Prelims Exam Topics

THE EÄRENDIL-1 MISSION

Context

- The **U.S. Federal Communications Commission (FCC)** has granted a **limited two-year operating licence** to **Reflect Orbital** for its **Eärendil-1** mission.

About Eärendil-1 Mission

- **Eärendil-1** is a **proof-of-concept technology demonstration satellite** designed to test the feasibility of **reflecting sunlight from space** using an orbital mirror.
- It is being developed and operated by **Reflect Orbital**, a California-based commercial aerospace startup.
- **Objective:** Redirect sunlight to selected locations after sunset to **extend solar power generation** and provide **emergency illumination** during disasters and rescue operations.
- **Key Features**
    - **Deployable Thin-Film Reflector:** Ultra-light mirror that remains folded during launch and automatically deploys in orbit.
    - **Motorized Precision Gimbaling:** Allows remote adjustment of the reflector to direct sunlight towards specific locations.
    - **Low Earth Orbit (LEO):** Operates in a **non-geostationary orbit** at an altitude of about **625 km**.
    - **High-Inclination Orbit: 88° orbital inclination** provides near-polar coverage over most parts of the Earth.

Low Earth Orbit (LEO):

- Extends from **160 km to 2,000 km** above Earth.
- Used by **Earth observation, remote sensing, communication satellites, and the International Space Station (ISS)**.

THE LONG MARCH 10B ROCKET

Context

- China successfully completed its **first reusable rocket landing**, with the **Long March 10B** booster making a precise **sea-based recovery** after stage separation.

About Long March 10B Rocket

- **Long March 10B** is China's **next-generation medium-to-heavy lift launch vehicle** featuring a **reusable first-stage booster**.
- It is designed to **reduce the cost of space launches** through **vertical landing** and **maritime recovery**.
- **Key Features**
    - **Payload Capacity:** Can carry up to **16 tonnes** to **Low Earth Orbit (LEO)**.
    - **Re-entry Control: Nitrogen thrusters** flip the booster after separation, while **grid fins** stabilize and guide its atmospheric descent.
    - **Sea-based Recovery:** Uses **hooks** to catch a **wire net** mounted on an automated recovery vessel instead of conventional landing legs.

GREAT INDIAN BUSTARD

Context

- The **first official assessment in seven years** by the **Wildlife Institute of India (WII)** found the **Great Indian Bustard** population to be **stable at around 110–150 birds**.

About Great Indian Bustard

- The **Great Indian Bustard** is one of the **heaviest flying birds** and is **endemic to the Indian Subcontinent**.
- It is the **State Bird of Rajasthan**.
- Prefers **open grasslands, scrublands, and rain-fed agricultural landscapes**.
- **Distribution:** Present in **Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, and Karnataka**, with the **Thar Desert in Rajasthan** serving as its last viable stronghold.
- **Threats**
    - **Power line collisions** due to poor frontal vision.

- **Habitat fragmentation** caused by roads, agricultural fencing, renewable energy projects, and urban expansion.
- **Predation** of eggs by free-ranging dogs and other predators.
- **Vegetation changes** and invasion by species such as **Prosopis juliflora**.

- **Conservation Status**
  - **IUCN Red List: Critically Endangered**
  - **Wildlife (Protection) Act, 1972: Schedule I**
  - **CITES: Appendix I**

SWAYAAN INITIATIVE

Context

The **Ministry of Electronics and Information Technology (MeitY)**, in collaboration with the **Drone Federation India (DFI)**, launched the **National Innovation Challenge for Drone Application and Research (NIDAR)** under the **SwaYaan** initiative.

About SwaYaan

- **SwaYaan** is a **MeitY initiative** launched in **2022** to strengthen India's **Unmanned Aircraft Systems (UAS)/drone ecosystem** and support the vision of making **India a global drone hub by 2030**.
- The initiative seeks to train **42,560 participants** through **formal and non-formal education** in drone and allied technologies.
- Implemented through a **hub-and-spoke model** involving **30 premier academic and R&D institutions**, including **IISc, IITs, IIITs, NITs, C-DAC, and NIELIT**.

