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**DECODE CURRENT**

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**ECO + AGRI + SCIENCE + ENV +  
SECURITY**

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**CONTENT**



**∞ \* (PR + FOMO +  
NOISE + FREEMIUM +  
FAKE CLAIMS) ^ ∞**



**MUDIT JAIN**

**EX-IPS | EX-IRS**

**AIR - 222, 207 & 173**



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ECONOMY

Banking, Currency and Crypto

Rupee at 91

- Rupee’s movement depends on **what’s happening in the market** and **how the RBI responds**.
- At **sharp depreciation of 4.3%** against USD in this calendar year, **Rupee has become worst performing currency in Asia** compared with peers like the Chinese Yuan and the Indonesian Rupiah.
- **Faring better** than structurally weak currencies like Japanese Yen, Korean Won.
- India is facing **twin shocks**: U.S. tariffs and high precious metal prices. The combination of **adverse geo-economic and geopolitical environments** is weighing upon India’s merchandise trade deficit.
- US **50% tariff on India** led to a **record \$41.7bn trade deficit in October**, triggering rupee slide (import surge is partly due to the **depreciating rupee** and also suggests **increased use of cheaper imported intermediate goods** rather than domestic).
- A **sharp spike in gold price** this year has triggered huge investment in gold and Gold ETFs, leading to a **200% increase in demand for gold in October**, causing the **gold import bill to spike to \$14.72 billion in October**. To finance bullion purchases, businesses **sold rupees to buy dollars**, creating a **‘dollar drain’**.
- FPIs pulling out in **large numbers from Indian equity**. When foreign investors exit, they **sell rupees to take dollars**.
- **Domestic investors**, spooked by volatility, are **pulling money out of the stock market** and **parking it in bullion**.

RBI’s Changed Approach

- Earlier, RBI was **selling dollars to arrest slide of rupee**. This year, RBI has **decided to intervene less**. It reflects RBI’s policy of **maintaining a managed-float**. RBI’s intervention record is reflected in **Balance of Payments data**, under **‘Reserve Assets’**. RBI’s calculated gamble is that **weak rupee will make Indian goods cheaper abroad** and **offset tariff pain**. **Depreciation of the nominal exchange rate does not guarantee real exchange rate depreciation**.
- **Low inflation** has recently helped the **Real Exchange Rate** fall.
- Thus, Rupee is weakening against dollar even as dollar is weakening against other currencies!

Sovereign Gold Bonds:

- **Debt securities** issued by **RBI** on behalf of the **government**, with each unit denoting a gram of gold. SGBs offer trading in the secondary market, allowing investors to accrue capital gains.
- **SEBI** was constituted as a **non-statutory body** in **1988** through **Gol resolution**. **Statutory** body in 1992.
- **Commodities traded on Indian commodity exchanges** are classified into **hard and soft commodities**. **Hard commodities** include metals and energy. **Soft commodities** include agriculture and agricultural-processed.

Balance of Payments (BoP):

- A **ledger** of a country’s **transactions with the rest of the world**. Shows how much money **went out of the country** and how much money **came in**. In the **BoP table**, a **minus sign** points to a **deficit**.
- Captures the **relative demand of the rupee vis-à-vis** the demand for **foreign currencies**.
- If an Indian wanted to buy an **American good or service**, or to **invest in US**, they would have to **buy dollars**. The **exchange rate** would be determined by the **relative demand of the two currencies**. If **Indians demanded more dollars** than **Americans demanded rupees**, the **exchange rate of the dollar relative to the rupee would go up**.

Digital Gold: Key Investment Risks

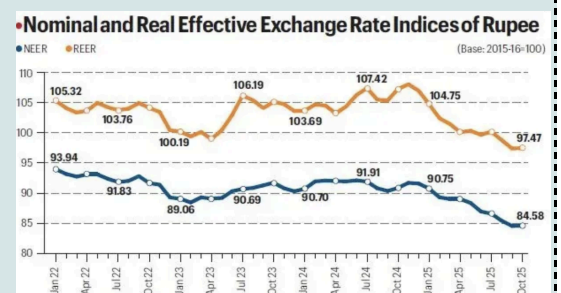
Understanding Unregulated E-Gold Product Dangers

- Counterparty Risk**: Digital gold platforms operate outside regulatory oversight. Risk of default from service providers with no clearing corporation guarantees.
- Operational Risk**: Platform failures, technical glitches, or business closures can lead to loss of investments with no recourse mechanisms.
- No Investor Protection**: None of the investor protection mechanisms under securities market purview are available for digital gold investments.
- Default Risk**: OTC ETF-like structure without regulatory backing makes digital gold vulnerable to provider defaults and business failures.

Unregulated vs Regulated Gold Investments

<p><b>✗ Digital Gold</b></p> <p>No regulation No demat required High counterparty risk No protection</p>	<p><b>✓ Gold ETFs/SGBs</b></p> <p>Sebi regulated Clearing corporation backed Transparent pricing Investor protection</p>
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- **NEER and REER** are **indices** similar to **CPI**. **CPI** is the **weighted average retail price** of a representative **consumer basket of goods and services** for a given month or year, relative to a **fixed base period**.
- The **NEERs/REERs** are indices of the **weighted average of the rupee’s exchange rates vis-à-vis** the currencies of **India’s key trading partners**. Basket comprises **40 currencies** and the **base year** (used as a reference for comparison with its value set at **100**) is taken as **2015-16**.
- The **currency weights** are derived from the **share of the individual countries in India’s total foreign trade**, just as the weight of each



commodity in the CPI is based on its relative importance in the overall consumption basket. The 40 currencies are of countries accounting for about 88% of India's annual trade flows.

- Any increase in the **NEER/REER** indicates the **rupee's effective appreciation** against the **40-currency basket** and decreases point to its **overall exchange rate depreciation**.
- The extent of the **rupee's recent depreciation** is even more if one looks at the **REER**. The **NEER** is a summary index capturing movements in the external value of the rupee against a basket of global currencies. But it doesn't factor in inflation.
- If a currency's **nominal exchange rate** falls less than the **domestic inflation rate**, it has actually **appreciated in "real" terms**. **REER** is basically the **NEER index adjusted** for the **inflation differentials** between the **home country** and its **trading partners**. **REER** is, in that sense, a **true gauge** of whether a currency is **undervalued, overvalued or fairly valued** relative to that of other countries.
- If the rupee's **nominal exchange rates stay the same**, but **prices in India rise faster** than in other countries, the **REER goes up**, making **Indian products** relatively **more expensive and less competitive** in the **global market**.

#### Depreciation & its Effects:

- A **weak rupee** makes it harder to achieve income growth targets and reduces the ability to attract overseas capital when returns are moderate. It pushes domestic wealth towards dollar assets under the Liberalised Remittance Scheme (LRS) or gold.
- A **depreciated rupee** reduces the overall capital available for the economy and makes capital more expensive. The rupee depreciation is largely triggered by tariffs and external forces like global market volatility. India's macroeconomic fundamentals remain robust.
- Depreciation creates an **opportunity** for investment as **Indian Government Bonds (IGBs)** have become **6% cheaper**. **Rupee** has also depreciated against the **euro, yen, British pound, Swedish krona, and Swiss franc**.
- **Pressure on the currency** is being driven by **three key factors**: sentiment, capital flows, and the global macro backdrop. **Rising U.S. bond yields** and expectations of a **Bank of Japan rate hike** have triggered an **unwinding of the yen carry trade**. This has led to **risk aversion** across **equities, credit, crypto**, and some **commodities**, adding **speculative pressure** on **emerging-market currencies**, including the **rupee**.

#### Internationalisation of Rupee

- **Internationalisation** is a process that involves increasing the use of the rupee in cross-border transactions.
- It involves **promoting the rupee for import and export trade** and **other current account transactions**, followed by its use in **capital account transactions**. These are **transactions between residents in India and non-residents**.
- Interlinked with **nation's economic progress**, requires **further opening up of the currency settlement** and a **strong swap and forex market**.
- Require **full convertibility of currency** on capital account and cross-border transfer of funds without any restrictions. India has allowed only full convertibility on the current account as of now.

#### Currency Swaps

- The RBI used its **first longer-term currency-swap as a systemic liquidity check**. In **2019**, it completed a **\$5 billion three-year dollar/rupee swap**. In **February 2025**, it carried out a **\$10 billion dollar/rupee buy-sell swap auction** to infuse **long-term rupee liquidity** into the banking system under global stress.
- Such swaps are a **standard tool by central banks** to supply liquidity, shore up **forex reserves**, and prevent **disorderly currency depreciation** when the dollar surges or capital flows reverse.
- Under **floating-but-managed regime**, the RBI can only **"smoothen volatility"** rather than fix the exchange rate.
- Between **November last year and now**, the RBI sold a net of **roughly \$50 billion in forex** to stabilise the rupee. Even so, the slide has continued, **highlighting the external pressures**. India's **forex are comfortable — \$693 billion**.
- This gives the RBI space to **tolerate modest currency depreciation** without triggering aggressive rate hikes, especially as India transitions from **cheaper Russian crude to relatively costlier U.S. oil imports**.
- With crude accounting for **over a fifth of total imports in FY25**, rupee depreciation combined with costlier oil imports could **exert upward pressure on inflation**.

#### OMO Purchases

- In view of **evolving liquidity conditions**, RBI announced OMO purchases of government securities worth ₹1,00,000 crore and a three-year USD/INR Buy-Sell swap of \$5 billion to inject durable liquidity.
- The RBI said it is committed to providing **sufficient durable liquidity** to the **banking system**. The **dollar-rupee swap** was clarified as a **liquidity measure** and **not to support the depreciating rupee**.

#### GENIUS Act – Stablecoins

**Why in news: Guiding and Establishing National Innovation for U.S. Stablecoins passed by the U.S. Senate.**

- Proposes **compliances** for **stablecoins** including anti-money laundering norms, full reserve backing, monthly audits.
- **Stablecoins** are **commodity-backed cryptocurrencies** & aims to strengthen the U.S. dollar by encouraging crypto use pegged to the greenback.

- A **cryptocurrency** is a digital medium of exchange that uses encryption techniques to control the creation of units and verify transactions. It operates on a distributed network of computers, making it nearly impossible to counterfeit or double-spend. Most cryptocurrencies are decentralised and use **blockchain technology**.
- In **traditional financial systems**, central banks or third-party institutions authenticate and record transactions involving fiat currency. In contrast, **cryptocurrency transactions** are verified by a network of private computers solving cryptographic puzzles. The process of verifying transactions and earning cryptocurrency is called **mining**.
- **Blockchain** powers these transactions, maintaining a **secure and transparent ledger**.

- **Hong Kong** will enforce its new **Stablecoins Ordinance**, introducing a licensing regime for **fiat-referenced stablecoins (FRS)**.

#### What are stablecoins?

- Cryptocurrencies pegged to **fiat currencies, commodities, or other assets** such as **metals** to maintain **stable value**. Pegging strategies include **fiat reserves, commodities, crypto collateral, or algorithms**.
- Different from **CBDCs**, as they are **privately issued** and can be pegged to **foreign currencies**.
- Used widely in **crypto trading, remittances, and savings**. Despite pegging, can **depeg** due to technical or global events. **US, Japan & Singapore** have introduced **specific stablecoin regulations**.
- **India has not legalised cryptocurrencies**, though it taxes transactions involving them. RBI has advocated banning virtual digital assets, while also piloting its **Central Bank Digital Currency**. CBDCs are digital currencies issued by central banks.

#### Types of Stablecoins

- **Fiat-backed stablecoins** are backed by traditional currencies like the U.S. dollar or Euro, held in regulated banks or institutions. Examples include USDT (Tether) and USDC (USD Coin).
- **Crypto-backed stablecoins** collateralised by other cryptocurrencies such as Ethereum.
- **Algorithmic stablecoins** maintain stability using automated algorithms that control supply and demand without actual reserves, though they are highly experimental and risky, as shown by TerraUSD.

#### What is a stablecoin?

A stablecoin is a crypto asset that aims to maintain a stable value relative to a specified asset, or a pool of assets

■ These assets could be a monetary unit of account such as the dollar or euro, a currency basket, a commodity such as gold, or unbacked crypto assets

■ This stability can also be achieved only if a centralised institution is in charge of issuing (minting) and redeeming (burning) these crypto assets



#### Crypto Transactions

- The value of cryptocurrency transactions in India crossed **₹51,000 crore** in 2024–25, up 41% over the previous year, an analysis of data shared with Parliament showed.
- Government collected **₹511.8 crore** as **TDS** on transactions. The rate of TDS is 1% on every transaction.
- Under the Finance Act 2022, the government introduced a provision in the Income Tax Act 1961, retained in the I-T Act 2025, mandating a 1% TDS on any transfer of **Virtual Digital Assets (VDAs)** or cryptocurrencies. In **2018**, RBI **banned banks from dealing** with crypto firms, but this was **overturned in 2020 by Supreme Court**.

#### RBI's Surplus

**Why in news:** **₹2.69 lakh crore** transferred by the **RBI to the Central Government** as surplus for **FY 2024–25**, the **highest ever**. This is **27% higher** than transferred in **2023–24**.

- RBI's transfers are **not called dividends** as it is **not a company** with shareholders.
- **Sources of RBI's revenue:** **Seigniorage** (difference between face value and printing cost of currency), **Interest income** from loans to government & banks and **Returns from foreign bond investments & currency exchange gains**.
- As per **RBI Act, 1934**, profits after provisioning are transferred to the Central Government.
- **Contingent Risk Buffer (CRB)** is RBI's **safety net** for financial stability crises. **Bimal Jalan Committee (2018)** recommended CRB be **5.5–6.5%** of balance sheet. In **2024–25**, CRB range revised to **4.5–7.5%**.
- **FY25 surplus due to:** Higher forex sales, Strong earnings on forex assets, Returns from liquidity management tools.

• Under **Economic Capital Framework**, RBI transfers surplus (not dividend) to the Central Government annually. **Bimal Jalan Committee** recommended that the ECF be **reviewed every five years**.

- RBI is a **full-service central bank**, responsible for **monetary policy, government borrowings, bank and NBFC regulation, and managing currency and payment systems**.
- Unlike commercial entities, **RBI doesn't pay dividends** but **transfers surplus income** to the government.
- Surplus is calculated **after provisions for bad debts, asset depreciation, staff funds, and other banking contingencies** are accounted for.

#### RBI

- **Established on April 1, 1935** under **RBI Act, 1934**. Central Office initially in **Kolkata**, moved to **Mumbai in 1937**.
- **Originally privately owned**, RBI was fully nationalised in 1949, making it fully owned by the Government of India.
- **Section 48 of RBI Act, 1934** provides **exemption from income-tax, super-tax, wealth tax** to RBI.
- **Preamble of RBI** outlines its **functions:** regulate issue of Bank notes, maintain reserves for monetary stability, operate currency and credit system for the country's advantage.

Monetary Policy

Why in news: RBI's Monetary Policy Committee (MPC) cut the repo rate to 5.50%, aimed at spurring growth.

- The repo rate cut will reduce the **interest** burden for borrowers but also lower the interest earned by depositors.
- The RBI also decided to reduce the Cash Reserve Ratio (CRR) by 100 basis points to provide liquidity. The **reduction in CRR will lower the cost of funding for banks** and improve monetary policy transmission to the credit market.
- Objective is achieving the **medium-term CPI inflation target of 4% within a +/- 2% band** while supporting growth.
- **Real GDP growth for 2025-26** has been **projected at 6.5%**.

- Under **Section 45ZB of the amended RBI Act, 1934**, the **central government** is empowered to constitute a **6-member MPC** to determine the **policy interest rate** required to achieve the **inflation target**. The **first such MPC** was constituted in **2016**. **6 Members:** RBI Governor as its ex officio chairperson, the Deputy Governor in charge of monetary policy, an officer of the Bank to be nominated by the Central Board and three persons to be appointed by the central government.
- RBI uses several **direct and indirect instruments** to maintain **price stability** while keeping objective of **growth**. The instruments are **Cash Reserve ratio (CRR), Repo rate, reverse repo rate, Statutory Liquidity Ratio (SLR), Standing Deposit Facility (SDF) Rate, Bank rate, and Liquidity Adjustment Facility (LAF)**.
- **Monetary policy** deals with the **supply and cost (interest rates) of money** in an economy.
- **MPC meets every two months** and may **tweak the repo rate** to control inflation and price fluctuations.
- The **policy stance of the RBI** is currently '**Neutral**'. This shift from an earlier '**Accommodative**' stance reflects a recalibrated approach to balance between **inflation control** and **economic growth**, allowing the RBI flexibility to **either raise or cut interest rates** depending on evolving economic data.
- **Repo Rate:** Interest rate at which RBI lends to commercial banks under the **Liquidity Adjustment Facility (LAF)** against government and approved securities.
- **Standing Deposit Facility (SDF) Rate:** Rate at which RBI accepts uncollateralised overnight deposits; 25 basis points below the policy repo rate; introduced in 2022 and replaced the fixed reverse repo rate as LAF floor.
- **Marginal Standing Facility (MSF) Rate:** Penal rate for overnight borrowing by banks dipping into SLR portfolio up to 2% limit; 25 basis points above the repo rate. **Liquidity Adjustment Facility (LAF):** RBI's mechanism to inject/absorb liquidity via overnight and term repo/reverse repo, SDF, MSF, OMOs, forex swaps, and MSS.
- **Reverse Repo Rate:** Interest rate at which RBI absorbs liquidity from banks against government securities under LAF; its use is now at RBI's discretion post SDF introduction. **Bank Rate:** At which RBI buys or rediscounts commercial bills; aligned with MSF rate; published under Section 49 of the RBI Act, 1934.
- **Cash Reserve Ratio (CRR):** Average daily balance banks (Cash) must maintain with RBI as a percentage of their net demand and time liabilities (NDTL). **Statutory Liquidity Ratio (SLR):** Banks must maintain specified assets (government securities, cash, gold) as a percentage of their demand and time liabilities.
- **Open Market Operations:** RBI's purchase/sale of govt securities to inject/absorb liquidity from banking system.

Expansionary Monetary Policy

Tax Revenue	Non-Tax Revenue
Direct taxes (income tax, corporate tax)	Fees and fines, Profits from state-owned enterprises, Royalties from natural resources
indirect taxes (GST, excise duty, customs).	Inter-governmental grants or transfers, Sales of goods and services, and Foreign aid

Why in news: The RBI cut the repo rate twice in 2025 bringing it to 5.5%.

- This indicates **expansionary monetary policy** stance, supported by low inflation and GDP growth forecast of 6.5%. Simultaneously, **fiscal policy has turned expansionary**, with **income tax cuts** announced in February 2025. Both tools are pushing up **aggregate demand** and could fuel

inflation.

- **Monetary policy** affects demand via **interest rates**, while **fiscal policy** operates through **taxation & government spending**. Expansionary fiscal policy could be neutralized by contractionary monetary policy, and vice versa.
- **Inflation** has fallen to a **six-year low of ~3% in June 2025**, aided by **early monsoons and strong harvests**. However, **credit growth** is at a **3-year low (9%)** and **unemployment rose to 5.6%** in May 2025. Despite **increased disposable income** from tax cuts, **consumer spending hasn't surged**, reflecting **demand-side stress**.
- If **output doesn't rise, tax collections fall**, leading to a **widening fiscal deficit**. Government may be forced to **cut spending** to maintain deficit targets, risking a **reduction in welfare expenditure**.

Banks Performance

- **Capital buffers strengthened:** CRAR rose from 13.5% (2015) to 17.5% (2025) with CET-1 increasing from 10.43% to 14.73% during the same period. **Asset quality improved:** GNPA and NNPA reduced to 2.3% and 0.5% in 2025 after rising to highs of 11.2% and 5.96% in 2018. **Profitability of banks** has enhanced significantly.
- Return on Assets **increased to 1.37%**, and Return on Equity to **14%**.
- Regulatory measures such as **Asset Quality Review (AQR)** initiated in **2015** and the **Prompt Corrective Action (PCA) framework** (supervisory tool used by RBI to monitor and address financial health of banks. It aims to identify banks with weak financial metrics and intervene early to prevent further deterioration.) had been **balanced and appropriate**.

### Aapki Poonji Aapka Adhikar

- The **Ministry of Finance** is working with **RBI** to develop a **unified portal** to help **savers and retail investors** claim **unclaimed assets**. The portal will cover **bank deposits, pension fund, shares, and dividends**.
- **Mega camp on "Aapki Poonji Aapka Adhikar" (Your Money Your Right)** organised by PNB.

### Master Directions

- **RBI** issued **244 consolidated Master Directions** after reviewing **around 3,500 directions, circulars and guidelines** to **reduce compliance burden** on **Regulated Entities (REs)**. The **11 regulated entities** include: commercial banks, small finance banks, payments banks, local area banks, RRBs, urban cooperative banks, rural cooperative banks, all India financial institutions, NBFCs, asset reconstruction companies, and credit information companies.

### RBI Norms for Digital Banking

- Mandatory for banks to obtain **explicit customer consent** for providing digital banking services. Banks **cannot make it mandatory** for customers to opt for any **digital banking channel** to avail facilities like **debit cards**.
- Banks can continue to **obtain and record mobile numbers** to send **transaction alerts** and for **KYC requirements**.
- Banks must put in place **risk mitigation measures** such as **transaction limits** (per transaction, daily, weekly, monthly), **transaction velocity limits**, and **fraud checks**, depending on their risk perception.
- Banks shall ensure continuous compliance with instructions issued by **DPSS under the Payment and Settlement Systems Act, 2007**.

### Payment System Operators

- **RBI** has recognised the **payment system operators' association** as a **self-regulated organisation (SRO)**.
- The recognition is in line with the **RBI's 2024 Omnibus Framework for Recognition of SROs for Regulated Entities**. The move reflects a shared vision based on **good governance, transparency, and innovation**.

### Gold Loan Rules

**Why in news:** **RBI released draft directions** to harmonise rules for **loans against gold** across banks and NBFCs, citing rapid portfolio growth and lending irregularities. The combined **gold loan portfolio** grew over **50%** in FY24. RBI's objectives include ensuring **borrower protection**, enforcing **clarity in credit processes**, and promoting **transparency**.

- **Loan-to-Value (LTV) ratio** remains at **75%**, but for consumption-based bullet loans, accrued interest will be included in LTV, lowering disburseable amounts.
- **Proof of ownership** of gold collateral is mandated; gold must be valued using 22-carat price; standardised purity assessment procedures to be implemented. **Concurrent loans** (for consumption + income generation) will be prohibited. **Loan renewal/top-ups** only allowed if the existing loan is standard and within LTV norms.
- Borrowers must **repay full principal + interest** before taking a new loan; **delay in returning collateral** beyond 7 days will attract **₹5,000/day compensation** to the borrower.
- **Implications on NBFCs and Borrowers:** NBFCs' flexibility in seamless renewals will be curtailed; operational costs & compliance burden will rise. May raise **interest rates** for borrowers.

### Post Offices Digital Payments

**Why in news:** **India Post** is phasing out its **Registered Post service** and merging it with **Speed Post**.

- A key initiative is integrating **UPI payments** at the time of booking Speed Post. **Advanced Postal Technology (APT) system** is being rolled out in phases, already active in **Delhi, Chennai**, and large parts of **Mumbai**. Over **86,000 post offices** (more than half of India's postal network) have been upgraded so far.
- The APT system includes UPI "collect mechanism", OTP-based authentication etc.

### Bank Mitras

**Why in news:** **Business Correspondent Resource Council** has appealed to **Parliamentary Committee on Finance** to **review Bank Mitras' remuneration. Bank Mitras' commissions**, last revised in **2014**.

- **Business Correspondents (BC)**, are local agents who act as intermediaries between banks and customers in underserved or unbanked areas. They are a critical pillar of the Pradhan Mantri Jan Dhan Yojana (PMJDY).

### Small Finance Bank

**Why in news:** **RBI** has decided to grant 'in-principle' approval to **AU Small Finance Bank Ltd. (AUSFB)** to transition to a **Universal Bank**. **Universal bank status** allows offering a **wide range of financial services and products** under one roof **without many restrictions**, unlike an SFB.

- **Small Finance Banks (SFBs) in India** created by **RBI** under guidance of **Government** for **financial inclusion**. **Supply of credit to**: Small business units, Small & marginal farmers, MSMEs and Other unorganised sector entities.
- **Basic banking activities**: Acceptance of deposits, Lending to unserved and underserved sections.
- **RBI Guidelines for SFBs (2014)**: Minimum paid-up equity capital: Rs. 100 crore; At least 25% branches in unbanked rural centres; At least 50% loan portfolio: loans & advances of up to Rs. 25 lakh; At least 75% of adjusted net bank credit to priority sector.

#### Eligibility Criteria for SFBs to Transition into a Universal Bank

1. **Scheduled status** with **satisfactory track record** of minimum **5 years**.
2. **Listing** on recognised stock exchange + **minimum net worth Rs. 1,000 crore** (previous audited quarter).
3. **Net profit** in last **two financial years** + **Gross NPA  $\leq$  3%** and **Net NPA  $\leq$  1%** (last two years).
4. Must meet prescribed **CRAR requirements** for SFBs.

- **NBFC (Non-Banking Financial Company)**: company registered under **Companies Act, 1956/2013**.
- Engaged in **loans & advances, acquisition of securities** (shares, stocks, bonds, debentures, govt/local authority securities), leasing, hire-purchase as principal business.
- **Excludes** institutions engaged in agriculture, industry, trade (other than securities), services, real estate sale/purchase/construction. **Residuary NBFC**: company whose **principal business = accepting deposits** (lump sum/installments/contributions/other manner).
- **Difference between Banks & NBFCs**: NBFCs cannot accept demand deposits; NBFCs not part of payment & settlement system, cannot issue cheques on itself; No DICGC insurance facility for NBFC depositors.
- **NBFCs & NRIs**: Can accept deposits from **NRIs**; Must comply with **FEMA (Deposit) Regulations, 2016 (as amended)**; **Interest rate ceiling** = cannot exceed **RBI-specified rate for scheduled commercial banks**.

#### UPI Intensity

**Why in news: Usage intensity of UPI transactions** — measured in **per capita volume terms** — is **highest in Telangana** among all Indian States. The **average value of a single UPI transaction** (the 'ticket size') has been **declining over time**, indicating **broader adoption for small payments**.

- **Cash withdrawal intensity** remains high in several northeastern States, as well as in Kerala, Goa, and Delhi. This pattern is linked to factors such as tourism, service-led cash usage, remittance inflows, continued rural cash dependence, and limited digital infrastructure.

#### UPI Expansion

- **India** is talking to countries, including those in **East Asia**, to make **UPI payments acceptable**.
- It is accepted in at least **8 countries**: Bhutan, Singapore, Qatar, Mauritius, Nepal, UAE, Sri Lanka, and France.
- Overseas acceptability of **India's digital payment network** enables **Indian tourists** to make **UPI payments abroad**.
- **UPI interface** accounted for a **majority share in transaction volume**, while **real time gross settlement** accounted for the **largest share in value terms**.
- During **2024-25**, **digital payments** grew by **17.9% in value terms**, accounting for **97.6% of India's total payments**.
- **Paper-based instruments (cheques)** declined during the year, representing the **remaining 2.4%**.

### Indian Economy

#### Economic Indicators

- **S&P Global** upgraded India's **sovereign rating to BBB (Stable) after 18 years**, citing growth, monetary credibility, and fiscal consolidation. (The upgrade lowers borrowing costs and widens investor base).
- Between 2013-14 and 2022-23, 24.82 crore Indians exited **multidimensional poverty**.
- India is the **third-largest energy consumer**, **fourth-largest refiner**, and **fourth-largest LNG importer**. **Ethanol blending** rose from 1.5% (2014) to 20% today, saving ₹1.25 lakh crore forex and paying ₹1 lakh crore to farmers.
- **300 compressed biogas plants** being set up under SATAT, with 5% blending mandate by 2028.
- The government's renewed **focus on boosting consumption** marks a policy re-prioritisation, as other engines of economic growth — private investment and net exports — remain sluggish or uncertain.
- With the economy's four key components — **household consumption, private investment, government expenditure, and net exports** — only **government expenditure** has shown strong momentum in recent years.
- **GST rate reforms**:
  - **Rural households**: Over 75% of monthly expenditure now falls under nil or 5% GST, up from 56% earlier.
  - **Urban households**: Coverage under nil or 5% GST increased from 50% to two-thirds of spending.

State	Debt as % of GDP	Public debt*	GSDP 2022-23
Punjab	40.35%	₹2,76,459 cr	₹6,85,147 cr
Nagaland	37.15%	₹13,242 cr	₹35,642 cr
West Bengal	33.70%	₹5,10,763 cr	₹1,515,564 cr
Himachal Pradesh	33.06%	₹63,363 cr	₹1,91,659 cr
Bihar	32.58%	₹2,42,846 cr	₹7,45,440 cr

\*as on March 31, 2023 Source: CAG report on State Finances 2022-23

- Despite record corporate profits, private investment levels remain stagnant.
- **Fiscal stress:** Fiscal deficit projected to decline from 6.4% (2022–23) to 4.4% (2025–26), but still high.
- **Debt-to-GDP ratio:** ~81%, far above FRBM target (60%).
- **Economic Survey 2024–25** highlighted rising corporate profits and stagnant wages, widening income inequality. In 2023–24, profits hit a 15-year high, while real wages lagged.
- India's **gross expenditure on R&D** stands at **0.64% of GDP**. **Government funding dominates**, whereas in the U.S., China, Japan, and South Korea, private enterprises fund over 70% of R&D.
- **Startup** sector expanded to over 2 lakh govt-recognised startups.
- Open Network for Digital Commerce (**ONDC**) processed over **326mn orders**. It is Govt's initiative launched in 2022 to "unbundle" e-commerce landscape. Unlike Amazon or Flipkart, which are closed marketplaces, ONDC is an open-source network that allows any seller to reach any buyer across different participating apps.
- The **PM GatiShakti National Master Plan** was opened to the **private sector**.
- The **Project Monitoring Group portal** onboarded over **3,000 projects** valued at more than **₹76 lakh crore**.
- Nearly **95% of India's trade by volume** and about **70% by value** moves through maritime routes. The Indian Ports Act, 2025 replaced a colonial-era framework. It introduced state-level dispute resolution, a statutory coordination council, and stronger norms on safety and environmental preparedness.
- The **Oilfields (Regulation and Development) Amendment Act, 2025** reduced investor risk. The Petroleum and Natural Gas Rules 2025 emphasised stability of terms and clearer timelines on approvals. Open Acreage Licensing Policy Round X offered 25 blocks across about 0.2 million square kilometres.
- The **National Deep Water Exploration Mission** signalled focus on **domestic resources and technology**.

### Goldilocks Economy

- A **Goldilocks economy** refers to an **ideal economic state** that is **neither too hot nor too cold, but just right**.
- It features **full employment, economic stability, and steady growth** without major expansion or contraction.
- Growth is **sufficient to avoid recession** but **not excessive to trigger inflation**.
- It maintains a **balanced relationship between growth, employment, and inflation**.

### PMI

- The seasonally-adjusted HSBC India Manufacturing Purchasing Managers' Index fell to **56.6 in November** from **59.2 in October**, marking the **slowest improvement in operating conditions since February**.
- **PMI** is measured on 0–100 scale & reading **> 50** indicates **expansion**, **< 50** denotes **contraction** and **50 denotes no change**. It is a **monthly** indicator with subtypes; manufacturing, service & composite (manufacturing + service).
- It is considered a **leading indicator**, meaning it provides early insight into the health of an economy before official government data like GDP or industrial production are released.
- The index is derived from monthly **surveys** sent to senior executives at private sector companies. **Manufacturing PMI is a weighted average of five main survey areas:** New Orders (30%), Output/Production (25%), Employment (20%), Supplier Delivery Times (15%) (inverted, as longer wait times often signal higher demand) and Stock of Items Purchased/Inventories (10%).

### IIP

**Why in news:** Growth in industrial activity during the **first half of the financial year** has been the **slowest in at least five years**, according to official data. The **Index of Industrial Production (IIP)**, released by **MoSPI**.

- **Released By:** NSO (formerly CSO) under the MoSPI. **Frequency:** Published monthly with a six-week time lag.
- **Base Year:** Currently 2011–12 (assigned a value of 100). Update: The government plans to update the base year to 2022–23 by May 2026. **3 Sectors:** Manufacturing: 77.63%, Mining: 14.37% and Electricity: 7.99%.
- **Eight Core Industries:** Constitute 40.27% of the total IIP weight. **Decreasing order of weightage:** Refinery Products (Highest), Electricity, Steel, Coal, Crude Oil, Natural Gas, Cement and Fertilizers (Lowest).

### Net FDI Inflow

**Why in news:** As per **RBI**, India received **\$81 billion in gross FDI inflows**, while **net FDI** was only **\$353 million**.

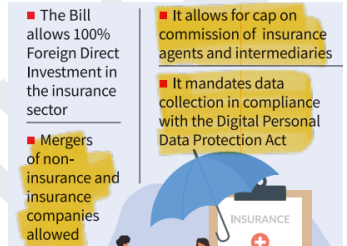
- **Gross FDI-to-GDP ratio** declined from **3.1% (2020–21)** to **2.1% (2024–25)**, and **net FDI-to-GDP ratio** dropped to nearly **zero**. Gap is explained by the rise in **outward FDI (OFDI)** and **disinvestment**, indicating capital outflows.
- **OFDI** includes investments in **tax havens** like **Singapore & Mauritius**, which are also top sources of India's inward FDI. This raises concerns over **"hot money"** and **global tax arbitrage**, with flows not boosting **domestic investment**.
- Nearly 56% of India's outward FDI was routed through low-tax jurisdictions like Singapore, Mauritius, the UAE, the Netherlands, the U.K., and Switzerland. **Singapore (22.6%), Mauritius (10.9%), UAE (9.1%)** together accounted for over 40% not solely for tax avoidance, but also for strategic business advantages.
- **Private Equity (PE)** and **Venture Capital (VC)** termed **Alternative Investment Funds** dominate FDI inflows. These mostly involve **brownfield FDI**, targeting existing firms. **Greenfield FDI** has declined.
- FDI inflows form a **modest share** of **Gross Fixed Capital Formation** (peaked at **7.5% in FY21**, declined thereafter).

- Since FY21, both **net and gross FDI** as a **percentage of GDP** have declined steadily.
- Rising **OFDI** suggests India may be used as a **transit point** for **tax avoidance** by international capital.
- **FDI** is showing **signs of decline and volatility**, marked by **rising disinvestments**, **shrinking net inflows**, and **increasing capital outflows** by Indian firms.
- **Manufacturing**, once a major FDI sector, saw its share **drop to 12%**, replaced by **financial and service sectors**.
- The **capital flight** weakens **domestic job creation**, **industrial growth**, and **innovation capacity**.
- Headline FDI figures are **misleading**, as a large portion comes via **financial centres like Singapore and Mauritius**, indicating **tax-driven flows** rather than **productive capital**. **Traditional FDI sources** such as the **U.S., Germany, and the U.K.** have **scaled back** their involvement.

Net FDI negative for second straight month in September. These figures refer to **direct investment**, which constitutes **investment into assets**, rather than **portfolio investment**, which has to do with **shares in a company**.

### 100% FDI in Insurance

- Sabka Bima Sabki Raksha Act passed.
- **100% FDI** would enable capital infusion, better technology, and better insurance products. It would allow **global companies** to enter the **Indian insurance market** without **domestic partners & invite more reinsurers** to India.
- **All Indian laws** will apply and companies will be **regulated like other insurance entities**.
- The Bill proposes changes to the Insurance Act, 1938, LIC Act, 1956, and IRDAI Act, 1999.
- The **FDI limit** was earlier raised from 26% to 49% in 2015 and from 49% to 74% in 2021. The amendment reduces net owned fund requirement for foreign reinsurance branches from ₹5,000 crore to ₹1,000 crore.
- The Bill empowers **IRDAI** to disgorge wrongful gains from insurers and intermediaries.
- The **maximum penalty** on insurance intermediaries is proposed to be increased from ₹1 crore to ₹10 crore.
- **Premium** collected from Indians by foreign insurance companies will be kept in the country. With **more companies**, **competition** would increase and **premiums** should **drop**.



### FPIs Withdraw

**Why in news:** FPIs withdrew **₹23,885 crore** from Indian stocks in 2025, marking **three consecutive months of net outflows**, according to **NSDL data**.

- FPIs have been withdrawing funds from the **Indian stock market intermittently since 2024** due to tariff uncertainties, weak corporate earnings, high valuations, and rupee depreciation, which reduces dollar returns.
- **India's share** in these funds was **21% in 2024**, but funds are now **rotating towards China**.
- China's allocation increased to 28.8%, marking a reversal in global emerging market investment trends.
- Analysts predict continued volatility in FPI flows due to the H1-B visa fee hike, 100% U.S. tariff on branded pharmaceuticals, and increased Chinese investments in AI.
- On a **PE basis**, **Indian markets remain relatively expensive** compared to global peers. **PE ratio**, which measures whether a stock's price justifies its earnings, shows **Indian stocks trading at 22 times their earnings**.
- Over the past year, **Indian market returns have been weak**, while **other global markets performed better**.
- **Total foreign investment** (portfolio + direct) as a **share of GDP** fell to a **25-year low in 2024–25**.
- **Weak private capital expenditure** and **slowing household incomes** have reduced private demand and lending growth. **World Bank's World Development Report 2024** stressed the **need for sweeping institutional reforms**.

### 4th Largest Economy

**Why in news:** India overtook Japan as **4th largest economy** in the world with a **nominal GDP of USD 4 trillion**. (US>China>India). India is also the **world's fastest-growing major economy**.

- As per **IMF's April World Economic Outlook**, India's GDP is \$4.19 trillion, marginally ahead of Japan. Only the US, China, and Germany are now ahead of India; India aims to become the 3rd largest economy in 2.5–3 years.
- **India's per capita income** has **doubled** from \$1,438 in 2013–14 to \$2,880 in 2025, per IMF. **GDP per capita** is still 12 times lower than **Japan's**. **Poland's GDP** is 4 times smaller than India's, yet its GDP per capita is 9 times higher.
- At current rates, **\$1 = ₹85.69**, India's nominal GDP is converted to USD for global ranking. As per this method, India became the **5th largest economy** in **2021**, projected to be **4th in 2025** and **3rd in 2028**. Exchange rate fluctuations hinder stable comparisons over time. This method ignores **differences in purchasing power** across countries.

#### Purchasing Power Parity (PPP) Method

- **PPP exchange rates** equalise the cost of a typical basket of goods across countries. Using PPP, India's GDP in 2024 was only 1.8 times smaller than the U.S., compared to 7.5 times with market rates.
- India became **3rd largest economy by PPP** in 2009. PPP-based comparisons can inflate GDP in poorer nations due to lower wages–prices. A large informal sector, underemployment, and unpaid female labour also skew PPP figures.

#### Per Capita GDP Reality Check

- India's per capita GDP (2024) was \$2,711, placing it in the lower-middle-income group. Sri Lanka and Bhutan had higher per capita GDPs at \$4,325 and \$3,913 respectively.

- India's global **per capita GDP rank** in 2024 was **144th (market rate)** and **127th (PPP)** among 196 countries.
- **45% of India's workforce** remained in agriculture. The share of wage and salaried workers in formal jobs was 23.9%. **Gross enrolment rate** in higher education was **32.7%**. **Life expectancy** in 2023 was 72 years in India. IMR in 2023 was 24.5 in India. **India's HDI** stood at 0.685 in 2023, indicating 'medium development'.
- **Viksit Bharat @ 2047** paper envisions India as a **USD 30 trillion economy** and a **high-income nation** (defined as > \$14,005 per capita income by World Bank). Six **strategic building blocks** under the Viksit Bharat plan: Macro-Economic Goals, Empowered Citizens, Sustainable Economy, Technology Leadership, Global Leadership (Vishwa Bandhu), and Enabling Governance, Security, Justice.

- **Only final goods and services** are included in GDP. **Intermediate goods** that are used as inputs in the production of other goods are **excluded** to avoid double counting.
- There are two main measures of GDP: **Nominal GDP and Real GDP**. **Nominal GDP**: It refers to the value of goods and services evaluated at current market prices without factoring in inflation or deflation. **Real GDP**: An inflation-adjusted measure that reflects both the value and quantity of goods and services produced by an economy in a given year.
- GDP is measured using three major approaches: **Expenditure, Income, and Product**.
  - **Expenditure approach** sums up consumption (C), investment (I), government spending (G), net exports (X-M).
  - **Income approach** totals income from wages, self-employment, rents, corporate profits, net interest, and adds net indirect taxes, depreciation, statistical discrepancy, and net ROW payments.
  - **Product approach or value-added method** adds market value of final goods and services, excluding intermediates.
- India's GDP is estimated by **CSO** using **two methods**. One is based on **economic activity** (at factor cost, this does not include taxes), and the second is on **expenditure** (at market prices, this includes taxes).

### World Bank Income Classification

**Why in news:** World Bank's income classification system groups countries into four categories based on **GNI per capita**: low, lower-middle, upper-middle, and high income.

- **GNI per capita** = average income of residents including income earned abroad. Reported in local currencies, converted to U.S. dollars via exchange rates. **Low income**: \$1,135 or less, **Lower-middle income**: \$1,136 – \$4,495, **Upper-middle income**: \$4,496 – \$13,935, **High income**: More than \$13,935 (2024).
- Introduced in **late 1980s**, aligned with **World Bank lending policies**.
- **Countries move between groups if GNI per capita crosses a threshold, due to:** Real income growth or decline, Exchange rate shifts, Population updates.
- **2004:** 37% lived in low-income countries. **2024:** less than **10% in low-income, 35% in upper-middle income**.

### CPI Inflation

**Why in news:** Retail inflation fell to **more than 8-year low of 1.54% in September** (.25% in October) due to **falling food and fuel prices**, according to official data. The rate is **below the Reserve Bank of India's lower comfort bound of 2%**.

- **Consistently low inflation** indicates that **supply is comfortably outstripping demand**. The current inflation rate is too low, breaching the lower bound of the flexible inflation targeting regime, especially if gold is excluded.
- **Low inflation** would **squeeze profit margins** and **increase the real value of debt and interest rates** for the **private sector**. Inflation has been **below the 4% target** for the **last nine months**, averaging **2.3%**.
- What is needed is a **sustained increase in real wages**, which requires the **private sector to take the lead**.
- **RBI** can support this by **cutting interest rates significantly** in the **next Monetary Policy Committee meeting**.
- **Core inflation** (non-food, non-fuel items). **CPI inflation** reflects the rate of inflation faced by consumers, distinct from **WPI**. As per **MoSPI**, **CPI measures** changes in prices of a fixed basket of 299 goods and services.
- Separate indices are constructed for rural and urban consumers, apart from an all-India aggregate index.
- **Base year for the current CPI series is 2012**, with a base index value of **100**.
- **CPI has six main components:** Food & beverages, Pan/tobacco/intoxicants, Clothing & footwear, Housing, Fuel & light, and Miscellaneous (services).
- **Food articles carry the highest weight—45%**—in the total CPI index. **Miscellaneous services component** is the **second-largest category** in CPI. Within food, cereals have the highest sub-weight at 9.67% of the total index.
- A rise in prices of food items like cereals, vegetables, milk, and pulses has the largest impact on CPI inflation. Food has high weightage in CPI because Indian consumers spend a significant portion of income on food needs.

- **Food inflation** in India refers to rate at which prices of food items increase over a period of time. As **inflation rises**, each **unit of currency** can buy **fewer goods and services**.
- **Favourable soil moisture, replenished groundwater, and higher reservoir levels** from abundant rainfall supported agriculture. The effects of the monsoon were **best seen in wheat production** and lower inflation.
- In India, **food inflation is commonly measured using price indices**, notably **CPI for food**.
- **Inflation formula:**  $((CPI_{x+1} - CPI_x) / CPI_x) \times 100$ . (CPI x is the value of CPI in the base year x).
- A **base year** is the **first year** of a series in an **economic or financial index**, typically set at **100**.
- **New base years** are introduced periodically to keep **data current**.
- A **base year** is used for **comparison** in measuring **business activity or economic indices**.

**MoSPI CPI Proposals**

- MoSPI has proposed key changes to CPI housing index for the new retail inflation series beginning **February**.
  - Monthly rent data collection** will now be done in both rural and urban areas, instead of the current practice of collecting it every 6 months only in urban.
  - Government and employer-provided accommodations** will be **excluded** from housing index because they do not reflect actual rental market transactions.
  - In the **current CPI**, housing has a weight of **21.67% in urban areas** and **10.07% at the all-India level**. The **new housing index** will expanded sample coverage by **collecting rent data** from all selected dwellings every month, instead of only one-sixth of the sample.
  - For the **CPI revision, 2024** has been selected as the **new base year**, with item baskets and weightages to be determined from **HCES 2023-24**.
  - The **new CPI series** is expected to be released from the **first quarter of 2026**.

**PROPOSED CHANGES IN HOUSING INDEX IN NEW CPI SERIES**

Parameters	Existing	Proposed
Coverage	Only urban areas	Both urban & rural
	12 dwellings per market*	Urban - 12 dwellings per market Rural - 6 dwellings per market*
	Employer provided accommodation included	Employer provided accommodation excluded
Methodology	3 methods used for different periods	1 method from the beginning - short index or chain index method
Source for dwelling type weights	Housing Condition Survey - NSS 69th round	Census 2011

\*as per availability

Source: MoSPI

**Flexible Inflation Targeting**

- The present **Flexible Inflation Targeting framework** in India (4% (+/-) 2%) is ending in **March 2026** and is under review. The **RBI** has released a discussion paper

seeking views on key issues.

- High inflation is a **regressive consumption tax** that affects **poorer households more disproportionately**, hurts **savings** and **misdirects investments**.
- Since **dismantling automatic monetisation (1994)**, RBI gained functional autonomy in monetary policy. In **2016**, India adopted the **FIT framework**, giving institutional autonomy.

**What to Target: Headline or Core Inflation**

- If the objective is to **promote savings, investments and protect the poor**, **headline inflation** should be targeted.
- The assumption that **'food inflation'** is only due to supply shocks is **not necessarily true**. Past episodes show **food inflation** under **expansionary monetary policy** rises more than under contractionary conditions.
- When aggregate demand does not change, **food inflation** only causes **relative price changes**.

Feature	Headline Inflation	Core Inflation
Composition	Entire CPI basket (incl. Food/Fuel)	Excludes Food & Fuel items
Volatility	High (spikes with monsoons/oil prices)	Low (steady long-term trends)
RBI's Role	The official target (4% +/- 2%)	Used to guide <b>Repo Rate</b> decisions
Significance	Best for understanding public sentiment	Best for gauging long-term demand

**Acceptable Level of Inflation**

- Phillips Curve** studies argued **growth-inflation trade-off**.
- Low inflation may **facilitate growth** in short run, but **high inflation hurts growth** → **threshold inflation** concept.
- Data show that **beyond 6% inflation, growth rate declines sharply**.
- Historically, high inflation (1970s-80s) resulted from **monetisation of fiscal deficit**.

**IMF - National Accounts Statistics (NAS)**

- IMF's annual review has given India's NAS including **GDP and GVA** a **grade of 'C'**, the second-lowest rating.
- This grade means the data available "have some shortcomings that somewhat hamper surveillance".
- The IMF noted that national accounts data are available with adequate frequency and timeliness and provide broadly adequate granularity. However, **methodological weaknesses somewhat hamper surveillance**, warranting an overall **sectoral rating of C** for national accounts.
- Across all data categories, India received a **grade 'B'**; the four grades are **A, B, C, and D**.
- IMF highlighted an **outdated base year of 2011-12** and use of **wholesale price indices as deflators** due to lack of **producer price indices**. Pointed discrepancies between **production and expenditure approaches** of measuring GDP.
- 2011-12 series included granular data from India's corporate sector through the MCA-21 database, replacing the Annual Survey of Industries. Proposed inclusion of GST data in GDP estimation in next year's series is welcome.
- Need to **enhance the coverage of expenditure approach data and informal sector**. India has historically used **income approach** to measure GDP, but also provides an estimate based on the **expenditure approach**. Due to differing data sources and their coverage, **2 estimates of GDP often differ**, attracting criticism.

**IMF's Rating**

- IMF's ratings range from **A to D**. An **A rating** is given when the data is **adequate for IMF surveillance**.
- B** is used for data that has **"some" shortcomings** but is **"broadly adequate"**.
- C rating** is for data with **"some" shortcomings** which **"somewhat hamper surveillance"**.
- D rating** is used when the data has **"serious shortcomings that significantly hamper surveillance"**.
- Set up in **1945**, the **IMF** works to achieve **sustainable growth and prosperity** for all of its **191 member countries**. It

does so by supporting **economic policies** that promote **financial stability and monetary cooperation**, which are essential to increase **productivity, job creation, and economic well-being**.

#### GDP

- **Only final goods and services** are included in GDP. **Intermediate goods** are those goods which are used as **inputs in the production of other goods** are **excluded** to avoid **double counting**.
- **Nominal GDP**: It refers to the value of goods and services evaluated at current market prices without factoring in inflation or deflation. **Real GDP**: An inflation-adjusted measure that reflects both the value and quantity of goods and services produced by an economy in a given year.

#### GDP Growth

- Data released by the **MoSPI**. The sharply higher-than-expected GDP came on the back of a **very low deflator**.
- The **lower nominal GDP growth** would make it more difficult for the government to achieve its **fiscal deficit target of 4.4%**, which had been pegged to a **nominal growth of 10.1%**.
- There has been **no upswing in Gross Fixed Capital Formation**, and high GDP growth rates are **not sustainable** without renewed momentum in **private investment**.
- The **unrealistically low GDP deflator**, implying **inflation of only 0.5%**, is at complete variance with the experience of households facing **crushing price rise**.
- **Outdated base year** and high **weightage of food in CPI** have prevented India from accurately capturing **price movements**, impairing the **RBI's monetary policy**.
- The biggest issue with national accounts statistics is the **inability to accurately capture the informal sector** because it consists of **unregistered and cash-based entities**.
- **Services sector**, contributing **60% of GDP**, grew by **9.2%**.

- **GDP Deflator** is the "ultimate" inflation gauge that shows how much the prices of everything produced in a country have risen. CPI (Retail Inflation) only tracks a "basket" of goods consumers buy (like milk, rent, and fuel). GDP Deflator tracks every single thing produced in the economy—including machinery, bridges, exports, and government services.  $\text{GDP Deflator} = (\text{Nominal GDP}/\text{Real GDP}) \times 100$ .
- **GFCF** is a measure of the total investment made in an economy toward "fixed assets" i.e. buildings, infra etc. High GFCF indicates that businesses and the government are confident about the future. In India, GFCF has been the "heavy lifter" of GDP, currently hovering around 34–35% of GDP.
- **ICOR** (Incremental Capital Output Ratio) tells how much extra investment is needed to produce one extra unit of output. A lower ICOR means investment turns into growth more efficiently. While the GFCFR does not fluctuate too much, the ICOR is very volatile. The probable reason is that ICOR is not estimated independently and is derived from dividing the real GFCFR by real GDP growth rate. Technology and management ultimately determine ICOR.
- **Hindu Growth Rate**: According to The New Oxford Companion to Economics in India, economist Raj Krishna coined the expression as "a polemical device" intended to draw attention to the meagre 3.5 per cent growth rate experienced by India over the long run.

