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IMPORTANT INSIGHTS

Trial in Absentia Under BNSS Gains Focus After NIA Seeks Proceedings Against Hafiz Saeed in Pahalgam Terror Case

Recent Developments:

- A **Special NIA Court in Jammu** has issued a **Non-Bailable Warrant (NBW)** against **Hafiz Saeed**, the Pakistan-based chief of the banned **Lashkar-e-Taiba (LeT)**, in connection with the **Pahalgam Terror Attack** investigation.
- The action follows the filing of a **supplementary chargesheet** by the **National Investigation Agency (NIA)** naming Hafiz Saeed as a key conspirator acting both individually and as the head of **LeT** and its proxy outfit **The Resistance Front (TRF)**.
- As Hafiz Saeed is unlikely to appear before an Indian court, the **NIA is expected to invoke Section 356 of the Bharatiya Nagarik Suraksha Sanhita (BNSS), 2023**, which provides for **Trial in Absentia** of proclaimed offenders.

Trial in Absentia: Meaning and Legal Basis

Definition:

- **Trial in Absentia** refers to a **criminal trial conducted without the physical presence of the accused**, provided the accused has deliberately **absconded** to **evade** the judicial process and fulfils the statutory conditions prescribed under law.
- **Section 356 of the BNSS, 2023** empowers courts to conduct a complete inquiry, trial and pronounce judgment against a **Proclaimed Offender**, even in the accused's absence, after complying with mandatory procedural safeguards.

Rationale Behind the Provision:

- The provision seeks to prevent **deliberate evasion of justice** by fugitives residing within or outside India.
- It aims to ensure that **serious criminal trials are not indefinitely delayed** merely because the accused remains absconding.
- It strengthens the efficiency of the criminal justice system while preserving the **constitutional requirement of a fair trial** through statutory safeguards.

Evolution from CrPC to BNSS

Position Under the Code of Criminal Procedure (CrPC), 1973:

- **Section 82(4)** provided for **proclamation and attachment of property** of absconding accused persons.
- **Section 317** permitted proceedings in the absence of an accused only in limited circumstances where personal attendance was unnecessary.
- **Section 299** permitted recording of prosecution evidence if there was no immediate possibility of arresting the accused.
- The earlier framework **did not permit a complete criminal trial in absentia**, resulting in prolonged pendency of cases involving absconding accused persons.

Change Introduced by BNSS:

- **Section 356 of the BNSS** introduces, for the first time, a statutory framework for **complete inquiry, trial and judgment in absentia** against proclaimed offenders, thereby addressing a major procedural gap in the earlier criminal justice system.

Applicability of Trial in Absentia

Eligible Category of Accused:

- The provision applies **only to a Proclaimed Offender** declared under **Section 84 of the BNSS**.
- A court may declare a person a proclaimed offender if:
 - The accused has absconded despite proclamation.
 - The alleged offence is punishable with **imprisonment of 10 years or more, life imprisonment, or death**.
 - The accused fails to appear before the court despite due process and judicial inquiry.

Scope:

- The provision is confined to **serious offences** and cannot be invoked for every criminal case or ordinary absconding accused.

Procedure Before Commencement of Trial in Absentia

Mandatory Preconditions:

- **Two consecutive arrest warrants** must be issued with an interval of at least **30 days**.
- A **public notice** must be published in a **local or national newspaper**, directing the accused to appear within **30 days**.
- The notice must be **affixed at the accused's last known residence** and displayed at the concerned police station.
- A **relative or friend**, wherever identifiable, must be informed regarding commencement of the trial.
- The court cannot commence the trial until **90 days have elapsed from the date of framing of charges**.
- The court must record written reasons establishing that the accused has absconded intentionally and there is **no immediate prospect of arrest**.

Safeguards to Ensure Fair Trial

Protection of Rights of the Accused:

- If the accused is not represented by a lawyer, the court must appoint a **State-funded defence counsel**.
- Evidence recorded before commencement of trial may be relied upon during proceedings.
- If the accused is subsequently arrested or voluntarily appears, the court may permit **cross-examination of witnesses** wherever necessary in the interest of justice.
- Statements of witnesses and judicial proceedings may be recorded using **audio-visual electronic means** to preserve transparency, authenticity and future judicial review.
- The accused retains the opportunity to participate in subsequent proceedings if apprehended.

Appeal Under Section 356

Special Restriction:

- A person convicted through **Trial in Absentia** cannot file an appeal unless he or she first **appears before the appellate court**.
- An appeal against conviction is generally not maintainable after **three years** from the date of judgment if the proclaimed offender continues to evade the judicial process.

Significance for India's Criminal Justice System

Administrative and Legal Importance:

- Prevents fugitives from frustrating criminal proceedings by remaining outside India's jurisdiction.
- Reduces long-pending criminal trials involving absconding accused.
- Strengthens India's legal response against **cross-border terrorism**, organised crime and economic offenders.
- Enhances judicial efficiency while balancing procedural fairness through statutory safeguards.
- Aligns criminal procedure with evolving challenges posed by transnational criminal networks.

Constitutional and Legal Issues

Constitutional Considerations:

- **Article 21** guarantees a **fair procedure established by law**, requiring that even absent accused persons receive procedural fairness.
- **Principles of Natural Justice**, particularly the right to be heard, remain relevant but may be deemed waived where the accused intentionally evades the judicial process after due notice.
- Judicial scrutiny is expected to ensure that **Section 356** is invoked only after strict compliance with statutory safeguards.

Challenges and Concerns

Implementation Issues:

- Courts must exercise caution to ensure that the accused has genuinely absconded and is not absent due to unavoidable circumstances.
- Effective international cooperation remains essential for eventual arrest and extradition of fugitives located abroad.
- Improper compliance with procedural safeguards may result in constitutional challenges.
- Continuous judicial oversight is necessary to prevent misuse against individuals who have not intentionally evaded trial.

Relevance for UPSC

GS Paper II:

- Polity and Governance, Criminal Justice Reforms, Rule of Law, Judicial Process, Internal Security.