About NIDAR:

A national challenge under the **SwaYaan Initiative** that promotes **drone innovation, research, and entrepreneurship** by offering a **₹40 lakh prize pool**, startup incubation, cloud credits, software support, mentorship, and internship opportunities.

UMANG PORTAL

Context

- Researchers have recently identified **significant security vulnerabilities** in the **UMANG Portal**.

About Unified Mobile Application for New-age Governance (UMANG) Portal

- **UMANG (Unified Mobile Application for New-age Governance)** is a **single digital platform** that provides citizens access to government services offered by **Central, State, and Local Government bodies** through a single interface.
- It is an initiative under the **Digital India Programme** of the **Ministry of Electronics and Information Technology (MeitY)**.
- It aims to provide **anytime, anywhere access** to government services, improving ease of governance and citizen service delivery.

INS MAHENDRAGIRI

Context

The **Indian Navy** commissioned **INS Mahendragiri**.

About INS Mahendragiri

- **INS Mahendragiri** is a **multi-role stealth frigate** of the **Project 17A (Nilgiri-class)**.
- It is designed by the **Warship Design Bureau (WDB)** of the Indian Navy and built by **Mazagon Dock Shipbuilders Limited (MDL), Mumbai**.
- **Speed:** Up to **28 knots**.
- Uses **Combined Diesel or Gas (CODOG)** propulsion for efficient cruising and high-speed operations.

About Project 17A

- **Project 17A** is the **follow-on programme to the Project 17 (Shivalik-class) stealth frigates**, designed by the **Indian Navy's Warship Design Bureau (WDB)**.
- Comprises **seven Nilgiri-class stealth frigates**: **INS Nilgiri, INS Himgiri, INS Udaygiri, INS Dunagiri, INS Mahendragiri, INS Taragiri and INS Vindhyagiri.**

SULPHUR DIOXIDE (SO_2)

Context

- A recent analysis found that **around 81% of sulphur dioxide (SO_2) emissions** from coal-fired power plants within a **300-km radius of Delhi-NCR** originate from plants exempted from installing pollution control systems.

About Sulphur Dioxide (SO_2)

- **Sulphur dioxide (SO_2)** is a **colourless, toxic, and highly reactive gas** with a pungent odour.
- **Major Sources**
    - **Coal-fired thermal power plants** (largest source).
    - **Petroleum refineries** and **metal smelting** industries.
    - Natural sources such as **volcanic eruptions, geothermal activity, and decomposition of organic matter**.
- Reacts with **oxygen and water vapour** to form **sulphate aerosols**, a major component of **$PM_{2.5}$**.
- Forms **sulphuric acid (H_2SO_4)** in the atmosphere, leading to **acid rain**.
- Can travel **hundreds of kilometres**, affecting air quality far from its source.

MĀORI TRIBE

Context

- During his **State Visit to New Zealand**, the **Prime Minister of India** referred to the Māori concept of **'Waka'** to symbolize the shared journey, friendship, and partnership between **India and New Zealand**.

About Māori Tribe

- The **Māori** are the **indigenous Polynesian people** of **New Zealand.**
- They are believed to have migrated to New Zealand in **voyaging canoes between 1200 and 1300 CE**.

About Waka: A **traditional Māori canoe (a long, narrow boat propelled by paddles)** symbolising **shared identity, collective responsibility, and a common journey**, traditionally used for **warfare, fishing, transport, and long-distance ocean voyages**.

SHANTI VISION

Context

- India launched its campaign for a **non-permanent seat in the United Nations Security Council (UNSC) for 2028–29**, with the **External Affairs Minister** unveiling the **SHANTI Vision** as the guiding framework for its candidature.

