Today's Prelims Topics

Hyper-Spectral Imaging Satellite

Context

- 3 hyperspectral satellites developed by Indian startup Pixxel recently launched by SpaceX Falcon-9.
    - With this, Pixxel has completed **Phase-1 of its Firefly Constellation**, placing a total of six satellites in orbit.

What is Meant by Hyper-Spectral Imaging Satellite

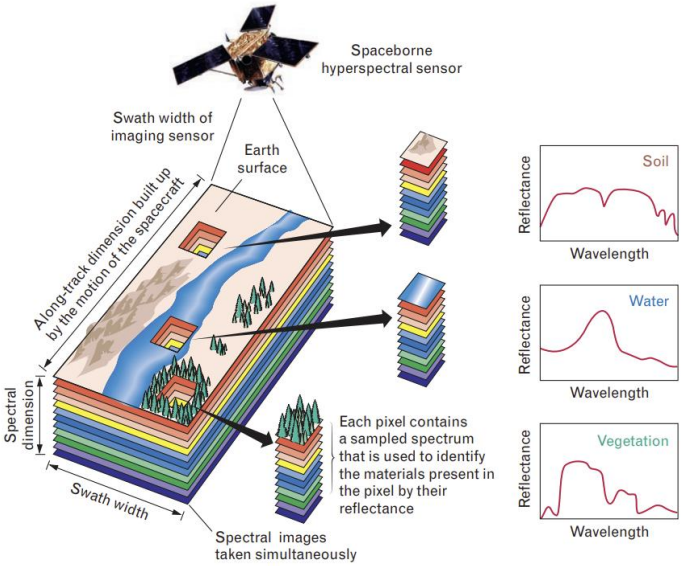
- A **hyperspectral imaging (HSI) satellite** is an Earth observation satellite that captures images across **dozens to hundreds of narrow spectral bands** (from visible to short-wave infrared), instead of just a few bands (as in RGB or multispectral imaging).
- It provides a **detailed spectral signature** for every pixel on Earth's surface, enabling precise detection of materials, gases, crops, or minerals.
- **Key Features:**
    - **Spectral Bands**: Captures data in **37 to 100+ bands** (vs 3 in RGB, 4–12 in multispectral).
    - **High Resolution**: Up to **5-metre resolution** (Pixxel's Firefly).
    - **Spectral Range**: Covers **visible (400 nm) to short-wave infrared (~2500 nm)**.
    - **Data Richness**: Each pixel contains a **continuous reflectance spectrum**, enabling chemical & physical property analysis.
    - **Constellation Advantage**: Multiple satellites provide **frequent global coverage** (Pixxel → 24 hrs with 6 satellites).

Multispectral Imaging

- It is a remote sensing technique where images are captured in a limited number of discrete spectral bands (usually 4–12 bands) across the electromagnetic spectrum.
- These bands include visible light (RGB) and often extend into near-infrared (NIR) and sometimes short-wave infrared.

About Firefly Constellation

- Firefly is Pixxel's flagship **hyperspectral imaging satellite constellation,** featuring six of the highest-resolution commercial hyperspectral satellites.
- Satellites are designed to deliver critical climate and Earth insights with unmatched precision.
- A **satellite constellation** is a network of identical artificial satellites with the same purpose and shared control, designed to work as a system.



Related Information

- A consortium led by Pixxel has secured an Indian National Space Promotion and Authorisation Centre (IN-SPACe) bid to establish **India's first fully indigenous commercial Earth observation satellite constellation** in partnership with the government.
- A satellite bus is the standardized structural and functional platform of a satellite that provides essential subsystems (power, propulsion, communication, etc.) on which mission-specific payloads are mounted.
- The same Falcon-9 mission also launched the payloads based on the **P-30 satellite bus** developed by the **Indian startup Dhruva Space.**

Source: Indian Express

Rare Earth Magnets

Context

Automakers are also scaling back on some non-essential vehicle components in order to minimize the use of rare earth magnets.

Rare Earth Magnets

- Permanent magnets made from alloys of rare earth elements.
- Extremely strong magnetic force, high energy density, superior performance in compact sizes.
- China dominates with nearly **90% of processing capacity**.
- **Types:**
    - **Neodymium (Nd-Fe-B):** Made of neodymium, iron, and boron; very powerful.
    - **Samarium Cobalt (SmCo):** Made of samarium and cobalt; strong and heat-resistant.
- **Applications:**
    - **Medical:** MRI machines, X-ray devices, PET imaging.
    - **Technology & Electronics:** Smartphones, hard drives, consumer electronics, jewelry.
    - **Industry & Defense:** Aviation, national defense, renewable energy equipment.
    - **Automobiles:** Widely used in **electric vehicles (EVs)** for motors and components.