GS Paper III:

- **Cross-Border Terrorism, Counter-Terrorism Framework, National Security, Legal Measures Against Terror Financing and Organised Crime.**

Prelims Pointers:

- **Section 356 BNSS** — Inquiry, Trial or Judgment in Absentia of a **Proclaimed Offender**.
- Applicable only after declaration under **Section 84 BNSS**.
- Restricted to offences punishable with **10 years or more, life imprisonment, or death**.
- Trial begins only after **90 days from framing of charges** and completion of mandatory procedural requirements.

Value Addition for UPSC

International Perspective:

- Several jurisdictions, including **France, Italy** and certain civil law countries, permit **Trial in Absentia** subject to procedural safeguards, whereas many common law jurisdictions traditionally require the accused's presence except in limited situations.
- International human rights standards generally accept **Trial in Absentia** only where the accused has been adequately informed of proceedings, has voluntarily absented himself or herself, and retains an effective opportunity to challenge the conviction upon appearance.
- The introduction of **Section 356 BNSS** reflects India's effort to reconcile **effective criminal justice, national security concerns and constitutional guarantees of due process**.

Azim Premji University Report Highlights Growing Fiscal Burden on States in Financing India's Expanding Welfare Architecture

Recent Developments:

- The Azim Premji University report titled "**Realising Rights: A Handbook of Welfare in India**" highlights that **State Governments** finance a disproportionately large share of India's welfare expenditure despite shrinking fiscal autonomy and increasing dependence on Union transfers.
- The report argues that growing reliance on **Centrally Sponsored Schemes (CSS)**, declining effective tax devolution, expansion of **cesses and surcharges**, and reduced taxation autonomy after **Goods and Services Tax (GST)** have widened **Centre-State fiscal imbalances**.
- It recommends strengthening **Cooperative Fiscal Federalism** through higher untied transfers, rationalisation of CSS, stronger **State Finance Commissions (SFCs)**, protection of States' revenue powers and adoption of the **Funds-Follows-Functions** principle.

Evolution of India's Welfare Regime:

State-Led Welfare Phase (1950s–1980s):

- Welfare policy was closely linked with planned economic development, poverty alleviation and rural transformation through direct State intervention.

- Major initiatives included the **Community Development Programme (1952)**, **Integrated Child Development Services (ICDS) (1975)** and the **Minimum Needs Programme (1975)**, which expanded access to education, health, nutrition and rural infrastructure.

Targeted Welfare Phase (1990s):

- Economic liberalisation and fiscal constraints shifted welfare policy from universal subsidies towards targeted assistance for vulnerable groups.
- Schemes increasingly differentiated beneficiaries using poverty-based criteria, including the **Targeted Public Distribution System (TPDS)** introduced in 1997, based on **Below Poverty Line (BPL)** and **Above Poverty Line (APL)** classifications.

Rights-Based Welfare Phase (2000s–2014):

- Welfare gradually evolved into a framework of legally enforceable entitlements, making governments accountable for service delivery.
- Landmark legislations included the **Right to Information Act, 2005**, **Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), 2005**, **Right of Children to Free and Compulsory Education Act, 2009**, and the **National Food Security Act (NFSA), 2013**.

Technology-Driven Welfare Phase (Present):

- Digital governance transformed welfare delivery through the **Jan Dhan–Aadhaar–Mobile (JAM) Trinity** and **Direct Benefit Transfer (DBT)** architecture.
- Schemes such as **Pradhan Mantri Kisan Samman Nidhi (PM-KISAN)** increasingly focus on direct income support, reflecting a shift from entitlement-based welfare towards beneficiary-oriented welfare delivery.
- Technology has improved transparency, reduced leakages and enabled targeted benefit delivery while expanding financial inclusion.

Current Status of Welfare Expenditure in India:

Coverage Expansion with Limited Fiscal Commitment:

- Welfare programmes have expanded significantly, with approximately **14 lakh Anganwadi Centres** operating across the country and subsidised food grains reaching more than **81 crore beneficiaries**.
- Despite this expansion, public expenditure on welfare remains below several recommended policy benchmarks.

Social Security Expenditure Gap:

- Combined expenditure of the Union and States on welfare accounts for nearly **7% of Gross Domestic Product (GDP)** and around **21% of total public expenditure**.
- Although India's **Tax-to-GDP Ratio** is comparable to many middle-income countries, expenditure on social protection remains relatively low as a proportion of GDP.

Centre-State Fiscal Asymmetry in Welfare Financing:

Disproportionate Welfare Responsibility of States:

- Combined allocations for selected welfare sectors during **Financial Year 2025–26** amount to nearly **₹24.20 lakh crore**, equivalent to about **6.77% of GDP**.
- The Union Government contributes only around **1.89% of GDP**, while States finance the majority of welfare expenditure.

Declining Effective Tax Devolution:

- The **14th Finance Commission** recommended **42%** tax devolution to States, while the **15th Finance Commission** recommended **41%**.
- However, effective devolution has remained around **29–32%** because a growing share of Union tax revenue is collected through **cesses and surcharges**, which are excluded from the divisible pool.
- The share of cesses and surcharges increased from nearly **10.4%** of Gross Tax Revenue in **2011–12** to more than **20%** by **2021–22**, reducing the untied resources available to States.

Growing State Expenditure on Social Services:

- States account for nearly **75.2%** of total expenditure on school education, making them the principal financiers of public education.
- States also bear substantial expenditure on public health, nutrition, food distribution and unconditional cash transfer schemes.
- According to the **16th Finance Commission**, States spend approximately **₹4.14 lakh crore** annually on unconditional cash transfers, significantly increasing their fiscal obligations.

State Innovations and Fiscal Challenges:

States as Laboratories of Welfare Innovation:

- Several successful national welfare programmes originated as State-level initiatives before being adopted by the Union Government.
- **Rythu Bandhu** of Telangana and **KALIA** of Odisha provided the policy foundation for **PM-KISAN**.
- **Tamil Nadu's Mid-Day Meal Scheme** later evolved into the national **PM POSHAN** programme.
- Despite pioneering innovative welfare models, fiscally active States often face borrowing restrictions and fiscal deficit constraints.