#### New Base Year

**Why in news: MoSPI is revising the base year for GDP, IIP, and CPI** as part of a broader data indicator expansion.

- The new GDP series will be released in 2026, using FY 2022–23 as the base year.
- For **IIP**, the revised base is **tentatively 2022–23**, and the **new series will be published from 2026–27**.
- For **CPI**, the new **base year will be 2024**, with data derived from the **HCES 2023–24**. The **new CPI series will be released from Q1 of 2026**, based on updated **item basket and weightage**. Initially, **HCES 2022–23** was to be used for CPI weights, but now the **latest HCES 2023–24** data will be used. MoSPI will source data from **online platforms** (airfare, rail fare, OTT services) and **administrative records** for petrol, diesel, LPG prices. MoSPI is also exploring scanner data and web scraping to improve accuracy, efficiency, and comprehensiveness of price data.
- **GDP calculation** will now include **GST data, UPI transactions, and E-Vahan portal data** in addition to traditional sources like **RBI, CGA, and MCA-21**. NSO is using GSTN data to conduct the new **Annual Survey of Service Sector Enterprises (ASSSE)**, a first in the NSS ecosystem.
- The next **HCES** will be held in **2027–28** and will now occur **every three years** instead of every five.
- MoSPI launched the **National Household Travel Survey (NHTS)** and **Domestic Tourism Expenditure Survey (DTES)**. The NHTS will assess origin–destination patterns, mode choice factors, and price elasticity of travel demand. DTES will capture data on tourism spending, trip purpose, transport mode, accommodation, destination etc.

A **base year** is the first year in an economic or financial index, typically set to a level of 100. Base years are updated periodically to keep the index data current and relevant. A base year enables comparison in measuring business activity or economic indices. Any year can serve as a base year, but analysts usually choose a recent year. For example, to calculate inflation from 2016 to 2024, 2016 is used as the base year. A base year also serves as a starting point for growth measurement or same-store sales comparisons.

### Income Survey

- The **Household Income Survey, 2026**, India's **first-ever comprehensive income survey**, aims to provide a clear picture of **how Indian households are earning, spending, and coping** with economic changes.
- To capture **direct household income data**, offering insights into **income distribution and class dynamics**.
- Existing tools like the **PLFS, HCES**, and the **RBI's Consumer Confidence Survey** have provided only **partial or indirect income insights**. PLFS focuses on labour market earnings, while HCES uses consumption patterns as a proxy for income. The new survey is designed to **measure income directly**.

### Scope and Coverage

- The survey will record information on **social group, religion, and occupation**, along with details of **agricultural and non-agricultural activities**. It includes data on **land ownership, dwelling type and size, loans, and property holdings**.
  - **Regular salaries**, including **allowances, overtime pay, bonuses, stock options, and severance pay**.
  - **Casual workers' earnings**, including **days worked, average daily wages, and tips**.
  - **Self-employed income**, including **type, quantity, and value of crops or goods sold**.
  - **Non-agricultural business receipts** and **sector details**.
- The survey will help identify **income disparities across social and occupational groups**. It will track **loan repayments** as a share of income, crucial for understanding **urban EMI-based spending** patterns.
- The survey will record **pension payments, family transfers** (like alimony or child support), and **remittances**.
- For the **first time**, it will capture **funds received through State-specific and Union schemes**.

### Household Finance Surveys

**Why in news:** MoSPI will conduct two key economic surveys — the **All-India Debt and Investment Survey (AIDIS)** and the **Situation Assessment Survey (SAS) of Agricultural Households** between **2026 and 2027**.

- The **AIDIS** is aimed at measuring **household indebtedness and asset ownership** across **rural and urban areas**.
- **SAS of Agricultural Households** launched in **2003** to **assess the economic conditions of farming communities**.
- The **AIDIS findings** are crucial for shaping national accounts, assessing inequality in asset distribution, understanding credit markets, and informing policies of the RBI, MoSPI, and other government institutions.
- The **SAS survey** gathers data on agricultural household income and expenditure, indebtedness and credit access, land and livestock ownership, crop and livestock production etc. The findings are used by the Ministry of Agriculture and Farmers Welfare, NITI Aayog, researchers, and financial institutions.

### MSME Facts

**Why in news:** MSMEs contributed nearly **30% to GDP in 2024**, with the target of **35% for the current year**.

- **Women-owned MSMEs constitute 20%** of all registered MSMEs, yet contribute only **10% of total turnover** and receive just **11–15% of total investment**.
- Under **Pradhan Mantri MUDRA Yojana (PMMY)**, **64% of loan accounts** are owned by women.
- **Udyam Assist Portal** was launched to bring **Informal Micro-Enterprises** into the **priority sector lending** net through **formal recognition**. In 2024, **1.86 crore IMEs** were registered, **70.5% owned by women**.

#### Mudra Yojna (Last Year's Update)

- Limit of Mudra loans will be enhanced to **₹20 lakh** from current ₹10 lakh for those entrepreneurs who have availed and successfully repaid previous loans under '**Tarun category**'.
- Loans for amounts up to ₹20 lakh will be provided under Credit Guarantee Fund for Micro Units (CGFMU).
- **Launched:** In April 2015 to promote micro and small enterprises. Loans are offered by Commercial Banks, RRBs, Small Finance Banks, MFIs, and NBFCs. **Beneficiaries:** Entrepreneurs, small vendors, artisans, women, and SC/ST/OBC businesses. **Regulator:** It is under the Ministry of Finance.
- Loans are refinanced by MUDRA Ltd., a subsidiary of SIDBI. **Categories of MUDRA Loans:** Shishu: Loans up to ₹50,000 – for startups and early-stage businesses. Kishor: Loans from ₹50,001 to ₹5 lakh – for growing enterprises. Tarun: Loans from ₹5 lakh to ₹10 lakh – for well-established businesses ready to scale.

### MSMEs & QCOs

**Why in news:** In the last three years, the **Bureau of Indian Standards (BIS)** has issued **84 QCOs** based on the recommendations of various ministries and departments, which is almost **45%** of all **187 QCOs** administered by it.

- **QCOs** are legal orders issued by departments or ministries under the **BIS Act**, which make it **mandatory** for domestic and imported products to conform with certain quality standards. The products **cannot be sold** unless they get a **certification from the BIS**.
- MSMEs have complained to the government that the **QCOs are akin to non-tariff barriers** and have **raised cost**.
- In India, **BIS formulates Indian Standards** for different products. **BIS certification scheme** is **voluntary in nature**, but for several products, **compliance to Indian Standards** is made **compulsory by the Central Government**.
- This is done under considerations of quality imports, public interest, protection of human, animal or plant health, safety of environment, prevention of unfair trade practices, and national security.
- **BIS Act, 2016** empowers the **government** to **mandate standardisation through compulsory certification**.

## Trade

## Export Concentration

**Why in news:** India's trade deficit contracted by over 54% to \$9.9 billion in 2025, compared to \$21.7 billion in 2024.

- Driven by merchandise exports, strong services exports, and a decline in merchandise imports.

## India's Export Centralisation

- **RBI Handbook of Statistics** on Indian States 2024–25 revealed **top 5 exporters**: Maharashtra, Gujarat, Tamil Nadu, Karnataka, Uttar Pradesh command **nearly 70%** of the **national export basket**.
- Firms are increasingly benefitting from **spatial clustering**, not expanding to **newer regions**.
- **5 years ago**, the top five States contributed **about 65%** of national exports; this has risen to nearly 70%.
- The **Herfindahl–Hirschman Index (HHI)** of India's export geography is **rising**, indicating **increasing concentration**.
- **UNCTAD 2023** estimates show the **top 10 global exporters** control **around 55%** of **world merchandise trade**.
- **PLFS data** shows **manufacturing employment** share stuck at **11.6%–12%**.
- Gujarat alone contributes over 33%. UP, Bihar, and MP together account for barely 5% of outbound trade.
- 8 northeastern States, with over 5,400 km of international borders, account for just 0.13% of national exports.
- The Prime Minister's Economic Advisory Council and the Board of Trade have no members from the region.
- The government introduced **The Trade Connect ePlatform** as a **single digital window for exporters**.
- The **Trade Intelligence and Analytics (TIA) portal** was launched to provide **real-time market data**.

## India–Myanmar Border and ASEAN Linkages

- Since the 2021 coup in Myanmar, trade across the border has collapsed. Zokhawthar (Mizoram) and Moreh (Manipur) have become securitised outposts instead of trade hubs.

## Gold

**Why in news:** India has attracted **over \$1 trillion in gross FDI since 2000**. In 2024, **global investment** fell by **over 11%**, and **international project finance** deals dropped by **27%**.

- **Gold** stands as the **most compelling domestic asset**, serving both as a **store of value** and a **symbol of security**. Indian households collectively hold **around 25,000 tonnes of gold** – the **largest private reserve in the world**.
- At current prices, this equates to **\$2.4 trillion**, or **over 55% of India's GDP (FY26 terms)** – a **value greater than all bank credit** combined. Despite this, India remains a **major gold importer**, meeting **87% of domestic demand**, with imports forming **8% of the total import bill**.

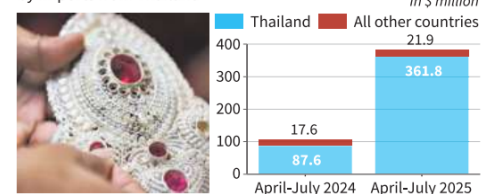
## Silver

**Why in news:** DGFT has restricted the import of plain silver jewellery unless expressly authorised. The move aims to **curb misuse of India's FTAs**.

- Follows a **steep rise in plain silver jewellery imports**.
- **Thailand** accounted for **bulk of imports**, a **330% surge**.
- DGFT now requires **importers of plain silver** to obtain a **valid import authorisation** from the **Directorate**. Step is intended to **monitor trade flows** and **prevent circumvention of FTA benefits** through **unauthorised imports**.

## Thai Silver Influx

The surge in silver jewellery imports into India has been driven by imports from Thailand



Source: Ministry of Commerce & Industry

## RoDTEP

**Why in news:** Govt extended the Remission of Duties and Taxes on Exported Products scheme until March 31, 2026.

- The **RoDTEP scheme**, launched in 2021, provides **refunds for embedded duties, taxes, and levies** not refunded under other schemes. Earlier, the scheme was **available only until February 2025**.
- In **May 2025**, after **lobbying by exporters**, the government **restored RoDTEP benefits** for **Advance Authorisation (AA) holders**, **Export-Oriented Units (EOUs)**, and **SEZ units**.

## Export Promotion Mission

- The **Centre** approved an **Export Promotion Mission** with an outlay of **₹25,060 crore** for **2025–26 to 2030–31**.
- Designed to boost India's exports by creating a **unified, tech-driven framework** for MSMEs, first-time exporters, and labor-intensive sectors, focusing on finance access (**NIRYAT PROTSAHAN**) and non-financial support like market access and branding (**NIRYAT DISHA**) to enhance global competitiveness.
- **Strengthen Competitiveness:** Make Indian exporters more competitive globally.
- **Empower MSMEs:** Provide targeted support for MSMEs, women-led enterprises, and SHGs.
- **Finance Access:** Improve access to affordable trade finance and credit.
- **Market Diversification:** Reduce reliance on single markets by exploring new ones.
- **Digital Ecosystem:** Create a seamless, technology-enabled platform for export support.

- **Two Core Sub-Schemes: NIRYAT PROTSAHAN:** Focuses on financial aspects, ensuring access to affordable trade finance. **NIRYAT DISHA:** Addresses non-financial needs like quality, branding, logistics, and trade intelligence.
- **Implementation: Collaborative Approach:** Involves the Department of Commerce, Ministry of MSME, Ministry of Finance, and other bodies. Offers digital assistance for compliance, certification, branding, and packaging.

### Credit Guarantee Scheme for Exporters (CGSE)

- To provide **100% credit guarantee coverage** of ₹20,000 crore to **lenders**. The scheme covers loans extended to **eligible exporters**, including MSMEs.
- **Coverage & Purpose:** 100% guarantee coverage on additional working capital/term loans to help exporters.
- **Loan Amount:** Up to 20% of existing fund-based/non-fund-based working capital limits, with a maximum loan of ₹50 crore per borrower. **Interest Rates:** Capped at 10% p.a. for Banks/FIs and 14% p.a. for NBFCs (1% below existing facility rates). **Fees & Terms:** Zero guarantee/processing fees and no prepayment penalties.
- **Validity:** Valid for loans sanctioned from November 19, 2025, to March 31, 2026.
- **Eligibility:** MSME (≥5% export turnover) and non-MSME (≥20% export turnover).

## E-Commerce

### Country of Origin

- **Union Department of Consumer Affairs draft rules** propose mandatory **searchable and sortable filters by country of origin** for **packaged commodities sold online**. Proposal applies to e-commerce platforms selling imported products.
- Draft Legal Metrology (Packaged Commodities) (2nd) Amendment Rules, 2025 propose adding sub-rule (10) to Rule 6. The government said the move will enhance **consumer empowerment and transparency** in online shopping.

### Dark Patterns

**Why in news:** The **Government has directed e-commerce platforms** to conduct **regular audits** to identify and eliminate **dark patterns**, rather than waiting for **CCPA intervention**.

- **Dark patterns** (or **deceptive patterns**) are **design tricks** used by websites/apps to **manipulate user behavior** against their intent. **Example:** Ads with **tiny or hidden close buttons** that mislead users into clicking them.
- The term was coined by **UX designer Harry Brignull in 2010**.
- In **2023, CCPA issued guidelines** specifying **13 dark patterns** for regulation: **False urgency, Basket sneaking** (Adds products to cart without consent), **Confirm shaming** (Guilt-tripping users), **Forced action, Nagging, Subscription traps, Bait & switch** (Advertises one product, delivers another (often inferior) etc).

- **E-Jagriti** is an **integrated digital platform** developed by the **Department of Consumer Affairs** and **NIC** to merge **e-Daakhil, Confonet, and OCMS** into one unified system to **simplify access for consumers, officials, judges, advocates, industry experts, and mediators**.

- Launched on **National Consumer Day 2024** (celebrated on **24th December**), alongside the '**Jago Grahak Jago App**', '**Jagriti App**', and '**Jagriti Dashboard**'.

### CCPA (Central Consumer Protection Authority)

- Constituted under **Section 10(1) of Consumer Protection Act, 2019**, which came into force in **2020**, replacing 1986 Act to **protect consumer rights** and address **unfair trade practices, false, and misleading advertisements**.
- **CCPA can act suo motu**, or based on a **complaint or direction from the central government**.
- It comprises a **Chief Commissioner** and other **Commissioners**, appointed by the **Central Government**. **Central Government** defines the **qualifications, tenure, salary, and service conditions** of the Commissioners.
- CCPA has an **Investigation Wing** headed by a **Director General**; **District Collectors** are empowered to investigate **local consumer complaints**.

## Manufacturing, Skill Development and Trade

### Dutch Disease

- **High government salaries** draw workers away from **manufacturing**. **Dutch disease** refers to an **economic windfall** causing **negative effects** on sectors like **manufacturing**. The term was coined after the discovery of the **Groningen gas fields (1959)** and its impact on **Dutch manufacturing**.
- Higher incomes of government employees increase **demand**, raise **domestic prices**, and under **free trade** boost **imports**, reducing demand for **domestic manufactures**. The theory of **induced innovation** holds that labour scarcity and high wages can drive technological and capital-biased growth.
- **John Habakkuk** argued that **19th-cent Britain** grew faster than the **U.S.** due to **relative scarcity of land and labour**.

### Self-reliant India

**Why in news:** Atmanirbhar Bharat Abhiyan (2020) reinforced self-reliance with a focus on **state-of-the-art value chains** and reducing import dependence in **strategic areas** like: Defence, electronics, semiconductors, pharmaceuticals, and critical minerals.

- India hosts the **world's 3rd-largest startup ecosystem**.
- India's **defence exports** reached **₹23,622 crore (FY25)**, targeting **₹50,000 crore by 2029**
- **Key national missions include:** National Quantum Mission and India Semiconductor Mission.
- Contributing to **AI growth** through: Projects like **Bhashini, FutureSkills Prime** for training AI-skilled professionals.

### SEZ Norms – Electronics

**Why in news:** The Union government has notified **changes to SEZ regulations for semiconductor and electronic parts manufacturing**. The changes aim to **reduce the minimum plot size and allow domestic supply** besides exports.

- **Rule 5 of the SEZ Rules, 2006, amended:** the minimum contiguous land area is reduced to 10 hectares from 50 hectares. **Rule 7 amended:** allows the Board of Approval to relax encumbrance-free land norms if land is mortgaged or leased to government agencies. **Rule 18 amended:** SEZ units in semiconductors and electronic components can now supply to the rest of India after paying applicable duties, not just export.
- Board of Approval approved **Micron Semiconductor Technology (Sanand, Gujarat); Aequs (Dharwad, Karnataka)**.
- **Semiconductors** are essential to modern electronics, powering devices like **phones, computers, smart TVs, and cars**. Core to technologies like **AI, machine learning, automation, and digitisation**.
- In **2021, China accounted for 35%** of global semiconductor production.

### Quality Control Orders

**Why in news:** Government will use **QCOs** to push Indian industry towards **international competitiveness**.

- All **non-subsidy support** will focus on **land acquisition** and easing **regulatory hurdles**. The government believes **subsidies have not been effective in boosting India's exports**.
- Discussions have emerged on providing **subsidies for production of rare earth batteries** due to supply crunch after **China's export ban**. **QCOs mandate** that products manufactured, imported, sold in India, or exported must meet minimum quality standards set by the Bureau of Indian Standards (BIS).
- **Exemptions from mandatory QCOs** exist for imports used in export production under schemes like advance authorisations, EOU, and SEZs.

### Factories (Gujarat Amendment) Ordinance

**Why in news:** Gujarat amended Factories Act, 1948 to allow women to work night shifts with safety measures.

- **Maximum daily working hours** have been increased from **9 to 12 hours**, with the **weekly limit retained at 48 hours**. Factories can extend work shifts to **12 hours per day (including intervals)** with **workers' written consent**.
- **Overtime wages** will be paid at **double the ordinary rate**. Employers must ensure **adequate lighting, CCTV surveillance, female security personnel, and safe transportation**. A **minimum of 10 women** must be scheduled per night shift, and **no worker can be forced** to work night shifts without consent.

### Employment-Linked Incentive

**Why in news:** ELI scheme to support **employment generation**. **First-time employees** will get **1 month's wage** (up to ₹15,000 in 2 installments, 1st installment after 6 months of service and 2nd after 12 months, both via DBT), while **employers** will get **incentives for up to 2 years** for generating additional jobs.

- Aims to **incentivise creation of more than 3.5 crore jobs** over two years.
- **Employees with salaries up to ₹1 lakh** will be **eligible** under the scheme. The government will provide **incentives up to ₹3,000/month for two years** for each **additional employee with at least six months of sustained employment**.
- In the **manufacturing sector, incentives will continue for the third and fourth years**.
  - For EPF wage slab up to ₹10,000, an incentive of ₹1,000 will be given to the employer. For wage slab over ₹10,000 and up to ₹20,000, a benefit of ₹2,000 will be provided. For wages over ₹20,000 (up to ₹1 lakh/month), an incentive of ₹3,000 will be given.
  - EPFO-registered establishments must hire at least two additional employees (if workforce <50) or five (if workforce ≥50) for at least six months. Payments to first-time employees under Part A will be made via DBT. Payments to employers under Part B will be credited to their PAN-linked accounts.
  - The scheme duration is two years, from August 1, 2025 to July 31, 2027.
  - It is part of the Prime Minister's Package for Employment and Skilling, with a budget 24-25 outlay of ₹2 lakh crore.

- The **EPFO** will **implement** the scheme. A **portion of the incentive** will be kept in a **"savings instrument of deposit account"** for a fixed period, **withdrawable later**.

- **Formal manufacturing sector** has seen a significant **negative change** in employment structure in recent decades. Share of **contract labour** doubled from **20% (1999–2000)** to **40.7% (2022–23)** across industries. **Contract workers** hired through third-party contractors excluded from **Industrial Disputes Act 1947** safeguards.

### Women – STEM

**Why in news:** **43% of STEM graduates in India are women**, the highest among major economies. However, **only 27% of the STEM workforce** is female.

- **FLFPR** rose to **41.7%** in 2023–24, higher in **rural areas (47.6%)** than **urban (25.4%)**. Globally, **only 31.5% of researchers are women** (UNESCO, 2021). **Gender Budget** increased from **6.8% (2024–25)** to **8.8% (2025–26)**.
- **UN Women’s WeSTEM programme** with **Madhya Pradesh, Gujarat**, and **Micron Foundation** focuses on skills, mindset change, and community engagement.

### Chemical Exports

**Why in news:** **NITI Aayog** proposed measures to nearly **double India’s \$44 billion chemical exports** by **2030**.

- Suggested **developing production clusters**, improving **port infrastructure**, and introducing a **sales-linked incentive scheme** to localise production and boost exports of **critical chemicals**.
- In **2023**, India had a **\$31 billion trade deficit** in chemicals and held a **3.5% share** in **global value chains (GVCs)**, compared to **China’s 23%**. India could **double its GVC share to 5–6%** by 2030 by shifting from **specialty chemicals**.
- Called for revamping existing **PCPIRs** (Dahej, Paradeep, Vizag), noting **Paradeep** and **Vizag PCPIRs** are far from completion. Plan includes developing **eight high-potential clusters** across **14 major** and **12 minor ports** in India.

## GST

### GST on Online Gaming

**Why in news:** **SC heard arguments** between the **government and online gaming companies** on whether **games of skill (rummy, chess, bridge)** become **games of chance when money is involved**, making them taxable under **GST**.

- **Betting on any game — skill or chance — is gambling** and thus **taxable** with 28% GST.
- Government insists on **28% GST on total entry amount**, while companies argue for **GST only on their earnings**.

### NITI Aayog & GST

**Why in news:** **10th Governing Council Meeting of NITI Aayog**.

- **NITI Aayog Governing Council meets only once a year** despite rules requiring meetings **at least once a quarter**.
- Governing Council of NITI Aayog **includes** the PM, CMs of all States and UTs with Legislature, Lt Governors of other UTs, Ex-Officio Members, Vice Chairperson, Full-time Members, and Special Invitees.
- It was **first constituted in 2015** and **reconstituted in 2021**, embodying the spirit of **cooperative federalism**.
- The Council provides a platform to address **inter-sectoral, inter-departmental, and federal issues** for national development. Governing Council chaired by the **Prime Minister**.
- **GST registration** is mandatory if all-India aggregate turnover is **above ₹40 lakh** for supply of **goods** (₹20 lakh in Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Puducherry, Sikkim, Telangana, Tripura, Uttarakhand).
- For **supply of services** or **mixed supplies**, GST registration is mandatory if turnover is **above ₹20 lakh** (₹10 lakh in Manipur, Mizoram, Nagaland, Tripura).

### Tax Contribution vs Devolutions

- **Maharashtra** had the **biggest negative difference**, where the share in taxes collected exceeded the share in devolution, contributing 36.1% of total revenue but receiving 6.65% of the Centre’s tax devolution.
- Other **States with negative differences** include Karnataka (8.8 percentage points), Haryana (4.3 pps), Gujarat (3.5 pps), Tamil Nadu (2.95 pps), Telangana (1.4 pps) and Goa (0.04 pps).
- On the other hand, Bihar’s share in devolution exceeded its contribution to total taxes by **8 pps**, Madhya Pradesh’s by **5.5 pps**, and Rajasthan by **3.55 pps**.

### Tobacco Control

**Why in news:** Since its introduction in **2017**, **GST** replaced multiple indirect taxes, establishing **“One Nation, One Tax”**.

- **28.6% of adults** and **8.5% of school-age children** (13–15 years) in India consume tobacco.
- Post-GST, there have been **no significant tax hikes** on tobacco. **Overall tax burden** remains **below WHO’s 75% recommendation: 22% for bidis, 54% for cigarettes, 65% for smokeless tobacco**.
- GST relies heavily on **ad valorem taxes**, which are **less effective** in curbing harmful product consumption than **specific excise taxes**. Since GST rollout, **central excise’s share** in tobacco taxation dropped from **54% to 8% (cigarettes)**, **17% to 1% (bidis)**, and **59% to 11% (smokeless tobacco)**.
- **Bidis**, although widely consumed and equally harmful, are **not subject to the GST compensation cess**.

- **Way Forward:** Raising GST rates on tobacco to the **peak statutory rate of 40%**.
- India has ratified the **WHO Protocol to Eliminate Illicit Trade in Tobacco Products**.

### GST Compensation Cess

**Why in news:** GST collections in **June 2025** stood at **₹1.85 lakh crore**, the **lowest in four months**.

- As a **consumption tax**, low collections indicate **low economic activity** and **system inefficiencies**.
- **Fuel & alcohol** remain outside GST. **GST Council's fitment & rate-setting committees** reviewed **rate rationalisation**.
- The **GST Compensation Cess** was levied above the **28% slab**. Initially meant to **compensate States for 5 years**, it was **extended till March 2026** to **repay post-COVID loans**.

### GST Reforms 2025

**Why in news:** The **GST Council** in its **56th meeting** approved major reforms: GST slabs reduced from **four (5%, 12%, 18%, 28%)** to **two (5% and 18%)**. A new **40% slab** introduced. W.e.f **September 22, 2025**.

**What is GST?**

- Introduced in **2017** as a **unified indirect tax**, subsuming state and central levies like **VAT, octroi, luxury tax, entry tax**. Based on **destination principle** – tax levied where goods are consumed.
- Allows **input tax credit** for manufacturers.
- **Broadened the tax base** by formalising businesses.
- Reform aimed at **boosting demand** and setting off a **virtuous capex cycle**: **Cheaper goods** → higher disposable income; **More consumption** → higher production & investment; **More jobs** → more spending, continuing the cycle.
- **7 Pillars of GST Reforms are:** Rate Rationalisation, Inclusion of Petroleum and Alcohol, Enhanced Compliance and Technology, Reduction of Litigation, Support for MSMEs, Greening the GST, Export Competitiveness.

**Impact on Goods:**

- **Cheaper:** Common-use items (toothpaste, butter, cheese, condensed milk, pasta, packaged coconut water, nuts, dates, sausages), electronics (ACs, TVs, small cars, bikes), and medical items (gauze, bandages, diagnostic kits).
- **Higher tax:** Clothes costing more than **₹2,500** (from 12% to 18%).
- **Luxury & sin goods** (high-end vehicles, tobacco) taxed at **40% slab**, but overall burden may reduce on **removal of compensation cess**.
- **FM** launched the **GST Appellate Tribunal (GSTAT)**. Justice in GST disputes will now be **fair, fast, transparent, and accessible to all**
- The **GST compensation cess stands abolished**, marking the end of the compensation era.
- **Article 246** demarcates taxation powers; **residuary power** vests with the Centre. **92nd Amendment** introduced Service Tax; **101st Amendment** brought GST in 2017.
- GST created a **destination-based tax**, shared tax base, and caused **erosion of States' fiscal autonomy**.

**Role of the Finance Commission**

- **Articles 268–293** define Centre-State financial relations.
- **Finance Commission (Article 280)** determines transfers to States.
- FC grants supplemented by **CSS, Central Sector Schemes**, and earlier **Planning Commission** grants (ended 2014).
- **Article 282:** direct Union grants; **Article 275:** statutory grants.
- **80th Amendment** introduced **global sharing**, replacing sharing of individual taxes. FC recommendations rose from **29.5% → 30.5% → 32% → 42% → 41%** (post J&K change). **Actual devolution** consistently lower due to **rising cesses and surcharges**.

**Dependence on Central Transfers**

- Central transfers constitute **44% of States' revenue receipts**.
- Expenditure: Pre-GST Centre 47% & States 53%; Post-GST Centre 48% & States 52%. Rise in Centre's expenditure linked to expanded **Centrally Sponsored Schemes** on State subjects.

### Apparel GST

**Why in news:** **Readymade garments priced above ₹2,500** now **attract 18% GST**, placing them in **luxury goods**.

- The domestic apparel market is estimated to be worth \$100 billion, with ethnic wear constituting around 25% of the total. Earlier, branded garments priced above ₹1,000 attracted 12% GST.
- This means a **saree priced at ₹1 lakh** attracts only **5% GST** as it is classified under **textiles**, whereas a **salwar set priced above ₹2,500** incurs **18% GST** as a **ready-made garment**.
- Previously, **manmade fibre (MMF)** attracted **18% GST**, **MMF yarn 12%**, and **garments 5%**. Now, the **GST on all MMF products has been unified to 5%**, streamlining the **tax structure for the synthetic textile sector**.

### Workforce

**Jobs**

- According to **RBI-KLEMS**, while only 2.9 crore jobs were created between 2004–2014, more than 17 crore jobs were created in the following decade. Formalisation has accelerated, as seen from EPFO data.
- **65% of India's population is under 35 years**, offering a **demographic dividend**.

**IT Sector**

- Employs **1% of workforce** but contributes around **7% to India's GDP**.
- Issues: **AI-driven automation, Generative and Agentic AI models, Skill mismatch, restrictive U.S. immigration policies** – increased **H-1B visa fees** and tariffs.

**Digital Labour Chowk**

- The **Construction Workers' Federation of India (CWFI)** has questioned its launch by the **Union Labour Ministry**.
- **Ministry:** A Ministry of Labour initiative under the e-Shram 2.0 framework, digitizing the traditional "Labour Chowks."
- **Direct Marketplace:** Creates a B2C/B2B platform connecting workers (plumbers, masons) directly to households/contractors, eliminating middleman commissions.
- **Social Security:** Automatically links registered workers to PM-SYM (Pension) and Accident Insurance via their Universal Account Number (UAN).
- **Skill Mapping:** Uses GIS-tagging to locate workers and integrates with the Skill India Digital Hub.
- **Urban Inclusion:** Aims to formalize the informal urban workforce.

**Menstrual Leaves**

- **Karnataka** has become **1st State** to approve **1 day of paid menstrual leave per month** for all women employees. The leave applies to women in **government offices, educational institutions, factories, and private organisations**.

**PLFS**

**Why in news:** Govt will revamp **PLFS**, started by NSSO under MoSPI in **2017**, to enhance **PLFS coverage and sampling design for high-frequency indicators**.

- The **revamped PLFS** will provide **monthly estimates** of key indicators like Labour Force Participation Rate, Worker Population Ratio, and Unemployment Rate for both rural and urban areas under the Current Weekly Status (CWS). **Quarterly** estimates for rural and urban areas at national and major State levels will also be generated under CWS.
- **Annual estimates** of employment indicators will be given under both Usual Status (ps+ss) and CWS frameworks.
- LFPR is defined as the **number of persons/ person-days** in the labour force per **1000 persons /person-days**.
- **FLFPR** measures the share of women who are either employed or actively seeking work. A higher FLFPR indicates greater gender equality and a more dynamic labour market.
- FLFPR fell from 31.2% in 2011-12 to 23.3% in 2017-18, before rising to **41.7% in 2023-24**.
- **Workers in India** are classified into self-employed, regular salaried, and casual workers. Economic development usually leads to a shift from agriculture to non-agriculture sectors. However, the **share of rural women in agriculture increased** from **71.1% in 2018-19** to **76.9% in 2023-24**.
- From **2025 onwards**, **PLFS annual results** will be based on the **calendar year (January–December)** to enhance **labour market analysis** and enable **timely updates** to international labour statistics databases.
- Each selected household will be **visited four times** over **four consecutive months** for detailed data collection.
- **Usual Status (ps+ss)** refers to activity over **past 365 days**, while **CWS** refers to the **last 7 days** prior to the survey.
- Currently, **urban PLFS data** is released **quarterly**, **rural annually**, and combined **annual reports** are published. In comparison, **CMIE** provides **weekly and monthly employment surveys**.

**Unemployment – PLFS**

- **PLFS** shows **rural unemployment** among persons aged 15+ declined to **4.4%**. **Urban unemployment rate "edged up slightly" to 6.2% for males and 9.0% for females**. Overall unemployment among 15+ **dropped to 5.2%**.
- **Self-employment dominated** in rural areas, while urban jobs were primarily **regular wage or salaried employment**.
- The rural workforce continued to **concentrate in agriculture**, with **57.7%** engaged in the sector..
- In urban areas, the **tertiary sector** remained dominant, employing **62%** of workers.
- The **FLFPR** aged 15+ increased to **33.7%**. **LFPR** increased to **55.8%** in **November**, the **highest since April**.
- Rise in **LFPR** was primarily driven by **rural areas**. The **female LFPR** showed a **steady rise from June 2025 to November 2025**. **Worker Population Ratio (WPR)** for persons aged **15 years and above** in **rural areas** increased.

**Gig Workers**

**Why in news:** **2025 Budget** formally recognised **gig and platform workers** and extended social protection schemes to them. Despite this, **PLFS 2025** did not incorporate meaningful changes to classify or represent gig work accurately.

- **Code on Social Security, 2020** defines gig and platform work as employment outside a traditional employer–employee relationship, yet the definitions remain vague. PLFS continues to classify gig workers under **ambiguous categories** such as ‘self-employed’, ‘own-account workers’, or ‘casual labour’.
- The **2022 Hindi film Zwigato** by **Nandita Das** and the book **OTP Please (2025)** by **Vandana Vasudevan** highlight the **struggles of gig workers** and the impact of the **gig economy** on society.
- **NITI Aayog (2022)**: Gig workforce projected to grow from **7.7 million (2020–21)** to **23.5 million (2029–30)**. Indian digital economy expected to be worth **\$1 trillion in 5 years**.
- The **gig economy**, employing **80 lakh–1.8 crore workers**, could **grow to 9 crore by 2030**.

### CII Partnership Summit–2025

- The 30th edition of the CII Partnership Summit 2025 was held in Visakhapatnam, Andhra Pradesh.
- Organized by CII in collaboration with the Ministry of Commerce and Industry and the Government of Andhra Pradesh under the theme: "Technology, Trust and Trade: Navigating the New Geoeconomic Order".

### Workplace Accidents

**Why in news: British Safety Council** estimates that **one in four fatal workplace accidents worldwide occur in India**.

- The **Factories Act, 1881** was the first law regulating labour conditions in India.
- The **Factories Act, 1948** covered factory licensing, machinery maintenance, working hours, rest breaks, canteens, and crèches. Based on the principle that decent working conditions and safety go hand in hand.
- **Workmen’s Compensation Act, 1923** and **Employees’ State Insurance Act, 1948** ensure compensation for loss of earnings or lifetime income. However, these laws do not hold employers criminally accountable.

**Occupational Safety, Health and Working Conditions (OSHC) Code, 2020**

- Enacted to consolidate 13 existing labour laws related to safety, health, and working conditions.

### Labour Codes

- **Centre notified 4 Labour Codes**, ushering in universal social security for gig workers, gender pay parity, expanded rights and safety for women workers, statutory backing for minimum wages, and fixed-term employment.
- **Codes**: Code on Wages (2019), Industrial Relations Code (2020), Code on Social Security (2020), and the Occupational Safety, Health and Working Conditions (OSHC) Code (2020).
- Codes **replace 29 fragmented labour laws**, many dating back to **1950s**.
- Although passed between **2019 and 2020**, implementation had been **held back due to protests from trade unions**.

### Background

- **Second National Commission on Labour** recommended consolidation into broader functional codes. **Labour** is in the **Concurrent List**, requiring both **Centre and States** to frame Rules.
- The Centre published draft Rules in 2020. As of 2025, 32 States and Union Territories have pre-published draft Rules. **West Bengal** and **Lakshadweep** have not pre-published draft Rules under any Code.
- **Delhi** has pre-published draft Rules only under the **Code on Wages**. **Tamil Nadu** is yet to pre-publish draft Rules under the **Code on Social Security**.
- Wage per worker (FY23): China>MH>KN>AP>KR>GJ>India>Vietnam.

### Codification and Legal Changes

- **Code on Wages** repeals the Payment of Wages Act (1936), Minimum Wages Act (1948), Payment of Bonus Act (1965), and Equal Remuneration Act (1976).
- **Industrial Relations Code** amalgamates the Trade Unions Act (1926), Industrial Employment (Standing Orders) Act (1946), and Industrial Disputes Act (1947).
- **Code on Social Security** nullifies nine Acts, including the Employees’ Compensation Act (1923), Maternity Benefit Act (1961), and Unorganised Workers’ Social Security Act (2008).
- **OSHC Code** repeals the Factories Act (1948), Mines Act (1952), and the Inter-State Migrant Workmen Act (1979).

### Worker–Centric Provisions

- Universal minimum wages, a national floor wage, and mandatory appointment letters for all workers.
- Timely payment of wages and clarity on working hours, including a 48-hour work week.
- Gender-neutral pay, equal remuneration, and prohibition of discrimination against women and transgender persons.
- Provident Fund and State insurance coverage extended to all workers, including gig and platform workers.
- The Code on Social Security provides universal ESIC coverage without geographic restriction, streamlined EPF procedures, simplified construction cess payments, and establishes a National Social Security Fund. The **Union PF** contributions by employers and employees in excess of the statutory monthly wage ceiling of ₹15,000 are voluntary.
- The OSHWC Code strengthens safety through safety committees, free preventive health check-ups, and improved workplace standards. Women are permitted to work at night with consent and adequate safety measures.

### Compliance Simplification and Enterprise Benefits

- Shift to single registration, single licence, and single return, reducing annual compliance, especially for MSMEs.
- Uniform definition of wages reduces disputes.
- Decriminalisation of minor offences promotes trust-based compliance.

- Increased use of digital processes, including algorithm-based inspections.
- Free market advocates have argued that earlier labour laws were a hindrance to India's growth potential.

**Workforce Profile and Future of Work**

- India has **643mn workers**, among **largest and youngest workforces**.
- India is expected to contribute **66% of new global workforce entrants**.
- Between **2017–24**, **16.83 crore jobs** were created, and **unemployment declined from 6% to 3.2%**.
- **Gig and platform workers** are covered under the **Social Security Code**, with numbers projected to grow from **1 crore (2024–25)** to **2.35 crore (2029–30)**.
- India's **female labour force participation rate** stands at **32.8%**.
- **Critics** questioned whether the Codes address demands such as ₹400 per day national minimum wage, MGNREGA, Right to Health Act, urban employment guarantee, social security for unorganised workers, and ending contract labour in core government functions.

	PRE-LABOUR REFORMS	POST-LABOUR REFORMS
Formalisation of employment	No mandatory appointment letters.	Mandatory appointment letters to all workers to ensure transparency, job security, and formalisation.
Social Security Coverage	Limited social security coverage	Under the Code on Social Security, gig & platform workers will also get social security coverage
Minimum wages	Minimum wages only for scheduled industries; large sections of workers not covered	Code on Wages introduced concept of floor wage, provides workers statutory right of minimum wage payment
Preventive healthcare	No legal requirement for employers to provide free annual health check-ups to workers	Employers must provide all workers with a free annual health check-up
Timely wages	No compliance for timely payment of wages	Mandatory for employers to provide timely wages. Provides financial stability, cuts work stress and boosts overall morale of the workers
Women's workforce participation	Female employment in night shifts and certain occupations was restricted	Women to be permitted to work at night and in all types of work across all establishments, subject to their consent and required safety measures
Compliance burden	Multiple registrations, licences and returns across various labour laws	Single registration, pan-India single licence and single return

**Shram Shakti Niti, 2025**

**Why in news:** Draft **National Labour and Employment Policy** was released for **public consultation**. It proposes to make social security universal and portable, aligning with the vision of a developed India by 2047.

- **Universal and portable social security** through a universal account integrating: EPFO, ESIC, PM-JAY, e-SHRAM and State Welfare Boards.
- Implementation of the **Occupational Safety and Health Code** with: Risk-based inspections, Gender-sensitive standards and Convergence of skill schemes.
- Rooted in **India's civilisational ethos of śrama dharma** – the **dignity and moral value of work**.
- **Expected Policy Outcomes:** Universal worker registration and social security portability, Near-zero workplace fatalities, Female labour-force participation to increase to 35% by 2030, Reduction in informal jobs through digital compliance, AI-driven labour governance across all States, Creation of millions of green and decent jobs, A One Nation Integrated Workforce ecosystem.
- **Phase I (2025–27):** Institutional setup and integration of social-security systems. **Phase II (2027–30):** Nationwide rollout of universal social security accounts, skill-credit systems, and district-level Employment Facilitation Cells.
- **Phase III (Beyond 2030):** Paperless governance, predictive analytics, and continuous policy renewal.
- **Accountability and Monitoring:** Progress tracking through real-time dashboards. Creation of a Labour & Employment Policy Evaluation Index (LPEI) to benchmark States. Annual Report to be presented to Parliament.
- **Employment and labour welfare** are part of the **Concurrent List** of the Constitution.

**Financial Markets**

**Short Selling**

**Why in news:** **Short selling (shorting)** involves **selling first and buying later**. It allows **selling without owning**. The trade is completed when the seller **buys back the stock to square off** the position.

**Types of Short Selling**

- **Spot Market (Cash Segment):** **Intraday**. Must **square off trade on same day** before 3:30p.m. No carry-forward allowed
- **Futures Market:** Short positions can be **carried forward** or **rolled over**. Requires **margin money**.
- If unable to square off in time, it results in **short delivery**, a **default**. The exchange **settles through auction**, and the trader incurs a **hefty penalty**. Especially risky for **illiquid stocks** where buyers/sellers are not easily available.

**SEBI Conflict of Interest**

- SEBI has proposed **expanding the definition of family**, strengthening **disclosures**, and placing **investment restrictions** on board members under a new framework to overhaul **conflict of interest regulations**.
- SEBI formed the committee, headed by former **CVC chief Pratyush Sinha**, after allegations of violating conflict of interest rules by former SEBI chief from which she was later exonerated.

- The committee recommended creating an **Office of Ethics and Compliance**, headed by an **Executive Director-level officer**, to oversee the framework.
- **Family** to include: Any person for whom the member/employee is a **legal guardian**; Any person **related by blood or marriage** to the employee or spouse and **substantially dependent** on the employee.
- These rules will apply to **SEBI employees and board members**.
- Under the **2008 guidelines**, the definition of family was limited to **spouse and children**. The term '**relative**' will now be defined in line with the **Companies Act, 2013**, and applied to both **members and employees**.

**Reforms**

- Nominee rules vary; a person may nominate **multiple for mutual funds**, with unclear legal rights.
- India's **corporate bond market** remains **shallow, illiquid, and opaque**, despite policy focus for decades. RBI had directed NSE to develop a **secondary bond market**, but it was ignored in favour of **more profitable equity trading**.
- As a **FATF member**, India must follow **KYC norms** & ensure identification of **Ultimate Beneficial Owners**. India's current **UBO thresholds** (10% for companies, 15% for partnerships) allow for **evasion of true ownership identification**.
- **NBFCs, brokers, and margin lenders** are functioning like banks without full oversight, posing major **systemic risk**.
- To counter **cyber frauds and market manipulators**, **SEBI** is planning a **robust system in coordination with investigative agencies**. No SEBI-regulated entity can advertise with **unregistered influencers**.
- SEBI is focusing on **investor awareness**, warning against **F&O losses**.
- SEBI is pushing for **whitelisting of apps**, ensuring **only approved apps remain on platforms like Play Store**.
- A **new UPI system** is being developed so that **money can only go to verified accounts**, minimizing fraud risk.
- **SEBI mandated that SIPs** with **three consecutive failed installments** (daily, weekly, monthly, fortnightly) be marked **invalid**. For **quarterly and bi-monthly SIPs**, failure to pay for **two consecutive periods** would render them invalid. **Asset Management Companies** must process SIP cancellation **within 10 days of investor request**. SEBI instructed AMC and AMFI to start providing **transparent SIP cancellation data by April 1, 2024**.
- **SEBI** has introduced **framework for risk monitoring** and **increased position limits** for **futures and options**. SEBI's latest circular replaces the **notional value-based method** with a **delta-based method** to calculate **open interest**. The **delta-based method** weighs **open interest by price sensitivity**, making it **impossible to manipulate trades**.

**Securities Market Code Bill 2025**

- Seeks to **unify 3 laws** governing the **securities market** and was referred to the **Standing Committee on Finance**. To consolidate the **Securities Contracts (Regulation) Act, 1956, SEBI Act, 1992, and the Depositories Act, 1996**.
- The move was announced in the **Union Budget 2021-22** to provide a **modern regulatory framework for investor protection and capital mobilisation**.
- To increase **SEBI members** to **15** from the current **9**. Board will include **Chairperson, 2 Central Govt officers, 1 RBI ex-officio member, and 11 others**. At least **5 members** will be **whole-time members**, compared to **3 at present**.
- The government proposed to **decriminalise minor, procedural and technical violations** into **civil penalties**.
- The objective is to **facilitate ease of doing business** and **reduce compliance burden**.
- The Bill would bring **unlawful gains or losses** under **civil penalties**. **Criminal punishment** would be limited to **market abuse**, including **insider trading** and trading with **material non-public information**.
- The Bill mandates **disclosure of direct or indirect interests** by **Board members** to prevent **conflict of interest**.

**Cat Bonds**

- Catastrophe bonds are **hybrid insurance-cum-debt product** that **convert insurance into tradable securities** & shift **hazard risk** from countries to the **global financial market**, enabling **faster payouts** and **reduced counter-party risk**.
- **Sovereign nations** sponsor cat bonds and pay premiums; **intermediaries** like the World Bank issue the bonds.
- Investors risk losing principal in case of disaster, leading to **higher coupon rates**. Coupon rates vary: **1-2% for earthquakes**, higher for **cyclones and hurricanes**.

**Tier I & II Bonds**

Points	Tier 1 Bonds (AT1)	Tier 2 Bonds
Capital Type	Core/Going Concern (CET1 buffer)	Supplementary/Going Concern
Maturity	Perpetual, callable after 5 years	Fixed, min. 5 years with amortization
Loss Absorption	Trigger-based write-down/conversion	Subordination in liquidation
Subordination	Junior to Tier 2/deposits	Senior to Tier 1/equity
Coupon Payments	Non-cumulative, discretionary	Fixed/regular, higher yields
Liquidity	High (easy to sell)	Lower (harder to liquidate)
Security	Unsecured, no guarantee	Unsecured subordinated debt
Investor Options	No put option	No put; call after min. period

<b>CAR (India)</b>	<b>Contribution</b>	Up to 1.5–2.5% of total (RBI phase-in)	Up to 2% of total CAR
<b>Purpose</b>		Absorb losses while operating	Secondary buffer post-Tier 1

### KIIFB Masala Bond Probe

- ED has slapped a show-cause notice on **Kerala CM** in connection with alleged **FEMA violations** linked to the masala bond issued by the **Kerala Infrastructure Investment Fund Board**. It is part of the funds raised through **rupee-denominated bonds (masala bonds)**, was used to purchase land, and this action was **“specifically prohibited”**.
- The KIIFB had floated ‘**masala bond**’ in the **London Stock Exchange** and the **Singapore stock exchange** to raise funds under **external commercial borrowing**.

#### Masala Bonds:

- A bond is an instrument to borrow money. Can be floated/issued by government or company **to raise funds**.
- Since **government bonds** (referred to as G-secs in India, Treasury in the US, and Gilts in the UK) come with the sovereign’s guarantee, they are considered one of the safest investments.
- **Masala Bonds** are the rupee-denominated bonds issued to overseas buyers for raising money by the Indian corporates. The price of the bond is denominated in Indian currency.
- **International Finance Corporation, investment arm of the World Bank, named them ‘masala’,** literally meaning ‘blend of spices’, to reflect Indian culture. Earlier, for raising money from abroad, Indian corporates relied on avenues such as external commercial borrowings.
- **Challenge with ECBs:** A weakening of the rupee during the bond’s tenure can significantly increase costs at redemption or repayment. By pricing or issuing bonds in rupees, the issuer gets rid of this risk, which instead **passes on to the investor**.
- In issuance of Masala Bonds, investors pay USD amount equivalent to INR principal determined at the market exchange rate on the date of transactions undertaken for issue and servicing of the bonds.
- The 2017 directive of the RBI stated that the **minimum original maturity period** for Masala Bonds raised **upto USD 50 million** equivalent in INR per financial year should be **3 years**. For bonds raised **above USD 50 million** equivalent in INR per financial year, the minimum original maturity period should be **5 years**.
- The first Masala bond was issued by the International Finance Corporation in 2014 for infrastructure projects. In 2019, Kerala became the first state to tap into the market for Masala Bonds to raise development funds.

#### External Commercial Borrowings (ECB):

- **Commercial loans** in the form of bank loans, buyers’ credit, suppliers’ credit, securitized instruments (e.g. floating rate notes and fixed rate bonds, non-convertible, optionally convertible or partially convertible preference shares) availed of from non-resident lenders with a minimum average maturity of 3 years.
- **ECB policy** is applicable to the **Foreign Currency Convertible Bonds (FCCBs)** which are bonds issued by an **Indian company** expressed in **foreign currency**, and the **principal and interest** in respect of which is payable in **foreign currency**. They are also required to adhere to the provisions of **FEMA**.

#### FEMA:

- FEMA came in 1999 as a successor to **FERA of 1973**, with changing economic conditions post-liberalisation **to boost external trade and payments** and promote the development of the foreign exchange market in India.
- FERA was designed for an era in India marked by a shortage of foreign exchange. It was aimed at conserving forex to ensure it was utilised only in the interest of the development of the country.
- Under FEMA, offences or violations were made a civil (rather than criminal) offence. It made transactions that are part of the current account, such as travelling abroad for tourism, education, etc., a matter of right.
- Restrictions were put in place on the capital account. Director and Assistant Director of ED has the power to conduct investigations into any violations of FEMA.

### Various Bonds

Type of Bond	Description	Key Features
<b>Government Bonds</b>	Issued by the government to fund infrastructure, development, or debt refinancing.	Low risk, backed by government credit; includes Treasury Bills (short-term), Treasury Notes (mid-term), and Treasury Bonds (long-term).
<b>Corporate Bonds</b>	Issued by corporations to raise capital for operations, expansion, or debt refinancing.	Higher returns than government bonds but higher risk; interest rates depend on the issuer’s creditworthiness.
<b>Municipal Bonds</b>	Issued by local governments to fund public projects like schools, hospitals, and roads.	May offer tax exemptions but carry higher risk due to varying creditworthiness of issuers.
<b>Zero-Coupon Bonds</b>	Sold at a discount to face value and do not pay periodic interest. Investors receive full face value at maturity.	Attractive for predictable returns; no regular interest payments; suitable for long-term investments.

