made** (seawall), etc.	**Storm Surge Modelling** - For information on placement and protection of **critical infrastructure.**	**Floating Cities** - E.g., Flood proof cities in **South Korea** and **Maldives.**	**Others** - Integrated Coastal Zone Management; Climate Action Plan, etc.

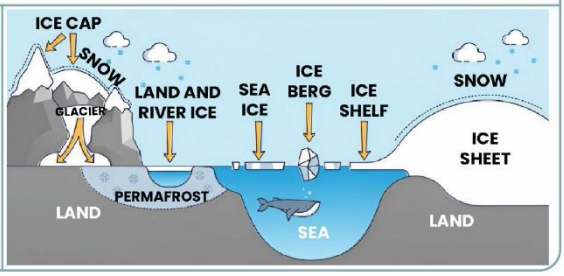
1.3.6. IMPACT ON CRYOSPHERE AT A GLANCE

Climate Change Impacts on Cryosphere

Cryosphere

Definition

- **Areas of snow or ice on Earth, subjected to temperatures below 0°C for at least part of the year and** includes continental ice sheets, ice caps, glaciers, permafrosts, etc.
- **E.g. Greenland, Antarctica, Hindu Kush Himalaya** etc.



Impacts of Climate Change on Cryosphere

Loss of Ice sheet **Greenland Ice Sheet** is currently losing **30 million tons of ice per hour. (State of Cryosphere 2024)**	**Loss of Glaciers** **Venezuela** lost all its glaciers (2024) **Nepal's Yala glacier** declared dead.	**Greening of Antarctica** Plant cover including vegetation across Antarctic Peninsula is increasing due to **climate crisis.**	**Predicted ice loss in Himalayas** In case of temperature rise by 2°C, Himalayas expected to lose half **of today's ice.**

Impact of melting Cryosphere

Positive feedback to climate change	**Rising sea levels**	**Impact water availability**	**Effect on the global ocean circulation**	**Others**
- Disturb **Earth Energy Budget** maintained by its high Albedo - Release of **Carbon** stored in **Permafrost soil**	- If all glaciers and ice sheets melted, global sea level would rise by more than **60m (NASA).**	- **80% of the world's fresh water** is in the form of glaciers, ice sheets, etc.	- Weakening of **Atlantic Meridional Overturning Circulation (AMOC)** - **Slowing of Antarctic Circumpolar Current (ACC)**	- **Rise in Natural Disasters** like Glacier Lake Outburst Floods (GLOFs). - **Threat to biodiversity:** Mountain systems host 25 of the world's 34 biodiversity hotspots

Initiatives

Global

- **UN Initiatives: 2025** designated as the **International Year of Glaciers' Preservation.**
- **UNESCO Intergovernmental Hydrological Programme.**
- **Himalayan Adaptation Network** by IUCN.
- **Living Himalayas Initiative** by World Wide Fund for Nature.

Indian

- **National Mission for Sustaining the Himalayan Ecosystem.**
- **Indian National Centre for Ocean Information Services (INCOIS)**
- **National Centre of Polar and Ocean Research (NCPOR)** maintains India's research stations in **Antarctica (Maitri and Bharati), the Arctic** (Himadri), and the Himalayas (Himansh).

Way Forward

Global collaboration by **integrating** local efforts with international frameworks.	**Combining satellite data** with airborne and ground observations of snow.	**Innovative financial mechanisms** integrating efforts across governments, multilateral development banks , private investors, etc.	**Others:** Robust national level data-sharing platforms, phased investment models, etc.

1.4. MITIGATION AND ADAPTATION

1.4.1. CLIMATE CHANGE MITIGATION AT A GLANCE

Climate Change Mitigation

Mitigation Target: Paris Climate Agreement, 2015

To substantially reduce global GHG emissions to

- Hold increase in global **average temperature to well below 2°C** (limiting it to **1.5°C**) of pre-industrial levels.

Emission Trends

India

3rd in total GHG emissions (UNEP's Emissions Gap Report, 2024)	**Per capita Emissions:** 4% of global emission **(Economic Survey, 2023-24)**

Global

Global GHG emissions set a new record in 2023 (with 1.3% increase from 2022 levels) (Emissions Gap Report 2024)

Major Challenges with Mitigation

Emission Gap Current national and international policies not ambitious enough to meet targets of Paris Agreement. **E.g. Green Climate Fund**	**Lack of International Collaboration: E.g.** US withdrawing from global treaties.	**Large disparities** 6 largest GHG emitters accounted for **63% of global GHG emission** (Emissions Gap Report 2024)	**Technological and Sectoral Challenges** › **Hard to abate sectors** like aviation, shipping, and cement production. › Use of high **energy demanding technologies like AI.**

Initiatives

Global: Global Methane Pledge, Powering Past Coal Alliance, Just Energy Transition Partnerships (JETs), Mission Innovation, etc.	**India: Panchamrit Target** declared in COP 26 (Aim to achieve Net-Zero emissions by 2070), **Mission Lifestyle for Environment' (LiFE), National Action Plan on Climate Change (NAPCC),** etc.

Way Forward

Cuts of **42% in emissions** by **2030** and **57% by 2035** (below 2019 levels) needed to get on track for 1.5°C. (Emissions Gap Report 2024)	› **Increase mitigation investment by atleast sixfold** › **Enhance financial pledges by delivering on Baku Finance Goal.**	Update NDCs to reflect the principal of **Common But Differentiated Responsibilities**	**Promote research and development in low-carbon technologies or carbon capture and storage (CCS)** for hard to abate sectors.

1.4.2. CLIMATE FINANCE

1.4.2.1. CLIMATE FINANCE AT A GLANCE

Climate Finance

Trends in Climate Finance: Global Landscape of Climate Finance 2024 (GLCF 2024)

- **>2X growth in Annual global climate finance: From** USD 674 billion (2018) to USD 1.46 trillion in 2021-22.
- **>20% compound annual growth rate (CAGR) in** Climate **mitigation** finance from (2018 - 2022)
- **54% of total funding** for mitigation activities from Private finance.

India's climate finance needs

- **~USD 250 billion per year till 2047** needed for energy transition. (NITI Aayog)
- **~USD 2.5 trillion** (at 2014–15 prices) needed to meet updated NDC targets by 2030
- **USD 10 trillion** needed to achieve **net-zero by 2070.**

Issues related to Climate Finance

Geographical imbalance **45% of climate finance** from 2018 to 2022 for **Advanced economies** and only **3% for least developed countries (LDCs)** (GLCF 2024)	**Mitigation and Adaptation imbalance** **90% of climate finance** goes to mitigation actions (UNDP).	**Debt Burden** **~94% of existing climate investment is either through debt or equity** (return seeking). (Climate Policy Initiative)	**Inadequate finance** Fivefold increase by **2030** under 1.5°C scenario (GLCF 2024).	**Adaptation Funding Gap** Developing countries require US$215-387 billion annually against US$28 billion in 2022 **(Adaptation Gap Report 2024).**

Mechanisms

Global

- **Loss and Damage Fund (LDF) (COP27)**
- **Green Climate Fund (2010) (COP 16)**
- **Adaptation Fund (2001).**
- **Special Climate Change Fund (SCCF) and Least Developed Countries Fund (LDCF)** established in 2001 (COP7)

India

- **National Adaptation Fund for Climate Change (NAFCC),** 2015.
- **Priority Sector lending** to renewable energy projects.
- **Issuance of Green Deposits and Green Bonds,**
- **Sustainable Finance Group (SFG)** set up under RBI.

Way Forward

Advocate principles of equity and climate justice to uphold the interests of Global south at climate negotiations.	**Innovative financing mechanisms** Like **green bonds, carbon markets,** mobilize private capital for adaptation, debt -for- climate swaps (debt relief in case of climate action).	**Role of Multilateral Development Banks Triple lending** capacity by 2030 as part of NCQG.	**Climate Budgeting** involves integrating climate targets with city's **Climate Action Plan.**

1.4.2.2. LOSS AND DAMAGE FUND (LDF)

Why in the News?

Decisions were made at **COP29** to ensure **full operationalization of LDF**, and is expected to **start financing projects** beginning in 2025.

About LDF

- It was agreed upon during **COP27** and **operationalized in COP28, Dubai**.
  - It is an outcome of **Warsaw International Mechanism (WIM)** for Loss and Damage, created in 2013.

- **Aim:** Provide **financial assistance to countries most vulnerable** to climate change.
  - **Total pledged financial support** for Fund has **exceeded $730 million.**
- **LD:** Refers to the **negative effects of climate change** that occur despite mitigation and adaptation efforts.
  - E.g., the loss of coastal heritage sites due to rising sea levels

Challenges in L&D fund

- Absence of **a mutually agreed definition** to categorize L&D activities.
- **Poor data availability** and **processes for systematically collecting**, recording, and reporting information on L&D.
- **Low pledges** in comparison to funding requirement estimated.
- **Low technical capacity** especially in developing countries – to scientifically model L&D.
- Difficulty in **quantifying nontangible L&D** like Non-economic losses (e.g., disappearance of cultures and ways of living etc.).

Way Forward

- Establishing mechanism to **assess the non-economic damage** and disbursing funds especially for vulnerable nations and communities.
- Account for **losses in ecosystem services and in human productivity and contribution to the macroeconomy**, including other aspects like cultural, spiritual, and psychological, etc.
- **Clear criteria for determining contribution levels** and mechanisms for monitoring and enforcing compliance.
- **Others:** Governance, transparency, and long-term financing, etc.

Conclusion

The Loss and Damage Fund is vital for addressing the **irreversible impacts of climate change** by protecting ecosystems, **supporting vulnerable communities**, and **mitigating humanitarian crises** such as food insecurity and poverty. It upholds **climate justice** by aiding regions with **minimal carbon footprints** but severe climate vulnerabilities, such as Small Island Developing States and parts of Africa.

1.4.3. CARBON TRADING AND MARKET AT A GLANCE

Carbon Market and Trading

Definition

- **Trading systems** where entities **buy carbon credits** to **offset their greenhouse gas emissions** by supporting projects that reduce or remove emissions.
  - **One tradable carbon credit** generally equals **one metric tonne of carbon dioxide.**

Types

Emissions trading system (ETS)	Carbon tax
Types: Cap-and-trade systems and Baseline-and-credit systems	

Significance of Carbon Trading and Market

Support developing Countries	Revenues	Coverage and Scope	Emissions Removal
in climate mitigation efforts by mobilizing significant financial resources.	Globally, ETSs and carbon taxes continued to generate over **USD 100 billion (2024) for public budgets.** (World Bank's State and Trends of Carbon Pricing 2025)	Carbon Pricing covers around 28% of GHG emissions. (World Bank's State and Trends of Carbon Pricing 2025)	**>50% emissions** (about 5 gigatons of CO2 per year by 2030) at no additional cost

Issues related to carbon markets

Carbon Colonialism	Lack of clear implementation guidelines	Effectiveness in Reducing Emissions	Others
Indigenous rights and local community impacts, needs of developing nations not adequately addressed	E.g., Lack of standardization, transparency, and robust monitoring, reporting, and verification (MRV) systems	Can undermine the overall environmental impact and dilute climate goals	Quality and Integrity of Credits Greenwashing Oversaturation of carbon credit markets Limited Coverage and Scope etc.

Way Forward

Global standards	Enhance Credit Quality and Integrity	Leverage Technology	Others
Implement internationally recognized standards like the **Core Carbon Principles (CCPs)**	Establish regulatory bodies Harmonize rules Independent 3rd party verification	**E.g.,** blockchain for transparent, tamper-proof tracking of credits and transactions.	**Safeguards** to protect indigenous communities and prevent market saturation **Codes of practice for carbon-related claims**

1.4.3.1. ARTICLE 6

Why in the News?

Rules for carbon trading under Article 6 of the Paris Agreement were finalized after a decade of negotiations.

About Article 6 of the Paris Agreement

- Details set of **tools/mechanisms of carbon market,** that allows countries to **voluntarily cooperate** to achieve their **Nationally Determined Contribution (NDC)**.
- It has **3 main mechanisms**: 2 Market-based and 1 Non-market based.
  - The two main market mechanism include **Bilateral deals between countries** and **a new global offset market.**

- **Significance of Article 6**
  - Carbon trading **under Article 6 could cut costs for NDCs by over 50%,** potentially saving $250 billion annually by 2030 (World Bank).
  - **Broader Impact** through use of non-market approaches (Article 6.8), **such as capacity-building platforms,** etc.

Mechanisms under Article 6		
Market based approaches		**Non-Market based approach**
Article 6.2	**Article 6.4**	**Article 6.8**
• **Decentralized approach** for **bilateral cooperation.** • Involves trading of **International Transferred Mitigation outcomes (ITMOs) causing adjustments in NDCs** on trade of ITMOs.	• **Centralized approach** under UNFCCC for transferring ITMOs termed as **Paris Agreement Crediting Mechanism (PACM).** • **Establishes a global carbon market.** • Uses **Baseline-and-crediting** mechanism similar to **Clean Development Mechanism (CDM)** of Kyoto Protocol.	• **Promote mitigation and adaptation** through finance, technology transfer, capacity building etc. • **No trading of emission reductions** involved. • **One Participating Party.**

Difference between Carbon trading of Kyoto Protocol and Paris Agreement

Aspect	Kyoto Protocol	Paris Agreement (Article 6)
Scope of Participation	**Limited to developed countries (Annex I)** with project hosting by developing countries.	**Inclusive of all countries.**
Adaptation Funding	Share of proceeds from CDM projects directed to the Adaptation Fund.	**5% of proceeds from Article 6.4 transactions** allocated to the Global Adaptation Fund.
Market Scope	**Project-based mechanisms like-** **› Clean Development Mechanism (CDM) and Joint Implementation (JI)**	**Combines market-based and non-market-based approaches.**
Legacy Credits	**Allowed use of older credits** from inactive projects, causing oversupply concerns.	Restricts legacy credit use; only post-2013 credits.

Key Challenges

- **Inadequate Quantification Standards:** The draft rules of Article 6 do not require countries to monitor reversals, such as CO_2 escaping from failed sequestration projects.
- **Double Counting:** Countries under Article 6.2 are **not strictly required to fix or avoid inconsistencies in their emission reduction calculations**, creating potential for counting of **same emissions reduction by more than one country.**
- **Limited coverage and scope:** Only 24% of global emissions are covered under carbon taxes and Emission Trading Systems (ETS)**. (World bank)**

Conclusion

A credible carbon market requires uniform **reporting standards, third-party verification, and strong safeguards against reversal risks**. These steps are essential to ensure transparency, integrity, and lasting impact of emission reduction efforts.

1.4.3.2. CARBON CREDIT TRADING SCHEME, 2023

Why in the News?

Union Environment Ministry notified draft Greenhouse Gases Emission Intensity (GEI) Target Rules, 2025 for **four energy-intensive sectors** (aluminium, cement, chlor-alkali, and pulp & paper) under Carbon Credit Trading Scheme, 2023.

Key Highlights of the Rules

- **GEI Targets Calculation:** As per **Bureau of Energy Efficiency's methodology,** specific to each **obligated entity** listed in the Schedule.
- **Compliance Requirements for Obligated Entities:** They must **meet GEI targets annually** as per the **Carbon Credit Trading Scheme, 2023.**
  - May also purchase **carbon credit certificates** from the **Indian Carbon Market (ICM)** to offset shortfalls.
- **Environmental Compensation:** To be imposed by the **Central Pollution Control Board (CPCB).**
- **Legal Backing:** Non-compliance addressed under the **Environmental Protection Act, 1986.**

About Carbon Credits Trading Scheme (CCTS), 2023

- Introduced through amendments in the Energy Conservation (Amendment) Act, 2022, it establishes **Indian Carbon Market under two mechanisms**:
  - **Compliance mechanism:** Mandatory program for the energy-intensive industries where Government sets GHG emission intensity targets.
    - Initially includes 9 sectors like **Fertiliser, Iron & Steel, Pulp & Paper, Petrochemicals, Petroleum refinery, etc.**
  - **Offset mechanism:** A **voluntary project-based mechanism** for entities not covered under compliance mechanism.

Challenges of CCTS

- **Lack of experience:** Among India's industry stakeholders of the **cap-and-trade market.**
- **Complex institutional framework**: Involvement of **multiple agencies** at different levels, difficulty in setting emission targets, lax/stringent targets can impact the price of credits in the market, etc.
- **Poor Market Transparency:** Leading to issues like **double counting** of GHG reductions, **poor assessment** of climate mitigation efforts, etc.
- **Others:** Uncertainty about Penalties; shortage of renewable sources makes it difficult to meet obligations, etc.

Conclusion

Establishing **clear methodologies for emission targets**, analyzing existing market instruments, ensuring fungibility of trading units, and strengthening institutional frameworks are key to building a transparent, efficient, and globally attractive carbon market in India.

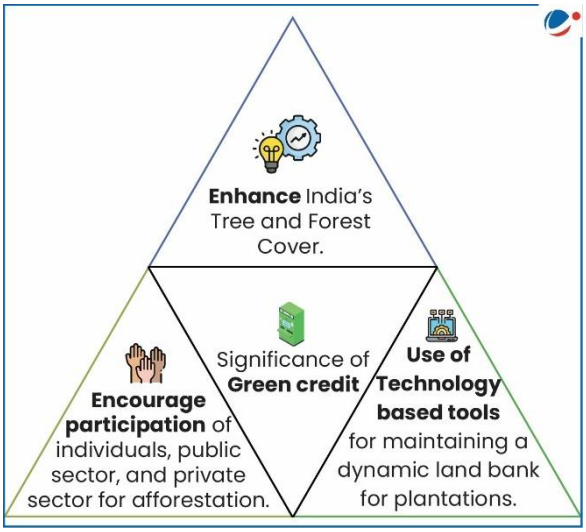
1.4.3.3. GREEN CREDIT PROGRAMME (GCP)

Why in the News?

Ministry of Environment, Forests and Climate notified methodology for Calculation of Green Credits (GC) under GCP including rules for **calculating green credit** for tree plantations.

About Green Credit Programme (GCP), 2023

- It is an innovative market-based mechanism to **incentivise environment positive actions** by different stakeholders such as Industries/institutions, State governments, philanthropies.
- **Eligible Activities:** Tree plantations, Sustainable agriculture practices, waste management, Air Pollution Reduction etc.
- **Key Features:**
  - Participation is **based on voluntary.**
  - Trading of credits allowed on a domestic platform
  - Companies can include **credits in ESG disclosures.**
- **Administering Body:** Indian Council of Forestry Research and Education (ICFRE), Dehradun.



About Green Credit (GC)

- A singular unit of an incentive provided for a specified activity, delivering a **positive impact on the environment.**
- These **credits can be traded on a dedicated exchange**, **similar to how carbon credits** are traded.

Green Credit	Carbon Credit
• Under the **Green Credit Program (GCP)** operating under **The Environment (Protection) Act, 1986.**	• Under **the Carbon Credit Trading Scheme** operating under **The Energy Conservation Act, 2001.**
• Provides advantages to **individuals and communities.**	• Primarily **benefit industries and corporations.**
Green credit activities may qualify for carbon credits, leading to climate co-benefits like carbon emissions reduction**, but not vice versa.**	

Concerns Associated with GCP

- **Incentivizes forest diversion**: Companies can **buy credits instead of restoring forests**, weakening environmental safeguards.
- **No real addition to forest cover**: Unlike compensatory afforestation (which requires converting **non-forest land** into forests), GCP allows **existing degraded forest land** to be used.
- **Evaluation and Long-term Sustainability**: GCP methodology lacks clear criteria for evaluating plantation success, especially tree survivability, allowing failed plantations to still earn credits.

Way Forward

- **Establishing the nature of Green Credit as a commodity derivative** like carbon credit would ensure their **effective regulation.**
- **Establishment of a Quantified Methodology** like carbon credit, which is equivalent to one tonne of carbon dioxide equivalent, Green Credit methodology should be outlined.
- **Clearly Defining Activities** to prevent **dual incentivisation** of the same activity for which carbon credits are issued.

Conclusion

Though a **promising initiative,** but its success will depend on the **clarity of methodologies and processes implemented** vis-à-vis the issuance and trading of green credits.

1.4.4. INDUSTRIAL DECARBONISATION IN INDIA AT A GLANCE

Industrial Decarbonization

Emission from Industrial Sector

Industrial Processes and Product Use constitute **8.06%** of the total emissions in India. (India's 4th Biennial Update Report)	**Steel sector** accounts for about **12%** of India's carbon dioxide (CO_2) emissions (steel is world's **largest carbon-emitting** manufacturing sector)

Challenges in Decarbonization

High dependence on conventional fuel (Contributes about 60%)	**Technological limitations** in important fields like low-carbon technology, CCUS etc.	**Shortage of green finance, higher** risk of green investments and **lack of bankable pipeline projects for investors**	**Limited availability of domestic resources** like reserves of rare earth elements (critical for EVs).	**Infrastructure challenges.** E.g., shifting to electrical vehicles would require expansion of charging infrastructure, etc.

Initiatives

Global	India
› **Industrial Deep Decarbonisation Initiative (2021):** Co-led by UK & India. › **Alliance for Industry Decarbonization** › **Global Matchmaking Platform**	› **Perform Achieve and Trade Scheme** › **National Green Hydrogen Mission** › **Sector Specific strategies:** Green Steel; SVAGRIHA (Simple Versatile Affordable GRIHA), for **small-scale stakeholders.**

Way Forward

Creating an Expert Group on Energy Transition to provide inputs comprising industry representatives from different sectors.	**Creating an administrative Setup at the Ministry level** around **energy-providing Ministries like** Ministry of New and Renewable Energy (MNRE), and Ministry of Power and Ministry of Coal at the core.	**Environment Impact Assessment** and Environment Management Plan for emitting industries.

1.4.5. METHANE EMISSIONS

Why in the News?

Recently, COP29 Presidency launched **Reducing Methane from Organic Waste Declaration** to support the implementation of the **2021 Global Methane Pledge (GMP)**.

About Reducing Methane from Organic Waste Declaration

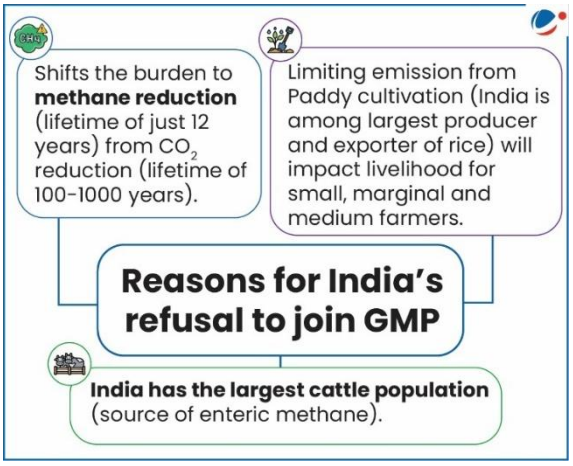
- Signatories declared their **commitment** to **set sectoral targets** to reduce methane from organic waste **within future NDCs.**
- It has been developed with the **UNEP-convened Climate and Clean Air Coalition (CCAC).**
- **India is not a signatory**.

About Global Methane Pledge (GMP)

- Launched at **COP26** by the **European Union** and the **USA.**
- It calls for Parties to take **voluntary actions** to reduce **global methane emissions** at least **30% by 2030 from 2020 levels.**

Need for Reducing Methane Emissions

- **High impact on temperature rise: 2nd largest** contributor to climate warming after CO_2 **and Global Warming Potential (GWP)** 28 times higher than CO_2.
  - Methane is **responsible** for **~30 % global temperature rise** since the Industrial Revolution. (Global Methane Tracker, 2025 by International Energy Agency, IEA).
- **Rising Trends**: **Atmospheric methane (CH4)** saw its largest **3-year increase on record**. (WMO's Greenhouse gas Bulletin))



Initiatives to reduce Methane Emissions

- **Globa:** Earth Surface Mineral Dust Source Investigation (EMIT), Airborne Visible InfraRed Imaging Spectrometer - Next Generation (AVIRIS-NG): Global Methane Initiative (2004), Methane Alert and Response System (MARS), etc.
- **India: National Mission on Sustainable Agriculture (**NMSA), **Direct Seeded Rice & Crop Diversification Programme, Gobar** (Galvanizing Organic Bio-Agro Resources) –**Dhan Scheme,** etc.

Conclusion

Reducing methane emissions calls for a combination of global technical and policy efforts, such as advancing international initiatives, improving **livestock feeding practices**, adopting **circular waste management, and implementing pre-mine degasification**. These must be complemented by innovative approaches like **low-energy combustion engines, biocovers on landfills**, etc.

1.5. KEY CONCEPTS IN NEWS

1.5.1. CARBON BORDER ADJUSTMENT MECHANISM (CBAM)

Why in the News?

Kazan Declaration adopted by BRICS rejected CBAM, calling it discriminatory.

About carbon border adjustment mechanism (CBAM)

- It is European Union's (EU) policy to impose a **carbon tax** on imports of certain products from countries with less stringent climate policies. **E.g.** Steel.
- CBAM, **implemented in 2023,** moves from transitional phase to full enforcement by **2026.**

Significance of CBAM

- **Support decarbonisation** of EU.
- **Prevents Carbon leakage,** when companies based in the EU move carbon-intensive production countries where less stringent climate policies than in the EU.
- **Fair price on carbon emitted** from carbon-intensive goods that are entering the EU.
- **Encourage cleaner industrial production** in non-EU countries.

India's Concerns

- It could create new **trade barriers** for its exports to the EU.
- CBAM **tax burden** would represent **0.05% of India's GDP** (Centre for Science and Environment).
- **Disproportionate burden** on small and medium enterprises (SMEs) compared to larger ones.

- **Stringent compliance requirements,** emissions tracking, certifications, digital filings, and verification protocols

Conclusion

CBAM's climate ambition is noble, but execution is bureaucratically extractive. However, the idea that **EU will set standards** for other countries is opposed by India.

1.5.2. GREENWASHING

Why in the News?

Central Consumer Protection Authority (CCPA) has issued guidelines for '**Prevention and Regulation of Greenwashing and Misleading Environmental Claims, 2024'.**

More on the News

- These guidelines are in the furtherance to the **Guidelines for Prevention of Misleading Advertisement, 2022.**
- Seek to **foster truthful practices** where **environmental claims are both truthful and meaningful**.

Key provisions of the guidelines

- **Defines greenwashing clearly: As any deceptive or misleading practice**, including **concealing, omitting, or hiding relevant information,** by exaggerating, making vague, false, or **unsubstantiated environmental claims.**
  - Also includes **use of misleading words,** symbols, or imagery.
- **Applicability: All** environmental **claims, manufacturer, service provide**r, product seller, advertiser, or an advertising agency **or endorser** whose **service is availed for the advertisement** of such products.
- **Substantiation of Environmental claim:**
  - **Use consumer friendly language and explain meaning or implication of technical terms**.
- **Adequate Disclosures:** Ensure **all environmental claims in ads or communications** are **fully disclosed**.

Need for regulating green washing

- **Erosion of Public Trust in genuine products:** E.g., in Volkswagen emissions scandal (2015), Volkswagen falsely advertised that their diesel cars were low-emission vehicles.
- **False environmental claims delay genuine solutions** to the climate change, while also making consumers to choose for the unsustainable products.
- **Free riding** allows businesses to benefit from **positive image of certifications** without actually implementing sustainable solutions.
- Redirecting resources towards the appearance of environmental friendliness may come at the **cost of innovation for substantial and lasting benefits.**

Other Initiatives taken to prevent Greenwashing

- **Bureau of Indian Standards (BIS): Eco-labelling of products and services** called IS/ISO 14024:1999.
- **Green Rating Project (GRP):** By **Centre for Science and Environment (CSE),** rates industrial units based on their environmental friendliness.

- **Indian Green Building Council (IGBC):** Rating system for green buildings,
- **Advertising Standards Council of India (ASCI):** Requires Advertisements making environmental/green claims be specific, accurate.
    - **Greenwashing TechSprint:** Organized by Global Financial Innovation Network (GFIN) **(RBI** participated).

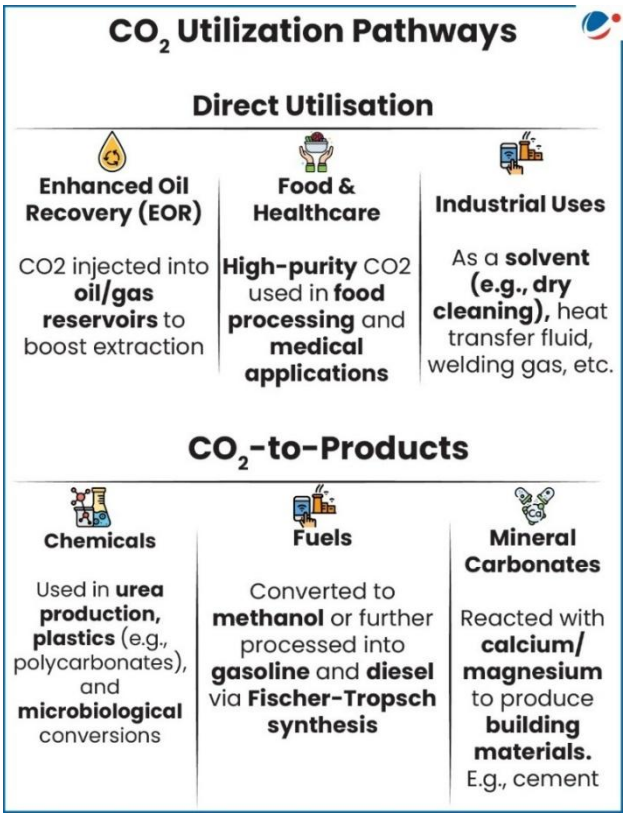
Conclusion

The recent guidelines could be made more effective by **Harnessing new technologies** including AI for **ensure accountability, Media Campaign for raising** public awareness, cross**-border cooperation and collaboration, etc.**

1.5.3. CARBON CAPTURE AND UTILISATION (CCU)

Why in the News?

India Unveiled First Cluster of Five Carbon Capture and Utilisation (CCU) Testbeds for Cement Sector with thrust on **Developing** it as an integrated unit in an **Industrial set up** through **Public Private Partnership (PPP)** funding model.



About Carbon Capture and Utilisation (CCU)

- **Definition:** Set of technologies that allow for the **capture & use of carbon as a feedstock** for making essential products such as fuels, chemicals, etc, predominantly derived from **fossil resources.**
- **Carbon Capture:**
    - **From industrial (e.g., cement plants) or energy (e.g., biomass power plants) sources**: Technologies like membranes, solvent absorption, etc.
    - **Directly from the air (Direct Air Capture - DAC)**: Ambient air is drawn through a gas trapping system where CO_2 is isolated from the rest of the air.
- **Carbon Utilisation:** Once captured, CO_2 can be utilised through **two main pathways:**
    - Direct Utilisation & CO_2-to-Products (**See image)**

Significance of CCUS

- **Decarbonisation of Hard to abate sectors:** Like cement, steel, etc., where technology involving use of fossil fuels are in a mature stage.
- **Propel Low carbon Hydrogen:** Coal gasification with CCUS.
- **Realization of Net Zero Targets:** With advancement in Direct Air Capture technology.

Issues with CCUS adoption in India

- **Variation in Carbon Capture Costs across sectors** depending upon source and concentration of CO_2.
- **Limited CO_2 storage Limit,** especially for saline aquifers and basaltic storage (geological data on pore space).
- **Absence of downstream CO_2 infrastructure** for transportation and storage.

Conclusion

Despite **high costs, regulatory complexities**, CCUS is a critical technology for **decarbonization** which can be promoted through **supportive government policies and advancement of technologies.**

1.6. KEYWORDS

Keywords				
Nationally Determined Contributions (NDCs)	Common but Differentiated Responsibilities (CBDR)	New Collective Quantified Goal on Climate Finance (NCQG)	Greening of Antarctica	Carbon Sink
Extreme Weather Events	Panchamrita targets	Global Stock Take (GST)	Climate Change Mitigation	Global Warming Potential (GWP)
Loss and Damage	LiFE- Lifestyle for the Environment	Planetary Boundaries	Debt for Climate Swaps	Positive Feedback Loop
Carbon Budget	Tipping Points	Emissions Gap	Emissions trading	Carbon tax
Decarbonization	Greenwashing	Article 6	Climate Budgeting	Climate Equity

1.7. PRACTICE QUESTION

Answer Canvas

Examine the outcomes of COP29 held in Baku, Azerbaijan. Discuss the challenges that remain in global climate negotiations and propose measures to address them.

Introduction	Body Part 1	Body Part 2	Conclusion
Briefly explain COP29	Outcomes of COP29	Challenges in Global Climate Negotiations	Measures to Address Challenges

2. ENVIRONMENTAL POLLUTION AND DEGRADATION

2.1. AIR POLLUTION

2.1.1. COAL THERMAL POWER PLANTS

Why in the News?

The Union Ministry of Environment, Forest and Climate Change (MoEF&CC) has issued **fourth extension for thermal power plants (TPP)** to comply with Sulphur dioxide (SO_2) emission norms.

More about the News

- **Extension from 2022 notification deadline:** Ministry extended deadlines for installing FGD systems in TPPs based on categories.
  - The flue gas desulfurization **(FGD) plant removes sulfur dioxides (SO_2)** from flue gas produced by boilers, furnaces, and other sources.
- In **2015,** MoEF&CC implemented India's first emission norms for SO_2, NO_x and mercury control, acknowledging the significant impact of coal-fired power plants on pollution levels

Major Pollutants from burning coal

- **GHGs:** Sulphur dioxide; Carbon dioxide (CO_2); Nitrogen oxides
  - Decarbonising coal-based thermal power sector in India can lead to **over 30% reduction in GHG emissions.**
- **Particulates (Including Fly ash):** Contribute to smog, haze, respiratory illnesses, and lung disease
- **Other:** Heavy metals like Mercury and bottom ash.

Why coal is still relevant for India's energy security

- **Most abundant fossil fuel:** Accounts for **55% of the country's energy need.**
  - India's electricity consumption is **expected to triple by 2050** [International Energy Agency (IEA)]
- **Large indigenous availability:** India holds **107,727 million tons (MMst)** of proven coal reserves as of 2016, **ranking 5th in the world.**
- **Socio-economic relevance**: Development of coal producing region like Bihar; Creation of jobs; etc.

Steps taken to reduce emission from Thermal Power Plants:

- Installation of **Flue Gas De-sulphurisation (FGD) Technology, Electro Static Precipitator (ESP), NOx Combustion Modification etc.**
- Thermal Power Plants are covered under **Perform, Achieve, Trade (PAT) Scheme**
- **Revised policy on Bio-mass Utilization for Power Generation** through Co-firing in Coal based Power Plants to use 5-10% blend of biomass pellets.
- Promotion of installation of **efficient Ultra Supercritical/Supercritical units over Subcritical Thermal Units.**
- **Retirement of inefficient and old thermal power plants** (267 units retired till June 2024)
- **Pilot Carbon Capture Project at Vindhyachal** commissioned by NTPC Ltd. with 20 Tonnes Per Day (TPD) capacity.

Conclusion

Mitigating pollution from coal use requires promoting **reuse and recycling of coal combustion by-products,** such as in cement and synthetic gypsum production. Additionally, fuel cleaning methods like **coal beneficiation and washing** can significantly reduce sulfur content, helping lower emissions at the source.

2.1.2. URBAN AIR POLLUTION IN INDIA AT A GLANCE

Urban Air Pollution in India

Urban Air Pollution in India

Status of Urban air Pollution
6 out of the 10 most polluted cities in the world were found to be located in India. **(2024 World Air Quality Report)**

Major Pollutants in the Air
Particulate Matter, PM 2.5 and PM 10, Ozone (O_3), Carbon Monoxide (CO), Nitrogen dioxide (NO_2), Sulfur dioxide (SO_2), Volatile Organic compounds(VOCs)

Causes of urban air pollution in India

Climatic factors
E.g., In North India: Low rainfall in September-October, sluggish winter winds , **Temperature Inversion in Winter conditions**

Airshed Dynamics and wind patterns
E.g., Dust storms from the Sahara and Thar deserts.

