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IMPORTANT INSIGHTS

CAQM Invokes Stage-I GRAP Across Delhi-NCR as Deteriorating Air Quality Renews Concerns Over Pollution Control Effectiveness

Recent Developments:

- On 21 October 2026, the Commission for Air Quality Management (CAQM) invoked Stage-I of the Graded Response Action Plan (GRAP) across the National Capital Region (NCR) after Delhi's Air Quality Index (AQI) reached 245, falling within the **Poor** category.
- The CAQM directed implementing agencies to enforce all **25 Stage-I action points** under the September 2026 GRAP framework, following an assessment of pollution levels and meteorological forecasts.
- The development renewed concerns about the effectiveness of emergency restrictions in addressing Delhi-NCR's persistent winter air pollution.

Graded Response Action Plan (GRAP):

Background and Objectives:

- The **Graded Response Action Plan (GRAP)** is an emergency pollution-control framework that introduces progressively stricter measures as air quality deteriorates.
- Initially notified by the **Ministry of Environment, Forest and Climate Change (MoEFCC)** in January 2017 following Supreme Court directions, GRAP seeks to prevent further deterioration through coordinated restrictions on major emission sources.
- GRAP applies across **Delhi-NCR**, including designated NCR districts of **Haryana, Uttar Pradesh and Rajasthan**, while the applicable stage is determined primarily by Delhi's AQI and pollution forecasts.
- The framework operates throughout the year, although its higher stages are frequently activated during winter because unfavourable meteorological conditions intensify pollution.

Institutional Evolution:

- The **Environment Pollution (Prevention and Control) Authority (EPCA)**, established in 1998, initially supervised GRAP implementation but faced limitations in enforcement and intergovernmental coordination.
- The **Commission for Air Quality Management in National Capital Region and Adjoining Areas Act, 2021** established CAQM as a statutory authority and replaced EPCA.
- CAQM coordinates pollution-control measures across NCR states, issues binding directions, monitors compliance and revises GRAP restrictions according to changing pollution conditions.
- Its decisions involve coordination with the **Central Pollution Control Board (CPCB)**, state pollution control boards, local authorities and agencies responsible for transport, industry and construction.

Four Stages of GRAP:

Stage-I: Poor Air Quality (AQI 201–300)

- Stage-I emphasises preventive enforcement through **mechanised road sweeping, water sprinkling, construction-dust mitigation, waste collection and prohibition of open waste burning**.
- Authorities strengthen enforcement of **Pollution Under Control (PUC)** certification, vehicle-emission standards and restrictions on visibly polluting or overaged vehicles.

- Industries, thermal power plants and diesel generator sets are monitored for compliance with applicable emission standards and fuel restrictions.

Stage-II: Very Poor Air Quality (AQI 301–400)

- Stage-II introduces stronger restrictions on **diesel generator operations**, enhanced pollution-hotspot management and increased parking charges to discourage private vehicle use.
- Authorities may stagger government office timings to reduce traffic congestion, while residential welfare associations are encouraged to provide electric heating alternatives for security personnel.

Stage-III: Severe Air Quality (AQI 401–450)

- Stage-III restricts specified **construction and demolition activities** and imposes additional controls on high-emission vehicles.
- Restrictions generally cover **BS-III petrol and BS-IV diesel four-wheelers** in Delhi and designated adjoining districts, subject to applicable exemptions.
- Schools may shift specified classes to **hybrid learning**, combining physical and online instruction.

Stage-IV: Severe+ Air Quality (AQI Above 450)

- Stage-IV imposes stringent restrictions on the entry of specified **trucks and heavy goods vehicles**, with exemptions governed by vehicle-emission standards and essential-service requirements.
- Additional restrictions may apply to construction activities, educational institutions and non-emergency commercial operations.
- GRAP restrictions are cumulative:** measures introduced under earlier stages generally remain operational when higher stages are invoked.

Air Quality Index and Pollution Indicators:

- The **National Air Quality Index**, launched by the CPCB in 2014, communicates ambient air quality through six categories: **Good (0–50), Satisfactory (51–100), Moderate (101–200), Poor (201–300), Very Poor (301–400) and Severe (401–500)**.
- India's AQI framework considers eight pollutants: **PM2.5, PM10, nitrogen dioxide (NO₂), sulphur dioxide (SO₂), carbon monoxide (CO), ozone (O₃), ammonia (NH₃) and lead (Pb)**.
- PM2.5** consists of fine particles measuring 2.5 micrometres or less, which can penetrate deep into the lungs and contribute to cardiovascular and respiratory diseases.
- PM10** includes inhalable particles measuring 10 micrometres or less, commonly associated with road dust, construction activities and other emission sources.

Causes of Winter Air Pollution in Delhi-NCR:

Emission Sources:

- Vehicular emissions**, particularly from congested roads and diesel-powered vehicles, contribute particulate matter and nitrogen oxides, while industrial combustion, thermal power generation and diesel generators add further pollutants.
- Construction activities, road dust and open waste burning** increase particulate pollution, while agricultural residue burning in neighbouring states contributes episodically during October–November.
- Firecracker emissions** during festivals can produce short-term increases in particulate matter and gaseous pollutants.

Meteorological Factors:

- **Temperature inversion** occurs when warmer air overlies cooler surface air, restricting vertical mixing and trapping pollutants near the ground.
- **Low wind speeds, shallow atmospheric mixing layers and reduced ventilation** limit pollutant dispersion, causing emissions from multiple sources to accumulate.
- These conditions demonstrate that Delhi's pollution is a **regional airshed problem**, requiring coordinated management beyond administrative boundaries.

Effectiveness and Limitations of GRAP:

- GRAP provides a structured mechanism for responding to pollution episodes, enabling authorities to implement restrictions before air quality reaches more hazardous levels.
- However, its **emergency-oriented approach** cannot independently address persistent emissions from transport, industry, construction and household fuel combustion.
- An analysis attributed to the **Centre for Research on Energy and Clean Air (CREA)** in October 2026 indicated that Delhi's winter air quality had not demonstrated consistent improvement over the preceding four winters.
 - The reported mean and median AQI during **2025–26** exceeded corresponding values for **2022–23**, indicating fluctuations rather than sustained improvement.
- Such comparisons do not establish that GRAP is ineffective during individual pollution episodes because meteorological variation, emission intensity and enforcement levels also influence measured AQI.
- Implementation challenges include uneven enforcement, limited pollution-source attribution, inter-state coordination difficulties and the economic disruption caused by abrupt restrictions.

Additional Preventive Measures Introduced by Delhi:

- A **23 June 2026 notification** introduced seasonal restrictions intended to reduce transport-related emissions independently of the prevailing AQI.
- From **1 November to 31 January**, non-Delhi-registered vehicles below **BS-VI emission standards** face operating restrictions, subject to notified exemptions for electric, CNG, emergency and specified official-duty vehicles.
- Authorised parking charges are scheduled to double from **1 November to 28 February**, excluding parking facilities managed by the **Delhi Metro Rail Corporation (DMRC)**.
- Where these preventive restrictions conflict with applicable GRAP directions, **GRAP takes precedence**, preserving the authority of emergency pollution-control measures.