About SHANTI Vision

- **SHANTI** stands for **Securing Holistic Advancement through Norms, Trust and Integrity**.
- It is India's strategic vision for promoting **peace, inclusive development, and effective global governance** through its 2028–29 UNSC campaign.

India as a Non-Permanent Member of the UNSC

- India is seeking election as a **non-permanent member** of the **UNSC for the 2028–29 term**.
- India has served as a non-permanent member of the UN Security Council (UNSC) eight times - first in 1950-51 and most recently in 2021-22.

ANEEL (ADVANCED NUCLEAR ENERGY FOR ENRICHED LIFE)

Context

- A recent study by **Clean Core Thorium Energy (CCTE)** challenged **BARC's** safety concerns regarding the use of **ANEEL**, a thorium-based nuclear fuel, in India's **Pressurised Heavy Water Reactors (PHWRs)**.

About ANEEL (Advanced Nuclear Energy for Enriched Life)

- **ANEEL** is an advanced **thorium-based nuclear fuel**, developed by **Clean Core Thorium Energy (CCTE), USA**, by combining **thorium** with **High-Assay Low-Enriched Uranium (HALEU)**.
- Designed as a **drop-in fuel** for **Pressurised Heavy Water Reactors (PHWRs)** with minimal modifications, it aims to improve nuclear power efficiency and sustainability.
- It can potentially generate **around six times more energy** than natural uranium fuel while producing **over 85% less spent nuclear waste** and reducing uranium consumption.

Mains Exam Topics

COMPRESSED BIOGAS: STRENGTHENING INDIA'S ENERGY SECURITY

Escalating geopolitical tensions in West Asia have heightened concerns over India's energy security, particularly as nearly **90% of its LPG imports transit through the Strait of Hormuz**, prompting renewed emphasis on domestic alternatives such as Compressed Biogas (CBG).

How Does CBG Support Circular Economy?

- **Advances Urban Waste-to-Energy Systems:** CBG converts municipal solid waste and sewage into clean energy, reducing landfill dependence while recovering valuable resources from urban waste streams.
    - **E.g.** Under the **Swachh Bharat Mission** and **SATAT**, urban organic waste is increasingly being processed into CBG instead of being dumped in landfills.
- **Promotes Closed-Loop Nutrient Cycling:** The by-product of CBG production, **Fermented Organic Manure (FOM)**, returns essential nutrients to agricultural fields, reducing dependence on chemical fertilisers and improving soil health.
    - **E.g.** The inclusion of **Fermented Organic Manure (FOM)** under the **Fertilizer Control Order (FCO)** and the **Market Development Assistance (MDA)** encourage its commercial use, enabling nutrients recovered from organic waste to be recycled back into agricultural soils.
- **Reduces Emissions through Biomass Utilisation:** CBG creates an economic use for agricultural biomass that would otherwise be burnt or left to decompose, reducing greenhouse gas emissions and air pollution.
    - **E.g.** By procuring over **1 lakh tonnes of paddy straw annually**, the **Sangrur CBG Plant (Punjab)** converts a major source of stubble-burning emissions into renewable fuel, demonstrating how CBG can simultaneously address air pollution and climate change.
- **Supports Energy Security through Import Substitution:** By replacing fossil-based CNG and LPG with domestically produced renewable gas, CBG reduces dependence on imported fuels and strengthens India's long-term energy resilience.
    - **E.g.** The **SATAT (Sustainable Alternative Towards Affordable Transportation)** initiative promotes CBG as a substitute for imported natural gas in the transport sector.

- **Strengthens Agrarian Circular Bioeconomy:** CBG integrates crop residues, cattle dung and other agricultural biomass into a **closed-loop rural production system**, creating new revenue streams while improving resource efficiency across the farm economy.
    - **E.g.** The **GOBARdhan** scheme enables farmers to monetise cattle dung and agricultural residues by supplying them to CBG plants, transforming farm waste into an additional source of rural income.

What are the Key Challenges in Scaling Up India's Compressed Biogas Ecosystem?