Agricultural practices
E.g. Stubble Burning in Punjab and Haryana

Urban and Industrial Factors
Construction and Demolition Waste, High Vehicle Density, Unscientific Waste Disposal etc.
E.g. Ghazipur landfill fire

Impacts of Urban Air Pollution

Health Impacts
Globally, air pollution accounted for the **2nd largest risk factor of death** after High blood pressure. ('State of Global Air/ 2024' Report)

Economic Losses
1.36% of GDP (2019 – World Bank) due to premature deaths and illness.

Damage to Structures
SO_2 and NO_2 corrode buildings **Example:** Taj Mahal's marble yellowing.

Urban Heat Island Effect
Cities warmer than rural areas due to emissions and built-up surfaces

Ecosystem Damage
- **Acid rain** leads to Lake Acidification and mercury in aquatic food chains.
- **Ground-level ozone** reduces photosynthesis, stunting plant growth.

Initiatives to Curb Air Pollution

National Clean Air Programme (2019): Reduce PM levels by 40% by 2026 in 131 cities.

Graded Response Action Plan: Emergency pollution control in Delhi-NCR.

CPCB: Enforces Air Act (1986); controls emissions, waste burning, etc.

SAFAR Portal: Real-time air quality data and public alerts.

Way Forward

Urban Planning & Green Initiatives
- **Promote Blue-Green Spaces**
- **Clean Air Zones:** Strict emission norms in high-pollution zones.

Sustainable Transport
- Improve public transport, pedestrian zones.
- **E.g., Copenhagen's Green Wave tech** promotes cycling via synced traffic lights.

Technological & Scientific Solutions
- Promote fuel cells, methanol, hydrogen fuel, and ultra-low sulphur fuels.

Integrated Policy Approaches
- **Airshed Management:** Region-based pollution control via natural dispersion studies.
- **Developing Particulate Emission Trading Market: E.g. Surat Emission Trading Scheme (ETS)**

2.2. WATER SCARCITY AND POLLUTION

2.2.1. EXTREME WATER STRESS IN INDIA AT A GLANCE

Extreme Water Stress

A country facing **"extreme water stress" means** it is **using at least 80% of its available supply,** and **"high water stress"** means it is **withdrawing 40% of its supply.**

Status of Water Stress in India

Limited sources Has 18% of the world's population but only 4% of **its water resources.**	**Depleted Groundwater** **~11% assessment units** categorized as **'Over-exploited' (Dynamic Ground Water Resource Assessment Report, 2024)**

Impacts

Threat to food security **~74% wheat cultivation area and 65% rice cultivation** area face significant levels of water scarcity (Composite Water Management Index NITI Aayog August 2019)	**Demand Supply gap** Domestic water demand expected to **double by 2030.**	**Economic impacts on industries, power plants etc.** **31% of global GDP** will be exposed to high water stress by 2050. (WRI Data	**Threat to water, sanitation and hygiene (WASH)** **Spread of waterborne** diseases and Neonatal and Child Mortality › **Increased Burden on women** (women and girls spend 200 million hours every day collecting water- UNICEF)

Causes of global extreme water stress

Overexploitation of water particularly for **agriculture. E.g.,** India is world's largest groundwater user	**Unsustainable water use policies.** **E.g.,** flood irrigation.	**Climate change** disrupts hydrological cycle and reduces water availability	~20% rural Households in India **lack tap water connections**	**Water pollution** **E.g.,** Uranium contamination found in around 12 state

Initiatives in India

Water conservation: › **National Water Mission, Jal Jeevan Mission** (JJM), **Pradhan Mantri Krishi Sinchai Yojana** (PMKSY)-Har Khet Ko Pani, Mission Amrit Sarovar (2022)etc.	**Groundwater recharge** › **Jal Kranti Abhiyan, Atal Bhujal Yojana (2020) Jal Shakti Abhiyan -** Catch the Rain, **National Aquifer Mapping and Management Program (NAQUIM) etc.**

Way Forward

Improve **water governance** through **one- water approach, nature-based solutions** and green infrastructure.	**Industrial water quotas, tradable water credits, etc.** to optimizing water usage in scarce regions and minimize the water supply deficit.	**Crop diversification, promotion of traditional water harvesting practices** like Johad, Rajasthan for Resolving Water Crisis in Agriculture.	**Support local programs like Telangana's MISSION KAKATIYA, Andhra Pradesh's Neeru-Chettu** programme for better conservation

2.2.2. WATER (PREVENTION AND CONTROL OF POLLUTION) AMENDMENT ACT, 2024

Why in the News?

Union Environment Ministry notified Water (Prevention and Control of Pollution) (Manner of Holding Inquiry and Imposition of Penalty) rules, 2024.

More on the News

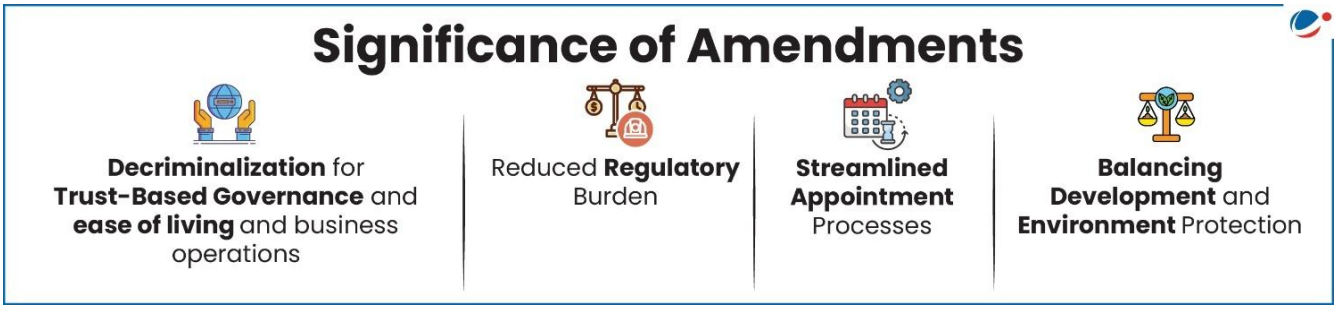
- The rules comes in backdrop of amendments wherein **offenses and violations of the Act were decriminalized, replacing them with penalties**
- **It had also allowed the Centre to appoint 'Authorised Officers'** to adjudicate offenses, violations and determine penalties.
- **About Water (Prevention and Control of Pollution) Act 1974**
  - The Act provides for the **prevention and control of water pollution, and for the maintaining or restoring of wholesomeness of water** in the country.
  - **Regulatory bodies**: Creation of the **Central Pollution Control Boards (CPCB)** and **State Pollution Control Boards (SPCB)**
  - **Approval:** Mandatory for industrial units to get **permission from their respective State boards** before setting up factories.

Key Amendments (Water Amendment Act, 2024)

- **Central government to prescribe** manner of nomination and terms and conditions of service of **Chairman of SPCB (**earlier Nominated by State government).
- **Central government,** in consultation with the CPCB, empowered to **exempt certain categories of industrial plants** from restrictions on **new outlets and discharges**. (earlier State Government)
  - **Central government may issue guidelines** for grant, refusal, or cancellation of consent granted by SPCB.
- In case of offences by government departments**,** Head of a department will be **required to pay penalty equal to one month of their basic salary** if department violates any provision.

Other provisions of Amendment Act 2024:

- **Allows to Appoint Adjudicating officer:** To determine penalties
- Penalties imposed by adjudicating officer will be **credited to the Environment Protection Fund** established under the **Environment (Protection) Act, 1986.**



Conclusion

There is need for **Stakeholder Engagement** through consultations with environmental experts, industry representatives, and civil society organizations to refine the amendments and address concerns. Also, **t**raining and capacity-building programs for Pollution Control Boards can enhance effective enforcement of environmental regulations.

2.2.3. GROUND WATER POLLUTION IN INDIA AT A GLANCE

Ground Water Pollution in India

Ground Water Pollution in India

Extent in India
- **~56% of India's districts** have **nitrates** beyond the safe limit of 45 mg/L in groundwater **(Annual Ground Water Quality Report, 2025).**

Major Groundwater Contaminants
- **Nitrate** (e.g. Rajasthan), **Fluoride** (e.g. Rajasthan) **Arsenic** (e.g. West Bengal),**Uranium** (e.g. Rajasthan) **Salinity** (e.g. Delhi)

Causes of Groundwater Pollution

Discharge of untreated industrial waste (heavy metals, chemicals, solvents).	**Excessive fertilizers and pesticides** lead to nitrate contamination.	**Urbanization & Waste Mismanagement** e.g. Sewage leaks, landfill runoff etc.	**Climate Change Impact** and overuse hinders aquifer replenishment, worsening water quality.	**Institutional and Management Gaps** because of multiple agencies like **CPCB, CGWA** and out-dated laws

Initiatives

Institutional
- **Central Ground Water Authority:** Under Environment (Protection) Act, 1986 to regulate and manage GW resources.
- **Central Ground Water Board (CGWB): Apex organization of the Ministry of Jal Shakti** dealing with GW and related issues.
- **Central Pollution Control Board (CPCB):** Promotes cleanliness of streams and wells, and aims to improve the quality of air in the country.

Legislative provisions:
- Water (Prevention and Control of Pollution) Act 1974,
- The Water Cess Act, 1977.

Way Forward

Legal Reforms
- Separate **groundwater rights from land ownership** & empower local bodies for regulation.

Phytoremediation
- E.g. using **aquatic plants** to accumulate and remove arsenic from GW.

Sequestration
- Addition of chemicals to control problems caused by iron and manganese without removing them.

Regulating Fertilizer Use
- Prevent **overuse of nitrogenous fertilizers** in agriculture.

2.2.4. COMMUNITY PARTICIPATION IN WATER CONSERVATION

Why in the News?

Recently, **Jal Sanchay Jan Bhagidari** initiative was launched by Ministry of Jal Shakti from Surat, Gujarat.

About Jal Sanchay Jan Bhagidari initiative

Inspired by **Gujarat's successful Jal Sanchay initiative**, it focuses on **water conservation through community participation** and plans to build ~24,800 rainwater harvesting structures for long-term sustainability.

Significance of Community Participation in Water Conservation

- **Foster Behavioural response: E.g., Jal Sahelis** in **Bundelkhand** have sparked a cultural shift towards Conservation.
- **Utilization of Local Knowledge and Insights: E.g., Bari Farming System (Assam)** involves co-existence of fruit trees, vegetable cultivations, and the pond.
- **Instilling a sense of ownership: Pani Panchayat, Odisha** involves the voluntary farmers' participation in harvesting and distribution of surface and ground water.

Other Examples of Community Participation in Water Conservation

- **Local Jal Samitis under Jal-Jeevan Mission:** Involves the participation of atleast 50% local village women.
- **Neeru-Chettu (Andhra Pradesh):** Rejuvenating and revitalising natural resources.
- **Jal Jeevan Hariyali (Bihar):** Identification, restoration, and renovation of all public water storage structures.
- **Jal Hi Jeevan Hai (Haryana):** Encouraging crop diversification and encouraging cultivation of lesser water intensive crops like Maize, Arhar, etc.
- **Mission Kakatiya (Telangana):** Reclamation of water tanks by restoring minor irrigation sources.
- **Traditional water storage systems in India: Jal Mandir** (Gujarat); **Khatri, Kuhl** (Himachal Pradesh); **Zabo** (Nagaland); **Eri, Ooranis** (Tamil Nadu); **Dongs** (Assam); etc.

Challenges with the community participation in Water Conservation

- **Limited Information and Capacity** due to lack of accessibility and complexity of the water resources data, limited technical knowledge required for water conservation.
- **Limited association with outsiders and Mere Ceremonial Involvement:** E.g. at Panchayat level.

Conclusion

Promoting participative water conservation requires **inclusive policy dialogue, active involvement of corporate and community stakeholders**, and the adoption of sustainable practices like **LiFE**. Encouraging modern technologies such as **solar-powered filtration and desalination**, along with policy support for less water-intensive crops, can ensure long-term water security.

2.2.5. WATER RECYCLING & REUSE IN INDIA AT A GLANCE

Water Recycling & Reuse in India

Status of Water use in India
- **Untreated wastewater: ~72% of India's wastewater** ends up in nearby rivers, lakes, etc. (Centre for Science and Environment (CSE))

Water Reuse Technologies
- **Membrane Bioreactor** (biological treatment + membrane filtration)
- **Ultrafiltration** (Separates Particulate matter from soluble compounds)
- **Reverse Osmosis and Disinfection Technologies** (UV/Ozone/Advanced Oxidation)
- **Electrodialysis Reversal**
- **Thermal Evaporation/ Crystallization**

Benefits of Water Recycling & Reuse

Environmental Benefits
- Reduces freshwater diversion
- Saves energy and cuts GHG emissions by reusing water,
- Recharges groundwater (e.g., Bengaluru uses treated water to refill lakes)
- Supports wetland and stream habitat restoration.

Socio-economic benefit
- **Enhances water availability** in arid/stressed areas like Marathawada, Vidarbha
- **Supplies water to industries and farms,** Improves agriculture using nutrient-rich wastewater.

Challenges of Water Recycling and Reuse

Low treatment capacity of Sewage treatment plants (STPs)	High Capital and Operational Costs of STPs	Low Compliance rate of STPs	Lack of specific framework	Other issues
~18.6%. in Class I cities and Class II towns	E.g., cost of Advanced treatment technologies	**23 % of treatment capacity** is meeting the consented parameters of State Pollution Control Boards (SPCBs)	No specific policy at Central or State level for treatment of polluted water or its ecological restoration	**Stigma:** Socio-cultural barriers Water recycling is energy-intensive

Initiatives

National Framework on Safe Reuse of Treated Water in 2022.	Power Tariff Policy 2016: Mandates all Thermal Power Plants to use the treated sewage water	The National Water Policy-2012 mandates recycle and reuse of water	Jal hi Amrit' initiative under AMRUT2.0 **incentivizes States /UTs** for efficient management of **Sewage Treatment Plants (STPs)/Used Water Treatment Plants (UWTPS).** UWTPs will be awarded **Clean Water Credits** through a Star Rating system.

Way Forward

Decentralized STPs at city-level	Governance reforms	Implement tiered volumetric pricing structure	Incentives for industrial, academic, and research institutions	Implement tradable water-use credits system
E.g. Bangalore's district split into 3 zones based on its natural topography	E.g., Karnataka, ULBs has defined responsibilities including coordination with Waste Water Reuse Resource Centre.	E.g., higher rates for non-recycled water	conducting R&D in water treatment Technologies.	Based on treated wastewater usage.

2.3. OTHER TYPES OF POLLUTION/DEGRADATION

2.3.1. LAND DEGRADATION AT A GLANCE

Land Degradation

Definition	Targets
Reduction in the **capability of the land to produce benefits from a particular land use** under a specified form of land management (FAO, 1999).	› **Global- Land Degradation Neutrality (LDN) target setting programme (LDN TSP):** Global voluntary commitments to restore **one billion hectares degraded land by 2030.** › **India - LDN target:** Restore **26 million hectares by 2030.**

Status of Land Degradation

India	World (World Atlas of Desertification)
› **Degraded land:** ~29% (ISRO Atlas, 2021). › **Land undergoing desertification:** 25%.	**75% of soils are already degraded;** this proportion will rise to **90% by 2050.**

Major Causes of Land degradation

Deforestation: 30 Mha Land Degradation in India (during 2018-19) happened through **Vegetation degradation.** (ISRO, 2021)	**Salinization / Alkalization:** About **50 % of the arable land in Punjab** has been damaged due to **salinity.**	**Improper crop rotations** Intensive **cereal-based rotations** (rice and wheat)	**Overgrazing** E.g., Degradation of **Banni grasslands of Gujarat.**

Impact of conserving land

Supports Agriculture and Forestry	**Highly efficient carbon sinks:** After oceans, **world's soils** are the **second largest** carbon pool on Earth.	**Supports biodiversity:** Host to some 25% of our planet's biodiversity.	Contribute to **water, nutrient** and **nitrogen cycling.**	Foundation of **basic ecosystem functions** and helps **regulate Earth's temperature.**

Initiatives

Global:	India:
› **United Nations Convention to Combat Desertification (UNCCD)** › **Bonn Challenge** aims to restore **150 million hectares of** degraded and deforested land by 2020 and 350 million hectares by 2030. › **World Soil Health Index** Announced By **UNESCO .**	› **National Action Plan on Climate Change (NAPCC)** › **Desertification and Land Degradation Atlas** of India. › **Schemes:** Soil Health Card, PM Krishi Sinchayee Yojana etc.

Way Forward

Enhancing restoration target	Utilizing Local and indigenous knowledge	
› To **1.5 billion hectares** of global land by 2030 to achieve a LDN world. (UNCCD Dash Board)	› **E.g.** Use of **Polyculture** technique called Milpa by Mayan People	› **Adopting Sustainable Agricultural Practices** like natural farming, agroforestry etc. › **Converting wastelands into productive agroforestry zones**

2.3.2. PLASTIC POLLUTION

Why in the News?

Recently Plastic Pollution Treaty Negotiations were adjourned in Busan, South Korea **without finalization of a treaty**.

About the Plastic Pollution Treaty

- The Treaty being negotiated has been mandated by a **2022 UN Environment Assembly resolution**.
  - It seeks to **addresses the full life cycle of plastic**, including its production, design and disposal.
- **India's stance on Plastic Pollution Treaty**
  - **Inability to support** any **measures to regulate the production of primary plastic polymers** as it could impact development rights of nations.
  - **Scope of instrument should be limited to addressing plastic pollution only** without overlapping with the mandate of other multilateral environmental agreements.
  - **No support to inclusion of any list with phase out dates**, at this stage.
  - Need of **due consideration to national circumstances and capabilities** and **financial and technical assistance** to developing countries**.**

Plastic Pollution in India

Challenges in tackling Plastic waste in India (Public Accounts Committee (PAC) report titled "**Pollution caused by Plastic")**

- **Absence of mechanism for assessment** of generation of plastic wastes.
- **Non-Compliance like** non-registration of plastic units, etc.
- **Units functioning without valid registration** due to lackadaisical approach of CPCB, SPCBs, etc.
- **Delay in elimination of Single Use Plastic (SUP)** as many states did not ban it.

Initiatives taken for Tackling Plastic Pollution in India

India

- **Plastic Waste Management Rules and its amendments: Plastic Waste Management Amendment Rules, 2021 banned identified single use plastic** item from 1st July, 2022.
- **Plastic Waste Management (Amendment) Rules, 2024**
  - **Inserted new Rule for responsibility of Panchayats at District level** to undertake assessment of plastic waste generated.
  - **Responsibility of Producers, Importers and Brand Owners** for collection of such plastic packaging
- **Extended Producer Responsibility on Plastic Packaging, 2022:** Policy principle that holds producers accountable for entire lifecycle of their products, particularly during take-back, recycling, and final disposal.
- India piloted a resolution in the **4th United Nations Environment Assembly** in 2019, on addressing **single-use plastic products pollution.**
- **Project REPLAN (Reducing Plastic from Nature)** launched by the Khadi and Village Industries Commission (KVIC).
- **Private sector collaborations:** India Plastics Pact (IPP), Un-Plastic Collective (UPC)

Recommendations

- Encourage producers to **develop separate waste stream** for collection of plastic packaging waste and **issuance of EPR certification on achieving annual targets.**
- Include penalty ULBs which do not set up **Plastic Waste Management systems**.
- **Incentivise producers and fund R&D** for developing eco-friendly alternative to SUPs.
- Assign **clear responsibilities** to stakeholders, establish **coordination mechanism**, **and Enforce strict compliance.**

Conclusion

As negotiations continue, the global community must demand a **framework that prioritises equity, accountability, and meaningful action.** For India, this **treaty holds particular significance**, offering a pathway to address domestic challenges such as weak enforcement, inadequate Extended Producer Responsibility (EPR) systems, and rising single-use plastic emissions.

2.3.3. OIL SPILLS AT A GLANCE

Oil Spills

Definition	Examples
Includes the **accidental or deliberate, operational spills of oil** from ships, especially tankers, offshore platforms and pipelines.	› Philippine oil tanker near Manila (2024) › MSC Elsa 3 sinking near Kochi, Kerala (2025) › Oil Spill near Kerch Strait (2024)

Causes of Oil Spills

Equipment breaking down due to human errors.	**Deliberate** acts by **illegal dumping.**	**Natural disasters** like hurricanes.	**Accidents** involving tankers, refineries, etc.

Impacts of oil spill

› **Environmental Impacts:**
  - **Threat to Biodiversity:** Marine mammals, Fishes, Turtles, Seabirds face threats like poisoning, hypothermia, drowning, damaged airways, loss of insulating ability etc.
  - **Impact Coastal and Marine Habitats:** Coral reefs risk smothering and toxicity; mangroves, marshes, and seagrasses suffer damage.

› **Socio Economic Impacts:**
  - **Fisheries Sectors:** Polluted Fisheries impact livelihood.
  - **Health Risks:** Exposure through direct contact, inhalation, or consumption of contaminated seafood.

Initiatives

National
› **National Oil Spill Disaster Contingency Plan (1996)**
› **Merchant Shipping Act, 1958:** Provision for prevention and containment of Pollution of Sea by Oil.

International
› **International Convention on Civil Liability for Bunker Oil Pollution Damage (2001):** India ratified the convention in 2015
› **International Convention for the Prevention of Pollution from Ships** or MARPOL (India is a signatory)
› **International Convention on Oil Pollution Preparedness Response and Cooperation** (OPRC) 1990 (India is a signatory)
› **International Convention for Safety of Life at Sea (SOLAS)**

Way Forward

Bioremediation	Sorbents	Standard SoPs	Use of Booms and Skimmers
› **E.g., Oilzapper & Oilivorous-S,** developed by TERI.	› **E.g., Milkweed plant's fiber,** commonly found in Rajasthan	› Safe barrel handling procedures and use of doubly walled equipment	› To limit spread and to remove oil spills

2.3.4. SOLID WASTE MANAGEMENT (SWM) IN INDIA AT A GLANCE

Solid Waste Management (SWM) in India

Solid Waste	Current status (TERI Study)
By-products of household or commercial activities that have **lost their value to the original owner(s)** but **may hold significance for others.** E.g., Municipal solid waste, industrial waste, etc.	› **Annual waste generation:** 62+ million tons › **Collection:** 43 million tons › **Treatment:** Only 12 million tons

Challenges in SWM in India

Inadequate Segregation of waste at source resulting in increased cost of Waste disposal.	**Underdeveloped storage infrastructure,** limited door-to-door waste collection, etc.	**Open dumps emitting methane gas,** contributing to fires, explosions, and global warming.	**Low Municipal Finance** due to difficulty in generating revenue, struggling to attract private capital due to poor Creditworthiness.	**Overlapping Jurisdiction,** Multiple agencies share oversight responsibilities.

Initiatives

Solid Waste Management Rules, 2016
- Mandates generators to **segregate waste at source into 3 streams** - Biodegradable, Non biodegradable, and Sanitary and Domestic Hazardous waste.
- Local authorities responsible for setting up waste collection, transportation, processing, and disposal systems.

Schemes
- **Swachh Bharat Mission (SBM-U) 2.0**
- **Garbage Free Star Rating Protocol** to assess the City's Municipal Solid Waste Management.

Way Forward

Scaling waste-to-energy Projects Enhanced Public Private Partnerships E.g. city of Mumbai, Bhopal, Bangalore	**Improve waste segregation.** E.g., CSIR-CMERI developed Municipal Solid Waste Processing Facility with advanced segregation Techniques.	**Financially strengthening municipal bodies.** E.g., Bruhat Bengaluru Mahangara Palike (BBMP) proposed a SWM Cess of ₹100 per month	**Technological Innovation: Bhopal Municipal Corporation** has developed **GPS-enabled vehicle tracking system** for door-to-door waste collection.

2.3.5. E-WASTE MANAGEMENT IN INDIA AT A GLANCE

E-waste management in India

Status of E-Waste in India

- Ranked **3rd largest e-waste generator** following only **China** and the **USA.** (Global E-Waste Monitor 2024 report).

Need for proper e-Waste Management

Economic benefits of recovering valuable materials like gold, silver, etc.	**Health hazards** (contains over 1,000 toxic materials)	**Environmental Risks** (non-biodegradable, leaching from landfills etc.)	**Social impact** (engagement of child labour, lack of safety equipment for collection etc.).

Challenges associated with E-Waste in India

Informal sector › Around 85% of e-waste is managed by the **unorganised sector.**	**Limited recycling/ collection facilities.** › **~33%** of total e- waste generated was collected and processed.	**Dumping** › **80% of E-waste in developed countries** meant for recycling is sent to developing countries such as India.	**Obsolescence** › **Focus short product lifecycles** with limited repair options, etc.

Initiatives

India	Global
› **E-waste (Management and Handling) Rules, 2011:** Introduced the concept of **Extended Producer Responsibility (EPR).** › **E-Waste (Management) Rules, 2016:** Introduced concept of **Producer responsibility Organization (PRO).** › **Battery Waste Management Rules, 2022.** › **Right to Repair portal.**	› **Basel Convention.** › **Global E-waste Statistics Partnership.** › **E-waste Challenge** by World Economic Forum. › **E-waste Coalition 2018** by seven organisations from the United Nations system.

Way Forward

Efficient recycling facilities and collaborating with specialized companies E.g., **Co-locating E-Waste Management Industrial Cluster** with **Manufacturing Clusters.**	**Technological Development** E.g., MeiTY developed indigenous technology for recovery of precious metals and plastics from e-waste.	**Other measures:** › **Stringent monitoring** and enforcement of rules; › **Corporate Responsibility;** › **Upgradation of skills of informal** sector, etc.

2.4. MISCELLANEOUS

2.4.1. REVISED CLASSIFICATION OF INDUSTRIES

Why in the News?

Central Pollution Control Board (CPCB) has directed **State Pollution Control Boards (SPCBs)** to adopt a **revised classification of industries**.

About Revised classification

- CPCB has classified a total of **419 sectors** into **Red (125)**, **Orange (137)**, **Green (94)**, **White (54)** and **Blue (9) category (Newly Introduced),** based on **Pollution Index (PI).**

- The Pollution Index PI of any industrial sector is a **number from 0 to 100** and the increasing value of PI denotes **the increasing degree of pollution load from the industrial sector**.

- Also, CPCB will **incentivize** industries which have demonstrated the successful **implementation** of **environmental management measures.**

Classification of Industries

- It originated in 1989 with the **Doon Valley (Uttarakhand) Notification** issued by **MoEFCC**, **Classification** based on PI was introduced in **2016.**
- **Purpose**: To ensure that the industry is established in a manner which is consistent with the environmental objectives.

Existing Categories of Sectors

Category	PI	Key detail /Examples
Red	PI> 80	**Not normally be permitted in ecologically fragile area / protected area.** E.g. Cement, manufacturing of automobiles, distilleries, etc.
Orange	55 ≤ PI < 80	E.g. Brick manufacturing, dry cell battery, coal washeries, etc.
Green	25 ≤ PI < 55	E.g. Manufacturing of Compact disc Computer (CD/DVD), chilling plants, etc.
White	PI < 25	These are **non-polluting; do not** require **Environmental Clearance (EC)** and Consent. E.g. Assembly of air coolers, cardboard manufacturing, medical oxygen, etc.

Note: For any new or left-out sector, the SPCB/ Pollution Control Committees (PCCs) are allowed to categorize the sector at its own level.

About Blue Category

- It Includes **Essential Environmental Services (ESSs)** facilities which are essential to control, abate and mitigate pollution generated from **Domestic and Industrial activities.**
- **Examples:** Municipal Solid Waste Management Facility, sewage treatment plants, etc.
  - **Compressed Biogas Plants (CBP)** based on various feedstock like municipal solid waste, agro-residue, etc. may be considered under **blue category.**

Usage/Relevance of classification:

- Used as a tool for deciding the **location/siting** of an industry, **For Sector specific plans for Industrial pollution control**
- SPCBs/PCCs may prioritize **environmental surveillance** programs based on the categories of sectors.
- **A tool for progressive environmental management**: Industrial units may **adopt cleaner technologies**, cleaner fuels, etc. to reduce PI, moving to lower pollution potential category.

Conclusion

The CPCB's revised classification of industries, including the introduction of the Blue category, reflects a progressive shift towards environmentally responsible industrial regulation.

2.4.2. WASTE TO WEALTH AT A GLANCE

Waste to Wealth

Waste to Wealth Techniques

Biological Processing
- **Composting biodegradable** and **organic waste** to yield bio-fertilizer.
- **Biomethanation** (anaerobic fermentation of biodegradable matter) to yield biogas, etc.

Thermal or Waste to Energy Processing
- **Incineration, Gasification** and **Pyrolysis** for production of electricity and heat/light from Municipal Solid Waste (MSW).

Processing for Reuse
- Using Plastic waste in road construction, recycling Construction, etc.

Significance of Waste to Wealth

Derive **economic benefits** from energy generation and extraction of valuable Resources.	Protect **environment from toxic waste;** Recycle materials and promote circular Economy.	Sustainably manage **high generation of waste,** especially from Urban areas.	Encourage **entrepreneurship and job creation.**

Challenges

Informal and inefficient collection.	**Limited financial capacity** of Local Bodies for processing.	**Lack of reliable data** of waste inventory.	**Costly and complex technologies.**	**Limited Private Participation.**

Initiatives

Waste to Wealth Mission under PM-STIAC with components like Swachhta Saarthi Fellowship, Su Dhara, Community Engagement, Waste to Wealth portal, etc.	**Policies and guidelines** for waste management like- **Solid Waste Management Rules, 2016;** Plastic Waste Management Rules, 2022; etc.	**500 new Waste to Wealth plants** under the **GOBARdhan** Scheme.	Mandating use of **Plastic Waste in Road Construction.**	**National Bioenergy Energy Programme:** It supports setting up of Bioenergy projects in the country.

Way Forward

Ensuring segregation at source and 100% waste collection through awareness generation.	**Institutional support in the waste processing rules** to encourage private sector participants.	Creation of **formal forward and backward** Infrastructure for waste processing activity.	Financially **Strengthening local bodies.**	**Using Bio Leaching** to extract metals (Copper, gold etc.) from waste materials.

2.5. KEYWORDS

Keywords				
Producer responsibility Organization (PROs)	Extended Producer Responsibility (EPR)	Flue gas desulfurization (FGD)	Participative Water Conservation	Progressive environmental management
Single-Use Plastic (SUP)	Temperature Inversion	Land Degradation Neutrality (LDN)	Extreme Water Stress	Debt-for-Nature Swaps

Polluter Pays Principle	Bioremediation	Stubble Burning	Bonn Challenge	Waste-to-Energy
Bio Leaching	Super-Critical Power plants	Green Wall	One Water Approach	Water Reuse and Recycling
Soil Salinization	Desertification	Segregation at Source	Urban Heat Island Effect	Greywater reuse

2.6. PRACTICE QUESTION

Answer Canvas

What is oil pollution? What are its impacts on the marine ecosystem? In what way is oil pollution particularly harmful for a country like India? (GS-III 2023, 10 marks)

Introduction	Body Part 1	Body Part 2	Conclusion
What is Oil Pollution?	Impacts of Oil Pollution on Marine Ecosystem	Socio-economic impacts	Way-Forward

3. SUSTAINABLE DEVELOPMENT

3.1. WORLD COALITION FOR PEACE WITH NATURE

Why in the News?

At the UN COP16 biodiversity, the **"World Coalition for Peace with Nature: A call for Life"** was launched.

More about the coalition

- **Nature: Voluntary** and **open to countries that agree to a set of principles aimed at changing humanity's relationship with nature**.
- **Objectives:**
  - **Address Environmental challenges** by changing relationship between humans and nature.
  - **Reaffirm Rights based approach** of the Kunming Montreal Global Biodiversity Framework.
  - **Mobilize funds**, adopt whole of government (maximize contribution from government institutions) and whole of society (involve civil society) approach sparking collective action.

About Peace with nature

It emphasizes on the **interconnectedness of environmental issues (E.g., the triple planetary crisis involving climate change, biodiversity loss and pollution)**, and advocates strategies that like **sustainable development, ecosystem conservation**, and **equitable participation** of all communities.

Significance of Peace with Nature

- **Ecological Sustainability:** E.g., Threat to food security due to loss of pollinators and fertile soil.
- **Climate resilience: E.g., mangrove restoration** protects coastal communities from disaster.
- **Others:** Achieve SDGs, conserve biodiversity (1 out of 8 million plant/animal species are threatened with extinction), promote environmental resilience, etc.

Challenges in making peace with nature

- **Current mode of development**: It prioritizes **short term economic** goals over **long term ecological preservation**. E.g., GDP as a metric fails to capture the threat to natural calamity.
- **Lax attitude toward environmental targets**: E.g., global goals like strategic plan for biodiversity 2011–2020 and its **Aichi biodiversity targets not being fully met.**
- **Others:** Growing human population with large scale extraction of materials, financial constraints, etc.

Way Forward

- **Transform economic and financial systems:** Incorporate full natural capital accounting into decision-making, re-defining inclusive wealth to include natural capital.
- **Shifting taxation:** From production and labour to resource use and waste
- **Others:** Financial assistance for Developing countries (accessible low-interest finance); reforming trade systems (promoting circular economy), low carbon food, water, and energy systems, etc.

Conclusion

Current trends have caused **ecological footprints** to exceed **Earth's Biological capacity** requiring efforts to ensure living in peace with nature through balance and harmony.

3.2. ENVIRONMENTAL ACCOUNTING

Why in the News?

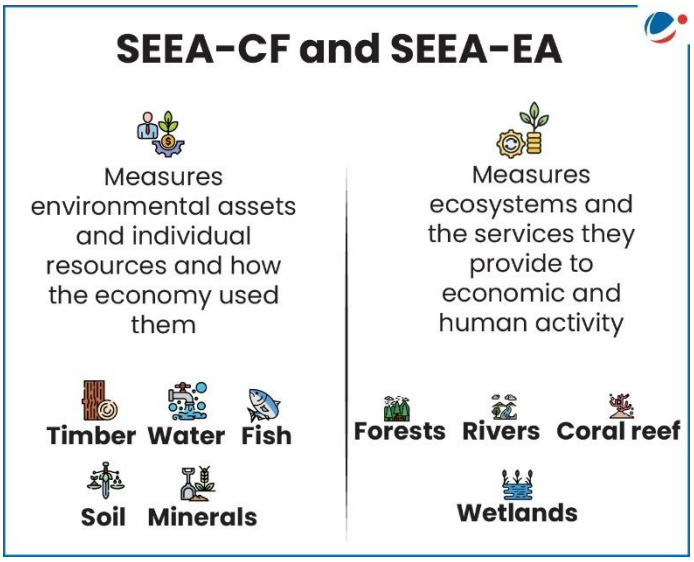
Union Ministry of Statistics and Programme Implementation (MoSPI) released 8th **"EnviStats India 2025: Environment Accounts"**

About EnviStats

- **1st EnviStats** were released in 2018 on **recommendations of Sir Partha Dasgupta Committee**.
- It has been compiled in accordance with the **SEEA (System of Environmental- Economic Accounting) Framework,** providing information about environment and key changes over time.
- **Includes Four areas-** Energy Accounts, Ocean Accounts, Soil Nutrient Index and Biodiversity.

About System of Environmental-Economic Accounting (SEEA)

- International framework for the **compilation of the Environment Economic accounts,** describing the interaction between economy and environment and changes in stock of environmental assets.
  - At global level **'Natural Capital Accounting and Valuation** of Ecosystem services (**NCAVES**)' was Launched by **United Nations Statistics Division (UNSD), UNEP and Secretariat of CBD in 2017. (India too participated)**
- **There are two sides of SEEA**- SEEA-Central Framework (SEEA-CF) and SEEA-Ecosystem Accounting (SEEA-EA) (refer infographic).



