Prelims Exam Topics

ZWAN–WOLF EFFECT ON MARS

Context

Scientists using Mars Atmosphere and Volatile Evolution (MAVEN) detected the **Zwan–Wolf effect** on Mars during a powerful **Coronal Mass Ejection (CME)** event.

About the Zwan–Wolf Effect

- **Meaning:** Planetary magnetic fields compress incoming solar wind, creating regions with lower charged-particle density. Ita **Process include:**
    - **Compression of Solar Wind:** As solar wind approaches a planet's magnetic field, it becomes compressed near the magnetic boundary.
    - **Pressure Difference Formation:** The compression creates pressure differences that push charged particles along magnetic field lines away from the stream.
    - **Formation of Low-Density Region:** This movement of particles creates regions with lower charged-particle density near the solar-wind stream.
- **Observed at Mars:** MAVEN observed intense magnetic structures pushing charged particles toward Mars' unlit side during a CME event.
- **Why the Finding Is Important:** Earlier, such magnetic effects were mainly associated with strongly magnetised planets like Earth.
- **Key Scientific Significance:** Shows that even weakly magnetised or "unmagnetised" planets can experience complex magnetic and plasma interactions.

About MAVEN Mission

- **Launched By:** National Aeronautics and Space Administration (NASA).
- **Launch Year: L**aunched in 2013 aboard an Atlas V rocket.
- **Orbit:** Entered Mars orbit in 2014.
- **Main Objective:** To study the Martian upper atmosphere, ionosphere and atmospheric loss to space.
- **Scientific Goal:** Understand how Mars lost most of its atmosphere and surface water over time.
- **Key Areas of Study:** Solar wind interaction, atmospheric escape, ionosphere and climate evolution of Mars.
- **Important Instruments:**

- Solar Wind Ion Analyzer (SWIA)
- Solar Energetic Particle (SEP) instrument
- Imaging Ultraviolet Spectrograph (IUVS)
- Magnetometer (MAG)
- Neutral Gas and Ion Mass Spectrometer (NGIMS)

- **Major Contribution:** Provided evidence that solar wind stripped away much of Mars' atmosphere after the planet lost its magnetic field.

CHANDRAYAAN-3 LUNAR SURFACE FINDINGS

Context

Data from Chandrayaan-3 revealed that the Moon's upper surface near the Shiv Shakti point contains two distinct layers within a few centimetres of depth.

Experiment and its findings

- **Hop Experiment:** Vikram lander briefly lifted about 40 cm and landed around 50 cm away to test future lunar take-off capability.
  - It demonstrates the capability of ISRO to get the lander to fire its engines and lift itself up from the surface.
- **Surface Disturbance:** Rocket plume displaced nearly 3 cm of loose lunar soil during the hop.
- **Instrument used:** ChaSTE(Chandra's Surface Thermophysical Experiment) measured thermal and physical properties of the newly exposed subsurface layer.
- **Key findings are**
  - **Two Distinct Layers:** Scientists found a loose porous upper layer followed by a denser compact layer below 2–6 cm depth.
  - **Sharp Temperature Drop:** Temperature at 10 cm depth was nearly 60°C lower than the surface.
- **Importance:** Findings are useful for future lunar habitats, moon walks and return missions.

Major Indian Lunar Missions

Mission	Year	Launch Vehicle	Key Objective	Major Achievement
Chandrayaan-1	2008	PSLV-C11	Lunar mapping	Discovery of water molecules on Moon

Chandrayaan-2	2019	GSLV Mk-III	Orbiter–lander–rover mission	Orbiter continues lunar observations
Chandrayaan-3	2023	LVM3-M4	Soft landing & rover study	First landing near lunar south pole
LUPEX (Planned)	ISRO–JAXA mission	Proposed	Polar water-ice exploration	Will study lunar volatiles

ULPGM-V3 MISSILE SYSTEM

Context

DRDO successfully completed final development trials of the **ULPGM-V3** (Unmanned Aerial Vehicle Launched Precision Guided Missile)

About the Weapon

- **Nature:** Indigenous fire-and-forget precision-guided missile designed for UAVs/combat drones.
- **Developer**: Developed by Research Centre Imarat along with DRDL, TBRL and HEMRL laboratories under DRDO.
- **Integrated Platform:** Integrated on UAVs developed by NewSpace Research and Technologies, Bengaluru.
- **Operational Modes**: Successfully tested in both Air-to-Ground and Air-to-Air modes.
- **Combat Roles:** Designed for anti-tank operations and for engaging drones, helicopters and airborne targets.
- **Key Feature:** Enables precision stand-off strikes from unmanned aerial platforms.
- **Strategic Significance:** Strengthens India's indigenous drone warfare and counter-drone capabilities under Aatmanirbhar Bharat.