Way Forward:

- **Year-round emissions reduction** should prioritise strict industrial standards, effective construction-dust management, cleaner fuels and continuous enforcement of vehicle-emission regulations.
- **Regional airshed management** requires coordinated action by Delhi, Haryana, Uttar Pradesh, Rajasthan and Punjab because pollution sources and atmospheric transport extend beyond state boundaries.
- **Cleaner mobility** should be promoted through reliable public transport, electric vehicles, last-mile connectivity, traffic management and reduced dependence on private vehicles.
- **Agricultural residue management** requires affordable machinery, crop diversification, biomass-based industries and economically viable alternatives to stubble burning.
- **Evidence-based governance** should combine source-apportionment studies, real-time monitoring, transparent compliance reporting and periodic evaluation of individual GRAP interventions.
- Long-term planning must integrate **urban development, public health, energy transition and environmental regulation** rather than relying predominantly on seasonal emergency restrictions.

Value Addition for UPSC:

- **GS Paper II – Governance:** CAQM illustrates statutory environmental governance, cooperative federalism, regulatory enforcement and intergovernmental coordination.
- **GS Paper III – Environment:** GRAP connects with air pollution, sustainable urbanisation, environmental monitoring, climate-related meteorological interactions and pollution-control technologies.
- **Constitutional Provisions:** **Article 21** protects the right to life, judicially interpreted to include the right to a healthy environment; **Article 48A** directs the State to protect the environment, while **Article 51A(g)** establishes citizens' environmental duties.
- **Important Legislation:** The **Air (Prevention and Control of Pollution) Act, 1981**, **Environment (Protection) Act, 1986**, and **CAQM Act, 2021** provide important statutory foundations for air-quality governance.
- **Related Programmes:** The **National Clean Air Programme (NCAP)**, launched in 2019, promotes city-level air-quality improvement, with a revised target of up to **40% reduction in PM10 concentrations or achievement of national standards by 2025–26**, using 2017–18 as the baseline.
- **Prelims Distinction:** **AQI** is a pollution-status indicator, **GRAP** is an emergency response framework, **CAQM** is a statutory regional regulator, and **CPCB** is the national pollution-control body established under the **Water (Prevention and Control of Pollution) Act, 1974**.
- **Mains Perspective:** Sustainable improvement requires transitioning from **reactive**, **AQI-triggered** restrictions towards **preventive, scientifically monitored and regionally coordinated emissions management**.

NITI Aayog Calls for an Integrated Care Economy to Strengthen Women's Employment and India's Ageing Society

Recent Developments:

- In **August 2026**, **NITI Aayog** released its report, **“Reimagining Care: Strategies for Empowering Caregivers in Viksit Bharat@2047,”** recommending coordinated reforms to strengthen India's caregiving ecosystem.
- The report emphasised **professional recognition, workforce training, social security, quality assurance and institutional coordination** to address the growing demand for care services.
- The **Union Budget 2026–27** proposed developing a care ecosystem and training **1.5 lakh multi-skilled caregivers**, highlighting the sector's employment and social welfare potential.
- India's fragmented care infrastructure remains a major challenge for **women's economic participation, healthy ageing and inclusive human development**.

Understanding the Care Economy:

Meaning and Scope:

- The **care economy** encompasses paid and unpaid activities that support the physical, emotional and social well-being of children, older persons, persons with disabilities and individuals requiring assistance.
- It includes **direct care**, such as feeding, nursing and personal assistance, alongside **indirect care**, such as cooking, cleaning and household management.

- The Indian care services market was estimated at **USD 29.62 billion in 2023**, with industry projections suggesting growth to **USD 72.31 billion by 2030**, at a compound annual growth rate of **13.76%**. These estimates concern market services rather than the entire unpaid care economy.

Major Components:

- **Unpaid care work** includes childcare, eldercare, household management and assistance to sick family members, primarily performed within households without monetary compensation.
- **Paid care work** includes services provided by nurses, doctors, domestic workers, childcare providers, professional caregivers, and frontline workers such as **ASHA and Anganwadi workers**, although their employment and remuneration arrangements differ.
- **Community-based care** involves self-help groups, community health workers, voluntary organisations and welfare institutions supporting vulnerable populations.
- Together, these activities constitute essential **social infrastructure** by sustaining households, supporting human development and enabling participation in the formal economy.

Why India Needs a Holistic Care System:

Gender Inequality and Employment:

- The **Periodic Labour Force Survey 2025** highlighted childcare and domestic responsibilities as major barriers to women's workforce participation, with the supplied estimate indicating that **44.4% of women outside the labour force** cited childcare or homemaking responsibilities.
- The **Time Use Survey 2024**, conducted by the **National Statistical Office (NSO)**, revealed significant gender disparities:
 - **41% of women aged 15–59** participated in unpaid household caregiving, compared with **21.4% of men** in the same age group.
 - Female participants spent approximately **140 minutes daily** on caregiving, compared with **74 minutes for male participants**.
 - Women performing unpaid domestic services spent approximately **305 minutes daily**, compared with **86 minutes for men**.
- The disproportionate care burden creates **time poverty**, restricting women's access to paid employment, education, skill development and economic independence.

Demographic and Social Changes:

- **Population ageing** is increasing demand for long-term care, rehabilitation and assistance with daily living.
 - NITI Aayog estimates that India's elderly population could reach **194 million by 2031** and **347 million by 2050**, representing approximately **20.8% of the population**.
- **Urbanisation, migration and the growth of nuclear families** are weakening traditional informal caregiving arrangements, increasing demand for accessible professional services.
- Rising life expectancy and chronic illnesses require integrated **healthcare, disability support, mental healthcare and community-based assistance**.

Government Initiatives Supporting the Care Economy:

Elderly Care and Digital Platforms:

- **SHATAYU Dashboard:** Launched by the **Ministry of Social Justice and Empowerment in May 2026**, it provides district-wise and state-wise information on the availability of trained geriatric caregivers.

- **JEEVAN Application:** The **Joint Elderly Empowerment and Virtual Assistance Network** provides senior citizens with information on welfare schemes, senior citizen homes, emergency assistance and support services through an accessible digital platform.
- **Vayo Manasa Sanjeevani:** Promotes awareness, online education and mental health support for older persons, contributing to healthy ageing.

Childcare and Nutrition:

- **Saksham Anganwadi and POSHAN 2.0** strengthen early childhood care, nutrition services and Anganwadi infrastructure.
- **Palna Scheme** supports institutional childcare through crèche facilities, helping working mothers balance employment and caregiving responsibilities.

State-Level Initiatives:

- **Odisha's Geriatric Caregiver Training Programme** offers a **three-month certificate course** to develop skills in providing physical and mental health assistance to older persons.
- **Karnataka's Carer's Monthly Allowance Scheme** provides **₹1,000 monthly** to eligible caregivers of persons with specified severe disabilities, including cerebral palsy, muscular dystrophy, Parkinson's disease and multiple sclerosis.
- Such initiatives demonstrate the potential of combining **caregiver training, financial assistance and community-based service delivery**, although coverage and eligibility differ across states.