- **Significance of Environmental Accounting**
  - **Current parameters like GDP overlooks environmental depletion and degradation**. E.g., cutting down rainforest and selling timber increases GDP but harms well-being.
  - Balance **economic growth with environmental sustainability** and promote **Data-driven policymaking.**

Other Key Initiatives in India for Environmental Accounting

- **Gross Environment Product Index (GEPI):** Novel method to **evaluate ecological development** caused by **human interventions,** with four key pillars, i.e. air, soil, tree and water.
  - Uttarakhand **become the first Indian state** to introduce it.
- **Green GDP**: Chhattisgarh introduced a **Green GDP,** which refers to **environmentally adjusted gross domestic product (GDP).**
  - The term **Green GDP** was coined **in the late 1980s** to reflect the impacts of economic activities on the environment.
  - **Calculation: Green GDP** = Net Domestic Product - (Cost of Depletion of Natural Resources + Cost of Degradation of Ecosystem)

Challenges with Environmental Accounting

- **High Implementation Costs:** For businesses, particularly for small and medium-sized enterprises (SMEs).
- **Complexity of Environmental Data:** Includes tracking of wide range of factors, including energy use, emissions, waste, and resource consumption.
- **Lack of Standardization:** Causing inconsistent reporting and difficulty in comparing environmental performance across organizations.

Conclusion

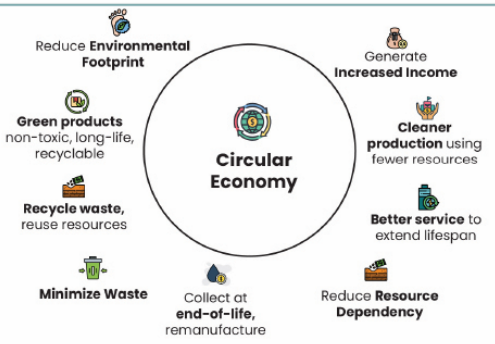
By incorporating environmental considerations into **financial decision-making**, environmental performance, cost optimisation, and sustainable growth could be achieved.

3.3. CIRCULAR ECONOMY AT A GLANCE

Circular Economy (CE)

Circular Economy Involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible causing **the life cycle of products to be extended.**

Current situation
Only 7.2 % of the global economy is circular with a declining trend (Circularity Gap report 2023)



Need of Circular Economy in India

Economic benefits
Resource circularity could save 11% of GDP by 2030 and 30% by 2050. (Economic Survey 2024-25)

Replacing Linear Economic Model
From 1970 to 2015, India witnessed a six-fold increase in its annual material consumption.

Others:
Reduce dependency on imported resources.
Increase household disposable income through lower costs for products and services.

Constraints

Require Systemic Change in how goods and services are designed, produced, consumed, and disposed.

Businesses need incentivization due to costly and time-consuming nature of transition.

Inefficiency in the waste management sector due to informal nature and lack of waste collection vehicles, sorting facilities, etc.

Downcycling i.e., Process of recycling materials into products of lower value and quality compared to the original material).

Initiatives

Regulatory measures: National Resource Efficiency Policy (NREP), 2019, Extended Producer Responsibility (EPR) etc.

Awareness campaigns: Swachh Bharat Mission, Ideas for LiFE (Lifestyle for Environment), etc.

Financial Incentives: Tax benefits, subsidies, and low-interest loans to the recycling industry.

Capacity building: Atal Innovation Mission, action plans are also formulated across 10 sectors including e-waste, lithium-ion batteries, etc.

Way Forward

Recognise and engage all stakeholders including ULBs, informal cooperatives, regulators, etc.

Encourage **decentralised governance and implementation** at municipal and panchayat levels

Encouraging **state-level data collection, monitoring, evaluation, transparency,** etc. for waste menegement

Supporting the circular economy through **public procurement policies, tax incentives, etc.**

3.4. SUSTAINABLE AGRICULTURE IN INDIA

3.4.1. NATURAL FARMING AT A GLANCE

Natural Farming

Definition
Chemical free, low-input, climate-resilient farming system based on locally available resources.

Key Components
- **Beejamrit** (cow dung, urine, etc.)
- **Jivamrit** (bio-stimulant for microorganism activity)
- **Mulching** (covering soil using live crops)
- **Whapasa** (using earthworms)
- **Plant Protection** (using biological concoctions), etc

Comparison with Natural Farming

Similarities: Both are **non-chemical systems** of farming relying on biomass management, rejuvenation of natural nutrient recycling, crop rotation and multiple cropping.

Differences

Parameter	Organic Farming	Natural Farming
Input	**Off-farm purchased organic inputs.**	No external inputs and **uses on-farm inputs.**
Soil Correction	**Need based soil correction** through natural mined minerals.	**Use of compost/ vermi compost and minerals are not allowed.**
Agro Practices	Requires practices like **plowing, tilting, mixing of manures, weeding, etc.**	**Decomposition of organic matter** by microbes and earthworm.
Cost	**More expensive** due to organic manures.	**Low cost** due to reliance on local biodiversity.

Constraints

Environmental Conservation
Encouraging local resources like Jivamrit, reduces reliance on costly fertilizers.

Ensure better health
As Natural Farming avoids synthetic chemicals, it eliminates health risks and hazards.

Improved Yield
By avoiding use of fertilizers, herbicides and pesticides.

Others
Employment generation, rejuvenating soil health, etc.

Associated Issues

Yield Uncertainty
Often produces **lower yields** with higher investments in initial phase

Input Supply Issues
- Availability of cow dung and urine for bio-fertilizers.
- Policy gaps on standards of natural inputs and lack of clear guidelines.

Others:
- Knowledge and Skill Gap. Market challenges including lack of dedicated supply chain.
- Climate change and pest issues. (E.g., Locusts).

Way Forward

Farmer Producer Organizations (FPOs)
For streamlined procurement, implementing robust supply chain, etc.

Introducing self-assessed certification systems
To authenticate natural produce

Others: Farmer Training, awareness generation, marketing support through dedicated retail outlets in urban areas, etc.

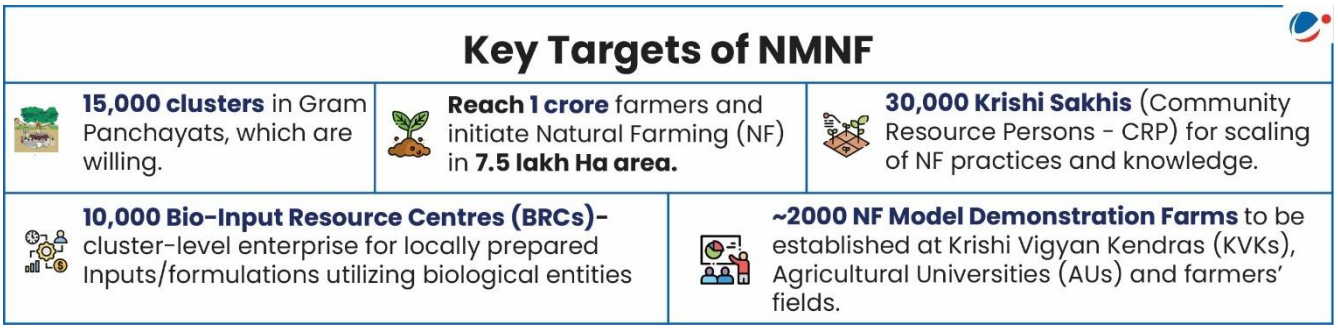
3.4.2. NATIONAL MISSION ON NATURAL FARMING (NMNF)

Why in the News?

Recently, Union Cabinet approved the launch of the **National Mission on Natural Farming (NMNF)** as a standalone **Centrally Sponsored Scheme** under **Ministry of Agriculture & Farmers' Welfare**.

About National Mission on Natural Farming

- **Type:** Centrally Sponsored Scheme
- **Tenure:** Till 2025-26
- **Ministry:** Ministry of Agriculture & Farmers' Welfare.
- **National Steering Committee (NSC):** At National level, under Chairpersonship of Minister of Agriculture & Farmers' Welfare.



Other Initiatives to promote Natural Farming

- **National Centre for Management of Agriculture Extension (MANAGE)**
- **National Centre for Organic and Natural Farming (NCONF)**
- **State level initiatives:** Prakritik Kheti Khushhal Kissan (PK3) Yojana, Himachal Pradesh, Natural farming practices under Gujarat Atma Nirbhar Package, Andhra Pradesh Community Managed Natural Farming (APCNF) model won 2024 Gulbenkian Prize for Humanity.

Conclusion

NMNF marks the shift to strengthen agriculture practices with s**cientifically backed approaches towards sustainability, climate resilience and safe food**, improving soil health, restoring ecosystems and reducing input cost to the farmers.

3.4.3. AGROFORESTRY AT A GLANCE

Agroforestry in India

Definition

Traditional and modern land-use systems that integrate trees and shrubs on farmlands and rural landscapes.	In India, it is defined for the calculation purpose as tree cover percent **greater than 10% on agricultural land.**

Types

Silvopastoral (trees and livestock)	**Silvoarable** (trees and crops)	**Hedgerows and buffer strips** (like sacred groves, Devrai in Maharashtra, Goa, etc.)	**Home gardens** (small-scale, mixed or urban)	**Forest farming**

Status in India

- **8.65% (28.42 million hectares)** of India's total geographical area covered under agroforestry.
  - **4 times** increase in demand for timber from the plywood industry alone expected by 2030.

Traditional methods of Agroforestry

Itteri system (Tamil Nadu): Cultivation of trees, shrubs, in small -linear patches.	**Khejri System (Arid North -west regions like Rajasthan):** Mainly focussing on the growth of Khejri.	**Taungya system (Kerala, West Bengal, Orissa, Karnataka, north east):** Inexpensive timber plantations.

Significance

Source of timber ~93 % of India's domestic timber is produced by trees in agroforestry plots.	**Enhance ecosystem services** Stores up to 30% more carbon than traditional agricultural systems.	**Increase forest cover** Help meet the target of increasing forest/tree cover to **33% [National Forest Policy (1988)].**	**Others: Diversified production** contributing to **food, nutritional, ecological security;** economic benefits, etc

India's approach & Initiatives taken

National Agroforestry Policy 2014: To promote agroforestry to improve productivity.	**Sub-Mission on Agroforestry (SMAF):** Under National Mission for Sustainable Agriculture (NMSA).	**GROW initiative:** By NITI Aayog to focus on transforming India's wastelands through agroforestry.	**The amendment to the Forest Act 1927 in 2017:** Redefined bamboo from a tree to grass.	Model rules for the **felling of trees on agricultural land** in a bid to promote agroforestry.

Issues related to Agroforestry growth in India

Procedural complexities: National Transit Pass System (NTPS), an online transit pass for inter-state and intra-state transportation of timber, bamboo etc. only issues transit permits and not tree feeling permits.	**Inability to utilise potential of agroforestry:** Only **17% of total agricultural land** is under agroforestry	**Import dependence:** India imported **~USD 2.7 billion worth** (12% of all agro based imports) of timber (2023).	**Others: Multiple state laws** (Agriculture, a state subject); Limited supply of high-quality planting materials; etc.

Way Forward

Arun Kumar Bansal committee on Agroforestry: Emphasized participatory approach with local communities	**Recommendations** suggested in **National Agroforestry Policy,**	
	Institutional mechanism: Institutional Setup at National level to **promote Agroforestry.**	**Easing Regulatory mechanisms:** Decentralized institutions of local governance, like Gram Sabhas, etc.

3.4.4. OTHER SUSTAINABLE AGRICULTURE PRACTICES IN NEWS

Practice	Details
Integrated Nutrient Management (INM)	• It refers to **maintenance of soil fertility and plant nutrient supply** at an optimum level for **sustaining desired productivity** • It works by optimizing **benefits from all possible sources of organic, inorganic, and biological components** in an **integrated manner.** • **Significance of INM: Enhanced soil fertility and health**; Sustainable crop production; cost effective, etc. • **Challenges of INM:** Careful decision making and nutrient management knowledge, accessibility and availability of organic inputs in remote areas, etc. • **Conclusion:** With the **right information, training, assistance, and additional research,** INM can ensure holistic and optimum nutrient supply to crops.

Regenerative Agriculture (RA)	• It is a farming system that works in **harmony with nature,** while maintaining and improving **economic viability.**
	• **Key Principles include:**
	  ○ **Minimizing soil disturbance** (minimum ploughing) keeping CO_2 in soil, and improving its water absorbency,
	  ○ **Maximizing crop diversity.**
	  ○ **Maintaining soil cover**, keeping living roots year-round, and integrating livestock.
	• **Benefits:** Reduction in soil erosion and greenhouse gas emissions.
	• **Challenges:** Significant adoption cost for small, marginal farmers, temporary yield loss initial discourages farmers, etc.
	• **Conclusion:** In order to make it viable, broader set of interventions from financial to technical capacity building is needed.

Biofloc Technology (BFT)	• BFT is a **closed, tank-based fish farming method** that utilizes beneficial microbes, called flocs, to maintain water quality. • Heterotrophic bacteria are used to convert **organic waste in the tanks into microbial biomass, which** can serve as an additional food source for fish or shrimp. • **Benefits:** Reduces the need for frequent water changes by naturally cleaning the water.
Recirculating Aquaculture Systems (RAS)	• RAS is a **closed-loop, tank-based aquaculture technique** that recycles water through advanced filtration systems. • The setup includes **automated culture tanks** equipped with mechanical and biological filtration units, ensuring efficient water use and a controlled environment for aquaculture.

Sustainable Nitrogen Management (SNM)	• SNM seeks to **minimize external nitrogen inputs and losses** and **increase recycling of nitrogen** within the production system.
	• **Recommendations for SNM:**
	  ○ **Increasing Nitrogen Use Efficiency (NUE)** through improved fertilization strategies, minimizing nitrogen excretion through manure, and integrating livestock systems with crop production.
	  > NUE is ratio of nitrogen recovered in the final output to the total Nitrogen used as input.
	  ○ **Encourage Biological Nitrogen fixation** using leguminous crops (eg. Soybean, alfalfa) in crop rotations.

3.5. MISCELLANEOUS

3.5.1. DIGITIZATION AND ENVIRONMENTAL SUSTAINABILITY

Why in the News?

Recently, **Declaration on Green Digital Action (GDA**) adopted in CoP-29 of UNFCCC.

Key Highlights of the Declaration

- **Leveraging Digital Technologies:** To support climate action **and building resilient digital infrastructure**.
- **Mitigating the impact of Digitization on climate**: Establishing metrics to measure its impact on environment.
- **Fostering Sustainable Innovation:** By facilitating investments; protecting intellectual property, etc.
- **Others:** Promoting Digital inclusion, literacy, data driven decision making, etc.

Environmental footprint of Digitalization (UN Trade and Development's Digital Economy Report 2024)

- **GHG emission:** ICT sector is estimated to have accounted for **1.5– 3.2 % of global GHG emissions** in 2020.
- **Surge in e-waste:** Increase in online shoppers has led to a 30 % rise in **digital-related waste** from 2010 to 2022, reaching 10.5 million tonnes globally.
- **Water footprints:** Data centres not only have considerable electricity needs but also require water for cooling.
    - In 2022, Global data centres alone consumed 460 terawatts hours (expected to double by 2026).
- **Ensuring supply of Critical minerals:** Demand for minerals required for digitalization like graphite, lithium, and cobalt could surge by 500 % to 2050.

Significance of Digital Technologies in Sustainable Development

- **Monitoring:** E.g., AI has been trained to **measure changes in icebergs 10,000 times faster** than a human, use of **AI for air pollution tracking** via **Global Environment Monitoring System Air Pollution Monitoring platform.**
- **Informed decision making:** Data analytics, cloud computing, etc., can optimise energy consumption.
- **Sustainable Design approaches:** Stress on **circular economy model** rather than **take-make-dispose.**
- **Promoting Open data sources:** Easily accessible information sources. Ex., **Digital Public Infrastructure, etc.**
- **Role in Disaster Management: Climate monitoring and forecasting** including **Early Warning Systems**, etc.
- **Facilitating Decarbonisation**: Helping companies to track, trace and reduce their emissions by 20-30%.
- **Collective Intelligence**: People work with the help of **technology** to mobilize a wider range of information, ideas, and insights, etc. E.g., Agrolly app for crop information, etc.

Conclusion

United Nations Environment Programme (UNEP) recommends adapting **standardized procedure, encourage companies to power data centres with energy, disclose environmental consequences** of AI based products in a bid to ensure its effective utilisation.

3.5.2. INDIAN HIMALAYAN REGION (IHR)

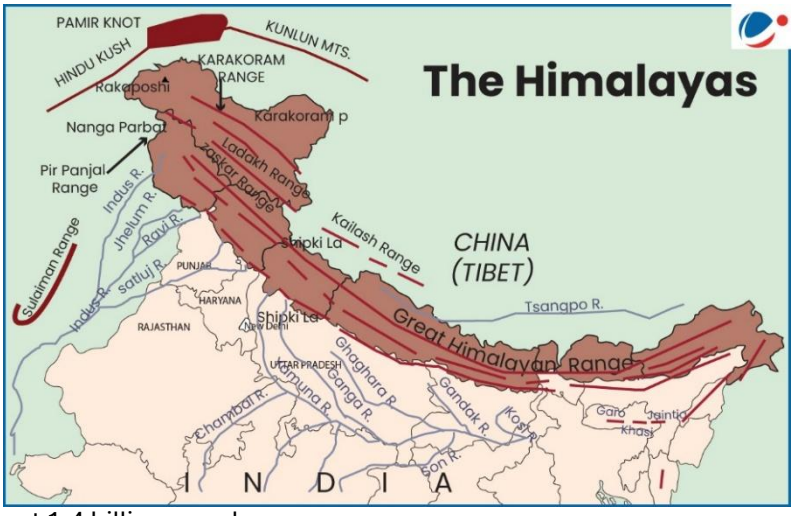
Why in the News?

Recent judgments of the Supreme Court (SC) on the new fundamental right to be free from climate change impact necessitates a sustainable development model for the **Indian Himalayan Region (IHR).**

Key Judgements for Sustainable development of IHR

- **MK Ranjitsinh vs. Union of India case (2024):** Right to be free from the adverse effects of climate change under Articles 14 and 21.

- **Ashok Kumar Raghav vs Union of India case (2023)**: SC asked the central government and the petitioner to suggest a way forward regarding **carrying capacity** of the Himalayan States/towns for sustainable development.
- **State of Telangana vs Mohd. Abdul Qasim case:** Adoption of an ecocentric view of the environment (where nature is at the core).



Importance of IHR

- **Known as a 'water tower of the earth'** with Himalayan glaciers feeding majority of rivers crucial for survival of about 1.4 billion people.
- **Prevents frigid, dry arctic winds blowing south** into the subcontinent and **acts as barrier for the monsoon winds, etc.**
- **Biodiversity Hotspots:** Himalaya Hotspot and the Indo-Burma Hotspot forms two of four Indian biodiversity hotspots with high species richness and endemism
- **Others:** Carbon sink (stores 5.4 billion tonnes of carbon); Provision of resources like **gucchi mushroom etc.**

Challenges associated with IHR

- **Deforestation and Habitat Loss**: Himalayan states reported a loss of 1,072 sq km of forest cover (2019 - 2021).
- **Accelerated Glacial Retreat and Hydrological Disruption: E.g.,** Gangotri glacier (Uttarakhand Himalaya) retreated by 1,700 metres between 1935 and 2022; expansion of Glacial lakes and GLOFs, etc.
- **Rising Tourism:** IHR records about **100 million tourists every year** with **240 million expected by 2025.**
- **Carrying capacity:** Many parts of the Indian Himalayan region have already exceeded their carrying capacity, especially in urbanized hill towns and popular tourist destinations (e.g., Joshimath, Mussoorie, Shimla).
- **Others:** Unsustainable development; Flaw in Environment Clearance System despite the region's vulnerability and fragility, etc.

Way-forward

- Establish a **"Himalayan Authority"** to coordinate integrated and holistic development of the Himalayan States.
- **"Smart Mountain Tourism Destinations"** similar to Smart Cities, introduce **'Green Cess'** (Payment for Environmental Services) based on eco-certification, etc.
- Building on best practices, (**e.g., Dhara Vikas in Sikkim** and others) for revival of springs.
- **Others:** Capacity building, Indian Himalayan Region to have its own Environment Impact Assessment (EIA).

Initiatives to Protect the Ecosystem of the Himalayan Mountain System	
India's Initiatives • **National Mission for Sustaining the Himalayan Ecosystem (NMSHE)** • **Centre for Cryosphere & Climate Change Studies** • **Sustainable Tourism & Waste Management**: Swadesh Darshan Scheme, etc.	**Global Initiatives** • **International Centre for Integrated Mountain Development (ICIMOD)** • **SECURE Himalaya Project:** Part of "Global Partnership on Wildlife Conservation and Crime Prevention for Sustainable Development" (Global Wildlife Program) funded by the Global Environment Facility (GEF).

Conclusion

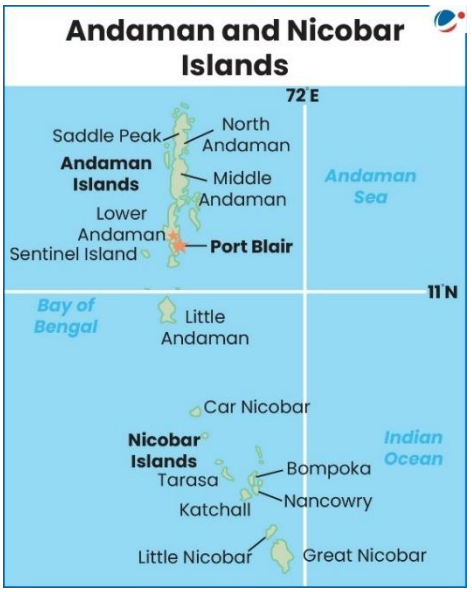
Habitat loss from land-use changes, illegal wildlife trade, forest fires, and rising anthropogenic pressures continues to threaten fragile Himalayan ecosystem, underscoring the need for stronger conservation.

3.5.3. GREAT NICOBAR ISLAND

Why in the News?

NITI Ayog prepared a Draft Report on **Social Impact Assessment (SIA)** Study for Greenfield International Airport – Great Nicobar highlighting its economic potential and environmental implications.

Concerns related to the project



- **Environmental concerns:** Loss of top soil, sewage waste generation at power plant sites, impact on mangroves on eastern flank,
- **Threat to fauna:** Artificial illumination of beaches impact sea turtles nesting and hatchlings, etc.
    - Leatherback turtle and the Nicobar megapode, species listed under **Schedule I of the Wildlife (Protection) Act, 1972,** face critical threats from this development.
- **Social:** In 2022, the Tribal Council of Great Nicobar and Little Nicobar withdrew its **No-Objection certificate (NOC)** for the project due to lack of transparency and the hasty consent process from tribal communities.
- **Health:** The **Shompen,** who have had limited contact with the outside world, remain highly vulnerable to **infectious diseases**.
- **Natural Disaster Vulnerability:** A&N are situated in a **high-risk seismic zone,** raising fears that the development could lead to catastrophic environmental consequences.

Way forward (Environmental Impact Assessment (EIA) report)

- **Protect Biodiversity** by halting construction activities during the breading seasons for leather back turtles, use of sodium vapor lights for lightings, etc.
- Implement Integrated **Solid waste management system**.
- **Policy Reforms:** Implement **Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013** for displaced people, strict measures to prevent trespaases in the shompen area, etc.

Conclusion

Great Nicobar Island has irretrievable **anthropogenic costs to biodiversity**, hence, the balance between **development and conservation** should be shaped by thoughtful policy and guided by principles reflecting **environmental responsibility** and **cultural sensitivity.**

3.5.4. ILLEGAL SAND MINING AT A GLANCE

Illegal Sand Mining

About Sand as a Resource

World's second-most exploited natural resource, after water. (UNEP)	Classified as **minor mineral** under **Mines and Minerals (Development and Regulation) Act, 1957**

Sand Mining **Removal of primary natural sand and resources** like minerals, metals **from natural environment** (Coast, land, rivers, etc.) **for extracting valuable crushed stone** etc. for subsequent processing.	**Factors responsible:** High demand in construction; organized sand mafias; lack of sustainable alternatives etc.

Consequence of Illegal Sand Mining

Flooding and Sedimentation Alters River course causing flooding, sedimentation, loss of fertile land, damage to infrastructure etc.	**Groundwater Depletion** Lowers groundwater table, affecting wells and causing water scarcity.	**Biodiversity Loss** Disrupts coastal/aquatic habitats, threatens endangered river species like gharial, otters, river dolphins etc.	**Health** **Extraction of silica sand from silica sand mines** causes silicosis (lung disease caused by inhaling crystalline silica dust) to workers.

Steps taken to tackle Illegal Sand Mining

Section 23C of MMDR Act allows **State Governments and UT Administrations** to create rules to prevent illegal mining, transportation, and storage of minerals.	**Sustainable Sand Management Guidelines (2016)** and **Enforcement & Monitoring Guidelines (2020)** focus on restoring river ecology.	**Sand Mining Framework (2018)** promotes alternatives like Manufactured Sand and sand from Overburden of coal mines.	**Mining Surveillance System** to use **space technology** for tracking and controlling illegal sand mining

Way Forward

Creation of a **national-level and state-level aggregate association** to exchange technical information and best practices similar to **Global Aggregate Information Network (GAIN).**	Development of **R&D centres** for developing **Manufactured sand, advanced sand** using air classification technology to prevent illegal mining of natural sand.	Developing a **national database** for the inventory of aggregates and sand for **effective monitoring.**	Implementing **effective governance** with coordination among different agencies through the use of latest technology like drones. **E.g., Telangana state model.**

3.6. KEYWORDS

Keywords				
Triple Planetary Crisis	Rights based approach	Circular Economy	Cumulative Environmental Impact Assessment	Gross Environment Product
Zero Budget Natural Farming	Regenerative Agriculture (RA)	Sovereign Green Bonds (SGrB)	Carrying Capacity	Water footprint

Right to Repair	Environmental Accounting	Social Impact Assessment (SIA)	Green GDP	Peace with Nature
Ecocentric approach	Ecosystem Services	Sustainable Food systems		

3.7. PRACTICE QUESTION

Answer Canvas

Analyze the socio-economic benefits of agroforestry for rural communities in India. How can government policies support its widespread adoption?

Introduction	Body Part 1	Body Part 2	Conclusion
What is Agroforestry? Examples of Traditional methods in India	Significance of Agroforestry	India's approach & Initiatives taken	Way-Forward

4. RENEWABLE ENERGY AND ALTERNATIVE ENERGY RESOURCES

4.1. RENEWABLE ENERGY IN INDIA AT A GLANCE

Renewable Energy (RE) in India

About
- It is energy derived from natural sources that are **replenished at a higher rate than they are consumed.**
- E.g. Solar Energy, Wind Energy, Geothermal Energy, Hydro Power, Ocean Energy, Bio Energy.

India's RE targets
- **Achieve 50% cumulative electric power installed** by 2030 from renewables. (INDC)
- Non-fossil fuel energy capacity of **500 GW by 2030. (Panchamrita targets)**
- **500 GW of renewable energy** installed capacity by 2030. **(Panchamrita targets)**

Current Status (Power Ministry, June 2025)
- **Installed Capacity of Renewable energy source** (Incl. Hydro): 226 GW (43.7% in total)
- **Share of different sources in total Installed Capacity:**
  - **Solar:** 23.1% (110 GW)
  - **Wind:** 10.7% (51 GW)
  - **Biomass cogeneration:** 2.1% (10 GW)
  - **Waste to Energy:** 0.1% (0.5 GW)
- **Global rankings:** India ranks **4th globally** in Renewable Energy Installed Capacity, **4th in Wind Power,** and **3rd in Solar Power** capacity. (IRENA RE Statistics 2025)

Challenges

Intermittency and discontinuous supply Wind and solar energy are intermittent because of their **dependence on environmental conditions.** **Impacts grid stability** in the absence of battery storage.	**Concentration of rare earth and critical minerals** Graphite (China, 79 %), rare earth (China, 60 %) etc.	**Increase in demand for land** E.g., Solar can need **300 times as much space as nuclear.**	**End-to-end lifecycle costs of renewable energy** Materials for solar batteries requires substantial water extraction and carbon emissions

Way Forward

Round-The-Clock (RTC) renewable energy supply contracts, which allow the internalisation of risks related to intermittency and dispatchability	**Enhance international cooperation in R&D,** especially in the domains of distributed RE	**Ensure supply chain of critical minerals** E.g., India joined **Mineral Security Partnership**	Improve **Centre-State Coordination** to identify exclusive RE zones.

4.2. JUST ENERGY TRANSITION IN INDIA AT A GLANCE

Just Energy Transition in India

Definition	Status of Just Energy Transition in India
› It is energy derived from natural sources that are **replenished at a higher rate than they are consumed.** › E.g. Solar Energy, Wind Energy, Geothermal Energy, Hydro Power, Ocean Energy, Bio Energy.	› Coal accounts for about **55% of India's commercial energy requirements** › Coal-based TPPs produce more than 70% of electricity. › **WEF Energy Transition Index (ETI):** Ranks 71st out of 118 countries (Down from 63rd in 2024)

Need for Just Transition

Energy Security	Climate Change Mitigation	Impact on Workers	Avoiding Discontent
Adoption of **diverse renewable energy sources** reduces reliance on volatile fossil fuels.	› GHG emissions must **peak before 2025** at the latest and **decline 43% by 2030.**	› ILO estimates that **24 million new green jobs** could be created **by 2030.**	› **E.g., Yellow Vest** protests in France (2018).

Challenges

Economic losses	High Costs	Energy security and accessibility	Grid Overhaul	Worker Vulnerability
› **Stranded fossil fuel assets** (i.e., no longer economically viable) could result in losses.	› E.g., India needs **› trillion dollars over next 3 decades to transition coal mining/thermal power sectors** (Just transition, Just Finance report)	› Energy demand expected to rise with vision to be **'Viksit'** or **'developed' by 2047.**	› Renewable integration is costly and needs complex grid upgrades.	E.g., in Coal-reliant regions, such as **India's Jharkhand.**

Initiatives

Indian Steps taken for Just Transition
- **Pradhan Mantri Khanij Kshetra Kalyan Yojana (PMKKKY)**
- **PLI Scheme:** National Programme on High Efficiency Solar PV Modules
- **Other initiatives:** Solar cities and parks, National Green Hydrogen Mission, and the Green Energy Corridors, etc.

Global Steps taken for Just Transition
- **Just Energy Transition Partnership (JETP):** Developed country provides support for developing country.
- **ILO Guidelines for a Just Transition**
- **'Just Transition for All' initiative:** By World Bank.

Way Forward

Explore sustainable financing through mechanisms like Just Energy Transition Partnership (JETP), green bonds, etc.	**Establish an Independent National Transition body** to oversee coal phase-out and Repurposing.	**Maintain and enhance social infrastructure,** e.g., compensation packages to formal workers engaged in low-carbon jobs.	**Develop and augment green energy infrastructure** by upgrading the transmission and distribution systems.

4.3. NUCLEAR ENERGY MISSION

Why in the News?

Union Finance Minister announced a dedicated **Nuclear Energy Mission in the Union Budget 2025-26.**

About the Nuclear Energy Mission

- **Target: To achieve 100 GW of nuclear power capacity by 2047,** aligning with its long-term energy transition strategy and broader **"Viksit Bharat"** vision.
  - **Current Status:** Installed nuclear energy capacity is **8.18 GW as of January, 2025.** The government plans to increase this to **22.48 GW by 2031-32.**
- **Aim:** Development of **small modular reactors (SMRs),** and setting up of at least 5 SMRs by **2033**.

Key Features

- **Private Sector Participation:** Proposed changes to **Atomic Energy Act, 1962,** and **Civil Liability for Nuclear Damage Act, 2010** to encourage private sector involvement in nuclear energy projects.
  - **Partnerships with private sector with motive of:** Setting up **Bharat Small Reactors (BSRs),** Research & development of **Bharat Small Modular Reactor**, and Research & development of **newer technologies** for nuclear energy.
  - **Bhabha Atomic Research Centre (BARC)** is also developing **SMRs** for **repurposing retiring coal-based power plants**.
- **Indigenous Technology Development**: Mission emphasizes development of BSRs, which are compact 220 MW Pressurized Heavy Water Reactors (PHWRs) designed **for captive use.**

Relevance of Nuclear Energy for India

- **Availability of Thorium Reserves:** India is home to one of the largest thorium deposits in the world.
- **Alternative to overcome issues in expanding RE in India:**
  - **Low waste/Pollution**: E.g., solar energy is associated with solar photovoltaic (PV) waste and extraction of critical minerals if water intensive and polluting.
  - **Limited land requirement**: E.g., Solar can need 300 times as much space as nuclear. (Economic Survey 2023)
  - **Ensure continuous supply**: Like intermittency and discontinuous supply etc.
- **Strengthening Energy Security Through Indigenous Capabilities:** E.g. Small Modular Reactors (SMRs) and BSRs.

Challenges with respect to Nuclear Energy for India (Economic Survey)

- **Public concerns about safety** and the uncertainty that the latest technologies are controlled by a few countries.
- **Geographical concentration of uranium** and other essential minerals.
- **Shortfall of Sulphuric Acid: Nuclear energy relies heavily on the stability of fossil fuel** supply chains to produce sulfuric acid for uranium extraction.
  - By 2040, estimates suggest that a **shortfall of sulphuric acid supply** could range from 100 million to 320 million tonnes.
- **Lack of a supportive ecosystem** and the monopolistic nature of nuclear fuel supply chains.

Way-Forward

- **Standardization and Licensing by regulatory frameworks** to facilitate the deployment of SMRs.
- **Consideration of Safeguards requirements** during early stages of SMR designs in close interaction with IAEA.
- **Innovative Financing Framework:** Availability of low-cost finance, green finance and incorporation of nuclear into green taxonomy.

Conclusion

With its **vast thorium reserves and strong institutional capabilities**, nuclear energy can play a crucial role in achieving India's climate goals and "Viksit Bharat" vision.

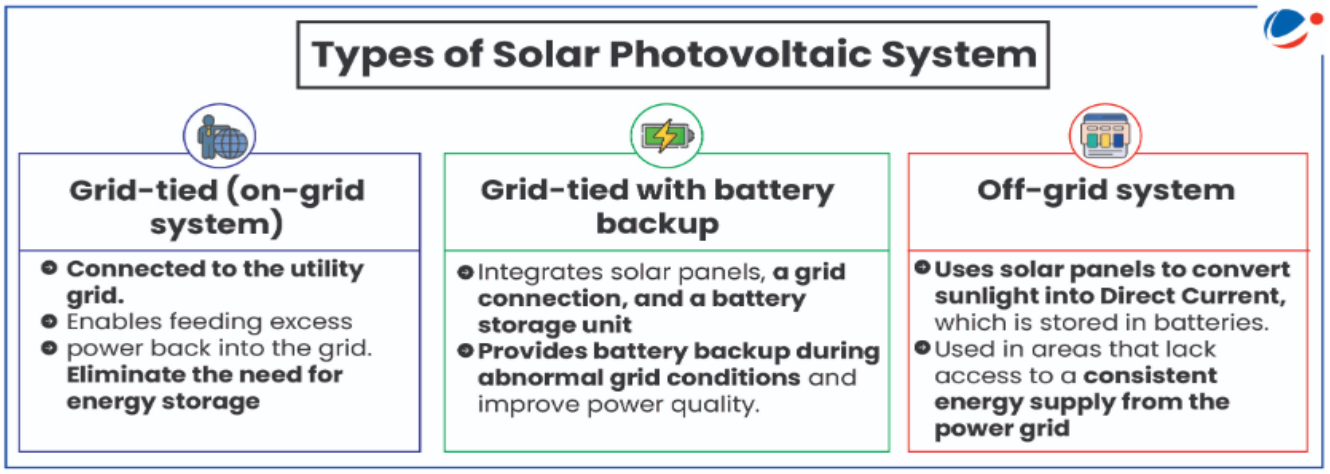
4.4. SOLAR ENERGY IN INDIA

Why in the News?

India has achieved a historic milestone by crossing **100 GW** of solar power capacity, with **PM Surya Ghar: Muft Bijli Yojana (PMSGMBY)** powering 10 lakh homes as of March 2025.