Challenges Associated with Centrally Sponsored Schemes (CSS):

Fiscal and Administrative Concerns:

- Many schemes such as **Integrated Child Development Services (ICDS)** and **Pradhan Mantri Matru Vandana Yojana (PMMVY)** operate under a **60:40 Centre-State funding pattern**, requiring States to mobilise matching resources.
- Proposed changes in rural employment programmes are expected to increase the financial contribution required from States.
- Release of Central assistance is frequently linked to policy reforms or mandatory implementation conditions, reducing States' fiscal flexibility.

- Under the **PM SHRI Scheme**, States were required to sign a **Memorandum of Understanding (MoU)** with the Union Government before receiving financial assistance, leading to concerns regarding federal autonomy.

Impact of Goods and Services Tax on Fiscal Federalism:

Reduction in Revenue Autonomy:

- The introduction of **Goods and Services Tax (GST)** subsumed several major State taxes, limiting States' independent taxation powers.
- States now depend significantly on the **GST Council**, Central tax devolution and compensation mechanisms for revenue stability.
- This has created a structural imbalance between constitutional expenditure responsibilities and available revenue sources.

Emergence of Fiscal Dependency:

- Shrinking untied transfers, tied CSS assistance, reduced taxation autonomy and borrowing restrictions have increased States' dependence on Union-controlled fiscal instruments.
- Such trends risk transforming **Cooperative Federalism** into a system of **Coercive Fiscal Federalism**, where expenditure responsibilities are decentralised but financial autonomy remains centralised.

Constitutional and Institutional Framework:

Relevant Constitutional Provisions:

- **Article 246A** provides concurrent taxation powers to Parliament and State Legislatures for GST.
- **Article 270** governs distribution of taxes between the Union and the States.
- **Article 275** provides for statutory grants-in-aid to States.
- **Article 280** establishes the **Finance Commission** to recommend tax devolution and grants.
- **Article 279A** establishes the **GST Council** as the institutional mechanism for cooperative fiscal decision-making.
- **Article 293** regulates State borrowing from the Union Government.

Measures Required to Reduce the Welfare Burden on States:

Strengthening Fiscal Federalism:

- The share of **cesses and surcharges** should be rationalised and confined to specific, temporary purposes to preserve the integrity of the divisible pool.
- **Centrally Sponsored Schemes** should undergo periodic rationalisation, with greater reliance on untied grants and flexible funding.
- The recommendation of the **Punchhi Commission (2010)** that CSS should remain limited to matters of national importance deserves greater implementation.
- A statutory **Fiscal Council**, as recommended by the **N.K. Singh Fiscal Responsibility and Budget Management Review Committee (2016)**, should independently assess fiscal sustainability and improve Centre-State fiscal coordination.
- Residual taxation powers of States should be protected to preserve fiscal autonomy in the post-GST framework.

- Fiscal transfers should better reflect differences in revenue capacity, demographic pressures, developmental needs and welfare expenditure across States.
- **State Finance Commissions (SFCs)** should be constituted regularly and their recommendations implemented in a time-bound manner to strengthen fiscal decentralisation.
- **Panchayati Raj Institutions (PRIs)** and **Urban Local Bodies (ULBs)** should receive greater authority to mobilise property taxes, user charges and other local revenues.
- Institutional forums such as the **Inter-State Council**, **Finance Commission** and **GST Council** should facilitate continuous political dialogue on fiscal issues.
- Fiscal transfers should increasingly follow the **Funds-Follows-Functions** principle, ensuring that revenue powers correspond to expenditure responsibilities.

Important Judicial Developments:

Recent Supreme Court Judgments:

- The **Mineral Area Development Authority (MADA) v. Steel Authority of India Limited (SAIL), 2024** judgment reaffirmed significant State taxation powers relating to mineral rights.
- The **State of Uttar Pradesh v. Lalta Prasad Vaish, 2024** judgment reinforced constitutional protection for State taxation powers relating to industrial alcohol.
- These decisions strengthen the principle that constitutionally assigned State revenue sources should not be unduly diluted.

UPSC Relevance:

GS Paper II:

- **Centre-State Relations, Fiscal Federalism, Finance Commission, Cooperative Federalism, Governance, Welfare Policies.**

GS Paper III:

- **Inclusive Growth, Public Finance, Fiscal Policy, GST, Social Sector Financing, Economic Development.**

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Prelims Pointers:

- **Finance Commission** is constituted under **Article 280**.
- **GST Council** is established under **Article 279A**.
- **Article 270** governs distribution of Union taxes.
- **State Finance Commissions** are constituted under **Articles 243-I and 243-Y**.
- **Cesses and surcharges** do not form part of the divisible pool of taxes shared with States.

Value Addition for UPSC:

Key Concepts and Committees:

- **Vertical Fiscal Imbalance** refers to the mismatch between revenue-raising powers and expenditure responsibilities across different levels of government.
- **Horizontal Fiscal Imbalance** refers to differences in fiscal capacity and expenditure needs among States.

- The **Second Administrative Reforms Commission**, **Punchhi Commission**, and successive **Finance Commissions** have consistently emphasised strengthening **Cooperative Fiscal Federalism** through greater fiscal autonomy, predictable devolution and institutional dialogue.
- Sustainable welfare financing requires balancing **macroeconomic stability**, **fiscal responsibility**, **State autonomy**, and **equitable social sector investment**, thereby ensuring effective implementation of the **Directive Principles of State Policy (DPSPs)** while preserving India's federal constitutional structure.

Novel Metal-Organic Framework Breakthrough Offers Highly Efficient Solution for Tritiated Water Purification from Nuclear Wastewater

Recent Developments:

- A study published in **Environmental Science & Technology** has demonstrated a highly efficient method for removing **Tritiated Water (HTO)** using an advanced **Metal-Organic Framework (MOF)** coated distillation system. The new technology significantly improves tritium separation efficiency compared to existing industrial methods.
- The research gains global significance because **Japan** has been releasing treated wastewater from the **Fukushima Daiichi Nuclear Power Plant**, where **tritium** remains the principal radioactive contaminant that cannot be removed through conventional treatment technologies.
- The breakthrough further highlights the expanding environmental applications of **Metal-Organic Frameworks (MOFs)**, a class of programmable porous materials recognised through the **2025 Nobel Prize in Chemistry**.