<b>Floating Rate Bonds</b>	Have variable interest rates that adjust periodically based on a benchmark rate.	Protect against rising interest rates; can be callable or non-callable; in India, rates are reset every six months.
<b>High-Yield Bonds</b>	Also known as junk bonds, issued by companies with low credit ratings.	Offer higher returns to compensate for higher default risk; suitable for investors willing to take on more risk.
<b>Convertible Bonds</b>	Can be converted into equity shares of the issuing company at a predetermined price.	Hybrid investment offering potential equity-like returns while maintaining bond security; fixed interest rate until conversion.
<b>Fixed-Rate Bonds</b>	Pay a constant interest rate throughout their tenure.	Provide stable income; unaffected by market interest rate fluctuations.
<b>Callable Bonds</b>	Allow issuers to redeem the bond before its maturity date.	Riskier for investors as they may lose out on higher potential returns if called early; often issued with higher coupon rates to attract buyers.
<b>Puttable Bonds</b>	Allow investors to sell the bond back to the issuer before maturity.	Offer flexibility for investors concerned about falling bond values or rising interest rates; generally trade at a premium due to added investor advantage.
<b>Tax-Free Bonds</b>	Issued by government-backed entities for specific purposes like infrastructure development.	Interest income is exempt from taxes; suitable for conservative investors seeking tax-efficient returns.
<b>Investment-Grade Bonds</b>	Issued by entities with high credit ratings (e.g., AAA-rated bonds).	Low-risk investment option with stable returns; popular among conservative investors.
<b>Climate/Green Bonds</b>	Issued specifically to fund environmentally sustainable projects like renewable energy or climate change mitigation.	Attract socially responsible investors; often backed by government or private institutions aiming for sustainability goals.
<b>Masala Bonds</b>	Rupee-denominated bonds issued by Indian entities in foreign markets to raise funds without currency risk exposure for issuers.	Denominated in INR but issued overseas; used for infrastructure projects and corporate expansion; reduces currency risk for issuers while transferring it to investors.
<b>Panda Bonds</b>	RMB-denominated bonds issued in China's domestic market by foreign entities like governments or international organizations.	Provides access to China's bond market; denominated in Chinese Renminbi; requires compliance with Chinese regulations.
<b>Samurai Bonds</b>	Yen-denominated bonds issued in Japan by non-Japanese entities to raise funds from Japanese investors.	Denominated in Japanese Yen; allows access to Japan's financial market while exposing issuers to currency risks unless hedged.
<b>ATI Bonds</b>	Additional Tier-1 bonds are perpetual debt instruments issued primarily by banks to enhance their core capital base under Basel III norms, allowing them to absorb losses during financial stress.	High risk due to potential loss absorption and coupon cancellation; no fixed maturity date but often include a call option; can defer or skip coupon payments; subordinate to other debt but senior only to equity in liquidation scenarios.

### Qualified Institutional Placement

**Why in news:** SBI has launched its **qualified institutional placement (QIP)** of up to **Rs 25,000 crore**.

- QIP is a capital raising instrument used by listed companies to raise funds by issuing equity shares to qualified institutional buyers. **QIBs** include **venture capital funds, pension funds and mutual funds**.
- A **listed company trades its securities on a stock exchange** and is **regulated by SEBI**.

### Domestic r/t FPI

- India's capital markets are witnessing a **structural shift** as **domestic household savings replace FPI money**, reducing exposure to volatile global capital but raising concerns about preparedness of new retail investors.
- **FPI ownership has fallen to a 15-month low**, while **domestic mutual funds and retail investors now own nearly 19% of the equity market**, making domestic savers the key stabilising force.
- This shift gives **RBI greater monetary policy flexibility**, with reduced pressure to defend the rupee and more room to manage the growth-inflation trade-off.
- However, **high IPO valuations and the "performance problem" in active fund management** raise risks for retail investors, potentially worsening **wealth inequality and undermining inclusive growth**.

### Gold ETF

- **Surging gold prices, geopolitical tensions, increased purchases by global central banks, and tariff-related uncertainties** have drawn investors towards **gold ETFs**.
- **Gold ETFs** are ETFs with **gold as the underlying asset**, allowing investors to hold gold **electronically** instead of physically. They offer safety since there are **no risks of theft or purity issues**.
- Investors prefer gold ETFs for **better liquidity, transparency, and global price alignment**. Earlier, gold ETFs were taxed as per **individual tax slabs**. Now, **LTCG** on gold ETFs held for over **12 months** are taxed at **12.5%**.
- An **ETF (exchange traded fund)** is a marketable security that tracks an **index, commodity, bonds, or a basket of assets** like an index fund. Unlike regular MFs, an **ETF trades like a common stock** on a stock exchange.
- The traded price of an ETF **changes throughout the day** as it is bought and sold on the exchange.
- The trading value of an ETF is based on the **net asset value (NAV)** of its underlying stocks.
- ETFs typically offer **higher daily liquidity** and **lower fees** than mutual fund schemes.
- ETFs are considered **more tax efficient** compared to other mutual fund schemes.
- There are **five types of ETFs**: equity ETF, bonds ETF, commodity ETF, international ETF, and sectoral/thematic ETF.

### SEBI Intraday Regulations

**Why in news:** SEBI has introduced a **new framework** for monitoring **intraday positions** in **equity index derivatives**.

- **Net intraday position** capped at ₹5,000 crore per entity in index options (earlier ₹1,500 crore end-of-day limit).
- **Gross intraday position** restricted at ₹10,000 crore, same as the existing end-of-day limit.
- The restriction applies **separately to long and short positions**. Framework is **effective from October 1**.
- **Objective:** Facilitate market-making activity on all trading days and prevent outsized intraday positions on expiry day for orderly trading. **Applicability:** restricted only to index options, which dominate the derivatives market.
- In simple terms, SEBI's new rule oversees **large trading positions of individual entities during the day**.

### US Treasury Securities

**Why in news:** Ahead of US's 50% tariff on Indian imports, **India reduced its exposure to US Treasury Bills (T-bills)** over the past year. This marks a cautious shift in the RBI's foreign exchange reserve strategy.

- India ranks 10th-largest investor in US Treasury Bills. Analysts note that the **US can freeze or restrict access** to Treasury securities in exceptional geopolitical or national security cases. After Russia's invasion of Ukraine, **US blocked Russia's access**.
- **RBI's gold** held abroad fell. Gold held domestically rose sharply. This shows the RBI's dual approach of diversification and liquidity maintenance.
- Treasuries, backed by the US government, are part of the world's largest and most active bond market. Investments in T-bills and government bonds are in **highly rated sovereign, central bank, and supranational debt**.
- With **foreign exchange reserves hitting record highs in 2025**, **RBI aims to balance** liquidity, security, and returns by spreading investments across sovereign debt, supranational bonds, deposits, and gold.
- The US remains the largest destination for **India's reserve investments**. RBI also holds high-rated government securities from **Japan, Germany, France, and the UK**. A portion of reserves is invested in bonds issued by multilateral institutions like the **World Bank, IMF, and ADB**. Other allocations include **deposits with central banks** and the **Bank for International Settlements (BIS)**, along with **physical gold**.
- This diversification ensures India's reserves are not overly dependent on a single asset class or geography.
- **Japan is the largest investor in US Treasury securities**. The **UK** and **China** follow.

### Securities Transaction Tax

**Why in news:** SC decided to examine a plea challenging the **constitutional validity** of **(STT, a direct tax levied on securities transactions under the Finance Act, 2004**.

- **Double taxation** is a key point raised: stock market traders pay **capital gains tax** on profits and also have to pay **STT** on the same transaction. **STT** is unique in India as it is imposed on the **act of carrying out a profession**, regardless of whether a **profit** is made, making it almost **punitive**.
- **STT** was introduced in 2004 to combat **tax evasion** in the stock market, similar to **TDS** for salaried individuals.
- However, **TDS** is refunded or adjusted at the end of the year, but **STT** has no such provision.

### Small Savings Scheme

**Why in news:** **Small Savings Schemes**, also known as **Post Office Savings Schemes**.

- **Interest rates** are set by the government quarterly. For the current quarter, the rates remain unchanged. This means it is **beneficial to investors**. The **basis for fixing rates** is that the interest rate will be **aligned with G-Sec rates** of similar maturity with a **spread i.e. mark-up**.

### Mutual Funds Regulations

**Why in news:** SEBI has proposed **major changes** to **mutual fund regulations** to **reduce investor costs** and **simplify rules**.

- Proposals **remove old rules, simplify language, and rationalise fee structures.**
- SEBI noted that **numerous amendments over 29 years** have made MF regulations **voluminous and complex.**
- SEBI has therefore undertaken a **comprehensive review** of MF regulations. As part of efforts to make MF schemes **cheaper for investors**, SEBI has **removed additional expense of 0.05%** charged by AMCs over **exit load.**

### Official Action Indicated (OAI)

- Shares of **Sun Pharmaceutical Industries** closed **2.77% lower** after the **U.S.** classified the company's facility in **Baska, Gujarat**, as **OAI**. **OAI status** implies **regulatory and/or administrative actions are recommended.**
- **OAI** is one of **three classifications** the U.S. FDA issues post facility inspection. **Voluntary Action Indicated** means objectionable conditions or practices were found but the agency is not prepared to take action. **No Action Indicated** means no objectionable conditions or practices were found during inspection.

### Financial Conditions Index

- Why in news:** In a bid to **enhance real-time monitoring** of the country's **financial health**, a recent **RBI study** has proposed the construction of a **Financial Conditions Index (FCI)** for India with **daily frequency.**
- The proposed **FCI** would serve as a **composite indicator** capturing conditions across the **money market, G-sec, corporate bonds, equities, and the foreign exchange market.**
  - The index aims to provide a **high-frequency gauge** of how **tight or easy financial market conditions are**, relative to their **historical average since 2012.**

### Insolvency and Bankruptcy Code (IBC)

**Why in news:** In **2016**, the **IBC** introduced a **time-bound, creditor-in-control framework** to streamline corporate insolvency and reduce delays, with a **maximum resolution period of 330 days.**

- The **RBI's 2024 report** notes IBC accounted for **48% of total bank recoveries** in FY 2023–24.
- NCLT and NCLAT face a dual burden of corporate insolvencies and cases under Companies Act. NCLT's structure, based on Eradi Committee recommendations from 1999, is outdated for current economic demands. NCLT has a sanctioned strength of 63 members.

#### About NCLT:

- It comes under the **Ministry of Corporate Affairs (MCA).**
- It is a **quasi-judicial body** in India, established in **2016**, under **Section 408 of the Companies Act, 2013.**
- Its creation was based on the recommendations of the **Justice Eradi Committee** and aimed to streamline **corporate dispute resolution.** The principal bench is in New Delhi. It serves as the **primary adjudicating authority** for insolvency cases under the Insolvency and Bankruptcy Code (**IBC**), **2016**, determining whether to revive or liquidate companies.
- You can **appeal an NCLAT decision to the Supreme Court of India** on a point of law.

## Resources, Minerals and Energy

### Energy and Efficiency

**Why in news:** India's **peak power deficit rose** from 0.69% (FY20) to about 5% (FY24) as new fossil-fuel-based production is time-consuming, and renewable integration poses challenges.

- **Enhancing energy efficiency holistically** is **quickest and least expensive way** to tackle rising power demand. **UJALA scheme**, launched a decade ago, reduced **cost of LED bulbs.** UJALA included the **Street Lighting National Programme**, leading to 1.34 crore LED installations and peak demand reduction. LED bulbs consume half the power of CFLs and one-ninth that of incandescent bulbs.
- Following the **Energy Conservation Act, 2001**, India adopted further efficiency measures across sectors.
- According to the **International Energy Agency**, energy efficiency (2000–2018) helped **avoid 15% energy demand and 300 Mt of CO<sub>2</sub> emissions.** Rising urbanisation and cooling needs have pushed **India's peak power demand to 250 GW**, making it the **third-largest power consumer** after **China and the U.S.**
- **70% of India's energy still comes from coal**, with plans to add **another 90 GW of coal capacity by 2032.**

### Clean Energy Share

**Why in news:** **50% of its total installed electricity capacity (484 GW)** is from **non-fossil fuel sources.** However, public data shows that clean energy contributes less than 30% to the actual electricity generated and supplied.

- Experts attribute the gap between installed capacity and actual usage to the **lower Capacity Utilisation Factor** of renewables. Solar CUF is ~20%, wind is 25–30%, while coal is 60% and nuclear is 80%.

### Investor-friendly

To simplify MF regulations which have become voluminous and complex over the years, SEBI has made a number of proposals

■ Additional expense of 0.05% charged by AMCs over exit load be done away with

■ First two slabs of the expense ratio of open-ended active schemes be revised upwards by 5 bps



■ Brokerage charges be slashed to 0.02% from 0.12% in cash market and to 0.01% from 0.05% in the derivatives market

- **Hybrid projects** combining solar, wind, hydro, and storage are recommended to meet peak and round-the-clock power demand.
- **Energy Transition Index 2024**, released by WEF, ranked 120 countries on progress toward a sustainable, affordable, and secure energy future. India ranked 63rd out of 120 countries in 2024 Global Energy Transition Index, improving from 67th in 2023.
- India added **31.25GW** of renewable energy, including 24.28 GW of solar power, in the current financial year alone.
- It took nearly 70 years to reach milestone of 1 Terawatt of power from renewable sources. **2nd Terawatt capacity in renewable energy sector** was achieved in just **two years**. **Between 2022–24 alone, India contributed 46 GW to global solar additions**, becoming the third-largest contributor.

Top 5 Countries:				
Rank	Country	ETI Score'24	System Performance'24	Transition Readiness'24
1	Sweden	78.4	79.4	76.8
2	Denmark	75.2	72.0	80.1
3	Finland	74.5	76.2	69.1
4	Switzerland	73.4	71.1	62.2
5	France	71.1	74.7	65.6

Bottom 5 Countries:				
Rank	Country	ETI Score'24	System Performance'24	Transition Readiness'24
115	Botswana	45.6	54.3	32.7
116	Mongolia	45.4	55.3	30.5
117	Mozambique	45.3	57.0	27.8
118	Tanzania	44.3	49.7	36.1
119	Yemen.	43.8	55.1	26.8
120	Democratic Republic of Congo	42.0	53.7	24.4

Installed Capacity	Thermal	Non-fossil fuel			Grand Total	Non-fossil fuel share (%)
		Nuclear	Large hydro	Renewables*		
June 2015	191.26	5.78	42	35.78	274.82	30.4
June 2020	230.9	6.78	45.7	87.67	371.05	37.8
June 2025	242.04	8.78	49.38	184.62	484.82	50.1

- **Odisha is emerging as renewable energy hub** with 3.1 GW renewable energy capacity and 34% clean share in the power mix. **Projected thermal power requirement is expected to grow to 307GW by 2035.**
- India holds the world's **fifth-largest coal reserves** and is the **second largest consumer of coal.**

**Grid Emission Factor**

- India's **Grid Emission Factor (GEF)** — measuring carbon intensity of electricity has **increased** from 0.703 tCO<sub>2</sub>/MWh in 2020–21 to 0.727 tCO<sub>2</sub>/MWh in 2023–24. This rise indicates that **India's electricity grid is becoming more carbon-intensive**, even with more renewables in the mix.

- While renewables form a large share of **installed capacity**, they **generate less electricity annually** compared to **coal or nuclear plants**. Solar and wind plants typically operate at 15–25% capacity utilisation, whereas coal and nuclear operate at 65–90%. In **2023–24, renewables (including hydro) supplied only 22% of total electricity.**
- **Energy efficiency** offers a key solution by reducing demand before supply needs to increase. Improving energy efficiency helps lower peak demand (especially at night), thereby reducing reliance on coal-fired power.
- **Central Electricity Authority's National Electricity Plan** projects India's GEF to fall to 0.548 by 2026–27 and 0.430 by 2031–32. India has reduced emissions intensity by 33% between 2005 and 2019, as per its Fourth Biennial Update Report to the UNFCCC.

- **Union Minister of Coal and Mines** launched the **Koyla Shakti Dashboard** and the **Coal Land Acquisition, Management, and Payment (CLAMP) Portal.**
- **Koyla Shakti** enables **real-time monitoring of coal movement** through rail, road, and multimodal systems, facilitating **data-driven decision-making** and **predictive analytics** for **demand forecasting and logistics planning.**
- The **CLAMP Portal** is a **unified digital solution** to streamline **land acquisition, compensation, and rehabilitation & resettlement (R&R)** processes in the **coal sector.**

**Oil and Gas**

- India is now the **3rd largest energy and oil consumer**, **4th largest refiner**, and **4th largest LNG importer.**
- By 2047, India's **energy demand is expected to grow 2.5 times**, contributing **25% of global incremental demand.**
- **Exploration acreage** doubled to **16%**, targeting **1 million sq km** by 2030.
- 'No-Go' areas reduced by **99%**, with streamlined **OALP rounds** and pricing incentives.
- **New gas pricing mechanism** pegs rates to 10% of Indian crude basket, with 20% premium for new wells.
- **Ethanol blending** rose from **1.5% (2013) to 19.7% (2025).**
- **SATAT** (Sustainable Alternative Towards Affordable Transportation) operationalised 100+ CBG (Compressed Bio Gas) plants, targeting **5% blending mandate by 2028.**
- **Gas pipeline network** spans 25,000 km; target: **33,000 km by 2030.** Gas included in **'No Cut' category**, ensuring stable supply for transport and domestic use.
- **Oilfields (Regulation & Development) Amendment Act 2024** enabled **hybrid leases** for renewables and hydrocarbons. **Discovered small fields (DSF)** brought under simplified contracts to unlock marginal reserves. Under **PM Gati Shakti**, over **1 lakh assets and pipelines mapped** digitally.

### Oil-Gas Imports – Solutions

**Why in news:** India's energy security is at a critical juncture with rising reliance on imported crude oil and natural gas, comprising over 85% and 50% of its needs respectively.

- Crude oil and natural gas imports accounted for nearly \$170 billion, or 25% of India's total merchandise imports.
- This substantial outflow of foreign exchange puts pressure on the rupee, increases the trade deficit, and affects macroeconomic stability. Despite the push for renewables, fossil fuels still meet over 80% of global energy demand, with hydrocarbons powering more than 90% of transport.

#### Import Basket

- Before 2005, over 70% of the crude oil came from Saudi Arabia, Iraq, Iran, Kuwait and UAE. From 2005 to 2015, crude oil supplies broadened to include Nigeria and Angola in Africa and Venezuela in South America.
- Iran's share in India's crude basket dropped to 0 by 2020.
- Russia accounted for less than 2% of India's crude oil imports in 2021-22. It stood at 35.8% in 2024-25.

#### Solutions

- **Coal Gasification:** Leveraging India's 150bn tonnes of coal with advances in gasification and carbon capture.
- **Biofuels:** Expanding ethanol blending and compressed biogas (CBG) production through schemes like SATAT.
- India has successfully reduced dependency on West Asia for crude oil, with imports from the region now under 45%, a shift reflecting long-term strategy.

### Global Oil Dynamics

**Why in news:** Crude remains the world's most valued commodity, with 100 mbpd produced and daily global trade exceeding \$3 billion.

- Supply boost due to shale, horizontal drilling, and ultra-deep shelf drilling.
- IMF WEO: global economy "in Flux, Prospects Remain Dim", with growth slowing to 3.2% (2025) and 3.1% (2026); world trade growth at 2.9% (2025-26). These indicators point to downside risks to oil prices.
- India's oil imports (2024-25): \$137 billion; every \$1 decline in oil price improves CAD by \$1.6 billion.
- **Benefits include:** Lower subsidy burden, Reduced inflation, Improved fiscal balance as government retains most gains, Enhanced capital expenditure and growth momentum.

### Ethanol Blending

**Why in news:** Debate on ethanol blending in petrol resurfaces due to concerns over food security, vehicle compatibility, and consumer choice in India.

- Ethanol (ethyl alcohol) is a biofuel derived from biomass, used as an oxygenate in petrol to improve combustion.
- **Sources:** C-heavy molasses (28-32%), B-heavy molasses (48-52%), sugarcane juice/syrup/sugar, damaged grains like broken rice/maize, and lignocellulosic biomass.
- **Process:** Fermentation of sugars → ethanol + CO<sub>2</sub> (via invertase and zymase enzymes).
- Lower calorific value than petrol → less energy per litre. Higher octane number than petrol → better knock resistance.
- Ethanol blending began after the 1970s oil shock. Promoted as carbon neutral.
- **India's Case:** Import substitution can save \$10 billion annually. Gains offset by \$10 billion fertilizer imports.

#### Technical and Vehicle Concerns

- Mileage drop from E10 → E20 is minor, becoming significant only at higher blends.
- Ethanol is hygroscopic, absorbing water → causes corrosion, rust, clogged fuel lines.
- Damages rubber/elastomer parts (pipes, tanks, injectors, filters), but not the combustion chamber.
- BS-IV/BS-VI vehicles manage better; issues limited.
- Older carbureted vehicles (pre-2020, ~95%) lack ECUs and cannot adjust to E20.
- ECU-equipped vehicles adapt air-fuel ratio and spark timing, reducing NO<sub>x</sub>, PM, CO emissions. For E20, engines may need spark timing advanced by 2-3°. Government: replacing rubber/gaskets is a one-time, low-cost fix.

#### Impact in India So Far

- Ethanol blending rose from 1.5% (2014) to 20% (2025).
- New vehicles (since 2023) carry E20 compatibility stickers; older ones need material replacement.
- Sugarcane is water-intensive (60-70 tonnes water/tonne), stressing aquifers in Maharashtra and other low-rainfall areas. 30% of India's land degraded (Desertification Atlas 2021).
- India adopted two ethanol-specific norms, planning E27 like Brazil.

#### Types

- **E5:** Contains 5% ethanol and 95% petrol. This was the early standard in India's blending program.
- **E10:** Contains 10% ethanol and 90% petrol. Most Indian vehicles manufactured after 2001 are compatible with E10.
- **E20:** Contains 20% ethanol and 80% petrol. India achieved nationwide rollout by 2025, five years ahead of the original 2030 target under the National Policy on Biofuels. Requires E20-compliant engines to avoid long-term damage to rubber and plastic parts. E20 is produced from sugarcane, rice, and maize.
- **E27:** Contains 27% ethanol and 73% petrol. Gov announced plans to target 27% blending by 2030.
- **E85 (Flex Fuel):** Contains 85% ethanol and 15% petrol. Used in Flex-Fuel Vehicles (FFVs), which can automatically adjust to any blend of ethanol and petrol.

- **E100:** Represents 100% pure ethanol. This is used as a standalone fuel in specially designed engines, primarily in Brazil and under trial for commercial vehicles in India.
- **Engine Health:** Higher blends (above E10) can be corrosive to older engines not designed for them. **Performance:** Ethanol has a higher octane rating (reducing engine "knock") but lower energy density, which can cause a slight (3–6%) drop in fuel mileage.

#### Butanol and ABE Biofuels

- Butanol & ABE (acetone–butanol–ethanol) mixtures are superior to ethanol as fuels.
- Produced by solventogenic **Clostridia**, capable of fermenting cellulosic & hemicellulosic substrates.
- *Clostridium beijerinckii* BA101 – a butanol tolerant, high–yield strain.

#### Biohydrogen

- **Fuel cells:** ~50% electrical efficiency, higher than most thermal technologies.
- Produced via heterotrophic acid fermentation of glucose → ABE solvents / carboxylic acids, with max yield: 4 mol H<sub>2</sub> per mol glucose. Key enzyme: Hydrogenase.
- *Clostridium* (high–yield), *Bacillus* (wastewater hydrogen), *Caldicellulosiruptor saccharolyticus* (92% theoretical yield, pulp–paper waste carbon).

#### Photosynthetic Biohydrogen

- Carbon–neutral, requires chlorophyll, water, CO<sub>2</sub>, light.
- **Cyanobacteria solutions:**
  - Spatial segregation – vegetative cells (oxygen), heterocysts (hydrogen).
  - Temporal segregation – photosynthesis (day), hydrogen evolution (night).
- Photosynthetic bacteria: can perform water–gas shift reaction at room temperature → hydrogen generation.

#### Biodiesel

- Produced by transesterification of plant & animal fat (triglycerides) with methanol + KOH catalyst.
- Novel catalysts: amorphous carbon, SiO<sub>2</sub>–ZrO<sub>2</sub>, ion exchange resins – recyclable & cleaner.
- Carbon footprint: ~55% CO<sub>2</sub> reduction, lower SO<sub>2</sub>, CO, particulates.
- Concerns: higher NO<sub>x</sub>, hydrocarbon emissions, soot mutagenicity.

#### Chemically Synthesised Liquid Fuels

- Via pyrolysis → produces syngas (CO + H<sub>2</sub>). With transition metal catalysts, syngas → liquid fuels.
- Lignocellulosic biomass use: ~90% fossil fuel emission reduction. Low SO<sub>2</sub> generation. Utilises woody low–grade land material → reduces land–use pressure.
- Challenge: High production costs → less competitive vs fossil fuels. If economical, better CO<sub>2</sub> & particulate reduction than E85 (gasoline–ethanol blend).

#### Microalgal Biodiesel

- Productivity up to 100x higher than best oilseed crops. Can be grown in pond systems using CO<sub>2</sub> from flue gas of thermal plants. Heterotrophic algae cultivation (e.g., *Chlorella protothecoides*, *Scenedesmus obliquus*) → high triglyceride accumulation using corn hydrolysate.

### Bamboo–based Ethanol

**Why in news:** PM inaugurated the **country's first bamboo–based ethanol plant** in **Golaghat district, Assam**.

- He also laid the foundation stone for a ₹7,230–crore polypropylene plant at the Numaligarh Refinery.
- Described as the **world's first to produce ethanol from green bamboo**.

### Ethanol – Cooperatives

**Why in news:** **Padma Shri Vitthalrao Vikhe Patil** pioneered the world's first cooperative sugar factory, bringing prosperity to farmers in Maharashtra, Gujarat, Karnataka, and Uttar Pradesh.

- Amit Shah urged sugar cooperatives to adopt multi–feed ethanol production using vegetable waste, corn, and rice during the non–crushing season. National Cooperative Development Corporation (NCDC) will finance these conversions, and cooperatives will be prioritised over private entities for ethanol procurement.

### Isobutanol + Diesel

**Why in news:** Transport Minister announced that the **Automotive Research Association of India** is exploring the **possibility of blending isobutanol with diesel** after **efforts to blend ethanol with diesel failed**.

- **Isobutanol** is an alcoholic compound with flammable properties, used as a solvent in industries such as painting. It can also serve as a biofuel, offering potential for emission reduction and import substitution in India's energy mix.
- **Isobutanol blends better with diesel** than ethanol, without requiring additives. It has a **higher flash point** than ethanol – making it less volatile and safer. Ethanol's low flash point was one reason it was deemed unsuitable for diesel blending. There is a **surplus of ethanol** in India; diverting part of this feedstock for **isobutanol production** could **utilise excess capacity** and **support sugar mills**.
- The India Sugar and Bio–Energy Manufacturers Association (**ISMA**) noted that ethanol supply potential exceeds **50% of the requirement** for **20% petrol blending**.
- **Feedstock:** Isobutanol can be made from sugarcane syrup, molasses, or grains – the same as ethanol.

- **Process:** Specially engineered microbes ferment natural sugars to produce isobutanol instead of ethanol. Production requires only minor retrofitting of existing ethanol plants.

#### Technical and Performance Issues

- **Miscibility:** Diesel and isobutanol may have **limited miscibility**, which can be improved by adding **biodiesel**.
- **Cetane number:** Isobutanol has a **significantly lower cetane number** than diesel, meaning **slower ignition** and **less efficient combustion**. Lower cetane can cause **diesel knock** (uneven fuel burning) and **engine damage**.
- **Safety:** A higher flash point makes isobutanol **safer to handle** compared with ethanol.
- If successful, **India would be the first country** to achieve **diesel blending with isobutanol**.

#### Blue-green Ammonia

**Why in news:** Combining blue and green ammonia production pathways provides cost and efficiency advantages.

- The **blue pathway** uses natural gas with carbon capture, while the **green pathway** uses renewable-powered electrolysis. The **hybrid** design utilizes oxygen from electrolysis in the natural gas reforming step and air as the nitrogen source. This approach **reduced the levelised cost of ammonia by 7%** compared to **standalone plants**.
- It also **cut lifecycle greenhouse gas emissions by 63%**, making the process **more sustainable and cost-effective**.

#### Extracting and Producing Nickel

**Why in news:** Nickel powers **gadgets, EVs, and green technologies**, but its extraction process is **carbon-intensive and polluting**. Producing 1 tonne of nickel can emit **20+ tonnes of CO<sub>2</sub>**. While EVs are clean in operation, battery material sourcing shifts pollution to **mining and processing sectors**.

#### New Hydrogen Plasma Method

- Uses **hydrogen plasma** instead of carbon as the reducing agent in an **electric arc furnace**.
- Hydrogen gas is converted to plasma (high-energy ions) that **rapidly reduces metal oxides**.
- The byproduct is **water (H<sub>2</sub>O)** instead of carbon dioxide (CO<sub>2</sub>).
- **Single-step, carbon-free process** that is: **18% more energy efficient**, **Cuts CO<sub>2</sub> emissions by 84%** compared to conventional methods.
- Works effectively on **laterite ores** (abundant but lower-grade). India's **Odisha Sukinda region** has significant nickel laterite deposits (0.4%–0.9% nickel). Reduces India's dependence on **imported high-grade ores**.

#### AC Temperature

**Why in news:** The Union Ministry of Power is considering restricting the temperature range of new ACs in India to **20–28 degrees Celsius** for **households, hotels, and cars**.

- In 2018, BEE issued **voluntary guidelines** to commercial establishments like **airports, hotels, malls, offices, government buildings** for optimum temperature settings. In **2020, government mandated a default setting of 24°C** for air conditioners but allowed users to change settings.
- According to **BEE estimates**, air conditioning load in India may reach **200 GW by 2030**. India's current cooling demand is about 50 GW, which is one-fifth of India's peak power demand.
- Every **1°C increase** in AC temperature setting saves **6% of electricity consumption**. Temperatures **below 18°C** are "uncomfortable" & "unhealthy" as they raise blood pressure through **vasoconstriction & sympathetic activation**. **Systolic blood pressure** rises by **6–8 mm (Hg)** at lower temperatures, raising long-term **hypertension risk**.
- Some studies suggest **16–19°C** for healthy young adults improves sleep quality. **Infants and older adults** may prefer around **19°C** due to weaker thermoregulation. **WHO's 2018 Housing and Health Guidelines** recommend **18°C minimum** for safe living-room temperature in cooler climates. **2016 longitudinal study:** people 50+ in spaces under 18°C had **higher blood pressure, lower vitamin D, poorer lung function**.

#### Copper Wire

**Why in news:** India's **copper cathode imports declined 34% y-o-y in FY25**, mainly due to a **three-month supply disruption** caused by a **QCO**.

- **Copper is a critical mineral** due to **limited domestic production** and its use in **EVs, ACs, and wind turbines**.
- India imports **30% of its copper cathode demand**. The **QCO mandates BIS certification** for both **domestic and foreign copper cathode suppliers** to sell in India. Most **Japanese producers received BIS certification only after QCO enforcement**.
- **Copper wire imports rose 17%**, mainly from **UAE**. Imports rose **despite the QCO enforced by DPIIT**.
- **Domestic copper cathode production increased 12.6% in FY25**. **Hindalco Industries Ltd produced 70%**. India was **self-sufficient in copper cathode until 2018**, when Vedanta's Tuticorin plant shut down.

#### Energy Stack

**Why in news:** The **India Energy Stack (IES)** is being proposed as a **digital public infrastructure** for the power sector, aiming to transform energy access, usage, and trading.

- Aims to integrate the **fragmented power ecosystem** — producers, grid operators, consumers, exchanges, and regulators. Enables **peer-to-peer energy trading** and **compliance with carbon offsetting**.

- In India, **electricity is a concurrent subject**.
- The **IES** will enable **unique identification, data integration, and digital system interoperability**.
- IES could foster a new **energy ecosystem** including **energy fintech, virtual power plants, and peer-to-peer trading**.
- **Prosumers** could **buy surplus energy, store in batteries, or sell rooftop solar** at peak prices.
- IES would support **decentralisation** and enable **prosumers** to manage assets **more actively and efficiently**.
- **Utility Intelligence Platform** is a key application layer of IES that would **enable integrated digital energy services**.

- Maharashtra, UP, Punjab, Gujarat, Tamil Nadu, Karnataka, Rajasthan, West Bengal, MP and Andhra Pradesh account for 70% of India's electricity consumption.
- Total installed capacity grew from **305 GW in 2015–16** to a projected **475 GW in 2024–25**.
- As of **June 2025**, India has already achieved **235.7 GW from non-fossil fuel sources**, including **226.9 GW of renewable energy** and **8.8 GW of nuclear power**. This **accounts for 49%** of the total installed power generation capacity of 475 GW. In **2017**, the per unit cost of **solar power** fell below that of **coal power**, spurring business interest in ground-mounted solar projects.
- Indian-made solar modules are **1.5–2 times more expensive** than those from **China** due to China's larger capacity, raw material control, and superior production lines.

### Building-Integrated Photovoltaics

**Why in news:** India has installed **over 17 GW** of rooftop solar (RTS) capacity. RTS is increasingly important for the **urban renewable energy transition**, but is limited by **scarce shadow-free rooftop spaces**.

- To scale further, India needs to move towards **Building-Integrated Photovoltaics**. **BIPV** integrates **solar elements** directly into the **architectural components** of buildings. Serves **dual purpose**: electricity generation & acting as **structural element**. Unlike RTS systems, BIPVs are embedded in **façades, roofs, windows, railings**.
- **Key BIPV installations include: CtrIS Datacenters, Navi Mumbai, Renewable Energy Museum, Kolkata – solar dome, Jindal Steel & Power, Odisha – large BIPV setup, Railway stations in Vijayawada and Sahibabad.**
- India's **PM Surya Ghar Muft Bijli Yojana (2024)** includes BIPV for **limited rooftop areas**.
- India aims for **300 GW solar by 2030** — this can't be met by **rooftop and ground-mounted** systems alone.
- **Perovskites** are commonly used in photovoltaic (PV) solar cells. They are called "metal-halide perovskites" as they are made of a combination of organic ions, metals, and halogens. Name "perovskite" comes from their crystal structure. Metal-halide perovskites serve as the main absorbing material or "active layer" in Perovskite Solar Cells. A thin layer of perovskite absorbs light, exciting electrons, which when extracted, generate electric power.

### Silicon PVs – Green Hydrogen

**Why in news:** **Silicon photovoltaics** are the most widely adopted renewable solution.

- Invented in **1954 by Bell Labs**, first used in satellites, later adopted globally. Current panels 18–21% reported **efficiency**, in-field 15–18%. Around 80% of global supply from **China**; India's production at **6 GW** and rising.
- Higher efficiency tech like **gallium arsenide thin-film (47%)** already demonstrated.
- Lower efficiency of silicon means **larger land area** required; land scarcity worsens challenge.

#### Costs of Green Hydrogen

- Produced via **electrolysis** using renewable electricity. Environment friendly but **energy-intensive**, needing more energy for production than its usable value. Storage and transport difficult due to **low density and leakage**.
- **Alternatives:** conversion into **green ammonia (NH<sub>3</sub>)** or **green methanol (CH<sub>3</sub>OH)** for easier transport, but reconversion requires more energy.

#### CO<sub>2</sub> Recycling and Future Technologies

- **Artificial photosynthesis (APS):** mimics natural photosynthesis using water, sunlight, CO<sub>2</sub>/N<sub>2</sub> to produce fuels.
- **Renewable Fuels of Non-Biological Origin (RFNBO):** being pursued in Europe; India must also invest.

### Revamped Distribution Sector Scheme (RDSS)

- **Installation of rooftop solar power plants** is being **expedited in Rajasthan** under RDSS to reduce transmission and distribution losses and improve power supply quality.
- **Fixing meters on transformers** has also been taken up rigorously under the RDSS.
- The Centre's nodal agency for RDSS is the **Rural Electrification Corporation (REC)**.
- The **RDSS** is aimed at **modernising power distribution** and making it more **efficient and financially stable**, with focus on smart metering, infrastructure upgrades and reforms, while funding is linked to performance targets.

### RTS

**Why in news:** Only 13.1% of the targeted 1 crore solar rooftop installations under the PM Surya Ghar Yojana achieved.

- The **PMSGY** is a Centre-led initiative aimed at encouraging households to install rooftop solar systems, with the government providing capital upfront via loans.
- **Subsidy disbursements** crossed \$1.05 billion benefiting over 16 lakh households. The **4.9 GW of installations under PMSGY** accounted for **44.5% of India's total residential rooftop capacity** as of 2025.
- The PM solar scheme incentivises only **"DCR-compliant modules"**, i.e., solar components entirely manufactured in India. These DCR-compliant modules are costlier by ₹12/watt compared to imported variants.

### Panchet Solar Issue

- **Panchet Dam** (1959) is the last of the four **multipurpose dams** built under the first phase of the **DVC**.
- The project will install **floating solar panels** on the **reservoir surface** and a **ground-mounted solar PV** system.
- This follows India's **'Panchamrit goals'** announced at **COP26, Glasgow (2021)**.
  - **Non-Fossil Capacity:** Reach 500 GW of non-fossil energy capacity by 2030.
  - **Renewable Energy:** Meet 50% of total energy requirements from renewable energy sources by 2030.
  - **Emission Reduction:** Reduce total projected carbon emissions by one billion tonnes between 2021 and 2030.
  - **Carbon Intensity Reduction:** Lower the carbon intensity of the economy by 45% by 2030, compared to 2005 levels.
  - **Net-Zero:** Achieve the target of net-zero carbon emissions by the year 2070.
- **Renewable energy projects**, especially **solar**, are **land-intensive** in a **land-scarce country** like India. Such projects are often exempted from mandatory social and environmental impact assessments.
- **48% of renewable energy project conflicts** are located on **common lands**. These **common lands** have historically been used by **indigenous communities, Dalits, and Adivasis**.

### Global Solar Expo-Rajasthan 2025

- **Organised by EQ International**, the expo served as a platform for industry leaders, policymakers, and innovators to showcase cutting-edge solar technologies.

### Solar Rise

**Why in news:** India added **24.5 GW of solar energy capacity in 2024**, becoming the **third-largest contributor globally** after **China and the US**. **UN Secretary-General's 2025 Climate Report** recognises India, alongside **Brazil and China**, as a leading developing country in scaling solar and wind energy.

- According to IRENA, if India follows a 1.5°C-aligned pathway, it could achieve 2.8% average annual GDP growth through 2050, more than double the G-20 average.
- By December 2024, India's cumulative **green, social, sustainability and sustainability-linked (GSS+)** debt issuance reached \$55.9 billion, a 186% increase since 2021, with green bonds accounting for 83%.
- **Green bond investment** crossed \$45 billion in 2025, with sustainable finance targets aiming for \$100 billion by 2030. The private sector contributed 84% of total green bond issuance.
- **Successful examples** include solar energy auctions under the Solar Park Scheme, sovereign green bonds, and SEBI-regulated social bonds channeling funds into climate action, education, and health care.

### Battery Energy Storage Systems

**Why in news:** BESS offers **grid stability** and enables better integration of renewables.

- BESS supports **peak load management, demand-supply balance**, and **decentralised energy systems**.
- By enabling **microgrids**, it ensures **clean and resilient energy access** even in remote areas.
- **Battery costs have dropped by 90%** in the past 15 years, but **regulatory, financial, and technical barriers** persist.
- India targets **500 GW non-conventional energy capacity by 2030**.
- Govt plans to install **47 GW of BESS by 2032** to support renewable deployment and grid integration. A **pilot BESS project** in Delhi by **BSES Rajdhani, IndiGrid, GEAPP** aims to create a **technical playbook** and **regulatory reforms**.

### Decade of Hydropower

**Why in news:** The **Arunachal Pradesh Cabinet** declared **2025-2035 as the 'Decade of Hydropower'**.

- Arunachal aims to harness its potential to generate **58,000 MW of electricity** through hydropower.
- **Arunachal Pradesh will receive 12% free power from each HEP, plus 1% for local area development fund** as per agreements. These projects aim to generate **19 GW of electricity**.
- Cabinet approved creation of **escrow account for effective utilisation of free power revenues**. Move aims to enable **strategic financial decisions for long-term sustainable growth and prosperity**.
- **Centre declared Siang Upper Multipurpose Project** a national project in 2008 due to its national significance. The SUMP is seen as a **counter to China's proposed 60,000 MW project on the Yarlung Tsangpo River in Tibet**.

### Geothermal Pilots

**Why in news:** India's **new national policy on geothermal energy** aims to build on interest from research firms in the US, Iceland, and Norway to test its commercial viability. Companies from Iceland and Norway are exploring R&D and pilot projects in the Gulf of Cambay, Arunachal Pradesh, and Uttarakhand.

- **Geothermal energy** taps the earth's heat from hot water springs or underground reservoirs, using steam to spin turbines, generate electricity. It is renewable and can be used for heating, cooling, greenhouses, and aquaculture.
- The **Geological Survey of India (GSI)** has mapped 381 hot springs with surface temperatures between 35°C and 89°C, which the MNRE policy seeks to support for exploration and development.
- India has an estimated **10.6 GW of geothermal potential**, which could increase with **further exploration**.
- Key **sites** include the Himalayan Geothermal Province (Uttarakhand, Himachal Pradesh, Ladakh, Jammu and Kashmir, Arunachal Pradesh), the Cambay Graben in Gujarat, and the Andaman and Nicobar Islands.
- Globally, less than **17 GW of geothermal capacity** is harnessed, led by the **US, Indonesia, and the Philippines**, while **Iceland and Norway** have pioneered **innovative technologies**.
- According to the IEA, China, the US, and India have the largest **market potential** for next-generation geothermal electricity, accounting for three-quarters of the global total. IEA estimates **India's geothermal market potential** to reach **4.2 GW by 2035** and nearly **100 GW by 2045**.

### Local Sourcing Norms

**Why in news:** As India targets **500 GW of non-fossil energy capacity by 2030**, **wind energy** is expected to contribute **one-fifth** of that goal. Only **4% of India's 1.1 TW wind potential** has been tapped.

- **MNRE** has revised the Revised List of Models & Manufacturers (**RLMM**) guidelines, mandating **local sourcing** of critical components like **blades, gearboxes, generators, and towers**.
- India has over **20 GW turbine manufacturing capacity**, but only **20% is utilised**; **blade capacity is 28 GW** and **generator capacity is 17 GW**, both underutilised.
- Wind turbines are grid-connected, data-exchanging systems & a single breach could lead to national grid failure.

### Wind Energy vs Birds

**Why in news:** In **HI 2025**, India added **3.5 GW wind capacity** (82% YoY growth), taking total to **51.3 GW**.

- India's **gross wind potential** at 150m height estimated at **1163.9 GW** (National Institute of Wind Energy).
- Thar Desert wind farms show highest bird mortality globally, including **Great Indian Bustard**.
- **Mortality rate:** Thar Desert = **1.24 birds/turbine/month** vs. earlier **0.47/year** (Kutch, Davangere).
- **Factors:** bird density, infrastructure density, configuration, geography, season.
- Thar Desert is part of the **Central Asian Flyway**, a major migratory route. **Raptors most affected. Power line collisions** also contributed to mortality.
- Global offshore wind capacity: ~83 GW. India targets 30 GW offshore wind by 2030.
- **National Offshore Wind Energy Policy** mandates EIAs, unlike other renewables. Gulf of Khambhat rapid EIA: documented 5 marine mammals (including dolphins, sharks) and one reptile.

### New Wind Energy Capacity

**Why in news:** **6 GW of new wind capacity** is expected to be added, the **highest-ever annual addition**.

- India is moving towards the goal of achieving 500 GW of renewable energy by 2030, with wind power contributing 100 GW or more. India currently has 54 GW of installed wind energy and 30 GW under implementation.
- **Tamil Nadu, Karnataka, Andhra Pradesh** together contribute almost half of India's total wind capacity of 54 GW.
- India's **wind industry has 70% local content** and under the **Atmanirbhar Wind Mission**, the goal is to increase this to 85% by 2030. GST on wind equipment has been reduced from 12% to 5%, cutting turbine cost.
- With **Approved List of Models and Manufacturers (ALMM) – wind framework**, India can meet 10% of global wind demand by 2030 and up to 20% by 2040, emerging as a global hub for turbine and component manufacturing.
- Government launched a **Viability Gap Funding scheme** for **offshore wind projects**, targeting **1 GW in the first phase – 500 MW each off Gujarat and Tamil Nadu**.

Next-gen nuclear energy solutions like SMRs offer scalable options for India's industrial and urban power demand growth, says a Rockefeller Foundation report

#### Nuclear power plants in India

**CURRENT:** 8 GW operational capacity, 5 GW in construction

**TARGET:** 100 GW by 2047

#### What nuclear could achieve by 2050

**168-328 GW:** Nuclear capacity under modelled scenarios

**13-28%:** Electricity generated via Small Modular Reactors (SMRs)

**10-21%:** Cost reduction if nuclear capacity is merged with renewable expansion

According to the report titled 'The Role of Nuclear Energy in Powering Universal Energy Abundance for Emerging Economies', India could achieve nuclear capacity of

**160 GW:** At 10 GW/year

**320 GW:** At 20 GW/year (15 GW after 2030)

**India's electricity demand growth projections**

**2025-2050:** 1,811 TWh per year – 7,250.7 TWh per year; **Annual growth rate:** 5.3%

SOURCE: BAYESIAN ENERGY/RADIANT ENERGY GROUP/THE ROCKEFELLER FOUNDATION

NOTE: \*TWH/YR: TERAWATT-HOURS PER YEAR; GW: GIGAWATT

### Nuclear Energy Targets

- Using the **correlation between HDI and per capita Final Energy Consumption (FEC)**, one can determine the **energy needed** to reach a **specific HDI**. To reach **HDI 0.9**, India will need to generate about **24,000 TWh per annum**.
- About **60%** will be used as **electricity**, and the rest to generate **hydrogen in electrolyzers**. **Hydrogen** is needed to **decarbonise** sectors such as **steel, fertilizers, and plastics**. When **alternative hydrogen processes** are developed at scale, **less electricity** will be needed.

**SMRs**

**Why in news:** Rail Vikas Nigam Ltd (RVNL) is in talks with Russia's Rosatom to build SMRs for energy needs of four mega rail projects, including the Rishikesh-Karnaprayag line.

- SMRs are advanced nuclear reactors with capacity up to 300 MW & require less installation space. Nuclear Energy Mission under Budget 2025-26 allocated Rs 20,000 crore for SMR R&D. Mission targets 5 indigenously designed and operational SMRs by 2033. India aims to achieve 100 GW nuclear power capacity by 2047 & **net zero by 2070**.

**Do you know?**

- **India's three-phase nuclear power programme** was envisioned by Dr Homi J Bhabha and Dr Vikram Sarabhai, focusing on energy security through optimal fuel use.
- **Stage 1:** Utilises Pressurised Heavy Water Reactors with natural uranium fuel, producing plutonium-239 (Pu239) and using heavy water as coolant and moderator; supplemented by imported Light Water Reactors (LWRs).
- **Stage 2:** Involves Fast Breeder Reactors like those at Kalpakkam, using plutonium-based fuel, which can breed U-233 from thorium, enhancing fuel sustainability. Reprocessing of spent fuel is essential in Stage 2 to utilise plutonium and fertile thorium efficiently.
- **Stage 3:** Based on the Thorium-U-233 (Th-U233) cycle, aiming to use U-233 in advanced thermal and fast reactors like the Advanced Heavy Water Reactor. Molten Salt Reactors are also being explored as a Stage 3 alternative, enabling long-term energy security through thorium utilisation.
- **Bihar** will be among the first states in India to get its first atomic plant under Nuclear Energy Mission. Alongside the nuclear plant, the **Centre has approved a 1,000 MW battery storage capacity project in Bihar to enhance grid stability and support renewable energy integration.**
- **COP28 'Declaration to Triple Nuclear Energy'**, IAEA-World Bank collaboration to support nuclear in developing nations.

**Private Players in Nuclear**

**Why in news:** For the first time, India's nuclear establishment has involved **private players** in a key nuclear power plant process previously handled entirely in-house.

- **Mumbai-based TEMA India** has been entrusted with **testing equipment** required for **upgrading depleted heavy water**, crucial for PHWRs. Earlier, this testing was done solely by BARC.
- The facility was **designed and built** by **TEMA India's nuclear vertical** under **technology transfer from BARC** and a **purchase order from NPCIL**.
- **TEMA India** dispatched the **first batch of tested distillation column sections** for **Unit 8 of Rawatbhata Nuclear Power Plant in Rajasthan**. **RAPP-8** is scheduled to **go critical soon**.

- **Heavy water (D<sub>2</sub>O)** is water with **deuterium** (a heavier isotope of hydrogen) instead of regular hydrogen. It is used as a **coolant and moderator** for slowing **fast-moving neutrons**, essential for **sustaining nuclear fission**.
- D<sub>2</sub>O must be **99.9% pure** for efficient functioning. Over time, it gets **contaminated with light water**, requiring the **depleted D<sub>2</sub>O** to be **upgraded back to 99.9%** using a **distillation process**.
- There are **24 operational nuclear reactors** in India with an installed capacity of **8,780 MW**.
- The immediate target is **22.4 GW of installed nuclear capacity by 2032**.

**Land Reforms**

**Why in news:** The Centre's push for **land and industrial reforms** has led to a **reduction in land wastage** and a **sharp rise in land records digitisation**. In 2020, the Centre launched the **Scheme for Special Assistance to States for Capital Investment**, offering **50-year interest-free loans**.

- While some loans were untied, a **significant portion was conditional** on implementing reforms like **road construction, digitisation, optical fibre, urban reforms, disinvestment, and monetisation**.
- **22 States reformed building bylaws** for **industrial and commercial plots**, with **18 States reducing land wastage** in factory plots to **below 30%**. Earlier, about **50% of factory land was used for parking and setbacks**.
- **90% of cadastral maps** showing **land ownership boundaries** have been digitised. **30% of land parcels** have been assigned **Unique Land Parcel Identification Numbers (ULPINs)**. **91% of Records of Rights** have been **digitised**.

**Textiles****India's Sector**

**Why in news:** Faces challenges from geopolitical tensions, fragmented supply chains, price volatility, climate change and consumer preferences.

- As **6th-largest textile exporter**, aligning with these trends enables India to **leverage the China Plus One strategy** and reduce dependency on China.
- **Regenerative (regen) farming** is conservation-based approach that restores soil health, boosts biodiversity, and sequesters atmospheric carbon to fight climate change. Unlike sustainable farming, which seeks to maintain the status

quo, regenerative farming aims to actively improve degraded resources through methods like no-till cultivation, cover cropping, and livestock integration..

- India accounts for **8.5% of global annual textile waste**; embracing **circularity** is essential to stay competitive.
- India is the second largest producer of cotton after China, accounting for 24% of global production.
- The textile and apparel industry contributes 13% to industrial production, 12% to exports, and about 2% to GDP.
- As per the Index of Industrial Production (IIP), textile manufacturing has slightly contracted over the past 10 years.
- The PLI Scheme for Textiles aims to promote MMF apparel, MMF fabrics, and technical textiles, to create 60–70 global players. The PM MITCRA Parks scheme aims to set up 7 textile parks on Greenfield/Brownfield sites.

### Quality Control Order

- The Centre has **revoked the QCO on polyester fibre and yarn, and PTA and MEG**. The decision was issued under **Section 16 of the BIS Act**. Earlier QCOs had **restricted imports** of polyester yarn, fibre, filament, and raw materials **PTA and MEG**. India faces a **shortage of PTA and MEG**, yet QCOs were introduced on them.
- These are **critical raw materials** for the **man-made fibre (MMF) sector**.
- The textile industry has urged the government **not** to impose anti-dumping duty (ADD) on **Mono Ethylene Glycol (MEG)**, a **key raw material for polyester fibre and filament production**.
- Textile industry consumes **70%–75% of locally produced Purified Terephthalic Acid (PTA) and MEG**.