Challenges in Developing India's Care Economy:

- **Fragmented governance** distributes caregiving responsibilities across ministries dealing with health, women and child development, social justice, labour and urban development, without a unified operational framework.
- **Fiscal constraints** limit investment in affordable childcare centres, eldercare facilities, workforce training and accessible community services.
- **Patriarchal social norms** continue to treat caregiving primarily as women's unpaid family responsibility, reducing its economic recognition.
- **Workforce shortages** persist in geriatric care, disability assistance and early childhood services because of inadequate training, certification and career pathways.
- **Weak regulation and quality assurance** create risks involving service standards, caregiver safety, institutional accountability and protection of care recipients.
- **Informal employment conditions**, including low wages, irregular working hours and inadequate social security, undermine the professionalisation of care work.

International Best Practices:

- **Colombia's National Care Policy, 2025** coordinates **34 government entities** through an integrated policy framework, recognising care as a shared responsibility of households, communities, markets and the State.
- **Brazil's National Care Policy, 2024**, followed by its **National Care Plan, 2025**, strengthens inter-ministerial coordination for integrated caregiving services.
- **Nepal** has used geospatial and demographic mapping to identify gaps in childcare, eldercare and disability services, supporting locally designed interventions and pilot programmes.
- These experiences demonstrate the importance of **integrated governance, care-needs mapping, public investment and recognition of unpaid caregiving**.

NITI Aayog's Recommendations and Way Forward:

Institutional and Regulatory Reforms:

- Establish a **National Caregiving Council** to coordinate policies, establish standards and improve cooperation between Union ministries, states and service providers.
- Develop a **National Caregiver Registry and digital portal** connecting trained caregivers with care recipients, while facilitating verification and service access.
- Introduce **minimum competency standards, standardised curricula, certification and continuing professional development** to strengthen service quality.

Workforce and Social Protection:

- Expand training aligned with the **National Skills Qualifications Framework (NSQF)** and establish accredited regional caregiving centres.
- Provide caregivers with **social security, occupational protection, insurance and grievance-redressal mechanisms**, while promoting professional recognition.
- Encourage **self-help groups, community organisations and home-based care providers** to expand affordable services in underserved regions.

Integrated Planning and Service Delivery:

- States should undertake **demographic and geospatial mapping** to assess caregiving demand, existing facilities and service gaps.
- Strengthen convergence between **Anganwadi centres, primary healthcare institutions, elderly welfare programmes and disability services**.
- Promote affordable childcare, flexible working arrangements and shared household responsibilities to reduce women's disproportionate unpaid care burden.
- Establish regular monitoring of **care quality, workforce availability, affordability and accessibility**, supported by reliable administrative data.

Value Addition for UPSC:

- **GS Paper I – Society:** The care economy is linked to gender inequality, changing family structures, population ageing, urbanisation and the social division of labour.
- **GS Paper II – Social Justice:** Caregiving reforms concern women, children, older persons and persons with disabilities, alongside welfare delivery and institutional coordination.
- **GS Paper III – Economy:** Investment in care infrastructure can generate employment, strengthen human capital and improve female labour force participation.
- **Constitutional Provisions:** **Article 14** guarantees equality before the law, **Article 15(3)** permits special provisions for women and children, **Article 39(e)** addresses the protection of workers' health and strength, **Article 41** concerns public assistance in specified circumstances, and **Article 42** provides for just and humane conditions of work and maternity relief.
- **Important Legislation:** The **Maintenance and Welfare of Parents and Senior Citizens Act, 2007**, **Rights of Persons with Disabilities Act, 2016**, and **Maternity Benefit Act, 1961** provide important legal foundations relevant to caregiving.
- **Sustainable Development Goals:** **SDG 5.4** specifically calls for recognising and valuing unpaid care and domestic work through public services, infrastructure, social protection and shared household responsibility; **SDGs 3, 8 and 10** address health, decent work and reduced inequalities.

- **Economic Concept:** Unpaid household care services are generally excluded from **Gross Domestic Product (GDP)** because they fall outside the production boundary of the core national accounts, although their contribution can be examined through **time-use surveys and satellite accounts**.
- **Mains Perspective:** A comprehensive care economy requires shifting from **family-centred, predominantly unpaid caregiving** towards a **shared, adequately financed, professionally regulated and gender-responsive care system** that supports inclusive growth and Viksit Bharat@2047.

India Advances Emerging Space Technologies to Strengthen Self-Reliance, Human Spaceflight and Global Space Competitiveness

What are the Key Developments in India's Space Sector?

- **Evolution of India's Space Programme:** India's organised space activities began with the establishment of the **Indian National Committee for Space Research (INCOSPAR)** in **1962**, followed by the launch of the first sounding rocket from **Thumba, Kerala, on 21 November 1963**. The **Indian Space Research Organisation (ISRO)** was established in 1969 to develop indigenous space capabilities and apply space technology to national development.
- **Technological Self-Reliance:** India is developing indigenous capabilities in reusable launch vehicles, next-generation launch systems, advanced propulsion, in-space docking, satellite navigation and Earth observation. These technologies reduce dependence on foreign suppliers, strengthen strategic autonomy and support the development of domestic space manufacturing.
- **Human Spaceflight Ambitions:** The **Gaganyaan Programme** aims to demonstrate India's capability to send astronauts into low Earth orbit and return them safely to Earth. The planned **Bharatiya Antariksh Station (BAS)** will support long-duration human spaceflight, scientific experiments and technology demonstrations in microgravity.
- **Private-Sector Participation:** Space-sector reforms have expanded opportunities for Indian start-ups and non-governmental entities in satellite manufacturing, launch vehicles, propulsion, Earth-observation services and ground infrastructure. Private participation can improve innovation, manufacturing capacity and commercial competitiveness.
- **Space Economy Expansion:** India's space-sector strategy targets a **USD 44-billion space economy by 2033**, supported by commercial launches, satellite-based services, indigenous technologies and private investment. Achieving this target requires stronger domestic demand, competitive exports and greater participation in global space value chains.
- **Industry and Startup Development:** **NewSpace India Limited (NSIL)** has signed 118 Technology Transfer Agreements covering 83 ISRO-developed technologies, helping transfer public-sector research into industrial applications. Cumulative investment in Indian space start-ups reportedly reached approximately **USD 618.5 million by March 2026**, reflecting growing investor interest in launch services, satellite systems and space-based applications.
- **Space-Sector Reforms:** The **Indian Space Policy 2023** provides the overarching framework for expanding commercial participation across the space value chain. **IN-SPACe (Indian National Space Promotion and Authorisation Centre)** facilitates and authorises eligible non-governmental space activities, while NSIL undertakes commercialisation of space technologies and services. ISRO continues to focus on advanced research, development and nationally important missions.

What are the Key Emerging Space Technologies Being Developed by India?

Next Generation Launch Vehicle (NGLV)

- **About:** The **Next Generation Launch Vehicle (NGLV)** is an advanced launch system being developed by ISRO to provide higher payload capacity, improved cost-effectiveness and partial reusability. It is intended to complement existing launch vehicles as India's requirements expand towards heavier satellites, human spaceflight and large orbital infrastructure.
- **Government Approval:** In **September 2024**, the **Union Cabinet approved the NGLV development programme with an allocation of ₹8,240 crore**, covering development and three developmental flights. The programme is intended to establish the design, engineering and operational foundations for a next-generation heavy-lift launch system.
- **Payload Capacity:**
 - The proposed vehicle is designed to carry approximately **30 tonnes to Low Earth Orbit (LEO)**, compared with the approximately 10-tonne LEO capability associated with LVM3, depending on the mission configuration.
 - A partially reusable configuration is being developed with a target payload capacity of approximately **14 tonnes to LEO**. Reusability is expected to reduce recurring launch costs by recovering and reusing suitable vehicle components.
 - The higher payload capacity will allow India to launch larger spacecraft, multiple satellites and heavier space-station modules, reducing dependence on foreign heavy-lift launch services.
- **Applications:** NGLV is intended to support the **Bharatiya Antariksh Station, human spaceflight, lunar exploration, interplanetary missions and large satellite constellations**. Its development is important for future missions requiring multiple launches, heavy payloads and more economical access to orbit.