Mains Exam Topics

INDIA–ITALY STRATEGIC PARTNERSHIP IN AN EMERGING GLOBAL ORDER

Context

India and Italy are rapidly expanding their Strategic Partnership with cooperation growing in trade, defence, AI, clean energy, connectivity and Indo-Pacific affairs.

About India–Italy Relationship

- **Strategic Partnership:** Bilateral ties upgraded to a Strategic Partnership in 2023 with the launch of the Joint Strategic Action Plan 2025–29.
- **Political Engagement:** Relations strengthened through frequent high-level visits, G20 interactions and G7 outreach engagements. (PM Meloni's India visit 2023; PM Modi's G7 Italy visit 2024)
- **Trade & Investment Cooperation:** Focus on machinery, clean technologies, defence, pharmaceuticals, textiles and automobiles. (Bilateral trade: €14.25 billion in 2025; target: €20 billion by 2029)
- **Industrial & Manufacturing Partnership:** "Make in India" and "Made in Italy" initiatives supporting industrial integration and resilient supply chains. (800 Italian firms in India; Tata Motors–Iveco deal worth €3.8 billion)
- **Technology & Innovation Cooperation:** Cooperation expanding in AI, quantum technologies, semiconductors, critical minerals and advanced manufacturing. (EPOC 2025–27 promotes joint research and researcher mobility)
- **Defence & Security Cooperation:** Collaboration growing in defence production, naval exercises, cyber security and counter-terrorism.
    - **E.g.** Defence Cooperation Agreement 2023; MILAN Exercise 2024; Joint Initiative to Counter Terror Financing 2025)
- **Space Cooperation:** Partnership increasing in satellite services, aerospace and ground-station technologies. (MoUs between Indian and Italian space firms during IAC 2024)
- **Energy & Climate Partnership:** Cooperation in renewable energy, green hydrogen and resilient infrastructure. (Italy joined ISA, CDRI and Global Biofuels Alliance)
- **Connectivity Cooperation:** Both support the India-Middle East-Europe Economic Corridor (IMEC) linking Indo-Pacific with the Mediterranean. (Italy is a founding IMEC member; Blue-Raman submarine cable activated between India and Genoa)

- **People-to-People Relations:** Strong diaspora, cultural and academic linkages support bilateral ties. (Indian diaspora in Italy is 1.86 lakh; largest Indian community in EU)

Significance of the Relationship

- **Indo-Pacific–Mediterranean Convergence:** Both increasingly view the Indo-Pacific and Mediterranean as interconnected strategic theatres.
- **Supply-Chain Diversification:** Partnership supports China-plus-one strategies and resilient manufacturing networks. (Italy identified India as a priority trade partner)
- **Technology Synergy:** Combines India's scale and start-up ecosystem with Italy's industrial and design strengths. (India having 100+ unicorns and 2 lakh start-ups)
- **Defence & Maritime Importance:** Expanding naval cooperation improves maritime security and Indo-Pacific engagement. (Regular naval port calls and PASSEX exercises)
- **Gateway Role:** Italy acts as India's gateway to Southern Europe while India provides access to Indo-Pacific and Global South markets.
- **Support for Multipolarity:** Both support strategic autonomy, rules-based order and diversified global partnerships.

Challenges in the Relationship

- **Trade Below Potential: B**ilateral trade remains modest compared to India's ties with Germany or France.
- **Regulatory & Market Barriers:** EU standards, visa norms and compliance requirements affect deeper integration.
- **Limited Defence Industrial Depth:** Defence-industrial cooperation is expanding but still limited compared to other strategic partners.
- **Slow Connectivity Implementation:** IMEC and related infrastructure projects remain at early operational stages.
- **Geopolitical & EU Constraints:** India–Italy cooperation is sometimes shaped by broader India–EU policy dynamics.