Status of solar energy in India

- India ranks **5th in Solar Power Capacity globally Installed solar energy capacity** of 110 GW (Power Ministry, June 2025)
- **Targets: Objective:** To install rooftop solar (RTS) and provide free electricity for up to 300 monthly units for 1 crore households. **(PMSGMBY)**
- **Potential in India:** 748 Giga Watt peak **(National Institute of Solar Energy).**



Significance of Solar energy in India

- **Rural Electrification through off-grid power generation** with fast capacity expansion.
- **Cost-saving**: E.g., Under PMSGMBY**,** 1 crore families are expected to **save Rs 15000 crore annually** through reduced electricity bills.
- **Grid Stability through Decentralized solar generation** by reducing reliance on central grid, minimizing transmission losses, and enabling better load management.

Factors behind growth of Solar Energy in India

- **Geographical Advantage:** Abundant solar radiation, with ~**300 sunny days per year** and **4-7 kWh/m^2/day.**
- **Financial support and encouraging investment:** India allowed 100% of foreign direct investment (FDI).
- **Indigenous manufacturing of solar components:** Through initiatives like Solar Park Scheme, Production Linked Incentive (PLI) Scheme under National Programme on High Efficiency Solar PV Modules, etc.
- **International Cooperation and Leadership:** Initiatives like International Solar alliance.

Challenges Related to Solar Energy in India

- **Land Acquisition:** Solar can need **300 times space as nuclear energy** (Economic Survey 2023-24).
- **Environmental concerns**: Extraction of minerals needed for Solar leave large **scars in landscape and require substantial water,** releasing ~15 tonnes of CO_2 per tonne of mineral. (Economic Survey 2023-24)
- **Decreasing trend in solar radiation**: Decline in the Solar photovoltaic Potential (SPV) in stations of IMD due to increase in aerosol load from carbon emissions (IMD Study)
- **High dependency on Imports:** E.g., reliance on China for components/minerals limits domestic manufacturing capacity
- **Gaps in R&D and Technology**: India lags in adoption of latest solar cell technologies (e.g. PERC (Passivated Emitter Rear Contact), bifacial, or thin-film technologies.

Initiatives taken to Promote Solar Energy

- **PM Surya Ghar Muft Bijli Yojana** to provide subsidies to install solar panels on roofs.
  - **Other key features:** Model Solar Village,Incentives to Local Bodies,National Portal, Component for payment security for Renewable Energy Service Company (RESCO), etc.
- **Grid Connected Solar Rooftop Programme** by Ministry of New & Renewable Energy to **achieve a cumulative installed capacity of 40,000 Megawatt (MW) by March 2026.**
- **Production-linked incentive scheme under National Programme on high efficiency Solar PV Modules**, aim to reduce import dependence.
- **Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM),** aims to achieve solar power capacity addition of 34.8 GW by March 2026.

Way Forward

- **Expansion of PLI Scheme** to **cover early-stage solar manufacturing** and focus on upstream solar production.
- **Increase land-use efficiency**: Promote agrivoltaics and increase development of floating solar panels.
- **Policy Simplification:** Harmonizing state and central policies can help streamline project approvals and incentivize investments.
- **Investment in R&D and advanced manufacturing technology** for a fully integrated solar supply chain.
- **Other:** Circular economy approach, **Reassessment of current import duties** on solar modules, **Collaboration with countries etc.**

Conclusion

A balanced approach, combining financial incentives, technological innovation, and international cooperation, will be crucial in making solar energy a cornerstone of India's energy security and green growth strategy.

4.4.1. INTERNATIONAL SOLAR ALLIANCE (ISA)

Why in the News?

Recently, **Paraguay** became the 100th country to join the International Solar Alliance (ISA).

About International Solar Alliance (ISA):

- It is a **treaty-based intergovernmental organization** that is an action-oriented, member-driven, collaborative platform for increased deployment of solar energy technologies.
- **Genesis:** Jointly announced by India and France in 2015 at the UN Paris Climate Change Conference **(COP-21 of the UNFCCC).**
- **Eligibility:** All UN Member States (2020 Amendment to Framework Agreement)
- **Guided by 'Towards 1000' strategy:**
  - Mobilise USD 1,000 billion of investments **in solar energy solutions by 2030**
  - Deliver energy access to 1,000 million people **using clean energy solutions**
  - Installation of **1,000 GW of solar energy capacity.**
  - Mitigate global solar emissions to the tune of **1,000 million tonnes of CO2 every year.**

Significance of ISA

- **Energy equity and justice**: Differentiated approach for High-income countries, Emerging economies, Low-income countries and SIDS.
- **Creation of a global solar energy market**: With reduced cost and collaborative development.
- **Facilitate standardised policies**: E.g. Standardised auction and Power Purchase Agreements (PPA) framework.
- **Platform for collaborative Research and Development**: In developing countries which lack the financial capability.
- **Significant shift in India's Foreign Policy**: India's global leadership in sustainability to further strategic interests. E.g. Mission LiFE.

Initiatives taken by ISA

- **One Sun One World One Grid (OSOWOG): connects different regional grids** through a common grid.
- **Solar Technology Application Resource Centre (STAR C):** for capacity-building and institutional strengthening.
- **Global Solar Facility:** to **catalyze solar investments** in underserved segments and geographies across **Africa**.
- **Development of Large-Scale Solar Power Projects** under **Solar Park** Concept in Cluster of ISA Member Countries.
- **ISA Solar Fellowship for Mid-Career Professionals** skilling of qualified professional manpower for management of solar energy projects.
- **MIGA-ISA Solar Facility:** It will combine ISA's technical expertise and MIGA's capacity to mobilise financing. Initially, **focussing on Sub-Saharan Africa**, with plans for global expansion

Challenges for ISA

- **Coordination issues among member states:** It hinders effective **implementation** of initiatives.
- **China dominates the global solar supply chain**: It is a hindrance to the achievement of **energy equity**.
- **Private sector participation**: In most developing countries, power falls under the **public sector domain** and involvement of private sector, although important for scaling, may make renewable energy **inaccessible**.
- **Other:** Issues of land acquisition and potential ecological harm & Technical challenges E.g. Grid integration.

Conclusion

Addressing **regional disparities, ensuring equitable energy access, and adopting a people-centric, inclusive approach** are key to accelerating solar adoption. The ISA plays a vital role by fostering global cooperation, mobilizing investments, and enabling technology transfer for a resilient and just energy future.

4.5. OFFSHORE WIND ENERGY IN INDIA AT A GLANCE

Offshore Wind Energy in India

Potential in India	Long-term target	Current Situation
› **36 GW and 35 GW** of offshore wind energy potential exist off the coast of **Gujarat and Tamil Nadu coast** respectively.	Addition of **30 GW** by **2030**	› **Installed capacity (June, 2025): ~51 GW** (10.7% of total installed capacity in India) › Globally, India **ranks 4th** in installed wind capacity.

Initiatives

National Offshore Wind Energy Policy – 2015 and Wind-Solar Hybrid Policy	**Declaration of trajectory for Wind Renewable Purchase Obligation** up to the year 2030.	Cabinet recently approved **Viability Gap Funding (VGF) scheme for implementation of Offshore Wind Energy Projects.**

Offshore vs. and Onshore wind energy projects

Offshore	Onshore
Pros: › **Stronger and uniform winds at sea.** › **Low number of major operational disasters.** › **No issues related to Land acquisition.** **Cons:** › Lack **dependency and predictability.** › **Tedious Transmission and distribution process.** › **High maintenance costs** due to **corrosive** effect of moisture.	**Pros:** › Cheaper with **lower infrastructure and maintenance costs.**` › **Less voltage drops** between wind turbine and consumer. › Proven **technology** and **reduced wear and tear .** **Cons:** › **Discomfort to locals** due to noise pollution. › **Reduced efficiency** due to unpredictable **wind speeds and direction.** › **Land availability and landscape** considerations.

Way Forward

Wind Resource Assessment as wind is an intermittent and site specific resource of energy.	**Maritime Spatial Planning** with expert opinion and demonstration projects to assess the viability of projects.	Discoms can **adopt FiT regulations** and make **offshore wind power procurement mandatory.**

4.6. HYDROGEN ENERGY IN INDIA AT A GLANCE

Hydrogen Energy in India

Hydrogen as Fuel
- Produces clean form of energy with Water and heat as only by-product.
- **Most common classifications: Grey** (Produced from fossil fuels), **blue** (Produced from natural gas), **and green hydrogen.**

Status
- Currently, India produces **6.5 million metric tonnes per annum (MMTPA) of hydrogen,** predominantly for use in Crude-oil refineries and fertilizer production. **(WEF)**

Benefits of Hydrogen as a fuel

Blend of H2 and **Natural gas** can be used to generate heat with lower emissions than using natural gas alone.	**Decarbonize sectors** like transportation, shipping, and steel, etc. and achieve **net zero emission by 2070.**	**Abundance and Extraction; Environmental Friendliness**	**Power and Efficiency** (3 times as powerful as gasoline)

Challenges of Hydrogen as a Fuel

High production costs of Green Hydrogen.	**Substantial energy and cost** in extraction and non-economical battery storage	**Requires huge investment** to establish a robust supply chains	**Storage and safety concerns** like flammability	**Resource scarcity:** Green Hydrogen production can require up to **9 litres of water per kilogram** of hydrogen.

Initiatives

Ministry of Steel inaugurated **India's 1st Green Hydrogen Plant** in the Stainless-Steel Sector.	GAIL has **initiated blending 2% hydrogen** in CNG networks and 5% in PNG networks in Indore.	NTPC has introduced **Hydrogen-based Fuel-Cell Electric Vehicle (FCEV)** buses in Leh.	Minister for New and Renewable Energy launched **Green Hydrogen Certification Scheme of India (GHCI).**	Indian Railway Minister announced the **development of the world's most powerful hydrogen fuel-run train engine**

Way Forward

Scaling up green hydrogen production, and fostering research and innovation will be critical.	**Developing efficient storage and distribution networks**	**Achieving economies of scale** - By **creating demand** in sectors such as transportation, industry, and power generation is essential

4.6.1. NATIONAL GREEN HYDROGEN MISSION

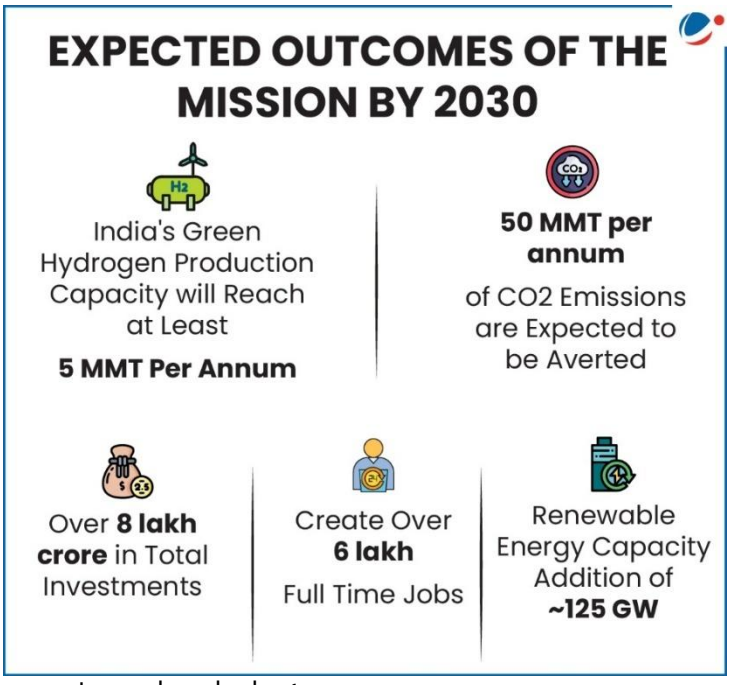
Why in the News?

MNRE has released Scheme Guidelines for funding of testing facilities, infrastructure, and institutional support for development of Standards and Regulatory framework under the **National Green Hydrogen Mission.**

About National Green Hydrogen Mission (NGHM) (2023)

- **Duration:** Phase I (2022-23 to 2025-26) and Phase II (2026-27 to 2029-30).
- **Objective:** To make India a Global Hub for production, usage and export of Green Hydrogen and its derivatives.

- **Key components:**
  - **Facilitating demand creation** through exports and domestic utilization.
  - **Strategic Interventions for Green Hydrogen Transition (SIGHT)** programme, which includes incentives for manufacturing of electrolysers and production of green hydrogen.
  - **Development of Green Hydrogen Hubs**



What is Green Hydrogen (GH_2)?

- It refers to **hydrogen produced through electrolysis,** which splits water molecules (H_2O) into hydrogen (H_2) and oxygen (O_2) using **electricity generated from renewable sources** like solar, wind, hydro etc.
- Another method of producing GH_2 is from **biomass**, which involves the gasification of biomass to produce hydrogen.
- **Applications of GH2:** Fuel Cell Electric Vehicles (FCEVs) Aviation and Maritime, Industry (Fertilizer Refinery, Steel, Transport (Road, Rail), Shipping, Power Generation.

Challenges in green hydrogen adoption

- **Economically viability:** Current cost of producing green hydrogen (**$4.10 to $7 per kg**) is still too high.
- **Difficulty in Hydrogen Storage:** Requires **high-pressure tanks** and cryogenic temperatures.
- **Resource scarcity:** Green hydrogen production can require up to **9 Liters of water per kilogram** of hydrogen.
- **Other issues:** Lack of Skill In the domain of hydrogen production; Lack of global standards on carbon intensity & safety etc.

Conclusion

Lowering production costs, providing incentives like **the PLI scheme,** ensuring **adequate financing,** and establishing an expert-led PMU are essential to advancing green hydrogen in India. With strategic investments and strong policy support, India can harness green hydrogen to decarbonize industries, boost energy security, and promote sustainable growth.

4.7. BIOFUELS IN INDIA AT A GLANCE

Biofuels in India

Definition

- Biofuels are used in place of or in blend with, **diesel, petrol for** applications like **transportation** etc. This includes Ethanol, **Compressed Bio Gas (CBG) etc**

BIOFUELS

First Generation (Edible biomass)
- Sugar beet
- Sugar cane
- Wheat
- Corn
- Oil crops

Second Generation (Non-Edible biomass)
- Wood
- Grass
- Straw
- Waste

Third Generation (Algal biomass)
- Macroalgae
- Microalgae

Fourth Generation (Breakthrough)
- Pyrolysis
- Solar to fuel
- Genetically modified organisms

Potential

- **28 GW** through Surplus biomass availability in India.
- **~ 14 GW** additional power through bagasse based cogeneration in Sugar mills.
- **Key driving factor:** Annual Biomass production in the Country is around 750 MMT

Current Installed capacity:
Biomass cogeneration: 10 GW (Power Ministry, June 2025)

Significance of Biofuels

Replacing natural gas with biogas and biomethane incrementally to 20% would help India cut natural gas import bills by **US$29 billion between 2025- 2030.**	**Biofuels can reduce well-to-wheel emissions by up to 80%** compared to their fossil fuel counterparts.	**Enables circular Economy by employing waste** (e.g., Municipal Solid Waste Management)	**Biofuel production also generates by-products** with widespread industrial applications. **E.g., Crude glycerine,** obtained from the production of biodiesel

Challenges in Biofuel adoption

Investments of at least **USD100-270 billion** in biofuels by **2030** to meet the targets outlined in current policies	Use of **major crops** to produce more biofuels will negatively impact **India's food security.**	Converting pastures into maize fields may increase **runoff of excess nitrogen and phosphorous** into surface and groundwater.	Biofuels have **less energy density than** fossil fuels, requiring **greater volume** to offer equal power output.

Initiatives

National Policy on Biofuels, 2018: promote the production of CBG and other bio-fuels.	**Pradhan Mantri JI-VAN Yojana (2019):** Promotes latest advancements in 2G ethanol capacity.	**Global Biofuels Alliance (2023):** India-led initiative to promote biofuel production.	**National Biofuels Coordination Committee** set up 1% and 2% Sustainable Aviation Fuel initial indicative blending targets for International flights	**Mandatory blending of Compressed Bio-Gas (CBG)** in CNG (Transport) & PNG (Domestic) segments of City Gas Distribution (CGD) Sector.

Way Forward by Institute for Energy Economics and Financial Analysis (IEEFA)

Increasing Market Viability through Targeted Subsidies and Investments	**Feedstock mapping** and aligning them with biogas plants	Encourage private sector participation	**Increased access to finance** at more affordable rates, etc.

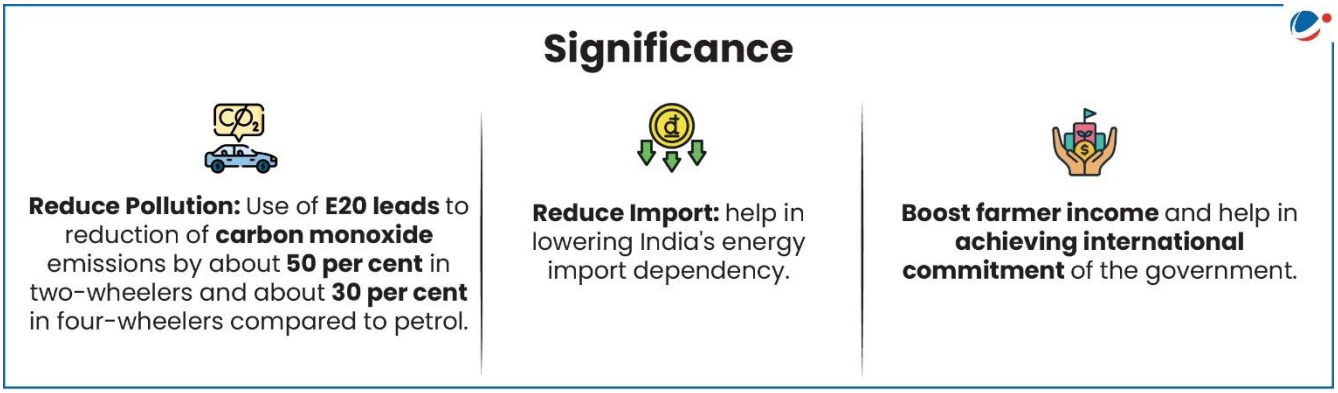
4.7.1. ETHANOL BLENDING

Why in the News?

India is gearing up to set a new target of **30% ethanol blending** in petrol by 2030, having already achieved a 20% blend **(March 2025).**

What is Ethanol Blending?

- It involves a **blended motor fuel containing ethyl alcohol** that is at least 99% pure, derived from agricultural products
  - **Ethanol is a biofuel** naturally produced by the **fermentation of sugars by yeasts** or via **petrochemical processes such as ethylene hydration.**
- **Key Targets:** Targets of **20% ethanol blending in petrol** by 2025 (Updated) and **5% biodiesel blending** in diesel by 2030. (National Policy on Biofuels, 2018 and Ethanol blending Program (EBP))



Challenges in Ethanol Blending

- **Producers:** Availability of feedstock, weather related issues
- **Oil Marketing Companies:** Need for additional storage tanks, logistics cost and emissions
- **Vehicle manufacturers:** Optimization of engine for higher blends, conduct of durability studies on engines and field trials

Initiatives launched for Ethanol Blending

- **Reduced GST** (from 18 to 5%) on ethanol under EBP.
- **PM JI-VAN YOJANA** for setting up **second-generation (2G) ethanol projects.**
- **Flexi-fuel engines** and components included under PLI scheme.
- **Amendment of Industries (Development & Regulation) Act,** 1951 to ensure free movement of ethanol in the country.

Way Forward:

- Ensure **uniform availability of ethanol blends** across India.
- Augmenting **infrastructure of Oil marketing companies.**
- **Providing tax incentive** to absorb R&D cost on E20 compatible design, etc.
- Encouraging use of **water saving crops** to produce ethanol**. E.g. Maize**
- Production from **non-food feedstock** to prevent tradeoff with food security
- **Clustering of ethanol distilleries**, Supplied from surplus to deficit states

Conclusion

Ethanol Blending has significantly enhanced foreign exchange savings, reduced carbon emissions, and supported sugar industries. It plays a vital role in promoting energy security, environmental sustainability, and rural economic stability.

4.8. METHANOL ECONOMY AT A GLANCE

Methanol Economy

Methanol (CH_3OH)

- **A low carbon, hydrogen carrier fuel** (colorless, flammable liquid) with a distinctive **odour similar to ethanol (drinking alcohol).**
- **Production:**
  - **Fossil fuel sources such as natural gas, coal, and oil.**
  - e-methanol produced from renewable sources such as recycled **CO_2, biogas, biomass, sewage sludge etc.**

Benefits of Methanol Economy

Lower energy demand and cost of production of methanol as compared to conventional processes.	**Reduce India's dependence on oil imports and** curbs pollution from electricity sector	**Transported more efficiently than hydrogen** (less flammable than hydrogen).

Challenges for Methanol Economy

Limited domestic natural gas resources and reliance on imported methanol.	**Lack of infrastructure** for production and distribution.	**Potential public safety concerns** related to its flammability and toxicity.	Additionally, **lower energy density of methanol** compared to conventional fuels.

Steps taken for Methanol Economy

World's First CO_2 to Methanol Plant launched by NTPC at Vindhyachal	**Bureau of Indian Standards has notified 20% DME blending with LPG**	**NITI Aayog's 'Methanol Economy' programme** is aimed at converting coal reserves and municipal solid waste into methanol.	**Notification for M-15, M-85, M-100 blends** has been issued by the Ministry of Road, Transport and Highways.

Way Forward

Focusing on Green methanol or E- methanol for Decarbonization and emission reduction.	Formulating **government policies** and **regulatory frameworks.**	**Expanding the use of methanol** across various energy applications.

4.9. GEOTHERMAL ENERGY IN INDIA AT A GLANCE

Why in the news?

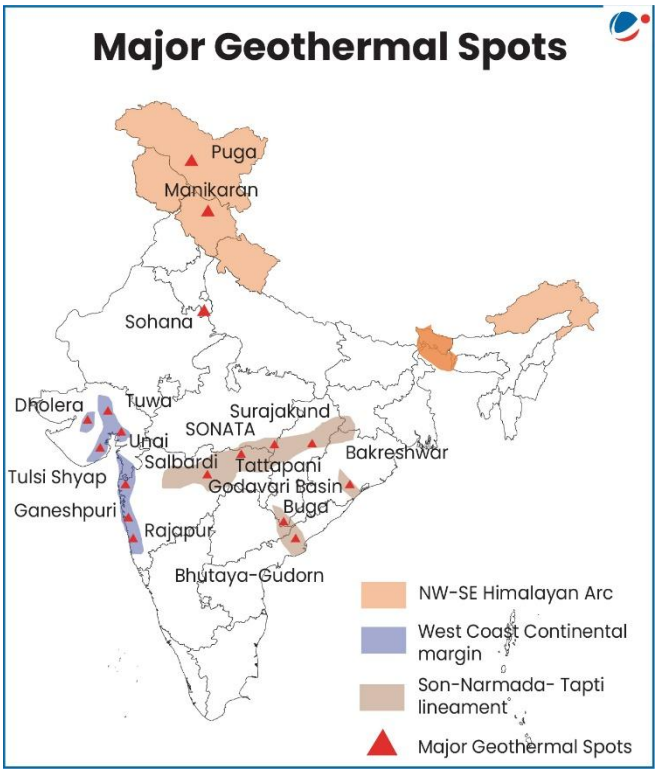
India has identified a potential of approximately **10,600 MW of geothermal power**, according to the Geological Survey of India's (GSI) report titled "Geothermal Atlas of India, 2022'.

About Geothermal Energy

- **Heat energy** from the earth**—geo (earth) + thermal (heat).**
- Geothermal technology extracts heat for **converting it into electricity.**
- This internal heat/thermal energy is generated from **radioactive decay and continual heat loss from earth's formation.**

Potential in India

- **Around 300 geothermal hot springs** exist in India (Geological Survey of India).
- **Puga and Chumathang in eastern Ladakh** are the **most promising** geothermal sites.
- **Advantages: Clean & inexpensive** renewable energy and Ability to **operate year-round** at high capacity factors.
- **Disadvantages/issues**
  - **Possible land subsidence, high transportation charges** (Due to remote plant location).
  - **Possible release of toxic chemicals** e.g. mercury, arsenic, boron, and antimony.
  - **Other Issues:** Higher capital costs, techno-economic viability issue due to remote location



Initiatives in India

- **Renewable Energy Research & Technology Development Programme (RE-RTD)**
- **100% financial support by MNRE to government**/non-profit research organizations and up to 70% to industry, startups etc.
- **Singareni Collieries Company limited (SCCL)** has commissioned a 20 kW pilot geothermal power plant in Manuguru.

Conlsuion

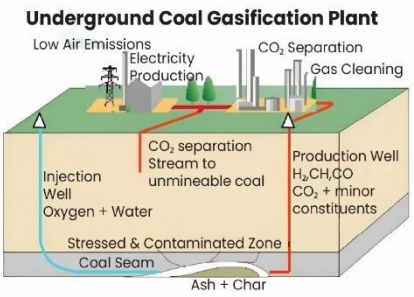
Advancing geothermal energy in India requires **detailed geological mapping, increased R&D incentives for cost-effective extraction technologie**s, and **investment in infrastructure** for efficient power distribution.

4.10. UNDERGROUND COAL GASIFICATION (UCG) AT A GLANCE

Underground Coal Gasification (UCG)

Definition

- **Energy manufacturing process** whereby coal is gasified or chemically converted into synthesis gas (syngas) in its **original coal seam.**
- Typically a mixture of **methane (CH4), carbon dioxide (CO2), hydrogen (H2)** and **carbon monoxide (CO).**
- Done by **injecting steam and air/oxygen** into the seam requiring temperatures over **1000°C.**



Products of UCG: Electricity; Chemical Feedstock to produce methanol, hydrogen, ammonia, etc.;

Targets - National Coal Gasification Mission: Coal gasification and liquefaction of **100 MT of coal by 2030.**

Benefits of UCG

Reduced capital expenditure	Energy Density	Other benefits
Does not require several **expensive process** units like in surface gasification complex.	Needs less than 3% of the land area required by Coal Bed Methane to produce the same amount of gas energy.	› **Access to unmineable coal** › **Reduce dependence on imports** › **Limited environmental impacts** › Potential of **recovering heating value** from high ash coal.

Challenges to UCG

Induced Subsidence:	Contamination of Groundwater:	Lack of proven Technology:	High technology cost	Unsteady-state process dependent
Deforming both the remaining coal and surrounding rocks.	Due to Chemicals formed like phenols, benzene, carbon dioxide, etc.	For conversion of coal to syngas.	affects Syngas & downstream products costs & Project viability.	on a number of parameters, like growth of the cavity, inherent variation in the properties of the coal along the seam, ash layer build-up, etc.

Initiatives

Scheme for promotion of Coal/Lignite Gasification:	Joint venture agreement (JVA):	Policy framework (2015) for development of UCG in coal and lignite bearing areas	
Financial assistance by PSUs and the Private Sector.	Setting up of **pilot ammonium nitrate plant using coal gasification (SCG)** through JVA such as CIL and BHEL in Jharkhand.	approved by Ministry of Coal.	Ministry of Coal launched an **Underground Coal Gasification pilot project in Jharkhand's** Jamtara District.

4.11. KEYWORDS

Keywords				
Just Energy Transition	Net Zero	Ethanol Blending	Bioeconomy	Renewable Purchase Obligations (RPOs)
Energy Security	Bharat Small Modular Reactor	Intermittency and discontinuous supply	Goal 7: Affordable and clean energy	Viksit Bharat 2047

Phasing out of coal	Critical Minerals	Fuel cell	Energy Storage Systems	One Sun One World One Grid (OSOWOG)
Grid Stability	Flex-fuel vehicles (FFVs)			

4.12. PRACTICE QUESTION

Answer Canvas

Explain the concept of Green Hydrogen and its significance in the context of India's energy transition. What are the key challenges in scaling up its production and adoption?

Introduction	Body Part 1	Body Part 2	Conclusion
Concept of Green Hydrogen	Benefits of Hydrogen as fuel	Challenges in Scaling up Green Hydrogen Production and Adoption	Way-Forward

5. CONSERVATION EFFORTS

5.1. INTERNATIONAL TREATIES AND CONVENTIONS

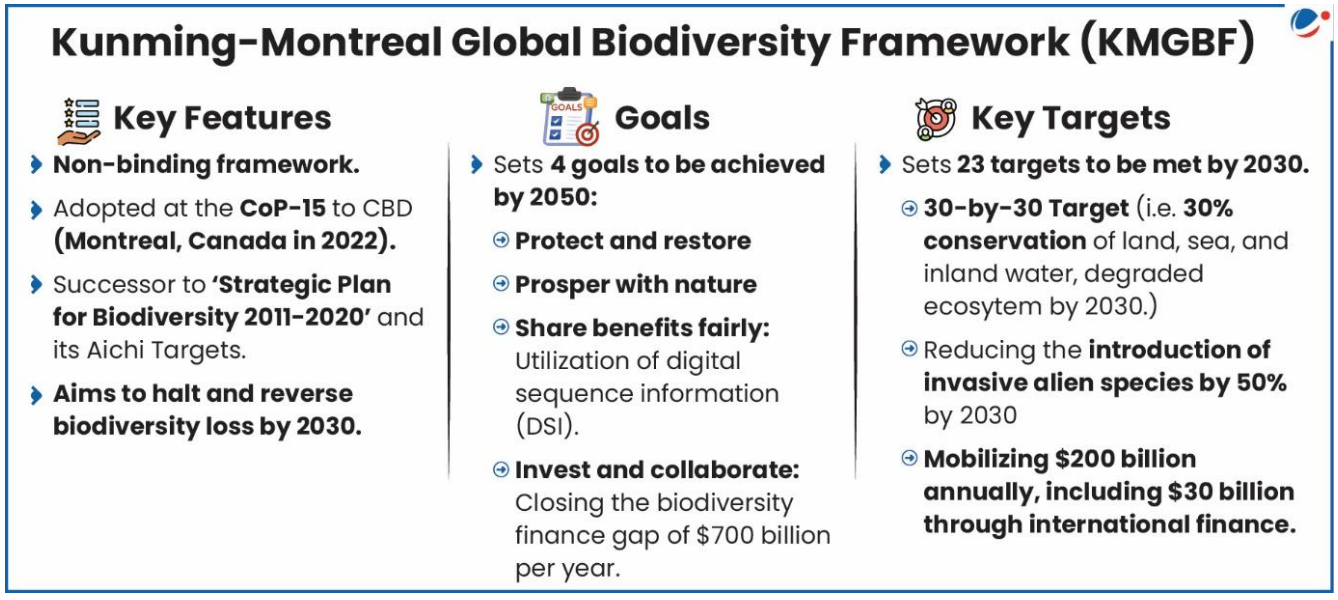
5.1.1. COP-16 TO THE UNCBD

Why in the News?

Recently, **16th Conference of Parties** (CoP-16) to the **UN Convention on Biological Diversity** (UNCBD) concluded in **Cali**, **Colombia** with the theme **"Peace with Nature".**

Major Outcomes of CoP-16

- **Operationalisation of Cali Fund** for sharing benefits in fair and equitable way.
- **Companies benefiting commercially** from Digital Sequence Information (DSI) to **contribute 1% of their profit** (0.1% of their revenues) to support Indigenous Peoples and local communities.
  - DSI is a policy term referring to **genomic sequence data** and other related digital data of organisms for research in agriculture, pharmaceuticals, biodiversity conservation etc.
- **Recognition of rights of indigenous communities**: Through establishment of **permanent subsidiary body** under **Article 8(j) of the UNCBD** and **Cali Fund.**
- **Launch of Kunming Biodiversity Fund (KBF)** under **Global Environment Facility** (GEF) to support the goals and targets under KMGBF.
- **Identification of Ecologically or Biologically Significant Marine Areas (EBSAs),** crucial for **30-by-30 Target under Kunming-Montreal Global Biodiversity Framework** (**KMGBF**) and **Biodiversity Beyond National Jurisdiction** (BBNJ) **Agreement** (High Seas Treaty).
- **Others: Thematic Action Plan** to address inequalities in capacity building, etc., in the field of **synthetic biology,** management of invasive alien species, global action plan on biodiversity and health embracing one health approach, etc.



Shortcomings of CoP-16

- **Developed countries lagged on their commitment to provide $20 billion annually** in international biodiversity financing **by 2025**.
  - Also, **pledges to GBFF were meagre** with **only $163 million** pledged during COP-16.
- **Only 44 countries out of 196 member states submitted their updated National Biodiversity Strategy and Action Plan (NBSAP)** aligned with KMGBF.

- **Lack of consensus on contributions** to Cali Fund (DSI Fund) and mechanisms for resource allocation.
- **Disagreements over biodiversity credits and offsets.**
- **Others:** No decision on updating and completing the **monitoring framework** under KMGBF; delay in **Planning, Monitoring, Reporting, and Review (PMRR)** mechanisms, etc.

About UN Convention on Biological Diversity (UNCBD)

- **Origin:** International **legally binding treaty adopted** at the **United Nation's Conference on Environment and Development** (UNCED), **Earth Summit**, Rio de Janeiro, Brazil in **1992.**
- Enforced in **1993** and **operates under United Nations Environment Programme** (UNEP).
- **Objectives**
  - **Conservation** of biological diversity
  - **Sustainable use** of its components
  - **Fair and equitable sharing** of the benefits arising out of the utilization of genetic resources
- **Protocols/Targets under UNCBD**
  - **Cartagena Protocol on Biosafety** (safe handling, transport and use of Living Modified Organisms).
  - **Nagoya-Kuala Lumpur Supplementary Protocol; Nagoya Protocol on Access and Benefit Sharing.**
- **Aichi Biodiversity Targets** (20 targets under 5 goals) under **Strategic Plan for Biodiversity 2011-2020.**

Conclusion

The roadmap for CoP-17 at Yerevan, Armenia, in 2026, lies in **solidifying financial mechanisms under KMGBF's Target 19** at the **next interim meeting** in **Bangkok**; **strengthening Monitoring Frameworks and PMRR mechanisms** for accountability; and **enhancing NBSAPs with time-bound action plans mirroring NDCs** under Paris agreement.

5.1.2. NATIONAL BIODIVERSITY STRATEGY AND ACTION PLAN (NBSAP)

Why in the News?

India unveiled its **updated National Biodiversity Strategy and Action Plan (NBSAP) for 2024-30** at CoP-16 to the **UN Convention on Biological Diversity (UNCBD)**.

About NBSAP

- Required by **every party** under **Article 6 of the UNCBD** as a primary tool for **mainstreaming biodiversity and implementing UNCBD** at the country level.
- India's **first NBSAP** was created in 1999; later **National Biodiversity Action Plan** was adopted in **2008**, updated in **2014** to align with **Aichi Biodiversity Targets.**

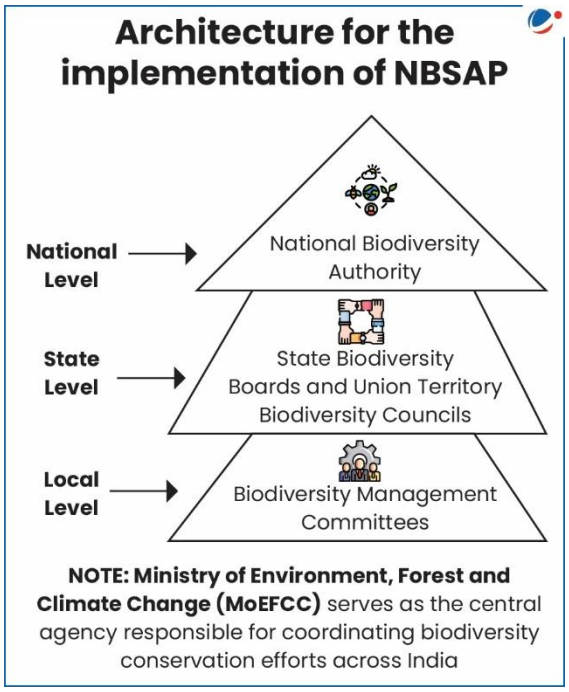
Key highlights of the updated NBSAP 2024-30

- **Approach**: **'Whole of Government' and 'Whole of Society'** approach aligning with KMGBF.
- **National Biodiversity Targets (NBTs)**: **23 NBTs** focused on **3 themes** – reducing threats to biodiversity; ensuring sustainable use of resources; and enhancing tools for implementation.
- **Implementation**: Ministry of Environment, Forest and Climate Change (**MoEFCC**) as the central agency
  - **Biological Diversity Act, 2002 provides for a multi-tier governance structure** (refer infographic).
- **Resource mobilization**: Through **implementation of Biodiversity Finance Initiative (BIOFIN)** at national level.
  - **BIOFIN** is a global partnership launched by **UNDP and the European Commission**.
- **Other features**: Emphasized upon adoption of **transformative approach focusing on ecosystem-management based bottoms-up approach** for implementing and mainstreaming biodiversity, capacity building, etc.