Tritium and Tritiated Water:

What is Tritium?

- **Tritium (^3H)** is a naturally occurring and artificially produced **radioactive isotope of hydrogen** containing **one proton and two neutrons**.
- Tritium is produced naturally through interactions between **cosmic rays** and atmospheric gases, while significant quantities are also generated in **nuclear reactors**, **nuclear fuel reprocessing facilities**, and **thermonuclear weapons**.
- Tritium undergoes **beta decay** with a half-life of approximately **12.3 years**, gradually transforming into **Helium-3**.

What is Tritiated Water (HTO)?

- When tritium chemically combines with oxygen, it forms **Tritiated Water (HTO)**.
- Since hydrogen in ordinary water is replaced by tritium, **HTO** behaves almost identically to normal water in physical and chemical processes.
- This chemical similarity makes separation of tritiated water from ordinary water one of the most difficult challenges in nuclear wastewater treatment.

Environmental and Health Concerns:

- Tritiated water can enter living organisms through **drinking water**, **food**, and **respiration**.

- Once inside the body, tritium circulates rapidly through the bloodstream and is distributed to various tissues.
- Although tritium emits relatively low-energy beta radiation, prolonged exposure and bioaccumulation remain important radiation safety concerns, particularly around nuclear facilities.

Fukushima Nuclear Wastewater Issue:

Background:

- Following the **2011 Fukushima Daiichi Nuclear Disaster**, large quantities of water were continuously used to cool damaged reactor cores.
- The contaminated water underwent treatment through the **Advanced Liquid Processing System (ALPS)**, which removes most radioactive isotopes except tritium.
- In **2023**, Japan began the gradual discharge of treated water into the **Pacific Ocean** after dilution, leading to international scientific and diplomatic debate.

Why Tritium Remains a Challenge?

- Conventional purification technologies effectively remove heavy radioactive isotopes.
- Tritium cannot be removed efficiently because **HTO** possesses nearly identical chemical properties to ordinary water.
- Consequently, dilution has remained the most widely adopted management strategy in the nuclear industry.

Conventional Methods for Tritium Removal:

Water Distillation:

- The most practical large-scale technology presently available is **fractional water distillation**.
- Separation depends upon the extremely small difference in boiling points between ordinary water and tritiated water.
- Achieving meaningful separation requires **very tall distillation columns**, making the process highly energy-intensive and expensive.

Limitations of Existing Technology:

- Conventional distillation towers use **packing materials** that merely increase the contact surface between liquid and vapour.
- These packing materials remain chemically inactive and depend entirely on gravitational separation.
- Existing systems become impractical for treating millions of tonnes of contaminated water stored at nuclear facilities.

New Metal-Organic Framework-Based Technology:

Scientific Innovation:

- Researchers coated **stainless-steel mesh** with a specially designed **Metal-Organic Framework**, namely **NH₂-MIL-101(Cr)**.
- The MOF functions like a microscopic porous sponge capable of selectively interacting with tritium atoms.
- The coating increased the effective internal surface area of the packing material by nearly **32 times**.

Working Mechanism:

- **Chromium-oxygen clusters** inside the MOF selectively capture tritium atoms.
- Simultaneously, hydrogen exchange occurs between tritium and ordinary hydrogen through catalytic proton exchange.
- Nitrogen-containing functional groups further facilitate efficient isotope exchange, thereby enhancing separation during distillation.

Performance of the New Technology:***Major Achievements:***

- The modified system achieved a record **42.5 theoretical plates per metre**, representing one of the highest separation efficiencies reported for water distillation.
- A **10-metre** industrial column using this material could become approximately **134 times** more effective than the best previously reported packing material.
- The technology is nearly **one million times** more efficient than conventional commercial packing materials currently used in industry.
- Experimental studies also demonstrated excellent operational stability and long-term reusability under continuous operation.

Significance of the Study:***Environmental Importance:***

- The technology offers a practical pathway for reducing tritium discharge into rivers, lakes and oceans.
- Improved detritiation can significantly strengthen environmental protection around nuclear installations.
- The innovation supports safer long-term management of radioactive wastewater.

Technological Importance:

- The study demonstrates how **programmable porous materials** can solve difficult isotope-separation challenges.
- The technology could substantially reduce energy consumption associated with nuclear wastewater treatment.
- The research opens new opportunities for advanced isotope separation technologies beyond nuclear applications.

Metal-Organic Frameworks (MOFs):***What are MOFs?***

- **Metal-Organic Frameworks (MOFs)** are crystalline materials formed by linking **metal ions** with **organic molecules** into highly porous three-dimensional networks.
- Their internal surface area may extend to **thousands of square metres per gram**, making them among the most porous materials ever developed.
- Scientists can precisely modify pore size, pore shape and internal chemistry to selectively capture specific molecules.

Unique Characteristics:

- Extremely high porosity.
- Large internal surface area.
- Programmable pore architecture.
- High adsorption capacity.
- Excellent selectivity towards gases, liquids and ions.
- Wide structural tunability for specialised industrial applications.

Major Applications of Metal-Organic Frameworks:***Environmental Applications:***

- Atmospheric water harvesting from extremely dry air.
- Removal of persistent pollutants including **Per- and Polyfluoroalkyl Substances (PFAS)**.
- Radioactive wastewater purification.
- Heavy metal removal from contaminated water.

Climate and Energy Applications:

- Carbon dioxide capture and storage.
- Hydrogen storage for clean energy systems.
- Gas purification and industrial gas separation.
- Methane storage and transportation.

Industrial and Scientific Applications:

- Chemical sensing.
- Drug delivery.
- Catalysis.
- Air purification.
- Advanced separation technologies.
- Battery and supercapacitor research.