Way Forward

- **Deepen Technology Partnership**: Increase cooperation in AI, semiconductors, cyber security and quantum technologies.
- **Expand Defence Collaboration:** Promote co-production, aerospace partnerships and maritime cooperation.

- **Operationalise IMEC:** Develop transport, energy and digital corridors connecting India with Europe.
- **Strengthen Research & Academic Links:** Expand university collaboration, mobility partnerships and innovation ecosystems.
- **Enhance Green Partnership:** Scale cooperation in renewable energy, hydrogen and climate-resilient infrastructure.

INDIA'S EV TRANSITION REQUIRES A ROBUST GRID STRATEGY

Context

Amid rising volatility in global crude oil prices due to the ongoing West Asian conflict, energy experts have highlighted that India's electric vehicle (EV) transition cannot succeed without parallel strengthening of the country's power infrastructure and grid management systems.

What is an EV Grid Strategy?

- An EV grid strategy refers to a coordinated framework that integrates transport electrification with electricity generation, transmission, and distribution systems.
- Rather than viewing EVs merely as battery-operated vehicles, the approach treats them as a large and interconnected electricity demand network capable of significantly influencing grid behaviour.

Key Data and Statistics on India's EV and Power Ecosystem

- **Rising Electricity Demand from EVs:** Electrifying India's nearly 420 million registered vehicles could require an additional 900–1,100 TWh of electricity annually.
    - Achieving even 50% fleet electrification by 2047 may increase yearly electricity demand by nearly 500 TWh, equivalent to about one-third of India's present power generation.
- **Freight Sector's High Energy Burden**: Heavy Goods Vehicles (HGVs) account for only about 2% of India's vehicle fleet but could consume nearly 450–565 TWh annually if fully electrified because of their high energy requirements.
- **Existing Power Capacity:** By mid-2026, India's installed power capacity reached 520.51 GW.
    - The country successfully handled a peak demand of 242.49 GW, while non-fossil fuel sources contributed over half of total installed capacity.

India's Expanding EV Ambition: Key Focus Areas

- **Strengthening Freight Corridors:** India aims to shift long-distance freight transport away from imported diesel toward domestically generated electricity.

  - Eg: Electrifying transport networks such as the Golden Quadrilateral requires advance planning of high-capacity transmission infrastructure before large-scale electric truck deployment.

- **Moving Beyond the Two-Wheeler-Centric Approach**: Policy attention is increasingly shifting toward electrifying commercial transport rather than focusing primarily on personal mobility.
  - Eg: Even 309 million electric two-wheelers would account for less than 7% of projected EV electricity demand, highlighting the dominant energy footprint of commercial fleets.
- **Managing Peak Electricity Demand**: Unregulated charging behaviour can place sudden stress on urban electricity systems.
  - Eg: Simultaneous evening charging by millions of EV users around 7 PM may overload local distribution networks, leading to brownouts and higher tariffs.
- **Expanding Clean Baseload Power:** The additional electricity required for EV charging must increasingly come from clean and reliable energy sources.
  - Eg: Combining solar, wind, and emerging technologies such as Micro Modular Nuclear Reactors near highway charging hubs can provide uninterrupted low-carbon power.
- **Developing a Circular Battery Economy:** India also seeks to establish domestic recycling and reuse systems for EV batteries to reduce import dependence and environmental risks.

Major Initiatives Undertaken

- **PM-E-DRIVE Scheme:** The scheme serves as the primary incentive mechanism for EV adoption, especially targeting high-impact segments such as electric buses and commercial vehicles.
- **National Electricity Plan (NEP) Expansion:** India plans to expand its transmission network to 6.48 lakh circuit kilometres by 2032, with an estimated investment of ₹9.15 lakh crore to facilitate renewable integration.
- **BIS Interoperable Charging Standards:** The Bureau of Indian Standards introduced an India-specific dual-plugin charging standard for electric buses, successfully tested at the Ahmedabad Ranip Depot.
- **Smart Meter Rollout under RDSS:** Around 4.05 crore smart meters have been installed under the Revamped Distribution Sector Scheme (RDSS), enabling digital monitoring and smarter electricity management.