Significance

- **Transformative approach:** Focusing on an **ecosystem-based management approach**.

- **Acknowledges environmental challenges**: Outlines strategies to address them through ecosystem restoration
- **Offers Key insights:** On the **current status of biodiversity** and its trends, existing policy and institutional framework, biodiversity expenditure, and potential biodiversity finance solutions.
- **Robust Implementation:** Through bottom-up approach, mainstreaming biodiversity, sectoral integration, and inter-agency cooperation.



Other Initiatives for Protecting Biological Diversity

- **Biological Diversity Rules, 2004:** Outlining the key functions of National Biodiversity Authority (NBA) dealing with granting approval for biodiversity related agreements, protection intellectual property, etc.
- **State Level: Arunachal Pradesh** released first State Biodiversity Strategy and Action Plan **to include district-level action plans** aligning with **NBSAP** and **KMGBF.**

Conclusion

India's **updated NBSAP adopts a comprehensive approach to biodiversity conservation**, integrating traditional practices with modern governance & collaborative strategies while addressing contemporary environmental challenges.

5.1.3. HIGH SEAS TREATY

Why in the news?

Union Cabinet has approved **India to sign** the Biodiversity Beyond National Jurisdiction (BBNJ) Agreement, also known as the **High Seas Treaty**. The **Ministry of Earth Sciences** will spearhead its implementation.

What are High Seas?

- Areas **outside the national jurisdiction** of any country (**National jurisdictions extends up to 200 nautical miles** (370 km) from coastline, called **Exclusive Economic Zone (EEZ)**).
- **Constitute about 64%, (two-thirds)**, of the total ocean area and are considered **global commons** (belonging to no one, everyone enjoys equal rights for navigation, overflight, scientific research, etc.).

BBNJ Agreement

- Formally called the **Agreement on Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction**.
- International treaty under the **United Nations Convention on the Law of the Sea (UNCLOS).**
  - On entering into force, BBNJ will be the **third implementation agreement** under UNCLOS, alongside its sister implementation agreements:
    - **1994 Part XI Implementation Agreement** (for exploration/ extraction of mineral resources).
    - **1995 UN Fish Stocks Agreement** (conservation and management of highly migratory fish stocks).
- **Adoption:** 2023 and is **open for signature** for two years, will be internationally legally binding 120 days after ratification by 60 countries.
- **Key Guiding Principles:** Polluter Pays, Common Heritage of Humankind; Freedom of Marine Scientific Research; Equity and Fair and Equitable Sharing of Benefits; etc.

Key Provisions of BBNJ Agreement

- **Scope of application:** To Areas Beyond National Jurisdiction (ABNJ), including high seas (excludes warship, military aircraft, or naval auxiliary).

- **Institutional Arrangement:**
  - **Conference of Parties (COP):** Main decision-making body.
  - **Scientific and Technical Body (STB)**
  - **Clearing-House Mechanism (CHM):** To access, information on its **substantive elements**.
- **Financial Mechanism:** Voluntary Trust Fund; Special Trust Fund; Global Facility Fund, etc.
- **Four Substantive Elements of BBNJ Treaty**
  - **Marine Genetic Resources (MGR):** Mechanism for **fair and equitable sharing of benefits** associated with MGRs and associated Digital Sequence Information (DSI) including traditional knowledge.
  - **Measures like Area-Based Management Tools (ABMT),** including Marine Protected Areas.
  - **Environmental Impact Assessments (EIAs)**
  - **Capacity-Building and the Transfer of Marine Technology**

Significance of BBNJ Agreement

- **Equitable economic order:** Realize a just and equitable international economic order taking into account the interests of developing States, whether coastal or landlocked.
- **Significance for India: Strategic expansion** of India in areas **beyond our EEZ (Exclusive Economic Zone), resource benefits,** etc.
- **Others:** Biodiversity conservation; mitigate impacts of climate change; promotion of traditional knowledge.

About UN Convention on Laws of the Seas (UNCLOS)

- Adopted in **1982** and enforced in **1994.**
- Almost **universal acceptance** (170 State Parties including India)
- **Features**
  - International law that defines the rights and duties of nations regarding activities in the oceans
  - **Establishes International Seabed Authority (ISA) to regulate mining and related activities on the ocean floor beyond national jurisdiction.**
- **Territorial Demarcation**
  - **Territorial Sea:** Extends up to **12 nautical miles (nm)** from shore with full sovereignty on coastal States.
  - **Contiguous Zone:** Extends up to **24 nm**; acts as a buffer zone.
  - **Exclusive Economic Zone (EEZ):** Extends up to **200 nm,** sovereign rights for exploitation and conservation of marine resources.
  - **High Sea:** Outside the jurisdiction of any state.

Conclusion

The agreement will play a crucial role in achieving the recent ambitious **"30x30" initiative to protect 30% of marine ecosystems by 2030.**

5.1.4. ANTARCTIC TREATY

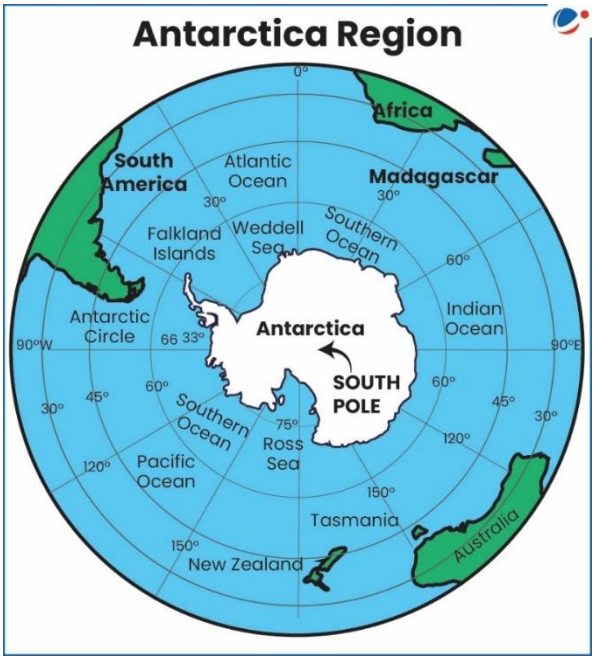
Why in the News?

Recently, **46th Antarctic Treaty Consultative Meeting (ATCM)** and **26th Committee on Environmental Protection (CEP)** hosted by the **National Centre for Polar and Ocean Research, Ministry of Earth Sciences** concluded.

About Antarctic Treaty

- **Genesis:** Signed in Washington, in **1959** by **12 countries** & enforced in **1961**.
- **Members:** 57 out of which 29 are **consultative parties** (participate in the decision-making).
  - **India has been a Consultative Party** since 1983.
- **Applicability:** Area south of 60° South latitude.

- **Key provisions:** Antarctica to be used for **peaceful purposes only; Facilitate international scientific cooperation in Antarctica; Prohibit nuclear explosions, radioactive waste disposal, and military deployments** in Antarctica.
- **Related Agreements**
  - **Protocol on Environmental Protection to the Antarctic Treaty (1991):** Designates Antarctica as a natural reserve.
  - **Convention for the Conservation of Antarctic Seals (1972):** For rational use of Antarctic seals.
  - **Convention on the Conservation of Antarctic Marine Living Resources (1980):** Conservation and rational use of krill, fin, fish, etc.



About Antarctica Region

- Comprises the area **south of 60 degrees South Latitude**, where **thick ice covers about 98% of the land.**
- Contains the **Largest international Marine Protected Area** i.e., **Antarctica's Ross Sea.**
- **Significance of the region:** Regulation of Global Climate; Slows Global Heating; Drives Important Ocean Currents; Drawdown millions of tons of CO_2 from the atmosphere.

Threats to the Region

- **Melting of Floating ice shelves:** Raising concerns about **sudden, uncontrollable sea level rise**.
- **Warming:** Average summer temperatures increasing by over 3°C between 1970 and 2020.
- **Impact on Biodiversity:** Warmer and more acidic than southern oceans due to increased absorption of CO_2 which disrupts marine ecosystems and food chains.
- **Human Impact:** Pollution, habitat disturbance, introduction of non-native species
- **Overfishing**: Collapse of krill and fish stocks, food web destabilization

India's initiatives for Antarctica

- India's first Antarctic research station was **Dakshin Gangotri** (1983).
  - India currently operates two research stations- **Maitri** (1989) and **Bharati** (2012).
  - **In ATCM- 46** India announced a plan to set up an **Antarctic research station, Maitri-II.**
- In 2022, India enacted the **Indian Antarctic Act**, 2022 reaffirming its commitment to the Antarctic Treaty.

Conclusion

The Treaty System is an example of peaceful cooperation, and is considered as one of the **most successful international agreements** to ensure the **ongoing protection** of an undisturbed continent.

5.2. FOREST AND WILDLIFE CONSERVATION

5.2.1. FOREST CONSERVATION IN INDIA AT A GLANCE

Forest Conservation

Status of Forests in India

Total forest and tree cover is 25.17% of the geographical area (increase from 24.62% in 2021) (India State of Forest Report 2023)

India ranked 3rd for average **annual net gain in forest area** from 2010- 2020. (State of World's Forests Report 2024)

Target

Green India Mission to **increase Forest/Tree Cover by 5 mha** and **improve** its quality on another **5 mha of forest/non-forest lands**.

Importance of Forests

Carbon sink
~24,000 mt of CO_2 has a worth of $120 billion, indicating financial wealth of forest.

Shields against extreme weather conditions Such as storms and floods, e.g., Mangroves and coastal forests.

Livelihood Support
Non-Timber Forest Products support livelihoods of about **275 million people** in India. (State of World's Forests Report 2024)

Others
Habitat for large number of flora and fauna species, shield against extreme weather conditions, etc.

Threats to Forests

Deforestation
India **Lost 3.3% of tree cover** due to deforestation from 2001 to 2022. **(Global Forest Watch)**

Plantations vs forests
Lakshadweep has **largest relative plantation area** at **76%.**

Climate Change
Fuels extreme heat thereby increasing wildfires.

Initiatives

India
- **Forest Conservation (Amendment) Act, 2023.**
- **Accredited Compensatory Afforestation.**
- **T.N. Godavarman judgment:** SC expanded the definition of **"forest"** to include all areas **recorded as "forest" in any government** (Union and State) record, etc.

- **REDD+ mechanism:** To **Reduce emissions from deforestation and forest degradation** adopted at UNFCCC COP13.
- **Bonn Challenge**
  EU's Nature Restoration Plan to recover atleast **20%** of EU's land and sea areas by **2030** and all by 2050.
  2030 Global Forest Vision (GFV)

Way Forward

Forest ecosystem restoration through **rehabilitation, reclamation, replacement, etc.**

Miyawaki Method of reforestation that deals with the regeneration of a forest suited for a specified locality.

Best Practices like Forest Environment Tax by Japan, Congo Basin Forest Partnership, etc.

Others: Rights based approach; balancing conservation with economic imperatives, etc.

5.2.2. ECOLOGICALLY SENSITIVE ZONES (ESZS) AT A GLANCE

Ecologically Sensitive Areas

Definition	E.g.,
Ecologically important and fragile areas around protected areas notified by central government under the **Environment (Protection) Act, 1986.**	Doon Valley, Bhagirathi, Western Ghats, Matheran, Mount Abu, etc.

Category of activities allowed (ESZ Guidelines)

Prohibited:	Regulated:	Permitted:
Commercial Mining, Setting of industries causing pollution, etc.	Felling of Trees, Establishment of hotels and resorts, etc.	Ongoing agriculture and horticulture practices by local communities, dairy farming, etc

Significance of ESZs

"Shock Absorber" for specialized ecosystems, such as Protected Areas or other natural sites.	"**Transition Zone**" from areas of high protection to areas involving lesser protection.	**Site-specific conservation** relating to regulation, rather than prohibition of specific activities

Challenges

Trade-off between ecological objectives and ease of doing business, especially in areas where development activities are taking place in proximity to these areas.	**Lack of information with the stakeholders** about the policy and its objectives and modalities of implementation.	**Limited Public Consultation** causing confrontation with the public and authorities.

Way Forward

Functional interface with local self-governments, namely, panchayats (three tiers) or urban local bodies, etc.	**Appropriate communication** with the public on the regulations and mutual consultations with the neighboring states.	**Dedicated budget allocation** for ESZ management.

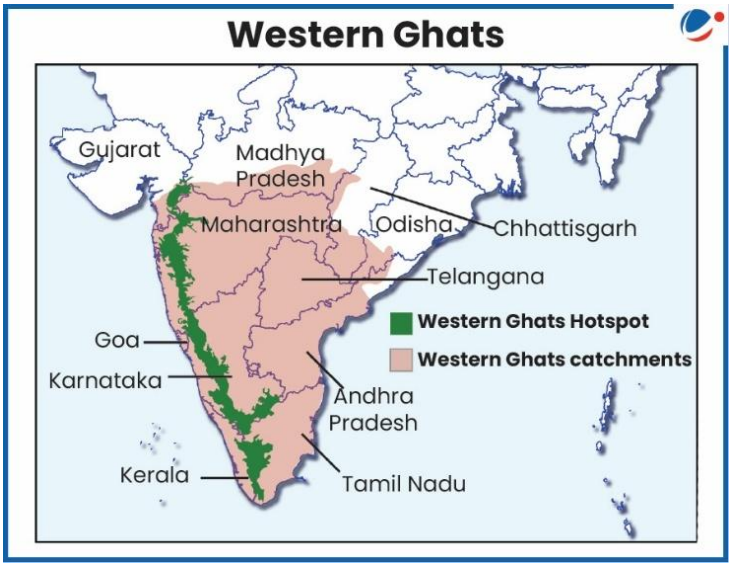
5.2.2.1. WESTERN GHATS

Why in the News?

The Karnataka government has **rejected the Kasturirangan committee report** on the protection of the fragile Western Ghats region from environmental degradation.

More on the News

- The **Kasturirangan committee** proposed 37% of the total Western Ghats area, roughly **60,000 square kilometres,** to be declared as **Eco-sensitive Area (ESA).**
- In June, **Karnataka, Maharashtra and Goa,** where the Centre proposed ESAs sought a reduction in its extent.



- Further, Ministry of Environment, Forests and Climate Change (MoEF&CC) issued a draft notification on the western ghats as an ESZ to protect the rich biodiversity.

Significance of the Western Ghats

- **One of the world's eight 'hottest hotspots'** of biological diversity and declared in **2012** by UNESCO.
  - **50% of India's amphibians and 67% of fish species are endemic** to this region, e.g., Nilgiri Tahr.
- **Caters to water needs of ~245 million people** in the peninsular areas.
- **~63% of India's woody evergreen taxa and numerous medicinal plants are endemic.**
- **Rich in iron, manganese and bauxite** ores in parts of the ranges.

Threats and Issues in Western Ghats

- **Anthropogenic impacts**: Urbanisation, agricultural expansion, Tourism activities, etc.
- **Global warming:** Including **climate change induced disasters**; risk to peninsular rivers, etc.
- **Issues with Implementing Committee Recommendations:** Opposition by States; development vs ecological protection, etc.

Way Forward

- **Institutional Reforms: Western Ghats Ecology Authority to** oversee the regulatory framework.
- **Western Ghats Sustainable Development Fund** to incentivise green growth, etc.
- **Others:** Generate awareness, participation of civil society; Time bound Notification of Western Ghats Eco-sensitive Areas, etc.

Conclusion

Western Ghats serve as an **important wildlife corridor** characterised by **high ecological sensitivity.** Protection of this region with the **participation of the local communities** is crucial for maintaining the **ecological balance.**

5.2.3. WILDLIFE CONSERVATION IN INDIA AT A GLANCE

Wildlife Conservation in India

Framework in India

Constitutional Provisions
Article 48A under DPSP; **Article 51(g)** under Fundamental Duties; Under **Concurrent List (7th Schedule).**

Legislative Framework
Wildlife (Protection) Act, 1972: Categorizes wildlife into 4 schedules, includes penalties for violation.
Protected Areas i.e., National Parks, Sanctuaries, Conservation Reserves, etc.

Key Achievements

Protected Areas
Covers **5.32% of India's geographica area** with >100 National Parks (as on Nov, 2023).

Species Conservation

Tiger
- **Population** increased to **3, 682 from 2967 in 2018.** (All India Tiger Estimation 2022)
- **Achieved the targets set under TX2 initiative in 2018 (4 years in advance)**

Elephant
Population Increased from 26,786 (2018 census) to **29,964 in 2022.**

Challenges

Habitat loss
10 million hectares of forests are destroyed annually (WWF)

Wildlife Crime
Rhinoceros, Pangolins worst affected (World Wildlife Crime Report, 2024)

Infectious Diseases
~50% of emerging infectious diseases are driven by **interconnections between ecosystem, animal and human health**. (IPBES Nexus Assessment Report).

Declining population
Wildlife population declined by 73% over the past 50 years (1970–2020). (WWF's Living Planet Report)

Other Key Initiatives/Efforts for Wildlife Conservation

Species specific Conservation Efforts: Species Recovery Programme; Project Tiger (completed 50 years in 2023); Project Cheetah (2002); etc.

International Big Cat Alliance (IBCA) a treaty-based intergovernmental organisation with its **Headquarters** and **Secretariat** in India

National Wildlife Database Centre and **Next Generation DNA Sequencing facility** at Wildlife Institute of India (WII)

Institutions: Wildlife Crime Control Bureau, National Tiger Conservation Authority, etc.

Schemes: Integrated Development of Wildlife Habitats (IDWH) as a centrally sponsored Scheme.

Way Forward

Recognizing the **role of NGO** (e.g., Wildlife Protection Society of India, Wildlife Trust of India, etc.)

Increasing resilience of nature reserves by minimizing tourism, creating more effective buffer zones, etc.

Landscape Approach to Conservation
Views protected areas as a network of populations interconnected to each other through corridors to support viable tiger populations.

5.2.4. NATIONAL BOARD FOR WILDLIFE (NBWL)

Why in the News?

The Prime Minister of India chaired the **7th National Board for Wildlife** meeting taking place after 10 years at **Gir National Park in Gujarat.**

About the National Board for Wildlife

- It is a **statutory body** established in 2003 after the amendment of the **Wildlife (Protection) Act, 1972 in 2002.**
- **Genesis:** Constituted an **advisory body** during 1952 and designated as the **Indian Board for Wildlife (IBWL).**
- **IBWL** was instrumental in setting in place the **Wild Life Protection Act, 1972**, the establishment of the **Gir National Park for Asiatic Lions**, declaring the **tiger as the national animal, etc.**
- **Members:**
  - **Chairperson:** Prime Minister of India.
  - **Vice-Chairperson:** Union Minister in charge of the Ministry of Environment & Forests and climate change.
  - **Other members:** Representatives from non-governmental organisations, eminent conservationists, ecologists and environmentalists etc. nominated by the Central Government/

Functions of NBWL

- Promote the **conservation and development** of wild life and forests by such measures as it thinks fit.
- **Framing policies** and advising Central and State Governments on **ways and means** of promoting wildlife conservation and effectively controlling poaching and illegal trade of wildlife and its products.
- **Making recommendations** on setting up of and management of national parks, sanctuaries and other protected areas and on matters relating to restriction of activities in those areas.
- **Carrying out or causing to be carried** impact assessment of various projects and activities on wild life or its habitat.

Concerns related to NBWL

- **Approval of Projects in Protected Areas:** E.g., **Ken-Betwa River linking project**, involving Daudhan Dam, was cleared despite submergence of nearly **100 sq km** of the **Panna Tiger Reserve**.
- **Threats to Endangered Species**: E.g., **Oil exploration** in Hollongapar Gibbon Sanctuary (Assam), threatens the habitat of the **Hoolock Gibbon**, India's only ape species.
- **Others:** Reduced Role of Independent Members; Neglect of local communities' opinion; insufficient monitoring post clearance; etc.

Way forward

- **Need for Expertise:** Through **qualified wildlife scientists**, and **conservation NGOs**, etc.
- **Institutionalize Local Community Participation:** Require Free, Prior, and Informed Consent (FPIC).
- **Others:** Balancing development and environment; leveraging scientific and technological tools like AI-Based habitat modelling, post clearance monitoring through annual compliance certificate, etc.

Conclusion

Being an apex body for **conservation of wildlife and its habitat**, the role of NBWL is of critical importance to ensure the **long-term protection of India's biodiversity.**

5.2.5. AGRICULTURE AND BIODIVERSITY CONSERVATION

Why in the News?

Recently, Union for Conservation of Nature (IUCN) released a flagship report titled **"Agriculture and Conservation"** exploring the relationship between **agriculture and conservation.**

Relationship between agriculture and conservation

Impact of Agriculture on Biodiversity	Impact of Biodiversity on Agriculture
Positive: ~17% of species on IUCN Red List have agriculture documented as a habitat.	**Positive:** Provisioning of services (production of biomass, etc.), regulating and maintenance services (climate regulation, etc.).
Negative: Threatens 34% of species on the **IUCN Red List of Threatened Species, direct threats** (conversion of natural habitats to croplands), **indirect** (introduction of invasive species, etc.).	**Negative:** Ecosystem disservices such as crop predation, pests and pathogens.

Key Measures to align Agriculture with Conservation

- **Financing For Sustainable Agriculture (ensuring food security, combating climate change, etc.):** Increasing role of collectives like FPOs, etc.
- **Innovative Practices:** Use of Green Manure (E.g., Dhaincha in Tamil Nadu) for promoting soil fertility, reducing weeds, etc.
- **Sustainable Nitrogen Management:** Improved fertilization strategies, encourage biological nitrogen fixation using leguminous crops (e.g., soybean, alfalfa, etc.), setting national commitments on reducing nitrogen pollution. (FAO)
- **Aquatic Foods:** 2023 **United Nations Framework Convention on Climate Change** (UNFCCC) Ocean Dialogue recognized the role of aquatic foods (fisheries and aquaculture) for critical climate solutions.
- **Policy Reforms:** Globally less than 5% of agricultural subsidies are green subsidies, good agricultural practices e.g., **International Year of Millets, 2023.**
- **Others:** Maintain ecosystem services, reform food policy to reduce food wastage, sustainable food systems (ensuring social, economic and environmental sustainability), etc.

Conclusion

Apart from Implementing **regenerative practices** and **circularity in agriculture, adoption of digital agriculture solutions** and **innovative agri-technologies** can align agriculture with biodiversity conservation.

5.2.6. HUMAN-WILDLIFE CONFLICT AT A GLANCE

Human-Wildlife Conflict (HWC)

Definition
It is **encountered between humans and wildlife leading to negative results**, such as loss of property, livelihoods, and even life (World Wide Fund for Nature).
E.g., wolf attacks in Bahraich, Uttar Pradesh (2024)

Management of HWC in India
- Primary responsibility of the respective **State/ UT Government.**
- Recently, Kerala declared HWC as a **state-specific disaster.**

Key Facts

Some Examples of Human-Wildlife Conflict (HWC): Predation on livestock or domestic animals by wildlife; Damage to crops/fences; intrusion into residential areas, etc.

1,510 deaths recorded in the country due to animal attacks in 2022 (*Accidental Deaths & Suicides in India 2022*)

Causes of HWC

Ecological
- **Seasonal changes**
- Extreme weather events(E.g., Melting ice in Arctic increased probability of Human-polar bear interaction)

Anthropological
- Changes in Land use, expansion of agriculture
- Conservation efforts (Sunderbans reaching its carrying capacity)
- Habitat fragmentation, etc.

Wildlife
- **Changes in animals movement patterns,** life cycles, ability of wildlife to adjust to evolving landscapes, etc.

Impacts

Psychological Impact on Communities Fear/anxiety, Loss of life and property.

Rising zoonotic diseases Like Nipah

Damage to crops Impact on commodity Production.

Others
Retaliatory killing, Predation of livestock, antipathy towards animals, etc.

Laws and Policy to tackle HWC

Forest and wildlife are listed in **the Concurrent List of the Constitution.**

Wildlife Protection Act of 1972 provides the statutory framework for protecting wild animals and plants.

Standard Operating Procedures (SOPs): Issued by Central government to manage Human-Tiger/Human-Leopard /Human-Elephant conflicts.

Others: National Wildlife Action Plan 2017-2035 (NWAP); National Human-Wildlife Conflict Mitigation Strategy and Action Plan (2021-26), etc.

Way forward:

National wildlife Action Plan (2017-2035)

Science-based plans for species-specific and region-specific conflict-mitigation programs.

Participation of local community involving dissemination of **Indigenous Traditional Knowledge.**

Technological interventions E.g., Project RE-HAB (Reducing Elephant – Human Attacks using Bees)

Others: Creation of database, awareness and training, building barriers like fences, etc.

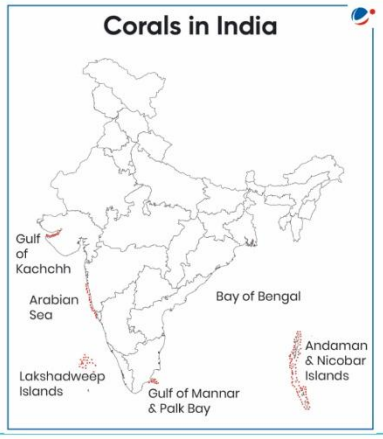
5.2.7. CORAL BLEACHING AT A GLANCE

Coral bleaching

Corals
Invertebrates that form reefs through **colonies of polyps** that secrete limestone skeletons relying on **symbiotic algae (zooxanthellae) for nutrition.**

Habitat
Shallow, sunlit waters between **30°N and 30°S latitude**, **temperature** (16-32°C), **depths** (<50 m).

Distribution
- **>1/3rd world's coral reefs** are found in **Australia, Indonesia and Philippines**.
- **Coral Triangle:** Marine area located in **western Pacific Ocean including** waters of Indonesia, Malaysia, Philippines, Papua New Guinea, Timor Leste and Solomon Islands.



Significance of Coral Reefs

Biodiversity Hotspots	Coastal Protection	Economic Value
Support approximately 25% of all marine species	Natural breakwaters **protecting coastlines from storms, erosion, and flooding.**	Estimated $10 trillion in **economic benefits globally through tourism, fisheries etc.**

Threats to Coral Reefs

Coral bleaching
Process in which **corals expel their symbiotic algae** due to environmental stressors like **changes in temperature, light or nutrients**.

Fourth Global Bleaching Event (GCBE) in 2024 impacted 77% of world's coral reefs.

In India, GCBE4 impacted **Andaman and Nicobar Islands, Gulf of Mannar, Lakshadweep, and the Gulf of Kachchh.**

Other Threats: Climate Warming; Coral Mining for Construction; Aquarium Trade; over fishing; Ocean Acidification; Pollution, etc.

Initiatives to prevent Coral Bleaching

India
- Coral Species are listed under **Schedule I** of the **Indian Wildlife (Protection) Act, 1972.**
- **National Committee on Wetlands, Mangroves and Coral Reefs (1986)**
- **Environment (Protection) Act, 1986:** Prohibits coral and sand use for construction.

Global
- **International Coral Reef Initiative (ICRI):** India is a member
- **CITES** lists coral species in **Appendix II** to regulate trade.
- **World Heritage Convention** designates coral reef sites for protection.

Way Forward

Reduce stormwater runoff to prevent water pollution and combat climate change.	**Cryopreservation E.g., Taronga Cryo Diversity Bank**	**Engineering Tools** **Biorock Technology** (Gulf of Kutch) **Artificial Reefs** (**Tamil Nadu**)

5.3. WETLAND CONSERVATION IN INDIA AT A GLANCE

Wetland Conservation in India

Wetland
Land area **saturated or flooded** with water, either seasonally or permanently.

Includes marsh, fen, peatland, marine water the **depth** of which at low tides does **not exceed 6 meters etc.**	Cover only **6% of Earth's surface** but support **~40% of global biodiversity**

Current Status in India

7 lakh wetlands covering **~16 Mha i.e., 4.86%** of the total geographic area of the country.	India **lost 2 out of 5 wetlands** in last 3 decades (Wetlands International).

Significance of Wetlands

Carbon sink and Water storage	**Nature's shock absorber** (prevents coastal erosion)	**Kidneys of landscapes** (filters out contaminants).	**Intrinsic cultural and recreational value;** create livelihoods	**Habitat** for wide range of Biodiversity

Schemes/Policies/Initiatives in India

Wetland (Conservation and Management) Rules 2017.	Establishment of **Centre for Wetland Conservation and Management (CWCM).**	**National Plan for Conservation of Aquatic Eco-systems (NPCA).**	**National Mission for Clean Ganga (NMCG)**	**Blue Flag Certification** (India has 12 Blue Flag Beaches)	**Party to Ramsar Convention** (India became a party in **1982** (Maximum Ramsar sites are in **Tamil Nadu** followed by **Uttar Pradesh).**

Constraints

Alteration of **natural hydrological regimes** due to groundwater salinization and over extraction, **waste disposal** from urban areas/ Agricultural fields etc.	**Proliferation of invasive species** like Water hyacinth, Salvinia etc.	**Unsustainable harvesting of wetland resources** such as wood, fish, water, sand etc.	**Unregulated development of tourism infrastructure and recreation facilities**	**Impacts of Climate change-** sea level rise, drought, **Harmful Algal Bloom (HAB), etc.**

Way Forward

Participatory conservation by involving local communities. **E.g.,** under Amrit Dharohar initiative	**Strict implementation of pollution norms.** E.g., penalize violations	**Ecosystem-Based Management** Develop integrated management plans that address hydrology, biodiversity, and local livelihoods	**Holistic and standardized protocol for monitoring** **E.g.,** Implement health cards, ecosystem health assessments, and GIS-based inventories

5.3.1. RAMSAR CONVENTION

Why in the News?

Recently, new Ramsar sites were recognized under the **Ramsar Convention** taking the total number to **91.**

About Ramsar Convention

- **Intergovernmental treaty** for **conservation and wise use of wetlands** and their resources.
  - The Convention defines wise use of wetlands as "**the maintenance of their ecological character**, achieved through the implementation of ecosystem approaches, within the context of sustainable development".
- Adopted at **Ramsar (Iran) in 1971** and came into force in **1975.**
- **'List of wetlands of international importance'** or the **Ramsar List** contains wetlands which hold **significant value for humanity.**
  - Wetlands in Ramsar list meet at least one of nine criteria **under the conventions** including supporting vulnerable, endangered, or critically endangered species or threatened ecological communities.
- **Examples of Sites in India: Oldest** (**Chilika Lake**, Odisha and **Keoladeo National Park,** Rajasthan designated in 1981) and **Latest** (**Khichan** and **Menar,** both in Rajasthan designated in 2025).
  - **Examples of Wetland City Accreditation (WCA):** Indore and Udaipur cities.
- **Montreux Record:** Ramsar sites where changes in ecological character have occurred, are occurring, or are likely to occur due to **technological developments**, **pollution** or **other human interference.**
  - **Examples:** Loktak (Manipur) and Keoladeo National Park (Rajasthan)

Significance of the Ramsar Convention

- **Fulfil Sustainable Development Goals:** All Ramsar wetlands are essential to ensure water quality and supply, food and water security, climate change, energy supply, health, biodiversity, etc.
- **Research and Data Exchange among Parties:** Including promotion of training on research and management.
- **International Cooperation:** Providing technical and financial aid to populations dependent entirely on wetlands.
- **Recognizes Intricate relationship between Humans and Environment:** For supporting both nature and society.

Challenges Associated

- **Implementation:** States to review their national laws and share information which they are reluctant to do.
- **Ambiguous Language:** In the convention text makes the obligation to restore wetlands uncertain.
- **Absence of Formal Dispute Settlement:** Hinders effective implementation.

Way Forward

- **Mutual Cooperation and Support among States:** To ensure regional implementation through sharing of technical guidance.
- **Building Societal consensus:** Acknowledging the importance of wetlands and impact of their destruction.
- **Monitoring:** E.g., Conducting Environmental Impact Assessment (EIA) to evaluate the impact of dredging activities.

Conclusion

According to various studies, wetland **provide substantial economic value** through services such as **flood protection and water purification**, which can **reduce disaster management and water treatment costs.**

5.3.2. MANGROVES CONSERVATION AT A GLANCE

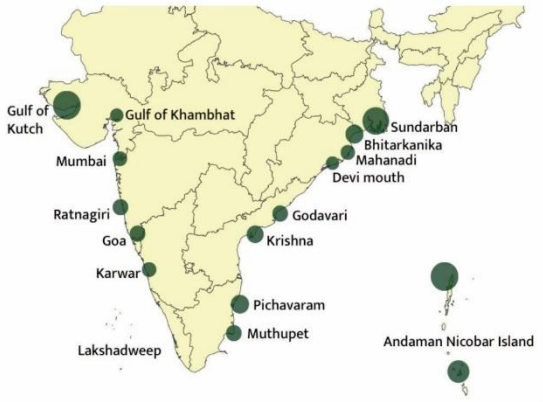
Mangroves Conservation

Mangroves

- Characteristic **littoral plant formations** of tropical and subtropical sheltered coastlines.
- Described as **'coastal woodland', 'tidal forest',** and **'mangrove forest'.**
- **Salt-tolerant plant communities** found in **intertidal regions** characterized by **high rainfall** (between 1,000-3,000 mm) and **temperature** (ranging between 26°C-35°C).

Extent in India

- **Total Mangrove Cover in India**: 0.15% of country's geographical area (ISFR, 2023).



Ecosystem services provided by Mangroves

Carbon sequestration: Store almost three times the amount carbon stored by tropical forests of the same size.	**Protection from coastal calamities: Reduce flood depths by 15- 20%,** and over 70% in some areas.	**Livelihood to coastal communities.**	**Biodiversity conservation**: Over 5,700 plant/animal species have been recorded in Indian mangroves.

Threats (State of the World's Mangroves 2024 by Global Mangrove Alliance)

Half of world's mangrove provinces are considered threatened (IUCN Red List of Mangrove Ecosystems). › Mangroves in **Lakshadweep** and **Tamil Nadu coast** are **critically endangered.**	**Development-related activities** Expansion of **industrial shrimp aquaculture** (Andhra Pradesh, West Bengal, Gujarat), **Conversion to oil palm plantations**, **rice cultivation**	**Others** › **Climate Change** › **Pollution and contaminants from coastal regions: E.g.- black carbon** from Kolkata and the Indo-Gangetic plain.

Initiatives for Mangrove Conservation

India

- **MISHTI (Mangrove Initiative for Shoreline Habitats & Tangible Incomes**) by MoEFCC.
- **Sustainable Aquaculture in Mangrove Ecosystem (SAIME)**
- **Magical Mangroves campaign**
- **National Coastal Mission Programme on** 'Conservation and Management of Mangroves and Coral Reefs'

Global

- **Mangrove Breakthrough** by GMA.
- **Mangrove Alliance for Climate,** headed by UAE in partnership with Indonesia.

Way Forward

Strengthening of existing laws like the Indian Forest Act,1927, **Environmental Impact Assessment (EIA), 1986 and Forest Conservation Act,1980**.	**Conservation by connecting the mangrove forest with the terrestrial forest** E.g., **Sundarban** mangroves connected to the Sundarban National Park.	Important mangrove patches can be declared as '**Mangrove Germplasm Preservation Centers'.**	**International cooperation** in line with the **UN Decade for Ecosystem Restoration 2021-2030**.

5.3.3. PEATLAND CONSERVATION AT A GLANCE

Peatland Conservation

Peatlands
- Terrestrial wetland ecosystems where **waterlogged conditions prevent plant material from fully decomposing** causing the production of organic matter to exceed its decomposition resulting in the net accumulation of peat.
  - **Peat** is **dead and partially decomposed plant remain** accumulated in situ under **waterlogged** conditions.

Global Peatlands distribution
- Covers **3.8% of the world's land area.**
  - **Naturally forested peatlands** in Europe and **tropical peat swamps** in Southeast Asia
  - **Permafrost area** of Russia and Canada
  - **High mountain peatlands** in the Andes and Himalayas.