India's Traditional Launch Vehicles

- **PSLV (Polar Satellite Launch Vehicle):** PSLV is ISRO's versatile workhorse launch vehicle, particularly suited to Earth-observation satellites, remote-sensing missions and payloads requiring polar or sun-synchronous orbits. Depending on the configuration, it can carry approximately **1,750 kg to a 600-km Sun-Synchronous Orbit (SSO)** and up to **1,425 kg to a Sub-Geosynchronous Transfer Orbit (Sub-GTO)**. Its adaptability has also made it suitable for launching multiple satellites in a single mission.
- **GSLV (Geosynchronous Satellite Launch Vehicle):** GSLV uses an **indigenous Cryogenic Upper Stage** and is designed to launch heavier communication and meteorological satellites towards geosynchronous transfer orbits. Its payload capability is commonly described in the approximately **two-tonne class for relevant transfer-orbit missions**. Indigenous cryogenic technology has strengthened India's ability to launch heavier satellites without relying on foreign launch services.
- **LVM3 (Launch Vehicle Mark-3):** LVM3 is India's heavy-lift launch vehicle, capable of placing payloads in the approximately **four-tonne class into GTO and the 8–10-tonne class into LEO**, depending on configuration and mission requirements. It is central to heavy communication-satellite launches and provides an important launch platform for India's human-spaceflight programme.
- **SSLV (Small Satellite Launch Vehicle):** SSLV is a **three-stage launch vehicle weighing approximately 120 tonnes**, designed primarily for small satellites and on-demand launch services. It can place payloads of up to approximately **500 kg into a 500-km planar orbit**. Its comparatively short preparation cycle and lower mission-specific infrastructure requirements are intended to serve commercial customers seeking flexible small-satellite launches.

Key Terms

- **Sun-Synchronous Orbit (SSO):** A near-polar orbit designed so that a satellite passes over a particular location at approximately the same local solar time on successive visits. This provides broadly consistent

illumination conditions, making it useful for comparing images collected on different dates. The actual revisit period depends on the satellite's orbit, altitude, instrument coverage and observation plan.

- **Geostationary Transfer Orbit (GTO):** An elliptical intermediate orbit used to transfer a satellite towards geostationary orbit. Its perigee is generally a few hundred kilometres above Earth, while its apogee approaches the altitude of **35,786 km**. Near apogee, the satellite uses an apogee motor to raise its perigee and circularise the orbit. Additional manoeuvres establish the required geostationary orbit.
- **Cryogenic Upper Stage:** The upper stage of a launch vehicle that uses extremely cold propellants, commonly **liquid hydrogen (LH₂) as fuel and liquid oxygen (LOX) as oxidiser**. Their high efficiency makes cryogenic propulsion especially useful for carrying heavier payloads into higher orbits.
 - India's indigenous cryogenic stage replaced dependence on the earlier Russian-supplied cryogenic stage used in GSLV development. Its development required advances in turbomachinery, combustion, materials, insulation and the management of extremely low-temperature propellants.
- **Low Earth Orbit (LEO):** An orbital region relatively close to Earth, widely used for Earth-observation satellites, many communication constellations, scientific spacecraft and crewed missions. Its lower altitude can reduce launch-energy requirements, although atmospheric drag can affect satellite lifetimes.
- **Geostationary Orbit (GEO):** A circular equatorial orbit at approximately 35,786 km above Earth's surface in which a satellite's orbital period matches Earth's rotation. A satellite in this orbit appears nearly stationary relative to a point on Earth, making GEO particularly useful for continuous communication and weather-monitoring coverage.
- **Sounding Rocket:** A suborbital rocket used to investigate the upper atmosphere, test scientific instruments and conduct short-duration experiments. It provides a comparatively economical platform for atmospheric research and early-stage technology validation.

Reusable Launch Vehicle (RLV) Technology

- **About:** Reusable launch vehicles are designed to recover and reuse major vehicle components instead of discarding them after a single flight. Reuse can reduce manufacturing costs per mission, limit material wastage and improve launch frequency, provided recovery, inspection and refurbishment remain economically viable.
- **Pushpak RLV Demonstrator:** ISRO's winged reusable launch vehicle demonstrator, known as **Pushpak**, is being used to validate autonomous navigation, aerodynamic control and precision landing technologies needed for future reusable launch systems.
 - ISRO conducted three **Reusable Launch Vehicle Landing Experiments (RLV-LEX)** in April 2023, March 2024 and June 2024.
 - During **LEX-03 on 23 June 2024**, Pushpak was released from an Indian Air Force Chinook helicopter at an altitude of approximately 4.5 km and from a point about 4.5 km from the runway. It autonomously corrected its cross-range trajectory and executed a controlled horizontal landing.
 - LEX-03 tested more challenging release and wind conditions, including a cross-range of approximately 500 metres, compared with 150 metres in LEX-02. The vehicle landed at a speed exceeding 320 km/h, demonstrating the need for precise guidance and control at high landing velocities.
- **Significance:** RLV experiments support the development of autonomous flight control, atmospheric re-entry, thermal protection, runway landing and vehicle recovery. These technologies may eventually enable lower-cost access to space, but the landing experiments do not mean that India already operates a fully reusable orbital launch vehicle.

Scramjet and Air-Breathing Propulsion

- **Scramjet Technology:** A **Supersonic Combustion Ramjet (scramjet)** is an air-breathing engine that uses oxygen from the atmosphere for combustion. Unlike conventional rockets, it does not need to carry all the oxidiser required during the atmospheric portion of flight, potentially reducing the mass of the propulsion system.

- **Working Principle:** Scramjets are designed for hypersonic flight, conventionally defined as speeds above **Mach 5**. In a scramjet combustor, airflow remains supersonic during combustion, creating demanding requirements for fuel injection, flame stabilisation, heat management and engine geometry. The engine also requires an initial high-speed condition and cannot independently provide the same launch capability as a conventional rocket.
- **ISRO Achievements:**
 - ISRO conducted a scramjet technology-demonstration test in **August 2016**, validating important aspects of supersonic combustion at a speed of approximately Mach 6.
 - A **Rohini RH-560 sounding-rocket experiment in July 2024** contributed to research associated with air-breathing propulsion systems.
- **Significance:** Air-breathing propulsion could improve the efficiency of future high-speed atmospheric flight and space-transportation systems by reducing the need to carry onboard oxidiser during the relevant flight phase. Practical deployment still requires extensive development and validation under demanding flight conditions.