Key Challenges in Grid Integration

- **Financial Stress on Discoms**: Many state distribution companies lack adequate financial resources to modernize transformers and substations.

- Eg: Commercial fleet operators often face delays in obtaining high-tension electricity connections because local utilities struggle with infrastructure upgrades.

- **Risk of Coal-Based Electrification:** If EV charging relies heavily on thermal power, emissions may merely shift from vehicle exhausts to power plants.
    - Eg: Greater dependence on coal-fired electricity could replace oil imports with rising coal imports from countries such as Australia and Indonesia.
- **Lack of Smart Charging Infrastructure**: Many existing chargers do not support real-time communication with the grid.
    - Eg: Deploying outdated charging systems today could create costly retrofitting requirements once nationwide smart tariff systems are introduced.
- **Sudden Demand Surges**: Uncoordinated charging patterns can sharply increase electricity loads during peak periods.
    - Eg: Simultaneous charging during extreme summer conditions may destabilize urban grids and damage local infrastructure.
- **Uneven Regional Preparedness:** EV adoption and renewable integration remain concentrated in a few leading states.
    - Eg: States such as Karnataka have achieved relatively high EV adoption, while many populous inland states still lag in grid preparedness.

Way Forward

- **Mandatory Smart Charging Standards:** Introduce nationwide regulations requiring all EV chargers to support automated and bidirectional communication with the grid.
- **Integrated Power and Transport Planning:** The Ministry of Power and the Ministry of Road Transport should jointly map future megawatt-scale charging infrastructure along freight corridors.
- **Dynamic Time-of-Use Tariffs:** Adopt variable electricity pricing systems that encourage consumers to charge EVs during periods of surplus renewable generation, particularly daytime solar hours.
- **Linking RDSS Funding with EV Readiness:** State discom funding under RDSS should be tied to measurable EV infrastructure and grid modernization targets.
- **Storage-Backed Highway Charging Hubs**: Develop Battery Energy Storage Systems (BESS) and pumped-storage hydro facilities near major highway charging stations to ensure reliable round-the-clock electricity supply.

EMPOWERING URBAN LOCAL BODIES (ULBS)

Context

India's accelerating urbanisation has once again drawn attention to the fragile condition of Urban Local Bodies (ULBs)

Constitutional Status of Urban Local Bodies

Urban local governance received constitutional recognition through the 74th Constitutional Amendment Act, 1992.

Key Constitutional Features

- **Part IX-A (Articles 243P–243ZG):** Provides the constitutional foundation for municipalities and urban local governance.
- **Three-Tier Urban Framework establishes:**
    - Municipal Corporations for larger cities,
    - Municipal Councils for smaller urban areas,
    - Nagar Panchayats for transitional regions moving from rural to urban status.
- **Twelfth Schedule:** Entrusts Urban Local Bodies with 18 functions, including urban planning, sanitation, roads, water supply, public health, slum redevelopment, and land-use management.
- **State Finance Commission (SFC):** Recommends fiscal devolution and financial distribution to local bodies at regular intervals.
- **State Election Commission (SEC)**: Conducts periodic municipal elections to ensure continuity of democratic governance.
- **Core Constitutional Vision**: Aims to deepen democratic decentralisation through the transfer of the three essential components of governance: Funds, Functions, and Functionaries (3Fs).

The Three Fs of Democratic Decentralisation

- **Funds**: Financial autonomy through predictable transfers and local revenue generation.
- **Functions**: Transfer of constitutionally assigned responsibilities to municipalities.
- **Functionaries**: Administrative independence through control over personnel and staffing.

Limitations of 74th Constitutional Amendment in empowering Urban Local Bodies

- **Incomplete Devolution of Powers**: The constitutional transfer of Funds, Functions, and Functionaries (3Fs) under Part IX-A has remained partial and uneven across states.