### Textiles Focused Research, Assessment, Monitoring, Planning and Start-up

- Centre has approved the **Scheme** to strengthen **research, innovation, and competitiveness** in the textiles sector. The scheme will be **effective from 2025–2026 to 2030–2031** and will bring together **research, data, and innovation** to position the nation as a **global leader in sustainability, technology, and competitiveness**.
- Tex-RAMPS is designed to address **critical gaps** in research, data systems, innovation support, and capacity development. The scheme aims to create **robust data systems** including **employment assessments, supply chain mapping, and the India-size study** to facilitate **evidence-based policymaking**.
- It will strengthen **State-level planning** and aid in dissemination of **best practices, capacity-building workshops, and organisation of sectoral events**. **Incubators, hackathons, and academia-industry collaborations** will be supported to nurture **high-value textile start-ups** and entrepreneurship.

### National Technical Textiles Mission (NTTM)

- Introduced by **Ministry of Textiles** in **2020**. Ending in **March 2026**, will likely be **extended by two years**.
- **4 components**: research, innovation and development, market development, export promotion, education–training.
- Its primary goal is to position India as a global leader in technical textiles—functional fabrics used for their performance rather than aesthetics (e.g., medical masks, bulletproof vests, agrotech or geotextiles).

### National Handloom Day

- 10th National Handloom Day was celebrated on August 7, 2024. The date commemorates the **1905 Swadeshi Movement**, which championed indigenous industries and hand-woven textiles.
- **VIRAASAT Exhibition**: A special fortnight-long exhibition titled "Viraasat" was organized at Handloom Haat, Janpath, featuring hand-woven masterpieces from across India. **E-Commerce Integration**: The India Handmade portal was further promoted to provide weavers direct market access, bypassing middlemen.
- **Bhartiya Vastra Evam Shilpa Kosh**: The 10th anniversary saw expanded updates to this National Repository of Indian Textiles and Crafts, which documents over 200,000 craft items for designers and researchers.

## Infrastructure – Telecom & Power

### Starlink

**Why in news:** Elon Musk's Starlink has received a **licence for providing satellite internet services in India**.

- Starlink is **3rd company** after **Eutelsat OneWeb & Jio Satellite Communications** to get licence from **Department of Telecommunications** for satellite internet services in India. **Amazon's Kuiper (4th)**, is still **awaiting approvals**.
- Starlink received authorisation to operate its **broadband satellite constellation** over **India** from **IN-SPACE**. **IN-SPACE** functions under the **Department of Space**. This is the **second major approval** for Starlink in India after **GMPCS authorisation** from the **DoT**. Starlink could provide internet where mobile connection is unavailable.

### Satellite Internet Service Rules

**Why in news:** Department of Telecommunications issued **amendments to the Unified Licence (UL) and GMPCS authorisation**, which satellite internet services require to operate in India.

- New rules include **enabling surveillance of users' web traffic**, similar to existing norms for telecom and broadband operators. **Satellite terminals sold abroad must be disabled on Indian soil**, and **India-purchased terminals must be disabled abroad**. Terminals used in India **must be manufactured domestically within 5 years**.
- Introduced **geofencing requirements** to prevent cross-border signal spillover and enhance surveillance capabilities.
- **Global Mobile Personal Communications by Satellite** is a license enabling mobile communication via satellite, especially in remote areas. It ensures network control localization and security monitoring near borders.
- **Geofencing** is a location-based technology that creates a virtual geographic boundary triggering alerts or actions when a device enters or exits the zone. Geofencing has been used by the government for monitoring quarantine compliance during COVID-19 and in applications like security and marketing.

### Telecom Policy Draft

**Why in news:** The government will soon release a **new National Telecom Policy**, seven years after the last one.

- The vision is to create a **"telecom product nation"** driven by **innovation**, connecting citizens **meaningfully**.
- The policy aims to **reduce the telecom sector's carbon footprint by 30%** and improve **cybersecurity**. Targets include **90% population coverage with 5G by 2030** and **100% with 4G**, and increasing **fiber-connected towers from 46% to 80%**. Plans call for **1 million Wi-Fi hotspots** and promotion of **satellite internet** in underserved areas.
- The draft pushes **local R&D in telecom** and aims for **150% growth in domestic manufacturing by 2030**.
- **AI use in telecom** is encouraged for **cybersecurity** and **complaint resolution**.
- Policy adds a **"circular economy"** focus by promoting **recycling of telecom equipment materials** for sustainability.

### Regulatory Assets

**Why in news:** SC directed **State Electricity Regulatory Commissions** and **DISCOMs** to clear existing regulatory assets in **4 years** and cap them at **3%** of **ARR**, while mandating **intensive audits** and **transparent recovery roadmaps**.

- **Regulatory assets** represent the **unrecoverable revenue gap** between **Average Cost of Supply (ACS)** and **ARR**. When **ACS > ARR**, DISCOMs incur losses per unit sold, which are deferred and recovered from consumers in the future, often with added **interest**.
- **Contributing factors:** Non-cost reflective tariffs, Delays in subsidies, Fuel price hikes.
- Consumers face higher tariffs due to deferred recovery of costs. **Interest charges** on regulatory assets further increase the burden on consumers. **DISCOMs** face **cash flow pressures** and often borrow to cover the shortfall, increasing their **debt burden**. **Financial distress** limits investment in: grid modernization, renewable etc.

### Internet Access

- **SDG Target 4.4.1:** Share of population with basic ICT skills. **SDG Target 4.4.2:** Share of population with proficiency in digital skills. **Broadband Penetration National average:**
  - 76.3% households with broadband. (**Rural:** 71.2%; **Urban:** 86.5%).
  - States with **>90% connectivity:** Delhi, Goa, Mizoram, Manipur, Sikkim, Haryana, Himachal Pradesh.
  - States with **<70% connectivity:** WB (69.3%), Andhra Pradesh (66.5%), Odisha (65.3%), Arunachal Pradesh (60.2%).
- **Mobile ownership:** 94.2% rural, 97.1% urban households.
- **4G usage:** >50% rural, >70% urban. **Non-4G tech (2G/3G):** 40.4% population. **5G usage:** Negligible across India.

### Digital Skill Proficiency (15+ Age Group)

- **Internet use:** 53.6% rural, 74% urban. **Online banking:** Only 37.8% can perform transactions.
- **PM-WANI (Prime Minister's Wi-Fi Access Network Interface)** is a national framework launched by DoT to democratize internet access through a decentralized network of public Wi-Fi hotspots.
- Over 4.08 lakh Wi-Fi hotspots had been set up across India. Initiatives for 2026 aim **to integrate PM-WANI with BharatNet**. TRAI has set a limit on what ISPs can charge PDOs for broadband plans up to 200 Mbps.

## Infrastructure- Railways

### Aizawl Rail Link

**Why in news:** Aizawl, Mizoram, has been linked to the **national railway network** via the **Bairabi-Sairang line**.

- **Bairabi**, located in **Kolasib** near Assam, was previously Mizoram's only railhead; **Sairang** is a satellite town **20 km from Aizawl**. **Bairabi-Sairang New Line** spans **51.38 km**. Mizoram becomes the **fourth NE state** with its capital connected by rail, after **Assam, Tripura, and Arunachal Pradesh**.
- It is divided into four sections; the Bairabi-Hortoki, Hortoki-Kawnpui, Kawnpui-Mualkhang, & Mualkhang-Sairang.
- It includes **India's tallest pier bridge** (Bridge 144) with a height of 105-114 metres, taller than the Qutub Minar.



- **Technically, the line is Mizoram's 2nd railway connection**, but it is officially celebrated as the state's "first" because it provides first direct link to capital, Aizawl, and integrates the state fully into the national broad-gauge network

**Kashmir Rail Link**

**Why in news:** PM inaugurated **Srinagar–Jammu–Delhi link**, marking **1st-ever all-weather rail connectivity** for Kashmir.

- The **Udhampur–Srinagar–Baramulla Rail Link (USBRL)** project is now **fully operational**. USBRL has been under construction for **28 years**, overcoming extreme Himalayan terrain to achieve completion.

**272 KM | 4 SECTIONS | 943 BRIDGES | 36 TUNNELS**

	Udhampur-Katra	Katra-Banihal	Banihal-Qazigund	Qazigund-Baramulla
Route Length	25 km	111 km	18 km	118 km
Bridges	50	49	33	811
Total length	1,488 m	7,035 m	275 m	4,210 m
Highest	85 m	359 m	15.75 m	22 m
Longest	154 m	467 m	45.7 m	45 m
Tunnels*	10	25	1	0
Total length	11 km	97 km	11.21 km	0
Longest	3.15 km	12.77 km	11.21 km	—

**ICONIC BRIDGES**

- **CHENAB BRIDGE** (above), the highest railway arch bridge in the world, soars 359 metres above the Chenab riverbed, its central arch spanning 467 metres.
- 29,880 TONNES of structural steel went into its construction.
- **BUILT TO WITHSTAND** earthquake forces of Zone V and wind speeds up to 266 km/hr, and to last for 120 years.
- **ANJI KHAD BRIDGE** is India's first cable-stayed railway bridge.

\*Main tunnel. Tunnels longer than 3 km have escape tunnels. Source: Indian Railways

- **Chenab bridge** is the world's highest railway arch bridge, standing 359 m above the riverbed—35 m taller than the Eiffel Tower.
- Designed by **Prof G. Madhavi Lata** (IISc), bridge remains stable even if 1 of its 8 supporting piers fails.
- It is the **only arch-shaped railway bridge in India**, with few equivalents globally (e.g. China).
- **Anji Khad Bridge:** India's **first cable-stayed railway bridge**. USBRL comprises **927 bridges**, including the Chenab and Anji Khad structures.
- A **Vande Bharat Express** service between **Srinagar and Katra** has also been flagged off.

**Amrit Bharat Station Scheme**

**Why in news:** PM inaugurated **103 redeveloped railway stations** under the **Amrit Bharat Station Scheme** including **Deshnoke in Bikaner**, near the **Pakistan border**.

- Launched in **2022**, aims to **transform**

**1,337 stations** into modern "city centres". Redeveloped stations feature modern toilets, lifts, escalators, free Wi-Fi, executive lounges, better waiting areas, and improved signage.

- The building designs **reflect local culture and heritage**, with aesthetically designed porches and landscaping.
- Most projects are being executed via **EPC model**, while 20 major stations like Pune, Delhi, Vijayawada, and Chennai Central are under **PPP mode**.

**Aabhar Online Store**

- **Indian Railways** will patronise the newly launched '**Aabhar**' online store to **promote local talent, exquisite gift items** manufactured by **indigenous tribes, handloom weavers**, and others under **One District One Product** and **GI**.
- The '**Aabhar**' online store is hosted by the **Government e-Marketplace**.
- It sources products exclusively from the **Central Cottage Industries Emporium, Khadi and Village Industries Commission**, and various **Central and State Handicraft and Handloom Emporiums**.
- The initiative is promoted under the '**Vocal for Local**' campaign to promote India's rich heritage through handlooms, handicrafts, artisanal goods & to provide market access to artisans, rural entrepreneurs, and women enterprises.
- To provide a market for local and indigenous products and create additional income opportunities for marginalised sections, the Indian Railways launched the '**One Station One Product**'. Under OSOP, artefacts made by indigenous tribes, handlooms by local weavers, and handicrafts such as chikankari are showcased across railway stations.

**DRISHTI System**

- **Railways** is planning to install **AI-based technology 'DRISHTI'** to enhance the **safety of freight trains**.
- The **AI-based Locking Monitoring System 'DRISHTI'** will reduce **traditionally manual checks** which are **time-consuming** and **impractical for long-haul rakes under dynamic conditions**.
- The technology is being developed through a **collaborative initiative** between the **Northeast Frontier Railway (NFR)** and the **IIT-Guwahati Technology Innovation and Development Foundation (IITG TIDF)**.

**Ticket Booking**

**Why in news:** The **e-ticketing system of IRCTC** is one of **India's most widely used e-commerce platforms**.

- An **anti-bot system** has been implemented, leading to the **de-activation of 2.5 crore suspect user IDs**.

- **Aadhaar verification is mandatory** immediately after booking a ticket.
- **Authorised agents are restricted from booking Tatkal tickets during the first 30 minutes** of the booking window.

### Hydrogen-powered Train

**Why in news:** Indian Railways tested its first **hydrogen-powered coach** at the **Integral Coach Factory (ICF), Chennai**.

- Supports India's mission to **reduce greenhouse gas emissions** and **increase renewable energy** share.
- **3,000-kg hydrogen facility** at **Jind** to fuel hydrogen through a 1-MW polymer electrolyte membrane (PEM) **electrolyser**. Operated as per **PESO** standards under **DPIIT**. Hydrogen will be used to **refill fuel tanks on the train**, where **fuel cells** will convert it into **electricity** to power the **train's electric motors**.
- **Electrolysis Principle:** An electrolyser splits  $H_2O$  into  $H_2$  and  $O_2$  using electricity. At the anode, oxygen is released as electrons flow through an external circuit to the cathode. PEM allows only protons to pass through, which combine with electrons at the cathode to form hydrogen gas. Membrane, typically made of fluoropolymer (like Nafion), ensures hydrogen and oxygen remain separated.
- **Fuel Cell Principle:** Inside the locomotive, the reaction is reversed. Hydrogen at the anode splits into protons and electrons. Protons pass through the membrane, while electrons flow through an external circuit, generating electric current. At the cathode, oxygen from air combines with protons and electrons to form water, the only by-product – making the process clean and emission-free.
- The **fuel cell reaction** (hydrogen + oxygen → water) is **spontaneous** and generates electricity.
- The **electrolysis reaction** (water → hydrogen + oxygen) is **non-spontaneous** and requires **electrical energy input**.

- Northern Railway zone's **hydrogen train project** has two major components: conversion of two 1600 HP diesel power cars into hydrogen fuel cell-powered traction system and setting up hydrogen fuelling facility at Jind.
- **Primary design, validation, and testing** is being undertaken by **Indian Railways' RDSO**.
- Planned operation is between **Jind & Sonapat** stations of Northern Railway in **Haryana**.
- Hydrogen trains eliminate **smoke** emissions, reduce **noise pollution**. They can operate on both **electrified and non-electrified routes**, offering **greater operational flexibility**. **Hydrail technology** is ideal for **routes where catenary electrification** (overhead wiring) is unfeasible or prone to damage and disruption. Can be **refuelled in 20–25 minutes**, which is faster than the recharge time required by battery-electric trains.

#### Hydrogen:

- Hydrogen is **lightest** element, colourless, odourless, tasteless, and highly flammable, requiring safety precautions.
- It is the **most common element** in nature but **exists only in combination** with other elements and must be extracted from compounds like water ( $H_2O$ ).
- Hydrogen is a **clean** molecule, but its extraction process is energy intensive. **Grey hydrogen** produced from fossil fuels and constitutes the bulk of current hydrogen production. **Blue hydrogen** produced from fossil fuels with carbon capture and storage. **Green hydrogen** produced using electrolyzers powered by renewable energy sources.

#### National Green Hydrogen Mission:

- Approved by the **Union Cabinet in 2023**. Supported by the **MNRE**. NGHM views Green Hydrogen as a **sunrise sector** for India. It targets building capacity to produce **at least 5 MMT per annum** of Green Hydrogen by **2030**.

### Removable Solar Panel

**Why in news:** **Varanasi** has become the **first city in India to have portable solar panels between railway tracks**.

- Banaras Locomotive Works (BLW) commissioned the indigenously-designed installation.
- **Indian Railways** has set a target to become a **Net Zero Carbon Emission Railway by 2030**.

### Green Railways

**Why in news:** The successful trial of India's first hydrogen-powered coach at the Integral Coach Factory (ICF) marks more than a technological breakthrough.

- Over 98% of the broad gauge network stands **electrified**, reducing diesel dependence. The renewable integration includes 553 MW of solar, 103 MW of wind, and 100 MW of hybrid capacity, totalling 756 MW commissioned.
- The Bureau of Energy Efficiency's "**Shunya**" **net-zero label** recognises innovations such as the first hydrogen-powered train, part of the "**Hydrogen for Heritage**" initiative to deploy 35 such units.
- Parallel measures include shifting **freight** from road to rail to raise its modal share to 45% by 2030.
- The **Indian Railway Finance Corporation (IRFC)** has played a pivotal role in mobilising climate-aligned capital, beginning with its \$500 million green bond issuance in 2017 for electric locomotive refinancing.
- Priority is to match electrification with genuinely decarbonised electricity, as a **coal-heavy grid** can dilute gains.
- If the **net-zero target is achieved by 2030**, Indian Railways could prevent over 60 million tonnes of annual  $CO_2$  emissions, equivalent to taking 13 million cars off the road.

#### Hydrogen for Heritage

- Aimed at introducing hydrogen-powered trains on scenic and culturally significant narrow-gauge and hill routes.
- Trains will use Hydrogen Fuel Cells instead of diesel engines. Green Hydrogen (produced via renewable energy) will be the fuel source. **Target:** Retrofitting/manufacturing 35 Hydrogen trains by 2024–25.
- **Initial Routes:** 8 heritage routes identified, including: Matheran, Darjeeling, Kalka–Shimla, Kangra Valley, Nilgiri.

### Metro Network

**Why in news:** India's metro train network has expanded rapidly over the past decade, growing from 248 km across 5 cities in 2014 to over 1,000 km across 23 cities by 2025.

- This growth makes **India the world's third-largest metro network**, after **China** and the **United States**.
- Delhi (394km) > Bengaluru (96 km) > Mumbai (80.2 km) > Kolkata (74 km).
- Smaller and newer metro systems in **Nagpur, Lucknow, and Pune** are also expanding.
- In 2024, **Kolkata** launched India's first underwater metro tunnel.

### Kavach

- **Indigenous anti-collision Kavach safety system commissioned** on over **2,000 km**.
- Comprises **5 major components**. It required continuous laying of **optical fibre cable (OFC)** along tracks and installation of **telecom towers**. Connected **767 stations to data centres**.
- **Trackside equipment** has been deployed along **3,413 km**. **4,154 locomotives** have been equipped with the **Kavach system**. **Stations** are being upgraded under the **Amrit Bharat Station Scheme**.
- An indigenously developed (RDSO) automatic train protection system that applies brakes automatically within specified speed limits to avert collisions if loco pilot fails to act.
- **Alternative Systems:** European ETCS Level II system could have been adopted temporarily in critical sections while Kavach matures. (European Train Control System is a radio-based train control system that provides continuous communication between the train and trackside, allowing for real-time movement authority updates and eliminating the need for traditional lineside signals in most cases). Installing Kavach costs ₹50 lakh per kilometre of track.

### Bio-plastic on Trains

- **Northeast Frontier Railway** has become **India's first railway zone** to shift to **compostable bio-plastic on trains**.
- The **ISO 17088-compliant bioplastic** used as packaging material was **developed at IIT Guwahati**.

### Rudrastra

- Railways operated "**Rudrastra**", a **long freight train** formed by combining six empty BOXN rakes at Ganjkhwaja station of Pandit Deen Dayal Upadhyay Division. **Length:** about **4.5 km** → **longest freight train of Indian Railways till date**.
- Undertaken by **DDU Division of East Central Railway** to **boost freight capacity** of Indian Railways.

## Infrastructure – Ports and Shipping

### Australia Ship

**Why in news:** An **Australian boatbuilder** launched what it described as the **world's largest electric-powered ship**.

- The **130-metre behemoth** is **capable of carrying 2,100 passengers**. Identified by boatbuilder **Incat** as **Hull 096**, the ship is an **aluminium catamaran**.

### Vizhinjam Port

**Why in news:** PM inaugurated the **Vizhinjam International Sea Port** in Kerala.

- **Vizhinjam** referred to as **Rajendra Chola Pattinam** in **1129 AD Pandya-Chola inscriptions**. Possibly the same as **Balita**, mentioned in **1st-century AD Periplus of the Erythraean Sea**. In the **1940s**, **Travancore** explored Vizhinjam's port potential; after decades, India's **first deep-water container transshipment port** has been inaugurated.
- Currently, **75% of India's transshipment cargo** is handled at **Colombo, Singapore, and Klang (Malaysia)**.
- India's **first greenfield and semi-automated port**, with a **skilled women workforce**.
- **MSC Irina**, the **world's largest container ship**, is expected to dock in **2025**.
- Infrastructure like **NH-66, Balaramapuram railway link, and Thiruvananthapuram ORR (63 km)** are crucial for port success. Proposal to rename the port as **Trivandrum International Sea Port Limited** for **global branding**.
- Union is advised to **reconsider the Colachel transshipment port**, only **40 km from Vizhinjam**, to avoid **economic duplication**. A **greenfield port policy** may be needed, akin to **airports**, preventing **new ports within 750–1000 km**.
- A **transshipment port** is where **cargo containers are transferred** from one vessel to another en route to their final destination. **India has 13 major ports and 217 non-major ports**, including private ones like **Adani's Mundra** and **Krishnapatnam**. **JNPT (Navi Mumbai)** and **Mundra Port** are India's largest container ports, each handling over 7 million containers annually.

### Maritime Development Fund

**Why in news:** **Budget 2025** launched a maritime push with **mega clusters**, a **₹25,000 crore Maritime Development Fund**, **customs duty exemptions**, and **infrastructure status for large vessels**.

- **Marine engines**, forms **15–20% of a ship's cost**, are vital for **performance, emissions, & life-cycle management**. **Over 90% of >6 MW marine engines** used in Indian ships are **imported**.

- **Maritime Development Fund** offers **long-term, low-cost financing** for **shipbuilding, repair, and maritime infrastructure**. Government will contribute **49%** of the fund, with the **rest from ports and private sector**.
- This initiative aims to **generate ₹1.5 lakh crore in investments by 2030**.
- **India ranks 2nd globally in ship recycling (2024)**, with a **33% share in 2023**, by **tonnage dismantled**. The **Alang Ship Breaking Yard** in Gujarat is a **key hub**.

**Shipping Regulations**

**Why in news:** Singapore-flagged **MV Wan Hai 503** caught fire **88 nautical miles off Kerala’s Beypore coast**. Earlier, Liberian container ship **MSC ELSA 3** sank off Kochi, Kerala.

- **International Maritime Organization (IMO)** regulates global merchant shipping & norms cover **pollution, safety, accidents, liabilities, responsibilities**; India implements them via **DG of Shipping** and domestic legislation.
- India has **not ratified** the **2004 Ballast Water Convention** and **2010 Hazardous and Noxious Substances (HNS) Convention**. HNS Convention covers liability for hazardous substances; India may consider ratification due to increasing coastal accidents. In MSC ELSA 3, India will use its merchant shipping laws to seek remedies.
- **Flags of Convenience (FOC) and Ownership:** Ships often owned in one country but registered in another for operational ease; these nations offer less intrusive scrutiny (FOC). Examples: Liberia, Marshall Islands.
- **Ship owner** liable for both cargo loss and environmental damage. **Bill of lading** governs cargo transport contracts; importer ultimately holds bill post-payment. Cargo damage claims covered by **Protection and Indemnity (P&I) Club**.
- **Polluter Pays Principle** upheld under **International Convention for the Prevention of Pollution from Ships**.
- **Nairobi Convention on Removal of Wrecks, 2007** governs salvage operations; India is a signatory. Ship owner responsible for salvage within India’s **sovereign waters (200nm)**; liable for damages **if ship cannot be refloated**.
- **Safety of Life At Sea (SOLAS)** evolved after **Titanic sinking** due to human error. SOLAS mandates sufficient **lifeboat capacity on both sides** of ships.

**Shipping Decarbonization**

**Why in news:** With global shipping aiming for **decarbonisation by 2040–2050**, India has a unique opportunity to emerge as a **green fuel hub**, supplying **green methanol and ammonia**.

- Presently, ships run on **Very Low Sulphur Fuel Oil (VLSFO), diesel, and LNG**, with **LNG** acting as a **transition fuel** before adoption of **green fuels like ammonia, e-methanol, and biofuels**.
- **Green hydrogen**, used to make green ammonia and methanol, is produced by electrolysis of water using renewable power. **Green ammonia** (hydrogen + nitrogen) is stable but requires extensive onboard changes. **Green methanol** (hydrogen + CO<sub>2</sub>) is easier to adopt and stored at ambient temperatures.
- **Green methanol costs \$1,950/tonne vs. \$560/tonne for VLSFO**. **PLI schemes** for **electrolysers** and **CCUS incentives** for CO<sub>2</sub> capture can support cost-efficient **green methanol production**. Government is creating **1.5 GW electrolyser capacity** and expanding **industrial CO<sub>2</sub> sources**, enabling **integrated fuel hubs**.

**Indian Carriage of Goods by Sea Act, 1925**

**Why in news:** Carriage of Goods by Sea Bill, 2025 was passed, repealing Indian Carriage of Goods by Sea Act, 1925.

<b>Bill Name</b>	The <b>Carriage of Goods by Sea Bill, 2024</b>
<b>Replaces</b>	<b>Indian Carriage of Goods by Sea Act, 1925</b>
<b>Existing Act Basis</b>	Based on <b>Hague Rules (1924)</b> and its amendments
<b>Scope of Existing Act</b>	Established <b>responsibilities, liabilities, rights, and immunities</b> for goods carried from a port in India to <b>another port in India or abroad</b>
<b>Bills of Lading</b>	A <b>document issued by a freight carrier to a shipper</b> containing details of <b>type, quantity, condition, and destination</b> of goods
<b>Adopted Rules</b>	<b>Hague-Visby Rules</b> (globally accepted maritime standard, followed by countries like <b>UK</b> )
<b>Expected Outcomes</b>	<b>Simplifies maritime trade laws</b> , reduces <b>litigation risks</b> , enhances <b>transparency</b> and <b>commercial efficiency</b> in cargo movement by sea

**LPG carrier Sahyadri**

**Why in news:** Shipping Ministry inducted **Sahyadri**, a **Very Large Gas Carrier (VLGC)**. Built in **South Korea**.

- **Purpose:** transport **LPG between Persian Gulf and India**, securing a **vital energy lifeline**.
- Vessel named **Sahyadri** after the **Western Ghats mountain range**.
- **Flag-hoisting ceremony** held at **Hamad Port, Qatar**, in presence of **Indian crew**.
- Second vessel to be renamed **Shivalik**, joining later this FY.

**Kaleshwaram Project**

**Why in news:** Described as Telangana’s lifeline is under controversy after barrages suffered **damages within three years** of inauguration and others developed cracks.

- Multi-purpose irrigation project on the **Godavari River at Kaleshwaram, Bhupalpally, Telangana**.
- Billed as the **world's largest multi-stage irrigation project** with a **canal network of 1,800 km**.

### Shipbuilding

**Why in news:** India, with **less than 1% share in global shipbuilding**, is **on course to be among the world's top five countries** in this sector by **2047**.

- The nation has a goal of ranking among the **top 10 maritime nations by 2030 and top 5 by 2047**.
- The maritime sector currently contributes **4% to India's GDP** and just 1% of global tonnage, with a vision to raise its share to 12% of national GDP and move from the 16th to the 5th position globally by 2047.
- Indian seafarers represent **12% of the global workforce**, with a goal to expand this to around 25%.
- The government is supporting this ambition through initiatives such as the **Shipbuilding Finance Assistance Scheme**, the **Maritime Development Fund**, **shipbuilding and repair clusters**, a **National Shipbuilding Mission**, the **Shipbreaking Credit Note Scheme**, and **upfront subsidies of up to 30% for non-conventional builds**.
- Under the **Maritime India Vision**, India is firmly on course to emerge as a global maritime superpower.
- Government has taken **unprecedented measures** including the creation of a **\$3 billion Maritime Development Fund**, with **45% earmarked for shipbuilding and ship repair** and **20% for building Indian tonnage**.

### Adani Ports

**Why in news:** **Adani Ports and Special Economic Zone (APSEZ)**, India's largest private port operator, has **banned sanctioned shipping vessels** from docking at its ports.

- The restriction includes the **Mundra Port**, which handles **nearly 10% of India's total crude oil imports**.
- **APSEZ operates 15 domestic ports and terminals**, holding a **27.8% market share**, with **6 ports on the west coast**, **5 in the south**, and **4 on the east coast**.

### New Maritime Initiatives

**Why in news:** Event, '**Samundar se Samridhi**' (**Transforming the Maritime Sector**), was jointly hosted by **Make in India**, the **Ministry of Ports, Shipping and Waterways**, the **Gujarat Government**, and the **Gujarat Maritime Board**.

- PM inaugurated the **Mumbai International Cruise Terminal at Indira Dock**, and laid the foundation stone for a new container terminal and facilities at **Syama Prasad Mookerjee Port in Kolkata**.

### Bureau of Port Security (BoPS)

- **BoPS** will be a **dedicated body** to oversee the **security of vessels and port facilities** in India. It is **modelled on the Bureau of Civil Aviation Security** & will be constituted as a **statutory body** under Merchant Shipping Act, 2025.
- Will function under the **MoPSW** & headed by a **Director General**, an **IPS officer (Pay Level-15)**.
- During the **one-year transition period**, the **DG of Shipping (DGS/DGMA)** will function as Director General, BoPS.
- **CISF** is designated as a Recognised Security Organisation (RSO) for seaport facilities. **Coastal security responsibilities** are currently shared by **Coast Guard, CISF, State maritime police**, and the **Navy**.
- The BoPS will ensure **timely analysis, collection and exchange of security-related information**. It will have a **special focus on cybersecurity**, safeguarding **port IT infrastructure** from **digital threats**.
- The Bureau will provide **regulatory oversight** relating to the **security of ships and port facilities**. It will address threats such as **maritime terrorism, arms smuggling, drug trafficking, human trafficking, poaching, illegal migration, piracy, and cybersecurity threats**.
- Will **enforce international standards**, including the International Ship and Port Facility Security (ISPS) Code.

### India's Maritime Expansion and Governance

- **Cargo handled at Indian ports** increased to 1,594 MMT in 2025. **Ship turnaround time** reduced to 48 hours.
- **Inland waterways cargo** increased to 145.5 MMT (2025). 9 Indian ports featured in the **World Bank Container Port Performance Index**. The **Maritime India Vision 2030** was launched in **2021**.
- The new legislation grants the **Union government greater authority over non-major (State-owned) ports**.

### Shipping Corporation of India (SCI)

- Government announced that the **state-owned SCI** would buy **more than 200 merchant ships** through **joint ventures**, marking a turnaround for SCI, which had been **on the verge of privatisation**.
- This marks a turnaround for a **mini-ratna** that once occupied the **commanding heights of Indian shipping**.
- SCI had a **fleet of more than 120 ships**, making it one of the **biggest ship owners in the world**.
- SCI's decline began during **LPG** in **1990s**. Under **WTO's GATS**, India committed to **Most Favoured Nation** principles for maritime carriers. Indian ships' share in **India's exim cargo** fell from **27% to 7%**.
- Funds from the **Maritime Development Fund** are being allocated for **SCI-led joint ventures**. These ventures will purchase ships with backing from **other PSUs**.

### Upgrading Shipyards

**Why in news:** The government has announced a ₹69,725 crore package to revitalise India's shipbuilding and maritime ecosystem, replacing the **2015 shipbuilding package** that expires in **March 2026**.

- The package aims to **expand India's large merchant shipbuilding capacity to 4.5 million gross tonnage**.
- Over the past **10 years, only about six small merchant ships** were built in India.

### India Maritime Week

**Why in news:** **\$5-billion Great Nicobar infrastructure project** includes a **transshipment port, power plant, and airport**.

- **4th edition of India Maritime Week 2025** by MoPSW at NESCO Exhibition Centre, Mumbai, Maharashtra. **Theme:** "Uniting Oceans, One Maritime Vision".
- Since the **inaugural India Maritime Week in 2016**, the event has **evolved into a global summit**, now featuring participation from **85 countries**.
- India's performance in the **World Bank's Logistics Performance Index** has **improved significantly**.
- The maritime sector contributes nearly **60% of India's GDP**. **Trade Volume:** The maritime sector handles 95% of India's trade by volume and 70% by value.
- The government aims to reduce **logistics costs** to single digits – around 9%, down from the current 16%. China's logistics cost is around 8% of GDP and Europe's about 12%.
- **Green Tug Programme:** Aiming for 100 eco-friendly tugs by 2040. **Digi Bandar:** A national framework launched to make all Indian ports data-driven and AI-enabled. **Green & Digital Corridors:** Agreement with the Netherlands to establish a sustainable shipping corridor connecting Indian ports with the Port of Rotterdam.
- **Sagarmanthan – The Great Oceans Dialogue:** The second edition (co-hosted with ORF) focused on blue economy and ocean governance. **Global Maritime India Summit (GMIS):** A core summit for high-level policy and investment discussions. **QUAD Ports of the Future Partnership:** High-level discussions on regional maritime security and economic cooperation.

### Maritime Amrit Kaal Vision 2047 (GMIS 2023)

- **Port Capacity:** Increase from ~2,600 MTPA to 10,000 MTPA (Million Tonnes Per Annum).
- **Shipbuilding:** Aiming for India to be among the Top 5 global shipbuilding nations (currently outside the top 10).
- **Transshipment Hubs:** Development of three major hubs: Vizhinjam (Kerala), Galathea Bay (Great Nicobar), and Kanyakumari (Tamil Nadu). **Inland Waterways:** 500 MTPA of cargo movement through National Waterways.

### Yamuna River Cruise Project

- The project aims to introduce **recreational boat cruises** and **ferry services** on the **Yamuna**.
- The **1,080-km Yamuna stretch** from **Jagatpur in Delhi** to **Prayagraj in Uttar Pradesh** has been notified as **NW-110**.

### MSC Irina

**Why in news:** **MSC Irina**, the **world's largest container vessel**, operated by **Mediterranean Shipping Company (MSC)**, reached **Vizhinjam International Seaport**.

- This marks the **first time** that **MSC Irina** is calling at a **South Asian port**.
- It is the **third Irina-class ship** to call at Vizhinjam, after **MSC Türkiye** and **MSC Michel Cappellini**.
- **Vizhinjam port** is **India's first deepwater transshipment port**. The port is managed by Adani Ports and SEZ Private Limited under a design, build, finance, operate and transfer (DBFOT) model. A **transshipment port** has terminals where cargo containers are shifted from one vessel to another before reaching their final destination.
- Located in the **Arabian Sea**, Vizhinjam lies just **10 nautical miles** from the **congested east-west international shipping lane**. Its **natural depth of 18 to 20 metres** is just **1 km from shore**, allowing **largest cargo vessels to dock without dredging**.

## Infrastructure– Roads and Highways

### Road Accidents

**Why in news:** With one of the **world's largest road networks**, India also sees one of the **highest road traffic fatalities**.

- In **2022**, India recorded **1.68 lakh road accident fatalities**, translating to **12.2 deaths per 1 lakh population**.
- **Right to safe road travel** is a part of **Right to Life (Article 21)** of the Constitution.
- By **2047**, **urban population** is expected to reach **50%** of the total population.
- The **Safe System Approach** focuses on **human vulnerability and error** in road design. It accepts that **mistakes will occur** but aims to ensure these don't lead to fatalities or serious injuries.
- **World Bank Report 2020** estimates a need for **\$109 billion investment over a decade** to reduce fatalities by **50%**.
- **Transport** accounts for **25% global energy-related CO2 emissions**, with **road transport** being largest contributor.
- **Trains** emit only **19g CO<sub>2</sub>/passenger-km**, compared to **63g for buses, 123g for aeroplanes, and 148g for cars**.
- **Continued dependence on road transport** in lower-income countries could cause a **16% rise in GHG emissions**.

from the transport sector. The EU aims to shift 30% of road freight to rail or ship by 2030, and over 50% by 2050. China has seen reduced road traffic and a cleaner environment by shifting to rail.

- **National Rail Plan** aims to increase rail freight share to **45% by 2030** via **Dedicated Freight Corridors**.
- India is the **third-largest GHG emitter**, with **14% of emissions** from transport, mostly road-based.
- In **2020, 90% of transport CO<sub>2</sub> emissions** came from **road transport**: two-wheelers (16%), cars (25%), buses (9%), freight LDVs (8%), and freight HDVs (45%).

### Road Accidents

**Why in news:** Over **1.73 lakh people were killed** and **4.47 lakh injured** in road accidents in **2023**, according to **NCRB**.

- **Two-wheeler riders** accounted for **nearly 46% of total fatalities**.
- **Speeding** and **careless driving** were the **two major causes** of road accidents.
- **Tamil Nadu** and **Uttar Pradesh** reported the **most deaths in two-wheeler accidents**.
- **Uttar Pradesh** also reported the **highest number of deaths** due to **SUV/car/jeep accidents (19.2% of total)**.
- **Cause-wise analysis** showed **58.6%** were due to **speeding** and **23.6%** due to **dangerous/careless driving or overtaking**. **National Highways** accounted for **34.6% of total deaths**, followed by **State Highways at 23.4%**.
- Top court asked States, U.T.s to frame road safety rules under **Sections 138(1A) and 210-D of the Motor Vehicles Act, 1988**. Section 138(1A) empowers States to regulate pedestrian and non-mechanical vehicle movement on public roads and national highways. **Section 210-D** mandates standards for design, construction, and maintenance of roads other than national highways.
- To identify **road defects**, **NHAI** will deploy **advanced sensors and data acquisition systems** across **23 States**, covering **over 20,000 km**. Exercise will involve deploying **vehicles equipped with advanced sensors**, including a 3D laser-based system, a GPS, and an electronic device measuring acceleration and angular velocity.
- The collected data will be uploaded on NHAI's **AI-based portal Data Lake**, where it will be **analysed by a dedicated team of experts**. **Electronic Detailed Accident Report (e-DAR)** project is a **central repository** for reporting and managing **road accidents data**.

### Actionable Intelligence for Sustainable Traffic Management

**Why in news:** To curb **traffic violations** near **educational institutions**, the **Bengaluru Traffic Police** will roll out a new feature on the **ASTraM app** to enable **college students** to **report offences** occurring around their campuses.

### FASTag

**Why in news:** **Highway Minister** announced a **FASTag-based annual pass** priced at **₹3,000** for **non-commercial private vehicles** like **cars, jeeps, and vans**. The pass will ensure **"hassle-free highway travel"**, valid from **August 15** for **one year or 200 trips**, whichever is earlier.

- **FASTag** is electronic toll collection system managed by NPCI-NHAI, launched in 2014 as pilot and made mandatory at toll plazas in 2021, uses **RFID** to automatically deduct toll from a linked bank account or prepaid wallet.
- **RFID** is a **wireless tracking system** to communicate identity or information via radio waves. RFID tags can carry encrypted data, serial numbers, and short descriptions; some high-memory tags are used in aviation. **3 types:**
  - **Passive tags** (used in FASTag): powered by **reader's electromagnetic energy**.
  - **Active tags:** have their own **battery** and transmit signals regularly. Range longer than passive tags.
  - **Semi-passive tags:** have an internal circuit with a power source but use **reader's radio waves** to respond.
- RFID tags operate at various **frequencies:** Low Frequency, High Frequency, and Ultra-High Frequency. The host computer system translates radio wave responses from tags into readable data.
- **MoRTH** will implement the **ANPR-FASTag-based Barrier-Less Tolling System** to enable **barrier-free vehicle movement** at selected toll plazas. AFS combines Automatic Number Plate Recognition (**ANPR**) technology with the existing FASTag system for toll deduction. **High-performance ANPR cameras** and **FASTag readers** will identify vehicles and **automatically charge tolls**.

### Network Survey Vehicles

- **NHAI** will deploy Network Survey Vehicles (NSVs) in 23 states, covering **20,933 km of NHs**, for **collection, processing, and analysis** of **road inventory and pavement condition data**.
- An **NSV** is a **specialised van or SUV** equipped with Laser, GPS, Video image processing tools, cameras, Inertial Measurement Units, Distance Measuring Indicator. These vehicles will collect data on the condition of NHs.
- Data will be collected for **2/4/6 and 8 lane projects** with **NSV before the start of work** and thereafter at regular intervals of six months. Data will be used for pavement maintenance, asset management, infra planning.
- **Pavement condition surveys** will be carried out using a 3D laser-based NSV system capable of automatic capture and reporting of road defects without human intervention, using high-resolution 360-degree cameras.
- **Policy guidelines on NSV surveys** have existed since **2019**, mandating surveys by the **authority's engineer and an independent engineer** before issuing **completion certificates** for new highway stretches.

- With this initiative, **NHAI** aims to **collect necessary data, process and analyse it, and upload it on the Road Asset Management System** in the **prescribed format**.

**Datalake**

- **MoRTH** has developed **RAMS (also called Datalake)** to create a **single road database for planning, budgeting, managing and maintaining the entire NH network through systematic and scientific life cycle analysis.**

**Satellite-based Tolling System**

- Government has **deferred adoption** of the **Global Navigation Satellite System** for toll collection due to **privacy concerns**. Under **GNSS**, toll collection works using **satellites** and an **on-board unit** fitted in vehicles, and toll is calculated based on the **distance travelled**.

**Additional information:**

- **RFID** is a **wireless tracking system** consisting of **tags and readers**.
- **Radio waves** are used to communicate **information or identity** to nearby readers.
- **RFID tags** can carry **encrypted information, serial numbers and short descriptions**.
- There are **high-memory RFID tags** designed for use in the **aviation industry**.
- **Types of RFID tags** include **passive tags, semi-passive tags, and active tags**.

**Toll Collection**

- **National Highways Act, 1956: Section 7** → Government may levy fees for services on highways. **Section 9** → Union government can make rules.
- **National Highways Fee Rules, 2008:** base rates fixed nationwide, not linked to cost recovery. Toll rates rise by 3% annually + 40% of WPI increase.
- **Collection models:** Publicly funded highways → Union government collects. PPP models (BoT, ToT, InvIT) → Concessionaire collects. **2008 amendment:** allowed toll collection in perpetuity; after concession period, toll goes to Consolidated Fund of India.
- Under the **amended National Highways Fee (Determination of Rates and Collection) Rules, 2008**, non-FASTag users paying through UPI will be charged 1.25 times the normal toll fee. Currently, cash payments attract double the toll fee, making the new UPI option cheaper but still higher than FASTag payments.

**Steel Truss Bridges**

**Why in news:** **Steel truss bridges** resist collapse even after major damage & have been the backbone of transport networks since the late 19th century, built from interconnected steel bars ideal for railways and highways. Famous Indian examples include **Pamban, Howrah, and Saraighat bridges**.

- The experiments revealed **six fundamental secondary resistance mechanisms:** Panel distortions, torsion of the whole structure, hinged rotations, out-of-plane bending, bridging by nearby members, and uniaxial bending.

**Infrastructure – Aviation**

**AI-171 Dreamliner**

**Why in news:** **Boeing 787-8 Dreamliner (Flight AI-171)** crashed shortly after take-off from **Ahmedabad to London**.

- Both **fuel control switches shifted to CUTOFF three seconds after take-off**, shutting down both engines. This led to **fuel starvation, loss of thrust**, and eventual **crash** of the Boeing 787-8.
- This is the **first-ever crash involving a Boeing 787 variant**.
- The accident draws parallels with **Air India Flight AI-855 ("Emperor Ashoka") in 1978**, which crashed near Bandra.
- Other incidents include **AI 182 ("Emperor Kanishka") mid-air bombing in 1985**, and **Air India Express AI 1344 skid-off in 2020**.
- Boeing 787 can fly 330 min on one engine—dual failure odds ≈ **1 in 1 bn**.

**Black Boxes:**

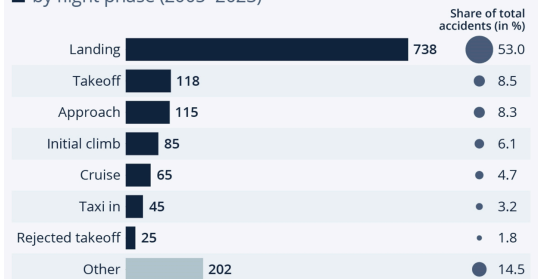
- **Black boxes**, painted bright orange, include the **Cockpit Voice Recorder (CVR)** and **Digital Flight Data Recorder (DFDR)**. They record flight parameters and audio for **post-crash reconstruction**.
- Use **solid-state memory**, are **water-resistant**, and have **locator beacons**.
- Despite **ICAO Annex 13** mandating a **30-day preliminary report**, India has **no legal deadline**. **DGCA's 360° evaluation** involves **flight operations, infrastructure, ATC, airworthiness, licensing, aerodrome standards, and training**.

**Sustainable Aviation Fuel (SAF)**

- **ATF** is a major source of carbon emissions, with aviation contributing 2.5% of global energy-related CO<sub>2</sub> emissions in 2023. The Indian government is preparing to introduce SAF blended with ATF for domestic flights.

**Most Airplane Accidents Happen During Landing**

Number of accidents in commercial civil aviation, by flight phase (2005-2023)\*



\* IATA members, accounting for 94 percent of all international flights. 2023 data up to end of June. Source: IATA

- This aligns with the mandatory phase of ICAO's CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation), effective from 2027. CORSIA applies to international flights and requires airlines to offset emission growth beyond 2020 levels.
- SAF is a biofuel made from sustainable feedstocks and is compatible with existing aircraft engines. Blending SAF with ATF allows airlines to stay within CORSIA emission limits and reduce their carbon footprint.
- Indian Oil Corporation (IOC) to start producing Sustainable Aviation Fuel (SAF) at Panipat refinery. IOC became the first company in India to receive the ISCC CORSIA certification for SAF production.
- Under NBCC (National Biofuel Coordination Committee), India has set indicative SAF blending targets for international flights: 1% blending in 2027 and 2% blending in 2028.
- Feedstock: Oils and fats, oil-rich seeds, algae oils, animal fats, Municipal Solid Waste (MSW), Agricultural & forestry residues: wood waste, sugarcane bagasse, corn stover, husks, straw, sugars & starches.

#### Montreal Convention 1999 (MC99)

- India is the third-largest domestic aviation market globally, after the US and China. Montreal Convention 1999 (MC99) is a treaty for the unification of rules governing international air carriage, finalized under ICAO.
- It provides a comprehensive legal framework for the carriage of passengers, baggage, and cargo by air, balancing the interests of travelers, cargo shippers, and the aviation industry.
- India became the 91st member of the Montreal Convention by signing it in 2009.
- In India, its provisions are implemented via the Carriage by Air (Amendment) Act, 2009, covering international carriage by airlines.

#### ICAO

- UN agency, established by the Chicago Convention of 1944 to ensure the safe and orderly growth of international civil aviation worldwide. ICAO officially came into existence on 4 April 1947, after sufficient ratifications of the Chicago Convention. The first official ICAO Assembly was held in May 1947 in Montreal.

#### Chicago Convention:

- Convention on International Civil Aviation, known as the Chicago Convention, was signed in 1944. The Convention's technical standards are overseen by ICAO. All 193 ICAO member countries, including India, the United States, and the United Kingdom, have agreed to follow its rules.
- Annex 13 of the Convention lays out the international protocols for investigating aircraft accidents and serious incidents. Chapter 5 of Annex 13 outlines the core responsibilities for conducting investigations.
- The objective of such investigations is not to assign blame or liability, but to improve aviation safety by identifying causes and preventing future accidents.

#### Bureau of Civil Aviation Security (BCAS):

- It is a regulatory authority under the Ministry of Civil Aviation responsible for civil aviation security in India.
- Formulates security standards, conducts audits & inspections, trains aviation security personnel, implements advanced security technologies at airports. Safeguards civil aviation against unlawful interference.
- **DGCA** is the statutory regulatory body for civil aviation, operating under the Ministry of Civil Aviation. It primarily oversees aviation safety, licensing, and airworthiness standards.

#### IndiGo

**Why in news: India's largest airline (65% market share). 60–70 aircraft grounded due to Pratt & Whitney engine issues. Experts: Restricting Turkish Airlines cooperation is counterproductive. Code-shares & partnerships expand reach, offer competitive fares.**

#### Flight Duty Time Limitation

- **IndiGo cancelled over 1,000 flights** following implementation of revised **FDTL rules**. However, **International flights** accounted for **less than 10% of the cancellations**, as they generate **higher revenue**.
- **DGCA** granted IndiGo **exemption** from **night duty restrictions**, including the **cap on two landings, until February 10**.

#### Evolution of FDTL Regulations

- In 2019, the DGCA introduced new rules reversing some pilot-friendly provisions of the 2011 rules. 2011 Nasim Zaidi Committee report had recommended safeguards on FDTL. After pilot bodies approached Delhi HC, revised norms were notified in 2024.

- **Revised FDTL Rules: Mandatory weekly rest period** for pilots increased from 36 hours to 48 hours. **Weekly cap on landings** between **midnight and early morning** reduced from six to two. **Maximum flying time** limited to eight hours. **Duty time** capped at 10 hours. **Restrictions imposed on pilot flying hours** for flights extending into night hours. **Personal leave** is **not counted** as part of the 48-hour weekly rest period.

#### Maintenance, Repair, and Overhaul (MRO):

- While addressing the **annual general meeting** of the **International Air Transport Association**, **PM** listed **MRO** as a **sunrise sector**. **India** is accelerating to establish a **\$4-billion MRO hub** in the country by **2030**.
- **100% FDI under automatic route**, **GST reduction**, and **tax rationalisation** have given **momentum** to the sector.
- **India** is the **world's third-largest and fastest-growing major aviation market**.

**Airport Tariff**

- In SC, **Government & Airport Economic Regulatory Authority of India** appealed TDSAT decision redefining tariff calculation. TDSAT had held that aeronautical and non-aeronautical revenue must be considered together for calculating aeronautical charges, known as the 'single-till' mechanism.
- **AERA** is a statutory body established under the AERA Act, 2008, to regulate tariffs and other charges for aeronautical services at "major" airports. It operates as an independent regulator under the Ministry of Civil Aviation.

**SAF National Policy**

- The Centre will release a national policy on Sustainable Aviation Fuel SAF, **derived from non-fossil sources**.
- **Global need for SAF was 2 million tonne** which by 2040 would rise to 183 million tonne.
- India has a **surplus** of 213 million tonne of agricultural residue along with adequate manufacturing capacity.
- To achieve **1% blending of SAF by 2027**, India will require **30 million litre**, while the **2% target for 2028** translates to **62 million litre**. Local oil makers collectively have an annual production capacity of **70 million litre**.

**Automatic Message Switching System (AMSS)**

- Air traffic at Delhi's IGI Airport was disrupted due to a technical failure in the AMSS, **the core communication backbone of ATC**, handling flight plans, NOTAMs, weather updates, and coordination messages across major Indian airports; its failure forced manual handling of 2,500+ daily aircraft movements.
- Delhi's AMSS uses **outdated message-switching software**, faces **server overload, integration issues, limited trained manpower**, and lacks modern cloud-based redundancy.