Source: IndianExpress

Article 6 of Paris Agreement

Context

The Ministry of Environment, Forest and Climate Change (MoEF&CC) has set up a **National Designated Authority (NDA)**, a mandatory body under Article 6.4 of the Paris Agreement (2015).

Article 6 of Paris Agreement

- **Article 6** : Enables the use of international carbon markets to help countries achieve their Nationally Determined Contributions (NDCs).
- **Article 6.2**: Countries can cooperate by linking their emissions trading systems through a common accounting framework.
- **Article 6.4, (also known as the Paris Agreement Crediting Mechanism (PACM)):** Create a UN-supervised mechanism to trade emission reduction credits from specific projects.

NDC (Nationally Determined Contributions):

- These are national climate action plans under the Paris Agreement, outlining each country's targets for reducing greenhouse gas emissions.
- They include strategies for both mitigation and adaptation.

India's Current Nationally Determined Contribution (NDC) Targets

- Reduce the **emissions intensity of GDP by 45% by 2030**, compared to 2005 levels.
- Achieve **50% cumulative electric power installed capacity from non-fossil fuel sources by 2030**.
- Develop an **additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent** through increased forest and tree cover by 2030.
- India has already met the non-fossil energy capacity target of 50% by June 2025, five years ahead of schedule.

What is a Nationally Designated Authority?

- These are government bodies that act as the **link between a country and the Green Climate Fund (GCF)**, providing strategic oversight and conveying national priorities for financing low-emission and climate-resilient development.
- **Composition: 21-member committee**, chaired by the **Secretary, Ministry of Environment, Forest and Climate Change**.
- **Countries that have designated an NDA:** 148.
- India has finalized a list of **14 eligible activities under Article 6.4 of the Paris Agreement**, including renewable energy with storage, offshore wind, green hydrogen, green ammonia, sustainable fuels, and carbon capture, utilization and storage (CCUS).

Source: The Hindu

Programmed Cell Revival

Context

The Centre for Cellular and Molecular Biology (CCMB) has made a significant breakthrough in regenerative medicine by developing a method for Programmed Cell Revival.

About Programmed Cell Revival

- **Programmed Cell Death (PCD)**: Normally an **irreversible, genetically regulated** process of cell self-destruction (e.g., Apoptosis, Autophagy, Necroptosis).
- Scientists at **CSIR-CCMB, Hyderabad** discovered a **"genetically encoded revival code"** that allows cells to **recover from a near-death stage** → termed **Programmed Cell Revival (PCR)**.
- Instead of dying, stressed/damaged cells can **reverse PCD and reprogram into stem-like cells**.
- **Significance**:
    - **Regenerative medicine** – tissue/organ repair, healing neurons or cardiac cells.
    - **Stem cell biology** – insights into de-differentiation.
    - **Cancer therapy caution** – cancer cells may exploit PCR.
        - Because it will **allow near-dead cells to recover instead of dying**, cancer cells exposed to suboptimal chemotherapy or radiotherapy may use this revival pathway to **evade death, regain stem-like properties, and grow back stronger**, leading to therapy resistance and relapse..

Source: The Hindu

Editorial Summary

Online Real-Money Gaming and the Mental Health Crisis

Context

Online real-money gaming in India has sparked debates around **economic opportunities, legality, taxation, and regulation**. While economic and legal aspects are discussed widely, the **mental health impact on children and adolescents** remains underemphasized.

Why Online Gaming is Addictive

- **Psychological Design:** Mimics gambling mechanics - variable rewards, immersive loops, instant gratification.
- **Peer Pressure & Social Validation:** Leaderboards, competitions, and online communities create **FOMO (fear of missing out)**.
- **Behavioural Hooks:** Daily "login bonuses," time-limited rewards, and near-miss outcomes that condition players' brains.
- **24x7 Availability:** Unlike traditional gambling, access is continuous, private, and harder for parents to monitor.
- **Algorithmic Manipulation:** Platforms track user behaviour and push tailored nudges to sustain engagement and spending.

Consequences of Addiction

- **On Children & Adolescents:**
  - **Identity crisis:** Children link self-worth with digital achievements ("winning in games"), altering self-perception.
  - **Behavioural changes:** Secrecy, lying, aggression, stealing money to fund gameplay.
  - Rising cases of **depression, anxiety**→ weakening **social cohesion** among peer groups.
  - **Academic underachievement** → affects **social mobility and opportunities** in future.
- **On Families:**
  - **Strained family structures:** Constant arguments, mistrust, secrecy weaken family as a **primary social institution**.
  - **Generational divide:** Parents struggle to monitor digital habits → widening communication gap between generations.
  - **Gender dimension:** Boys more likely to be involved in real-money gaming, girls more in social media → creates **gendered patterns of digital addiction**.
  - **Financial stress:** Sudden debts and drained bank accounts.
- **On Society at Large:**
  - **Erosion of social capital:** Distrust within families spills into wider community.
  - **Hidden inequality:** Poor households hit harder by financial losses from gaming addiction, leading to **greater economic vulnerability and social marginalisation**.
  - **Youth alienation:** Excessive screen time reduces participation in **community, sports, and civic life**, weakening collective bonds.