Electric and Green Propulsion Technologies

- **Electric Propulsion:** Electric propulsion uses electrical energy to accelerate propellant and generate thrust. It generally produces lower thrust than chemical propulsion but can operate efficiently over extended periods, making it useful for satellite station-keeping, orbit raising and selected deep-space missions.
 - In **March 2025, ISRO completed a 1,000-hour life test of an indigenous 300-millinewton stationary plasma thruster**. The endurance test assessed the system's ability to operate for an extended period, an important requirement for spacecraft propulsion.
 - The thruster technology offers a specific impulse at least six times higher than conventional chemical propulsion systems, according to the supplied technical information. **Specific impulse** measures propellant efficiency; a higher value means that a given mass of propellant can produce more total impulse.
 - A planned demonstration aboard **TDS-01** is intended to advance the evaluation of electric propulsion in a spacecraft environment. Electric propulsion is not a direct substitute for high-thrust launch propulsion because its thrust is comparatively low.
- **Green Propulsion:** Green propulsion covers alternative propellants and propulsion systems intended to reduce toxicity, handling hazards or other environmental and operational burdens. The benefits vary with the specific propellant formulation and its performance.
 - **ISROSENE:** An indigenous rocket-grade kerosene formulation being developed for liquid-oxygen-kerosene semi-cryogenic propulsion systems. Such systems combine a liquid oxidiser with a hydrocarbon fuel and can support the development of powerful, domestically produced rocket engines.
 - **Bellatrix Aerospace:** The company has developed a **1-newton-class green monopropellant thruster** with support under the Defence Research and Development Organisation's **Technology Development Fund**. Its in-orbit functionality was demonstrated in January 2024, providing evidence of the technology's performance in a space environment.
 - Green monopropellant systems and electric propulsion are distinct technologies: monopropellant thrusters generate thrust through chemical decomposition or reaction, whereas electric thrusters use electrical energy to accelerate propellant.

Radioisotope Heating and Power Technologies

- **Radioisotope Heater Units (RHUs):** RHUs use the heat released by radioactive decay to maintain spacecraft instruments and components within suitable operating-temperature ranges. They can be useful in extremely cold environments, including lunar regions that receive little sunlight.

- **Radioisotope Thermoelectric Generators (RTGs):** RTGs convert heat produced by radioactive decay into electrical energy, generally through thermoelectric materials. They can provide power for long-duration missions where solar illumination is weak, intermittent or unavailable.
- **Indian Initiative:** ISRO and the **Department of Atomic Energy (DAE)** are collaborating on radioisotope-based heating and power technologies for potential future missions, including lunar and Mars exploration.
- **Scientific and Strategic Importance:** Radioisotope systems can improve mission endurance and reduce dependence on solar panels. Their development also requires specialised materials, radiation-safety measures, reliable containment, strict handling procedures and regulatory oversight. RHUs and RTGs have different functions: RHUs principally provide heat, whereas RTGs generate electrical power.

Space Docking and In-Orbit Servicing

- **SpaDeX Mission:** ISRO's **Space Docking Experiment (SpaDeX)** was designed to demonstrate rendezvous, proximity operations, autonomous docking and undocking using two small spacecraft, designated SDX-01 and SDX-02. Docking is a critical capability for future missions in which separately launched spacecraft or modules must join in orbit.
 - The two SpaDeX spacecraft were launched aboard **PSLV-C60 on 30 December 2024**.
 - **First successful docking took place on 16 January 2025**, making India the fourth country to demonstrate space-docking capability after the United States, Russia and China.
 - On **13 March 2025**, ISRO successfully undocked the spacecraft in a circular orbit at an altitude of approximately 460 km and an inclination of 45 degrees. The spacecraft subsequently operated independently, demonstrating the ability to separate after a docking operation.
 - A second autonomous docking was successfully completed on **20 April 2025**, followed by bidirectional power-transfer demonstrations on 21 April. The experiment involved operating a heater in one spacecraft using electrical power supplied by the other spacecraft.
- **In-Orbit Servicing:** Docking and rendezvous technologies can support satellite refuelling, maintenance, repair, upgrades and the extension of spacecraft service lives. They may also allow spacecraft to exchange equipment or power and support the assembly of large orbital structures.
- **Strategic Importance:** Docking is essential for the planned **Bharatiya Antariksh Station**, selected lunar sample-return architectures and missions in which multiple launches must combine to achieve a single objective. It also strengthens India's capacity to conduct complex autonomous orbital operations. However, experimental docking does not itself establish an operational satellite-refuelling service or a completed space station.

Indigenous Satellite Navigation and Communication

- **Navigation with Indian Constellation (NavIC):** NavIC is India's indigenous regional satellite-navigation system, designed to provide **positioning, navigation and timing services over India and approximately 1,500 km beyond the Indian mainland**.
 - The system provides a **Standard Positioning Service (SPS)** for civilian users and an encrypted **Restricted Service (RS)** for authorised users.
 - NavIC supports applications in road and maritime transport, fleet management, disaster management, location-based services and strategic operations. Its utility depends on satellite coverage, signal availability, compatible receivers and the service requirements of users.
 - Indigenous navigation capability reduces dependence on foreign satellite-navigation systems and strengthens resilience in applications where reliable positioning and timing are important.
- **Advanced Communication Satellites:**
 - **GSAT-24 (2022):** A communication satellite developed to support direct-to-home television broadcasting. Its capacity was leased to Tata Play, illustrating the commercial use of India's satellite infrastructure.
 - **GSAT-N2/GSAT-20 (2024):** A high-throughput communication satellite with approximately **48 Gbps capacity**, intended to expand broadband connectivity and support applications such as in-

flight connectivity. High-throughput satellites use substantial bandwidth and advanced payload designs to deliver greater data capacity.

- **CMS-03/GSAT-7R (2025):** A multi-band communication satellite launched to strengthen the Indian Navy's satellite-communication capabilities. It supports secure and reliable connectivity for maritime operations and contributes to India's broader maritime-domain awareness and national-security infrastructure.

Advanced Earth Observation Technologies

- **NASA-ISRO Synthetic Aperture Radar (NISAR):** NISAR is a joint Earth-observation mission developed by NASA and ISRO and launched on **30 July 2025** aboard the GSLV-F16 launch vehicle.
 - It carries **NASA's L-band radar and ISRO's S-band radar**, making it the first spaceborne Earth-observation mission to use these two radar frequencies together in a systematic global imaging mission.
 - Its 12-metre reflector antenna and SweepSAR imaging technology provide a wide observation swath of approximately 240 km while maintaining high-resolution radar imaging.
 - NISAR can observe Earth during both day and night and through cloud cover, providing an advantage over many optical imaging systems. Its planned global observation cycle is approximately **12 days**.
 - Applications include monitoring ground deformation, earthquakes and landslide-prone areas, glacier and ice-sheet movement, vegetation dynamics, woody biomass, agricultural activity, soil moisture, wetlands, surface-water resources and selected oceanic and coastal processes.
 - By July 2026, NISAR's S-band radar data products had entered a public-release phase, marking progress from launch and commissioning towards scientific and operational applications. The mission demonstrates how international scientific cooperation can combine complementary technologies and expertise.
- **Hyperspectral Imaging Satellite (HySIS):** Launched in **November 2018**, HySIS observes Earth across numerous narrow spectral bands. Different materials reflect and absorb electromagnetic radiation in characteristic ways, enabling hyperspectral sensors to help distinguish vegetation, soil, minerals and other surface materials.
 - Its applications include agriculture, forestry, mineral exploration, soil analysis and water-resource monitoring. Such data can improve crop assessment, resource mapping and environmental monitoring when combined with field observations and suitable analytical methods.
 - Unlike radar imaging, hyperspectral observation relies on reflected or emitted radiation in selected spectral bands and can therefore be affected by cloud cover, atmospheric conditions and illumination.