2025 Nobel Prize in Chemistry:***Award Details:***

- The **2025 Nobel Prize in Chemistry** was awarded jointly to **Susumu Kitagawa, Richard Robson, and Omar M. Yaghi** for pioneering the discovery and development of **Metal-Organic Frameworks (MOFs)**.
- Their work established an entirely new class of highly porous crystalline materials that now support major advances in environmental science, energy technology and materials engineering.

Way Forward:***Policy and Technological Measures:***

- **Metal-Organic Framework (MOF)**-based separation technology should be scaled up through pilot projects to assess its commercial feasibility for large-scale nuclear wastewater treatment.

- Greater investment in **advanced materials research**, **radioisotope separation technologies**, and **energy-efficient purification systems** should be encouraged to improve radioactive waste management.
- International collaboration among nuclear regulators, research institutions, and the **International Atomic Energy Agency (IAEA)** should be strengthened for developing globally accepted standards for tritium management.
- Continuous environmental monitoring, transparent disclosure of radiation data, and independent scientific assessment should accompany any discharge of treated nuclear wastewater to build public confidence.
- Nuclear energy expansion should be complemented with robust radioactive waste management policies that integrate technological innovation, environmental sustainability, and public health safeguards.

UPSC Relevance:

GS Paper III:

- **Nuclear Energy, Environmental Pollution, Radioactive Waste Management, Science and Technology, Advanced Materials, Environmental Sustainability.**

Prelims Pointers:

- **Tritium** is a radioactive isotope of hydrogen.
- **HTO** denotes tritiated water.
- **ALPS** removes most radionuclides except tritium.
- **MOFs** are crystalline porous materials composed of metal ions and organic linkers.
- Tritium primarily emits **beta radiation**.
- Tritium has a half-life of about **12.3 years**.

Value Addition for UPSC:

Related International Frameworks and Concepts:

- The **International Atomic Energy Agency (IAEA)** provides safety standards and scientific guidance for radioactive wastewater management, including environmental monitoring of tritium discharges.
- Advanced porous materials such as **Metal-Organic Frameworks**, **Zeolites**, and **Covalent Organic Frameworks (COFs)** are emerging as next-generation materials for pollution control, carbon capture, hydrogen storage and sustainable water treatment.
- The development of highly selective isotope-separation technologies supports the goals of **safe nuclear energy**, **environmental protection**, **resource efficiency**, and **sustainable industrial innovation**, making advanced materials science an increasingly important component of future clean-energy transitions.

Conclusion:

- The development of **Metal-Organic Framework (MOF)**-based tritium separation represents a major advancement in radioactive wastewater treatment by addressing one of the most difficult challenges in nuclear waste management.
- By combining **advanced materials science**, **environmental protection**, and **clean energy objectives**, this innovation has the potential to make nuclear power safer and more sustainable while supporting responsible management of radioactive contaminants.

Trump Withdraws Proposed Strait of Hormuz Transit Fee Amid Legal Concerns and Global Maritime Opposition

Recent Developments:

- **United States President Donald Trump** withdrew his proposal to impose a **20% transit fee** on commercial cargo passing through the **Strait of Hormuz**, barely a day after announcing it, and stated that the proposal would instead be replaced by **Trade and Investment Deals** with Gulf countries.
- The proposal faced strong opposition from the **International Maritime Organization (IMO)**, shipping companies and legal experts, who argued that international law does not permit mandatory transit charges through international straits used for navigation.
- The controversy emerged amid renewed **United States–Iran tensions**, military escalation around the Strait of Hormuz, and continuing concerns regarding global energy security and freedom of navigation.

About the Strait of Hormuz:

Geographical Significance:

- The **Strait of Hormuz** is a narrow maritime passage connecting the **Persian Gulf** with the **Gulf of Oman** and the **Arabian Sea**.
- It lies between **Iran** to the north and **Oman** and the **United Arab Emirates (UAE)** to the south.
- It is one of the world's most important **maritime chokepoints** for energy transportation.

Strategic Importance:

- Nearly **20% of global petroleum liquids** and a significant share of global **Liquefied Natural Gas (LNG)** trade pass through the Strait every day.
- Major energy exporters using the Strait include **Saudi Arabia, Iraq, United Arab Emirates, Kuwait, Qatar, and Iran**.
- Any disruption in the Strait immediately affects global oil prices, shipping costs, insurance premiums and supply chains.

Trump's Proposed Transit Fee:

Original Proposal:

- The proposal declared the **United States** as the "guardian" of the Strait and sought a **20% reimbursement fee** on commercial cargo to recover the costs of providing maritime security.
- The proposal intended to charge vessels transiting the Strait irrespective of their nationality.

Major Ambiguities:

- It remained unclear whether the fee would be calculated on the **cargo value, shipping cost, or security expenditure** incurred by the United States.
- No institutional mechanism was specified for collection, enforcement or dispute resolution.
- The proposal failed to clarify the legal authority under which such charges could be imposed.
- Questions also arose regarding whether the United States could realistically guarantee uninterrupted security in such a conflict-prone region.

Legal Issues under International Maritime Law:

Position under UNCLOS:

- The **United Nations Convention on the Law of the Sea (UNCLOS)** recognises the principle of **Transit Passage** through straits used for international navigation.
- Ships and aircraft enjoy the right of continuous and expeditious passage without unnecessary interference.
- International law generally does not permit mandatory tolls merely for transiting a natural international strait.
- Although neither the **United States** nor **Iran** has ratified **UNCLOS**, many of its navigation provisions are widely regarded as **Customary International Law**.

Position of the International Maritime Organization (IMO):

- The **International Maritime Organization** opposed the proposal, stating that there is **no legal basis** for imposing mandatory transit fees on international straits.
- The proposal was also viewed as inconsistent with the long-standing United States policy supporting **Freedom of Navigation** worldwide.

Why the Proposal was Considered Impractical:

Economic Concerns:

- A **20% fee** linked to cargo value would substantially increase shipping costs.
- Higher freight costs would eventually increase international prices of crude oil, natural gas, fertilisers and other traded commodities.
- Shipping companies would also face higher insurance and operational expenses.

Diplomatic and Strategic Concerns:

- The proposal contradicted the traditional United States position opposing similar Iranian claims over the Strait.
- It could have indirectly strengthened Iran's future claims for imposing its own transit charges.
- The proposal risked undermining confidence in international maritime governance.