- **Weak Feedstock Supply Chain:** Fragmented biomass availability, inadequate mechanisation and high transportation costs make feedstock aggregation economically challenging, particularly for crop-residue-based CBG plants.
    - **E.g.** A **Centre for Science and Environment (CSE) 2026** study found that **Punjab's paddy straw is available only for 30–40 days after harvest**, whereas CBG plants require a continuous year-round feedstock supply, necessitating costly aggregation, storage and transportation infrastructure.
- **Financing Constraints:** High capital costs, uncertain gas pricing and the lack of assured long-term off-take agreements reduce project bankability and discourage private investment.
    - **E.g.** Despite support under **SATAT** and **GOBARdhan**, many projects struggle to secure credit due to uncertain gas procurement and limited commercial viability of by-products.
- **Inadequate Gas Infrastructure:** Limited pipeline connectivity, synchronisation hurdles for grid injection and inadequate gas distribution infrastructure restrict the commercial scalability of CBG.
    - **E.g.** Despite the launch of the **Development of Pipeline Infrastructure (DPI) Scheme**, many CBG plants remain unconnected to the **City Gas Distribution (CGD)** network due to pipeline connectivity and grid-synchronisation challenges, limiting commercial offtake.
- **Policy and Regulatory Bottlenecks:** Fragmented implementation, multiple statutory approvals and procedural delays increase project timelines and discourage private investment in the CBG sector.
    - **E.g.** Delays in obtaining statutory clearances, including approvals from the **Petroleum and Explosives Safety Organisation (PESO)**, have slowed project execution. Consequently, against the **SATAT** target of **5,000 CBG plants**, only about **132** had been commissioned by **June 2026**.
- **Failure of By-product Monetisation:** The financial viability of CBG plants depends not only on gas sales but also on the successful marketing of **Fermented Organic Manure (FOM)**. However,

weak farmer acceptance and competition from subsidised chemical fertilisers limit its commercial uptake.

- **E.g.** Despite the **₹1,500 per tonne Market Development Assistance (MDA)**, many CBG plants continue to face difficulties in marketing **FOM**, affecting overall project profitability.

Way Forward

- **Strengthen Biomass Supply Chains:** Develop decentralized biomass aggregation, storage and logistics systems through FPOs and cooperatives while improving access to farm mechanisation for efficient feedstock collection.
    - **E.g.** Leverage the **Agriculture Infrastructure Fund (AIF)** to provide interest-subvention loans for FPOs to procure **biomass balers, pelletisers and storage infrastructure**, reducing feedstock aggregation costs.
- **Create a Bankable CBG Investment Ecosystem:** Improve investor confidence through assured demand, long-term offtake agreements and stable pricing mechanisms to attract institutional finance.
    - **E.g.** Effectively implement the **CBG Blending Obligation (CBO)**, which mandates **City Gas Distribution (CGD)** entities to blend CBG with natural gas, ensuring predictable demand and improving project bankability.
- **Expand Gas Infrastructure and Market Integration:** Accelerate pipeline connectivity and simplify grid-injection standards to facilitate seamless integration of CBG into the national gas network.
    - **E.g.** Fast-track the **Development of Pipeline Infrastructure (DPI) Scheme** to connect CBG plants with the **City Gas Distribution (CGD)** network.
- **Develop a Sustainable Market for Fermented Organic Manure (FOM):** Strengthen commercial demand for FOM through market-based interventions that complement existing certification and subsidy mechanisms.
    - **E.g.** Introduce **mandatory co-marketing (bundling)** of FOM with subsidised chemical fertilisers through existing fertiliser distribution networks to improve market absorption and plant viability.
- **Streamline Regulatory and Institutional Framework:** Establish a single-window clearance mechanism and strengthen inter-agency coordination to reduce project delays and improve ease of doing business.

- **E.g.** Integrate approvals from **PESO**, State Pollution Control Boards and other agencies through a dedicated digital **single-window clearance portal** for CBG projects.