Arguments for Banning/Regulating	Limitations of a Ban Alone
• **Protect minors**: Shield impressionable children from early addiction. • **Prevent family financial losses**. • **Address public health emergency**. • **Global precedent**: China, South Korea, and Singapore have introduced age	• **Psychological displacement**: Addiction may shift to pornography, social media, or substance abuse. • **Underground markets**: Banned platforms may go black-market, increasing risks. • **Loss of revenue and innovation** in

restrictions and playtime limits.	gaming industry. ● Difficult to enforce bans uniformly across digital platforms.

What is missing in Current Discourse

- **Public Health Dimension:** Online gaming addiction should be recognised as a **mental health disorder**, similar to **WHO's classification of Gaming Disorder (2019)**.
- **Legal Ambiguity:** Supreme Court has repeatedly debated **skill vs. chance** games → A **central regulatory framework** is missing.
- **Economic Considerations:** Online gaming industry projected to touch **$5 billion by 2025**, Bans may discourage investment, but unchecked growth risks massive social costs.
- **Governance & Institutional Response:** Fragmentation between **MeitY (IT regulation), Health Ministry, and State Governments**.
    - Lack of child online safety laws specific to gaming addiction (unlike cyber-bullying laws).
- **Ethical Dimension:** Companies exploit **psychological vulnerabilities of children**, undermining **ethical business practices and societal trust**.

Way Forward

- **Regulation + Safeguards:** Age-gating, playtime limits, and strict parental controls.
    - Transparent disclosure of in-game spending and risks.
    - Ban predatory "loot box" style gambling mechanics.
- **Mental Health Framework:** School-based **digital addiction screening** & Training parents and teachers to detect behavioural warning signs.
- **Awareness & Education:** National campaigns on **safe digital habits** & Workshops for parents on healthy tech supervision.
- **Technology Solutions:** AI-based monitoring of excessive playtime.
    - Panic button/lock features built into apps.
    - Strict KYC norms to prevent minors from bypassing age restrictions.
- **Policy Integration:** Bring gaming addiction under **National Child Policy**.
    - Create a **National Digital Wellness Mission**, similar to POSHAN Abhiyaan.
    - Align with **National Education Policy (NEP 2020)** emphasis on mental health.

Online gaming addiction is not just an individual or legal problem; it is a **societal issue** affecting families, youth, and community life. It reflects deeper themes of **globalization, consumer culture, weakening family bonds, intergenerational conflict, and rising inequality**. India must move beyond bans towards a **multi-sectoral approach** that combines regulation, counselling, community engagement, and digital literacy.

Detailed Coverage

India's Bio-economy to Touch $300 Billion by 2030

Context

On the completion of one year of the BioE3 Policy, the Union Minister of Science and Technology launched India's first National Biofoundry Network, aimed at making biotechnology a key driver of the country's economy.

What is Bioeconomy?

- **Bioeconomy** refers to the use of **biological resources, processes, and technologies** to produce sustainable goods and services across sectors like **healthcare, agriculture, industry, and environment**.
- It integrates **biotechnology, bioenergy, biomaterials, bio-agriculture, and bio-health**, contributing both to **economic growth and ecological sustainability**.
- It is the **economy powered by biology**-where innovations like biofuels, biodegradable plastics, genome editing, biofertilizers, vaccines, and organ-on-chip devices come together to serve society.