United States–Iran Contest over the Strait of Hormuz:

Strategic Competition:

- The Strait has become a major arena of geopolitical competition between the **United States** and **Iran**.
- Iran has asserted greater control over parts of the Strait and has challenged vessels operating outside designated shipping corridors.
- The United States has responded through military deployments and naval operations to protect maritime trade.

Recent Developments:

- A temporary **United States–Iran agreement** in **June 2026** briefly improved shipping activity through the Strait.
- Renewed military tensions subsequently reduced commercial vessel movements and increased risks for global shipping.

- Iran temporarily restricted commercial navigation, prompting renewed United States naval operations in the region.

Importance of the Strait for India:

Energy Security:

- India imports nearly **40%** of its crude oil, **60%** of its **Liquefied Natural Gas (LNG)** and around **90%** of its **Liquefied Petroleum Gas (LPG)** requirements through the Strait of Hormuz.
- India's overall import dependence exceeds **88%** for crude oil and remains significant for natural gas and LPG.

Economic Implications:

- A **20% transit fee** could have substantially increased India's annual energy import bill.
- Every increase of **1 US Dollar per barrel** in crude oil prices significantly raises India's import expenditure.
- Higher energy prices would widen the **Current Account Deficit (CAD)**, increase inflationary pressures, weaken the **Indian Rupee**, and adversely affect industrial competitiveness.

India's Response to the Crisis:

Policy Measures:

- India has consistently supported **Freedom of Navigation** through international waterways.
- The Government diversified crude oil sourcing to reduce immediate supply risks.
- Temporary measures were adopted to ensure domestic fuel availability and prevent panic buying.
- Following improved regional conditions, some emergency restrictions were gradually withdrawn.
- India also increased crude oil imports to strengthen strategic energy security despite higher international prices.

Broader Implications for Global Trade:

Global Economic Impact:

- The Strait of Hormuz remains one of the world's most critical maritime chokepoints.
- Any disruption affects global energy markets, inflation, maritime insurance, shipping costs and international trade.
- Prolonged instability could accelerate diversification of global energy transport routes and strategic petroleum reserves.

Way Forward:

Strengthening Maritime Security and Energy Resilience:

- International disputes relating to strategic waterways should be resolved through **international law**, **multilateral diplomacy**, and established maritime institutions.
- The principle of **Freedom of Navigation** should remain central to global maritime governance.
- Energy-importing countries should diversify crude oil suppliers, expand **Strategic Petroleum Reserves (SPR)** and accelerate renewable energy adoption to reduce vulnerability.

- Greater cooperation among regional stakeholders, including Gulf countries, should be encouraged to ensure uninterrupted commercial navigation.
- International institutions such as the **International Maritime Organization (IMO)** should continue strengthening maritime safety, conflict prevention and legal certainty for global shipping.

UPSC Relevance:

GS Paper II:

- **International Relations, India–West Asia Relations, International Law, Global Governance, Maritime Security.**

GS Paper III:

- **Energy Security, Economic Development, Infrastructure, Internal and External Security, Supply Chain Resilience.**

Prelims Pointers:

- **Strait of Hormuz** connects the **Persian Gulf** with the **Gulf of Oman**.
- **UNCLOS** recognises the principle of **Transit Passage** through international straits.
- **International Maritime Organization (IMO)** is the specialised United Nations agency responsible for maritime safety and prevention of marine pollution.
- The Strait of Hormuz is among the world's most important **oil transit chokepoints**.

Value Addition for UPSC:

Related Concepts and Institutions:

- Important global maritime chokepoints include the **Strait of Hormuz, Bab el-Mandeb Strait, Strait of Malacca, Suez Canal, Panama Canal, and Turkish Straits**, all of which are critical for international trade and energy security.
- India's maritime strategy is guided by initiatives such as **Security and Growth for All in the Region (SAGAR)**, the **Indo-Pacific Oceans Initiative (IPOI)**, **Mission-Based Deployments**, and the **Information Fusion Centre – Indian Ocean Region (IFC-IOR)**, which strengthen maritime domain awareness, secure Sea Lines of Communication (SLOCs), and enhance regional maritime cooperation.
- Ensuring **Freedom of Navigation**, adherence to **international maritime law**, diversification of energy sources, and resilient global supply chains will remain central to global energy security and India's long-term strategic interests.

Conclusion:

- The rapid withdrawal of the proposed **Strait of Hormuz transit fee** demonstrated the legal, diplomatic and economic limitations of imposing unilateral charges on an international maritime passage.
- For India, the episode highlights the continuing strategic importance of the Strait of Hormuz and reinforces the need to strengthen **energy security**, diversify import sources, uphold **rules-based maritime order**, and actively support **cooperative maritime governance** in the Indo-Pacific and West Asian regions.

ISRO Successfully Qualifies Critical Crew Module Systems Strengthening India's Gaganyaan Human Spaceflight Mission Readiness

Recent Developments:

- The **Indian Space Research Organisation (ISRO)** successfully completed three major qualification tests for the **Gaganyaan Mission's Crew Module**, validating critical systems related to astronaut safety, module separation, and structural integrity during atmospheric re-entry. These milestones significantly advance India's preparations for its first indigenous human spaceflight mission.
- The successful qualification covered the **Crew Module Up-righting System (CMUS)**, **Crew Module–Service Module Connect Disconnect System (CSCDS)**, and the Crew Module's capability to withstand **Apex Cover separation loads**, confirming the reliability of essential mission-critical technologies.

Gaganyaan Mission:

About the Mission:

- **Gaganyaan** is India's first indigenous **Human Spaceflight Mission**, designed to demonstrate the capability of launching **three astronauts** into **Low Earth Orbit (LEO)**, sustaining them safely in orbit for a specified duration, and bringing them back safely through controlled atmospheric re-entry and sea recovery.
- With the successful execution of Gaganyaan, India will become the **fourth country**, after the **United States**, **Russia**, and **China**, to independently develop and demonstrate human spaceflight capability.
- The mission represents a major step towards India's long-term objective of establishing sustained human presence in space and developing advanced-space exploration capabilities.

