Prelims Exam Topics

HARA MANGROVE FOREST

Context

Recent satellite images have detected an oil spill off the southern coast of Qeshm Island, posing a major environmental threat to the Hara mangrove ecosystem.

About Hara Mangrove Forest

- **Type & Location:** Mangrove ecosystem located around Qeshm Island and the Strait of Hormuz in Iran's Persian Gulf.
- **Dominant Species:** Mainly composed of **grey mangrove**, adapted to saline coastal conditions.
- **Status:** Designated as a **UNESCO Biosphere Reserve**.
- **Salt Tolerance & Coastal Protection:** Specialised roots help the mangroves cope with saline water, while their dense root systems reduce **coastal erosion** and store large amounts of carbon.
- **Marine Nursery:** Provides breeding and sheltering grounds for **shrimp, crabs and fish**, supporting regional fisheries.
- **Biodiversity:** Serves as an important habitat for migratory birds such as **great stone-curlew and herons**.

FRIEDREICH'S ATAXIA (FRDA)

Context

A new study has explained why **Friedreich's ataxia (FRDA)** is concentrated in populations with European, West Asian and South Asian ancestry but is rare or absent in several other populations.

About Friedreich's Ataxia

- **Nature:** Rare **autosomal-recessive genetic disorder** causing progressive damage to the nervous system and heart.
- **Gene & Protein:** Caused mainly by mutations in the **FXN gene**, which produces **frataxin**, a mitochondrial protein important for cellular energy and iron-sulfur metabolism.
- **Inheritance:** Disease usually develops when an individual inherits pathogenic variants in **both copies** of the FXN gene; carriers with one copy generally remain asymptomatic.

EARTHQUAKE SWARM IN MAHARASHTRA

Context

Maharashtra has recorded **29 small, shallow earthquakes** in the past fortnight, with most occurring around **Nashik**, forming an **earthquake swarm**.

About Earthquake Swarm

- **Definition:** A sequence of earthquakes occurring over days or longer without a clearly identifiable **mainshock**; magnitudes may be comparable and fluctuate.
- **Difference from Aftershocks:** Aftershocks follow a distinct **mainshock**, while swarms lack a dominant initial earthquake.
- **Prediction:** An earthquake swarm **does not necessarily indicate** that a larger earthquake is imminent.

Why Maharashtra Experiences Earthquake Swarms?

- **Intraplate Location:** Maharashtra lies within the **Indian Plate**, away from major plate boundaries, but stresses within the plate can reactivate existing fractures.
- **Deccan Traps:** Extensive **basaltic lava flows** of the Deccan Traps contain fractures and weak zones that can transmit accumulated crustal stress.
- **Local Geological Structures: Shear zones and fractures** around regions such as Nashik provide pathways for stress release and seismic activity.
- **Water-Induced Seismicity:** Rainwater entering deep fractures can increase **pore pressure**, potentially triggering earthquakes; this has been proposed for the **2018 Palghar swarm**.
- **Reservoir-Induced Seismicity:** Water loading and pressure changes around reservoirs can alter stresses along faults, notably associated with the **Koyna-Warna region**.

SOUTH ASIAN FREE TRADE AREA (SAFTA)

Context

The Directorate of Revenue Intelligence (DRI) has uncovered fraudulent imports of South-East Asian **areca nuts** into India by falsely declaring them as Bangladeshi-origin goods to claim **SAFTA duty exemptions**.

About SAFTA

- **Nature:** Regional free trade agreement of the **South Asian Association for Regional Cooperation (SAARC)**.
- **Implementation:** Came into force in **2006**, replacing the **SAARC Preferential Trading Arrangement (SAPTA)**of 1993.
- **Members: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka**.
- **Objective:** Reduce trade barriers, facilitate movement of goods, promote fair competition and enhance regional economic cooperation.
- **Rules of Origin:** Preferential tariff benefits are available only to goods meeting prescribed **origin criteria** in a SAFTA member country.
- **Special Treatment:** Provides **special and differential treatment to Least Developed Countries (LDCs)** among member states.