**Internet on Aeroplanes**

- **In-flight internet works by treating the aircraft as a flying Wi-Fi router**, with passengers' devices connecting to onboard Wi-Fi rather than directly to ground networks.
- **Backhaul connectivity is provided either via Air-to-Ground (ATG) towers** over land or **satellites**, with **LEO satellites** offering lower latency than older geostationary satellites. Inside the aircraft, a **local network of routers and Wi-Fi access points** distributes connectivity, with access managed through **captive portals and traffic controls**.
- **Bandwidth is limited and shared**, often resulting in slower speeds and restrictions on data-heavy services.
- **Airplane mode is required** to prevent uncontrolled cellular transmissions that could interfere with aviation systems and overload terrestrial mobile networks. **Certified in-flight internet systems are designed to avoid interference**, using regulated frequencies, shielding, and rigorous safety testing to ensure flight safety.

**Airbus A320 Aircraft**

- **Intense solar radiation** corrupted **critical flight control data** of **Airbus A320 family** aircraft.
- Required **software-hardware modification**. The **A320 family** includes **A319, A320 and A321** aircraft.

**Navi Mumbai International Airport**

- **Adding a new aviation gateway to the Mumbai Metropolitan Region (MMR)**, Navi Mumbai International Airport (NMIA), developed and operated by **Adani Airports commenced commercial flight operations**.
- This is a **greenfield airport**, established to **take the load off the existing Mumbai airport**.

**Automobile****EV Manufacturing**

**Why in news: Central Government notified guidelines** to promote **domestic manufacturing** of electric cars by reducing **import duty to 15%** (from 70–100%) for companies investing **₹4,150 crore** in India's EV manufacturing.

- The scheme, titled **Scheme to Promote Manufacturing of Electric Passenger Cars in India (SPMEPCI)**, allows up to **8,000 fully built EVs per year** to be imported at the reduced duty for **five years**, provided operations begin within **three years**. Imported EVs must have a **minimum CIF value of \$35,000** to avail the 15% customs duty.
- Manufacturers must ensure **25% Domestic Value Addition** in 3 years and **50% in 5 years**.
- **China has world's highest EV adoption rate, largest charging network, and top EV production**.
- In FY 2025, EVs made up **7.8% of India's vehicle sales**: Electric three-wheelers: **57% of category**, Electric two-wheelers: **6.1%**, Passenger vehicles: **2.6%** and Commercial vehicles: **0.9%**.
- India emerged as largest market for electric 3-wheelers in 2024, but electric passenger vehicle share remains low.
- In 2024, **Indian OEMs (Tata, Mahindra)** produced **80% of electric cars domestically**, while **Chinese EV imports** remained under **15%** due to high duties and strong local offerings.
- **Neodymium-Iron-Boron (NdFeB) magnets** are essential for **EV electric motors**, providing **strong magnetic fields** for efficient performance. Also vital for **power steering, wiper motors, and braking systems** in EVs.

- India's electric 4-wheeler manufacturing capacity is set to be 4th-largest EV manufacturer globally, after China, Europe, and the US. EV penetration in India was just 2% in 2024, compared to Vietnam's 17%.

- EVs include both pure electric vehicles and plug-in hybrid electric vehicles (with both battery and ICE).
- Key government initiatives include PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-Drive), e-AMRIT, and state-level EV subsidies.

### EV Growth – Niti Aayog

**Why in news:** The report titled 'Unlocking a \$200 Billion Opportunity: Electric Vehicles in India' said continuation of incentives alone may not help India reach the 2030 target of 30% EV sales.

- India's EV adoption is slower than China, US, and EU. Global EV penetration = 17%, while India = 7.6%.
- According to the report, India has the highest EV penetration rate in three-wheelers (16%), followed by two-wheelers (5%), buses (7%), cars (2%), and trucks (0.07%).

- **Battery EV:** Replaces ICE vehicles with a Li-ion battery, fully powered by electricity. More efficient compared to hybrids and plug-in hybrids.
- **Plug-in Hybrid EV:** Uses both ICE and a battery charged from an external socket (has a plug). The battery is charged using electricity rather than the engine. More efficient than HEVs but less efficient than BEVs.
- **Hybrid EV:** Combines internal combustion engine (usually petrol) and a battery-powered motor. The petrol engine drives the vehicle and charges the battery when empty. Less efficient than BEVs and PHEVs.
- **Fuel Cell EV:** Generates electric energy from chemical energy. Hydrogen FCEV uses hydrogen and air to generate electricity, producing heat and water as byproducts. Powered entirely by electricity, but has range and refueling processes similar to conventional cars and trucks, unlike BEVs.
- **Sodium-Ion (Na-Ion) Battery:** JNCASR (Bengaluru) has developed a super-fast charging sodium-ion battery. Can charge up to 80% in just six minutes and is expected to last over 3,000 charge cycles. Promising Alternative to Lithium-Ion Batteries. Sodium is more abundant than lithium and can be extracted from seawater at lower costs. NASICON is a class of polyanionic materials with a known structure in electrochemical materials.

### EV

**Why in news:** Cities like Cairo, Dakar, Santiago, and Bogotá are adopting cleaner public transport to reduce pollution.

- China leads global EV sales, followed by Europe and the U.S.
- Fuel Cell Electric Vehicles offer benefits like longer range, quick refuelling and are lighter than Battery Electric Vehicles. They are suited for long-distance travel, rugged terrain, and extreme cold. Fuel cell buses and trucks cost 20–30% more than BEVs.
- In 2023, EVs made up 5% of total vehicle sales in India. Electric car registrations grew by 70% against a 10% growth in overall car sales. India saw the fastest growth in the three-wheeler segment, capturing ~60% of global electric three-wheeler sales. India overtook China as the largest electric three-wheeler market.
- India ranks second globally in electric two-wheeler sales behind China. China, India, ASEAN countries dominate global two- and three-wheeler market, while other regions account for <5% of global sales in these categories.
- National Electric Mobility Mission Plan (NEMMP) 2013 had an ambitious (though unfulfilled) goal of achieving 6–7 million units of hybrid and electric vehicles on Indian roads by 2020.
- Faster Adoption and Manufacturing of Hybrid & Electric Vehicles (FAME India) scheme.
  - FAME-I (2015): Focused on Technology Development, Demand Creation, Pilot Projects, Charging Infrastructure.
  - FAME-II (2019): Shifted focus to public and shared transportation, subsidizing electric buses, three-wheelers, and two-wheelers. FAME-III (2024–2025): Expanded incentives to include heavy electric trucks and EV charging stations Ministry of Heavy Industries.

### Scheme to Promote Manufacturing of Electric Passenger Cars (SPMEPC)

- Ministry of Heavy Industries invited auto players to submit interest for the SPMEPC in India. The scheme permits automakers to import up to 8,000 EVs at a reduced duty rate of 15% (instead of 70–100%) if they commit to invest ₹4,150 crore in local EV manufacturing. The deadline for submissions ended with not a single applicant.

### China – India – WTO – EV – PLI

**Why in news:** China has filed a complaint over India's subsidies for EVs and batteries and PLI Scheme.

- China has also filed similar complaints against Türkiye, Canada, and the European Union (EU).
- China has sought consultations with India, which is the first step in the WTO dispute settlement process. If consultations do not yield a satisfactory resolution, China can request the WTO to establish a panel.
- China is India's second-largest trading partner, underscoring the economic importance of bilateral relations.
- In 2024–25, India's exports to China fell by 14.5%. However, imports from China increased by 11.52%.
- The complaint concerns three PLI schemes related to: Advanced Chemistry Cell (ACC) battery manufacturing, Automobile and Advanced Automotive Technology (AAT) products, and Electric Vehicle (EV) production.

- China claims that the PLI schemes provide financial benefits contingent upon **Domestic Value Addition**, violating WTO's non-discrimination principles amounting to **Import Substitution subsidies prohibited under WTO law**.

#### WTO Law on Subsidies

- The **Agreement on Subsidies and Countervailing Measures (SCM)** governs the use of industrial subsidies.
- **Article 1** defines a subsidy as a **financial contribution by a government that confers a specific benefit**.
- **Subsidies are classified as:**
  - **Prohibited subsidies** — export-based or import-substitution subsidies.
  - **Actionable subsidies** — permissible but challengeable if they cause trade injury.
  - **Non-actionable subsidies** — allowed under specific conditions (e.g., R&D, environmental objectives).
- Under **Article 3.1(b) of the SCM**, **import-substitution subsidies** (those contingent on using domestic over imported goods) are **prohibited** as they **distort fair trade**.
- An **IS subsidy** also breaches:
  - **Article III.4 (GATT)**: requires national treatment, prohibiting countries from treating imported goods less favourably than domestic products.
  - **Article 2.1 (TRIMS)**: prohibits investment measures that conflict with national treatment obligations. TRIMS explicitly identifies local content requirements as prohibited.
- India maintains that **DVA requirements are not equivalent to local content mandates**. Domestic value addition can occur through multiple means — including **assembly, R&D, and innovation** — not just **use of local materials**.

#### Dispute Resolution at the WTO

- The process begins with **bilateral consultations** between **India and China** to reach an **amicable settlement**.
- If unresolved, the case proceeds to a **three-member WTO Dispute Settlement Panel**. However, **Appellate Body** of the WTO has been non-functional since 2019, due to U.S. blocking appointments. Any appeal would therefore suspend final adjudication, effectively maintaining the status quo.

#### Involution – Chinese EV Sector

**Why in news:** China is facing what is locally called **nèijǔǎn** or “**involution**”, where **price wars** in certain sectors, especially **EVs**, are causing **losses** due to **low prices**. Similar trends seen earlier in China's **solar industry**.

#### Draft CAFE Rules

**Why in news:** India has proposed to **revamp its vehicle emissions rules**, known as the **Corporate Average Fuel Efficiency (CAFE) norms**, with the introduction of **CAFE 3 draft standards**.

- The **CAFE 3 norms** aim to address a long-standing demand by carmakers to provide emissions relaxation for small, lightweight cars, a metric followed in some countries globally.
- The **draft norms**, issued by **BEE** for **public consultation**, will apply to all **M1 category vehicles** — passenger cars with a seating capacity of up to nine people including the driver and a maximum weight of 3,500 kg. Under the proposed rules, **each carmaker must meet specified emissions targets**, failing which **penalties** will be imposed.
- The CAFE 3 draft introduces new concepts such as **emissions pooling**, allowing multiple carmakers to combine their emissions data to meet targets. The rules also propose emissions discounts for carmakers that sell EVs.
- The proposed framework brought out by the **BEE** seeks **tightening fleet-average CO2 emissions** from **113 gram/km to 91.7 gram/km**. Draft includes a relaxation for petrol cars weighing 909 kg or less, measuring under four metres, and equipped with engines up to 1,200 cc. Such cars will get a **3 g/km relaxation** in their CO2 numbers.

- **Bharat Stage (BS) emission standards** are norms instituted by the government to regulate air pollutants from ICEs, including motor vehicles. India has been following **Euro emission norms** with a time lag of five years.
- **India introduced emission norms in 1991** and **tightened them in 1996**, requiring technology upgrades like catalytic converters to reduce exhaust emissions. **Fuel specifications** based on environmental considerations were notified in **1996**, implemented by **2000**, and incorporated in **BIS 2000 standards**.
- Following the **Supreme Court order of 1999**, the Centre notified **BS-I (BIS 2000)** and **BS-II** norms. **BS-I and BS-II** were broadly equivalent to **Euro I and Euro II** respectively.
- **BS-II** applied to the **NCR and other metros**, while **BS-I** applied to the **rest of India**.

#### Fishing

#### Fishing Limit

**Why in news:** **Total Allowable Catch (TAC)** is a **limit on the total quantity of fish** that fishers can catch in a particular area. Governments and agencies **impose TACs** to **prevent overfishing** and ensure **sustainable fish populations**.

- Recent TAC-related dispute involves **U.S. and Russia** over **Patagonia toothfish** caught in **South Atlantic Ocean**. In 2021, **Russia refused to admit TAC** for this species set by **Commission on the Conservation of Antarctic Marine Living Resources (CCAMLR)**. As a result, a **U.S. judge blocked the import** of Patagonia toothfish last month.

### Fisherwomen's Day

- Celebration of the **first International Fisherwomen's Day** in **Mumbai**. **Fisherwomen from over 40 countries** participated in the events marking the day.
- Organisations such as **World Forum for Fisherpeople** and **National Fishworkers Forum** highlighted role and struggles of fisherwomen. Fisherwomen stated that their **land is being grabbed under Slum Redevelopment Authority**.
- They sought **reimplementation of the 2011 Coastal Regulation Zone (CRZ) notification** and demanded scrapping of the **CRZ 2019 notification**. Under the **2011 CRZ notification**, fishing colonies are protected under **CRZ III**.
- **Women constitute nearly half** of the employed fisheries workforce globally, though fisheries has been traditionally male-dominated. **Indian fisherwomen** account for about 44% of the total fisher population, according to the government. They form a workforce of more than 1.24 crore in fisheries.

### Deep-sea Fishing

- Govt notified rules for **Sustainable Harnessing of Fisheries in EEZ**, giving priority to fishermen cooperative societies and fish farmer producer organisations (FFPOs) for deep-sea fishing operations.
- Rules aim to **facilitate deep-sea fishing & enhance seafood exports** through value addition, traceability, certification.
- The rules define an **"operator"** as an **individual, enterprise, FFPO, or Fisheries Cooperative**, including multi-State cooperatives, responsible for operating or managing a fishing vessel. **Centre will provide training & capacity-building** for traditional & small-scale fishers, fisheries cooperatives, SHGs, & FFPOs.
- The **mother-and-child vessel concept** will enable **mid-sea transshipment** under an **effective monitoring mechanism**.
- In the **Andaman & Nicobar Islands and Lakshadweep**, accounting for **49% of India's EEZ**, this is expected to **boost exports of high-quality fish**.
- The rules require applications for **catch certificates and health certificates** to be submitted through **designated online portals**, integrated with the **ReALCRaft portal**.
- The EEZ Rules take a firm stand against **harmful fishing practices** such as **LED light fishing, pair trawling, and bull trawling**. A **minimum legal size for fish species** will be prescribed to **conserve biodiversity**.
- **Mariculture practices** such as **sea-cage farming and seaweed cultivation** will be promoted as **alternate livelihoods**.

### Fisheries Schemes

- On **World Fisheries Day 2025 (Nov 21)**, the **FAO** calls for a renewed commitment to **Blue Revolution**, supporting the Government's theme: **"India's Blue Transformation: Strengthening Value Addition in Seafood Exports."**
- India contributed **10.23 million tonnes**, becoming the **second-largest aquaculture producer** globally.
- Past decade marked transformation under **India's Blue Revolution** and **Pradhan Mantri Matsya Sampada Yojana, Climate-Resilient Coastal Fishermen Villages Programme** and **draft National Fisheries Policy 2020**.
- **FAO-India** collaboration began with the **Bay of Bengal Programme (BOBP)**, improving **small-scale fishing technologies, sea safety, and post-harvest management**.
- The **BOBLME** project supported the **Ecosystem Approach to Fisheries Management (EAFM)** and **National Plans of Action** against **IUU fishing**.
- A **Technical Cooperation Programme (TCP)** aims to strengthen **fishing ports and harbours**, with pilot sites at **Vanakbara (Dadra & Nagar Haveli and Diu)** and **Jakhau (Gujarat)**. TCP will provide **strategic and operational tools** for investment planning to address environmental, social, and economic challenges.
- **Matsya Seva Kendras (MSKs)**: To provide a one-stop solution for a range of extension services through trained aquaculture professionals; Government Assistance: Up to 60% support for women and weaker sections; Mobilize start-ups, cooperatives, and fish farmers' organizations to share best practices.
- Centre will develop 100 climate-resilient coastal fishermen villages across the country. Funding: ₹2 crore per village under the **Pradhan Mantri Matsya Sampada Yojana**. Common facilities like fish-drying yards, processing centres, fish markets, and emergency rescue facilities will be created. Promoting Climate-Resilient Practices like seaweed cultivation, artificial reefs, and green fuel.

### Regional and International Bodies

#### WTO - PLI Scheme

**Why in news:** The **U.S. questioned India's PLI scheme for specialty steel** at the **WTO**, citing concerns over **subsidies amid global steel overcapacity**. India defended the scheme, stating it aims to **reduce import dependence on higher grades of steel** and promote **self-sufficiency**.

- **Specialty steel is among 14 sectors** covered under the **PLI scheme launched in 2021**. It aims to **boost domestic manufacturing, attract global investment, generate employment** in high-growth sectors.
- India countered that it was a **net importer of steel in FY25**, justifying the need to enhance local output. Although India is the **second-largest steel producer**, it remains **dependent on imports for specialty and high-end steel**.
- India clarified that the PLI scheme is **WTO-compliant**, with **no export obligations or export-linked subsidies**.

**IMF – EFF**

**Why in news:** IMF Executive Board approved funding to Pakistan under EFF and RSF. India abstained from the vote, citing Pakistan's poor track record, potential misuse for state-sponsored terrorism. India, Bangladesh, Bhutan, and Sri Lanka collectively hold only 3.05% of the IMF vote share, while U.S. holds 16.49%, Japan 6.14%, and China 6.08%.

- Extended Fund Facility provides assistance to countries with serious medium-term balance of payments problems due to structural weaknesses. It offers repayment periods to support medium-term structural reforms. Unlike development banks, the IMF does not finance specific projects, but supports policy reforms through financial aid.

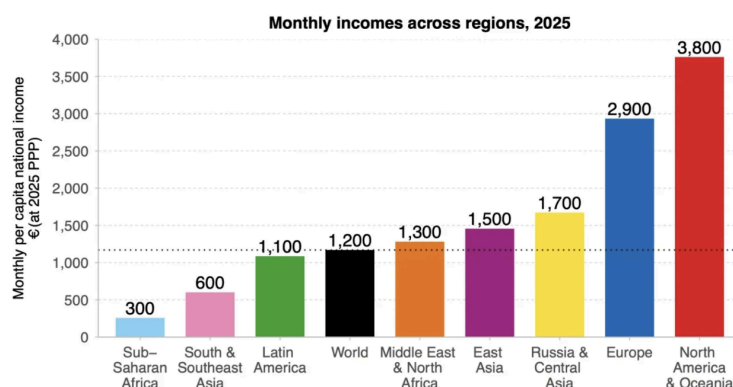
**Retaliatory Tariffs**

- India maintains U.S. measures are not consistent with GATT 1994 and the Agreement on Safeguards (AoS). India argues the U.S. failed to hold mandatory consultations under Article 12.3 of AoS, giving India the right to retaliate.
- India proposes to suspend concessions and increase tariffs on selected U.S. products after 30 days.
- Under Article 1 of GATT (1994), all WTO members must grant MFN status to other member countries. MFN status ensures non-discrimination in trade—any special favour (e.g., lower tariffs) given to one country must be extended to all WTO members.

**Reports and Misc****RBI's Remittances Survey**

**Why in news:** Inward remittances hit a record \$118.7 billion in 2023–24, surpassing FDI inflows and financing over half of India's merchandise trade deficit.

- Advanced Economies (AEs) like the U.S. (27.7%), U.K., Canada, Australia, and Singapore now contribute 51.2% of India's remittances, overtaking the six GCC countries (37.9%).
- Large-value transfers above ₹5 lakh make up 29% of total remittance value, although they represent just 1.4% of all transactions, indicating dominance by high-earning Indians.
- States like Maharashtra, Kerala, and Tamil Nadu receive 51% of remittances, while Bihar, Uttar Pradesh, and Rajasthan get under 6%, reflecting historical out-migration and unequal access to migration infrastructure.

**World Inequality Report**

- Income inequality in India remains among the highest in the world, with top 10% of earners capturing 58% of national income, while bottom 50% receive only 15%, according to the World Inequality Report 2026.

- India's wealth inequality Gini was 75.
- Wealth inequality is even greater in India, with the richest 10% holding around 65% of total wealth and the top 1% holding about 40%, the report released by the World Inequality Lab said.

- As per the World Inequality Report 2022, the top 10% in India held 57% of the total national income while the bottom 50% share was 13% in 2021.

- Global top 10% owns 75% of all wealth, while the

bottom 50% holds just 2%. The top one-in-a-million collectively hold 3% of global wealth, more than the bottom half of the world's adult population.

- Women earn only 61% of what men earn per working hour; when unpaid labor is included, this falls to 32%.
- Poorest half of the global population accounts for only 3% of carbon emissions associated with private capital ownership. The top 10% account for 77% of emissions.
- Elites pay proportionally less than households earning much lower incomes.

- Gini index/coefficient, named after the early 20th century Italian statistician Corrado Gini, has historically been the most commonly used measure of inequality.
- It measures inequality on a scale from 0 to 1 (or 0% to 100%), with higher values indicating higher inequality.
- The Gini Index measures the extent to which the distribution of income or consumption among individuals or households within an economy deviates from a perfectly equal distribution. In simpler terms, it provides a clear picture of how evenly income is distributed within a country.

- According to the Global Inequality Report, 83% of countries experience high income inequality, covering 90% of the world's population. High income inequality corresponds to a Gini coefficient above 0.4.
- A Gini coefficient of 0 indicates perfect equality, while 1 represents perfect inequality.

- A major reason for persistent inequality is the rising share of **national income accruing to capital** compared to **labour income**. Between **1990 and 2024**, the **capital share of national income** increased in **56% of countries**, covering **74% of the world's population**.
- In **India**, **97% of the population** lives in households with **less than \$100 annual capital income per person**.
- Between **2019 and 2024**, **average global CEO pay** increased by **50%**, while **average worker pay** rose by **less than 1%**. Due to unequal wealth accumulation, **private wealth** has far outpaced **public wealth**.

### Gini Index

**Why in news: WB report** shows **inequality in India has decreased** significantly between **2011-12 and 2022-23**. India is now the **fourth most equal country globally** on the **Gini Index**, after **Slovak Republic, Slovenia, and Belarus**.

- India's **Gini Index** fell from **0.288 (2011-12)** to **0.255 (2022-23)**, placing it in the **"moderately low" inequality category**. **Extreme poverty** declined from **16.2% to 2.3%** over the same period.
- India's Gini score is lower than **China (35.7)** and much lower than the **U.S. (41.8)**.
- The **Gini Index** measures **income, wealth, or consumption distribution**, ranging from **0 (perfect equality)** to **100 (absolute inequality)**. India's measurement is based on **consumption inequality**, not income or wealth.
- **Consumption inequality** is naturally lower since poorer households spend most of their income, unlike the rich who save and accumulate wealth. **HCES surveys** used by the World Bank may miss **high incomes** and involve **methodological changes**, making comparisons less reliable.

### Hurun India Wealth Report 2025

- According to the **Mercedes-Benz Hurun India Wealth Report 2025**, **India** is projected to have **871,700 millionaire families by 2025**, each with a **net worth of at least Rs 8.5 crore (US\$1 million)**. This marks a sharp jump.
- **Maharashtra** has consolidated its position as the **country's richest state**.
- **Mumbai** is at the **top among the cities**, followed by **New Delhi** and **Bangalore**.

### Financial Sector Assessment (FSA) Report

- **World Bank**, in its latest **Financial Sector Assessment report**, stated that India achieving its vision of becoming a **\$30 trillion economy by 2047** would require impetus to **financial sector reforms** to boost **private capital mobilisation**.

### Meghalaya Filmmaking

**Why in news: Meghalaya** has launched a **film policy** positioning the State as a **preferred destination for film shoots**.

- The policy is **open to films in all languages**. Financial assistance up to ₹1 crore will be provided to production houses shooting at least 75% of their content in Meghalaya.
- An **additional ₹50 lakh incentive** will be granted if **local artists, musicians, and other talent are engaged**.

### Homestays in Uttarakhand

**Why in news: Army** inaugurated a **tent-based homestay facility** in the **border village of Garbyang**, Pithoragarh district, Uttarakhand. The initiative aims to promote sustainable tourism and enhance rural livelihoods.

- Under **Operation Sadbhavana**, the Army is focusing on sustainable development in border villages. The project will promote tourism and boost rural development. It aligns with the **Centre's Vibrant Villages Programme**.

### Nobel Economics Prize

**Why in news: Joel Mokyr, Philippe Aghion, and Peter Howitt** won the 2025 Nobel Prize in Economics for **"having explained innovation-driven economic growth,"** the Royal Swedish Academy of Sciences announced.

- The award, formally called the **Sveriges Riksbank Prize in Economic Sciences** in Memory of Alfred Nobel, is worth 11 million Swedish Kronor (\$1.2 million). Nobel economics prize is the **final prize of the year** to be awarded.
- Laureates have shown that sustained growth cannot be taken for granted.
- Joel Mokyr used historical observations to identify the factors necessary for sustained growth based on technological innovations. Philippe Aghion and Peter Howitt developed a mathematical model of creative destruction, describing an endless process where new and better products replace the old.
- The **original Nobel Prizes** were established in the **will of Swedish inventor Alfred Nobel** and have been **awarded since 1901**. The **Economics Prize** was **established later**, first awarded in 1969 to Norway's Ragnar Frisch and Jan Tinbergen of the Netherlands for their work in dynamic economic modelling.
- **Nikolaas Tinbergen**, Jan's brother, also became a **Nobel laureate**, winning the **Medicine Prize in 1973**.

### Indian Institute of Packaging

- Autonomous body under the Ministry of Commerce and Industry, established in 1966 to upgrade the standards of packaging in India, opened its **Bengaluru Centre**. HQ in Mumbai.

- It is a **UN-certified agency** for testing and certifying packaging for the transport of dangerous goods by air, sea, and road. IIP is leading the "**Green Packaging Initiative**" to find alternatives to Single-Use Plastics (SUP).
- The new facility would play a vital role in **packaging education, research, testing, and certification**.
- **IIP Bengaluru** would integrate AI-enabled testing, data analytics, and smart packaging demonstrations, building capacity for innovation, skill development, and industry collaboration in next-generation packaging technologies.

**HDI**

**Why in news: India moved up 3 spots in HDI, ranking 130 out of 193 countries in 2023**, as per the **Human Development Report 2025** by **UNDP**. India's HDI value improved to 0.685 in 2023 from 0.676 in 2022, placing it in the medium human development category.

Rank	Country	HDI
1	Iceland	0.972
2	Norway	0.97
2	Switzerland	0.97
4	Denmark	0.962
5	Germany	0.959
5	Sweden	0.959
130	Bangladesh	0.685
130	India	0.685

- **GNI per capita** rose to \$9,046.76 in 2023 from \$2,167.22 in 1990, showing substantial growth. 135 million Indians escaped multidimensional poverty between 2015-16 and 2019-21.
- **Inequality reduces India's HDI by 30.7%**, among the highest losses in the region. While **health and education inequality** have improved, **income and gender disparities** remain significant. **FLFPR and political representation lag**.
- **Life expectancy in India rose to 72 in 2023** from **58.6 in 1990**, the highest since the index began, reflecting post-COVID recovery.

- Published by the **Human Development Report Office** for **UNDP**, exploring themes using the **human development approach** since **1990**. UNDP publishes several indices: **HDI, IHDI, Gender Development Index, Gender Inequality Index, Gender Social Norms Index, Multidimensional Poverty Index, and Planetary Pressures-adjusted HDI**.
- HDI is a **composite index** measuring average achievement in life expectancy, expected years of schooling, mean years of schooling, and GNI per capita (PPP\$ 2017).
- **HDI classification:** < **0.550**: Low human development; **0.550-0.699**: Medium human development; **0.700-0.799**: High human development;  $\geq$  **0.800**: Very high human development

**Extreme Poverty Eradication Programme**

- On its **69th Formation Day (November 1, 2025)**, **Kerala declared the eradication of extreme poverty**.
- The achievement follows a four-year, state-led programme under the Extreme Poverty Eradication Programme (EPEP) launched in **2021**, driven by the **LSG & extensive community participation**.
- As per **NITI Aayog's National Multidimensional Poverty Index (2023)**: Kerala recorded only 0.55% multidimensionally poor population – lowest in India, compared to the national average of 14.96%.

**Implementation**

- Around 4 lakh trained enumerators, including Kudumbashree workers and local officials, identified extremely poor households through field surveys, avoiding self-enrolment errors. (Kudumbashree Mission, a globally recognised self-help group model, promoted women's empowerment and community participation).
- A total of 64,006 extremely poor families were identified and verified through Grama Sabhas. Each family received a customised micro-plan, tailored to its unique needs – a shift from one-size-fits-all welfare models.

**GIFT City**

- **International Financial Services Centres Authority (IFSCA)** is a **special unified regulator for all financial services**, created under the **Ministry of Finance**, to act as a single regulatory window for financial services companies looking to do business in Gujarat International Finance Tec-City (GIFT City).
- **Companies** are given a **corporate tax holiday for 10 consecutive years out of 15 years of operation**, and there is **no GST on services received by units in GIFT IFSC or provided to GIFT IFSC units**.
- When you open a company in **GIFT City**, it is **designated a non-resident** so all the **business is conducted in international currencies not the rupee**.
- **\$19 billion off \$61 billion of external commercial borrowing** done by **Indian firms** now come from **GIFT City**.

**AGRICULTURE**

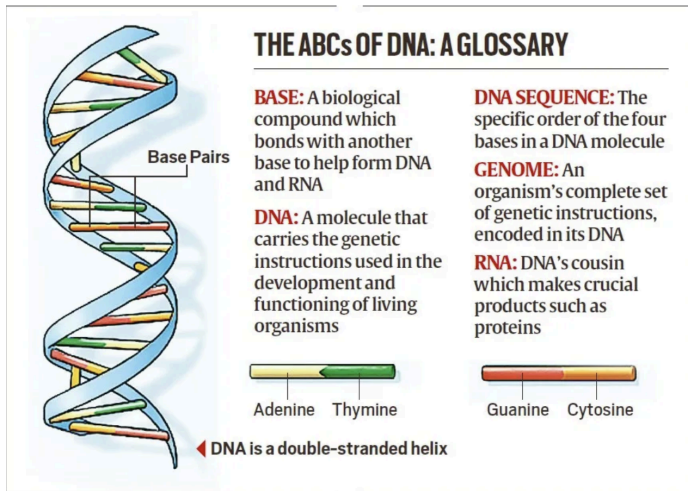
**Food & Crops**

**Genome Edited Rice**

**Why in news: India becomes 1st country to develop rice varieties using genome editing technology.**

- Developed by **ICAR-led researchers**.
- **DRR Dhan 100 (Kamala)**: Derived from Samba Mahsuri, known for superior yield, drought tolerance, high nitrogen use efficiency, and 20 days earliness.
- **Pusa DST Rice 1**: Derived from MTU 1010, showed 9.66% higher yield under inland salinity, 14.66% under alkalinity, and 30.4% advantage under coastal salinity stress.

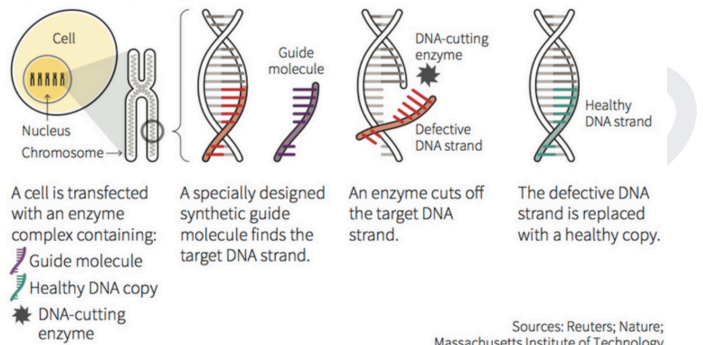
- Developed using Site-Directed Nuclease 1 and 2 (SDN-1 and SDN-2) genome editing techniques.
- Kamala and Pusa DST Rice 1 are not GM crops, as SDN-3, which involves foreign genes, was not used.
- SDN-1 repairs DNA without external input, and SDN-2 uses a guide sequence; both result in precision mutation.
- No foreign gene present in the final product; hence, exempt from GM regulations in several countries.
- Both varieties field-tested under the All India Coordinated Research Project on Rice during 2023 and 2024.
- International scientific community has approved both.



**DNA editing**

A DNA editing technique, called CRISPR/Cas9, works like a biological version of a word-processing programme's "find and replace" function.

**HOW THE TECHNIQUE WORKS**



- **Genetic Engineering** is different from GM, which involves inserting **genes from unrelated species** into host plants. **GM crops** may use genes from organisms like **Bacillus thuringiensis** to produce pest-toxic proteins. **GE only edits the native genes** of a plant without incorporating **foreign DNA**.
  - **India has exempted GE crops** from biosafety regulations under the Environment Act, 1986. These regulations apply to **GM crops**, which are treated as "**hazardous substances**" under the Act. The exemption means GE crops no longer require clearance for field trials or commercial release under these rules.
  - **CRISPR-Cas technology** uses Cas enzymes as molecular scissors to precisely modify DNA sequences. (CRISPR-Cas9 technology won the Nobel Prize in Chemistry in 2020.)
  - Scientists at **IIRR used CRISPR-Cas12** to edit the 'cytokinin oxidase 2' (Gn1a) gene in Samba Mahsuri rice. The Gn1a gene controls the number of grains per panicle by regulating an enzyme's expression. Editing this gene reduces its expression, thereby increasing grain number and improving yield.
  - The new GE rice line **IET-32072 or 'Kamala'** has an average yield of 5.37 tonnes/hectare with a potential of 9 tonnes/hectare. This is higher than the parent Samba Mahsuri variety, which yields 4.5 tonnes (average) and 6.5 tonnes (potential) per hectare.
  - **Paddy is India's principal kharif crop**, occupying one-third of the total area under all foodgrain crops. It contributes approximately 40% to India's overall foodgrain production.
  - Scientists have created the first **rice pangenome** by combining key genomic parts from 144 wild and cultivated Asian rice varieties. Like the Human Genome Project, the pangenome reveals full genetic diversity including both core and unique genes across rice types. It will help in developing rice varieties with traits like disease tolerance and climate resilience, crucial amid rising temperatures and arsenic uptake concerns.
  - Gene **Chalk9** controls **chalkiness in rice grains**. Discovery enables breeders to reduce chalkiness and improve grain quality. Chalky rice grains appear opaque instead of translucent after milling. Increases breakage during milling, lowering quality. Influenced by multiple genes and environmental factors like high temperature.
- About Site-Directed Nuclease (SDN) 1, 2 and 3:**
- **SDN1** produces a double-stranded break in the plant genome and modifies an existing trait without inserting foreign DNA or editing the site directly.
  - **SDN2** makes double-stranded break & during the cell's repair process, edits a small sequence at the target site.
  - **SDN3** involves site-specific insertion of a large foreign DNA fragment to introduce a new trait into the genome.
- Rice Yield & Microbes**
- **Microbes in rice paddies** determine whether **arsenic**, a carcinogen and plant toxin, builds up in rice grains and triggers **drastic crop losses**.
  - The study identified a balance between **arsenic-methylating bacteria** (convert inorganic arsenic into toxic organic forms) and **demethylating archaea** (undo this process). Where **methylating bacteria dominate**, rice absorbs **DMA** and its more toxic derivative **DMMTA**, which pose health risks and induce **straighthead disease**.
  - The condition can cause **up to 70% yield losses**, even when **total arsenic levels are low**.
  - Newly cultivated paddy regions in **U.S., southern Europe, and China** have high methylating-to-demethylating ratios, making them **high-risk zones**. India mostly has old paddies with balanced microbes.
  - **Silicon fertilisation** reduces arsenic uptake; crop rotation can avoid destabilising microbial communities.

### GM Maize Trials

- **Field trials of two GM maize varieties** are set to begin this **kharif season** at **Punjab Agricultural University**. The trials were approved by the **GEAC** after getting consent from the Punjab government.
- The **GEAC** recommended **Bayer Crop Science Ltd.'s proposal** for **confined field trials** of **herbicide-tolerant** and **insect-resistant transgenic maize**. The trials aim to study weed-control efficacy using glyphosate-K salt and the efficacy of insect-protected maize against lepidopteran pests.
- Trials are **for research purposes only**, and any **commercial decision** lies with the **Central government**.
- **Scientific literature** documents **glyphosate's harmful effects on human health and the environment**.
- **HT-Bt cotton**, engineered to survive **glyphosate spraying**, never received **official clearance** in India as trials by **Mahyco-Monsanto** were suspended over a decade ago and no approval followed.
- Despite the lack of approval, **HT-Bt seeds leaked** into farms across **Gujarat, Maharashtra, Telangana, Andhra Pradesh, and Punjab**, with illegal cultivation covering **15–25% of cotton acreage**.
- Since **2015**, government intervention in **private seed contracts** has been a major challenge, with the **Cotton Seed Price Control Order (SPCO)** slashing **Bt cotton seed royalties**, discouraging **research and development**.
- **Cotton exports** declined after **2011-12**, and by **2024-25**, India became a **net importer** of raw cotton.

### Clustering Maize

- **Novel form of plant communication** in **maize (Zea mays)** involving compound **linalool**, which could help strengthen **crop resilience** against pests and diseases. **Linalool**, a **volatile compound** with a floral scent, acts as a **warning signal** between plants. When maize plants are **attacked by insects**, they release **linalool**, which **alerts neighbouring plants**.
- In densely planted fields, inner plants suffered less damage, showing that crowding boosts protection. However, this stronger defence caused slower growth & lower biomass, revealing a trade-off between protection & productivity.
- **Maize (Zea mays)** was domesticated from **teosinte**, a wild grass in **Mesoamerica** over **9,000 years ago**. It is now the **world's most widely grown grain**, serving as **food, animal feed, biofuel**, and a **raw material** for various industries. However, its reliance on **large-scale monocultures** makes it **vulnerable to pests, diseases, and climate change**.
- Experts project that under the **high-emissions scenario (SSP585)**, **maize productivity** could **fall by up to 24%**.
- Exposure to **linalool** activates **jasmonate signalling** in maize roots — a stress-response hormone linked to pest and wound resistance. This induces production of **HDMBOA-Glc**, a **defensive metabolite** released into the soil. **HDMBOA-Glc** enriches **beneficial bacteria**, which trigger **salicylic acid signalling** in neighbouring plants.

### GM Mustard

**Why in news:** Two key decisions — **FSSAI's 2021 ban** on blended mustard oil and the **Supreme Court's 2024 ruling** against GM mustard (DMH-11) — were aimed at **protecting consumer health**.

- Indian mustard oil contains **40–54% erucic acid**, significantly above the **internationally accepted level of <5%**.
  - Erucic acid is a monounsaturated omega-9 fatty acid found in high amounts in Indian mustard and rapeseed oil.
  - It has potential cardiotoxic effects, leading to international regulations limiting safe consumption to less than 5%.
- **Canola oil**, developed in Canada, contains **<2% erucic acid** and is widely used as a **healthier substitute**.
- **Blending mustard oil** with other edible oils can lower erucic acid content, improve fatty acid profiles, reduce LDL and raise HDL cholesterol.
- The **indigenous GM mustard DMH-11** has **30–35% erucic acid**, lower than traditional varieties. Cultivating DMH-11 would reduce the **need for oil blending** and **cut down India's edible oil import bill**.

### Neera Production

**Why in news:** Bihar launched the **Mukhyamantri Neera Samvardhan Yojana** to promote **neera (palm nectar)** production.

- Under the Act (Bihar Prohibition and Excise Act, 2016), toddy is banned.
- Neera is promoted as a **health drink** rich in **minerals** (calcium, iron, potassium, sodium, phosphorus), **antioxidants**, and is a **natural probiotic** aiding **immune system and haemoglobin levels**.

### Turmeric

- Union Home Minister inaugurated the **HQ of National Turmeric Board (NTB)** in **Nizamabad, Telangana**.
- The government has set a target of achieving one billion dollars in turmeric exports by 2030.
- **India is the largest producer, consumer, and exporter of turmeric** in the world.
- Most turmeric production comes from **Telangana, Maharashtra, and Meghalaya**.
- India holds more than **62% share of world turmeric trade**.

### Beej Utsav

**Why in news:** A four-day '**Beej Utsav**' (**seed festival**) was held in the tribal belt at the tri-junction of Rajasthan, MP, and Gujarat. The festival highlighted the role of indigenous seeds in agricultural sustainability.

- **Activities:** 'Beej Samvad' (seed dialogue), biodiversity fairs, 'seed ball' making, and plantation drives. Community honours like 'Beej Mitra' (seed friend) and 'Beej Mata' (seed mother) were awarded to seed-preserving farmers.
- Nearly 70% of small farmers rely on market-driven **hybrid seeds**, urging a return to seed sovereignty.
- India's **total foodgrain production reached 353.96 million tonnes**, marking an **increase of 6.5%** over previous year.

### Eggs

- FSSAI clarified reports alleging **carcinogenic substances** like **nitrofurans metabolites (AOZ)** in **eggs**.
- The use of **nitrofurans** is **strictly prohibited** at all stages of **poultry and egg production** under the **Food Safety and Standards (Contaminants, Toxins and Residues) Regulations, 2011**.
- An **Extraneous Maximum Residue Limit (EMRL)** of 1.0 microgram per kilogram is prescribed for nitrofurans metabolites for regulatory enforcement only. EMRL represents the minimum detectable level by advanced laboratory methods and does not permit use of the substance.

### Policies & Misc

### CROPIC

**Why in news:** Ministry of Agriculture and Farmers Welfare plans to launch **CROPIC**, a study to gather **crop information** using **field photographs** and **AI-based models**.

- CROPIC stands for **Collection of Real Time Observations & Photo of Crops**. Crops will be photographed 4–5 times during their cycle to assess health and potential mid-season losses. Will use an **AI-based cloud platform** for photo analysis and information extraction & a **web-based dashboard** for **visualisation**.
- The study is conducted for the **Pradhan Mantri Fasal Bima Yojana (PMFBY)** to create a **directory of crop signatures** and enable **automation of loss assessment** and **compensation** to eligible farmers. **CROPIC mobile app** has been developed for **field photograph collection**, and photos will be **crowd-sourced** directly from **farmers**.
- The photographs will be analysed for **crop type, crop stage, crop damage**, and its **extent**. It will use an **AI-based cloud platform** for **photo analysis** and **information extraction**, and.
- CROPIC will be **rolled out initially in 50 districts per season**, covering different agro-climatic zones and three major notified crops in each district for each season.
- The **Fund for Innovation and Technology (FIAT)** under PMFBY is used for funding CROPIC. FIAT has a total outlay of around ₹825 crore for different technology innovations under crop insurance schemes.

#### Namo Drone Didi:

- **Central sector scheme** to empower 15000 **women-led SHGs** by providing **drone technology** for agricultural services. Goal of creating at least **two crore Lakhpati Didis** (rural women earning in lakhs) through **SHGs**.
- Under the scheme, each woman receives a **drone worth ₹10 lakh** for just **₹2 lakh**, with **80% subsidy** on drone cost.
- **Drone Pilot training** is included as part of the **Drone Package**.

#### More:

- FIAT was approved by the **Union Cabinet** in **2025** to fund **technological initiatives** under schemes like **Yield Estimation System using Technology (YES-TECH)** and **Weather Information and Network Data Systems (WINDS)**.
- **Digital Agriculture Mission**, approved in 2024 aims to create **DPI**, with key components being **AgriStack**, **Krishi Decision Support System**, and **Soil Profile Maps**.
- **SATHI (Seed Authentication, Traceability, and Holistic Inventory)** is a national portal by the Ministry of Agriculture and NIC to monitor seed production and distribution, ensuring **traceability from origin to farmers**.

### Dairy's Circular Economy

- **Implementation of circular economy model** across country will increase dairy farmers' income by 20% over the next 5 years. **Banas Dairy's model:** Selling biogas and fertilizer produced from cattle dung procured from farmers.
- The circular economy model also includes **leather production** from hides harvested from the cattle that die naturally.

### Wheat – Desertification

- An **innovative experiment** to **grow wheat for the first time in arid land** using **desert 'soilification' technology** powered by an **indigenous bioformulation** has been carried out by researchers at the **Central University of Rajasthan (CUoR)**.
- The initiative aims to **halt the expansion of the Thar Desert** towards **NCR**, addressing the **accelerating desertification** caused by the **degradation of the Aravali ranges**.

### BHARATI

- **APEDA** launched a new initiative called **BHARATI, Bharat's Hub for Agritech, Resilience, Advancement and Incubation for Export Enablement**. It is designed to **empower 100 agri-food and agri-tech startups**.

### Mayonnaise

**Why in news:** Tamil Nadu became the third State after Kerala and Telangana to ban mayonnaise made from raw eggs. Raw egg mayonnaise poses high food poisoning risks due to contamination by Salmonella typhimurium, Salmonella enteritidis, E. coli, and Listeria monocytogenes.

- The ban applies **only to raw egg-based mayonnaise**, not to **pasteurised egg or vegetarian mayonnaise**.
- Improper preparation and storage of raw egg mayo, especially at room temperature, raises contamination risks.
- Salmonella can contaminate eggs internally before shell formation, making raw egg-based products risky.

### Ethanol – Food vs Fuel

**Why in news:** India has achieved its **20% ethanol blending target** in FY25, **ahead of schedule**, and now aims to increase the **ethanol-petrol blending ratio to 30%**.

- **Sugarcane production has declined** since 2022, prompting the Centre to increase FRP to protect farmers. As a result, retail sugar prices have risen, affecting consumer affordability.
- Factors behind the decline include **red-rot disease, deficient rainfall, and flowering issues**.
- **Ethanol Blending Programme** began in the **early 2000s** to reduce **fossil fuel dependence** and **oil imports**. Ethanol supply grew from **40 crore litres in FY14** to **670 crore litres in FY24**, after bans on using **sugarcane juice, syrup, and B-heavy molasses** were lifted.
- **Native to India:** Saccharum barberi is native to North India; however, the modern high-yielding variety (Saccharum officinarum) originated in South East Asia/New Guinea.
- **Top Producing States:** UP (Highest production), Maharashtra (Highest recovery rate), Karnataka, Tamil Nadu, Bihar.
- **Top Producing Countries:** Brazil (World Leader), India (2nd largest), China, Thailand, Pakistan.
- **Climate:** Tropical to Sub-tropical, 21°C to 27°C temperature, 75cm to 150cm rainfall, deep rich loamy soil.
- **Tropical (South) cane** has higher sugar content and longer crushing seasons compared to Sub-tropical (North).

- **FRP** is the minimum price sugar mills are **legally required** to pay sugarcane farmers & is decided annually by the **CCEA**, headed by PM, based on recommendations of the **CACP**.
- Unlike MSP, **FRP has legal backing**, and mills must pay it within **14 days** as per the **Sugarcane Control Order, 1966**. Failure to pay FRP allows the **cane commissioner** to take action, including **attachment of mill properties**.
- FRP is linked to **sugar recovery rate**; higher recovery leads to higher FRP. **MSP is a floor price** at which the government procures crops if market prices fall below it. It was introduced in **1966–67**.
- **MSPs are recommended by CACP**. Final decisions on MSPs & FRP are made by **CCEA**.
- While recommending MSPs, **CACP considers** demand-supply, cost of production, market price trends, inter-crop parity, terms of trade, 50% margin, and consumer impact.
- **MSP covers 7 cereals:** paddy, wheat, maize, bajra, jowar, ragi, barley; **5 pulses:** chana, arhar/tur, urad, moong, masur; **7 oilseeds:** mustard, groundnut, soybean, sunflower, sesamum, safflower, nigerseed; **4 commercial crops:** cotton, sugarcane, copra, raw jute.

### Sugar – Ethanol Sourcing

- The **sugar sector** has expressed concern over the **reduction in ethanol sourcing** for the **2025–2026 ethanol supply year**. **ISMA** urged the **Centre** to ensure that **at least 50% of ethanol** is **sourced from the sugar sector**.
- Sugar mills seek revision of minimum selling price.

- Till **2017–18**, mills produced ethanol only from **C-heavy molasses**, final dark brown liquid byproduct of cane processing. From **2018–19**, mills began making ethanol from **B-heavy molasses** and **whole cane juice**.
- From **2018–19**, the government fixed **separate ex-distillery prices** for ethanol made from **rice, maize and damaged foodgrains**. This move was mainly intended to **help sugar mills**.
- The grains used were largely **maize and rice**, sourced from **FCI** and the **open market**.
- **Ethanol production** involves **fermentation of sugar by yeasts**. In **molasses or cane juice**, sugar is present as **sucrose**. **Grains contain starch**, which must be **extracted and broken down into simple sugars** before fermentation, distillation and dehydration. Ethanol is produced with **99.9% alcohol concentration**.
- It is different from **94% rectified spirit**, used in paints, pharmaceuticals, personal care products and other industries. It is also different from **96% extra neutral alcohol**, which is used to make **potable liquor**.

#### Sugarcane

- Modern sugarcane plants are **hybrids with multiple chromosomes (polyploidy)**, arising due to **commercial transport and breeding by humans** across regions and countries, including **Afghanistan, Sri Lanka, and Indonesia**.
- **Sugarcane**, apart from being a **cash crop for sweetness**, is also used for **bioethanol production**.
- India produces large quantities of sugarcane across **13 States**. The **top five producing States** were **Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, and Gujarat**. The **Sugarcane Breeding Institute, Coimbatore**, the oldest such institute, conducted **molecular genetic analyses in 2006**.
- Brazil > India > China > Thailand > Pakistan.
- **Traditional medicine practitioners** in **China, India, and Pakistan** have long used **sugarcane in therapies**.

### Biohappiness

**Why in news:** In Arunachal Pradesh, tribal communities like the **Nyishi and Apatani** consume diverse greens, millets, legumes, tubers, and wild fruits with known **nutritional and medicinal properties**.

- **Traditional knowledge and culinary practices** of tribal communities are disappearing at a similar pace.
- India hosts **8% of global biodiversity** on just **2% of global land area**, is one of **17 megadiverse countries**, and contains parts of **4 biodiversity hotspots**. It is also one of **8 global food-crop diversity centres**, with forest services valued at **₹130 trillion annually**, sustaining rural livelihoods.
- Global food systems depend heavily on **rice, wheat, and maize**, providing over 50% of plant-based calories. This overdependence causes nutritional imbalances, higher vulnerability to climate, and rising NCDs.
- Indigenous crops like **millets, buckwheat, amaranth, jackfruit, yams, and tubers**, classified as **Neglected and Underutilized Species (NUS)** or **orphan crops**, are being revived.
- Over 50 years ago, **M.S. Swaminathan** envisioned an **Evergreen Revolution** based on **ecological balance and nutrition security**, not chemical intensification.
- **Megadiverse Countries:** Australia, Brazil, China, Colombia, DRC, Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, PNG, Peru, Philippines, South Africa, US, Venezuela.
- **4 Biodiversity Hotspots of India:** Himalayas, Western Ghats, Indo-Burma Region, Sundaland (includes Nicobar).
- **8 Global Food-Crop Diversity Centres** (Vavilov Centres identified by Nikolai Vavilov, these are primary centers of origin for major cultivated plants): China, India, Central Asia, Asia Minor (Near East), Mediterranean, Abyssinia (Ethiopia), Central America (Mexico-Guatemala), South America (Andean region).

### Biostimulants

- A **biostimulant** is a substance or microorganism that **stimulates plant processes** to improve nutrient uptake, growth, yield, quality and stress tolerance. Biostimulants are separate from fertilisers and are used mainly as a spray to enhance crop yield, quality and growth.
- Biostimulants are usually sold across the counter in **liquid form** and **sprayed on crops**.
- **Example: Protein hydrolysate** is a mixture of amino acids and peptides formed by breaking down proteins. Protein hydrolysates can be derived from plants such as soy or maize or from animal sources like feathers, hides or tissue.
- **Fertiliser (Inorganic, Organic or Mixed) (Control) Order (FCO), 1985:** Before 2021, biostimulants were sold freely in India with no specific rules governing their sale, safety and efficacy. In 2021, the Government brought them under the FCO, requiring companies to register products and prove safety and effectiveness.