Mission Objectives:

- Demonstrate indigenous human spaceflight capability.
- Validate crew safety technologies throughout launch, orbital operations, re-entry, and recovery.
- Develop critical technologies required for future space stations and deep-space missions.
- Strengthen India's self-reliance in advanced space technologies.

Recent Qualification Tests:

Crew Module Up-righting System (CMUS):

- The **Crew Module Up-righting System (CMUS)** ensures that the Crew Module automatically returns to an upright position after splashdown in the sea.
- The system operates using **stored cold-gas technology**, which activates inflatable bags to rotate the capsule into a stable floating position.
- This mechanism is a critical astronaut safety feature because rescue operations require the capsule to remain upright after landing.

Crew Module–Service Module Connect Disconnect System (CSCDS):

- The **Crew Module–Service Module Connect Disconnect System (CSCDS)** enables safe separation between the **Crew Module (CM)** and the **Service Module (SM)** during the final phase of the mission.
- The mechanism consists of **CSU-1**, located on the Crew Module, and **CSU-2**, located on the Service Module.

- During re-entry, CSU-1 disconnects first to separate the Crew Module from the Service Module, followed by CSU-2, ensuring complete mechanical separation before atmospheric re-entry.
- Successful separation is essential for ensuring that only the Crew Module enters Earth's atmosphere while the Service Module burns up safely.

Apex Cover Separation Test:

- The qualification test verified the structural integrity of the Crew Module during **Apex Cover** separation.
- The Apex Cover protects parachutes and associated recovery systems throughout launch and orbital flight.
- Before parachute deployment, the Apex Cover is jettisoned to enable the safe opening of the parachute system during descent.
- Successful separation ensures reliable deployment of recovery parachutes and safe splashdown.

Major Components of Gaganyaan:

Launch Vehicle Mark-3 (LVM3):

- **Launch Vehicle Mark-3 (LVM3)** serves as the launch vehicle for the Gaganyaan Mission.
- It is India's heaviest operational launch vehicle and is capable of placing heavy payloads into **Low Earth Orbit**.
- Human-rating modifications have been incorporated to enhance mission reliability and crew safety.

Crew Escape System (CES):

- The **Crew Escape System (CES)** protects astronauts during launch emergencies.
- It consists of high-thrust solid rocket motors capable of rapidly carrying the Crew Module away from the launch vehicle in case of any malfunction during launch or ascent.
- The system provides emergency escape capability both on the launch pad and during the initial ascent phase.

Orbital Module (OM):

- The **Orbital Module (OM)** comprises the **Crew Module (CM)** and the **Service Module (SM)** connected through a separation mechanism.
- It supports astronauts throughout launch, orbital operations, and atmospheric re-entry preparations.

Crew Module (CM):

- The **Crew Module (CM)** is the habitable compartment where astronauts remain throughout the mission.
- It maintains an Earth-like pressurised environment, life-support systems, communication equipment, and astronaut safety systems.
- It is specifically designed to withstand intense thermal and mechanical loads during atmospheric re-entry.

Service Module (SM):

- The **Service Module (SM)** provides propulsion, electrical power, thermal regulation, avionics, attitude control, and mission support throughout the orbital phase.
- It remains attached to the Crew Module until the de-orbit sequence and subsequently separates before atmospheric re-entry.

Crew Module Re-entry and Recovery Process:

Sequence of Re-entry:

- After completion of orbital operations, the Service Module activates its propulsion system to reduce orbital velocity and initiate de-orbit.
- Following de-orbit, the Service Module separates from the Crew Module using redundant separation mechanisms.
- The Service Module disintegrates during atmospheric entry due to intense aerodynamic heating.
- The Crew Module survives atmospheric re-entry using its thermal protection system and gradually reduces speed through aerodynamic braking.
- Multiple parachutes deploy sequentially to slow the capsule before splashdown in the sea.
- Recovery teams subsequently retrieve the Crew Module and astronauts from the designated recovery zone.

Why Sphere-Cone Configuration is Preferred:

Engineering Advantages:

- A purely spherical spacecraft provides maximum internal volume with minimum structural mass but generates almost no aerodynamic lift during re-entry.
- Lack of lift causes rapid vertical descent, exposing astronauts to extremely high **G-forces**.
- The **Sphere-Cone Configuration** combines a spherical forebody with a conical afterbody to balance aerodynamic stability, lift generation, and thermal protection.
- The blunt spherical surface produces a detached shock wave that keeps intense heat away from the spacecraft.
- The conical section provides directional stability and controlled descent, significantly improving astronaut safety.
- The **Gaganyaan Crew Module** adopts the **Sphere-Cone Configuration**, similar to several successful human spaceflight capsules.

Dynamic Instability During Re-entry:

Meaning:

- **Dynamic Instability** refers to rapidly increasing oscillations experienced by the spacecraft while descending through Earth's atmosphere.
- The phenomenon becomes particularly significant near transonic speeds due to changing shock-wave patterns and turbulent airflow.

Control Mechanism:

- Small reaction control thrusters continuously adjust the spacecraft's orientation to maintain the desired attitude.
- Stable attitude control prevents excessive oscillations and ensures controlled parachute deployment.

Significance of the Qualification Tests:

Technological Importance:

- The successful tests validate several critical human-rated technologies developed indigenously by **ISRO**.
- The qualification enhances confidence in astronaut safety throughout the mission profile.

- These technologies will support future reusable spacecraft, space stations, and deep-space exploration missions.

Strategic Importance:

- Human spaceflight capability strengthens India's strategic technological leadership.
- Indigenous development reduces dependence on foreign human spaceflight technologies.
- The programme promotes innovation across aerospace engineering, advanced manufacturing, robotics, electronics, and life-support systems.

Challenges in Human Spaceflight:

Major Engineering Challenges:

- Maintaining life-support systems under microgravity conditions.
- Ensuring crew safety during launch abort scenarios.
- Managing extreme thermal loads during atmospheric re-entry.
- Maintaining communication throughout re-entry despite plasma blackout.
- Achieving highly reliable parachute deployment and sea recovery.
- Minimising vibration, acceleration, and dynamic instability experienced by astronauts.