NATIONAL CONSUMER DISPUTES REDRESSAL COMMISSION (NCDRC)

Context

The Supreme Court has raised concern over the **pendency of cases in the NCDRC** and suggested considering **regional and circuit benches** to reduce the backlog.

About National Consumer Disputes Redressal Commission

- **Nature:** Quasi-judicial body established in **1988** under the **Consumer Protection Act, 1986**, with its headquarters in **New Delhi**.
- **Mandate:** Provides **inexpensive, speedy and summary redressal** of consumer disputes involving goods and services.
- **Current Legal Framework:** Functions under the **Consumer Protection Act, 2019**, which replaced the 1986 Act.
- **Jurisdiction:** Under the **2021 Jurisdiction Rules**, NCDRC entertains consumer complaints where the value of goods or services **paid as consideration exceeds ₹2 crore**. It also hears **appeals against State Commission orders** and exercises **revisional jurisdiction**.
- **Hierarchy:** It is the **national-level tier** of the three-tier consumer dispute redressal system comprising **District, State and National Commissions**.
- **Composition:** Headed by a sitting or retired **Supreme Court Judge** or a sitting or retired **Chief Justice of a High Court**.

- **Appeal:** An order of the NCDRC can be challenged before the **Supreme Court** under the Consumer Protection Act.

Who Can File a Complaint?

Consumer, recognised consumer association, Central/State Government, or one or more consumers representing numerous consumers with the same interest.

LOGGERHEAD SEA TURTLE

Context

Mumbai Police recently rescued a **100-kg Loggerhead sea turtle** found struggling to swim in the Arabian Sea.

About Loggerhead Sea Turtle

- **Size: World's largest hard-shelled turtle** and the **second-largest living turtle** after the leatherback.
- **Habitat & Distribution:** Found across most of the world's oceans except the coldest waters; important nesting sites occur along the **western Indian and Atlantic Oceans**, including Oman, the U.S. and Australia.
- **Physical Features:** Characterised by a **large head, powerful jaws, reddish-brown carapace, yellowish plastron and four flippers**.
- **Feeding:** Strong jaws allow it to feed on **hard-shelled prey** such as whelks and conchs.
- **Navigation:** Uses the **Earth's geomagnetic field** to navigate across long distances.
- **Lifespan:** Can live for **80 years or more**.
- **Conservation Status:** Classified as **Vulnerable** on the **IUCN Red List**; WPA Status: **Schedule I**

ROTATING DETONATION ENGINE (RDE)

Context

An India-based defence start-up has demonstrated a **Rotating Detonation Engine (RDE)** at a **DRDO facility in Hyderabad**.

About Rotating Detonation Engine

- **Nature:** Advanced propulsion technology that uses **continuous detonation** of a fuel-oxidiser mixture to generate thrust or mechanical energy.

- **Efficiency:** Can offer around **10–25% higher thermodynamic efficiency** than conventional combustion systems, though practical performance varies with design and operating conditions.

Key Features

- **Detonation:** Unlike conventional engines that use **deflagration** (subsonic flame propagation), RDEs use **detonation**, involving a supersonic shock wave coupled with rapid combustion.
- **Combustion Chamber:** Uses an **annular chamber** formed by two concentric cylinders; fuel and oxidiser are continuously injected into the narrow ring-shaped gap.
- **Continuous Operation:** Detonation waves circulate around the annulus, consuming the fresh mixture and continuously producing high-pressure gases for thrust.
- **Advantage:** Higher combustion pressure and improved energy conversion can potentially reduce **fuel requirements** and increase payload capacity in rockets or missiles.
- **Challenges:** Requires precise fuel injection, stable detonation, advanced materials and manufacturing capable of handling **very high temperature, pressure and rapid pressure oscillations**.