Conclusion

India's emerging space technologies mark a shift towards a **self-reliant, innovation-driven and commercially competitive space ecosystem**. Next-generation launch vehicles and reusable systems aim to improve access to space, while advanced propulsion and radioisotope technologies can support longer and more efficient missions. SpaDeX has demonstrated docking capabilities required for complex orbital operations, and indigenous navigation, communication and Earth-observation satellites provide services for development, scientific research and national security.

Value Addition for UPSC

- **Mains Perspective:** India's next phase of space development requires a balance between strategic autonomy and international cooperation, public research and private investment, ambitious missions and reliable implementation, and technological innovation and the long-term sustainability of outer space.

India Expands Green Hydrogen Production, Industrial Applications and Safety Framework Under Its National Green Hydrogen Mission

Recent Developments:

- In **October 2026**, the Ministry of New and Renewable Energy (MNRE) organised a stakeholder consultation on hydrogen standards and safety in New Delhi during **World Hydrogen and Fuel Cell Day**. The event highlighted the need for improved testing, training and coordination across hydrogen production, storage, transportation and utilisation.
- The report *India's Hydrogen Standards: Gap Assessment and Preliminary Action Framework*, prepared with **Boston Consulting Group (BCG)**, was released to identify regulatory gaps and recommend measures for safe hydrogen deployment.
- On **17 July 2026**, India's first indigenous hydrogen-powered train was inaugurated on the **Jind–Sonipat section in Haryana**, demonstrating the potential of hydrogen fuel cells for cleaner rail mobility.
- By February 2026, approximately **8,000 tonnes per annum** of green hydrogen production capacity had been commissioned under the National Green Hydrogen Mission. Incentives had been awarded for 8.62 lakh tonnes per annum of production capacity and 3,000 MW per annum of domestic electrolyser manufacturing capacity.

What Is Green Hydrogen and Why Is It Important?

- **Green hydrogen** is hydrogen produced using renewable energy, primarily through water electrolysis powered by solar or wind electricity. Its emissions are substantially lower than those of conventional fossil-fuel-based hydrogen when the prescribed production and processing standards are met.
- Hydrogen is an **energy carrier**, not a primary energy source. It can store, transport and deliver energy for industrial processes, transport and power applications.
- In a **fuel cell**, hydrogen reacts electrochemically with oxygen to generate electricity, with water and heat as direct by-products. The overall environmental benefit depends on how the hydrogen is produced, transported and used.
- Green hydrogen can decarbonise **hard-to-abate sectors**, including fertilisers, petroleum refining, iron and steel, heavy-duty transport and shipping, where direct electrification may be technically difficult or economically less practical.
- India's solar and wind resources offer opportunities to reduce fossil-fuel imports, improve **energy security**, create domestic manufacturing capacity and develop potential export markets for hydrogen and its derivatives.

How Is Green Hydrogen Produced?

- **Water electrolysis** uses electricity to split purified water into hydrogen and oxygen. When the electricity comes from eligible renewable sources, the process can produce green hydrogen with substantially lower emissions.
 - **Chemical reaction:** $2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$.
 - An **electrolyser** contains a cathode, an anode and an electrolyte or ion-conducting membrane. Hydrogen forms at the cathode and oxygen at the anode, and the gases are collected separately.
 - Approximately **9 litres of water** are theoretically required to produce 1 kg of hydrogen; actual consumption can be higher because of purification and operational requirements.
 - The hydrogen is subsequently dried, purified and compressed for storage, transport or industrial use.

- The environmental performance depends on the source of electricity, equipment efficiency, water treatment and processing requirements. Electrolysis powered by carbon-intensive electricity does not automatically qualify as green hydrogen.

What Is India's Green Hydrogen Policy Architecture?

National Green Hydrogen Mission:

- The Union Cabinet approved the **National Green Hydrogen Mission (NGHM)** in January 2023 with an outlay of **₹19,744 crore**, implemented by MNRE. Its objective is to establish India as a global hub for green hydrogen production, utilisation and exports.
- The Mission targets at least **5 million metric tonnes (MMT) of annual green hydrogen production by 2030**, with the possibility of reaching 10 MMT depending on export demand.
- Its major components include financial incentives, demand creation, industrial pilot projects, research and development, enabling infrastructure, certification and skill development.

Strategic Interventions for Green Hydrogen Transition:

- The **SIGHT programme** has an allocation of **₹17,490 crore up to 2029–30**. It supports domestic electrolyser manufacturing and green hydrogen production through financial incentives.
- Incentives have been awarded to **15 companies for 3,000 MW per annum of electrolyser manufacturing capacity** and for **8.62 lakh tonnes per annum of green hydrogen production capacity**. Awarded capacity represents planned or contracted potential, not necessarily operational production.

Industrial Pilot Projects and Green Hydrogen Hubs:

- **Steel:** Five pilot projects have been sanctioned, with ₹455 crore allocated up to 2029–30 for low-carbon steelmaking, including support for testing 100% hydrogen injection.
- **Mobility:** Twelve projects cover **70 hydrogen vehicles**, comprising 27 buses and 43 trucks, with 16 refuelling stations planned across 21 routes.
- **Shipping:** V.O. Chidambaranar Port Authority has awarded a **₹38.12 crore green methanol bunkering and refuelling project**, including an MNRE grant of ₹35 crore.
- **Green hydrogen hubs** concentrate production, consumption, innovation and shared infrastructure. Deendayal Port in Gujarat, V.O. Chidambaranar Port in Tamil Nadu and Paradip Port in Odisha have been recognised as such hubs.
- An indigenous **1 MW green hydrogen plant** was commissioned at Kandla Port in July 2025, while Hydrogen Valley Innovation Clusters have been awarded in Jodhpur, Odisha, Pune and Kerala.

Enabling Policies and Regulatory Standards:

- Eligible green hydrogen and green ammonia plants commissioned by **31 December 2030** can receive a 25-year waiver of Inter-State Transmission System charges, subject to applicable conditions.
- The Green Hydrogen and Green Ammonia Policy provides for open access to renewable electricity within 15 days and banking of surplus renewable electricity for up to 30 days, subject to regulations.
- The **Green Hydrogen Standard, notified in 2023**, sets a maximum well-to-gate emissions intensity of **2 kg of CO₂ equivalent per kg of hydrogen**, averaged over 12 months. Its scope includes eligible electrolysis-based and biomass-based production pathways.
- The **Green Hydrogen Certification Scheme of India**, introduced in 2025, provides a framework for emissions monitoring, verification and certification. The Bureau of Energy Efficiency accredits verification agencies.

- Research support includes **₹400 crore for research and development**, while ₹100 crore has been allocated to green hydrogen technology start-ups. The Mission also aims to generate over **6 lakh jobs by 2030**.

What Are the Major Applications of Green Hydrogen?