### Women in Agriculture

**Why in news:** **UNGA declared 2026 as International Year of the Woman Farmer.**

- NFHS data puts female land ownership at **8.3%**.

#### Government Initiatives Supporting Women Farmers

- **Mahila Kisan Sashaktikaran Pariyojana:** skill enhancement and resource access.
- **Sub-Mission on Agricultural Mechanisation:** 50–80% subsidy on farm machinery.
- **National Food Security Mission:** 30% budget allocation for women farmers in several States and UTs.

#### ENACT Project

- Enhancing Climate Adaptation of Vulnerable Communities through Nature-based Solutions and Gender Transformative Approaches in Assam led by WFP and Govt. of Assam.
- Weekly agriculture and climate advisories sent via phones to 300+ farmers across 17 villages. Climate Adaptation Information Centres enable video conferencing, expert consultations, and weather advisories.
- Partnerships with agriculture departments, rural livelihoods missions, meteorology, and universities.
- Promotes flood-resistant rice, livelihood diversification, and market linkages.

### Prime Minister Dhan-Dhaanya Krishi Yojana

- **Cabinet** approved **PMDDKY** to boost **agricultural productivity** and promote **sustainable practices**. The scheme was **announced in the Union Budget 2025–26**. It is expected to **benefit 1.7 crore farmers** across the country.
- PMDDKY will **focus** on augmenting post-harvest storage at the panchayat and block levels, improving irrigation, and facilitating long-term and short-term credit.
- The **implementation** will be done through convergence of 36 schemes, State-level programmes, and private sector partnerships. Includes major schemes like PM-KISAN, PM Fasal Bima Yojana, and relevant State schemes.
- **100 districts** will be identified based on low productivity, low cropping intensity, and less credit disbursement. The scheme will benefit at least one district in each State/UT, with the number of districts per State based on Net Cropped Area and operational holdings. PMDDKY is modelled on the **Aspirational District Programme**.
- Progress to be tracked using **117 key indicators**, monitored monthly. Success depends on inclusion of States, local self-governments, PACS, agriculture universities, and farmer/trader organizations.

### Fisheries Sustainability

- **10 Indian marine and saline fish and shrimp varieties** are set to receive **Marine Stewardship Council (MSC)** certification soon. The **first batch** will be submitted for certification in **2026**.
- Experts estimate that the certification could increase the **revenue** of the fisheries sector by **30%**.
- Under the **Pradhan Mantri Matsya Sampada Yojana (PMMSY)**, the **Union Government** will subsidize the certification process, which is conducted by third-party auditors.
- **Sustainability** is a key aspect of India's fisheries, and while some fish varieties may not immediately qualify, many are amenable to certification. Certification will provide **access to premium markets** and ensure **better prices**.
- Certification is based on the **FAO Code of Conduct for Responsible Fishing** and **Guidelines for Eco-labelling** of fish.
- Marine Stewardship Council (MSC) certification is a global gold standard for sustainable, **wild-capture fisheries**. NGO was founded by WWF and Unilever. Products with the "**Blue Fish**" label guarantee the seafood was caught using sustainable methods. **Ashtamudi Lake Short-neck Clam (Kerala)** was India's first fishery to receive certification.

### Terrace cultivation

- It is also known as **step farming**, and is practiced, for example, in **Senapati district of Manipur**. An **ancient agricultural technique** of growing crops on hills or mountains by cutting the slope into flat platforms or steps called terraces.
- It **prevents soil erosion** and **surface runoff** by reducing the slope gradient and allowing water to be **retained and absorbed**, conserving **soil moisture and nutrients**. It **increases cultivable area** on hilly or mountainous terrain.
- Types of terraces include **bench terraces**, **contour terraces**, and **broad-based terraces**, each suited for different **slope gradients** and **crop requirements**.
- Terrace farming promotes **sustainable agriculture** by improving **soil fertility**, controlling **water flow**, and supporting crops like **rice, wheat, barley, and vegetables** in hilly areas.

### CIMMYT

- **Norman Borlaug** ushered in **India's Green Revolution** through his high-yielding, semi-dwarf wheat varieties such as Lerma Rojo 64A, Sonora 63, Sonora 64 and Mayo 64.
- **International Maize and Wheat Improvement Center (CIMMYT)**, headquartered in **Mexico**, is seeking financial support from the Indian government and private sector.
- CIMMYT works on **wheat and maize**, which together **cover over a quarter of the world's cropped area**. It is facing **fund crunch** due **shutting down** of **USAID**. CIMMYT's **research and field trials** focus on **raising yields** and **breeding varieties** with **heat tolerance**, **disease resistance** and **biological nitrification inhibition (BNI) traits**.
- **Wheat** is prone to **yield losses** from **mercury spikes**. Studies show every **1°C rise in night temperatures** lowers **wheat yields** by an **average of 6%**.

- The early Green Revolution blockbuster varieties in India were developed through selections from CIMMYT materials, including Kalyan Sona (1967), Sonalika (1968) and PBW 343 (1995).
- In 2011, CIMMYT established the Borlaug Institute for South Asia (BISA) as a joint venture with ICAR. BISA has three research stations at Ludhiana (Punjab), Jabalpur (Madhya Pradesh) and Samastipur (Bihar).
- CIMMYT has opened a "doubled haploid" facility for maize at Kunigal (Karnataka) with the University of Agricultural Sciences, Bangalore. This first-of-its-kind facility in Asia produces genetically pure inbred lines of maize for further crossing and breeding of hybrids by public institutions and private seed companies.

### World Food Prize

**Why in news:** Brazilian microbiologist Mariangela Hungria has been awarded the **2024 World Food Prize** for her work on **biological alternatives to chemical fertilizers**. The **World Food Prize** is awarded by the **Iowa-based World Food Prize Foundation** and carries a **\$500,000 reward**.

- She worked with **Brazilian farmers** to implement these **natural nitrogen-enriching methods** to maintain high yields without chemical fertilizers. Her research helped boost yields of **wheat, corn, and beans**, with especially strong results in **soybeans**, making **Brazil the world's largest soybean producer**.
- **Norman Borlaug**, Nobel Peace Prize winner in 1970, **founded the World Food Prize**, which has honoured **55 individuals since 1987**.
- Ms. Hungria's method involves **soil bacteria interacting with plant roots** to naturally produce nitrogen, reducing **greenhouse gas emissions and water pollution**. In contrast, **U.S. soybean farming** requires less intervention due to **residual nitrates from corn**, making her method less applicable there.

### M.S. Swaminathan

- **Immunisation programme** and the **Green Revolution led by M.S. Swaminathan** were key reasons for the **fall in India's death rate**, said **Gopalkrishna Gandhi**.
- The Man Who Fed India, **biography of Dr. Swaminathan** by **P. Jayakumar** was launched.
- Moved by the **Bengal famine (1942-43)**, he shifted from **medical science to agriculture**.
- He chose **genetics and plant breeding** because **a good variety benefits both small and large farmers**.

- In **1954**, he joined the **Central Rice Research Institute, Cuttack**, working on **gene transfer from Japonica to Indica rice varieties** for higher yield.
- He stressed the need for **semi-dwarf varieties responsive to fertilisers**, unlike traditional tall varieties that **lodged under heavy grain load**.

Revolution	Sectors
White Revolution	Operation Flood, launched in 1970, ushered in the White Revolution and transformed the dairy sector in India.
Yellow Revolution	Launched in the early 1990s to achieve self-sufficiency in Oilseed production
Blue Revolution	Launched in 2015-26, it aims to transform the Fisheries sector
Black Revolution	Self-sufficiency in the crude/petroleum sector
Golden Revolution	Increase in the production of honey and horticulture
Silver Revolution	Launched in the 1970s and 1980s to increase egg production and the growth of the poultry sector

- His experiments with **mutagenesis** failed, leading him to collaborate with **Orville Vogel** and **Norman E. Borlaug**.
- With Borlaug's help, **Mexican dwarf wheat varieties ('Lerma Rojo', 'Sonora-64')** were bred with **Japanese varieties** in India. By **1963-68**, this resulted in the **"Wheat Revolution"**. **1968 wheat harvest** success enabled phasing out of **PL 480 imports**. Later, **overuse of water and fertilizers** caused environmental concerns.
- Swaminathan also worked on **mangrove restoration** and **coastal land preservation in Odisha (1994-2006)**.
- In **1999**, he introduced **trusteeship management of biosphere reserves**.

- He implemented the **Gulf of Mannar Biosphere Reserve Trust** with support from the **Global Environment Facility**. After the **2004 Indian Ocean tsunami**, he advised **mangrove plantation along shorelines** to reduce disaster impact.
- As head of **National Commission on Farmers**, he recommended **MSP = cost of production + 50% margin**.
- India lags behind: **China has 8 agri-research institutes in world top 10**, India none in top 200.
- **Funding**: India spends 0.43% of agri-GDP on R&D, half of China's level.

### Farmer Suicides

- **NCRB** reported that **10,786 farmers and agricultural workers committed suicide in 2023**.
- The **highest number of cases** were from **Maharashtra (38.5%)**, followed by **Karnataka (22.5%)**.
- **Farm suicides accounted for 6.3%** in the country in 2023.
- **Andhra Pradesh (8.6%), Madhya Pradesh (7.2%), and Tamil Nadu (5.9%)** recorded **high numbers**.
- West Bengal, Bihar, Odisha, Jharkhand, Himachal Pradesh, Arunachal Pradesh, Goa, Manipur, Mizoram, Nagaland, Tripura, Chandigarh, Delhi, and Lakshadweep reported **no farm suicides**.

### Pulses Self-Reliance Mission

- **PM** launched **Pulses Self-Reliance Mission**, worth **over ₹11,000 crore**, seeks to **expand pulse cultivation by 35 lakh hectares**, directly benefitting **around 2 crore pulse farmers**.
- India produced **252.4 lakh tonnes** of pulses in **2024-25**, yet procurement of notified pulses at **MSP** fell substantially in the last two years. The country imported **₹1.2 lakh crore** worth of **edible oil** and **₹30,000 crore** worth of **pulses** in **2023-24**. About **55%** of edible oil demand is met through imports.
- The Prime Minister urged farmers to **go beyond wheat and rice**, emphasising the importance of **protein-rich crops** like **pulses** for addressing **India's nutritional needs**, especially for children and vegetarians.
- India still **imports large quantities of pulses**, making **self-reliance in pulse production** crucial.
- It aims to eliminate India's import dependency on pulses by 2027. **Target**: Increase production to 325 Lakh Tonnes by 2027 (India is currently the world's largest producer, consumer, and importer of pulses).
- **Focus Crops**: Tur (Arhar), Urud, and Masur (Lentils), as India is mostly self-sufficient in Chana (Gram) and Moong.
- **Strategy**: Expanding area under cultivation (especially in rice fallows and inter-cropping) and increasing productivity through HYV. **Procurement**: The government (via NAFED and NCCF) offers assured procurement at MSP for farmers who register on the E-Samridhi Portal for Tur and Masur.
- **Seed Hubs**: Setting up over 150 Pulse Seed Hubs through ICAR to provide quality climate-resilient seeds.

### Tractor Exports

- **India is emerging as a leading global tractor supplier**, with exports worth \$1.15 billion reaching 162 countries in 2024-25. However, growing export volumes have led to increasing environmental externalities.
- An analysis by the International Council on Clean Transportation (**ICCT**) found that **emissions from tractors** and other non-road equipment in India are projected to surpass those from road vehicles by 2030.
- India's **adoption of Bharat Stage (TREM) IV standards** for agricultural tractors in 2023 cut particulate emission limits by up to 94%, nearly matching U.S. and EU norms. By **April 2026**, the **Bharat Stage (TREM) V standards** will align most Indian tractors with U.S. Tier 4f and EU Stage V requirements.
- **Tractor exports to Belgium surged** following the **implementation of TREM IV norms**. Also expanding in **markets without emission norms**, such as **Bangladesh, South Africa, and Thailand**.

- An expert committee appointed by the Centre recommended 'Tractor Emission Norms (TREM) Stage V' from October 1, 2026. Farmers' outfits urged the government not to treat tractors as commercial vehicles. They said stricter emission norms should apply only to tractors above 70 horsepower (HP), which are often used for non-agricultural purposes.

### Paddy Procurement

- The State government has requested the Centre to relax the permissible moisture content for paddy procurement from 17% to 22% due to recent rainfall. Lower moisture prevents the grain from heating up and rotting in silos.
- **Milling Yield:** Ideally, for the best Out Turn Ratio (OTR)—which is 67% for raw rice—the moisture should be controlled to prevent the grains from breaking during de-husking.
- Under the **Decentralised Procurement Scheme (DCP)** of the Union Ministry, State governments procure paddy and wheat on behalf of the Centre. States are also responsible for storing and distributing the grain in accordance with the Centre's food policies. The Union government bears the full cost of procurement and is responsible for monitoring the quality of foodgrains procured. Farmers are paid MSP fixed by the Central government.
- Since procurement follows **Central norms, State governments must comply with specified quality and moisture standards. Centre can relax quality norms** if a State requests it due to **uncontrollable factors such as rainfall**. In the past, such relaxations have been granted to **Andhra Pradesh and Punjab**.

### Madhya Pradesh

- MP government has sought Centre's permission to withdraw from DCP scheme due to growing financial strain from wheat and paddy purchases. CM has requested that the State be allowed to **return to the Centralised Procurement Scheme** through the FCI.

### PLISFPI

- PM inaugurated 11 food processing projects worth ₹808 crore under **PM Kisan Sampada Yojana** and **PLISFPI**.
- **Production Linked Incentive Scheme for Food Processing Industry** is a Central Sector Scheme aimed at creating "Global Food Manufacturing Champions" under Ministry of Food Processing Industries (MoFPI) from 2021-22 to 2026-27. Managed through a Project Management Agency (PMA), which is currently IFCI Limited.
- **Viksit Krishi Sankalp Abhiyan**, a nationwide campaign celebrating **India's progress in agriculture**.

### Herbicides

- Reports of **dwarfing disease in rice** caused by the **white-backed plant hopper** have been observed in **Punjab and Haryana** during the current **kharif season**. **Crop protection chemicals** are commonly known as "**pesticides**".
- The **white-backed plant hopper** feeds on **rice plants** and spreads **Fiji virus disease**, causing **stunted growth (dwarfing disease)**. Insect injects **virus while sucking sap from young plants**.
- Pesticides also include **fungicides** for fungal diseases like **blast, sheath blight in rice, powdery mildew, rusts in wheat**. They include **herbicides** to kill or inhibit growth of **weeds**. **Herbicide market** is growing at **highest rate – over 10%**.
- **Weeds**, unlike **insect pests** and **disease-causing pathogens**, don't directly damage crops but compete for **nutrients, water and sunlight**. **Yield losses** occur because crops are deprived of these essential resources.
- Weeds sometimes **harbour pests and pathogens**, causing further harm. **Weed control** has traditionally been done through **manual removal by hand** or with **lightweight short-handled tools** like the **khurpi**.
- There are also **power weeders** with **3-10 horsepower engine capacity** used between rows of standing crops to remove weeds.

### Fake Fertilizers

- Sale of counterfeit or substandard fertilizers is prohibited under **Fertilizer (Control) Order, 1985**, under **Essential Commodities Act, 1955**. States directed to **stop forced tagging** of **nano-fertilizers or biostimulants** with **conventional fertilizers**. **Permission to sell biostimulants** cannot be given if farmers are **not benefitting** from them.
- **Biostimulants** stimulate physiological processes in plants and help enhance the yield from a harvest. Plant-derived waste materials and seaweed extracts are sometimes used in biostimulant production.
- The **Fertiliser (Inorganic, Organic or Mixed) (Control) Order, 1985** regulates the **manufacturing and sale of biostimulants**. Biostimulants are defined as substances or microorganisms that **enhance nutrient uptake, growth, yield, crop quality, and stress tolerance** in plants.
- Biostimulants **do not include pesticides or plant growth regulators**, which are regulated under the **Insecticide Act, 1968**. As they did not fall under fertiliser or pesticide categories, **biostimulants were sold without government approval** for a long time. **Fertilisers are governed by the 1985 Fertiliser Control Order** and **pesticides by the Insecticides Act, 1968**. The **Union Ministry of Agriculture and Farmers' Welfare** issues the **FCO** under the **Essential Commodities Act, 1955**, and updates it as needed.

### Fertilizer Prices

- India is preparing for **higher fertilizer prices** ahead of the crucial **rabi (winter) crop season** after **China suspended exports of urea and specialty fertilizers**. Suspension covers **specialty fertilizers** like **TMAP (Technical Monoammonium Phosphate)** and **Urea-solution products like AdBlue**, **conventional fertilizers** such as **DAP and urea**.

### Fertilizer Effects

- **Unscientific use of fertilizers and climate change** are contributing to **degradation of organic carbon**. When **organic carbon is low**, **deficiency of micronutrients** in soil is high, and when **organic carbon is high**, the deficiency is low.
- **Organic carbon is highly correlated with elevation** — higher elevation means **higher organic carbon**.
- **Organic soil carbon is negatively correlated with temperature** — regions like **Rajasthan and Telangana** with high temperatures have **low organic carbon content**.
- **Temperature, rainfall and elevation** are the three important factors determining **organic carbon concentration**.
- **'Agri-ecological base' map** to assess the impact of cropping systems and fertilizer use on organic carbon. The map can help in policy decisions, particularly for carbon credit and assessing land degradation.
- **Haryana, Punjab and parts of western UP** have intensified fertilizer application skewed towards **urea and phosphorus**, which has **negatively impacted organic carbon** in the soil.

- **India's urea consumption** is set to touch **40mt** due to **surplus monsoon-induced demand** and **MRP remaining unchanged for over a decade** due to **government making neem coating mandatory** for all urea (**2015**).
- **Neem coating** was expected to enable gradual release of 46% nitrogen, improve nutrient use efficiency, reduce bags per acre, and curb illegal diversion. **Neem coating**, 45-kg bags (2018) and Nano Urea launched in 2021 have not lowered consumption after 2017-18. **Urea is India's most widely used fertiliser**.
- There are **two concerns** over **rising urea consumption**: The **first concern is imports**. Even domestically-manufactured urea uses natural gas as feedstock, which is mostly imported. India's consumption of urea is second only to China's 51 mt, with China's production largely coal-based.
- The **second concern is NUE**. Barely 35% of the nitrogen (N) applied through urea is utilised by crops to produce yields. The remaining 65% N is lost through ammonia release or leaching after conversion into nitrate. Declining NUE has led farmers to apply more fertiliser for the same yield.
- **India cannot sustain** the increase in consumption of **urea, DAP, muriate of potash** and other fertilisers containing only **primary nutrients (N, P, K)**. Fertilisers must be **coated with secondary nutrients (S, calcium, magnesium)** and **micronutrients (zinc, boron, manganese, molybdenum, iron, copper and nickel)**.

### Food Systems – Emissions

- The **EAT-Lancet Commission on Healthy, Sustainable, and Just Food Systems** report highlights that food systems drive five of the six breached planetary boundaries. **Food production** accounts for about **30% of GHGs**.
- **Foods from animals** contribute the **major share of agricultural emissions**, while **grains dominate nitrogen, phosphorus, and water use**.
- **India's cereal-heavy diet** needs to evolve to include more vegetables, fruits, nuts, and legumes to meet sustainability benchmarks by 2050. **Supply-side reforms** are crucial to address **water stress, soil degradation, and dependence on fossil fuels in cold chains and food processing**.

### Draft Seeds Bill

- After two failed attempts in **2004** and **2019**, the Union government has introduced a **new draft Seeds Bill**.
- The proposed legislation aims to **replace the Seeds Act, 1966** and the **Seeds (Control) Order, 1983**.
- Seeks to **regulate seed quality**, ensure farmers' access to **high-quality seeds at affordable rates**, protect farmers from losses, and **liberalise seed imports** to promote access to global varieties.
- Proposes to **decriminalise minor offences**, promoting **ease of Doing Business** and reducing compliance burden.
- **Every seed dealer must obtain a registration certificate** from the State government before selling, importing, exporting, or supplying any seed.
- Mandates regulation of seed sales so that seed varieties **meet minimum standards of germination, genetic purity, physical purity, traits, seed health**, and other norms as per the **Indian Minimum Seed Certification Standards**.
- Establishes **27-member Central** and **15-member State seed committees**. Central committee can recommend **minimum limits of germination, genetic and physical purity, traits, seed health** and additional standards. State committee can advise on **registration** of seed producers, processing units, dealers, distributors and nurseries.
- The **Indian seed industry** was built on a **strong foundation in the 1960s** with the establishment of the **National Seeds Corporation**, and boosted by **enabling policies and regulatory support** from the **late '80s**.
- The **Protection of Plant Varieties & Farmers Rights Act, 2001**, and the release of Bt cotton hybrids in 2002, were important milestones towards a technology-driven seed sector, boosting industry growth and farm productivity.
- **1966 legislation** was enacted during **Green Revolution**, when **private seed industry** was **minimal**. High-yielding wheat and paddy varieties, developed by ICAR institutes and SAUs, made India self-reliant in cereals by the 1980s.
- **Public sector institutions** continue to dominate breeding of wheat, paddy (including basmati), sugarcane, pulses,

soyabean, groundnut, mustard, potato, onion, and other crops grown as open-pollinated varieties (OPV). OPVs allow farmers to save grain as seed for re-planting.

- **Current Seeds Act** applies only to **notified varieties**. Seeds of **non-notified varieties or hybrids** cannot be **certified**.
- Most **private hybrids** are neither **"notified" nor "certified"**, as they are not officially **released**. These seeds are **"truthful labeled"**, where companies state **minimum germination, genetic purity, and physical purity** parameters.

### Crop Loss Norms

- **Agriculture Ministry** recognised modalities for covering crop loss due to **wild animal attacks** and **paddy inundation** under the **Pradhan Mantri Fasal Bima Yojana**. Crop loss due to **wild animal attacks** will be recognised as the **fifth 'Add-on Cover'** under the **'Localised Risk' category**.
- **States** will notify the list of **wild animals** responsible for crop damage and identify **vulnerable districts or insurance units** based on **historical data**. **Farmers** will be required to report losses within **72 hours** using the **Crop Insurance app** by uploading **geotagged photographs**.

### Pradhan Mantri Fasal Bima Yojana

- **Capped Premiums:** Farmers pay only 1.5% to 2% for food grains and 5% for commercial crops.
- **End-to-End Coverage:** Protects against sowing failure to post-harvest losses and wild animal attacks.
- **Tech-Led Audits:** Uses satellite imagery (YES-TECH) and AI for instant, unbiased damage assessment.
- **72-Hour Window:** Localized losses must be reported within 72 hours via the mobile app for claim eligibility.
- **Guaranteed Payouts:** Features a 12% interest penalty for late payments to ensure farmers get paid on time.

### Plant Varieties Act

- A committee headed by eminent agriculture scientist **R.S. Paroda**, appointed by the **Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA)**, has started **stakeholder consultations** on the amendments.

### PDS

- **Anna Sahayata Holistic AI Solution (ASHA)**, an **AI-based platform** allowing beneficiaries to share feedback through **AI-enabled calls** in their preferred language. Through ASHA, beneficiaries can report whether they **received full entitlement**, the **quality of foodgrains**, and any **difficulty at Fair Price Shops**.
- The system uses **multilingual translation, sentiment analysis, automated grievance categorisation, and real-time dashboards** for administrators.
- ASHA reaches **20 lakh beneficiaries monthly**, developed with the **Wadhvani Foundation** and backed by the **India AI mission** via **Bhashini's multilingual AI infrastructure**.
- **CWC's new enterprise resource planning platform 'Bhandaran 360'**, integrates **41 modules** covering HR, finance, marketing, warehouse management, contract management, project monitoring and other core functions.
- **'Smart EXIM Warehouse System'** for container freight stations and general warehouses.
- **ANNA DARPAN, microservices-based platform** replacing the existing **Depot Online System**, was also launched.

### Natural Farming

- **South India Natural Farming Summit 2025** was conducted by farmers' associations to propagate the ideals of **G. Nammalvar**, the late organic farming scientist. Organized by **Tamil Nadu Natural Farming Stakeholders Forum**; linked to **national schemes** like **BPKP (Bharatiya Prakritik Krishi Paddhati)** and **PKVY (Paramparagat Krishi Vikas Yojana)**.
- The **National Mission on Natural Farming**, initiated last year, has had its effect on **lakhs of farmers**.

### From Last Year's Compilation

- FM announced that one crore farmers will be initiated into natural farming over the next two years. The initiative will be supported by certification, branding, scientific institutions, and gram panchayats, with 10,000 bio-input resource centres to be established. The scheme is part of the **National Mission on Natural Farming (NMNF)**, aimed at motivating farmers to adopt chemical-free farming.
- **Natural farming excludes the use of chemical fertilizers and pesticides**, promoting biomass recycling, mulching, cow dung-urine formulations, and pest management through diversity. Natural farming can enhance farmers' income, restore soil fertility, improve environmental health, and mitigate greenhouse gas emissions. Study found improved crop yields, farmers' incomes with lower biological input costs, increasing food security. There is a need for rigorous scientific studies on crop yields before large-scale implementation.

### Food Colouring

- **Chemical adulteration in food**, particularly through the use of **non-permitted synthetic dyes**. One of the most persistent among them is **auramine O**, a bright yellow industrial dye **banned under Indian food safety regulations**.
- It is a **synthetic yellow dye** used in **textile and leather processing, printing inks, paper manufacturing, and microbiological staining procedures**. It is **not approved for use as a food colour in India**.
- Research links its ingestion to **liver and kidney damage, enlargement of the spleen, mutagenic effects, and potential carcinogenic outcomes**.

### International Treaty on Plant Genetic Resources for Food and Agriculture

- **Scientists for Genetic Diversity** expressed concern over the “**compromise proposal**” at the **11th session of the governing body (GBII)** of the **International Treaty on Plant Genetic Resources for Food and Agriculture**.
- **GBII** held in **Lima, Peru**. The proposal relates to **enhancing the functioning** of the **Multilateral System on Access and Benefit Sharing (MLS)**, including a **revised Standard Material Transfer Agreement (SMTA)**.
- **Mandatory payment schedules and rates** for genetic resource use were **shelved** to **GB12**.

### Animal Blood Bank Network

**Why in news:** Department of Animal Husbandry has released draft **Guidelines for Blood Transfusion & Blood Bank for Animals** in India to formalise and standardise veterinary blood banking and transfusion practices.

- India's livestock population is 536.76 million (20th Livestock Census, 2019). India has the **world's largest cattle and buffalo population** and the **second-largest goat population**.
- **Animal husbandry and dairying sector** contributes about **30% of agricultural GVA** and **5.5% of national economy**.
- India lacks a national regulatory framework and standardised protocols for veterinary transfusion medicine.
- The draft **prohibits monetary incentives** for animal blood donation by pet or livestock owners.
- The **blood volume in humans and animals** ranges between **7% and 9% of body weight**. Transfusion is required when blood volume falls below this level. Like humans, animals have multiple blood groups based on species-specific antigens on red blood cell membranes. Number of blood groups: Cattle – 11, Dogs – 9, Horses – 8, Cats – 4.

## SCIENCE & TECHNOLOGY

### Solar System and Celestial Bodies

#### GRAIL

**Why in news:** The **earth's moon is tidally locked**, meaning **one side always faces the Earth** and the other always faces away. **Far side of the moon looks very different** from the near side. NASA's **GRAIL mission** reported **month-on-month changes in the moon's gravity** due to **tides on Earth (Tidal Pull of Earth)**.

- **Tidal deformation:** Gravitational pull from Earth causes Moon to deform slightly.
- **Monthly changes:** GRAIL measured how this deformation causes shifts in Moon's gravitational field.
- Moon's **near side is warmer, softer, and slightly molten**.
- Scientists predicted a **temperature difference of 100–200°C between the hemispheres**.
- Models suggest a **partly molten layer of rock 800–1,250 km beneath the near side** surface. This molten layer may have **erupted long ago to form dark lava plains** on the near side.
- The **far side crust is thicker**, possibly **preventing magma from reaching the surface**.
- These findings contribute to understanding why the **moon is Janus-faced**, with two contrasting sides.

- **GRAIL** stands for **Gravity Recovery and Interior Laboratory**, a **NASA lunar science mission** launched in **2011**.
- The mission consisted of **two twin spacecraft**, named **Ebb and Flow**, which orbited the **Moon in tandem**.
- Its primary objective was to **map the Moon's gravitational field** to study its **internal structure and geological history**.
- **GRAIL** revealed that the **Moon's crust is more porous and thinner** than previously believed.
- It discovered **linear features called “dikes”**, suggesting the Moon experienced **slight expansion early in its history**.
- Mission helped explain **Moon's nearside-farside asymmetry**, linking it to **tidal deformation & gravitational variations**.
- It used a **gravity-mapping technique** similar to NASA's **GRACE Earth mission** and provided **vital data for future lunar research**.

#### Moondust

- **Moondust** poses health concerns similar to urban dust; astronauts during the **Apollo missions** reported **eye and lung irritation**. Lunar dust is **statically charged**, making it stick to surfaces easily.
- Researchers tested dust impact on **bronchial and alveolar lung cells**, which handle **air passage** and **oxygen exchange** respectively. **Larger lunar dust particles** were **toxic & inflammatory** only at **very high concentrations**. **Smaller particles** of moondust were found to be **less toxic to bronchial cells** than Earth's **PM2.5**.
- However, both **moondust and Earth dust killed alveolar cells**, showing significant health risks.
- With **NASA's Artemis II** scheduled for **2026**, understanding moondust is crucial for **designing safe lunar habitats**.

#### Lunarcrete

- It is an **umbrella term** for **concrete made on the moon**, being explored as the **US and China** race to establish **long-term lunar settlements** to protect people from **radiation** and **extreme temperature swings**.
- **Lunarcrete** uses **lunar regolith** as its **main aggregate**, instead of **sand and gravel**.

- A key **challenge** is the **binder**, since **Portland cement** requires **large amounts of water**, which is **scarce on the moon**. **Researchers** are exploring **binders that minimise or eliminate water use**.
- Another option is **sulphur lunarcrete**, where **sulphur is melted**, mixed with **regolith**, and allowed to **cool into a solid**. **Sulphur** can act like **cement without water**, but it **softens at high temperatures**.
- A third approach involves **heating regolith** with **microwaves or concentrated sunlight** so grains **melt and fuse into bricks**. When exposed to **120°C to -130°C**, the **walls maintained an internal temperature of 22°C**. **Double-layer lunarcrete walls** with an **empty space in between** were found to be **excellent insulators**.

### Lunar Fission Surface Power Project

- **US** plans to deploy a **small nuclear reactor on the Moon** by the **early 2030s**, marking the **first permanent nuclear power source beyond Earth orbit**.
- **Solar power limitations** due to **two-week-long lunar nights** and **low sunlight at the poles** make **energy independence** crucial for a **sustained Moon and Mars presence**, increasing the importance of **nuclear power**.
- While **radioisotope thermoelectric generators (RTGs)** have powered deep-space missions, their **low power output** is insufficient for **human habitats and industrial activity**.
- **Martian regolith** can offer **natural radiation shielding** for buried reactors.
- The existing legal framework, based on the **1992 UN Principles on Nuclear Power Sources in Outer Space**, is **non-binding**, focuses mainly on **RTGs and electricity generation**, and leaves **governance gaps** for **nuclear propulsion systems and environmental protection**.
- **Russia** plans to put a **nuclear power plant on the moon** in the **next decade** to supply its **lunar space programme** and a **joint Russian-Chinese research station**.

### Moon Day

- **International Moon Day** is celebrated every year on **July 20** to commemorate **first moon landing by Apollo 11 in 1969**. **UNGA recognised** this date in **2021**, based on a proposal from **Committee on Peaceful Uses of Outer Space**.

### Supermoon

- Occurs when a **full moon or new moon** coincides with the **moon's closest approach to Earth** in its **elliptical orbit**, known as the **perigee**. When the moon is near **perigee** and **directly opposite the sun**, the **full moon appears 14% larger and 30% brighter** than at its farthest point — creating a **supermoon**.
- The term '**supermoon**' was **popularised by astrologer Richard Nolle in the 1970s**.
- The **enhanced brightness** makes the moon appear **more vivid**, especially **low on the horizon**.
- **Supermoons influence ocean tides**, causing **perigean spring tides**, where **high tides are higher and low tides are lower** than normal. These **tide variations** can **worsen coastal flooding** when combined with **storm surges**.

### Blood moon

- During this event, the **moon appears dark red or copper-coloured** due to a phenomenon called **Rayleigh scattering**.
- In a **total lunar eclipse**, the earth comes between the sun and the moon, blocking direct sunlight from reaching the lunar surface. However, **not all sunlight is blocked** — the blue light is filtered out, and the **red light is scattered by the earth's atmosphere**, giving the moon its **reddish hue**.
- **Rayleigh scattering** occurs when **light interacts with particles smaller than its wavelength**, causing **shorter wavelengths (blue light)** to scatter more strongly. This is also the **reason Earth's sky appears blue**, as blue light has the **shortest wavelength in visible light**.
- During a **blood moon**, **earth's atmosphere absorbs blue light** while **refracting red light** toward **moon's surface**.
- The **exact shade of red** during the blood moon **depends on dust and smoke levels** in the **earth's atmosphere**.

### Theia

- Researchers studied **Theia**, body that **hit Earth to form Moon**, by measuring **differences in iron isotopes** in **lunar rocks, Earth rocks, meteorites**. Iron isotope data were compared with **zirconium and molybdenum** measurements.
- **Earth's and the Moon's iron isotope compositions** were found at one end of a range defined by **meteorites from the inner solar system**. **Theia probably formed closer to the Sun** than most material that built the **Earth**.

### Solar Flares & CMEs

- **Solar flares, coronal mass ejections (CMEs), and energetic storms** create **space weather** that affects **satellites and astronauts**, disrupting **communications, navigation, and power grids** on earth.
- **CMEs** are sudden discharges of a large amount of plasma from the sun's corona. Solar wind is a continuous outflow of charged particles from the corona. A **solar flare** is a massive explosion triggered by the rapid release of energy from twisted magnetic fields above sunspots, generating radiation across the electromagnetic spectrum.
- Predicting solar flares is difficult due to limited knowledge of how **magnetic fields emerge**.

- In **2023**, ISRO launched **Aditya-L1**, India's first solar observatory. Aditya-L1 is stationed 1.5 million km from earth at Lagrange point 1 (L1). L1 lies on the sun-earth line, detecting eruptions moving towards earth.
- **Lagrange points** are positions where gravitational forces between two bodies balance orbital motion, allowing spacecraft to hover with minimal fuel.
- **L4** is 60° ahead of earth's orbit and **L5** is 60° behind, allowing observation of solar regions before they rotate towards earth. L4 and L5 are 30 million km from earth, complicating data transmission.
- The upcoming project is the **National Large Solar Telescope**, whose size makes it unsuitable for **space deployment**.
- India has recently **opened its space sector** to private companies.

- **Astronomers detected the first-ever CME from a star other than the Sun.** Discovery used data from the **LOFAR European radio telescope network**.
- CME originated from a **red dwarf star (StKM 1-1262)** about **133 light years away** and lasted **around one minute**. The explosion was at least 10,000 times more powerful than known solar storms.
- **Red dwarf stars**, common hosts of **Earth-sized exoplanets**, appear to have **more violent and erratic magnetic activity** than the Sun. The finding opens a **new field of "space weather" studies for other star systems**, with major implications for **planetary habitability and life beyond Earth**.

### Temperature of Planets or Stars

- **Astronomical temperatures** are usually measured using **spectroscopic methods**. The **spectroscope was invented in 1859** by **Robert Bunsen and Gustav Kirchhoff**.
- It was first used to analyse elements in substances heated to **incandescence**, each element emitting characteristic wavelengths of visible light. Bunsen discovered caesium and rubidium using this device.
- Over time, scientists **refined star classification** based on spectral analysis. Today, astronomers use the **entire electromagnetic spectrum (X-rays, infrared, etc.)**, not just visible light, for such studies.

### Star Catalogue

**Why in news:** The **Shi's Star Catalogue** is **China's and World's oldest star catalogue**.

- Researchers identified **two observational periods**: around **355 BC** and **125 AD**.
- The original observations date to the **'Warring States' period** in China's history.
- Updates were likely added during the **Eastern Han dynasty**, possibly during the time of **Zhang Heng**.

### Stars Structure

- Astrophysicists have described **massive stars** as having **nested shells** of fusion: hydrogen, helium, carbon-oxygen, neon-magnesium, silicon-sulphur, ending in an **inert iron core**. This **stellar shell model** is a **cornerstone of stellar evolution theory** but has mostly remained **theoretical**.
- Researchers observed **supernova SN 2021yjf**, whose light showed **silicon and sulphur signatures**. Silicon and sulphur form only in the inner shells near the **iron core**, confirming the **concentric shell structure extends inward**.
- It also marks discovery of a **new class of supernova – Type Icn**, defined by **silicon- and sulphur-rich signatures**.

### Star HOPS-315

- When **rocky worlds like Earth** began to form, dust in the **young Solar System** first **heated until it vaporised** and then cooled so that **refractory minerals** could crystallise.
- Researchers studied **star HOPS-315** in **Orion**, whose **protoplanetary disc** was tilted enough for Earth-based observation, and saw **rock vapour cool and crystallise**. A protoplanetary disc is a rotating, pancake-shaped mass of gas and dust around a newborn star where dust grains stick and grow into rocks, planets, moons, and atmospheres.
- Observations were conducted by **NASA's James Webb Space Telescope (JWST)** and **ALMA observatory in Chile**.

### Asteroid YR4

**Why in news:** Scientists used **ATLAS telescope in Chile** to discover **asteroid 2024 YR4**, a **near-Earth asteroid** posing a potential Moon impact threat in 2032. **YR4 is 65 m wide**, smaller than the 140 m threshold for "potentially hazardous".

- **The asteroid's Torino rating** (method for categorizing the impact hazard associated with near-Earth objects such as asteroids and comets) was downgraded from **3 to 0**, indicating no threat to Earth.
- A lunar impact would **create a 500–2,000 m wide crater** and release energy **340 times that of the Hiroshima bomb**, but **won't affect the moon's orbit**.
- **Asteroids are tracked using automated sky surveys**, and their orbits are modeled to assess **impact probability** using tools like the **NASA Sentry system**. Scientists stress **asteroids are the only preventable natural disaster**, though large impacts could **disrupt Earth's climate for years**.

### Space Object – ASKAP J1832-0911

**Why in news:** Scientists have discovered a **mysterious object** named **ASKAP J1832-0911** in the **Milky Way**, approximately **15,000 light years** from Earth. It was first detected by **NASA's Chandra X-ray Observatory**.

- ASKAP J1832–0911 belongs to the class of “long period radio transients” (LPTs), which emit intense radio waves over tens of minutes. LPTs emit radio pulses every few minutes or hours and were first identified in 2022.
- Although around 10 LPTs have been found so far, ASKAP J1832–0911 is considered unique among them.

### Space Object – 3I/ATLAS

- Scientists using the **ATLAS survey telescope in Chile** reported the discovery of a space object named **3I/ATLAS**.
- The object was identified as **interstellar** based on its **highly elliptical orbit** and **velocity of 57–68 km/s relative to the sun**. Its path was found to **trace back to the constellation Sagittarius**.
- **NASA confirmed** that **3I/ATLAS poses no threat to Earth**.
- Its **rich water ice content** and **ancient origin** offer opportunity to study **primordial material from another star system**.

### Andromeda vs Milky Way

**Why in news:** The **Milky Way–Andromeda collision** might not happen, with a **50–50 chance within the next 10 billion years**, lower than earlier predictions.

- The **sun**, already **4.5 billion years old**, is expected to **die in about 5 billion years**, engulfing **Mercury, Venus, and possibly Earth**, leaving Earth as a **burnt ball**. The team used data from **NASA’s Hubble Space Telescope** and **ESA’s Gaia spacecraft** to simulate future galaxy scenarios.
- **Milky Way and Andromeda** have both collided with other galaxies in the past. Earlier theories predicted their collision in **about 5 billion years**, forming galaxy called **Milkomeda**.
- The **Triangulum galaxy** increases the merger chances, while the **Large Magellanic Cloud** reduces them.

### Alaknanda

- **Astronomers from India** discovered the **second farthest spiral galaxy** using the **James Webb Space Telescope (JWST)** and named it **Alaknanda**. **Milky Way** is called **Mandakini** in **Hindi** and is also a **spiral galaxy**.
- Team plans further studies using the **Atacama Large Millimeter/submillimeter Array in Chile**.

#### James Webb Space Telescope (JWST)

- **NASA** led its development with the **European Space Agency** and **Canadian Space Agency**. It was launched aboard a rocket in **2021**. It examines **every phase of cosmic history**: from the **Big Bang** to the formation of **galaxies, stars, and planets** to the evolution of our own **Solar System**.
- The science goals for the **Webb** can be grouped into **four themes**:
  - Look back **13.5 billion years** to see **1st stars and galaxies** forming out of the **darkness of the early universe**.
  - Compare **galaxies** to today’s **grand spirals** and understand how galaxies assemble over **billions of years**.
  - To see where **stars and planetary systems** are being born.
  - Observe **atmospheres of extrasolar planets** and find the **building blocks of life** elsewhere in the universe.
- **JWST** has already produced data that is **redefining our understanding of the universe**. This includes spotting some of the **oldest galaxies in the universe**.

#### Galaxies

- They are **fundamental building blocks** of our visible universe, each containing **billions of stars**, like our Sun.
- They can broadly be classified into **two types: elliptical and spiral**.
- A typical **spiral galaxy** has two structural components: a **central bulge** and a **disk**.
- **Modern astronomy** provides a fairly good understanding of how the universe has developed into its **present state**. **Smaller galaxies** are known to have **merged and coalesced** into more massive ones.
- **More than half of the mass** of the present day galaxies has been acquired in the **last eight billion years**.

### Jarosite Mineral

**Why in news:** **Jarosite**, a **yellow–brown mineral containing potassium, iron, and sulphate**, serve as geological clock on Mars. Scientists sampled 6 jarosite veins from Kachchh, Gujarat, whose arid, salty terrain resembles Mars.

- In lab tests, **jarosite showed luminescence**, storing and emitting energy from **natural radiation**, even after being **heated to 450°C**. Due to its **toughness, abundance on Mars**, and ease of reading with **small heaters and LEDs**, **future Mars rovers could use jarosite to date dust storms, flood deposits, and volcanic ash**.

### Superkilonova

- A **rare kind of cosmic explosion**. When **two neutron stars** smash into each other, the material tossed into space includes **heavy radioactive elements** like **gold, platinum, and neodymium**.
- Over time the elements **decay**, and the emissions in the **optical and infrared** spectrum are called a **kilonova**.
- A **superkilonova** has an **additional energy source**.
- After the merger, some **ejected matter** may **fall back**, become **hotter**, and heat the **surrounding ejecta**. This makes it **brighter and bluer** than a **kilonova alone**, and possibly **longer-lasting**.
- The **brightness and light fingerprint** could be explained by a **superkilonova** where a **supernova blows up a massive star into two neutron stars**, which then **merge to produce a kilonova**.

**Black Hole Morsels**

- **Hypothetical micro-black holes**, far smaller than their parent black holes **roughly comparable in mass to asteroids** and therefore **much hotter**. They are **remnants of black hole mergers** and could provide unprecedented insights into the quantum nature of space and time.
- Signals from these morsels could be detectable **with present-day gamma-ray telescopes**.
- A **black hole** is cited as the **best natural laboratory to study quantum gravity**. Black holes are not entirely 'black'; **Stephen Hawking** showed that they should **leak a faint amount of energy, now called Hawking radiation**, due to **quantum effects near the event horizon**. To verify this radiation, researchers are exploring black hole morsels.
- This is important because **Hawking radiation carries imprints of underlying quantum structure of spacetime**.
- It could reveal **deviations from existing theories of subatomic particles** and point to 'new physics'.

**Black Hole Merger**

- A **black hole merger** occurs when two black holes orbit each other, lose energy through gravitational waves, and eventually crash into one another, forming a single, larger black hole.
- **Gravitational waves** are invisible ripples in spacetime emitted during the merger, detectable by observatories like LIGO (US), Virgo (Italy), and KAGRA (Japan).
- Detecting such events helps scientists **study black holes and understand the universe better**.
- Scientists reported the discovery of an unusually **massive black hole merger**, named **GW231123**. In the event, two black holes of approximately **137 and 103 times the mass of the sun** merged into a **larger black hole**.
- This was significant because **black holes of such high mass are considered rare**. The discovery suggests that **large black holes can form from mergers of smaller black holes**, not only from **dying stars**.
- **Both original black holes were spinning very fast**, which **challenges current theories** of their formation.
- **LIGO** stands for **Laser Interferometer Gravitational Wave Observatory** and has **two detectors in the United States**.
- LIGO made the **first detection of gravitational waves in 2015**, giving the **first experimental validation** of Einstein's **General Theory of Relativity** proposed 100 years ago. 2015 discovery resulted in a **Nobel Prize** two years later.
- After the first detection, other observatories came up — the **Virgo detector** in Italy and **KAGRA** in Japan. Together, LIGO, Virgo, and KAGRA form the **LVK collaboration**, which made the latest discovery.
- A **third LIGO observatory** is proposed in **India**, called **LIGO-India**, but construction is **running behind schedule**. **DAE** is handling project and has selected **Hingoli district, Maharashtra** for the observatory.
- In **2025**, a global detector network (**LIGO-Virgo-KAGRA**) detected **GW250114**, the clearest gravitational-wave signal to date, from a merging black hole pair. Improved detector sensitivity (reduced laser noise, better mirrors, lower uncertainty) enabled **high-precision testing of fundamental physics**.
- Analysis of GW250114 provided the **strongest observational evidence yet for Hawking's Black Hole Area Theorem (1971)** — total event horizon area **never decreases** after mergers.
- Post-merger "ringing" frequencies confirmed the **Kerr solution (1963)** for **rotating black holes**, empirically validating predictions of general relativity.

**Universe**

- The **universe** has **no top, bottom, middle, or centre**. Scientists know the **universe is spreading out in all directions** and **all places** simultaneously. The **Big Bang** is not a **central event** in space; space **grew everywhere at once** after it.
- **Human mind** is used to a **three-dimensional world** with **beginnings and ends**, so it struggles to grasp the universe's shape. **Universe bends space and time** and has **no edges or vertices**. Therefore, the **universe has no centre**.

**Life on Mars**

- In 1976, **NASA's Viking mission** detected signs of metabolism, but another instrument found no organic molecules.
- In 1996, the **meteorite ALH 84001** showed microfossil-like shapes, but lab experiments reproduced similar structures through nonbiological processes.
- During 2000s, several studies reported **methane** in Mars's atmosphere, yet later measurements failed to confirm.
- In 2005, reports suggested **life in Martian caves sustained by liquid water**, but NASA later rejected.
- Recently, new data from the **Perseverance rover** indicated **mudstones in Mars's Jezero Crater**. These mudstones contained **carbon, ferrous phosphate, and sulphide minerals**. The study noted that **organic materials and these minerals often occur together**, prompting questions about potential biological processes.

**MAVEN Mars**

- **NASA** has **lost contact** with its **Mars Atmosphere and Volatile Evolution (MAVEN) spacecraft**, the **Mars orbiter** studying how the planet's **atmosphere is escaping into space**, measure the **thin upper atmosphere** and the **ionosphere**, and observe interactions with **sunlight and the solar wind**.
- These measurements help scientists estimate how **Mars** went from having **flowing water** to a **cold, dry world**.
- **MAVEN** also carries a **relay radio** to pass messages between the **Earth** and **rovers**, including **Curiosity** and **Perseverance**. The **upper atmosphere** changes with **time of day, season, and solar activity**.

- Its instruments measure **gases, ions**, the **solar wind**, and the **magnetic environment** around **Mars**.
- **NASA** has shifted more **relay work** to other orbiters, including the **Mars Reconnaissance Orbiter** and **Mars Odyssey**.

### Mars Electrical Environment

- Using the **Perseverance rover's microphone**, scientists detected **55 electrical 'sparks'** from **dust and sand grains rubbing together** over **two Martian years**. The signals show that **near-surface electric fields on Mars** can become **strong enough to trigger lightning-like discharges**.
- **Electrical discharges** can **lift dust** and **alter how dust clumps together** on **Mars**. Sparks can drive chemical reactions, producing oxidising molecules and chlorine compounds in the Martian atmosphere and soil.

### Rare Earth Hypothesis

- Proposed in **2000** by **Peter Ward and Donald Brownlee**. Argues that **microbial life may be common**, but **complex multicellular life is rare** due to the need for many **stringent, sequential conditions**.
- **Kepler mission data** shows that **Earth-sized planets in habitable zones of Sun-like stars are not rare**, weakening the claim that Earth's **size and orbit** are exceptionally uncommon.
- The focus has shifted from **planet location to planet properties**, especially **atmosphere retention**, as planets like **Venus** show that being in the habitable zone is insufficient.
- **Planets around M-dwarf stars** often lose atmospheres due to **intense stellar radiation**, creating **false oxygen biosignatures**, though a minority may retain atmospheres under specific conditions.
- **Long-term climate stability**, possibly aided by **plate tectonics**, remains uncertain; while helpful for complex life, it may not be **strictly necessary** for life to arise.
- Overall, evidence suggests **complex, Earth-like ecosystems may be rarer than habitable-zone planets**, keeping the **Rare Earth Hypothesis plausible but unproven**, pending future biosignature and atmospheric detections.

### Earth Rotation & Revolution

- We don't feel the Earth moving because **everything around us moves with it at the same constant speed**.
- The Earth rotates once every **24 hours**, so at the equator we move at about **1,600 km/hr**.
- The Earth also travels around the Sun at about **1,07,000 km/hr**.
- This motion is **smooth and constant**, so there is **no change in speed or direction** for our bodies to sense.
- Our inner ears detect motion only during **acceleration**, like when a car starts, stops, or turns.
- When a car moves steadily on a smooth road, we don't feel the motion — the same idea applies to Earth's movement. We move along with the **planet, air, oceans, and everything on it**. We also can't directly see the motion because the **Sun and distant stars appear fixed** from our perspective. Only through **scientific observations** such as star movements or time measurements do we know the Earth is in motion.

## Indian Space

### Gaganyaan

**Why in news: ISRO expects Gaganyaan mission to launch Indian astronauts into space in the first quarter of 2027.**

- The mission will be **preceded by three test launches** — two uncrewed and one with a robot. The revamped Gaganyaan programme includes eight missions, both crewed and uncrewed, to be completed by **2028**.
- The first uncrewed Gaganyaan mission, with **robot Vyommitra on board**, is expected later this year; 90% of infrastructure and tests are ready, and all propulsion systems are in place.
- **Gaganyaan** aims to **demonstrate human spaceflight capability** by launching a crew of **3 members** into a **400 km orbit** for a **3-day mission**. Crew will return to Earth, landing in **Indian sea waters**.
- **Well Deck Trials:** ISRO & Navy, successfully conducted well deck trials of the Gaganyaan mission's crew module to ensure the crew module can be recovered quickly and with minimal discomfort once it touches down in the sea.