Status
Nearly **12% of global peatlands** with **more than 60% of peatlands** in **India** being degraded. (Global Peatland Hotspot Atlas, 2024).

Major Threats
Agriculture, peat extraction, industrial activities and infrastructure development.

Significance of Peatland

Carbon storage	Biodiversity conservation	Ecosystem services
Stores at least **550 Gigatonnes** of carbon globally – more than twice in all the world's forests.	Vital habitats for rare and threatened species.	Regulating and purifying water, agriculture & have a net cooling effect on climate.

Initiatives

Guidelines for **Global Action on Peatlands (2002),**	The **UN Environment Assembly (UNEA-4) resolution** on Conservation and Sustainable Management of Peatlands (2019)	**UNEP Global Peatlands Initiative:** Formed at the **United Nations Framework Convention on Climate Change (UNFCCC) COP in Marrakech, Morocco in 2016.**

Way Forward

Decision Making process to incorporate **full long term cost** of potentially damaging activities.	Adopt **Responsible Peatland Management** based on the principle of **wise use of peatlands.**	Formulation of **Peatland Management Plans** to include recent scientific information on greenhouse gas fluxes.	Ensure the use of peat in horticulture and other applications only after **analysing its suitability.**

5.3.4. MARINE PROTECTED AREAS (MPAS) AT A GLANCE

Marine Protected Areas (MPAs)

Definition
- Space in the ocean where **human activities is strictly regulated than the surrounding waters (as per ENVIS).**
- Given special protections for natural or historic marine resources by local, state, territorial, native, regional, or national authorities.

MPAs in India
Gulf of Mannar Marine Park (Tamil Nadu), **Lothian Island** (West Bengal), **Gahirmatha** (Odisha).

Significance

Reservoirs of genetic material
For natural or assisted recovery of areas affected by pollution.

Refuges for countless marine species
Shield from threats like overfishing, habitat destruction, etc.

Others
- Reference site as a base line for **scientific research**
- **Nature-based recreation** and tourism
- **Climate change adaptation** and mitigation, etc.

Challenges in conservation of MPAs

Monitoring and enforcing regulations over vast and remote ocean areas is resource-intensive and technologically demanding

Balancing the interests of diverse groups—such as fishers, conservationists, tourism operators, and indigenous communities

Gaps in ecological and socio-economic data hinder their design, management, and evaluation

Global Initiatives to Protect Marine Biodiversity

Kunming-Montreal Global Biodiversity Framework aims to protect 30% of the planet's oceans and lands by 2030.

Agreement on Marine Biodiversity of Areas beyond National Jurisdiction (High Seas Treaty).

United Nations Human Rights Council (UNHRC) Resolution recognizing the **connection between** plastic pollution, ocean protection, and the right to a clean, healthy and sustainable environment.

Way Forward

Invest in advanced monitoring technologies such as satellite tracking, drones, and automated vessel identification systems.

Include local communities, fishers etc. within **wider integrated ocean** and **coastal management systems.**

Provide **technical expertise** and **capacity building support** on governance of MPAs.

5.4. GENETIC RESOURCES AND TRADITIONAL KNOWLEDGE AT A GLANCE

Genetic Resources and Associated Traditional Knowledge

Genetic Resources (GRs)
Resources that are contained in **medicinal plants, agricultural crops,** and animal breeds.
- **While GRs** themselves cannot be directly protected, **inventions** developed using them can be protected.

Traditional knowledge (TK)
Knowledge system held by **indigenous communities.**

Importance of Traditional Knowledge

Natural Resource Management: E.g. **karez' or 'surang bavi' system to** harvest rainwater in Bidar region.	**Advancing scientific and technical research** E.g., **Polyculture technique called Milpa** by Mayan People towards regenerative agriculture.	**Industrial applications E.g.,** Many plant-based medicines are derived from traditional knowledge.	**Global Problem Solving** Like Forest Conservation E.g. **Khasi and Garo tribes** for conservation of sacred groves in Meghalaya, **Soligas Tribe** for managing Biligiri Rangaswamy Temple Wildlife Sanctuary (BRTWS).

Challenges associated with India's TK and GRs

Biopiracy Exploitation, patenting, and commercialization of TK and GRs by foreign entities without benefit-sharing.	**Limited rights to Farmers** E.g., Farmers developing staple food through generations with **no effective rights over them.**	**Lack of Documentation** Enhances **loss or erosion in transmission of traditional knowledge** to younger generations in the face of **modernization and cultural change.**	**Others** Inadequate Global Legal Framework, inefficient conservation of biodiversity, etc.

Measures by Government to Protect India's TK and GRs

Traditional Knowledge Digital Library (TKDL)	**Legislations:** Patent Act, 1970; The Protection of Plant Varieties and Farmer's Rights Act, 2001; Biological Diversity Act, 2002; Geographical Indications Act 1999, etc.	**Ministry of AYUSH**: Dedicated ministry for traditional medicine.	**UNESCO recognition**: Yoga, recognized as Intangible Cultural Heritage.

Way Forward

Ensuring adequate income to the community experts on traditional knowledge.	**Incorporating TK as part of the curriculum for schools**, universities and research centres.	**Enhancing traditional medicine and healing arts** in state-run hospitals.	Recognizing leaders, experts and innovations in TK in various fields **by providing incentives.**	**Ensuring Access and Benefit Sharing (ABS)** covered under CBD, Bonn Guidelines and Nagoya Protocol (2010)

5.4.1. TREATY ON INTELLECTUAL PROPERTY, GENETIC RESOURCES AND ASSOCIATED TRADITIONAL KNOWLEDGE

Why in the News?

This historic new treaty has been adopted by the member states of the **World Intellectual Property Organization (WIPO)**.

About the Treaty

- This is **first WIPO Treaty** to address the interface between Intellectual Property (IP), Genetic Resources (GR) and Traditional Knowledge (TK) and include **provisions specifically for Indigenous Peoples** as well as local communities.
- It will establish in international law a **new disclosure requirement for patent applicants** whose inventions are based on GR and/or associated TK.
- **Disclosure:** Such patent applicants must **disclose**:
  - Country of origin or source of GR;
  - Indigenous peoples or local community that provided the associated TK.
- **Members:** Any **member states** of WIPO **may become party** to this treaty.
- **Non-retroactivity:** Not applicable on patents filed prior to entry into force of this treaty.

Conclusion

The treaty would **curb biopiracy, enhance ethical innovations** and would go a long way in making the **IP framework more inclusive.**

5.4.2. BIOLOGICAL DIVERSITY (ACCESS AND BENEFIT SHARING) REGULATION 2025

Why in the news?

The National Biodiversity Authority (NBS) has issued new rules — **Biological Diversity (Access and Benefit Sharing) Regulation 2025.**

More on the news

- Rules seek to regulate the fair sharing of benefits from the use of biological resources and associated knowledge.
- Notified by the **NBA in accordance with the Biodiversity Act (BDA) 2002 replacing the 2014 rules**.
- One of the most well-known ABS cases from India involves the **Kani tribal community of Kerala** and the Arogyapacha plant (Trichopus zeylanicus), traditionally used by the tribe for its revitalizing properties (**Jeevani drug).**

Key Highlights of the Rules

- **Inclusion of Digital Sequence Information (DSI**)
- **Prior Informed Consent (PIC):** Prior intimation to National Biodiversity Authority for approval.
- **Benefit Sharing** of profits based on Annual turnover.
- **Benefit Sharing for High-Value Biological Resources**: Not less than **5% of the proceeds of the auction** or sale amount or the purchase price and could be **more than 20%** in case of commercial use.
- **Transfer of Research Results (Non-IPR Use)**
- **Benefit Sharing for IPR Commercialisation**: Upto 1% of the annual gross ex-factory sale price (excluding taxes).

Challenges with Implementation

- **Transboundary Nature of Resources**: Makes difficult to obtain PIC among multiple stakeholders.
- **Academic vs Commercial Research**: Difficult to distinguish between them with potential misuse.
- **Limited regulation**: Of the customary laws that govern traditional knowledge.
- **Others**: Weak Institutional Capacity to implement CBD; Time intensive and cumbersome documentation, lack of robust markets, monitoring issues; low awareness, etc.

Way Forward

- **Multilateral Benefit-Sharing:** Across borders, in line with Nagoya Protocol.
- **Empower Indigenous Communities**: Legally recognize customary laws and integrate them into ABS frameworks.

- **Clarify Research Use:** Set clear rules distinguishing academic from commercial research to prevent misuse
- **Others: Digitize Documentation** through technological use; improve monitoring, etc.

Conclusion

Along with being just and fair, these rules ensure **local researchers** play a central role in any **commercially-viable research** into the uses of their own biodiversity.

5.5. KEYWORDS

Keywords				
Digital Sequence Information (DSI)	Free, Prior, and Informed Consent (FPIC)	Fair and equitable sharing	Kunming-Montreal Global Biodiversity Framework (KMGBF)	'Whole of Government' and 'Whole of Society'
Landscape Approach to Conservation	"30x30" initiative	Carbon sequestration	Ecosystem services	Nature's shock absorber
Biopiracy	Traditional knowledge (TK)	Access and Benefit Sharing (ABS)	Illegal, Unreported, and Unregulated (IUU) fishing	Kidneys of landscapes
Key Biodiversity Areas	Nature Based Solutions			

5.6. PRACTICE QUESTION

Answer Canvas

What is the Biodiversity Beyond National Jurisdiction (BBNJ) Agreement? Discuss its key provisions and explain how India's participation in the treaty can benefit the country.

Introduction	Body Part 1	Body Part 2	Conclusion
What is BBNJ Agreement?	Key Provisions of BBNJ Agreement	Significance of BBNJ Agreement	Conclusion

6. DISASTER MANAGEMENT

6.1. DISASTER MANAGEMENT IN INDIA AT A GLANCE

Disaster Management in India

Major Disaster Risks in India

59% of landmass prone to **moderate to very high intensity earthquakes .**	**>40 million hectares (12% of land)** prone to **floods and river erosion.**	**5,700 km** of ~7,500 km long **coastline** prone to **cyclones and tsunamis.**	**~68% of cultivable area** vulnerable to **drought.**

India's Vision and Approach to DM

- **Approach:** Moving from relief-centric approach to a zero casualty approach.
- **Vision as per National Disaster Management Plan (NDMP), 2019: Make India disaster resilient** across all sectors, building local capacities and significantly decrease the loss of lives, livelihoods and assets.

Challenges related to Disaster Management

Low insurance penetration with coverage below 1% in India, **limiting ability to share disaster risk**	**Low investment in Disaster Risk Reduction (DRR)**	**Lack of fundamental infrastructure** like early warning system, search and rescue facilities etc.)	**World is moving closer to Risk tipping points** like Groundwater depletion; glaciers melting etc.

Initiatives

Legislative and policy National Disaster Management Act 2005, and **National Disaster Management Plan, 2019, Prime Minister's Ten Point Agenda** on DRR	**Financial Arrangements National Disaster Response Fund;** National Disaster **Mitigation Fund**	**Institutional National Disaster Management Authority (NDMA);** National Crisis Management Committee (NCMC); National Disaster Response Force (NDRF); National Institute of Disaster Management (NIDM)	**NDMA guidelines** For disasters like earthquakes, cold wave, cyclone etc.

Way Forward

Build Back Better: post-disaster recovery approach to reduce future vulnerability and **improve community resilience**	**Setting specific goals and targets aligned** with the Sendai framework.	**Equipping existing infrastructure** like common Service Centres (CSC) for early warning, relief and rescue etc.	**Expanding financial resources** through international collaborations, public-private partnership, etc.	**Investment in DRR: $1 invested in DRR saves $15 in recovery** costs. Most funding still goes to post-disaster response.

6.2. THE DISASTER MANAGEMENT (AMENDMENT) ACT, 2024

Why in the News?

The Disaster Management (Amendment) Act, 2024 was enacted recently to amend the **Disaster Management Act 2005.**

Need for Amendment in Disaster Management Act (DMA) 2005

- **Inadequate Integration of Disaster Risk Reduction (DRR).**

  - **E.g.** 2013 **Uttarakhand floods** demonstrated a lack of focus on DRR due to **inadequate land-use planning, early warning systems, and construction regulation**.
- **Fostering effective community participation**, which is **vital for resilience and recovery,** as **community members are first responders** in times of disaster.
- **Weak Project Planning and Execution** of Disaster management activities by **NDMA.**
- **Insufficient Addressing of Health-Related Issues** like epidemics/bioterrorism threats in previous act.
- **Addressing Systemic and Cascading** nature of disasters and climate risks.

Key amendments under Disaster Management (Amendment) Act, 2025

- **National Disaster Management Authority (NDMA) and State Disaster Management Authority (SDMA)** given responsibility to prepare DM plans (earlier with National Executive Committee and State Executive Committee)
- **New functions added for NDMA and SDMA**: **Taking periodic stock** of disaster risks**, Providing technical assistance** to authorities.
- **NDMA empowered to specify the number and category of officers and employees**, with previous approval of the central government.
- State governments empowered to constitute a separate **Urban Disaster Management Authority (UDMA) for state capitals and** a **State Disaster Response Force (SDRF).**
- **Statutory status** to **National Crisis Management Committee (NCMC) and the High Level Committee (HLC)**
  - NCMC will function as the **nodal body for dealing with major disasters** with serious or national ramifications.
  - HLC will provide **financial assistance to state governments during disasters.**
- **Provides for the creation of a disaster database** at the national and state levels.

Potential Issues with Act

- **Financial constraints** of Urban Local Bodies to effectively set up and run the UDMAs.
- **Excessive rulemaking power to Central government,** through delegated legislation to make rules on specific matters, could potentially overlap with legislative powers reserved for States.
- Bill is brought under **Entry 23 of the Concurrent List of Seventh Schedule** which deals with "social security and social insurance, employment and unemployment" as Disaster Management is not mentioned in **Seventh Schedule.**
- Bill **does not expand the list of notified disasters** to include climate-induced disaster such as heatwaves.

Key Provisions of Disaster Management Act 2005

- **Establishment of Authorities:** Act establishes a three-tier structure for disaster management.
  - **National Disaster Management Authority (NDMA):** For disaster management at the national level.
  - **State Disaster Management Authorities (SDMAs):** For disaster management at the state level.
  - **District Disaster Management Authorities (DDMAs):** For disaster management plans at the district level.
- **Preparation of Disaster Management Plans:** At national, state, and district levels.
- **National Disaster Response Force (NDRF):** Establishes NDRF for specialized response to disasters.
- **Funding Mechanisms:** Provides for National Disaster Response Fund (NDRF) and State Disaster Response Funds (SDRF)

Conclusion

Act aims to strengthen disaster risk reduction and management by **introducing new structures like Urban Disaster Management Authorities**. However, its success will hinge on overcoming challenges related to coordination, authority, and resource allocation among various levels of government.

6.3. TECHNOLOGY IN DISASTER MANAGEMENT & RISK REDUCTION (DMRR)

Why in the news?

Recently, advancement in geospatial technology based on AI, Machine Learning (ML) and Internet of things (IoT) have been widely used in DMRR.

Use of Technology in Disaster Management Cycle

- **Prevention/Mitigation:** Improving predictions and reducing risks. E.g., **building hazard maps using AI.**
- **Preparedness:** To help create and implement emergency plans. It can also be used to monitor potential threats, such as weather patterns that could lead to a natural disaster.
  - **Disaster prediction and early warning systems:** E.g. Google Disaster Alerts
  - **Odisha State Disaster Mitigation Authority** has developed a web based platform called **"SATARK"** to provide warning information for various hazards.
  - **Event simulation:** E.g. Mobile Learning Hub Philippines.
- **Response:** To coordinate and manage the response effort.
  - **Disaster detection:** E.g. Earthquake detection through X (Formerly twitter).
  - **Emergency communication:** E.g., Covid-19 chatbots launched by WHO.
  - **Search and rescue:** E.g. **Use of drones in Wayanad after landslide** for search and rescue mission.
- **Recovery:** Technology can help with rebuilding process after a disaster. **E.g. use of drones to transport essential goods.**

Conclusion

The **integration of technologies** has significantly **improved the accuracy of early warnings**, efficiency of emergency responses, and effectiveness of post-disaster recovery. However, the full potential of these technologies can only be realized by **addressing challenges especially for vulnerable groups** like women.

6.4. EARTHQUAKE MANAGEMENT IN INDIA AT A GLANCE

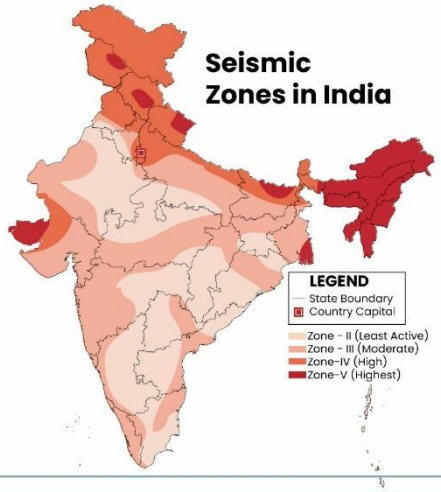
Earthquake Management in India

Definition
Sudden, rapid shaking of the earth caused by the **shifting of underground rock.**

Causes
Tectonic Plate Movements; Fault Slippage (Build-up of stress along the fault line overcomes the friction between rocks); Volcanic and anthropogenic activities, etc.

Vulnerability In India:

- **59% of the Indian landmass** classified as earthquake-prone.
- **11% fall in very high-risk zone V,** 18% in high-risk zone IV, and 30% in moderate-risk zone III.



Recent Earthquakes and their reasons

Myanmar earthquake: "Strike-slip faulting" (Sagaing fault) between the Indian and Eurasian plates.	**Taiwan: Reverse Faulting** (Split between 2 sections of rock in Earth's crust caused by compressional forces).	**Chile:** Prone to Earthquake due to its location on ring of fire.	**Delhi-National Capital Region (NCR): Shallow Earthquake** resulting from **"in situ material heterogeneity".**

Challenges

Difficult to **predict**	**Lack of earthquake-resilient infrastructure**	**Movement** of **Indian and Eurasian plate** towards each other	Central Himalaya, considered a prominent **'seismic gap**	**High cost of retrofitting,** etc.

Initiatives

Earthquake Risk Assessment and Mapping by the Geological Survey of India (GSI)	**Indian Standard Code for seismic design and construction of structures** (IS 1893) by BIS.	**National Disaster Management Authority's (NDMA) guidelines**	**Others: Earthquake Early Warning System (EEWS), National Earthquake Risk Mitigation Project (NERMP),** Mobile application 'India Quake' ,etc.

Way forward (NDMA Guidelines)

Ensure **incorporation of Earthquake resistant design features.**	**Facilitate selective strengthening and seismic retrofitting** of existing priority structures.	**Others:** Improve the compliance regime; capacity development interventions; strengthen emergency response capability, etc.

6.5. LANDSLIDE MANAGEMENT AT A GLANCE

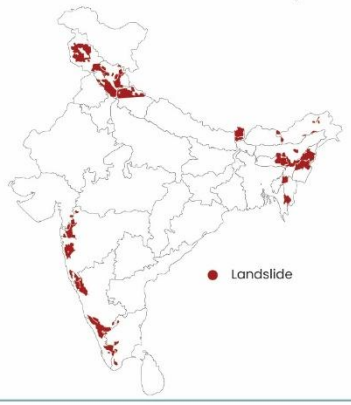
Landslide Management in India

Landslide occurs when **gravity forces** on **hill slope material exceed** the **frictional forces** holding the material in place, causing slope failure.

India's Landscape Susceptibility to Landslides (Indian Landslide Susceptibility Map (ILSM)

- **13.17%** of India's geographical area. India accounts for about **8% of global fatalities** due to landslides.
- **Northwest Himalayas contribute**- 66.5% of landslides in India, **followed by the Northeast Himalayas** -**18.8%** and the **Western Ghats - 14.7%.**

Landslide Incidence Map



Recent Occurrences and Reasons

Sikkim landslides: Unplanned construction and hydel projects.	**Uttarkashi Landslide:** Triggered by a cloudburst, Unregulated Building Construction etc.	**Wayanad (Kerala):** Primarily caused by **heavy rainfall, unstable soil conditions, and deforestation.**	**Aizawl (Mizoram):** Unscientific earth cutting and failure to ensure good drainage in the unstable hill terrain.	**Papua New Guinea Landslide:** Geographical location of country **(It sits on the Pacific 'Ring of Fire').**

Causes of Landslides

In Himalayas:

- **Geological Factors: Steep slopes** and **rapid rivers** causing **toe erosion, rockfalls,** and **intense water saturation** from snowmelt.
- **Other reasons:** construction activities, lack of comprehensive land use policy, Hydropower Projects and excessive tourism.

In Western Ghats:

- **Basalt rocks, high gradient, Deforestation, Mining, Construction activities.**
- **Western Ghats require less rainfall** to trigger landslides compared to Himalayas due to greater water retention and increased pore water pressure.

Initiatives

National Landslide Susceptibility Mapping (NLSM) Programme by **Geological Survey of India.**	**Landslide Atlas of India** by National Remote Sensing Centre of ISRO.	**Geological Survey of India** recently established **National Landslide Forecasting Centre (NLFC)**	**Bhusanket Web Portal and Bhooskhalan Mobile App**

Way forward (NDMA Guidelines)

National Landslide Risk Management Strategy			NDMA Guidelines
No construction in the areas having **slopes above 30 degrees or areas falling on spring lines and first-order streams.**	**Preparation of Mountain Zone Regulations and Policies:** Formulation of land-use policies and techno legal regime, updation of building regulations, review of BIS code etc.	**Stabilization and Mitigation of Landslide and Creation of Special Purpose Vehicle (SPV) for Landslide Management**	**Provisions in MNREGA scheme for structural mitigation of landslides, No construction in the areas having slopes above 30 degrees, Fast-growing trees and useful grasses to be grown.**

6.6. HEATWAVES MANAGEMENT IN INDIA AT A GLANCE

Heatwave Management in India

- **IMD criteria for Heat waves:** Maximum temperature of **40° C (Plains)** and **30° C (hills).**
- **Declaration of Heat waves:**
  - **Based on actual temperature:** Recorded maximum temperature of **45° C** or above for all locations and **37° C** or more for coastal locations.
  - **Based on departure from normal: Heat wave** when departure is **4° C to 5° C** and **severe heat wave** when **6° C.**

Vulnerability in India

- **13% of the districts and 15% of the population** are moderate to very highly vulnerable
- **4% of the districts and 7% of the population** are highly vulnerable.

Conditions favorable for Heat waves

- **Anti-cyclone, Absence of moisture** in the upper atmosphere, **Cloudless sky, Prevalence** of hot dry air over a region.

Reason of increasing heatwaves in India

- **El Nino effect, Urban heat island effect, Climate Change, Westerly Winds, Deforestation and Land Use Changes** etc.

Impact of Heatwaves

Human Health	Environment	Loss of productivity	Economic and Social Impacts
Over **10,000 people lost their lives** due heat waves between **2000-2020 (IMD).**	**Increasing energy demand** due to usage of cooling; wildfires and droughts; worsens air quality.	India expected to lose around **5.8% of daily working hours due to rising temperatures by 2030** (UNESCAP).	Increased migration; Affects crop productivity impacting food security.

Initiatives

Action taken by IMD- Color code impact based heat wave warning. E.g., **Green** (Normal day); **Yellow** (Heat Alert); **Orange** (Severe Heat Alert); **Red** (Extreme Heat Alert)	**Heat Action Plans** by IMD in collaboration with NDMA and local health departments.	**Climate Hazard & Vulnerability Atlas** of India, **Heat Index** launched by IMD

Way forward (NDMA Guidelines)

A national level strategy and plan to combat heat wave should be developed.	Examine the local cause of **disproportionate rise in temperature** and **identify vulnerable hotspot.**	**New heatwave criteria must be evolved** based on gridded data with maximum and minimum temperature.	**Integrate climate variability mitigation and adaptation** efforts in heat plan.	**Up gradation of forecast system** to provide heatwave alerts minimum of 2-3 weeks prior.

6.7. DROUGHT MANAGEMENT IN INDIA AT A GLANCE

Droughts Management in India

Droughts
Defined for any area when the rainfall deficiency in that area is **≥26% of its long term normal.** (IMD)

IMD classifies drought based on rainfall deficiency in a specific area

Vulnerability in India

- **91 districts in India** fall in the **'Very High' drought risk category** and another **188 districts** in the **'High' drought risk category.**
- These are primarily in **Bihar, Assam, Jharkhand, Odisha, and Maharashtra.**

Classification of Droughts as per National Commission on Agriculture in India

Meteorological Drought	Hydrological Drought	Agricultural Drought
Occurs when >10% rainfall deficit.	Characterized by the depletion of surface and subsurface water resources.	Arises when **soil moisture** and **rainfall** are insufficient to support healthy crop growth.

Recent examples of major droughts

Rayalaseema (Andhra Pradesh (2024)), **South American Drought** (2024), **Europe** (2022), **2020–2023 Horn of Africa drought** etc.

Causes of Droughts in India

Climatic	Physical	Socioeconomic
73% of rainfall occurs within the short South-West Monsoon season	Poor water management **(e.g., Cherrapunji paradox).** Groundwater overuse, limited surface storage.	High population, poverty, migration from drought-hit areas.

Initiatives

National Policy on Disaster Management	**National Agricultural Drought Assessment** and **Monitoring** System	**Rashtriya Krishi Vikas Yojana** (RKVY)	**Pradhan Mantri Krishi Sinchai Yojana** (PMKSY),

Way Forward (Reactive, Proactive and Prospective Drought Risk Management and Adaptation)

Reactive	Proactive	Prospective
Reactive drought management	Drought Risk management and adaptation	Systemic risk management and adaption
MEASURES INCUDE: Emergency food and drinking water assistance Subsidies for restoring crops and livestock Relief funds	**MEASURES INCUDE:** Early warning systems De-stocking of livestock and adjusting cropping patterns Introducing seasonal micro-credit and crop assurance schemes	**MEASURES INCUDE:** Climate smart agricultural systems Disaster resistant Water supply systems Land-use planning to achieve Land Degradation Neutrality

6.8. CYCLONE MANAGEMENT IN INDIA AT A GLANCE

Cyclone Management in India

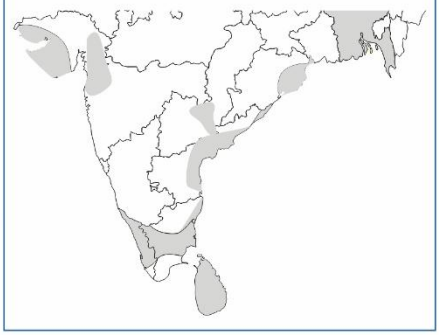
Definition

- **Large-scale system of air that rotates around the centre of a low-pressure area** accompanied by **violent storms and bad weather** rotating **anticlockwise** in Northern Hemisphere and **clockwise** in Southern Hemisphere.
- Also known as **Typhoons** (**Western Pacific** and **South China Sea), Hurricanes (Atlantic)**, and **Willy-willies** (**Western Australia)**

India's vulnerability

- India is exposed to **nearly 10% of the World's tropical cyclones.**
- Impacts **8% of the geographical area** in **13 Coastal States and Union Territories (UTs).**

Cyclone Prone Areas in India



- **Favourable Conditions for cyclone formation: High sea surface temperature (> 27° C);** Presence of **Coriolis force;** Small **variations** in the **vertical wind speed;** Pre-existing **weak low-pressure area** or; low-level-cyclonic circulation
- **Cyclones in India:** Occur in the months of **May-June** and **October-November.**

Recent Occurrences

- Cyclone **Dana** (2024) Along Odisha Coast; Cycone **Fengal** (2024) , Along Tamil Nadu, Puducherry; **Cyclone Remal** (2024) over Bay of Bengal.

Management Framework in India

- **Institutional Measures: National Cyclone Risk Mitigation Project** by MHA; **Project management and institutional support** at National, State and District level; etc.
- **Dynamic impact based Color coding warnings:** By IMD like Green (no action), yellow (be watchful), orange (be alert), and Red (take action).
- **Other steps: Web Based Dynamic Composite Risk Atlas & Decision Support System** tool covering 13 Coastal States and UTs; **Indian National Centre for Ocean Information Services (INCOIS)** set up **Storm Surge Early Warning System**

Way forward (NDMA Guidelines)

- Establishing **state-of-the-art cyclone early warning system** (EWS).
- **Mapping and delineation of coastal wetlands**, patches of mangroves and shelterbelts.
- **Exclusive eco-system monitoring network** to study the impact of climate change.
- Establishing a **comprehensive 'Cyclone Disaster Management Information System' (CDMIS).**

Best Practice: Odisha Model with the goal of 'zero-human casualties'

Proactive approach

- First Indian state to establish a disaster management authority- Odisha State Disaster Management Authority (OSDMA)

Early warning system

- Cyclone or tsunami warnings through sirens and mass messaging

Resilient infrastructure

- Multi-hazard disaster-resilient houses
- Embankments
- Multi-purpose cyclone shelters, evacuation roads along coastline

Community-Based Disaster Preparedness (CBDP)

- Community-led mock drills across state
- Training gram panchayats, women's SHGs and a 100,000+ cadre of volunteers

6.9. GLACIAL LAKE OUTBURST FLOODS (GLOFS) AT A GLANCE

Glacial Lake Outburst Flood (GLOF) in India

Definition

- Sudden release of significant amount of water retained in a glacier irrespective of the cause.

Recent Occurrences

- **2023 (GLOF at South Lhonak, Sikkim), Kedarnath (2013), Chamoli (2021).**

GLOF Vulnerability in India

- More than nine million people in **High Mountain Asia (HMA)** are **vulnerable to GLOF.**
- **Glaciers are set to lose 30–50% of their volume** compared with 2015 by 2100 due to global warming. (ICIMOD's Hindu Kush Himalaya assessment report).

Major Causes of GLOFs

Rapid glacier advance. (E.g., Gilkey Glacier, Alaska)	**Moraine dam instability** (E.g., South Lhonak GLOFs, Sikkim), **Ice dam failure, Seismic activity**	**Human Activities** (Unregulated urbanization, irrational mining, deforestation, hydropower projects, GHG emissions etc.)

GLOF Flood Mitigation measures

National Disaster Management Authority (NDMA) guidelines on management of GLOFs in 2020.	**Structural Measures like** Creation of reservoir, depressions, embankments, etc.	**Early Warning System:** NDMA has planned to install early warning systems for real-time alerts at most of 56 at-risk glacial lakes in India.	**Guidelines for Hydro projects** by Central Electricity Authority (CEA) for **slope stability**.	**GLOF risk mitigation project** for the States of Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh.

Way forward (NDMA Guidelines)

Focus on the **latest scientific research** and case studies from the Himalayas and other mountain ranges such as the Alps, Tian Shan Range and the Andes.	Facilitate collaboration among **experts, policymakers, and stakeholders** to develop and implement comprehensive strategies for monitoring & mitigating GLOF risks.	**Examine structural and non-structural mitigation measures,** including controlled breaching, siphoning, & the construction of outlet control structures.	**Advancing Monitoring and Early Warning Systems**: Integration of satellite- based monitoring, Geographic Information Systems (GIS), and remote sensing technologies.

6.10. FIRE SAFETY IN INDIA AT A GLANCE

Fire Safety in India

Status of Fire Accidents in India

- **7,435 people were killed** in over 7,500 fire accidents in India in 2022 (NCRB).
- **Recent Fire Accidents:** Fire accidents in a gaming zone in Rajkot (Gujarat), firecracker factory in Harda (Madhya Pradesh), private hospital in Delhi

Reasons behind Major fire incidents in India

Major Fire Incidents	Non-compliance of Fire safety standards and protocols
Coaching centres in **Mukherjee Nagar** and Kalu Sarai (Delhi)	**Narrow staircases, Lack of emergency** exits, Lack of sprinkler system
Kumbakonam School fire **(Tamil Nadu, 2004)**	Usage of **highly flammable materials** (thatched roof) in building, lack of safe fire exits
AMRI Hospital fire in **Kolkata** (2011)	**Inactive fire alarms** and **sprinklers,** Lack of adequate training, Unsafe storage of flammable material

Fire Safety Standards and regulations in India

- **Constitution:** Fire service is a **State subject** and included in the **12th Schedule** of the Constitution of India.
- **National Building Code (NBC) by Bureau of Indian Standards (BIS)** acts as the central standard for fire safety in India.
  - **Mandatory requirement for State governments to incorporate the NBC recommendations** on minimum fire safety into their local bylaws.
- **Others:** Model Building Bye Laws 2016 by **Ministry of Housing and Urban Affairs;** Model Bill to Provide for the **Maintenance of Fire and Emergency Service** for **the State,** 2019; **Fire and Life Safety guidelines** by Ministry of Health.

Challenges in maintaining Fire Safety Standards

- **Absence of uniform safety legislation** across states.
- NBC provisions, including **'Fire and Life Safety' audits**, are recommendatory in nature.
- **Shortage of staff and proper fire fighting equipment:** In 2019, there was a shortage of 5,191 fire stations and 5,03,365 personnel.
- **Urbanization-related challenges:** High population density, Poor Urban Planning **E.g., Kamala mills fire in Mumbai 2017.**

Way Forward (NDMA Guidelines)

- **Enactment of a Fire Act at state level** for mandatory clearance from the fire department for certain buildings and premises.
- **Improve the outreach of the Fire Services** to the block and the Gram Panchayat level.
- Professional Head of fire services at the state level and district level (chief fire officer)
- **Research & Development of indigenous**, less water-consuming fire extinguishing **technologies**

6.11. DAM SAFETY IN INDIA AT A GLANCE

Dam Safety in India

Status in India

- **India is the 3rd largest** dam owing nation (**5,700 dams**) after USA and China.

Major Dam Failures across the globe

1975: Banqiao dam failure in **China.**	**1979: Machchhu Dam** failure **in Morbi, Gujarat** claimed over 2,000 lives.	**2023: Derna dam** collapse in **Libya** claimed over 3,800 lives.	**2023:** Damage to **Chungthang Dam** in Sikkim due to floods.

Challenges associated with Dams

- **Ageing dams**: **80% of dams** in India are over 25 years old.
- **Seismic vulnerability**: For example, the earthquake in **Bhuj** (Gujarat) in 2001.
- **Non-compliance with legislative mandates** as highlighted by the CAG audit report.

Initiatives

- **National Register of Large Dams (NRLD)** complied and maintained by CWC.
- **Dam Rehabilitation and Improvement Project (DRIP)**
- **Dam Health and Rehabilitation Monitoring Application (DHARMA)**
- **Dam Safety Act, 2021:** Having a **4-tiered Institutional Mechanism**
  - **Centre level:** National Dam Safety Authority (NDSA) and NCDS
  - **State Level:** State Committee on Dam Safety and the State Dam Safety Organization.

Way Forward

- **Integrated water management considering hydrological units**involving allied disciplines such as soil management, land use, etc.
- **Using advanced technology** for collecting information such as **remotely operated underwater vehicles (ROVs) and drones** for upstream underwater inspection of dam body and reservoir floor.
- **Decommissioning of large dams and assessing the alternatives to large dams** such as building medium or minor irrigation based small storage structures.

6.12. KEYWORDS

Keywords				
Inclusive Disaster Risk Reduction	Sendai Framework	Community-based Disaster Management (CBDM)	Climate Change Adaptation	Ecosystem-based Disaster Risk Reduction
Build Back Better	Post-Disaster Impact Assessment	Non-structural Mitigation Measures	Seismic Zones	Joint Forest Management
Disaster Management Cycle	Early Warning System	Disaster risk resilience	Dam Rehabilitation and Improvement	Disaster Vulnerability
Mass Wasting	Soil Liquefaction	Zero Casualty Approach	Hazard Zonation	

6.13. PRACTICE QUESTION

Answer Canvas

Discuss about the vulnerability of India to earthquake related hazards. Give examples including the salient features of major disasters caused by earthquakes in different parts of India during the last three decades.

Introduction	Body Part 1	Body Part 2	Conclusion
Start with any Recent Example	India's Vulnerability to Earthquakes (Map)	Major Earthquake Disasters in India and their reasons	Way-Forward

7. GEOGRAPHY

7.1. EL-NINO - MONSOON LINK

Why in the news?