MEDAK FORT

Context

The postal department recently issued a **commemorative postal cover and stamp** on the historic Medak Fort in Telangana.

About Medak Fort

- **Location:** Historic **hill fort in Medak town, Telangana**.
- **Origin:** Built in the **12th century** during the reign of **Kakatiya ruler Pratapa Rudra**; originally known as **Methuku Durgam**.
- **Historical Role:** Served as a **military command post** for the Kakatiyas and later the **Qutb Shahis**.

Key Features

- **Structure:** Spread across about **100 acres** and includes a lake, barracks, warehouse, granaries and an **11-foot-long 17th-century cannon**.
- **Entrances:** Three major gateways—**Prathama Dwaram, Simha Dwaram** with lion figures, and **Gaja Dwaram featuring** elephant sculptures.

- **Architectural Elements:** Main entrance has the **Gandabherundam**, the double-headed emblem associated with the **Vijayanagara Empire**.
- **Later Additions:** Houses a **17th-century mosque** built during the Qutb Shahi period.

NATIONAL ANUBHAV AWARDS

Context

The **National Anubhav Awards, 2026** were recently conferred on **15 awardees** in New Delhi.

About National Anubhav Awards

- **Launch & Nodal Department:** Launched in **March 2015** by the **Department of Pension & Pensioners' Welfare (DoPPW)** under the Ministry of Personnel, Public Grievances & Pensions.
- **Purpose:** Recognises and incentivises **valuable contributions, experiences and suggestions** of retiring employees.
- **Eligibility:** Employees of the **Central Government, Central Public Sector Enterprises (CPSEs) and Public Sector Banks** who are **due to retire within the next 8 months or have retired within the previous 3 years** can submit Anubhav write-ups.
- **Recognition: National Anubhav Awardees** receive a **medal, certificate and ₹10,000 prize**, while **Jury Certificate Winners** receive a **medal and certificate**.

Mains Exam Topics

NUCLEAR ENERGY SECURITY

Context

The **US–Iran war and disruption risks around the Strait of Hormuz** have exposed India's vulnerability to external energy shocks, reinforcing the need for greater **energy security through reliable domestic power sources**. With India targeting **100 GW of nuclear capacity by 2047**, rising uranium requirements could make **uranium imports a strategic energy-security dependency alongside crude-oil imports**.

What structural constraints have historically limited the expansion of nuclear power in India?

- **Technology & Fuel Isolation:** International sanctions restricted access to nuclear technology, fuel and equipment, forcing India to develop an indigenous reactor ecosystem and slowing capacity expansion.
    - **Example:** The post-**1974 Pokhran-I** technology-denial regime persisted until the **2008 NSG waiver**.
- **Three-Stage Strategic Sequencing:** India prioritised long-term energy autonomy through the **PHWR → FBR → thorium** pathway rather than rapid deployment of imported reactors, creating a trade-off between strategic autonomy and expansion speed.
    - **Example:** The long development of the **500 MWe PFBR at Kalpakkam** delayed Stage-II scale-up.
- **Restricted Capital Architecture:** Nuclear generation remained concentrated within a state-controlled institutional framework, limiting broad private capital participation and market-led capacity addition.
    - **Example:** The **Atomic Energy (Amendment) Act, 2015** enabled NPCIL–PSU joint ventures but retained strong state control over nuclear generation.
- **High Capital & Execution Risk:** Large reactors require high upfront investment, long construction periods and complex engineering, increasing **Interest During Construction (IDC)** and financing risk.
    - **Example:** Prolonged construction of **Kudankulam** and the **PFBR** illustrates the impact of long gestation.
- **Regulatory, Liability & Social Friction:** Stringent safety requirements, supplier-liability concerns, land acquisition and public opposition can delay projects and raise costs.

- **Example: Section 17(b) of the CLND Act, 2010** complicated foreign vendor participation, while **Kudankulam** and **Jaitapur** faced strong local resistance.

How can Small Modular Reactors transform India's nuclear power expansion strategy?