### HLVM3:

- ISRO has begun assembling **Human Rated Launch Vehicle Mark-3** for maiden uncrewed flight of Gaganyaan.
- Gaganyaan-G1, the **first of three uncrewed test missions**, aims to simulate an actual human spaceflight. It will place the orbital module in a **170 km x 430 km elliptical orbit**, which will later be circularized.
- **Components:** S200 motors, L110 and C32 stages, Crew escape system elements, Crew Module, Service Module & Orbital Module. The **crew module** integration is progressing and will undergo thermo-vacuum tests at **U.R. Rao Satellite Centre** before final integration with the service module.
- The mission will flight-test **Vyommitra**, a humanoid robot developed by the **ISRO Inertial Systems Unit (IISU)**.
- Two additional uncrewed missions, **G2 and G3**, are planned before the **manned mission**.

### Astronauts

- One of the four astronauts (**Shubhanshu Shukla**) travelled to **ISS** as part of a collaborative effort with NASA. First Indian astronaut to go to the ISS.
- NASA identified **Axiom Space**, a private entity, for the joint mission to the ISS.

- **Astronaut Selection Board** chose 4 astronauts (Shubhanshu Shukla, Prashanth Nair, Ajit Krishnan, and Angad Pratap) from IAF test pilots for India's first manned space mission, Gaganyaan. All 4 astronauts completed spaceflight training in Russia and are now undergoing training at ISRO's Astronauts Training Facility (ATF) in Bengaluru.
- **Axiom-4** is 4th private astronaut mission to the ISS. **Launch Provider: SpaceX**, under contract with Axiom Space.

### Kosmos 482

**Why in news:** A **Soviet-era spacecraft, Kosmos 482**, launched in 1972, re-entered atmosphere & splashed in Bay of Bengal. Built to land on Venus as part of Venera programme, it was stuck in Earth's orbit due to a rocket malfunction.

- Uncertainty in re-entry timing and location was due to solar activity and the craft's deteriorated condition.
- **Surviving debris**, if any, will **belong to Russia** under **UN space treaties**.

### PSLV-C61 Failure

**Why in news:** PSLV-C61 mission failed to place the EOS-09 Earth Observation Satellite into its sun-synchronous polar orbit due to a technical glitch in the third stage.

- The failure occurred after a **fall in chamber pressure** in the **solid rocket motor** during the third stage, which is meant to provide **high thrust post-atmospheric phase**.
- EOS-09 was designed for **radar imaging** using **Synthetic Aperture Radar** and **C-band data-link**, with civilian uses like **land-use mapping** and **hydrology**, and **defence surveillance**.
- This is the **third PSLV failure**, following earlier failures in **1993 (PSLV-D1)** and **2017**. It comes after the **NVS-02 navigation satellite failure**, which failed during **orbit-raising** due to a **valve malfunction**.
- Failure happened during **63rd PSLV flight**, and the **27th in PSLV-XL configuration**. The previous mission, **SpaDeX (2024)**, was successful.
- EOS-09 was built on **RISAT-1 heritage bus** and was similar in scope to **EOS-04**. Aimed to **increase frequency of remote sensing data**.

#### The Role and Structure of PSLV

- PSLV is a **four-stage rocket**, designed for launching satellites into **Sun-Synchronous Polar Orbits (SSPOs)**.
- **Stage 1:** HTPB propellant with six strap-on boosters (XL config)
- **Stage 2:** Vikas engine, burning UDMH and nitrogen tetroxide
- **Stage 3:** Solid rocket with HTPB fuel
- **Stage 4:** Twin engines using monomethylhydrazine and mixed oxides of nitrogen
- India is launching the **Space-Based Surveillance-3 programme** to deploy 52 surveillance satellites, with 31 built by the private sector under ISRO's supervision.

- ISRO operates 3 main launch vehicles: **PSLV, GSLV, LVM3**, chosen based on **payload weight** and **target orbit**.
- PSLV is ISRO's **most reliable and versatile launcher**, used for Earth Observation, Geo-stationary, and Navigation payloads; also launched Chandrayaan-1 (2008) and Mars Orbiter (2013).
- **Earth Observation Satellites** provide data used in agriculture, water resources, urban planning, rural development, mineral prospecting, environment, forestry, ocean resources, and disaster management.
- **Space debris** includes both natural objects like meteoroids and man-made debris such as defunct spacecraft, rocket stages, dead satellites, and collision fragments.

### ISRO Launches GSAT-7R

- ISRO launched **Navy's advanced communication satellite GSAT-7R (CMS-03)** from the **Satish Dhawan Space Centre, Sriharikota**. The **indigenously** designed and developed satellite, weighing approximately **4,400 kg**, is **India's heaviest communication satellite** to date.
- GSAT-7R was launched aboard **ISRO's most powerful launch vehicle, LVM3 (Bahubali)**, on its **M5 mission** into a **GTO**. GSAT-7R is **heaviest Indian-built communication satellite launched from Indian soil**.
- Due to its **high mass**, the launch vehicle targeted a **standard GTO**. After GTO insertion, the satellite uses its own **propulsion systems** to reach **geostationary or geosynchronous orbit**.
- **GSAT-7R** will provide **robust and secure telecommunication coverage** across the **IOR**. Its advanced payload includes transponders supporting voice, data, and video links over multiple communication bands. The satellite will ensure seamless connectivity among the Navy's ships, submarines, aircraft, and Maritime Operations Centres.
- **India's communication satellites** are heavy because they combine **wide coverage, high power, and long service life** in a single spacecraft. To cover the entire country and nearby seas, the payload supports multiple channels across C, Ku, and Ka bands. This requires large deployable antennas, high-power amplifiers, waveguides, filters, switches, and analog or digital transponders.

**Eye in the sky**  
The Indian Space Research Organisation is launching an Earth Observation Satellite (EOS-09) on board PSLV-C61 in its 101<sup>st</sup> mission

**LAUNCH SNAPSHOT**  
Date & time: May 18, 5:59 a.m.

Vehicle: PSLV-C61 (63rd mission of PSLV)

Launch pad: First Launch Pad, Satish Dhawan Space Centre, Sriharikota

Countdown duration: **22 hours**

**1** EOS-09 complements and supplements data from the Resourcesat, Cartosat and RISAT-2B series satellites

**2** The new satellite carries fuel for post-mission de-orbiting, ensuring it decays in two years and leaves no debris

**KEY APPLICATIONS**

- Agriculture & forestry monitoring
- Urban & infrastructure planning
- Disaster management
- National security surveillance

**EOS-09 satellite (RISAT-1B)**

Weight: **1,696.24 kg**

Orbit: Sun Synchronous Polar Orbit (SSPO)

Mission life: **5 years**

Function: All-weather, high-resolution imaging of the Earth's surface across the country's vast territory

- **Antenna pointing mechanisms**, along with **structural strength** and **thermal control systems**, add further mass.
- High throughput over **12–15 years** requires **several kilowatts of power**, necessitating **large solar arrays, batteries, and power-conditioning units**, along with protective structures.
- **Chemical propulsion systems**, still common on Indian satellites, require **significant fuel reserves** for these tasks.
- **LVM-3**, earlier known as **GSLV Mk 3**, uses **solid, liquid, as well as cryogenic–fuel engines**. It can put up to **8,000 kg in LEO** (up to an altitude of **2,000 km**) and up to **4,000 kg in geosynchronous orbit** (about **36,000 km**).
- **ISRO** has been working on **increasing the carrying capacity**, especially for the **human spaceflight mission**. One way is to **increase the thrust** produced by the **third or cryogenic upper stage**, which accounts for **nearly 50% of the velocity** needed to place satellites in **geosynchronous transfer orbits**.
- The **C25 stage** can carry **28,000 kg of propellant** producing a **20 tonnes thrust**. The new **C32 stage** will carry **32,000 kg of fuel** and produce a **22 tonne thrust**.
- The space agency is also looking at using a **semi-cryogenic engine** instead of the **liquid-propellant based second stage**. A **cryogenic engine** uses **liquified gases at extremely low temperatures** such as **liquid oxygen and hydrogen**.
- A **semi cryogenic engine** uses a **liquified gas and a liquid propellant**. **ISRO** plans to use **refined kerosene and liquid oxygen** for the second stage, which may be **cheaper and increase capability**.
- The **heaviest payload** carried to low earth orbit is **5,800 kg** for the **OneWeb mission**.

Tamil Nadu – Space Policy

**Why in news:** Tamil Nadu joins Karnataka & Gujarat in drafting state-specific space policies. Complements Indian Space Policy 2023 to develop space ecosystem. Covers satellite manufacturing, launch services, satellite-based applications.

Current Space Infrastructure and Capabilities in Tamil Nadu

- **ISRO Propulsion Complex** at Mahendragiri, Tirunelveli tests: Earth storable propellant engines, cryogenic engines, and launch vehicle stages and Undertakes R&D and technology development programmes.
- Kulasekarapattinam, Thoothukudi selected for India’s second **spaceport**.
- NIT Tiruchi hosts the Space Technology **Incubation Centre (STIC)** for ISRO-linked projects.

Rationale and Institutional Push

- **IN-SPACe**, under **Department of Space**, urged State to draft a policy for promoting **Non-Government Entities**.
- Aims to attract **₹10,000 crore investments** and create **10,000 jobs** in the next **five years**.
- Encourages use of **space technologies** in **governance and public service delivery**, including: Disaster management, agriculture, transport, fisheries, revenue, health, and urban administration.

Antariksh Prayogshala (Space Labs)

- **IN-SPACe** rolled out **Request for Proposal** to establish **Space Labs** at **select academic institutions** across **India**.
- These labs will provide **hands-on training** and **exposure** to students pursuing **space technology courses**.
- Under the scheme, **up to 7 academic institutions** will be selected in a **phased manner** from **different zones**. To ensure **balanced regional representation**, **one lab** is proposed in **each zone**. The labs will also be available to **NGEs** for utilisation in the **respective zone**.

- **IN-SPACe** will provide **financial support** of up to **75% of the total project cost**, capped at **₹5 crore per institution**.
- The **selection process** will be carried out in **two stages**. Institutions will be **screened based on eligibility criteria**.



HAL SSLV

**Why in news:** HAL has secured a ₹511 crore Transfer of Technology deal from ISRO to build and operate Small Satellite Launch Vehicles (SSLVs). SSLVs are designed to place satellites under 500 kg into Low Earth Orbit (LEO).

- The agreement aims to **commercialise SSLV launches** for broader market access.
- ISRO’s SSLV is **3-stage launch vehicle** with 3 solid propulsion stages and a liquid based Velocity Trimming Module (VTM) as terminal stage.

- **SSLV** is designed for **low-cost launches, short turnaround times, minimal infrastructure**.

- PSLV is the **third generation** of Indian launch vehicles and was **first used in 1994**.
- PSLV-XL variant can carry payloads of around **1,860 kg**.
- GSLVs launch **communication satellites** into **GTO**.
- **Geostationary Earth Orbit** is a **circular orbit 35,786 km** above Earth's equator, used for **telecommunications satellites**.

### Global Space Exploration Conference

**Why in news:** ISRO and ESA signed a **Joint Statement of Intent on Human Space Exploration at GLEX 2025**.

- ESA is considering collaboration on India's **Bharatiya Antariksha Station**, a **five-module space station** planned for **2035**, with **BAS-1 launching in 2028**. ESA may support ISRO by providing **cargo delivery** for BAS construction.
- ISRO plans to launch and **dock individual BAS modules in orbit**; it has already demonstrated this ability in **SpaDeX mission**. **BAS** will be modular space station in Low Earth Orbit for scientific research and international collaboration.
- **GLEX 2025** aims to promote the exchange of policy, technical and programmatic information on global space exploration. The event brings together scientists, engineers, policymakers, entrepreneurs, and educators.

### Chandrayaan-5

**Why in news:** Chandrayaan-5, also called **LUPEX**, is a **joint lunar mission by ISRO and JAXA** focused on exploring **water and water-ice** on the Moon's surface and subsurface.

- The mission is in **design phase** with **instrument selection and engineering model testing** nearly completed. **Weighing 6.5 tonnes**, Chandrayaan-5 is scheduled for launch aboard **Japan's H3 rocket** in **2027-28**.
- **JAXA's rover** will explore water-rich areas, drill into the lunar surface, and perform in-situ water content and quality measurements. The mission was approved by Cabinet in March 2025, following the success **Chandrayaan-3's south pole landing**. **Chandrayaan-4** is planned as a sample return mission to bring lunar material back to Earth for analysis.
- **ISRO is developing the lander** and **JAXA is building the 350-kg rover** for Chandrayaan-5.
- **ESA and NASA** are contributing instruments, including a **mass spectrometer (ESA)** and **neutron spectrometers (NASA)**. **Spectrometers** will be used for in-situ analysis of hydrogen and other elements, helping understand the Moon's mineral and elemental composition.

### SpaDex-2

**Why in news:** ISRO is planning 2nd **SpaDeX (Space Docking Experiment)** mission to dock 2 satellites in **elliptical orbit**.

- **Docking** is the process of joining two satellites in space, critical for Chandrayaan-4 and the BAS.
- In the **first SpaDeX mission**, two 220-kg satellites were launched into a 470-km circular orbit and docked. The mission demonstrated **power sharing** and the ability to receive **commands as a single composite unit**. With this, **India became the fourth country** after the **US, Russia, and China** to achieve **in-space docking**.
- **Docking in a circular orbit** is easier due to **constant velocity and trajectory**, unlike in an **elliptical orbit** where they **continuously change**.
- This capability is essential for missions like **Chandrayaan-4**, where multiple modules may be launched separately and require docking in Earth and lunar orbits. For moon missions, ISRO uses elliptical Earth orbits and gradually raises the apogee via engine burns at perigee, enabling fuel-efficient lunar transfers.

- Spacecraft visiting the **ISS** follow the **International Docking System Standard (IDSS)**, **baselined in 2010**.
- India uses an **androgynous docking mechanism**, where **Chaser and Target satellites have identical systems**.
- India's mechanism is **similar to IDSS** but uses **2 motors** instead of the **24 motors** used in the **IDSS system**.

### Space-Based Surveillance-III

- Following **Operation Sindoor**, the Union government decided to **fast-track the launch of 52 surveillance satellites** for enhanced **border and coastline monitoring**.
- **SBS-III programme**, approved in **2023** by the **PM-led CCS**, to develop **next-generation satellites** over the next **10 years**. ISRO will launch first **21 satellites** & **private companies** will manage the remaining **31 satellites**.
- **Defence Space Agency** will operate and manage the satellite system. The first set of satellites is expected to be launched by 2026. The satellites will use AI to enhance decision-making, performance, and efficiency.
- **Indian satellites** like **Cartosat** and **RISAT** played a key role in tracking **enemy movements** and confirming **strike impacts** during Operation Sindoor.
- **SBS-I (2001)**: Launched after the Kargil War; involved 4 satellites (Cartosat and RISAT series). **SBS-II (2013)**: Added 6 more satellites to enhance resolution and frequency.

### Axiom-4 Mission: Boosting India's Gaganyaan Readiness

- The astronauts also carried **cultural artefacts** representing India's artistic legacy, symbolising **cultural diplomacy in space**.

**Shubhanshu Shukla's Space Experiments:**

- Conducted **seed germination study** under **microgravity**, with **green gram and fenugreek** sprouting in petri dishes.
- Seeds will be grown on Earth over generations to study **genetic, microbial, and nutritional changes**.

- Deployed and stowed **microalgae samples**, studied for **food, oxygen, and biofuels** production in long-duration missions.
- Highlighted excitement over **stem cell research** aimed at enhancing **growth, recovery, and injury repair**.

### Scientific Studies on Board the ISS

- **Voyager Displays study** examined eye movement and coordination in space.
- **ENPERCHAR study** analysed how astronauts perceive and interact with their orbital environment to design supportive habitats.
- **Cerebral blood flow study** explored effects of microgravity and elevated CO<sub>2</sub> on cardiovascular function, with potential benefits for astronauts and patients on Earth.
- **Radiation monitoring** carried out using the Rad Nano Dosimeter, assessing astronaut safety in orbit.

### Crop Seeds on ISS Project

- Seeds from India sent to ISS for **Space Biology Lab (IIST)** experiment: **Rice (Jyothi, Uma), Horse gram (Kanakamani), Tomato (Vellayani Vijay), Sesame (Thilakathara), Brinjal (Soorya)**.
- Seeds exposed to **microgravity** will undergo **post-flight studies** by IIST and **Kerala Agricultural University (KAU)** in Thiruvananthapuram.

### Shukla's Return and Mission Highlights

- **Shubhanshu Shukla** and Ax-4 crew returned after an **18-day ISS mission**, completing **320 Earth orbits** and **8.4 million miles of spaceflight**. The crew performed **60+ research activities** and **23 outreach events**.
- Recovery involved **fast boats and vessel Shannon**, ensuring safety and chemical checks before capsule retrieval.

### DEALING WITH BODY WASTE IN SPACE

While eating on the ISS is relatively easy, urinating and defecating is not. The lack of gravity becomes a big hurdle here.

■ In space, astronauts urinate into a specially-designed hose with a suction system. This hose, suited both for male and female anatomies, pulls the urine away from the astronaut's body and deposits it into specialised vessels. The stored urine is then purified and recycled aboard the ISS to create drinking water for astronauts. This is a must because liquids both consume space and take up weight – as such it is not viable to send enormous amounts of water required to sustain astronauts in space. Water must be used judiciously, and recycled wherever possible.

■ To defecate, astronauts sit on customised toilets which too are equipped with suction systems. These systems begin working the moment the toilet seat is lifted – this helps eliminate odour. Astronauts need to strap themselves firmly to the toilet seat to ensure they do not drift away while defecating. Faecal matter is directed to waste containers. All solid waste, including toilet paper, wipes and gloves, are loaded onto cargo spacecraft returning to Earth. Most of it is released when the spacecraft is entering the Earth's atmosphere: here it gets burnt due to friction. Occasionally, some samples are sent to laboratories on Earth to check on the health of the astronauts.

### Ham Radio:

- **Shubhanshu Shukla** interacted with students in India via **ham radio** from ISS. **Ham radio** (amateur radio) is a **licensed service** using **radio waves** for education, knowledge sharing, and **emergency/SOS communication**. Ham radio communication can be **hyper-local, global, and even in space**.
- In India, anyone **above 12 years** can operate a ham radio with a licence issued by **MEITY**. Amateur radio was **first used in space** in **1983** on a **space shuttle** to connect space and Earth.
- ISS has **ARISS** (Amateur Radio on the International Space Station) to facilitate **astronaut-student interactions**.
- Ham communication attempts occur when the ISS is **cruising past the horizon**, with the best window lasting **5–8 minutes**. Despite advanced technologies, **radio remains one of the most reliable and stable** forms of communication and serves as an **effective alternate medium**.

### Microgravity:

- Microgravity is the condition in which people or objects appear to be weightless. The effects of microgravity can be seen when astronauts and objects float in space. The prefix "Micro-" means "very small," so microgravity refers to a condition where gravity seems to be very small. It is not the same as zero-gravity.

### Microgravity Experiments:

- He conducted & completed all **seven microgravity experiments**:
  - **Study of space microalgae** examined their ability to generate food, oxygen, and biofuels and tested their resilience in microgravity for sustaining human life on extended space missions.
  - **Myogenesis study** involved microscopic observations and sample collection to understand muscle cell behaviour.
  - **Sprouting of methi and moong seeds** studied germination in space, exposed sprouts to **-80°C** temperatures.
  - **Astronaut health and safety studies** assessed radiation exposure (Rad Nano Dosimeter), mental and cardiac health, heat transfer, adaptability, and used neuromuscular electrical stimulation to combat muscle loss.
  - **Muscle atrophy** investigation used the Life Sciences Glovebox and included irrigating crop seeds under microgravity to support sustainable space agriculture.
  - Research on **Indian strain of Tardigrades** aimed to identify genes responsible for their extreme resilience.
  - **Cyanobacteria study** findings could aid carbon and nitrogen recycling systems in space and establish their potential as a superfood for long missions.
  - **Voyager Display experiment** studied human interaction with electronic displays in microgravity and tested if screens increase stress or fatigue; designed by IISc, Bengaluru.
  - **Seed resilience trials** tested rice, cowpea, sesame, brinjal, and tomato seeds exposed to microgravity to advance space agriculture and develop climate-resilient plant varieties for Earth and beyond.

### Splashdown:

- When a spacecraft begins to **re-enter the Earth's atmosphere** at an altitude of **110–120 km**, it travels at speeds up to **27,359 kph**. There isn't enough time for it to **decelerate** to speeds suitable for **vertical landing on ground**. **Additional braking systems** and **structures like landing legs** would be required for ground landing.
- It is **safer** to land a spacecraft in **water** even at **25–30 kph** – the speed of the **Axiom-4 spacecraft** at splashdown.

- The **low viscosity** and **high density** of water provide a **greater cushion** during landing.
- Water absorbs enough **shock from the impact** to avoid **damage** to the spacecraft.
  - During **re-entry**, spacecraft experience **deceleration** due to **friction** but need **additional measures** to slow further. One method is using **parachutes**. Spacecraft usually deploy **two drag parachutes** first to **stabilise** the vehicle after re-entry and **reduce speed**. The **Dragon spacecraft** deploys these parachutes at around **18,000 feet**.

### Shubhanshu Shukla

**Why in news:** The mission was scheduled from NASA's Kennedy Space Centre, Florida, via **SpaceX's Falcon 9** rocket and the **Dragon** spacecraft. **Axiom-4 (Ax-4)** is a commercial mission by **Axiom Space**, contracted by NASA using SpaceX systems. It's **not part** of NASA's regular resupply missions.

- **Reasons for Postponement:** A **liquid oxygen (LOX) leak** was detected during an engine test. Falcon 9 engines use **rocket-grade kerosene and LOX**, making any leak a critical safety issue.
- The mission was delayed **four times** due to a combination of **weather** and **technical faults**.
- **LOX leak detection is complex** as LOX turns into invisible vapour; repairs require repeated warm-cold testing using **liquid nitrogen**.
- Detection tools included **ultrasonic microphones, thermal imaging, bubble tests, and helium signature tests**.

### Historic Significance

- He became the **634th astronaut in space** and the first Indian in Earth orbit after **Rakesh Sharma (1984)**.
- Shukla is also among the shortlisted astronauts for India's **Gaganyaan mission**, expected in **2027**.
- ISS decommissioning planned by **2030**.

### Docking Process and 28-Hour Journey

- **Dragon spacecraft**, named **Grace**, undertook a 28-hour journey to ISS.
- ISS and Dragon operate in **separate orbits**; orbital mechanics required **multiple phasing burns** to synchronize position and velocity vectors. Ax-4 crew was welcomed by astronauts from **NASA, JAXA (Japan), and Roscosmos (Russia)**.
- Axiom-4 mission hosts **around 60 scientific experiments**, representing **31 countries** including **India, U.S., Poland, Hungary, Saudi Arabia, Brazil, Nigeria, UAE**, and several European nations.

## THE AXIOM-4 MISSION

<p><b>Launch Date:</b> June 8, Sunday, 19:40 IST</p> <hr/> <p><b>From:</b> Kennedy Space Centre, Florida</p> <hr/> <p><b>Crew:</b> Peggy Whitson (Commander, US), Shubhanshu Shukla (Pilot, India), Slawosz Uznanski-Wisniewski (Mission Specialist Poland), Tibor Kapu (Mission Specialist, Hungary).</p>	<p style="text-align: center; background-color: #003366; color: white; padding: 2px;"><b>KEY EXPERIMENTS</b></p> <ul style="list-style-type: none"> <li>■ Physical and cognitive impact of using computer screens in microgravity, particularly how pointing tasks, gaze fixation and rapid eye movements are affected in space</li> <hr/> <li>■ Behaviour and response of tardigrades, or water bears, in space. Known to survive in very tough conditions, behaviour of tardigrades can offer clues to molecular mechanisms that help survival in extreme environments.</li> <hr/> <li>■ Impact of spaceflight on six varieties of crops</li> <hr/> <li>■ Growth and cellular responses in cyanobacteria in microalgae. The results of these studies can help in development of life support systems in future spacecraft.</li> </ul>
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### Docking Stages:

- **RENDEZVOUS:** The first stage involves aligning the orbits of the spacecraft and the ISS, achieved through multiple thruster burns over several hours.
- **FINAL APPROACH:** Within a few 100m of ISS, the vehicle enters the "final approach corridor". Laser ranging and thermal imagers provide precise distance and alignment data to onboard computers for trajectory correction.
- **CONTACT & CAPTURE:** Dragon's soft capture ring makes initial soft contact with the International Docking Adapter (IDA). Hard capture follows with 12 hooks extending and locking into the IDA, completing docking.

### Zero-G indicator:

- A Zero-G indicator is a small item (often a plushie) that visually signals weightlessness to astronauts. For the Axiom-4 mission, the Zero-G indicator is a swan plushie named 'Joy'. The swan plushie was chosen as it symbolizes wisdom, loyalty, resilience, and natural beauty in India, Hungary, and Poland.

### Tardigrades:

- Shukla will study revival, survival, and reproduction of tardigrades during his two-week stay at the ISS. Tardigrades, or "water bears", are resilient aquatic animals that have existed for ~600 million years, predating dinosaurs.
- Fully grown tardigrades are about 0.5 mm long, with four pairs of legs and specialised mouthparts for feeding on plant cells, algae, and small invertebrates.
- They are found worldwide, with their most common habitat being thin films of water on mosses and lichens, earning them the nickname "moss piglets".
- Tardigrades exhibit cryptobiosis, reducing metabolism to less than 0.01% and water levels by over 95% — a state called anhydrobiosis. In both states, they form a durable, shrunken form called a tun, allowing them to survive extreme environments. They produce unique CAHS proteins (cytoplasmic-abundant heat soluble) that are crucial to their resilience.
- At the ISS, tardigrades will be sent in tun state, revived, and studied under space radiation and microgravity. The experiment aims to identify genes responsible for their resilience and DNA repair mechanisms in space. Findings will help in developing astronaut protection strategies and preserving biological materials for long space missions.
- Tardigrades were discovered in 1773 by Johann August Ephraim Goeze. They can survive temperatures from -272.95°C to 150°C, UV radiation, pressures of 40,000 kPa, and even 30 years in a freezer.
- Tardigrades were first sent to space in 2007 aboard ESA's Foton-M3 mission, involving 3,000 moss piglets.

**NISAR**

- **NISAR (NASA–ISRO Synthetic Aperture Radar)** is the first joint satellite mission of NASA and ISRO, successfully launched from the Satish Dhawan Space Centre, Sriharikota onboard GSLV-F16.
- The 2,392-kg satellite was placed in a 743 km sun-synchronous orbit with a five-year mission life.
- It is the first satellite to use dual-frequency **SAR – NASA's L-band and ISRO's S-band** – with a 12-metre unfurlable mesh reflector antenna integrated with ISRO's modified I3K spacecraft bus.
- Uses **SweepSAR technology** for the first time to provide **high spatial resolution** with a **242 km swathe width**.
- Provides all-weather, day-and-night global coverage every 12 days. **L-band SAR** penetrates forests and soil for subsurface mapping, while **S-band SAR** captures surface features like crops, forests, and water bodies.
- **SAR creates high-resolution images** using **microwave pulses** instead of visible light, making it effective in **dark or cloudy conditions**. SAR systems emit **microwave signals** and record the **echoes** reflected from surfaces.
- **Microwaves can penetrate** clouds, smoke, light rain, enabling SAR to operate day & night in all weather conditions. SAR satellites can map wide swaths of land in a single pass and differentiate materials (soil, vegetation, water, metal) based on how they reflect microwaves. Scans with **3–10 m spatial resolution** and **cm-level vertical accuracy**.
- In **disaster mode**, delivers **damage proxy maps in under 5 hours**.

**Applications**

- Tracks ground deformation, vegetation dynamics, ice sheet movement, sea ice classification, ship detection, shoreline monitoring, storm characterisation, soil moisture changes, surface water mapping, and disaster response.
- Generates annual biomass maps (1 ha resolution), quarterly cropland maps, and flood vs dry area maps.
- Crucial for land subsidence, infrastructure monitoring, agriculture planning, and climate change studies.

**Development and Operations**

- **ISRO contributions:** I-3K spacecraft bus, S-band radar, Ka-band telecom system, high-gain antenna, integration in Bengaluru. **NASA (JPL) contributions:** L-band SAR, 12-m mesh antenna, carbon-composite boom, avionics, solid-state recorder, GPS receiver.
- **Data relay:** NASA's Near Earth Network (Alaska, Svalbard, Chile) + ISRO ground stations (Shadnagar, Antarctica).
- **Operations:** JPL Mission Operations Center (overall), ISRO Telemetry Network, Bengaluru (day-to-day).

**HOPE**

- Protoplanet, a Bengaluru-based company, launched **Human Outer Planet Exploration (HOPE)** in Tso Kar, Ladakh to prepare for **possible manned missions to the Moon and Mars**.
- HOPE will serve as a **research station** where selected "crew" will take turns inhabiting it during a 10-day isolation mission. Participants will undergo **physiological and psychological studies** to assess human adaptability.
- The **high-altitude, cold desert-like conditions** of Ladakh act as an **analogue site** closely mimicking the geological and environmental conditions of the moon and Mars. (Indian astronaut will step on moon by 2040: Minister)
- Researchers have confirmed that **jarosite**, a mineral discovered in Matanomadh (Kutch, Gujarat) in 2016, is around 55 million years old, corresponding to the Paleocene period.
- **Matanomadh**, located about 100 km west of Bhuj, shows **environmental and chemical similarities to Mars**, making it ideal for Mars-analogue studies. The site could serve as a test bed for Mars exploration, supporting rover testing, drilling, instrument validation, and geochemistry experiments.
- **Analog space missions** are Earth-based field tests conducted in locations with physical similarities to extraterrestrial environments, helping validate systems and strategies for future Mars missions. Results from these analog missions aid in solving challenges for spaceflight research and validating technologies for real planetary missions.
- The **Human Space Flight Centre (HSFC)** of ISRO leads such analog studies, including the **Ladakh Human Analog Mission (LHAM)** in 2024 and the **Anugami Isolation Study** in 2025 involving Gaganyatri astronauts.
- **Ladakh**, known as the **cold desert of India**, offers **high UV radiation, extreme temperature variations, and scarce water**, making it an **ideal terrestrial analogue for Martian research**.

**Hanle – Dark Sky Reserve**

- **Hanle, Ladakh**, is home to one of the **darkest skies in the world**, rated **Bortle-1** – the highest clarity rating on the nine-point scale for stargazing. It has been designated as **India's first Dark Sky Reserve**, a protected area aimed at preserving night-sky visibility by minimising light pollution.
- The **Hanle Dark Sky Reserve** is managed through a MoU between the **Indian Institute of Astrophysics (IIA), Bengaluru**, the **UT of Ladakh**, and the **Ladakh Hill Development Council, Leh**.
- Located within the **Changthang Wildlife Sanctuary**, the reserve surrounds the **Indian Astronomical Observatory**, a major research facility operated by IIA.
- **Indian Astronomical Observatory hosts:** Himalayan Chandra Telescope (HCT), GROWTH India Telescope (in collaboration with IIT Bombay), High Altitude Gamma-Ray Telescope Array (HAGAR) (with TIFR) & Major Atmospheric Cherenkov Experiment (MACE) (with BARC)
- To reduce light pollution, the IIA distributed lamp shades, blackout curtains, and warm-toned bulbs.
- **Hanle hosts an annual "Star Party"**, an astronomy festival; the **third edition** was held recently.
- The region offers views of rare **astronomical phenomena**, including:

- **Zodiacal light** – a faint twilight glow caused by sunlight scattering off interplanetary dust.
- **Gegenschein** – a bright spot in the sky opposite the Sun's position.
- **Belt of Venus** – pinkish band above horizon during twilight, formed by **backscattered sunlight** above Earth's shadow.
- Hanle's unique environment – **low oxygen, low humidity, and high ultraviolet radiation** – makes it highly suitable for astronomical observations. The village is located at an **altitude of about 4,250 metres above sea level**, providing clear and stable atmospheric conditions for night-sky studies.

### BlueBird

- ISRO launched the **BlueBird communication satellite** from Sriharikota. Developed by **U.S.-based AST SpaceMobile**.
- The launch was conducted as part of the **LVM3-M6 mission** under a **commercial agreement** with **AST SpaceMobile**.
- The mission aimed to deploy a **next-generation communication satellite** designed to provide **high-speed cellular broadband directly to smartphones** across the globe.
- **BlueBird Block-2** satellite is the **largest commercial communication satellite** to be deployed into **LEO**.
- **BlueBird Block-2** satellite, weighing **6,100 kg**, became the **heaviest payload launched by LVM3 from Indian soil**. The launch also marked **ISRO's first dedicated commercial launch for a customer from the United States**.

### EOS Constellation

- **IN-SPACe** announced the selection of the **PixxelSpace India-led consortium** to design, build, and operate India's first fully **indigenous commercial Earth Observation (EO) 12-satellite constellation** under the PPP model.
- The **consortium** includes PixxelSpace India, Piersight Space, Satsure Analytics India, and Dhruva Space.
- The constellation will deliver **Analysis Ready Data (ARD)** and **Value-Added Services (VAS)** for climate change monitoring, disaster management, agriculture, marine surveillance, national security, and urban planning, and also meet global geospatial intelligence demand.

### ISRO 75,000kg Rocket

- Over four decades after the **first indigenous launch vehicle SLV-3** (35-kg payload), **ISRO is conceiving an advanced heavy-lift rocket** capable of carrying **75,000 kg payload** to space.
- A **Venus Orbiter Mission** has been approved to study the planet Venus.
- A **Next Generation Launch Vehicle with recoverable first stage** has also been approved.

### CE20 Cryogenic Engine

- **ISRO** has demonstrated the **bootstrap mode start test** on the **CE20 cryogenic engine** which powers the **upper stage of LVM3** rocket. The test on the CE20 cryogenic engine was conducted under vacuum conditions in the **High-Altitude Test (HAT)** facility at ISRO Propulsion Complex, Mahendragiri for a duration of 10 seconds.
- Test is important towards enhancing the **restart capability** and **mission flexibility** of future **LVM3 flights**.
- **CE20 cryogenic engine**, powering the **LVM3 upper stage**, is already qualified for operation at thrust levels ranging from 19 to 22 tonnes in flight with a single start, and also for the Gaganyaan missions.
- During nominal operation, the **engine ignition** is initiated under **tank head conditions**, followed by the start of **turbo pumps** using a **stored gas start-up system**.
- For future missions, **multiple in-flight restarts** of the **CE20 engine** will be needed for **flexible multi-orbit missions**, but the current set-up requires an **additional start-up gas bottle** for each restart.
- Achieving **bootstrap mode start**, where the engine builds up to **steady operation without external start-up assistance**, is stated by **ISRO** to be **essential**.

### National Space Law

- India will celebrate its second **National Space Day on August 23**, marking Chandrayaan-3's success and upcoming projects like Gaganyaan, Chandrayaan-4, and BAS. India lacks a **comprehensive national space law**.
- **Outer Space Treaty (1967)**: Space is the province of all mankind, prohibits national appropriation, makes states responsible for national activities (govt. or private).
- **U.S., Japan, Luxembourg** have national laws enabling licensing, liability, insurance, and commercial rights.
- **India's Regulations Includes**: Catalogue of Indian Standards for Space Industry, Indian Space Policy, 2023 outlining private participation, IN-SPACe Norms, Guidelines, Procedures (NPG) for authorisation of activities.
- IN-SPACe lacks legal backing; must be empowered as **central regulator**.

### Liquid Oxygen Leak

- ISRO flagged a **liquid oxygen leak** in Falcon-9's oxidiser line. Leak traced to a **crack in the fuel line**.
- ISRO noted that **cracks in oxidiser/fuel lines cannot be ignored**, unlike blockages that can be rectified. With **40 years of liquid engine experience**, ISRO warned vibrations during launch would have **widened the crack**.

### ISRO's Integrated Main Parachute Airdrop Tests

- ISRO successfully conducted its first Integrated **Air Drop Test (IADT-1/IADT-01)**, marking a key milestone in preparations for India's maiden human spaceflight programme — Gaganyaan.
- The test took place at the **Babina Field Firing Range (BFFR)** in **Jhansi, Uttar Pradesh**.
- The test validated the **parachute-based deceleration system** designed to ensure the safe descent of astronauts.
- It evaluated the **parachute-based deceleration system** for the crew module during the final stages of re-entry.
- **Capsule slowed by** atmospheric drag, heat shields, drogue chutes, and main parachutes.
- The parachute system for the Gaganyaan Crew Module comprises **10 parachutes of four types**.
- Upon release of the drogues, **three pilot parachutes** deploy to extract **three main parachutes**. The **main parachutes** further slow down the Crew Module to ensure a **safe touchdown**. The system has **redundancy** — **two of the three main parachutes** are sufficient for a safe landing.
- The main parachutes deploy using **reefed inflation**, where the parachute first opens **partially (reefing)** and then fully opens after a predetermined time (**disreefing**), using a **pyro device**.
- A **dummy crew module (~4.8–5 tonnes)** was dropped from **3 km altitude** using an **IAF Chinook helicopter**.
- **Lead agency:** Vikram Sarabhai Space Centre, managing 90% of activities. **Collaborating agencies:** Human Space Flight Centre, SDSC-SHAR, Indian Air Force, DRDO, Indian Navy, Coast Guard.
- **TV-D1 (2023)** demonstrated Crew Escape System (CES). **TV-D2** will test CES under complex abort conditions.

### Critical Systems Under Development

- Crew Escape System (CES) with five types of motors, already static tested.
- Environmental Control & Life Support System (ECLSS) for oxygen, temperature, waste, fire safety.
- Integrated Vehicle Health Management System (IVHMS) to autonomously detect faults and trigger aborts.
- Propulsion systems for crew and service modules tested. HLVM3 rocket strengthened with reliability modifications.
- Indigenisation of escape motors, composites, and safety tech.

### ISRO's Launch


- ISRO currently conducts **5–6 launches annually**. Maximum launches in a year: **9 (2016)**.
- Expansion relies heavily on **private space companies** (around **350 in operation**).
- Includes **Chandrayaan-4, 5, 6, 7, 8** before the **crewed Moon mission (2040)**.
- **Chandrayaan-4 & 5:** sample return missions (expected 2027–28 timeline). **Chandrayaan-5:** joint mission with JAXA.
- Roadmap also includes **Mars lander mission. Mangalyaan (2013)** was an **Orbiter**, not a lander.

### Multi-messenger Astronomy

- Multi-messenger astronomy is a **new way to study the universe** using **more than one kind of messenger** from space.
- Traditionally, **astronomy relied on light** across the spectrum from radio waves to X-rays. Scientists can now detect **gravitational waves, neutrinos, and cosmic rays** as additional messengers.
  - **Gravitational waves** are ripples in spacetime caused by powerful cosmic collisions.
  - **Neutrinos** are subatomic particles created in nuclear reactions.
  - **Cosmic rays** are fast-moving charged particles from outer space.
- Light shows a star's **surface**, **gravitational waves** reveal **violent events**, and **neutrinos** expose **internal processes**.
- In 2017, light and gravitational waves from two colliding neutron stars were detected simultaneously.
- **India** made **multi-messenger astronomy** with **AstroSat**. It combined **ultraviolet, optical, and multiple X-ray bands** in one mission. It enabled **simultaneous tracking** of **stellar flares, black hole outbursts, and neutron star activity**.

#### Eyes on the sky

RAD@home showcases the power of research driven with the help of citizen science, with the able assistance of the Giant Metrewave Radio Telescope (GMRT)



The GMRT is one of the largest and most sensitive low-frequency radio telescopes in the world. DESIBOY101 (CC BY) (Pbnc)

- The RAD@home initiative, launched in 2013 by Ananda Hota, now has about 4,700 Facebook members participating
- Most members are not professional astronomers, yet after a little training, they help spot unusual astronomical phenomena
- On October 2, the group reported a double odd radio circle (ORC), only the second such astronomic object known of this type
- ORCs are vast, faint radio rings around galaxies; their origins remain uncertain, with multiple hypotheses
- A student first noticed the double ORC; collaborators then corroborated the find with archival radio and optical observations

### Citizen Scientists

- **RAD@home**, a **citizen-science astronomy group** led by **University of Mumbai** has been active since **2013** and now includes **~4,700 members**, mostly non-professional astronomers.
- The group reported a **rare double Odd Radio Circle (ORC)** using **LOFAR telescope data**, only **2nd known twin-ORC system** and among the **most powerful ORCs detected**.
- **ORCs** are **large, faint circular radio structures** surrounding distant galaxies and remain **poorly understood** objects in astronomy.
- **RAD@home** uses data from major facilities like **LOFAR (Europe)** and **GMRT (India)**, highlighting India's role in **radio astronomy**.
- The initiative trains participants to analyse **multi-wavelength galaxy data** and identify **unusual radio galaxies**, challenging earlier assumptions (e.g., **spiral galaxies hosting radio jets**).

**Aditya-L1**

- Using the **Visible Emission Line Coronagraph (VELC)** aboard **Aditya-L1**, scientists at the **Indian Institute of Astrophysics** and **NASA** collaborated to **estimate crucial parameters of a CME**.
- Scientists said these are the **very first spectroscopic observations of a CME in the visible wavelength range**.
- The **unique spectroscopic observations** with the VELC allowed them to **study CMEs very close to the sun's visible surface** for the first time. VELC provides a **sustained view of the sun for 24 hours every day** due to its position at the **sun-earth Lagrangian L1 location**.
- India's first dedicated space-based solar observatory, currently operational at Sun-Earth L1. Positioned approximately 1.5 million km from Earth, it provides an uninterrupted, eclipse-free view of the Sun.
- The year 2026 is critical as Aditya-L1 is tracking the Sun during its Solar Maximum—the peak of its 11-year activity cycle—marked by a significant increase in solar storms and CMEs.
- **SUIT (Solar Ultraviolet Imaging Telescope)**: Captured full-disk images of the Sun in near-UV wavelengths.
- **ASPEX & PAPA** for decoding solar wind composition and were instrumental in studying "Gannon's Storm" (May 2024), the strongest solar storm of the 21st century.

**Related News**

- Aditya L-1 revealed why **2024 Gannon's storm** behaved **unusually**. Sun's **magnetic fields** were **breaking and rejoining** within the storm. Usually, a **CME carries a twisted magnetic rope** that interacts with **Earth's magnetic shield**. This time, **two CMEs collided** and were **squeezed**, causing **magnetic field lines to snap and rejoin**, a process called **magnetic reconnection**. This **reversal of the magnetic field** made the storm's **impact stronger than expected**.

**Grahaa - Nano Satellite**

- **Grahaa Space**, a Bengaluru-based startup, received authorisation from **IN-SPACe** to launch its **maiden nano-satellite mission 'Solaras S2'** as a **technology demonstration**. **Solaras S2** will be launched from **Alcântara Space Center** using the **Hanbit-Nano launch vehicle** developed by **Innospace**.
- Supported by the **Indian Institute of Space Science and Technology (IIST) incubation centre** and **IN-SPACe**.
  - GOI, as part of its 2020 space sector reforms, established **IN-SPACe** to promote private sector participation in space activities. IN-SPACe had proposed a Rs.1000 crore **Venture Capital Fund**.
  - IN-SPACe, an **autonomous nodal agency** under DoS, serves as a single-window facilitator for private participation in India's space sector. Promotes, authorizes, and supervises private space activities, including building satellites/launch vehicles, providing space-based services, sharing ISRO infra, establishing new facilities.
  - **Interface Role**: Acts as a bridge between ISRO and Non-Governmental Entities (NGEs), optimizing space resource utilization and boosting space-based activities. Assesses private players' needs (including educational/research institutions) and integrates them into ISRO's plans. Headquartered in Ahmedabad.

**Skyroot's Orbital Rocket**

- PM inaugurated **Skyroot Aerospace's Infinity Campus** in **Hyderabad** via **video conference**.
- He unveiled the startup's **first orbital rocket, Vikram-I**, capable of **launching satellites to orbit**.
- **More than 300 space startups** are contributing to **India's space future**.

**World Space****Auction of Mars Meteorite**

- A **Martian meteorite (25 kg)** discovered in **Niger's Sahara Desert (2023)** was auctioned at **Sotheby's, New York, for \$5.3 million**, the largest of its kind. Since it **landed in Niger**, it should belong to Niger under national patrimony laws.
- The meteorite, named **NWA 16788**, is of **immense research value**. Larger than most Martian meteorites, offers insights into **Mars's geological history**.

**OCO-2 & 3**

- **Trump** asked **NASA** to prepare for **shutdown of two major satellites** monitoring **atmospheric CO2 and crop health**.
- **OCOs** (Orbiting Carbon Observatory series): Dedicated Earth remote sensing satellites to study atmospheric CO2 & climate change. **OCO-1 (2009)** failed after launch. **OCO-2 (2014)** launched as replacement measures atmospheric CO2, sources & sinks, tracks crops & growing seasons via photosynthesis glow.
- **OCO-3 (2019)** sent to ISS, built from spare components of OCO-2.
- Before OCOs, CO2 measured mainly by ground instruments, lacked global coverage → OCOs filled the gap.

**OCO Discoveries:**

- **Boreal forests (taiga)** play major role in absorbing CO2, not just tropical rainforests.
- **Natural carbon sinks** (forests) can turn into carbon emitters during drought or deforestation.
- **Cost of maintaining OCOs** is a small fraction of original design & launch expenses.
- **GHGs** are gases in **Earth's atmosphere** that **trap heat**. **Sun emits shortwave radiation (sunlight)** → passes through

atmosphere → absorbed by **Earth's surface** → warms the planet.

- Some sunlight is **reflected back** as **infrared radiation (long wavelength heat)**.
- **GHGs (CO<sub>2</sub>, methane/CH<sub>4</sub>)** cannot absorb **shortwave radiation**, but they **trap infrared radiation**.
- **Reason:** unlike **O<sub>2</sub> & N<sub>2</sub>**, which are **two-atom molecules**, **CO<sub>2</sub> & CH<sub>4</sub>** have **three or more atoms**. This structure gives them **multiple ways to stretch, bend, twist**, enabling them to **absorb & re-radiate heat**.

**Satellite Internet**

- A new **space race** is underway to **claim radio frequencies and orbital slots** around the earth, driven by companies deploying **large satellite megaconstellations**.
- **Megaconstellations** are large fleets of satellites working together to deliver **satellite internet**. In satellite communications, **spectrum** refers to the **range of radio frequencies** used for **wireless data transmission**.
- **Radio frequencies** are as essential to space activity. **International Telecommunication Union (ITU)** allocates electromagnetic spectrum bands to satellites and ground stations. The most sought-after bands are Ku-band (12–18 GHz) and Ka-band (26–40 GHz) for high-speed satellite internet, and L-band (1–2 GHz) for GPS.
- Satellites must **coordinate spectrum use** to avoid **signal interference**. **Spectrum alone is insufficient**; satellites also require **specific orbital positions** to reach ground antennae.
- **SpaceX's Starlink**, launched in **2019**, operates over 8,000 satellites, with plans for up to 42,000. **OneWeb** (headquartered in the UK, it is owned by a French-headquartered group) has 648 satellites. **Amazon's Project Kuiper** plans 3,200 satellites. **China's GuoWang** is also part of this expansion.

**Role of the ITU**

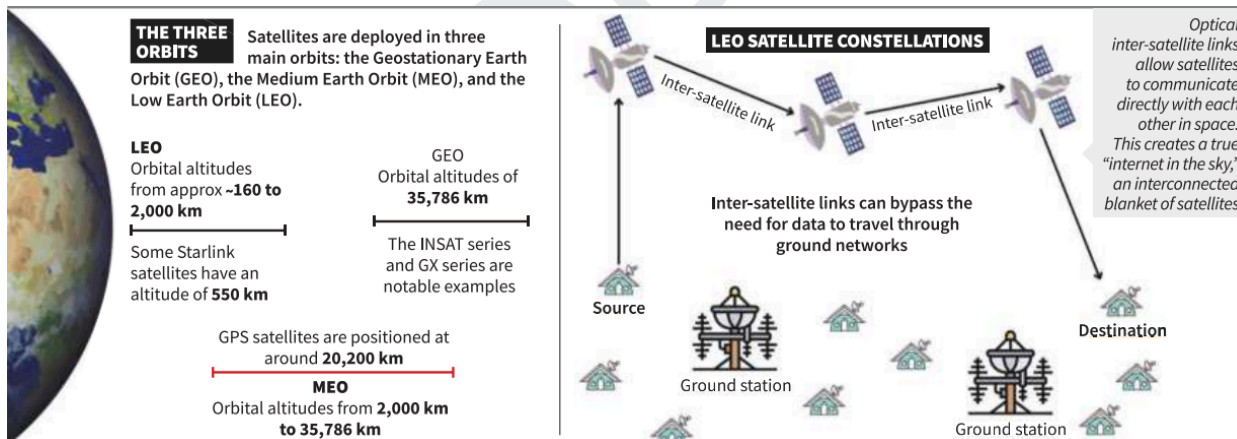
- **UN specialised agency** with **194 member states**. Sole global coordinator for satellite spectrum and orbital slots.
- It follows a **first-come, first-served coordination system**, requiring operators to **file frequency applications**.
- The **World Radiocommunication Conference 2023** introduced reforms. **Resolution 8** requires operators to **notify deviations** between planned and actual orbital deployments.
- Megaconstellation operators must deploy **10% within two years, 50% within five years, and 100% within seven years**.

**Connectivity Gap and Importance of LEO Satellites**

- On the Global Connectivity Index, Switzerland scores 34.41, while India scores 8.59.
- **LEO satellites (150–2,000 km)** offer lower latency and higher bandwidth than geostationary satellites (35,786 km).
- **Latency of 20–40 ms**, compared to 600+ ms, enables telemedicine and online education in remote regions.
- This aligns with the ITU's '**Connecting Humanity Action Blueprint**'.

**India's Position**

- **ISRO's GSAT-N2** has a throughput of 48 Gbps and covers remote regions, including A&N Islands & Northeast.
- **Bharti Enterprises' 39% stake in OneWeb** places India in the global LEO ecosystem.
- **Starlink** is set to debut in India, marking a major transformation in **internet infrastructure**.
- **TRAI** has recommended **administrative spectrum allocation** instead of **auctions**.



**Mega-Constellations & Innovations**

- **On-board signal processing** → improves efficiency and lowers user terminal cost.
- **Optical inter-satellite links** → direct satellite-to-satellite communication creates global "internet in the sky."
- **Seamless hand-off** needed due to high-speed movement of LEO satellites (~27,000 km/hr).

**Applications:** Communications, Transportation, Disaster management, Healthcare, Agriculture, Defence & security.

**Challenges:** High costs, Security risks. In **2023**, ITU adopted **ITU-R 74**, calling for **sustainable use of spectrum and orbital resources**. It includes measures to **mitigate space debris**. Satellites must be **removed from orbit within 25 years** after completing their missions.

### Satellite Lights

- Scientists simulated the orbits of **lakhs of satellites** and found that if all proposed satellite megaconstellations fly, a **third of the Hubble's images** and **over 96% of images from three future space telescopes** would contain at least one satellite streak, while some exposures could show over a hundred.
- Since satellites are **brighter than distant galaxies**, these streaks could ruin observations, meaning even space telescopes aren't safe from **satellite light pollution**.