- **Fertilisers:** Green hydrogen can replace fossil-fuel-derived hydrogen in ammonia production, enabling lower-emission **green ammonia** for nitrogen-based fertilisers, including urea.
- **Petroleum refining:** Hydrogen is used in desulphurisation and hydrocracking. Replacing conventional hydrogen with green hydrogen can reduce emissions associated with refinery operations.
- **Iron and steel:** Hydrogen can act as a reducing agent in **Direct Reduced Iron (DRI)** production, reducing dependence on coal and potentially lowering process emissions.
- **City gas distribution:** Hydrogen can be blended with natural gas in limited proportions, subject to pipeline compatibility, safety standards and technical requirements.
- **Road and rail transport: Fuel Cell Electric Vehicles (FCEVs)** generate electricity onboard through the reaction of hydrogen and oxygen. Hydrogen can be useful for heavy-duty buses, trucks and trains requiring long operating ranges and relatively quick refuelling. India's first indigenous hydrogen-powered train was inaugurated on the Jind–Sonipat section in July 2026.
- **Shipping:** Green hydrogen can be converted into **green ammonia and green methanol** for use as alternative marine fuels, subject to vessel compatibility, safety requirements and port infrastructure.
- **Energy storage:** Surplus renewable electricity can be converted into hydrogen for long-duration storage and later use, supporting renewable energy integration and grid flexibility.

What Challenges Must India Address?

- **High production costs:** Electrolysers, renewable electricity, financing and hydrogen processing remain important cost components, limiting competitiveness against conventional hydrogen.
- **Infrastructure gaps:** Hydrogen requires specialised storage, compression, transportation, refuelling and industrial handling facilities. Developing these systems demands substantial investment and rigorous safety protocols.
- **Demand uncertainty:** Producers need reliable long-term buyers in steel, fertilisers, refineries and transport to justify large capital investments.
- **Water and resource constraints:** Electrolysis requires purified water, making water availability and sustainable sourcing important considerations, particularly in water-stressed regions.
- **Technology dependence:** Domestic manufacturing of electrolysers, membranes, catalysts and fuel-cell components is necessary to strengthen supply-chain resilience and reduce import dependence.
- **Certification and safety:** Consistent emissions accounting, credible certification, trained personnel and harmonised technical standards are essential for public safety and international trade.

Conclusion:

The National Green Hydrogen Mission links renewable energy expansion with industrial decarbonisation, domestic manufacturing and energy security. Achieving its 2030 target will require translating announced capacity into operational production, building dependable demand, reducing costs and strengthening infrastructure, research and certification. Green hydrogen can contribute to India's **Net Zero emissions goal by 2070**, provided that its production remains genuinely low-carbon and economically viable.

Value Addition for UPSC:

- **GS Paper III:** Renewable energy, energy security, industrial decarbonisation, environmental sustainability, infrastructure and technological self-reliance.

- **Prelims facts:** NGHM was approved in **January 2023**; its outlay is **₹19,744 crore**; the 2030 production target is **5 MMT annually**; SIGHT has an allocation of **₹17,490 crore**; the Green Hydrogen Standard sets a limit of **2 kg CO₂-equivalent per kg of hydrogen** on a 12-month average well-to-gate basis.
- **Mains linkage:** Green hydrogen supports the energy transition by connecting renewable electricity, industrial feedstocks, transport and long-duration energy storage.
- **Policy approach:** Prioritise demand aggregation, competitive renewable electricity, indigenous technology, targeted industrial pilots, sustainable water use, safety standards and credible emissions certification.

India Launches Tobacco-Free Youth Campaign 4.0 to Strengthen Prevention, Cessation and Tobacco Control

Recent Developments:

- On **28 October 2026**, Union Minister of State for Health and Family Welfare **Prataprao Jadhav** launched the fourth edition of the **Tobacco-Free Youth Campaign (TFYC 4.0)** in New Delhi and administered the **‘Say No to Tobacco’** pledge.
- The **60-day nationwide campaign**, running from 28 October to 26 December 2026, aims to prevent tobacco initiation among young people, encourage cessation, strengthen enforcement and promote tobacco-free environments.
- The campaign places special emphasis on **universities and colleges** and follows a six-pronged strategy covering information and awareness activities, tobacco-free educational institutions, tobacco-free villages, enforcement of tobacco-control laws, higher educational institutions and social-media engagement.
- Under the previous 3 editions, more than **5.8 lakh educational institutions and 73,000 villages** were declared tobacco-free, strengthening community participation in tobacco prevention.

What Is the ‘Say No to Tobacco’ Pledge?

- The pledge is a **public-health awareness and behavioural commitment initiative** under TFYC 4.0. It encourages young people to reject tobacco and nicotine addiction and promote tobacco-free communities.
- The **Ministry of Health and Family Welfare (MoHFW)** is the nodal ministry, while educational institutions, healthcare professionals, enforcement agencies and communities support implementation.
- The campaign seeks to prevent tobacco use before addiction develops, encourage existing users to quit and empower young people as ambassadors of a **Tobacco-Free India**, contributing to the vision of **Viksit Bharat 2047**.
- Tobacco-free campuses are a major priority because early exposure to tobacco and nicotine can lead to dependence and harm adolescent brain development. Awareness activities must be supported by compliance with tobacco-control laws and access to cessation services.

Why Is Tobacco Control a Public-Health Priority?

- **Health burden:** Tobacco use causes cancer, cardiovascular diseases, stroke and chronic respiratory illnesses. Nicotine is highly addictive, and exposure during adolescence can adversely affect the developing brain.
- **Global mortality:** The World Health Organization’s updated tobacco fact sheet reports that tobacco kills more than **7 million people annually**, including over **1.6 million non-smokers** exposed to second-hand smoke.
- **Indian context:** India experiences approximately **13.5 lakh tobacco-related deaths annually**. The Global Adult Tobacco Survey 2016–17 estimated that nearly 267 million adults, or 28.6% of adults, used tobacco.

- **Economic burden:** Tobacco-related illnesses and premature deaths reduce productivity and increase healthcare expenditure. A study covering people aged 35 years and above estimated the economic cost of tobacco use in India at **₹1,77,341 crore in 2017–18**, equivalent to about 1% of GDP.
- **Environmental damage:** Tobacco cultivation can deplete soil nutrients and contribute to deforestation. Tobacco production and consumption also generate substantial waste, while discarded cigarette filters and other tobacco products create additional pollution and waste-management costs.

How Is India Fighting Against Tobacco?

International Commitments:

- **WHO Framework Convention on Tobacco Control (WHO FCTC):** India became a Party to this international public-health treaty in **2004**. It promotes evidence-based measures to reduce tobacco demand and supply, protect people from tobacco smoke and strengthen national tobacco-control policies.
- **World No Tobacco Day:** Observed annually on **31 May**, it raises awareness of the health, social, economic and environmental consequences of tobacco consumption.