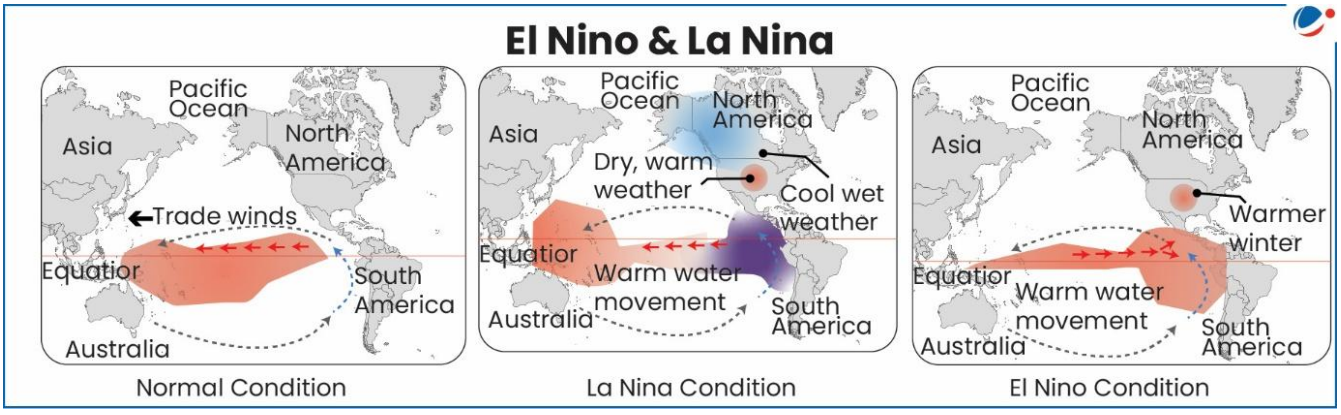
Recently, a paper published in Nature's Scientific Report revealed the **regional and temporal variability of Indian summer monsoon rainfall** in relation to El Niño southern oscillation (ENSO).

More in News

- Study showed that the El Nino-monsoon relationship **diminished in Central India**, and became **stronger in North India and there is no considerable variation over South India.**

About El Niño southern oscillation (ENSO)

- **ENSO** is a recurring climate pattern involving changes in the temperature of waters in the **central** and **eastern** tropical Pacific Ocean. (Occurs in **irregular cycles of 2–7 years)**
- **Phases of ENSO:** ENSO-neutral and 2 **Extreme Phases- El Nino** and **La Nina**
  - In the neutral phase, **tropical Pacific sea surface temperatures (SST)** are generally close to average.
- **El-Nino Modoki** is a **coupled ocean-atmosphere phenomenon in the tropical Pacific Ocean.**
  - It is associated with **strong anomalous warming in the central tropical Pacific and cooling in the eastern and western tropical Pacific.**



El Niño-monsoon relationship

- **ENSO is one of the most prominent tropical modulator of the Indian monsoon** and represents the largest interannual climate signal in the tropics.
  - **Other phenomena that affect Indian summer monsoon rainfall (ISMR):** Indian Ocean Dipole (IOD); Pacific Decadal Oscillation (PDO); Atlantic Meridional Oscillation (AMO); Atlantic Zonal Mode (AZM) etc.
- There exists an **inverse relationship between ENSO and Indian monsoon rainfall.**
  - **El Niño tends to suppress monsoon rainfall.**
  - **La Niña generally enhances monsoon rainfall.**

How El Nino impacts Monsoon

- Causes the **weakening of walker circulation**, which disrupts the normal flow of air and moisture.
- Shift in **Jet Stream** that **influences the movement of weather systems** and moisture transport.
- **Weakening of the pressure gradient** between the **Indian Ocean and the Pacific Ocean** and changes in wind patterns.
- **Leads** to **atmospheric stability** that **inhibits the vertical movement** of air and suppresses the development of **convective clouds.**

- **Other impacts of El Nino: Impact marine fisheries worldwide.** Localized threats to food security, **drought situation, rise in the general price level, etc.**

Conclusion

To date, there is no clear consensus on whether the ENSO-monsoon relationship will weaken or stay intact amidst a warming climate. In light of this uncertainty, it is advisable for researchers and policymakers to i**nvest more in studying ENSO and monsoon patterns** and enhancing our understanding of the mechanisms driving these climate systems.

7.2. 150 YEARS OF INDIA METEOROLOGICAL DEPARTMENT (IMD)

Why in the news?

Marking **150 years** of IMD, the Prime Minister launched **Mission Mausam.**

About the Mission Mausam

- **Ministry**: Ministry of Earth Sciences (MoES).
- **Aim:** Making India a "**Weather-ready and Climate-smart**" nation to mitigate the impact of climate change
- **Implementation:** The **Phase-I** of Mission Mausam will be implemented during 2024-26 and **Phase-II** will be implemented during 2026-31 in the next financial cycle.
- **Implementation: IMD, the Indian Institute of Tropical Meteorology**; Pune, and the **National Centre for Medium-Range Weather Forecasting**; Noida.

History of IMD (Ministry: Ministry of Earth Sciences (MoES))

- **Genesis: In 1875** with its **headquarters at New Delhi.** (Initially it was Calcutta).
- **Mandate:**
  - Provide **meteorological information for weather-sensitive activities** such as agriculture, irrigation, shipping, aviation, and offshore oil explorations.
  - **Warn against severe weather phenomena** like tropical cyclones, norwesters, duststorms, heavy rains and snow, cold and heat waves, etc.
  - **Research in meteorology and allied disciplines**.

Major achievements of the IMD

- IMD collects **reliable weather data** forming the backbone of our forecasts and services.
- Over the years, IMD has easily perfected art of **monsoon forecasting** to predict **seasonal rainfall patterns since 1886.**
- **Accurate cyclone warnings** by IMD have reduced number of deaths **from 10,000 (1999) to near zero (2020-2024).**
- **Boost to telecommunication:** Directorate of telecommunication was established in 1970 along with high speed switching computers in 1970 and Delhi became the Regional Telecommunication Hub.
- **Specialized services** for aviation, agriculture, energy, and water resource from flight safety to crop advisories.
- **Role in global climate resilience:** India's IMD serves as **UN Early Warning for All advisor to five developing nations**, demonstrating leadership in global climate resilience.

Conclusion

From pioneering meteorological research to **adopting state-of-the-art technology**, IMD continues to evolve, ensuring its **services remain relevant and impactful** in an era of climate change and i**ncreasing weather unpredictability.**

7.3. BHARAT FORECAST SYSTEM

Why in the News?

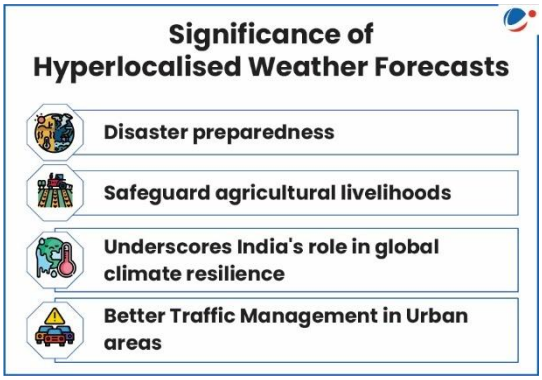
Recently, Ministry of Earth Science has launched indigenously developed **Bharat Forecast System** enabling hyper local weather forecasting.

Key Features of Bharat Forecast System

- **High-Resolution Forecasting:** The BFS can provide **6 km resolution forecasts** for tropical region.
  - The global forecast models run by the European, British, and US have a **resolution between 9 km and 14 km.**
- **Local Forecasting**: It will deliver **operational forecasts down to the panchayat level**.
- **Accuracy:** It has shown **30%-64% improvement in extreme rainfall forecasts** using real-time modeling based on the '**Triangular Cubic Octahedral Grid model.'**
  - It is a deterministic model that provides a definitive forecast rather than a range of possibilities.
- **Doppler Weather Radar Network:** Will utilize **40 Doppler Weather Radars**, ensuring robust, real-time input for accurate forecasting.

About hyperlocal weather forecasting

It is a specialized form of meteorology that **pinpoints weather conditions to extremely localized areas.**



Key Challenges in hyperlocal weather forecasting

- **Out-dated prediction models:** Current prediction software used in forecasting (**Global Forecasting System (GFS) and Weather Research and Forecasting (WRF) Models)**
- **Lack of weather monitoring ground stations:** Currently, IMD operates around **800 automatic weather stations (AWS),** 1,500 automatic rain gauges (ARG) and 37 doppler weather radars (DWR).
  - This is against the total **requirements of more than 3,00,000 ground stations (AWS/ARG) and around 70 DWRs.**
- **Underutilized data from ground stations:** Due to issues with IMD data-sharing and reliability.
- **Difficulty in predicting small-scale events:** Due to their erratic and dynamic nature.

Other Key initiatives taken to facilitate hyperlocal weather forecasting

- **IFLOWS-Mumbai:** Developed by Ministry of Earth Sciences
- **CoS-it-FloWS**: Collects hyper-local data for flood forecast launched in the flood-prone Periyar and Chalakudi river basins was launched in Kerala
- **Others**: Gram Panchayat (GP)-Level Weather Forecasting; Mission Mausam; Weather information network and data system (WINDS)

Way Forward

- **Investing in Research & Development:** To understand the complexities posed by climate change and harnessing the potential of AI that offers better prediction at lower cost.
- **Coordination between agencies and experts:** Including urban and infrastructure planners to take into account the local ecology and socio-economic conditions.
- **Continuous upgradation of weather forecasting infrastructure:** Along with installation of ocean observation systems and high-resolution Earth Observation satellites.
- **Addressing regional disparities:** Optimum coverage of Eastern and North-eastern regions with Doppler radars.

Conclusion

Realizing the full potential of **hyperlocal forecasting requires** significant **investments in technology, research, and infrastructure, coupled with stronger coordination** between public agencies, private entities, and local communities.

7.4. RIVER LINKING PROJECT

Why in the News?

Maharashtra government has **approved the Wainganga-Nalganga river linking project,** while PM also laid foundation stone of **Ken-Betwa Linking Project (KBLP)**.

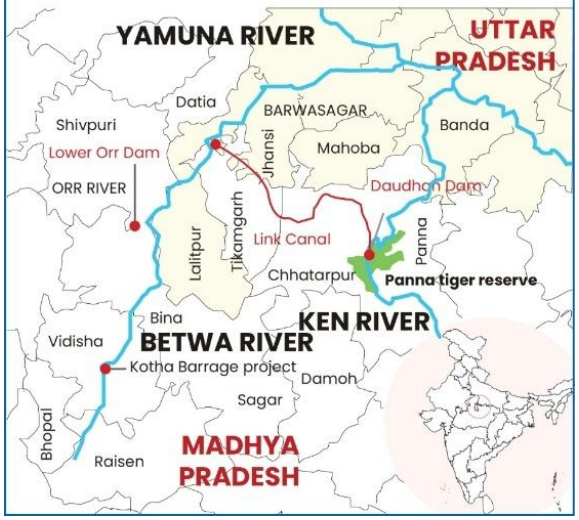
Interlinking of Rivers

- **National River Linking Project (NRLP)** aimed to link different surplus rivers of country with the deficient rivers so that the excess water from surplus region could be diverted to deficient region.
- **Background:** The **National Perspective Plan (NPP)** was prepared by the then Ministry of Irrigation (now Ministry of Jal Shakti) in **August 1980**.
  - Under the NPP, the National Water Development Agency (NWDA) has identified **30 links (16 under Peninsular Component & 14 under Himalayan Component)** for preparation of Feasibility Reports.
- In **2021**, Union Cabinet approved the **implementation of Ken Betwa river link (First interlinking river project)**.

Judicial pronouncement in context of Interlinking of Rivers

In Re: Networking of Rivers (2012): SC recognised the need for inter-linking of rivers in India and directed the Central Government to constitute a **Special Committee** for Inter-linking of Rivers which will be responsible for carrying out the inter-linking program.

Ken Betwa Link Project



Benefits of Interlinking of Rivers

- Aims to benefit **35 million hectares of irrigation,** especially in stressed regions like Bundelkhand.
- Help in generation of around **34000 Megawatt of hydro power** (National Perspective Plan).
- Use canals as **waterways for navigation.**
- **Others:** Employment generation, Growth of Service sector, **Increasing water availability** for drinking and industrial purposes etc.

Challenges of Interlinking of Rivers

- **State Water Dispute:** Interlinking Rivers requires consensus among states.
- **Environmental Impact:** E.g., **Diverting Ken's water to Betwa could disrupt local biodiversity**, with unknown impacts on the native fish population.
- **Loss of forests:** The proposed **Daudhan dam for Ken Betwa Link Project**, is expected to put over **10 per cent of the tiger habitat of Panna Tiger Reserve** under water.
- **Social and Economic Cost:** The Polavaram Link project, part of the interlinking of Mahanadi-Godavari-Krishna-Pennar-Cauvery-Vaigai Rivers, has affected around 1 lakh families, with 80% being tribals.
- **Bilateral Challenges:** Himalayan rivers like the Ganga and Brahmaputra flow across multiple international boundaries.

Government Steps

- **Task Force for Interlinking of River:** Ministry of Water Resources, River Development & Ganga Rejuvenation constituted in 2015 to look into the issues relating to Interlinking of Rivers.
- **Special Committee for Interlinking of Rivers:** Constituted in 2014, which formed 3 sub-committees
- **Group on Intra-state River Links (**In 2015) was formed to review key issues.
- **National Bank for Agriculture and Rural Development (NABARD) Funding:** For the Accelerated Area Benefited Programme component of Pradhan Mantri Krishi Sinchayee Yojana through Long Term Irrigation Fund.

Conclusion

Enhanced community involvement, smart technologies, stronger EIAs, and integrating traditional solutions like the Mangal Turbine are key to the ILR project's success. With these steps, ILR can enhance water management, boost agriculture, and drive sustainable, inclusive growth.

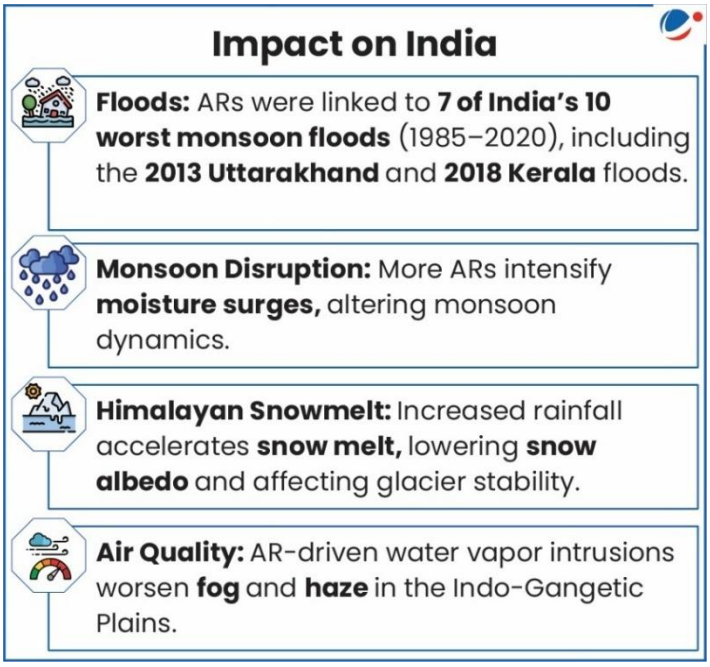
7.5. ATMOSPHERIC RIVERS

Why in the News?

Scientists warn that **intensification and increased frequency of atmospheric rivers** due to global warming is worsening extreme rainfall events and weather patterns.

What Are Atmospheric Rivers?

- Atmospheric Rivers (ARs), **often called "flying rivers,"** are long, narrow air corridors that **transport massive amounts of water vapor** from the tropics toward the poles.
  - Typically **2,000 km long**, **500 km wide** and **3 km deep**.
  - Embedded in **low-level jet streams** within **extra tropical cyclones**.
  - Account for **90% of global moisture transfer** outside the tropics.
- Recent Examples of Impact of ARs:
  - **New Zealand** experienced an **atmospheric river that caused record rainfall, flooding, and displacement (2022).**
  - **California** was struck by 12 atmospheric rivers between December 2022 and March 2023, resulting in intense rainfall, flooding, and wind damage.



Impact of Climate Change on ARs

- **Warming Atmosphere**: Higher temperatures increase moisture-holding capacity, amplifying rainfall intensity during AR events.
- **Frequency and Strength**: By 2100, ARs are projected to become **50–290% more frequent**, broader, and longer.
- **Poleward Shift**: Due to sea surface temperature changes and La Niña–induced changes in Walker circulation, ARs are moving **6–10° toward the poles**.
- **Dual Threat**: ARs can worsen **floods** in some regions while depriving others of rainfall, causing **drought-like conditions**.

Consequences of Shifting AR Patterns

- **Subtropics**: Longer droughts and declining water availability, affecting agriculture and water security.
- **Higher Latitudes**: More extreme precipitation, floods, and faster **sea-ice melting**, especially in the **Arctic**.
- **Indian Ocean Region**: **Warming seas** and increased **vapour pressure deficit (VPD)** enhance evaporation, fueling AR formation and landfall.

Conclusion

Atmospheric Rivers, once known for their role in replenishing freshwater, are now becoming **agents of extreme climate disruption** (Intensified by **climate change). Urgent climate action, better forecasting, and region-specific mitigation strategies** are essential to manage the evolving threat posed by atmospheric rivers**.**

7.6. KEYWORDS

Keywords				
El Niño southern oscillation (ENSO)	Global Ocean Circulation	Pacific Ring of Fire	Dead Zones	Planetary Boundaries
Hyper Local Weather Forecasting	Ken-Betwa Linking Project (KBLP)	Aquatic Deoxygenation	Ocean Acidification	Polar Vortex

7.7. PRACTICE QUESTION

Answer Canvas

Climatic happenings in India are closely linked to the El Niño southern oscillation (ENSO). How is Indian summer monsoon rainfall affected by the ENSO?

Introduction	Body Part 1	Body Part 2	Conclusion
About ENSO	El Nino Monsoon relationship	How El Nino impacts Monsoon	Importance of studying the linkage

8. ENVIRONMENT PREVIOUS YEAR QUESTION 2013-2024 (SYLLABUS-WISE)

GS I: Indian Heritage and Culture, History and Geography of the World and Society

Salient features of world's physical geography

Climatology

- What are aurora australis and aurora borealis? How are these triggered? (GS I 2024, 15 marks)
- Troposphere is a very significant atmospheric layer that determines weather processes. How? (GS-I 2022, 15 Marks)
- What characteristics can be assigned to monsoon climate that succeeds in feeding more than 50 percent of the world population residing in Monsoon Asia? (GS-I 2017, 15 Marks)
- Discuss the concept of air mass and explain its role in macro-climatic changes. (GS-I 2016, 12.5 Marks)
- How far do you agree that the behaviour of the Indian monsoon has been changing due to humanizing landscape? Discuss. (GS-I 2015, 12.5 Marks)
- Mumbai, Delhi and Kolkata are the three Mega cities of the country but the air pollution is much more serious problem in Delhi as compared to the other two. Why is this so? (GS-I 2015, 12.5 Marks)
- Most of the unusual climatic happenings are explained as an outcome of the El-Nino effect. Do you agree? (GS-I 2014, 10 Marks)
- What do you understand by the phenomenon of 'temperature inversion' in meteorology? How does it affect weather and the habitants of the place? (GS-I 2013, 5 Marks)
- Bring out the causes for the formation of heat islands in the urban habitat of the world. (GS-I 2013, 5 Marks)

Geomorphology

- How are the fjords formed? Why do they constitute some of the most picturesque area of the world? (GS-I 2023, 10 marks)
- Define mantle plume and explain its role in plate tectonics. (GS-I 2018, 10 Marks)
- What do you understand by the theory of continental drift? Discuss the prominent evidences in its support. (GS-I 2013, 5 Marks)

Hydrology

- The groundwater potential of the Gangetic valley is on a serious decline. How may it affect the food security of India? (GS I 2024, 15 marks)
- Why is the world today confronted with a crisis of availability of and access to freshwater resources? (GS-I 2023, 10 marks)
- What are the forces that influence ocean currents? Describe their role in fishing industry of the world. (GS-I 2022, 15 Marks)
- What are the environmental implications of the reclamation of the water bodies into urban land use? Explain with examples. (GS-I 2021, 10 Marks)
- The interlinking of rivers can provide viable solutions to the multi-dimensional inter-related problems of droughts, floods and interrupted navigation. Critically examine. (GS-I 2020, 15 Marks)
- Discuss the geophysical characteristics of Circum-Pacific Zone. (GS-I 2020, 10 Marks)
- How do ocean currents and water masses differ in their impacts on marine life and coastal environment? (GS-I 2019, 15 Marks)
- What is water stress? How and why does it differ regionally in India? (GS-I 2019, 15 Marks)
- What are the consequences of spreading of 'Dead Zones' on marine ecosystem? (GS-I 2018, 10 Marks)
- "The ideal solution of depleting ground water resources in India is water harvesting system." How can it be made effective in urban areas? (GS-I 2018, 15 Marks)

- Defining blue revolution, explain the problems and strategies for pisciculture development in India. (GS-I 2018, 15 Marks)
- Account for variations in oceanic salinity and discuss its multi-dimensional effects. (GS-I 2017, 15 Marks)
- In what way micro-watershed development projects help in water conservation in drought-prone and semi-arid regions of India? (GS-I 2016, 12.5 Marks)
- Explain the factors responsible for the origin of ocean currents. How do they influence regional climates, fishing and navigation? (GS-I 2015, 12.5 Marks)
- India is well endowed with fresh water resources. Critically examine why it still suffers from water scarcity. (GS-I 2015, 12.5 Marks)

Distribution of key natural resources across the world (including South Asia and the Indian sub-continent)

- Comment on the resource potentials of the long coastline of India and highlight the status of natural hazard preparedness in these areas.(GS-I 2023, 15 marks)
- Describing the distribution of rubber producing countries, indicate the major environmental issues faced by them. (GS-I 2022, 15 Marks)
- Examine the potential of wind energy in India and explain the reasons for their limited spatial spread. (GS-I 2022, 10 Marks)
- India has immense potential of solar energy though there are regional variations in its development. Elaborate. (GS-I 2020, 15 Marks)
- Why is India taking keen interest in resources of Arctic region? (GS-I 2018, 10 Marks)
- The effective management of land and water resources will drastically reduce the human miseries. Explain. (GS-I 2016, 12.5 Marks)
- What are the economic significances of discovery of oil in Arctic Sea and its possible environmental consequences? (GS-I 2015, 12.5 Marks)
- Whereas the British planters had developed tea gardens all along the Shivaliks and Lesser Himalayas from Assam to Himachal Pradesh, in effect they did not succeed beyond the Darjeeling area. Explain. (GS-I 2014, 10 Marks)
- How does India see its place in the economic space of rising natural resources rich Africa? (GS-I 2014, 10 Marks)
- Critically evaluate the various resources of the oceans which can be harnessed to meet the resource crisis in the world. (GS-I 2014, 10 Marks)
- It is said that India has substantial reserves of shale oil and gas, which can feed the needs of the country for quarter century. However, tapping of the resource does not appear to be high on the agenda. Discuss critically the availability and issues involved. (GS-I 2013, 10 Marks)
- With growing scarcity of fossil fuels, the atomic energy is gaining more and more significance in India. Discuss the availability of raw material required for the generation of atomic energy in India and in the world. (GS-I 2013, 10 Marks)

Factors responsible for the location of primary, secondary, and tertiary sector industries in various parts of the world (including India)

- Identify and discuss the factors responsible for diversity of natural vegetation in India. Assess the significance of wildlife sanctuaries in rain forest regions of India. (GS-I 2023, 15 marks)
- Account for the present location of iron and steel industries away from the source of raw material, by giving examples. (GS-I 2020 10, Marks)
- Discuss the factors for localisation of agro-based food processing industries of North-West India. (GS-I 2019, 10 Marks)
- Petroleum refineries are not necessarily located nearer to crude oil producing areas, particularly in many of the developing countries. Explain its implications. (GS-I 2017, 15 Marks)
- "In spite of adverse environmental impact, coal mining is still inevitable for development." Discuss (GS-I 2017, 10 Marks)

- Why did the Green Revolution in India virtually by-pass the eastern region despite fertile soil and good availability of water? (GS-I 2014, 10 Marks)
- Account for the change in the spatial pattern of the Iron and Steel industry in the world. (GS-I 2014, 10 Marks)
- Do you agree that there is a growing trend of opening new sugar mills in southern states of India? Discuss with justification. (GS-I 2013, 5 Marks)
- Analyze the factors for the highly decentralized cotton textile industry in India. (GS-I 2013, 5 Marks)

Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclone etc.

Cyclones/Tornedos/Tsunamis and other Atmospheric Phenomena

- What is the phenomenon of 'cloudbursts? Explain. (GS I 2024, 10 marks)
- What is a twister? Why are the majority of twisters observed in areas around the Gulf of Mexico? (GS I 2024, 15 marks)
- Discuss the meaning of colour-coded weather warnings for cyclone prone areas given by India Meteorological department. (GS-I 2022, 10 Marks)
- Tropical cyclones are largely confined to South China Sea, Bay of Bengal and Gulf of Mexico. Why? (GS-I 2014, 10 Marks)
- The recent cyclone on the east coast of India was called 'Phailin'. How are the tropical cyclones named across the world? Elaborate. (GS-I 2013, 5 Marks)

Landslides

- Differentiate the causes of landslides in the Himalayan region and Western Ghats. (GS-I 2021, 10 Marks)
- "The Himalayas are highly prone to landslides." Discuss the causes and suggest suitable measures of mitigation. (GS-I 2016, 12.5 Marks)
- Bring out the causes for more frequent occurrence of landslides in the Himalayas than in the Western Ghats. (GS-I 2013, 5 Marks)

Volcanic Activity

- Mention the global occurrence of volcanic eruptions in 2021 and their impact on regional environment. (GS-I 2021, 10 Marks)

Flooding

- Account for the huge flooding of million cities in India including the smart ones like Hyderabad and Pune. Suggest lasting remedial measures. (GS-I 2020, 15 Marks)
- In what way can floods be converted into a sustainable source of irrigation and all-weather inland navigation in India? (GS-I 2017, 15 Marks)
- Major cities of India are becoming vulnerable to flood conditions. Discuss. (GS-I 2016, 12.5 Marks)

Geographical features and their location

- Briefly mention the alignment of major mountain ranges of the world and explain their impact on local weather conditions, with examples. (GS-I 2021, 15 Marks)
- The process of desertification does not have climatic boundaries. Justify with examples. (GS-I 2020, 10 Marks)
- Why are the world's fold mountain systems located along the margins of continents? Bring out the association between the global distribution of fold mountains and the earthquakes and volcanoes. (GS-I 2014, 10 Marks)
- Explain the formation of thousands of islands in Indonesian and Philippines archipelagos. (GS-I 2014, 10 Marks)
- Major hot deserts in northern hemisphere are located between 20-30 deg N latitudes and on the western sides of the continents. Why? (GS-I 2013, 10 Marks)
- There is no formation of deltas by rivers on the Western Ghats. Why? (GS-I 2013, 5 Marks)

Changes in critical geographical features (including water-bodies and ice-caps) and in flora and fauna and the effects of such changes

- What is sea surface temperature rise? How does it affect the formation of tropical cyclones? (GS I 2024, 10 marks)
- Discuss the consequences of climate change on the food security in tropical countries. (GS-I 2023, 10 marks)
- How do the melting of the Arctic ice and glaciers of the Antarctic differently affect the weather patterns and human activities on the Earth? Explain. (GS-I 2021, 10 Marks)
- How will the melting of Himalayan glaciers have a far-reaching impact on the water resources of India? (GS-I 2020, 10 Marks)
- Examine the status of forest resources of India and its resultant impact on climate change. (GS-I 2020, 15 Marks)
- Assess the impact of global warming on the coral life system with examples. (GS-I 2019, 10 Marks)
- How can the mountain ecosystem be restored from the negative impact of development initiatives and tourism? (GS-I 2019, 15 Marks)
- Discuss the causes of depletion of mangroves and explain their importance in maintaining coastal ecology. (GS-I 2019, 10 Marks)
- Mention the advantages of the cultivation of pulses because of which the year 2016 was declared as the International Year of Pulses by the United Nations. (GS-I 2017, 10 Marks)
- How does the cryosphere affect global climate? (GS-I 2017, 10 Marks)
- The states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand are reaching the limits of ecological carrying capacity due to tourism. Critically evaluate. (GS-I 2015, 12.5 Marks)
- Bring out the relationship between the shrinking Himalayan glaciers and the symptoms of climate change in the Indian sub-continent. (GS-I 2014, 10 Marks)

GS III: Technology, Economic Development, Bio diversity, Environment, Security and Disaster Management

Conservation

Biodiversity

- Comment on the National Wetland Conservation Programme initiated by the Government of India and name a few India's wetlands of international importance included in the Ramsar Sites. (GS-III 2023, 15 marks)
- How is the government of India protecting traditional knowledge of medicine from patenting by pharmaceutical companies? (GS-III 2019, 15 Marks)
- Define the concept of carrying capacity of an ecosystem as relevant to an environment. Explain how understanding this concept is vital while planning for sustainable development of a region. (GS-III 2019, 15 Marks)
- What is wetland? Explain the Ramsar concept of 'wise use' in the context of wetland conservation. Cite two examples of Ramsar sites from India. (GS-III 2018, 10 Marks)
- How does biodiversity vary in India? How is the Biological Diversity Act, 2002 helpful in conservation of flora and fauna? (GS-III 2018, 15 Marks)

Renewable and Alternate Energy

- Discuss several ways in which microorganisms can help in meeting the current fuel shortage.(GS-III 2023, 10 marks)
- The adoption of electric vehicles is rapidly growing worldwide. How do electric vehicles contribute to reducing carbon emissions and what are the key benefits they offer compared to traditional combustion engine vehicles? (GS-III 2023, 15 marks)
- Do you think India will meet 50 percent of its energy needs from renewable energy by 2030? Justify your answer. How will the shift of subsidies from fossil fuels to renewables help achieve the above objective? Explain. (GS-III 2022, 15 Marks)

- Describe the benefits of deriving electric energy from sunlight in contrast to the conventional energy generation. What are the initiatives offered by our Government for this purpose? (GS-III 2020, 15 Marks)
- One of the intended objectives of Union Budget 2017-18 is to 'transform, energize and clean India'. Analyse the measures proposed in the Budget 2017-18 to achieve the objective. (GS-III 2017, 15 Marks)
- Give an account of the current status and the targets to be achieved pertaining to renewable energy sources in the country. Discuss in brief the importance of National Programme on Light Emitting Diodes (LEDs). (GS-III 2016, 12.5 Marks)

Sustainable Agriculture

- What is Integrated Farming System? How is it helpful to small and marginal farmers in India? (GS-III 2022, 15 Marks)
- How and to what extent would micro-irrigation help in solving India's water crisis? (GS-III 2021, 10 Marks)
- How far is Integrated Farming System (IFS) helpful in sustaining agricultural production? (GS-III 2019, 10 Marks)
- Sikkim is the first 'Organic State' in India. What are the ecological and economic benefits of Organic State? (GS-III 2018, 10 Marks)

Environment Pollution and Degradation

Climate Change

- The Intergovernmental Panel on Climate Change (IPCC) has predicted a global sea level rise of about one metre by AD 2100. What would be its impact in India and the other countries in the Indian Ocean region? (GS-III 2023, 15 marks)
- Discuss global warming and mention its effects on the global climate. Explain the control measures to bring down the level of greenhouse gases which cause global warming, in the light of the Kyoto Protocol, 1997. (GS-III 2022, 15 Marks)
- Describe the major outcomes of the 26th session of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC). What are the commitments made by India in this conference? (GS-III 2021, 15 Marks)
- Explain the purpose of the Green Grid Initiative launched at World Leaders Summit of the COP26 UN Climate Change Conference in Glasgow in November, 2021. When was this idea first floated in the International Solar Alliance (ISA)? (GS-III 2021, 10 Marks)
- 'Climate Change' is a global problem. How India will be affected by climate change? How Himalayan and coastal states of India will be affected by climate change? (GS-III 2017, 15 Marks)
- Should the pursuit of carbon credits and clean development mechanisms set up under UNFCCC be maintained even though there has been a massive slide in the value of a carbon credit? Discuss with respect to India's energy needs for economic growth. (GS-III 2014 12.5, Marks)

Air Pollution

- Discuss in detail the photochemical smog emphasizing its formation, effects and mitigation. Explain the 1999 Gothenburg Protocol. (GS-III 2022, 10 Marks)
- Describe the key points of the revised Global Air Quality Guidelines (AQGs) recently released by the World Health Organisation (WHO). How are these different from its last update in 2005? What changes in India's National Clean Air Programme are required to achieve these revised standards? (GS-III 2021, 10 Marks)
- What are the key features of the National Clean Air Programme (NCAP) initiated by the Government of India? (GS-III 2020, 15 Marks)

Water/River Pollution

- Industrial pollution of river water is a significant environmental issue in India. Discuss the various mitigation measures to deal with this problem and also the government's initiatives in this regard. (GS III 2024, 10 marks)

- What are the salient features of the Jal Shakti Abhiyan launched by the Government of India for water conservation and water security? (GS-III 2020, 10 Marks)
- Suggest measures to improve water storage and irrigation system to make its judicious use under depleting scenario. (GS-III 2020, 15 Marks)
- Elaborate the impact of National Watershed Project in increasing agricultural production from water-stressed areas. (GS-III 2019, 10 Marks)
- Discuss the Namami Gange and National Mission for Clean Ganga (NMCG) programmes and causes of mixed results from the previous schemes. What quantum leaps can help preserve the river Ganga better than incremental inputs? (GS-III 2015, 12.5 Marks)
- Enumerate the National Water Policy of India. Taking river Ganges as an example, discuss the strategies which may be adopted for river water pollution control and management. What are the legal provisions of management and handling of hazardous wastes in India? (GS-III 2013, 10 Marks)

Other types of Environmental Pollution and degradation

- What is oil pollution? What are its impacts on the marine ecosystem? In what way is oil pollution particularly harmful for a country like India? (GS-III 2023, 10 marks)
- Explain the causes and effects of coastal erosion in India. What are the available coastal management techniques for combating the hazard? (GS-III 2022, 15 Marks)
- Coastal sand mining, whether legal or illegal, poses one of the biggest threats to our environment. Analyse the impact of sand mining along the Indian coasts, citing specific examples. (GS-III 2019, 10 Marks)
- What are the impediments in disposing the huge quantities of discarded solid wastes which are continuously being generated? How do we remove safely the toxic wastes that have been accumulating in our habitable environment? (GS-III 2018, 10 Marks)

Environmental Impact Assessment

- What role do environmental NGOs and activists play in influencing Environmental Impact Assessment (EIA) outcomes for major projects in India? Cite four examples with all important details. (GS III 2024, 10 marks)
- How does the draft Environmental Impact Assessment (EIA) Notification, 2020 differ from the existing EIA Notification, 2006? (GS-III 2020, 10 Marks)
- Not many years ago, river linking was a concept but it is becoming reality in the country. Discuss the advantages of river linking and its possible impact on the environment. (GS-III 2017, 10 Marks)
- Rehabilitation of human settlements is one of the important environmental impacts which always attracts controversy while planning major projects. Discuss the measures suggested for mitigation of this impact while proposing major developmental projects. (GS-III 2016, 12.5 Marks)
- Environmental Impact Assessment studies are increasingly undertaken before a project is cleared by the Government. Discuss the environmental impacts of coal-fired thermal plants located at coal pitheads. (GS-III 2014,12.5 Marks)
- What are the consequences of Illegal mining? Discuss the Ministry of Environment and Forest's concept of GO AND NO GO zones for coal mining sector. (GS-III 2013, 10 Marks)