### Micrometeoroids and Orbital Debris (MMOD)

- Gained attention after **space debris struck the Chinese crewed vehicle Shenzhou-20**, causing a **crack in the return capsule window**. These are extremely small particles ranging from **a few micrometres** to about **2mm**. Each weighs **less than a dried grape**. About **80–90% originate from asteroid belt collisions**, with some coming from **comets**.
- They travel at very high speeds of **11–72 km/s** & consist of **human-made objects** in Earth's orbit that no longer serve a purpose, including exploded rocket stages, defunct satellites, accidental collisions, anti-satellite weapon tests.
- Debris can lead to a collision cascade called the **Kessler Syndrome**, potentially making **space travel impossible**.
- **Inter-Agency Space Debris Coordination Committee (IADC)** includes agencies such as **NASA, ESA, ISRO and JAXA**. IADC develops **technical standards for space debris mitigation**. These standards underpin guidelines adopted by **UNCOPUOS**. The guidelines are "**soft law**", meaning **voluntary and non-binding**.

#### Distribution of MMOD in Space

- **Orbital debris** is concentrated in **Low Earth Orbit (LEO)** between **200 km and 2,000 km** altitude.
- **Micrometeoroids** exist throughout space but are denser near Earth due to **gravitational pull**.
- Micrometeoroids are **effectively uncountable** and cause **billions of impacts annually** on spacecraft.
- MMOD risk in LEO is **highly directional**. The **forward-facing surface** of a spacecraft faces the **highest hazard** due to **maximum relative collision speed**. Spacecraft are protected using **Whipple shields**. These shields are designed to **absorb and disperse impact energy** from MMOD collisions.

### Ionic Liquids

- Scientists found that **life can exist on rocky super-earths** with **volcanic activity** and **little water** due to **ionic liquids**. **Ionic liquids** are **salts that stay liquid even in a vacuum**.
- In the lab, they were made by mixing **volcanic sulphuric acid** with **nitrogen-containing organic molecules** found on planets, then letting the **extra acid evaporate**.
- These liquids are **stable**, can **dissolve biological molecules**, and may **support life without water oceans**.

### NASA's Interstellar Mapping and Acceleration Probe

- IMAP to map the **heliosphere's** boundary, trace energetic particles, and improve space weather forecasting.
- **Space isn't empty**; the **sun emits a continuous stream of charged particles** called the **solar wind**. The solar wind creates a vast region called the **heliosphere**, which acts as a **protective bubble** shielding planets from **cosmic rays and interstellar particles**.
- Variations in the solar wind affect **space weather**, which can **damage satellites, harm astronauts, and disrupt communications** on Earth.

### Europe's Space Aspirations

- **Europe** is expanding its **independent space launch capabilities**, with **Sweden's Esrange Space Center** emerging as a key site for orbital rocket launches. For decades, Europe has depended on the **U.S. (NASA's Cape Canaveral)** and **France's Guiana Space Centre** in South America for satellite launches.
- **Esrange Space Center**: Located in Kiruna, Sweden, over 200 km north of the Arctic Circle, Esrange is owned and operated by the Swedish Space Corporation (SSC). Initially built in the 1960s, it has evolved into a hub for Arctic-based space research and orbital launch development.
- Alongside Esrange, **Andøya Spaceport** in **northern Norway** is also advancing as a launch site.
- Countries like **Portugal, Spain, Italy, Germany, and the United Kingdom** are developing or proposing their own **spaceport projects** to build a diversified **European spaceport portfolio**.

### Autonomous Satellites

**Why in news:** The **Space Age began in 1957** with the launch of **Sputnik** by the Soviet Union.

- Traditional satellites function as **passive tools** for imaging, communication, GPS. Satellites are becoming AI-powered & **autonomous** enabling them to **analyze, decide, and act independently**, known as **satellite edge computing**.

#### Applications of AI in Satellite Autonomy

- **Automated operations:** In-orbit docking, inspections, debris removal, and refuelling.
- **Self-diagnosis and repair:** Detecting faults and initiating repairs without human input.
- **Route optimization:** Navigating orbital paths to avoid hazards and reduce fuel use.
- **Real-time geospatial intelligence:** Detecting disasters and coordinating responses from orbit.

- **Combat support:** Identifying threats and autonomously tracking or engaging targets.

**Associated Risks and Solutions**

- AI **hallucinations** or misjudgements in space can result in misclassification and unintended manoeuvres.
- **Outer Space Treaty (OST, 1967)** and **Liability Convention (1972)**, assume human control.
- **Dual-use nature** (civilian + military) of AI satellites poses added risks of misinterpretation.
- Adopt strict liability frameworks and insurance models similar to: **1996 HNS Convention** (hazardous substances), **1999 Montreal Convention** (international air carriage).

**China’s Tianwen-2**

**Why in news:** Spacecraft to collect samples from **near-Earth asteroid 2016HO3** and explore **main-belt comet 311P**.

- **Tianwen-2 mission** will place it among a few countries (**US and Japan**) that have **returned asteroid samples to Earth**.
- The mission **aims to return asteroid samples by 2027**, offering insights into the **solar system’s formation**.
- The mission targets **Kamo’oalewa**, a **quasi-satellite** of Earth discovered in **2016** by the **Pan-STARRS 1 telescope** in Hawaii. **Quasi-satellites** orbit the **Sun**, but remain gravitationally influenced by Earth, giving the illusion they orbit the planet. **Kamo’oalewa’s orbit is highly elliptical**, and it appears to alternately **lead and trail Earth** in its orbit. The asteroid has likely remained in its current orbit for **100 years** and may stay for another **300 years**.
- **Kamo’oalewa might have originated from the Moon** following a collision.
- Studying the asteroid may help validate theories about the **Moon’s formation** via a **collision between Earth and a small planet**. China’s **Tianwen-2** will use the **“touch-and-go” technique** to collect samples, as done in **OSIRIS-Rex (US)** and **Hayabusa2 (Japan)** missions.

**WHAT OBSERVATORY IN CHILE WILL EXPLORE**

Rubin’s Simonyi Survey Telescope, which has the world’s largest camera, can observe an area of the sky equivalent to 40 full moons arranged in a line

- MILKY WAY STRUCTURE**  
Rubin will create a detailed map of our galaxy to ascertain how it was formed.
- DARK MATTER & DARK ENERGY**  
It will help scientists better understand the nature of these substances.
- SOLAR SYSTEM CENSUS**  
Rubin is expected to discover millions of new asteroids and comets.
- THE CHANGING SKY**  
It will build the most detailed time-lapse view of the cosmos ever generated.

**THE OBSERVATORY**  
It is named after American astronomer Vera C Rubin (seen on right), who provided evidence about dark matter for the first time in the 1970s.

**Vera Rubin Observatory**

- Vera Rubin Observatory houses **world’s largest digital camera**, the size of a **small car**, weighing **2,800 kg** with a **3,200-megapixel resolution**.
- **Simonyi Survey Telescope** is unique for its wide field of view, largest camera, and rapid movement.
- Unlike Hubble (1% of the Moon’s disc) or James Webb (75%), Rubin’s telescope observes an area equal to **40 full Moons**.
- **Rapid Movement:** Traditional telescopes take **10 minutes** to adjust; Rubin’s telescope moves faster. The observatory will **scan the southern sky for 10 years**, collecting **20 terabytes of data nightly**.
- **US-led project** sits atop **Cerro Pachón** in the **Andes Mountains**.

**Honda Reusable Rocket Test**

**Why in news:** Honda successfully tested an **experimental reusable rocket** in **Hokkaido, Japan**, aiming for a **suborbital launch capability by 2029**. It marks

the **first successful vertical landing**.

- **Suborbital launches** touch the edge of space but do not enter orbit, making them ideal for scientific testing and satellite deployment. Honda’s move mirrors global trends, with players like SpaceX’s Falcon 9, Blue Origin, and ISRO working on reusable space vehicles.
- Other **Japanese entities** like **JAXA (with its non-reusable H3 rocket)** and **startups like Space One and Innovative Space Carrier** are also entering the space race.

**China’s Reusable Rocket**

- The maiden test of **Zhuque-3**, a **next-generation reusable rocket** by **LandSpace**, failed to achieve a **controlled landing**.
- **SpaceX and Blue Origin (Jeff Bezos)**.
- **Rocket reusability**, pioneered commercially by **SpaceX’s Falcon 9**, involves **complex high-energy manoeuvres** such as **engine relight, re-entry survival, and precision landing**.

Rank	Country/Agency	Key Vehicle	Status
1st	USA (SpaceX)	Falcon 9	Fully Operational (15+ reuses per booster)
2nd	India (ISRO)	RLV-TD / LEX	Successfully tested landing & autonomous return
Pending	China	Zhuque-3 / Long March 10	In testing phase; recent crash in Jan 2026

**Japan H-2A Rocket**

- Japan launched **GOSAT-GW satellite** aboard the **H-2A rocket**, marking the **50th and final flight** of the H-2A before its retirement. **Global Observing Satellite for Greenhouse Gases and Water Cycle** will monitor **carbon, methane, and GHGs** & share high-resolution data on **sea surface temperature and precipitation** globally.
- Since its debut in **2001**, the **liquid-fuel H-2A** (with two solid-fuel boosters) recorded **49 flights** with a **98% success rate**—its only failure occurred in **2003**.

- The **H-2A** will be replaced by the **H3**, developed by Mitsubishi Heavy Industries and JAXA, designed to carry **larger payloads at half the cost**. Japan is also developing the **Epsilon rocket** to cater to **small payload markets**.

### Human-rating Launch Vehicle

- Human-rating ensures a space system can safely carry humans, with an acceptable level of risk. As per NASA standards, acceptable risk is **0.2% probability of a catastrophic crew-loss event during ascent and descent**.
- Fully operational human-rated launch vehicles flying crews to Earth orbit include **Russia's Soyuz-2**, **China's Long March 2F**, and **SpaceX's Falcon 9**. United Launch Alliance's **Atlas V** completed a crewed test flight in 2024 with **Boeing Starliner**, but awaits certification for routine operations. **NASA's Space Launch System** is human-rated, has flown **Artemis I (uncrewed)**, and is preparing for its first crewed mission.

### Who certifies human-rating

- In the U.S., **NASA** grants final human-rating certification for crewed flights, including commercial systems like **Crew Dragon** and **Starliner**. **U.S. FAA** licenses launches for public safety but does **not** certify crew safety.
- **China Manned Space Agency (CMSA)** certifies China's systems; **Roscosmos** certifies Russia's **Soyuz**.

### Success Rates

- **Soyuz**: over 150 crewed missions since 1967, ~98% success; two early fatal missions (1967, 1971); 100% crew safety success since 1971, with successful escape-system saves in 1975, 1983, 2018.
- **U.S.**: 135 missions (1981–2011), 133 successes (98.5%); two fatal accidents (Challenger 1986, Columbia 2003).
- **SpaceX Falcon 9 + Crew Dragon**: 100% success across 20 human orbital flights, including ISS rotations and private missions such as Axiom-4 piloted by Indian astronaut Subhanshu Shukla.

### India and Gaganyaan

- India's maiden human spaceflight programme **Gaganyaan** will use the **LVM-3** launch vehicle. **LVM-3 selection rationale**: 7 consecutive successful orbital flights (including Chandrayaan-3), highest reliability in ISRO's fleet.
- **Indigenous propulsion** (Vikas liquid engines, **C25 cryogenic engine**, **S200 boosters**).

### Astronaut Suit

- Atmospheric pressure presses on our bodies with **about 20 tonnes of force**, but we don't feel it because our bodies **push back with equal force**. As altitude increases, the **atmosphere gets thinner** and its pressure drops.
- When the human body is suddenly exposed to **vacuum**, lethal effects occur such as **ebullism** (boiling of bodily fluids), **decompression**, and **lack of oxygen** (hypoxia).
- The absence of pressure causes gases to **expand rapidly** in lungs and tissues, leading to **loss of consciousness in seconds** and **death in minutes**. Astronauts wear **special suits** during space travel for protection.
- **Extra-vehicular activity (EVA) suits**, used outside spacecraft, have **12–14 layers** and act as a **personal spacecraft** protecting against vacuum, extreme temperatures, radiation, and space debris; each weighs **100–130 kg**.
- **Intra-vehicular activity (IVA) suits** are worn inside the spacecraft and include a **flight suit** and a **pressure suit**.
- A **flight suit** provides fire resistance and protection against temperature extremes and low pressure. **Pressure suit** provides **full-body pressurisation**, oxygen supply, thermal regulation; it weighs **8–10 kg** with two or three layers.
- In **1961**, Yuri Gagarin wore a specialised IVA suit called **SK-1**. U.S. & Russia have developed **8 to 10 suit designs**.
- During the **Soyuz 11 mission (1971)**, three cosmonauts died due to a **vent valve opening early**, causing rapid loss of cabin pressure and suffocation. The disaster led to a **mandate to wear IVA suits** during ascent and descent due to risks such as high G-forces, sudden pressure loss, extreme heat, and vibrations.
- In **Gaganyaan**, India's first human spaceflight mission, the gaganyatris will use the **Russian Sokol KV2 suit** manufactured by Zvezda. The suit has two layers: an **inner pressure bladder** made of rubberised polycaprolactam and an **outer restraint layer** of white nylon canvas for structural support and protection.

### JUNO – INO

- China has **finished building its Jiangmen Underground Neutrino Observatory (JUNO)**. **India-based Neutrino Observatory (INO)** has been in limbo for years. JUNO has also released its **first analyses of neutrinos**, subatomic particles that are very hard to catch because they **rarely interact with matter**.
- The **massive size** of the INO detector (weighing **50 kilotonnes**) was the original trigger of its downfall in India. The INO detector could not be situated in an existing facility. The INO collaboration planned to **install the detector inside a mountain in Theni, Tamil Nadu**, with the mountain's **rock serving as a natural shield**.
- Neutrinos come in **three flavours** and can **oscillate between them** as they travel through space.
- Figuring out **how the three neutrino masses are ordered** is an important open question.
- Neutrino oscillations are described by  **$\theta_{12}$ ,  $\theta_{13}$ , and  $\theta_{23}$** .  **$\theta_{13}$**  has been pinned down by previous experiments.
- **JUNO and INO** were conceived to use this knowledge to determine the **neutrino mass ordering**. JUNO's second paper reported that it had **measured  $\theta_{12}$  very precisely**. India may not have the resources to take a shot at the **next big mystery**, which will require **more specialised and sophisticated technologies**.

### From Last Year's Compilation:

- **Neutrinos** are **subatomic particle** with no electric charge, a small mass, and are **left-handed** (direction of spin is opposite to direction of motion). They are the **second-most abundant particles** in the universe after **photons** and the

- most abundant **matter particles**. They are produced when **leptons interact with matter**, e.g., **muon-neutrino**, **electron-neutrino**, and **tau-neutrino**. They **rarely interact** with matter, making them difficult to study.
- **Challenges in Studying Neutrinos:** A **muon-neutrino** interacts with an atom's nucleus only once in a **million times**, producing a muon and a proton. Large detectors with fine tracking capabilities are required.
  - **NOvA Experiment** in the U.S. creates a beam of neutrinos that travel to a **14,000-tonne detector** located 800 km away. Managed by **Fermi National Accelerator Laboratory**, it aims to determine the role of neutrinos in **cosmic evolution**. The experiment focuses on understanding its role in the **universe's evolution**.
  - Neutrinos may gain mass through a mechanism **different from other matter particles**, challenging **Standard Model of particle physics**. Neutrinos can **oscillate** (change type as they travel), a quantum mechanical phenomenon.
  - **Mass hierarchy problem** has 2 models: **Normal order:** One type is much heavier, others are lighter, **Inverted order:** One type is lighter, others are heavier. NOvA data supports the **normal order**, but results are inconclusive.
  - Neutrino astronomy began in 1987 when neutrinos from a **supernova** were detected three hours before the light from the explosion reached Earth.
  - **Applications of Neutrinos:** Neutrinos are excellent carriers of information across large distances due to their low interaction rate. Unlike **electromagnetic waves**, neutrinos can pass through **1,000 light years of lead** and can overcome barriers like seawater. If transmission and detection technology improves, neutrinos could replace electromagnetic waves in communication.
  - **Global Neutrino Research:** Leading experiments include: **Super-K III** (Japan), **SNO+** (Canada), **MiniBOONE** and **NOvA** (U.S.), **IceCube** (Antarctica), **Jiangmen Underground Neutrino Observatory** (China), etc. In India, the **India-based Neutrino Observatory** (Tamil Nadu) is funded by the **Department of Atomic Energy** but faces delays due to **procedural lapses** and lack of political support. A major unknown about neutrinos is **their exact mass**, though we know the

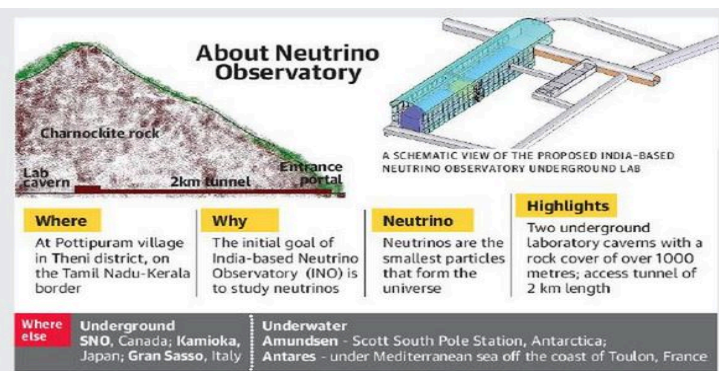
**difference in the squares of their masses. AMoRE experiment in South Korea** is searching for this process using **Mo-100 nuclei cooled to near absolute zero**.

- In 1960s, Indian, Japanese, and British scientists discovered atmospheric neutrinos in Kolar, Karnataka.

- **Neutrino Oscillation:** 2015 Nobel Prize in Physics recognized neutrino oscillation, discovered at **Super-Kamiokande**. **Japan's Super-Kamiokande**, operational since 1996, played key role in discovering cosmic neutrinos after **Supernova 1987A**.

### KATRIN – Neutrino Mass

**Why in news:** The **KATRIN experiment** (Karlsruhe Tritium



Neutrino Experiment) aims to measure **neutrino mass**.

- Its 200-tonne spectrometer was built in **Deggendorf, Germany**.
- Neutrinos are **extremely light, neutral, and weakly interacting** subatomic particles. Discovered in 1938; their mass was confirmed through **particle oscillations** (2015 Nobel Prize).
- **Oscillations** reveal only mass differences, not absolute masses. Standard Model predicts neutrinos to be massless —their mass hints at **physics beyond the Standard Model**.

### Challenges

- Neutrinos travel near **speed of light**, making direct mass measurements hard.
- Existing techniques rely on beta decay of tritium, focusing on the **energy spectrum of emitted electrons**.
- Neutrinos rarely interact — e.g., a **light-year-long metal block** is needed to block a single solar neutrino.

### Google's 'Project Suncatcher'

- With **Project Suncatcher**, **Google** has joined the race to put **AI data centres in space**, exploring **solar-powered satellite constellations** hosting **data centres in space**. The idea is similar to satellite constellations like **Starlink**.
- The difference is that Google aims to deploy **high-performance AI accelerators** and build a **space-based infrastructure**. Relies on **solar-powered satellites** connected by **free-space optical links** into a **distributed network**.
- Tech leaders including **Jeff Bezos**, **Elon Musk**, and **Sam Altman** have plans for **data centres in orbit or on the Moon**.
- Google stated that **the Sun is the ultimate energy source**. In the right orbit, a **solar panel can be up to 8 times more productive** than on Earth. Solar power in space can be generated **nearly continuously**.

### Technology Architecture

- The proposal involves placing **Tensor Processing Units (TPUs)** in space.
- These would be connected by **free-space optical links**.
- Data transfer rates could reach **tens of terabits per second**.
- The approach mirrors how **low Earth orbit satellites** beam internet to Earth.

### Key Challenges

- Maintaining **high-speed connectivity** between satellites. Satellites must remain within **about one kilometre** of each other. This requires **extremely precise station-keeping**. Hardware must withstand **radiation** and **extreme temperatures**. Google is testing **Earth-designed chips** like the **Trillium TPU v6e** for **radiation resistance**.
- Cooling hardware remains difficult because **conventional cooling systems do not work well without gravity**.
- **Space weather** can damage electronics. Increasing **space debris** poses risks to physical hardware.
- **Quantum Artificial Intelligence Lab** was launched in **2013** by **Google**, with **NASA's Ames Research Center** hosting the lab, to study how **quantum computing** might advance **machine learning**.
- **Google self-driving car project** began in **2009** with the goal of **creating self-driving cars** to improve **road safety**. In **2016**, the project was renamed **Waymo** and became an **independent company** and a **subsidiary of Alphabet**, **Google's parent company**. **Waymo** is an **autonomous driving technology company** that uses **advanced AI, sensors, and machine learning** to power its vehicles.

## AI and Quantum

### AI Preparedness Index

- The **AI Preparedness Index** in **Asia-Pacific** region varies drastically, ranging from **over 70% in advanced economies** to **under 20% in fragile states**. The **Index by IMF** assesses countries' **digital infrastructure, human capital and labour market policies, innovation and economic integration, and regulation and ethics**.
- The report notes that **inclusive adoption** will require **strengthening both hard and soft foundations**.
- **Hard infra:** Affordable internet, reliable and clean electricity, cooling resources, and adequate computing capacity. Internet access has expanded rapidly across Asia-Pacific, but inequalities remain.
- **Soft infra:** Human capital, strong public institutions, and legal frameworks that ensure secure and fair access.

### Google's AI Matryoshka

**Why in news:** **Google I/O 2025** marked **unveiling of an AI-centric future**, structured like a **Matryoshka doll** with AI at its core. Google is **restructuring its entire ecosystem around AI**.

- At the core lie **foundational models Gemini 2.5 Pro (Deep Think)** and **Gemini 2.5 Flash**, offering enhanced **reasoning and efficiency**. These models are powered by **TPU v7 (Ironwood)** with **42.5 exaFLOPS per pod**, offering a **tenfold performance boost**. Generative models like **Imagen 4, Veo 3, and Lyria 2** raise concerns about **copyrights**.

### Sarvam and IndiaAI Mission

**Why in news:** **Sarvam, Bengaluru start-up**, selected to build **India's first indigenous LLM** under **IndiaAI Mission**.

- Sarvam's LLM will be **capable of reasoning, designed for voice, and fluent in Indian languages**. The model will not be open-sourced; compute support will come via government-backed AI data centres.
- Sarvam is building **three LLM variants**: Sarvam-Large: for advanced reasoning and generation; Sarvam-Small: for real-time interactive applications; Sarvam-Edge: for on-device tasks
- LLM will be **built, trained, and deployed entirely in India**.

#### IndiaAI Mission

- To **democratise compute**, improve **data access & quality**, develop **indigenous AI**, promote **ethical-impactful AI use**.
- **Objectives:** Apply AI to health, education, agriculture, mobility, infra, smart cities; Improve decision-making, generate new applications, and boost productivity. **Seven Pillars:** Compute Capacity, Foundational Models, Datasets, Application Development, Future Skills, Startup Financing, Safe and Trusted AI.
- India is a **founding member** of **GPAI**, an **OECD-supported initiative** for responsible AI development and cooperation.
- Comes under the **MeitY** to: Build a high-end AI computing infrastructure with over **10,000 GPUs**; Create an AI marketplace for pre-trained models and resources.
- **IndiaAI Datasets Platform (AI Kosha):** Provide access to high-quality, non-personal datasets for startups in Indian languages to reduce biases.

• **LLMs** are general-purpose AI models trained to solve language-related tasks like text classification, summarisation, question answering, and text generation. The term '**Large**' refers to both the **huge volume of training data** and the **high number of parameters (model knowledge)**, which define its **problem-solving skill**.

• '**General Purpose**' implies that LLMs can handle a **wide range of language tasks** without being trained for each one.

### Garbhini-GA2

- Researchers at **IIT-Madras** and **Translational Health Science and Technology Institute, Faridabad** are developing **Garbhini-GA2: AI Model for Foetal Age Prediction** using ultrasonography.
- Half of all pregnancies in Indian women are high-risk pregnancies (HRPs) (Journal of Global Health, 2023). Causes: severe anaemia, high blood pressure, pre-eclampsia, hypothyroidism.

**AI - News**

**Why in news:** Influencers and generative AI are reshaping news consumption by amplifying a fragmented alternative media environment (FAME), according to the 2025 Digital News Report by the Reuters Institute.

**Kairali AI Chip**

- Makers of **Kairali AI Chip**, developed by **Digital University Kerala**, clarified that it is an **academic research initiative** and **not a commercial product**.
- They highlighted the **ground-breaking achievement** of designing a **functional AI test chip** at a **State-funded institution** with **limited infrastructure and funding**.
- Developers stated that Kerala's **first silicon-proven AI chip** was a **prototype** built by **Master's and PhD students**, validated under **MeitY's Chip to Startup (C2S) programme**. Test chip was created with **limited resources** using **Efabless platform, open-source tools**, and a **130nm fabrication process**.
- C2S aimed at transforming India into a global hub for semiconductor design & to develop 85,000 industry-ready professionals over 5 years (by 2027) at B.Tech, M.Tech, and PhD levels. It focuses on VLSI and Embedded System Design. Implemented by C-DAC.

**Nvidia Chips - China**

- **Trump** announced that **Chinese firms can import Nvidia's H200 GPUs**, subject to a 25% revenue surcharge payable to the U.S. government. Nvidia's H200 GPUs are used for AI workloads and are one generation behind the Blackwell (B200) chips, with performance boosted by Nvidia's CUDA software ecosystem.
- Since **2018**, the **U.S. and allies (Japan, South Korea, Netherlands)** have **restricted advanced chip exports to China** due to dual-use (civil-military) concerns and to preserve technological and commercial leadership.
- Restrictions have **pushed China to accelerate indigenous R&D**, with firms like **Huawei** developing **domestic chips**. Allowing limited H200 sales is seen as a **strategic compromise**: it lets U.S. firms access the **Chinese market**, while **reducing China's urgency to develop cutting-edge alternatives**.
- Gaps persist in China despite successes like **cost-efficient AI models (e.g., DeepSeek)**.

**Budapest Open Access Declaration**

- **Budapest Open Access Declaration in 2002** challenged practices of the **scholarly publishing industry**, which had long **excluded vast sections of the global research community** from accessing knowledge using **expensive paywalls**.
- The declaration came as the **open access movement** started questioning why, in a **digital age** in which **printing and postage no longer dictated costs**, access to knowledge **remained behind expensive subscription paywalls**.
- PM called for a **global compact** to prevent the **misuse of AI**. He said technology applications should be **"global" not "national"**, and based on **open source** rather than exclusive models.
- India will host the **AI Impact Summit in February 2026** with the theme **"Sarvajanam Hitaya, Sarvajanam Sukhaya"**.

**Google Data Centre**

- **Google** announced an investment of \$15 billion over the next five years to build a **'gigawatt-scale' AI-focused data centre** in **Visakhapatnam**. This will be Google's largest AI hub **outside the US**.
- **Will partner with Bharti Airtel** and **AdaniConneX** (data centre services provider) to develop the facility.
- The **AI hub** aims to offer **high-performance and low-latency computing services** for businesses.
- The investment will also help **create a connectivity hub in Visakhapatnam**, enabling **multiple international sea cables to land in the Port City**.
- **AI data centres** consume massive energy — **GPU racks use 80–150 KW** compared to **15–20 KW** for traditional servers. **AI is now the most significant driver of increased energy consumption** in the data centre sector.

**Global AI Data Centre Infrastructure**

- The **U.S.** leads with **51%** of global capacity (Texas, Wisconsin, Northern Virginia, Phoenix, Ohio, Pennsylvania).
- Other nations developing AI infrastructure: **China, Norway, U.K., Germany, Japan, Malaysia**.
- **Visakhapatnam (Google)** and **Jamnagar (Reliance Industries)** have been selected for **GW-scale AI data centres**.

**Small Modular Reactors (SMRs)**

- Provide flexible sizing (1–300+ MW), factory-built cost efficiency, passive safety, and 24/7 stable baseload power. Global SMR investment: \$15.4 billion.
- **Advantages include:**
  - Smaller reactor cores with reduced nuclear material.
  - Passive safety features like natural convection and automated shutdown.
  - Accident-tolerant fuels maintaining integrity at higher temperatures.
  - Longer mitigation times (hours/days) and smaller offsite emergency zones.
  - Do not require costly transmission infrastructure.

**International Collaboration and Safety Frameworks**

- Nuclear Harmonization and Standardization Initiative (NHSI) promotes regulatory harmonisation.
- IAEA SMR Regulators' Forum shares experiences and best practices globally.

- Safeguards by Design Programme integrates international safeguards into early design.
- Emphasis on developing new regulatory frameworks for SMR transportation and waste management.

### Data Centre Industry

- India's data centre industry has grown from **less than 650 MW in 2019** to **1.4 GW**, according to S&P.
- Installed capacity is expected to reach **2 GW by 2028** if announced projects roll out on time.
- **Power usage effectiveness (PUE)** is used to assess how efficiently electricity is utilised by data centres. India faces disadvantages due to its **tropical climate**, increasing **cooling costs**. **Reliable electricity supply** remains a challenge.
- **MeitY's IndiaAI Mission** is providing **subsidised access to Nvidia GPUs** through providers like **Yotta**.
- **MeitY** released a **draft data centre policy in 2020**, but it was **not finalised**. **UP, Tamil Nadu, Maharashtra, and Karnataka** have their **own data centre policies**. Since **2016**, the Union government has encouraged **local storage of Indian user data**. **DPDP** allows restrictions on foreign jurisdictions for data storage.
- **Mumbai** accounts for **half of the data centre market**, even on the **demand side**.

### India AI Governance Guidelines

- **MeitY** unveiled the **India AI Governance Guidelines** outlining an approach to **regulating and promoting the use of AI**.
- **India** is the **world's second largest user of LLMs** like **ChatGPT** after the **U.S.**
- The **guidelines state** that "India's goal is to harness the transformative potential of AI for inclusive development and global competitiveness, while addressing the risks it may pose to individuals and society."
- They recommend setting up **lines of communication between** different parts of the government, including Ministries, sectoral regulators, and standards setting agencies. Overarching inter-ministerial body proposed is the "**AI Governance Group**". Framework recommends roles for the **RBI, NITI Aayog, and BIS** etc.
- The **RBI** has already released the **FREE-AI Committee report** (Dr. Pushpak Bhattacharyya) for banking and finance.
- Safety-related recommendations rely on the **AI Safety Institute (AISI)** framework. In India, the AISI functions as an **online framework**, with academia brought together under the **IndiaAI Mission**.
- State governments are encouraged to **increase AI adoption** through **infrastructure development**.
- The guidelines recommend **legal changes in copyright law** to address **AI and intellectual property** concerns.
- They reiterate priorities such as building **AI models for Indian languages** and push for the **use of locally relevant datasets** to create **culturally representative models and applications**.
- Another recommendation supports the **integration of DPI with AI** through **policy enablers**.
- **AI** can be classified into **two types: Artificial Narrow Intelligence (ANI) or weak AI, and Artificial General Intelligence (AGI) or strong AI**.
  - **ANI** is designed for **specific tasks** and excels within a **narrow domain**. Examples include **virtual assistants like Siri, recommendation systems like Netflix, and image recognition software**. **ANI systems are highly specialised and cannot transfer expertise to unrelated tasks**.
  - **AGI** aims to **replicate human cognitive abilities**, enabling performance of **any intellectual task** a human can do. **AGI** would have **general reasoning, context understanding, and adaptability across domains**. It would enable **autonomous learning and problem-solving without task-specific programming**.

### AILA

- **IIT-Delhi** has developed an **AI agent** capable of conducting **scientific experiments** in laboratories **independently**. **AILA (AI Lab Agent)** can **control devices** in a **research centre** and make **real-time decisions** during experiments.

### AI Labelling

- **MEITY** proposed **mandatory disclosure and labelling** of **AI-generated "synthetic" content** on social media platforms. & released a **draft amendment** to the **IT (Intermediary Guidelines and Digital Media Ethics Code) Rules, 2021**.
- Synthetic media is **artificially or algorithmically created, modified, or generated** to appear authentic. Labelling such content is complicated since not all altered media is made by **generative AI**. Over **50% of all Internet content** is now considered **AI-generated**.
- The amendment requires social media companies to allow users to **self-declare** if the content they upload is **AI-generated**. If users fail to declare, platforms must **proactively detect and label AI-generated content**.
- Rules mandate labels covering **10% of visual area** for synthetic videos or **10% of initial duration** for synthetic audio. Rule applies to **all types of synthetic content**, including **text** and is **not limited to photorealistic content**.

### Random Forest

- A **random forest** is a **machine-learning method** that makes predictions by **combining decisions of many decision trees**. A **decision tree** works **bottom-up**, asking **questions at each node** and moving left or right until a **final decision at a leaf**. **Single trees** are easier to understand but can **overfit the data** and not **generalise well**.
- A **random forest** reduces overfitting by building **many trees** trained on **different random samples** of the data.

## AI - Copyright

- **Digital News Publishers Association**, representing **news media outlets with a digital presence**, has **sued OpenAI** in **Delhi HC** for **copyright infringement**.
- **DPIIT's working paper on AI and Copyright Issues** is **welcome**:
  - Proposal seeks to **remunerate content providers** without putting **India's AI ecosystem** at a **disadvantage**.
  - The paper proposes a **mandatory licensing framework**. A **non-profit copyright society-like body**, **Copyright Royalties Collective for AI Training (CRCAT)**, would **collect payments** from **AI developers** based on **revenue accrued** from training on **Indian content producers' data**, only once they **commercialise their models**. Payments would not be sought when firms are **mining data from the Internet** to **develop or train** models
- This model is similar to the **"compulsory licensing"** for **radio stations**, which allows playing music by paying a **fee** to **rights holders**.



## Virtual Minister

- **Albania** unveiled **Diella**, the **world's first AI Minister**, to take care of its **public procurement process**. It is based on **LLMs** that power **ChatGPT** and **Gemini**, and is developed in **association with Microsoft**.
- The **Balkan country**, which nurses hopes of **joining the EU**, has been riddled with **corruption**.
- With **Humphrey** in the **U.K.** and **Albert** in **France**, digital assistants aiding in bureaucratic work is not new.

## Arka and Arunika

- **PM** has commissioned India's most powerful **High-Performance Computing (HPC)** systems **Arka** and **Arunika**.
- The **Arka** system at **IITM Pune** has a **11.77 Peta Flop** capacity. **Arka** will help improve the **horizontal resolution** of global weather prediction models to **6 km** from the existing **12 km**.
- **HPC Arunika** at the **National Center for Medium Range Weather Forecasting (NCMRWF)**, **Noida**, has a **8.24 Peta Flop** capacity. **Arunika** will be beneficial in upgrading **weather forecast resolution** at the **block level**.

## Supercomputers vs Normal Computers

- India's supercomputing ecosystem, led by **C-DAC** under the **National Supercomputing Mission (NSM)**, is expanding rapidly with **indigenous development of hardware and processors** such as **Rudra** and **AUM**.
- A **supercomputer** is designed to perform massive, complex, and calculation-intensive tasks & are critical for scientific research, weather forecasting, nuclear simulations, and AI model training. They are vital for applications like climate modelling, space simulations, defence research, and drug discovery.
- Based on **parallel computing**, processors (**cores**) work simultaneously on parts of a problem.
- **Main Components**:
  - **Processors**: CPUs for general tasks; GPUs for repetitive mathematical operations in simulations. **Nodes**: Groups of processors with memory, acting like small computers; thousands of such nodes exist in a supercomputer.
  - **Network**: High-speed data connections between nodes for fast communication. **Memory & Storage**: Each node has its own memory; large systems use petabyte-scale storage and specialised file systems for smooth data flow.
  - **Cooling Systems**: Use water pipes, refrigeration units, or liquid immersion to manage heat.
  - **Power Requirement**: Comparable to that of a small town, demanding efficient power distribution.

### Software and Performance

- Controlled by specialised **operating systems** managing **task scheduling**, **memory**, and **inter-processor communication**. Uses **parallel programming languages** such as **MPI (Message Passing Interface)** and **OpenMP**.
- **Load balancing algorithms** ensure all processors work efficiently, avoiding idle time.
- Performance measured in **flops (floating-point operations per second)**: **Laptops**: Billions of flops, **Supercomputers**: **Exaflops (10<sup>18</sup> operations per second)**.

### India's Supercomputing Journey

- Originated in the **late 1980s**, when **Western export restrictions** spurred indigenous development.
- **C-DAC** (est. 1988) created the **PARAM series**, starting with **PARAM 8000 (1991)**.
- **National Supercomputing Mission (NSM)** launched in **2015** by **DST** and **MeitY**, aims to establish **70+ high-performance computing facilities** nationwide, develop **indigenous hardware, software, and processors**.
- **Exascale Computing**: Next-gen systems performing over **10<sup>18</sup> operations/sec** (e.g., **JUPITER** in Germany, powered by renewable energy).

- **Neuromorphic Computing:** Mimics the **human brain**, integrating **processing and memory** on one chip for higher efficiency.

### Amazon Web Services

- **AWS data centre on U.S. east coast** experienced **increased error rates and latencies**, triggering a **major outage**. The disruption had spread to several **AWS data centres in Northern Virginia**, particularly affecting the **U.S.-East-1 cluster**, which is AWS's **largest and most active region**.
- The outage impacted digital services of over 2,000 companies including Amazon, Snapchat, Signal, ChatGPT, Perplexity, Canva, Roblox, Duolingo, Fortnite, Coinbase, and Epic Games.
- The outage originated from a **DNS error** that disrupted **DynamoDB database APIs** in the **US-East-1 region**.
- **Domain Name System** acts as an **internet lookup mechanism**, translating a website's URL (e.g., www.instagram.com) into its corresponding **IP address** (e.g., 57.144.150.34). When a **DNS system fails**, users cannot connect to services because **the network cannot find the correct server**, even if the service itself is operational.
- **DNS failures** can occur due to various reasons — such as domain registration lapses, faulty automated updates, or changes to DNS service providers.
- Experts warn that **cloud outages may increase** as **AI adoption grows** within enterprises, since **AI systems require massive data ingestion into the cloud**, increasing **load and complexity** on major providers like **AWS, Microsoft Azure, and Google Cloud**.

### Majorana Particles

- Scientists are exploring **Majorana particles** — exotic entities that are their own antiparticles — as a potential foundation for **error-resistant quantum computers**. This concept promises to overcome one of quantum computing's toughest challenges: maintaining **quantum coherence** and **stability of qubits**.
- Proposed in the **1930s by Italian physicist Ettore Majorana**, these particles are unique because they are **identical to their antimatter counterparts**. In contrast, typical matter and antimatter (like electrons and positrons) annihilate each other upon contact.
- **Physicists** have created **Majorana-like quasiparticles** in **superconducting materials** cooled to near absolute zero.
- Quantum computers rely on **qubits**, which can exist in a **superposition of 0 and 1**. The main obstacle is **decoherence** — the tendency of qubits to lose their quantum state due to environmental noise.
- Traditional systems (like **superconducting or ion-trap qubits**) require **complex error correction**, where hundreds or thousands of physical qubits maintain one logical qubit.
- **Majorana-based qubits** could be **inherently stable** by design, potentially removing the need for such redundancy.
- Majorana modes belong to a rare class of quantum objects called **non-Abelian anyons**. When these particles are **exchanged or "braided"**, their **joint quantum state changes**, and the order of exchanges affects the outcome.
- Computations using **braiding patterns** depend only on the **topology** (the over-and-under pattern of the paths), not the specific details of motion. Could enable **topological quantum computers**.

### Double Quantum Dot

- To realise their **quantum clock**, the scientists used a device called a **double quantum dot (DQD)**.
- **Quantum dots** are minuscule human-made islands in a **semiconductor material**, so small that they can hold only **one extra electron** at a time. The **inventors of quantum dots** were rewarded with the **Nobel Prize for Chemistry in 2023**.
- A **double quantum dot** acts like two artificial atoms placed side-by-side. It traps individual electrons in two tiny "wells," allowing scientists to control their movement and quantum states for computing.

### Quantum Key Distribution

**Why in news:** IIT-Delhi and DRDO successfully demonstrated **QKD** over **1 km of free space**, a first-of-its-kind achievement in India.

- The demonstration used **entanglement-based QKD**, where any eavesdropping attempt **instantly alters the quantum state**, alerting users and ensuring communication security. A **secure key rate of 240 bits/second** with **<7% error rate** was achieved, falling within the acceptable threshold for real-world application.
- **QKD enables safe sharing of encryption keys** using **quantum physics**, not for encrypting the message itself.
- Two types of QKD: **prepare-and-measure QKD** (uses single photons in known states) and **entanglement-based QKD** (uses entangled photon pairs).
- **Quantum entanglement** ensures that measurements on one photon **instantly affect** its entangled pair, offering **ultra-secure communication**.
- QKD ensures that **any attempt at hacking** introduces **detectable errors**, providing **real-time breach detection**.
- **National Quantum Mission (NQM)** launched in **2023**, has a **₹6,000 crore budget** running till 2031.
- Applications include **banking, telecom, and defence**, where data integrity and secure channels are paramount.

**Vision for Satellite-Based Quantum Communication**

- India could be **technologically capable of satellite-based quantum communication by 2030**. Satellite-mediated QKD avoids the **cost and instability** of long-distance **fibre optic cables**, ideal for **pan-India or global-scale networks**.
- The demonstration marked **India's longest free-space QKD**, over 1 km without cable — a major leap toward **satellite-to-ground QKD**.

#### Challenges in Free-Space QKD

- **Free-space channels** face challenges like **air turbulence, pollution, and photon beam divergence**. These disturbances **increase error rates** compared to more stable **fibre-optic channels**.
- **China** achieved **satellite-based QKD** in **2017** and **2020**, covering **1,000–1,700 km**.

#### Google's Quantum Echoes

- Using a 65-qubit Willow superconducting processor, **Google measured how quantum information spreads and refocuses** within an entangled system, a breakthrough termed **Quantum Echoes**. Unlike the 2019 Sycamore experiment that claimed "quantum supremacy", Quantum Echoes was not a speed race but a **test of understanding**.
- Scientists measured **out-of-time-order correlators (OTOC)** to observe how **disturbances travel through qubits**.
- It **does not bring the world closer to breaking encryption or Q-day**. **Q-day** refers to when a cryptographically relevant quantum computer can break public-key encryption. Data intercepted today could be decrypted later, a risk called **"harvest now, decrypt later."**
- **U.S. NIST** has standardised **post-quantum cryptography** algorithms: CRYSTALS-Kyber for encryption, Dilithium for digital signatures. These rely on mathematical problems believed to resist classical-quantum attacks.

#### Limits of Current Quantum Computers

- Breaking RSA-2048 would need millions of logical qubits and may take 5–8 years. RSA encryption depends on the difficulty of factoring large prime numbers. Classical computers would need billions of years to reverse this process.
- Google's Willow and IBM's Condor have only a few hundred noisy qubits. Fault-tolerant quantum computers require millions of logical, error-corrected qubits, far beyond current capability.

#### How Quantum Computers Work

- Quantum computers use **qubits** based on **superposition** and **entanglement**. Qubits can exist as **0 and 1 simultaneously**. This allows testing **many possibilities at once**.
- **Shor's algorithm** converts factoring into finding **repeating patterns** using the **Quantum Fourier Transform (QFT)**.
- Scaling this would allow **exponentially faster factoring** of RSA numbers.

#### Quantum Echoes vs Shor's Algorithm

- Shor's algorithm targets computational advantage and cryptographic impact.
- Quantum Echoes studies how quantum information spreads and re-emerges.
- Quantum Echoes focuses on **physical understanding**, not solving equations.

#### Quantum-Classical Transition

- In the **1920s**, **Albert Einstein** proposed a modified **double-slit experiment** to expose a **contradiction in quantum theory** by simultaneously determining a **photon's path** and observing **wave interference**.
- **Niels Bohr** countered that such an experiment would fail due to **quantum uncertainty and complementarity**, but the idea remained **untested for nearly a century**.
- Researchers from **China** have now **experimentally realised Einstein's thought experiment** by replacing the movable slit with a **single trapped atom**, with results published in **Physical Review Letters**.
- By **cooling the atom close to its quantum ground state**, scientists made its **momentum uncertainty comparable to that of a photon**, allowing detection of the atom's **recoil** when a photon scattered off it.
- When **momentum uncertainty was high, which-path information vanished** and a **clear interference pattern** appeared; when uncertainty was low, **path information increased** but **interference weakened**.
- The experiment **vindicates Bohr's critique**, strengthens confidence in **quantum theory**, and offers a new platform to study the **quantum-classical transition**, with implications for **future quantum technologies**.

### Energy

#### Natural Hydrogen

**Why in news:** If **harvested in a sustainable manner**, **natural hydrogen** may provide a **clean** and **potentially low-cost fuel** to meet growing energy needs and reduce **carbon emissions**. It is most likely **abundant in India** too.

- Hydrogen is currently manufactured mostly from **natural gas** via an **energy-intensive and polluting process**.
- **Green hydrogen**, though clean, is expensive and demands vast amounts of wind and solar power to scale.
- **Natural hydrogen** occurs as a **free gas** in geology, formed through: **Serpentinisation** (interaction of water and iron-containing rocks); **Radiolysis of water** by radioactive rocks; From **organic matter at depth**.

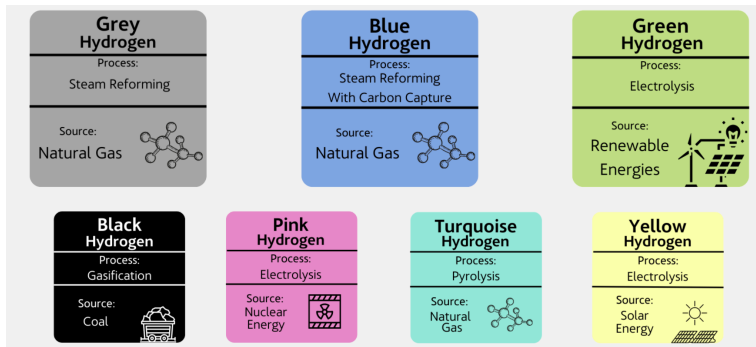
#### History of its Extraction

- In **1987**, during drilling for water in **Bourakébougou, Mali**, **flame** erupted from a borehole. In **2012**, **Chapman Petroleum** confirmed the gas was **98% hydrogen**.

- **Geological environments** like **ranges** (Pyrenees, Alps, Himalayas) are recognised for hydrogen generation.
- **Helium co-existence** suggests **radiolysis** role. Hydrogen found in **coal mines** suggests origin from **organic matter**.

**Current Reserves**

- **Poorly known** due to limited exploration. In **India**, hydrogen potential is **mostly untapped**, but promising:
  - Ultramafic/mafic and basaltic assemblages; Andaman & Himalayan ophiolite complexes
  - Greenstone sequences in Dharwar and Singhbhum; Sedimentary basins (Vindhyan, Cuddapah, Gondwana, Chhattisgarh); Fractured basement rocks and hot springs



- Natural hydrogen exploration faces **technical, logistical, economic, and safety-related challenges**.
- Inspired by **U.S. ARPA-E projects**, India can explore: Induced hydrogen production by **flowing water into rock. Simultaneous hydrogen production & carbon sequestration** by injecting CO<sub>2</sub>-rich water into iron-bearing rocks.
- **Globally**, hundreds of seeps found in Australia, USA, Spain, France, Albania, Colombia, South Korea, Canada.
- In **France**, finds in Lorraine (May 2023) and Moselle (March 2025) regions total 92 million tonnes, worth \$92 billion, ~half of current global production.

- Best estimate: **tens of trillions of tonnes** exist. If **2%** are exploitable, could meet hydrogen demand for **200 years**.

- **Green hydrogen** is produced by **splitting water via electrolysis**, using **renewable energy**.
- It is a **clean-burning molecule** that can **decarbonise** sectors like **iron & steel, chemicals, and transportation**.
- It enables **utilisation of excess renewable energy** that cannot be stored or used by the grid.
- In **2023**, **MNRE introduced a green hydrogen standard**, capping emissions at **2 kg CO<sub>2</sub> per kg of hydrogen**.
- The **certification scheme** applies only to green hydrogen from **electrolysis or biomass conversion**.

**Na-ion Battery**

**Why in news:** A team at JNCASR, Bengaluru has developed a super-fast charging sodium-ion (Na-ion) battery that charges up to 80% in six minutes and lasts over 3,000 cycles, nearing Li-ion battery performance.

- The battery is based on **'NASICON-type' chemistry**, enhanced using novel material engineering and nanotechnology to overcome traditional Na-ion limitations like slow charging and short lifespan.
- **China** dominates the global lithium-ion battery supply chain and refining capacity. **China is also advancing in sodium-ion batteries** 'Naxtra' Na-ion batteries by end of 2025, enabling EVs to run up to 500 km per charge.

- **Lithium-ion batteries** use scarce and costly elements like cobalt, nickel, copper, and lithium. **Sodium** is abundant, extractable from seawater, and environmentally friendly, unlike lithium which requires mining in select regions like the **Lithium Triangle (Argentina, Bolivia, Chile)**.
- **Sodium-ion batteries** are **safer**, as they can be **transported at zero volts**, avoiding the **fire risk** posed by lithium. They use **aluminum** (cheaper) instead of **copper**, and support a **higher operating temperature range**.
- Challenges: **nascent technology, limited manufacturers, higher costs, lower energy density, and limited shape flexibility** (not prismatic or cylindrical).
- **Cycle life** of sodium-ion batteries is **lower** compared to **LiFePO<sub>4</sub> batteries**, which can last **8,000+ cycles**.
- **JNCASR's breakthrough** involved nanoparticle downsizing, carbon coating, and aluminum doping in the anode, enabling faster and safer ion movement. These improvements allow sodium-ion batteries to power **EVs, solar grids, drones, & rural homes, with rapid charging and minimal fire/degradation risk**.

**Kazakhstan's Nuclear Plant**

**Why in news:** Rosatom will lead an **international consortium** to build **Kazakhstan's first nuclear power plant** near **Ulken**.

- The plant will use **advanced VVER-1200 reactors**. Project was **approved by referendum** in Kazakhstan.
- Plant aims for **capacity of 2.4 gigawatts by 2035**. **China, France, and South Korea** are also involved in the project.

**About VVER-1200 reactors:**

- **VVER-1200 reactor:** a **Generation III+ Russian-designed Pressurized Water Reactor (PWR)**.
- **Capacity:** about **1,200 MW electric power**. **Advanced version of VVER-1000**.
- Provides **20% higher power output** compared to earlier model.
- Features **enhanced safety systems, improved fuel efficiency, and additional security measures**.
- **Countries using it:** Russia, China, Bangladesh, Belarus.

**Nuclear Sector**

- **AEA (1962):** Debate since 2007 on whether to amend it to allow **private sector entry**; based on recommendations of **Dr. Raja Ramanna Committee (1997)**.
- Nuclear share in total power: **just over 3%**. Installed capacity (2023): **8.8 GW across 24 reactors**.