- **Manufacturing-Led Scaling:** Factory fabrication and modular assembly can reduce site-specific construction, **capital lock-in and Interest During Construction (IDC)**, enabling repeatable capacity addition.
  - **Example:** India is developing the **BSMR-200** and **SMR-55** as indigenous SMR designs.
- **Private Capital Integration:** Captive SMRs can bring **industrial balance sheets** into nuclear expansion, widening participation beyond conventional state-funded projects.
  - **Example:** NPCIL has invited private industries to finance and build **220 MWe Bharat Small Reactors** as captive plants, while the **SHANTI Act, 2025** enables wider private participation.
- **Brownfield Repowering:** Deploying SMRs at retiring thermal sites can reuse **land, grid connectivity and existing infrastructure**, reducing greenfield siting barriers.
  - **Example:** BSMR-200 is intended for **repurposing retiring fossil-fuel power plants**.
- **Distributed Industrial Deployment:** Smaller units can shift nuclear generation from a few large sites toward **industrial clusters and remote/off-grid locations**, reducing dependence on gigawatt-scale plants.
  - **Example:SMR-55** is designed for remote and off-grid applications, while BSMR-200 targets energy-intensive industries.
- **Beyond Electricity:** SMRs can expand nuclear demand into **industrial heat and hydrogen**, making nuclear relevant to hard-to-abate sectors beyond the electricity grid.
  - **Example:** India is developing an **up to 5 MWth High Temperature Gas Cooled Reactor (HTGCR)** for hydrogen production.

Why could uranium imports become a critical strategic dependency for India's 100 GW nuclear target by 2047?

- **Volumetric Demand Surge:** Raising nuclear capacity from **8.78 GW to 100 GW** will sharply expand long-term uranium requirements, making domestic supply alone difficult to sustain.

- **Domestic Mining Constraints:** India's uranium supply remains constrained by limited production capacity and slow expansion of new mines, making imports necessary to support the safeguarded fleet.
    - **Example:** New UCIL mining projects at **Rohil (Rajasthan)** and **Jajwal (Chhattisgarh)** are still undergoing statutory clearances.
- **Stage-II Transition Lag:** India's original strategy depends on FBRs multiplying the utility of scarce domestic uranium, but the long gestation of Stage-II historically increased dependence on uranium-consuming PHWRs and imported reactors during the transition.
    - **Example:** The **500 MWe PFBR** only attained first criticality in **April 2026**, underscoring the time required to commercialise the closed-fuel-cycle pathway.
- **Geopolitical Supply Concentration:** Greater import dependence exposes nuclear fuel security to a concentrated international supply chain and possible disruptions in trade, shipping or foreign policy.
    - **Example:** India has sourced uranium from **Canada, Kazakhstan, Russia and Uzbekistan**, making supplier diversification strategically important.
- **Safeguards & Strategic Bifurcation:** Imported uranium is tied to India's **IAEA-safeguarded civilian reactor fleet**, reinforcing the separation between civilian reactors dependent on international fuel and strategic facilities outside safeguards.

Way Forward

- **Dual-Track Expansion:** Combine rapid deployment of **700 MWe PHWRs and large LWRs** with SMRs rather than relying on a single technology pathway.
- **Mobilise Private Capital:** Operationalise the **SHANTI Act, 2025** through clear licensing, liability and safety rules to bring private companies and joint ventures into reactor financing and operation.
- **Build a Domestic Fuel Buffer:** Accelerate uranium exploration, mining and processing while maintaining diversified imports and adequate strategic inventories to reduce supply-shock vulnerability.
- **Standardise & Replicate:** Shift from project-specific construction to **standardised reactor designs, fleet-mode procurement and modular manufacturing** to reduce gestation and IDC.

- **Integrate Nuclear with Industrial Decarbonisation:** Deploy SMRs for **captive power, process heat, hydrogen and retiring coal-site repowering**, increasing nuclear demand beyond grid electricity.