Disaster and disaster management

- What is disaster resilience? How is it determined? Describe various elements of a resilience framework. Also mention the global targets of Sendai Framework for Disaster Risk Reduction (2015-2030). (GS III 2024, 15 marks)
- Flooding in urban areas is an emerging climate-induced disaster. Discuss the causes of this disaster. Mention the features of two such major floods in the last two decades in India. Describe the policies and frameworks in India that aim at tackling such floods. (GS III 2024, 15 marks)
- Dam failures are always catastrophic, especially on the downstream side, resulting in a colossal loss of life and property. Analyze the various causes of dam failures. Give two examples of large dam failures.(GS-III 2023, 10 marks)

- Explain the mechanism and occurrence of cloudburst in the context of the Indian subcontinent. Discuss two recent examples. (GS-III 2022, 10 Marks)
- Discuss about the vulnerability of India to earthquake related hazards. Give examples including the salient features of major disasters caused by earthquakes in different parts of India during the last three decades. (GS-III 2021, 10 Marks)
- Describe the various causes and the effects of landslides. Mention the important components of the National Landslide Risk Management Strategy. (GS-III 2021, 15 Marks)
- Discuss the recent measures initiated in disaster management by the Government of India departing from the earlier reactive approach. (GS-III 2020, 15 Marks)
- Vulnerability is an essential element for defining disaster impacts and its threat to people. How and in what ways can vulnerability to disasters be characterized? Discuss different types of vulnerability with reference to disasters. (GS-III 2019, 10 Marks)
- Disaster preparedness is the first step in any disaster management process. Explain how hazard zonation mapping will help in disaster mitigation in the case of landslides. (GS-III 2019, 15 Marks)
- Describe various measures taken in India for Disaster Risk Reduction (DRR) before and after signing 'Sendai Framework for DRR (2015-2030)'. How is this framework different from 'Hyogo Framework for Action, 2005'? (GS-III 2018, 15 Marks)
- On December 2004, tsunami brought havoc on 14 countries including India. Discuss the factors responsible for occurrence of Tsunami and its effects on life and economy. In the light of guidelines of NDMA (2010) describe the mechanisms for preparedness to reduce the risk during such events. (GS-III 2017, 15 Marks)
- The frequency of urban floods due to high intensity rainfall is increasing over the years. Discussing the reasons for urban floods, highlight the mechanisms for preparedness to reduce the risk during such events. (GS-III 2016, 12.5 Marks)
- With reference to National Disaster Management Authority (NDMA) guidelines, discuss the measures to be adopted to mitigate the impact of recent incidents of cloudbursts in many places of Uttarakhand. (GS-III 2016, 12.5 Marks)
- The frequency of earthquakes appears to have increased in the Indian subcontinent. However, India's preparedness for mitigating their impact has significant gaps. Discuss various aspects. (GS-III 2015, 12.5 Marks)
- Drought has been recognized as a disaster in view of its spatial expanse, temporal duration, slow onset and lasting effects on vulnerable sections. With a focus on the September 2010 guidelines from the National Disaster Management Authority (NDMA), discuss the mechanisms for preparedness to deal with likely El Nino and La Nina fallouts in India. (GS-III 2014, 12.5 Marks)
- How important are vulnerability and risk assessment for pre-disaster management? As an administrator, what are key areas that you would focus on in a Disaster Management System? (GS-III 2013, 10 Marks)

9. APPENDIX: KEY DATA AND FACTS

Climate Change	

India and Climate Action	• **India's Nationally Determined Contributions (NDCs) Targets for 2030**
	  ○ **Reduce Emissions Intensity of its GDP by 45%,** from 2005 level.
	  ○ Achieve **~50% cumulative electric power** installed capacity from **non-fossil fuel**-based resources.
	  ○ **Additional carbon sink of 2.5-3 billion tonnes of CO_2** through additional forest tree cover.
	• **Achievements/Progress**
	  ○ **Reduced Emission Intensity of GDP:** by **36%** (Between 2005 to 2020)
	  ○ **Share of non-fossil sources:** 46.52% of installed capacity (Oct 2024).
	  ○ **Additional carbon sink of 2.29 billion tonnes of CO_2 created** through forest and tree cover (2005 to 2021)

Key Outcomes of UNFCCC COP29	• **New Collective Quantified Goal on Climate Finance (NCQG)**: Mobilize at least $300 billion annually for developing countries by 2035. • Finalized rules for **Article 6 of Paris Agreement (International carbon markets).** • Launched **Baku Adaptation Road Map** and **Baku High-Level Dialogue on Adaptation** • **Lima Work Programme on Gender and Climate Change** extended for 10 years.
Climate Change impacts on Vulnerable Sections	• **Women: 80% of people displaced** by climate change are women. (UN figures) • **Indigenous Communities:** 40% of land occupied by Indigenous peoples lies in areas of high biodiversity affected by Climate Change. • **Marginal Farmers:** Over 1/3rd of marginal farmers had to cope with extreme weather events at least twice in five years.
Climate Change impacts on Small Island Developing States (SIDS)	• SIDS lost **US$153 billion** due to weather extremes (from 1970-2020). • Least responsible for the **climate crisis (1% of Global emissions)**.
Climate Change impacts on Socio-Economic Indicators	• **Education:** Increase of **1°C in outdoor temperature** can result in a substantial decline in test scores. *(World Bank)* • **Health:** 85% of NCD deaths caused by Climate Change and air pollution.
Sea Level Rise	• From 2014-2023, **global mean sea level rose** at a rate of **4.77 mm per year.** • **>10% of land** in Mumbai, Yanam, and Thoothukudi would be **submerged** by 2040.
Climate Change impacts on Cryosphere	• **Greenland Ice Sheet**: Losing 30 million tons of ice/hour. ***(State of Cryosphere 2024)*** • **Venezuela** lost all its glaciers (2024) • If all glaciers and ice sheets melted, **global sea level would rise by more than 60m** (*NASA*).
Climate Change Mitigation	• **Global GHG emissions set a new record in 2023** (with 1.3% increase from 2022 levels) *(Emissions Gap Report 2024)* • **India:** 3rd in total GHG emissions **(UNEP's Emissions Gap Report, 2024).** • **Need:** Cuts of 42% in emissions by 2030 and 57% by 2035 (below 2019 levels) to get on track for 1.5°C. (*Emissions Gap Report 2024*)

Climate Finance	• **India's climate finance needs**
	  ○ **~USD 250 billion per year till 2047** needed for energy transition. (NITI Aayog)
	  ○ **USD 10 trillion** needed to achieve net-zero by 2070.
	• **Inadequate finance:** Fivefold increase needed by **2030** under 1.5°C scenario *(GLCF 2024)*.
	• **Development:** Loss and Damage Fund (LDF), agreed upon during COP27, operationalized in COP28.

Carbon Trading and Market	• **Emissions Removal by 2030 by Carbon markets:** 50% emissions at no additional cost. • **Key Developments:** Article 6 of Paris Agreement finalized in COP29. ○ **Mechanisms:** 2 Market based- Bilateral deals between countries and a new global offset market and 1 Non-Market based approach. • **Key Indian Mechanisms:** Compliance and Offset mechanisms under Carbon Credit Trading Scheme (CCTS), 2023; Green Credit Programme (GCP).
Industrial Decarbonisation	• **Emissions from Industrial Processes and Product Use**: 8% of the total emissions in India. *(India's 4th Biennial Update Report)* • **Steel Sector:** 12% of India's CO_2 emissions.
Methane Emissions	• **Methane:** 2nd largest contributor to climate warming after CO_2. • **Methane's Global Warming Potential (GWP):** 28 times higher than CO_2.
Greenwashing	• **Making a product or policy seem more environmentally friendly** or less damaging than it is in reality. • **Types:** Greenhushing, Greenrinsing, Greenlabeling, Greenlighting etc. • **Example:** In 2015, Volkswagen used **software to manipulate emission tests in its Clean Diesel cars.** • **Initiatives in India:** Standard for eco-labelling of products and services by BIS; Consumer Protection Act, 2019; SEBI's BRSR norms.
Environmental Pollution and Degradation	
Coal Thermal Power Plants	• **Key Pollutants from TPP:** GHGs: Sulphur dioxide; Carbon dioxide (CO_2); Nitrogen oxide, Particulates (Including Fly ash), Heavy metals like Mercury and bottom ash. • Coal accounts for **55% of the country's energy need** • **Measures to Reduce Emissions:** Perform, Achieve, Trade (PAT) Scheme; Biomass Co-firing Policy; Ultra Supercritical/Supercritical units over Subcritical Thermal Units.
Urban Air Pollution in India	• **Status: 6 of 10 most polluted cities** of the world in India. **(*2024 World Air Quality Report*).** • **Impact:** Economic Loss **~$36.8 billion/year (1.36% of GDP, 2019** – *World Bank*) due to premature deaths and illness. • **Initiatives:** National Clean Air Programme (2019); Graded Response Action Plan; Air Act (1986); SAFAR Portal.

Extreme Water Stress	• **Status:**
	  ○ **India** has **18%** of World population and but only **4%** of its water resources.
	  ○ **~11% of groundwater** units assessed are **'Over-exploited'.** *(Dynamic Ground Water Resource Assessment Report, 2024)*
	• **Impacts: 31% of global GDP** to be exposed to high water stress by **2050. (WRI)**
	• **Initiatives:** National Water Mission; Jal Jeevan Mission (JJM); Atal Bhujal Yojana (2020); National Aquifer Mapping and Management Program (NAQUIM), etc.

Water (Prevention and Control of Pollution) (Manner of Holding Inquiry and Imposition of Penalty) rules, 2024	• **Key Features: Offenses and violations** of the Act **decriminalized** and replaced with **penalties, Authorized Officers** appointed by Centre, to adjudicate offenses. • **Water (Prevention and Control of Pollution) Act 1974:** Created **Central Pollution Control Boards (CPCB)** and **State Pollution Control Boards (SPCB)**
Ground Water Pollution	• **Status (India) : ~56%** of districts have nitrates beyond safe limit of **45 mg/L in groundwater (Annual Ground Water Quality Report, 2025).** • **Major Contaminants: Nitrate** (Rajasthan), **Arsenic** (West Bengal), **Uranium** (Rajasthan)
Community Participation in Water Conservation	• **Examples: Neeru-Chettu** (Andhra Pradesh); **Jal Jeevan Hariyali** (Bihar); **Mission Kakatiya** (Telangana); **Jal Hi Jeevan Hai** (Haryana), etc. • **Traditional water storage systems in India: Jal Mandir** (Gujarat); **Khatri, Kuhl** (Himachal Pradesh); **Zabo** (Nagaland); **Eri, Ooranis** (Tamil Nadu); **Dongs** (Assam), etc.
Water Recycling and Reuse in India	• **Untreated Wastewater: ~72% of India's wastewater** ends up in nearby rivers, lakes, etc. • **Water Reuse Technologies:** Membrane Bioreactor; Ultrafiltration; Reverse Osmosis and Disinfection Technologies, etc. • **Initiatives:** National Framework on Safe Reuse of Treated Water, 2022; National Water Policy-2012; 'Jal hi Amrit' initiative under AMRUT2.0.
Land Degradation	• **Status:** ○ **India**: 29% degraded land; 25% land undergoing desertification ○ **Global**: 75% of soils degraded • **Targets:** ○ **Global:** Restore **1 billion hectares degraded land by 2030 (***Global- Land Degradation Neutrality (LDN) target setting programme)* ○ **India:** Restore **26 million hectares by 2030.** • **Initiatives:** Global [Bonn Challenge (restore 150 million by 2020 and 350 million hectares by 2030)] India (Desertification and Land Degradation Atlas of India; Soil Health Card, PM Krishi Sinchayee Yojana, etc.).
Plastic Pollution in India	• **Status:** ○ Ranks **3rd** globally in generation of **single-use plastic (SUP).** • **Initiatives:** Plastic Waste Management Rules; Extended Producer Responsibility on Plastic Packaging, 2022; Global (Global Partnership on Plastic Pollution and Marine Litter (GPML), UNEP Plastics Initiative, etc.).
Solid Waste Management (SWM) in India	• **Current Status (TERI Study): Annual waste generation-** 62+ million tons; **Collection-** 43 million tons; **Treatment-** Only 12 million tons. • **Initiatives: SWM Rules, 2016** (mandates waste segregation into 3 streams); Swachh Bharat Mission (SBM-U) 2.0; Garbage Free Star Rating Protocol, etc.
E-Waste Management in India	• **Status: 3rd largest generator** following China and USA *(Global E-Waste Monitor 2024 report).* • **Initiatives:** Extended Producer Responsibility (EPR) under E-waste (Management and Handling) Rules, 2011; Producer responsibility Organization (PRO) under E-Waste (Management) Rules, 2016; Global (Basel Convention; E-Waste Coalition, 2018).

Oil Spills	• **Meaning: Accidental** operational spills of oil from **ships.** • **Recent Occurrences:** Philippine oil tanker near Manila (2024); MSC Elsa 3 sinking near Kochi, Kerala (2025); Near Kerch Strait (2024). • **Initiatives:** National Oil Spill Disaster Contingency Plan (1996); Merchant Shipping Act, 1958; International Convention for the Prevention of Pollution from Ships or MARPOL (India is a signatory); Bioremediation (E.g., Oilzapper & Oilivorous-S).
Revised Classification of Industries	• **New Classification:** CPCB classified into **Red**, **Orange**, **Green**, **White** and **Blue category (Newly Introduced).** • **Blue Category:** Includes **Essential Environmental Services (ESSs)** that control, abate and mitigate pollution from **Domestic and Industrial activities.** • CPCB has followed a **revised methodology** based on **Pollution Index (PI).** ○ **Existing Categories: Red** (PI> 80); **Orange** (55 ≤ PI < 80); **Green** (25 ≤ PI < 55); **White** (PI < 25).
Waste to Wealth	• **Techniques:** Biological Processing; Biomethanation; Thermal/Waste to Energy Processing. • **Initiatives:** Solid Waste Management Rules, 2016; Plastic Waste Management Rules, 2022; National Bioenergy Energy Programme, etc.
Sustainable Development	
Circular Economy (CE)	• **Current situation** Only **7.2 % of the global economy** is circular with a declining trend (Circularity Gap report 2023) • **Economic Benefits:** Save **11% of GDP** by **2030 & 30%** by **2050.** (Economic Survey 2024-25) • **Initiatives:** National Resource Efficiency Policy (NREP), 2019; Extended Producer Responsibility (EPR), Swachh Bharat Mission, Ideas for LiFE (Lifestyle for Environment), etc.

National Mission on Natural Farming (NMNF)	• **Key Components:** Beejamrit, Jivamrit, Mulching, Whapasa, Plant Protection.
	• **National Mission on Natural Farming (NMNF):** standalone centrally sponsored scheme.
	  ○ **15,000 willing clusters** in Gram Panchayats.
	  ○ **10,000 Input Resource Centres (BRCs)**
	  ○ **Reach 1 crore** farmers and initiate Natural Farming (NF) in **7.5 lakh Ha** area.
	• **Other Initiatives:** National Centre for Management of Agriculture Extension (MANAGE); Andhra Pradesh Community Managed Natural Farming (APCNF).

Agroforestry	• **Definition in India:** Tree cover percent **>10%** on agricultural land. • **Status in India:** 8.65% of India's total geographical area. • **Traditional Methods: Itteri system** (Tamil Nadu); **Khejri System** (Rajasthan); **Taungya system** (Kerala, West Bengal, Orissa, Karnataka, Northeast). • **Initiatives:** National Agroforestry Policy 2014; Sub-Mission on Agroforestry (SMAF) Under National Mission for Sustainable Agriculture (NMSA); GROW initiative (NITI Aayog).

Indian Himalayan Region (IHR)	• **Issues:**
	  ○ Himalayan states lost of **1,072 sq km of forest cover (2019 -2021)**
	  ○ **Gangotri glacier** (Uttarakhand Himalaya) retreated by **1,700 metres between 1935 and 2022.**
	• **Supreme Court (SC) cases:** MK Ranjitsinh vs. Union of India case (2024); Ashok Kumar Raghav vs Union of India case (2023); State of Telangana vs Mohd. Abdul Qasim case.

	• **Initiatives:** National Mission for Sustaining the Himalayan Ecosystem (NMSHE); Global Snow Leopard Ecosystem Protection Program (GSLEP); International Big Cats Alliance (IBCA), etc.
Renewable Energy and Alternative Energy Resources	
Renewable Energy (RE) in India	**India's RE targets** • Achieve **50%** cumulative **electric power installed** by 2030 from renewables. (INDC) • **500 GW of renewable energy** installed capacity by 2030. **(Panchamrita targets)** **Progress** • **Installed Capacity of Renewable energy** (Incl. Hydro): **226 GW** (43.7% in total) *(Power Ministry, June 2025)*
Just Energy Transition	• **Status in India:** Coal-based Thermal Power Plants produce more than **70% of electricity**. • **WEF Energy Transition Index (ETI):** India's rank 71/118 countries (63rd in 2024). • **Initiatives:** Pradhan Mantri Khanij Kshetra Kalyan Yojana (PMKKKY); National Programme on High Efficiency Solar PV Modules; ILO Guidelines for a Just Transition.
Nuclear Energy Mission	• **Aim:** Development of **small modular reactors (SMRs),** setting up of at least 5 SMRs by **2033**. • **Target: 100 GW** of nuclear power capacity by **2047.** • **Current Installed nuclear energy capacity:** 8.18 GW (January 2025)

Solar Energy in India	• **Status in India:**
	  ○ **Solar energy capacity: 110 GW** (*Power Ministry, June 2025*)
	  ○ India ranks **5th** in Solar Power Installed Capacity globally.
	  ○ **Potential:** 748 Giga Watt peak (*National Institute of Solar Energy*).
	• **Initiatives:** PM Surya Ghar Muft Bijli Yojana; Grid Connected Solar Rooftop Programme; Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM).

International Solar Alliance (ISA)	• **Origin:** 2015 at Paris **(COP-21 of the UNFCCC)** by India and France.
	• **Guided by 'Towards 1000' strategy:**
	  ○ Mobilise **USD 1,000 billion investments** in solar energy solutions by **2030**
	  ○ Installation of **1,000 GW** of **solar energy capacity.**
	• **Other ISA Initiatives:** One Sun One World One Grid (OSOWOG); MIGA-ISA Solar Facility; Global Solar Facility.

Offshore Wind Energy in India	• **Long-term target:** Addition of **30 GW** by **2030.** • **Current Installed Capacity: ~51 GW** (10.7% of total installed capacity) (June 2024). • **Initiatives:** National Offshore Wind Energy Policy, 2015 and Wind-Solar Hybrid Policy, Viability Gap Funding (VGF) scheme for Offshore Wind Energy Projects.
Hydrogen Energy in India	• **Status:** 6.5 million metric tonnes per annum (MMTPA). • **Initiatives:** Hydrogen-based Fuel-Cell Electric Vehicle (FCEV) buses in Leh; Green Hydrogen Certification Scheme of India (GHCI); Hydrogen fuel-run train engine.
National Green Hydrogen Mission	• **Duration:** Phase I (2022-23 to 2025-26) and Phase II (2026-27 to 2029-30). • **Expected Outcomes:** Green Hydrogen Production capacity of **5 MMT per Annum by 2030.** • **Key components:** Strategic Interventions for Green Hydrogen Transition (SIGHT) programme, Development of Green Hydrogen Hubs.

Biofuels	• **Potential: 28 GW** through Surplus biomass availability in India. • **Current Installed capacity of Biomass cogeneration**: 10 GW (*Power Ministry, June 2025)* • **Initiatives**: National Policy on Biofuels, 2018; Pradhan Mantri JI-VAN Yojana (2019); Global Biofuels Alliance (2023); National Biofuels Coordination Committee.
Ethanol Blending	• **Key Targets: 20%** in **petrol** by **2025** (Updated) and **5% biodiesel blending** in diesel by **2030.** (National Policy on Biofuels, 2018) • **Initiatives:** National Policy on Biofuels, 2018; Ethanol blending Program (EBP) targeting 20% ethanol blending in petrol by 2025; PM JI-VAN YOJANA; Flexi Fuel Engines, etc.
Geothermal Energy in India	• **Potential:** 10,600 MW of geothermal **power** *(Geothermal Atlas of India, 2022).* • **Initiatives:** Renewable Energy Research & Technology Development Programme (RE-RTD); Renewable Energy Technology Action Platform.
Underground Coal Gasification (UCG)	• Energy manufacturing process where coal is gasified/chemically converted into synthesis gas (syngas) in its original coal seam. • **Initiatives:** Scheme for promotion of Coal/Lignite Gasification; Policy framework (2015) for development of UCG in coal and lignite bearing areas; Underground Coal Gasification pilot project in Jharkhand by Ministry of Coal.
Conservation Efforts	

CoP-16 of UNCBD	• **Held at: Cali**, **Colombia** with the theme **"Peace with Nature".**
	• **Major Outcomes:**
	  ○ Operationalization of **Cali Fund**
	  ○ **Recognition of rights of indigenous communities** through establishment of **permanent subsidiary body** under **Article 8(j) of the UNCBD**
	  ○ Launch of **Kunming Biodiversity Fund (KBF)** under **Global Environment Facility** (GEF)

Kunming-Montreal Global Biodiversity Framework (KMGBF)	• **Non-binding,** adopted at **CoP of CBD (Montreal, Canada, 2022).**
	• To **half** and **reverse biodiversity loss** by **2030.**
	• **Sets 4 goals** and **23 targets** to be met by **2030.**
	  ○ **Key Goals:** Share benefits fairly; closing the biodiversity **finance gap of 700 USD per year.**
	  ○ **Key targets:** 30 by 30 targets; mobilize **USD 200 billion** including **USD 30 through international finance.**

National Biodiversity Strategy and Action Plan (NBSAP)	**Key Highlights of India's updated NBSAP 2024-2030** • **Approach**: **'Whole of Government'** and **'Whole of Society**.' • **National Biodiversity Targets (NBTs): 23 NBTs** focused on **3 themes** – reducing threats to biodiversity; ensuring sustainable use of resources; and enhancing tools for implementation. • **Resource mobilization**: Through **Biodiversity Finance Initiative (BIOFIN)** at national level.
High Seas Treaty	• Formally called **Agreement on Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction**. • Under the **United Nations Convention on the Law of the Sea (UNCLOS).** • **Scope of application:** To **Areas Beyond National Jurisdiction (ABNJ),** including high seas (excludes warship, military aircraft, or naval auxiliary). ○ Part-II deals with Marine Genetic Resources, applies to **government vessel.**
Antarctic Treaty	• **Applicability:** Area south of 60° South latitude.

	• **India's initiatives for Antarctica: Dakshin Gangotri** (1983, 1st research station); Currently operational are **Maitri** (1989) and **Bharati** (2012); **Antarctic Act** (2022).
Wetland Conservation in India	• **Current Status: 7 lakh wetlands** covering **~16 Mha i.e., 4.86%** of the total geographic area of the country. ○ India **lost 2 out of 5 wetlands** in last 3 decades (Wetlands International). • **Significance:** Covers **6% of Earth's surface** but support **~40% of global biodiversity** • **Schemes/Policies/Initiatives:** Wetland (Conservation and Management) Rules 2017; Centre for Wetland Conservation and Management (CWCM); National Plan for Conservation of Aquatic Eco-systems (NPCA); Blue Flag Certification.
Mangrove Conservation	• **Total Mangrove Cover in India** is **0.15%** of country's geographical area (ISFR, 2023). • **Threats:** ½ of world's mangrove provinces are threatened (**IUCN Red List of Mangrove Ecosystems).** • **Initiatives:** MISHTI (Mangrove Initiative for Shoreline Habitats & Tangible Incomes); Sustainable Aquaculture in Mangrove Ecosystem (SAIME); Mangrove Alliance for Climate.
Peatland Conservation	• **Global Peatlands distribution:** Covers **3.8% of the world's land area.** • **Status:** ~12% of global peatlands and >60% of peatlands in India degraded. (*Global Peatland Hotspot Atlas, 2024)* • **Initiatives:** Guidelines for **Global Action on Peatlands (2002), UNEP Global Peatlands Initiative** (COP UNFCCC in Marrakech, Morocco in 2016).
Marine Protected Areas (MPAs)	• **MPAs in India: Gulf of Mannar Marine Park** (Tamil Nadu), **Lothian Island** (West Bengal), **Gahirmatha** (Odisha). • **Global Initiatives to Protect Marine Biodiversity:** Kunming-Montreal Global Biodiversity Framework; United Nations Human Rights Council (UNHRC) Resolution.
Forest Conservation	• **Tree and forest cover in India:** 25.17% of geographical area (increase from 24.62% in 2021) (*India State of Forest Report 2023).* • **Threats:** India **Lost 3.3% tree cover** to deforestation (2001-2022) (*Global Forest Watch).* • **Initiatives:** Forest Conservation (Amendment) Act, 2023; Green India Mission to increase Forest/Tree Cover by 5 mha; REDD+ Mechanism; Bonn Challenge; EU's Nature Restoration Plan (recover 20% of EU's land and sea by 2030).
Ecologically Sensitive Areas (ESA)	• **Governed Under:** Environment (Protection) Act, 1986. • **Examples:** Doon Valley, Bhagirathi, Western Ghats, Matheran, Mount Abu, etc. • **Activities allowed (ESZ Guidelines): Prohibited** (Commercial Mining, setting of polluting industries); **Regulated** (Felling of Trees); **Permitted** (Ongoing agriculture and horticulture).
Wildlife Conservation in India	• **Legislative Framework:** Wildlife (Protection) Act, 1972 categorizes wildlife in 4 schedules. • **Protected Areas:** 5.32% of India's geographical area with >100 National Parks (Nov, 2023). • **Achievements:** ○ **Tiger Population** increased to **3, 682 from 2967 in 2018.** *(All India Tiger Estimation 2022)* • **Species specific Conservation Efforts:** Species Recovery Programme; Project Tiger (completed 50 years in 2023); Project Cheetah (2002); International Big Cat

	Alliance (IBCA); Integrated Development of Wildlife Habitats (IDWH), centrally sponsored Scheme.
Human Animal Conflict	• **1,510 deaths** due to animal attacks (*Accidental Deaths & Suicides in India 2022)* • **Recent Example:** Wolf attacks in Bahraich, Uttar Pradesh (2024). • **Initiatives:** Wildlife Protection Act of 1972**;** National Wildlife Action Plan 2017-2035 (NWAP); National Human-Wildlife Conflict Mitigation Strategy and Action Plan (2021-26).
Coral bleaching	• **Distribution:** >1/3rd world's coral reefs in Australia, Indonesia and Philippines. • **Coral Bleaching: Fourth Global Bleaching Event (GCBE)** in 2024 impacted 77% of world's coral reefs. • **Initiatives: Coral** listed in **Schedule I** of the **Wildlife (Protection) Act, 1972; Mangroves and Coral Reefs (1986); International Coral Reef Initiative (ICRI)**; etc.
Genetic Resources (GR) and Traditional Knowledge (TK)	• **GR:** Resources in medicinal plants, agricultural crops, and animal breeds. • **TK:** Knowledge system held by **indigenous communities.** • **Example: karez' or 'surang bavi' system** in Bidar region; **Polyculture technique called Milpa** by Mayan People; **Khasi and Garo tribes** sacred groves conservation in Meghalaya. • **Initiatives:** Traditional Knowledge Digital Library (TKDL); Protection of Plant Varieties and Farmer's Rights Act, 2001; Geographical Indications Act 1999, UNESCO recognition (Yoga).

Biological Diversity (Access and Benefit Sharing [ABS]) Regulation 2025	• Notified by **NBA in accordance with the Biodiversity Act (BDA) 2002 replacing 2014 rules**.
	• Most well-known ABS cases from India involves the **Kani tribal community of Kerala** and the **Arogyapacha plant (Trichopus zeylanicus),** for revitalizing properties (**Jeevani drug).**
	• **Key Provisions**
	  ○ **Inclusion of Digital Sequence Information (DSI**)
	  ○ Prior intimation to **National Biodiversity Authority** for approval.
	  ○ **Benefit Sharing of profits based on Annual turnover**
	  ○ **Benefit Sharing for High-Value Biological Resources.** E.g. red sanders, agarwood, etc.

Disaster Management	
Disaster Management (Amendment) Act, 2025	**Key amendments** • **National Disaster Management Authority (NDMA)** and **State Disaster Management Authority (SDMA)** given responsibility to prepare DM plans (earlier with National Executive Committee and State Executive Committee) • State governments empowered to constitute separate **Urban Disaster Management Authority (UDMA) for state capitals and State Disaster Response Force (SDRF).** • **Statutory status** to **National Crisis Management Committee (NCMC)** and **High-Level Committee (HLC).**
Earthquake Management in India	• **Vulnerability:** 59% of the Indian landmass classified as earthquake-prone • **Recent Earthquakes: Myanmar earthquake,** ("Strike-slip faulting" between the Indian and Eurasian plates); **Taiwan** (Reverse Faulting), etc. • **Initiatives:** Earthquake Risk Assessment and Mapping by GSI; Indian Standard Code for seismic design and construction of structures (IS 1893) by BIS; National Disaster Management Authority's (NDMA) guidelines, etc.

Landslide Management in India	• **India's Susceptibility: 13.17%** of India's geographical area. **8% of global fatalities.** • **Northwest Himalayas:** 66.5%**, Northeast Himalayas:** 18.8%, **Western Ghats** - 14.7%. • **Recent Occurrences:** Sikkim, Uttarkashi, Wayanad. • **Initiatives:** National Landslide Susceptibility Mapping (NLSM); Landslide Atlas of India; National Landslide Forecasting Centre (NLFC), etc.
Heatwave Management in India	• **IMD criteria for Heat waves:** Maximum temperature of **40°** C **(Plains)** and **30°** C **(hills).** • **Vulnerability: 4**% of the districts and 7% of the population are highly vulnerable**.** • **Initiatives:** Color code impact-based heat wave warning, Heat Action Plans, Climate Hazard & Vulnerability Atlas of India, Heat Index launched by IMD.
Droughts Management in India	• **Definition:** When rainfall deficiency in an area is **≥26%** of its **long term normal** (26-50%: Moderate drought); (>50%: Severe Drought). • **Vulnerability:** 91 districts in 'Very High' drought risk category. • **Recent examples:** Rayalaseema (Andhra Pradesh (2024)), South American Drought **(**2024), • **Initiatives:** National Policy on Disaster Management; National Agricultural Drought Assessment and Monitoring System; Rashtriya Krishi Vikas Yojana (RKVY); etc.
Cyclone Management	• **India's vulnerability:** Exposed **to nearly 10% of the World's tropical cyclones.** • **Recent Occurrences:** Cyclone Dana (2024), Odisha; Cyclone Fengal (2024), Tamil Nadu, etc. • **Institutions:** National Cyclone Risk Mitigation Project (NCRMP) by MHA; IMD's Dynamic impact-based Color-coding warnings, Indian National Centre for Ocean Information Services (INCOIS).
Glacial Lake Outburst Flood (GLOF) in India	• **Vulnerability:** >9 million people in High Mountain Asia (HMA) are vulnerable to GLOF. • **Recent Occurrences:** 2023 (GLOF at South Lhonak, Sikkim), Chamoli (2021). • **Initiatives:** National Disaster Management Authority (NDMA) guidelines; Guidelines for Hydro projects by Central Electricity Authority (CEA).
Fire Safety in India	• **Status:** 7,435 people killed in over 7,500 fire accidents in India in 2022 (NCRB). • **Recent Accidents:** Gaming zone in Rajkot (Gujarat), private hospital in Delhi. • **Initiatives:** Fire service a **state subject** (included in 12th Schedule); National Building Code (NBC) by BIS; Model Bill to Provide for the Maintenance of Fire and Emergency Service for the State, 2019; Fire and Life Safety guidelines by Ministry of Health.
Dam Safety in India	• **Status:** 3rd largest dam owing nation (5,700 dams) after USA and China. ○ **80% of dams** in India are over **25 years old**. • **Major Dam Failures:** Derna Dam (Libya, 2023); Chungthang Dam (Sikkim, 2023) • **Initiatives:** National Register of Large Dams (NRLD); Dam Rehabilitation and Improvement Project (DRIP); Dam Health and Rehabilitation Monitoring Application (DHARMA); Dam Safety Act, 2021.
Geography	
El Niño Southern Oscillation (ENSO)	• Associated with **strong anomalous warming** in the central tropical Pacific and **cooling** in the **eastern and western tropical Pacific.** • **Inverse relationship between ENSO and Indian monsoon rainfall.** ○ **El Niño** tends to **suppress monsoon rainfall.**

	○ **La Niña** generally enhances **monsoon rainfall.**
India Meteorological Department (IMD)	**Key Achievements** • Accurate cyclone warnings reduced deaths **from 10,000 (1999) to near zero (2020-2024).** • IMD serves as **UN Early Warning for All advisor to five developing nations**.
River linking project	• **National Perspective Plan (NPP):** National Water Development Agency (NWDA) identified 30 links (16 under Peninsular Component & 14 under Himalayan Component) for preparation of Feasibility Reports • **Examples:** Ken-Betwa Linking Project (KBLP), Wainganga-Nalganga river linking project

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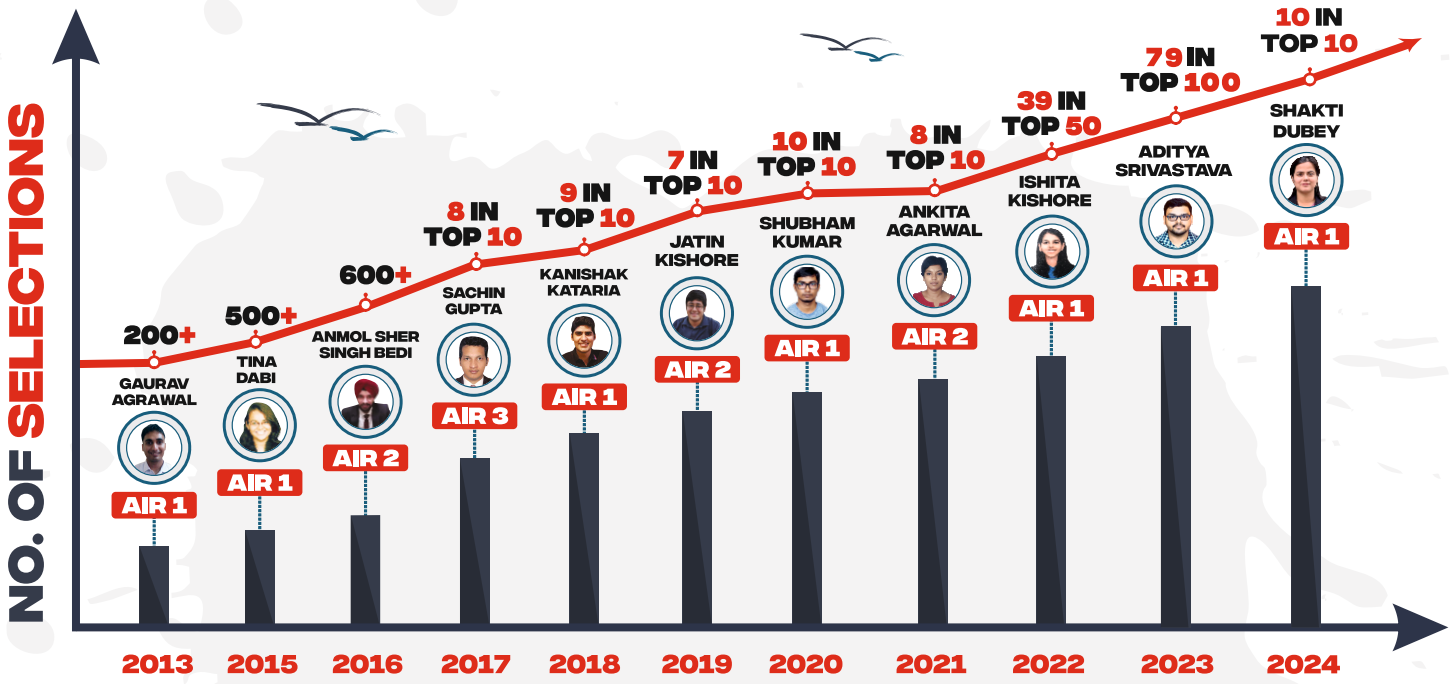

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