National Legislation and Programmes:

- **Cigarettes and Other Tobacco Products Act, 2003 (COTPA):** The Act regulates tobacco advertising, trade, distribution, packaging and labelling. Its provisions also restrict smoking in public places, prohibit sales to and by minors, and prohibit the sale of tobacco products within 100 yards of educational institutions.
- **National Tobacco Control Programme (NTCP):** Launched in **2007–08**, the programme supports public awareness, implementation of COTPA, training of stakeholders, tobacco-use surveillance and cessation services. Its institutional structure includes national, state and district tobacco-control cells.
- **Prohibition of Electronic Cigarettes Act, 2019:** This law prohibits the production, manufacture, import, export, transport, sale, distribution, storage and advertisement of electronic cigarettes, including covered electronic nicotine-delivery devices.
- **National Tobacco Quitline Services (NTQLS):** The toll-free number **1800-11-2356** provides counselling to people seeking to quit tobacco. Cessation centres also support behavioural interventions and treatment.
- **mCessation Programme:** Introduced in **2016**, this initiative uses mobile technology to provide tobacco-cessation support and reinforce quitting behaviour.
- **Tobacco taxation:** Higher and better-designed taxes can reduce affordability and consumption while generating revenue for public-health programmes. Tax policy should account for differences among cigarettes, bidis and smokeless tobacco to avoid encouraging substitution towards cheaper harmful products.

What Are the Hidden Costs of Tobacco?

- **Environmental degradation:** Tobacco cultivation can increase pressure on soil, water and forests. Processing tobacco also requires resources, while discarded tobacco products contribute to land and water pollution.
- **Healthcare expenditure:** The estimated economic burden of tobacco-related diseases and premature deaths in India reached **₹1,77,341 crore in 2017–18** among people aged 35 years and above, demonstrating the substantial cost borne by households and the economy.
- **Occupational health risks:** Tobacco workers may face exposure to nicotine through the skin, including the risk of green tobacco sickness during cultivation and harvesting.
- **Waste management:** Cigarette butts, tobacco packaging and smokeless-tobacco waste impose additional collection, treatment and disposal costs on local authorities.

What Measures Can Strengthen Tobacco Control?

- **Improve enforcement:** Strengthen implementation of COTPA and the electronic-cigarette prohibition law through regular inspections, penalties for violations and effective protection of children around educational institutions.
- **Increase cessation support:** Expand accessible counselling, quitline services and evidence-based treatment through primary healthcare facilities, hospitals and community health programmes.
- **Use taxation strategically:** Review tobacco taxation across product categories to discourage consumption, reduce affordability and limit substitution towards cheaper tobacco products.
- **Strengthen monitoring:** Use regular surveys and enforcement data to assess tobacco-use trends, identify vulnerable groups and measure the effectiveness of campaigns.
- **Support alternative livelihoods:** Help tobacco farmers transition towards economically viable alternative crops and provide skill development and livelihood assistance to workers affected by changes in tobacco production.
- **Promote youth participation:** Integrate tobacco-prevention education into schools and universities, encourage peer-led campaigns and use digital platforms to counter tobacco promotion and misinformation.

Conclusion:

The Tobacco-Free Youth Campaign 4.0 strengthens India's tobacco-control efforts by combining youth participation, awareness, legal enforcement and cessation support. Sustained progress requires more than pledges: it depends on effective implementation of tobacco-control laws, accessible treatment, evidence-based taxation, reliable monitoring and protection of young people from tobacco marketing and exposure.

Value Addition for UPSC:

- **GS Paper II:** Public health, government programmes, international conventions, regulatory enforcement and interdepartmental coordination.
- **GS Paper III:** Human capital, economic costs of preventable disease, environmental pollution and sustainable livelihoods.
- **Prelims facts:** TFYC 4.0 was launched on **28 October 2026** for 60 days; COTPA was enacted in **2003**; India became a Party to WHO FCTC in **2004**; NTCP began in **2007–08**; electronic cigarettes are covered by the **2019 Act**.
- **Mains perspective:** Tobacco control requires a **whole-of-government and whole-of-society approach** that combines demand reduction, supply regulation, taxation, cessation services, youth engagement and environmental responsibility.

QUESTIONS

1. Consider the following pollutants evaluated under the National Air Quality Index (AQI) framework launched by the Central Pollution Control Board (CPCB):

- (1) PM_{2.5} and PM₁₀
- (2) Carbon Monoxide (CO) and Ozone (O₃)
- (3) Carbon Dioxide (CO₂) and Methane (CH₄)
- (4) Ammonia (NH₃) and Lead (Pb)
- (5) Nitrogen Dioxide (NO₂) and Sulphur Dioxide (SO₂)

How many of the pollutant pairs mentioned above are included in the computation of India's National AQI?

- (A) Only two
- (B) Only three
- (C) Only four
- (D) All five

2. With reference to the legal and structural parameters of the Care Economy in India, consider the following statements:

- (1) Under the UN System of National Accounts (SNA), unpaid domestic care work falls outside the core Production Boundary.
- (2) Article 39(e) of the Constitution mandates the State to ensure that citizens are not forced by economic necessity.
- (3) Under the Rights of Persons with Disabilities Act, 2016, "High Support" care services are recognized as a statutory entitlement.
- (4) The Maintenance and Welfare of Parents and Senior Citizens Act, 2007 makes it legally mandatory for state governments to establish and manage senior citizen homes in every district.

Which of the statements given above are correct?

- (A) 1 and 2 only
- (B) 1, 2, and 3 only
- (C) 3 and 4 only
- (D) 1, 2, 3, and 4

3. Consider the following:

Assertion (A): Hyperspectral Imaging Satellites (HySIS) can distinguish minute variations in soil chemistry.

Reason (R): Every chemical compound in the soil absorbs and reflects specific wavelengths of light based on its molecular bonds.

Select the correct answer using the code given below:

- (A) Both A and R are true, and R is the correct explanation of A.
- (B) Both A and R are true, but R is NOT the correct explanation of A.

- (C) A is true, but R is false.
 (D) A is false, but R is true.

4. Consider the following pairs matching Hydrogen Color/Classification Codes with their primary production pathways:

Pair	Classification Code	Production Process & Feedstock
1.	Grey Hydrogen	Produced from natural gas via Steam Methane Reforming (SMR) without Carbon Capture
2.	Blue Hydrogen	Produced from fossil fuels via SMR combined with Carbon Capture and Storage (CCS)
3.	Green Hydrogen	Produced via water electrolysis powered entirely by renewable energy (solar/wind)
4.	Pink/Purple Hydrogen	Produced via water electrolysis powered by nuclear energy

How many of the above pairs are correctly matched?

- (A) Only one pair
 (B) Only two pairs
 (C) Only three pairs
 (D) All four pairs

5. Consider the following statements:

Statement 1: Nicotine exposure during adolescence causes structural and functional alterations in the developing prefrontal cortex of the brain.

Statement 2: The prefrontal cortex is the last region of the human brain to reach full structural maturity, undergoing significant gray matter thinning and myelination throughout adolescence.

Which one of the following is correct in respect of the above statements?

- (A) Both Statement 1 and Statement 2 are correct, and Statement 2 is the correct explanation for Statement 1.
 (B) Both Statement 1 and Statement 2 are correct, but Statement 2 is NOT the correct explanation for Statement 1.
 (C) Statement 1 is correct, but Statement 2 is incorrect.
 (D) Statement 1 is incorrect, but Statement 2 is correct.

ANSWER KEY

1 – Answer (C), 2 – Answer (B), 3 – Answer (A), 4 – Answer (D), 5 – Answer (B)



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