Way Forward:

Strengthening India's Human Space Programme:

- Successful completion of all remaining qualification tests should be followed by uncrewed demonstration missions before the first crewed launch.
- Continued investment in reusable launch technologies, advanced propulsion systems, and indigenous life-support technologies should be prioritised.
- The experience gained through Gaganyaan should support the development of India's proposed **Bharatiya Antariksh Station** and future lunar exploration missions.
- Stronger collaboration between **ISRO**, academia, industry, and international partners will accelerate India's long-term human space exploration capabilities.
- Sustained investments in human spaceflight infrastructure, astronaut training, and advanced space technologies will strengthen India's position as a leading global space power.

UPSC Relevance:

GS Paper III:

- Space Technology, Science and Technology, Indigenisation of Technology, Research and Development, Strategic Technologies.

Prelims Pointers:

- **Gaganyaan** is India's first indigenous human spaceflight mission.
- **LVM3** is the launch vehicle for Gaganyaan.
- **Crew Escape System (CES)** provides emergency crew evacuation during launch.
- **Crew Module (CM)** houses astronauts, while the **Service Module (SM)** provides propulsion and mission support.

- **Sphere-Cone Configuration** provides optimum aerodynamic stability during atmospheric re-entry.
- **Dynamic Instability** refers to uncontrolled oscillations during atmospheric re-entry.

Value Addition for UPSC:

Related Missions and Future Space Vision:

- The **Gaganyaan Programme** forms the foundation for India's long-term human space exploration roadmap, including the proposed **Bharatiya Antariksh Station** by **2035** and an **Indian Crewed Lunar Mission** by **2040**, as announced by the Government of India.
- Supporting initiatives such as the **Indian National Space Promotion and Authorisation Centre (IN-SPACe)**, **NewSpace India Limited (NSIL)**, and the **Indian Space Policy, 2023** aim to strengthen public-private collaboration, commercial space activities, and indigenous technological capability.
- Human spaceflight technologies developed under Gaganyaan—including **crew safety systems**, **human-rated launch vehicles**, **environmental control and life-support systems**, **advanced avionics**, and **precision recovery technologies**—will generate significant technological spillovers for defence, aviation, robotics, healthcare, and advanced manufacturing sectors.

Conclusion:

- The successful qualification of critical **Crew Module** systems marks a significant milestone in India's journey towards achieving indigenous human spaceflight capability and demonstrates the growing maturity of **ISRO's** human-rated technologies.
- By mastering complex technologies related to crew safety, atmospheric re-entry, recovery, and mission reliability, the **Gaganyaan Mission** lays a strong foundation for India's future ambitions in sustained human space exploration and advanced space infrastructure development.

QUESTIONS

1. Consider the following pairs under the BNSS, 2023:

- (1) Proclaimed Offender : Applicable to offenses with punishment of 7 years or more.
- (2) Section 356 Trial : Enables full trial and final pronouncement of judgment.
- (3) The 90-Day Buffer : Minimum time gap mandatory between two consecutive warrants.
- (4) Post-Arrest Remedy : Absolute right to recall all witnesses for cross-examination.

How many of the pairs given above are correctly matched?

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

2. Consider the following statements:

Statement-I: The Union Government's reliance on conditional fiscal assistance mechanisms under instruments like the Net Borrowing Ceilings (NBCs) and specific scheme Memorandums of Understanding (MoUs) has faced criticism for leaning towards coercive federalism.

Statement-II: The post-GST fiscal framework has expanded the independent, residual taxation autonomy of State governments, allowing them to autonomously alter tax rates to meet localized welfare deficits.

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

- (A) Both Statement-I and Statement-II are correct and Statement-II is the correct explanation for Statement-I
- (B) Both Statement-I and Statement-II are correct and Statement-II is not the correct explanation for Statement-I
- (C) Statement-I is correct but Statement-II is incorrect
- (D) Statement-I is incorrect but Statement-II is correct

3. Consider the following statements regarding the physical and chemical properties of Tritium and its separation from water:

- (1) Tritium is a naturally occurring stable isotope of hydrogen that forms tritiated water (HTO) when it bonds with oxygen.
- (2) Tritiated water behaves in a chemically identical manner to regular water, rendering standard chemical precipitation methods ineffective for separation.
- (3) Conventional water distillation separates tritiated water by exploiting the significant and wide variance between the boiling points of HTO and H₂O.
- (4) Living organisms absorb tritiated water rapidly due to its structural parity with regular water, leading to its fast systemic distribution via blood.

Which of the statements given above are correct?

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

4. Consider the following micro-statements regarding India's macroeconomic metrics during the 2026 maritime shock:

- (1) Energy Import Bill : Triggered a direct surge instead of a decline.
- (2) Rupee Exchange Rate : Experienced downward depreciation pressure.
- (3) Domestic Fuel Market : Witnessed state-enforced industrial rationing.
- (4) Sourcing Strategy : Prioritized fiscal optimization over supply continuity.

Which of the configuration combinations given above accurately represent India's structural response?

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

5. Consider the following statements:

Statement-I: A completely spherical aerodynamic configuration is rejected for human spaceflight re-entry modules despite its structural and volumetric efficiency.

Statement-II: A perfect sphere falls down on a purely ballistic trajectory without generating aerodynamic lift, thereby subjecting the crew to unsustainably high g-forces.

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

- (A) Both Statement-I and Statement-II are correct and Statement-II is the correct explanation for Statement-I
- (B) Both Statement-I and Statement-II are correct and Statement-II is not the correct explanation for Statement-I
- (C) Statement-I is correct but Statement-II is incorrect
- (D) Statement-I is incorrect but Statement-II is correct

ANSWER KEY

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



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In today's fast-changing world, staying updated with current affairs is essential for both academic success and professional growth. Awareness of national and international events not only broadens general knowledge but also sharpens critical and analytical thinking skills. It enables individuals to form well-informed opinions, which are crucial for competitive examinations, group discussions, interviews, and impactful essay writing.

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