- **Limited Transfer of Municipal Functions:** States have devolved only about 9 of the 18 functions listed in the Twelfth Schedule. Core sectors such as water supply, urban planning, and slum redevelopment often remain under state control.
    - **Eg: A 2022 report by CAG** found that municipalities in many states exercised complete authority over only four functions, partial authority over several others, and negligible control over the rest.
- **Dominance of Parastatal Agencies:** State governments frequently assign critical urban responsibilities to specialised agencies such as development authorities, housing boards, and water boards instead of elected municipal bodies.
- **Bureaucratic Control through SPVs:** Urban initiatives like the Smart Cities Mission are often implemented through Special Purpose Vehicles (SPVs) led by bureaucrats rather than elected representatives, bypassing municipal institutions and reducing democratic accountability.
- **Weak Financial Autonomy**: Municipalities remain financially dependent on higher levels of government due to inadequate revenue-generating capacity.
- **Poor Own-Source Revenue Generation:** Urban local bodies generate only a limited share of their own income.
    - **Eg: A 2022–23 report by the RBI** highlighted the heavy dependence of municipalities on grants and transfers, alongside weak local tax mobilisation.
- **Ineffective State Finance Commissions:** Although the Constitution mandates State Finance Commissions (SFCs) to recommend fiscal devolution, states frequently delay their constitution and often ignore their recommendations, limiting financial empowerment of ULBs.
- **Dependence on State Cadre Officials:** Most municipal employees are deputed from state services and remain accountable primarily to state bureaucracies instead of elected municipal authorities.
- **Political Centralisation of Urban Governance:** State governments continue to retain substantial authority over municipal administration, limiting genuine democratic decentralisation.
- **Weak and Symbolic Mayoral System:** In many states, mayors either lack executive authority or are indirectly elected, reducing the office to a ceremonial role rather than a powerful urban leadership position.
- **Neglect of Ward Committees:** Although ward committees were envisaged to deepen citizen participation, they function effectively in only a few states, weakening grassroots urban democracy.

Reasons why India fails to Monetise Urban Land Unlike China

- **China's Land-Based Revenue Model**: China systematically monetised urban land through long-term leasing rather than outright sale. This enabled local governments to significantly expand revenues from land transactions and land-related taxes.
- **Rapid Growth in Chinese Land Revenues**: Chinese local government revenues from land taxes and sales remained around 1–2% of GDP in the early 2000s, accelerated sharply after 2009, and expanded rapidly during the 2010s.
- **Peak Revenue Expansion in China**: By 2020, China's land-related revenues had crossed 10% of GDP before beginning to decline gradually after 2021.
- **India's Stagnant Land Revenue Base**: In contrast, India's revenue from land taxes remained broadly stagnant at nearly 1% of GDP between 1999 and 2021, despite a major real estate and urbanisation boom.
- **Impact of the Urban Land Ceiling Act (ULCRA):** The Urban Land Ceiling and Regulation Act (ULCRA), 1976 aimed to curb land concentration but instead fragmented urban land markets and trapped large portions of land in prolonged legal disputes.
- **Contrast with China's State-Controlled Land System:** Unlike India, China maintained extensive state control over land resources, allowing local governments to use land monetisation as a major instrument for financing infrastructure and urban development.
- **Weak Property Tax Administration:** Poor property valuation systems, weak assessment mechanisms, and inefficient tax collection practices continue to limit municipal revenue mobilisation.

Way Forward

- **Genuine Transfer of the 3Fs**: States should ensure meaningful devolution of Funds, Functions, and Functionaries to Urban Local Bodies in accordance with the constitutional mandate of the 74th Constitutional Amendment.
- **Strengthening Municipal Revenue Systems:** Urban local bodies need stronger financial foundations through property tax reforms, rational user charges, and effective land value capture mechanisms, so that dependence on state grants can be reduced.
- **Enhancing Administrative Independence:** Municipalities should be provided greater authority over recruitment, staffing, and personnel administration to improve efficiency, accountability, and institutional capacity.

- **Reforming Urban Land Monetisation:** Governments must unlock the economic potential of underutilised public land and adopt scientific land valuation practices to generate stable and sustainable municipal revenues.
- **Promoting Competitive Sub-Federalism:** Tier-II and Tier-III cities should be empowered through decentralised governance, infrastructure investment, and localised economic planning to emerge as new centres of growth and innovation.