Current Status of India's Bioeconomy

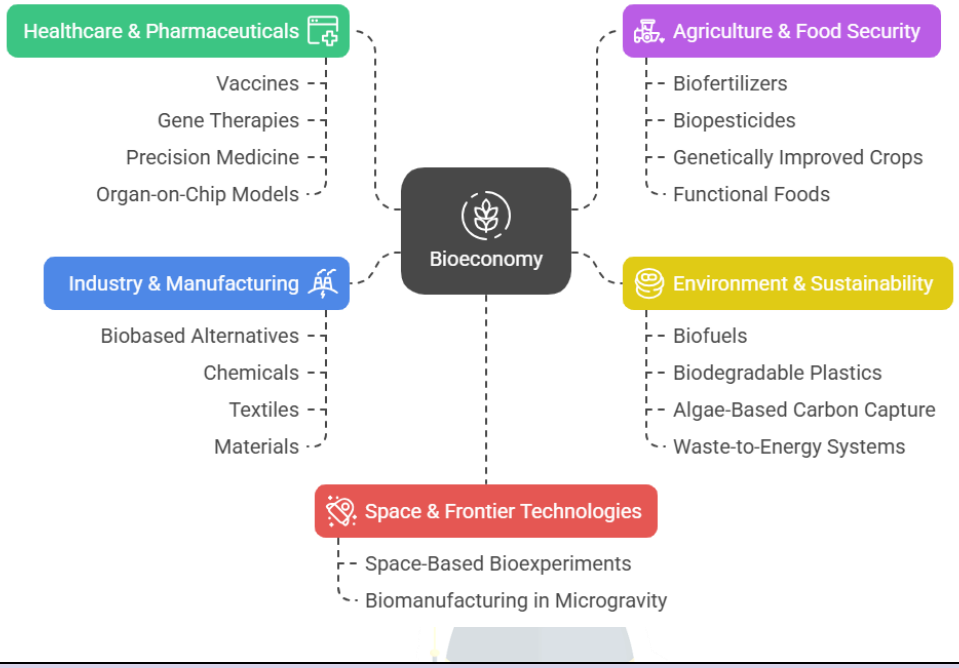
- India's bioeconomy has **grown over 16 times in a decade**, from **$10 billion in 2014 to $165.7 billion in 2024**.
- The sector contributes 4.25% to GDP with a compound annual growth rate (CAGR) of 17.9% over the past four years.
- India is among the top producers of vaccines globally and developed the world's first DNA COVID19 vaccine.
- Ethanol blending increased from 1.53% in 2014 to 15% in 2024, with a target of 20% by 2025.
- **Research growth:** Over 2000 research proposals received in areas such as cell & gene therapy, climate-smart agriculture, carbon capture, and functional foods.

Significance of Bioeconomy in India's Growth

- **Economic Growth Engine:** Biotechnology contributes to **3–5% of GDP** through pharma, agriculture, and bio-industries.
- **Employment & Innovation:** Over **6,000 biotech startups** and **760+ biotech products** are active (2023).
    - **Eg: BioE3 Challenge** funds youth innovators with up to ₹25 lakh each, creating a strong startup ecosystem.
- **Food & Agricultural Security:** Biofertilizers and **genome-edited crops** reduce dependence on chemical inputs and enhance climate resilience.
    - **Eg:** Use of **Bt Cotton** has made India the world's **2nd largest cotton producer**.
- **Health & Pandemic Preparedness:** India is a **global vaccine hub**, supplying **60% of world vaccines**.
    - **Eg: Covaxin & Covishield** (COVID-19 vaccines) demonstrated India's bioeconomy strength in crisis.
- **Environmental Sustainability:** Biofuels, biodegradable plastics, and algae-based carbon capture reduce fossil fuel dependence.
    - **Eg: Ethanol blending programme** achieved **12% blending in 2023**, saving ₹41,000 crore in oil imports.

- **Strategic & Frontier Technologies:** Collaboration with **ISRO** on **space biotechnology**; 3 DBT-backed experiments on the **International Space Station**.

Potential Applications of Bioeconomy



How can Bioeconomy assist in combating climate change?

- **Reducing Fossil Fuel Dependence:** Biofuels (ethanol, biodiesel, compressed biogas) reduce reliance on crude oil.
  - **Eg:** India's **12% ethanol blending in 2023** saved **17.3 MMT crude oil imports** and cut **51.9 MMT CO_2 emissions** since 2014
- **Carbon Capture & Sequestration: Algae-based technologies** absorb atmospheric CO_2 and produce biomass for fuels or animal feed.
- **Sustainable Agriculture & Land Use:** Biofertilizers and biopesticides reduce nitrous oxide emissions from chemical fertilizers. **Climate-smart crops** ensure food security under changing climate.
- **Waste Management:** Conversion of **agri-residues and municipal solid waste** into bio-CNG, bioethanol, and bioplastics reduces landfill methane emissions.

Challenges in building a strong Bioeconomy

- **Regulatory Bottlenecks:** Slow approval processes for biotech products, concerns about biosafety and bioethics.
- **Infrastructure Gaps:** Limited advanced biomanufacturing facilities and skilled manpower compared to the US/EU.
- **Bio-piracy concerns:** India's rich biodiversity makes it a hotspot for bio-piracy, where foreign companies exploit indigenous biological resources without proper benefit-sharing
- **Funding & Innovation Ecosystem:** Startups face capital constraints and long gestation periods for biotech products.
- **Supply chain issues:** India's biotechnology sector remains dependent on global supply chains for essential raw materials, equipment, and advanced technologies.
- **Global Competitiveness:** India lags behind China and the US in patent filings, R&D intensity, and technology commercialization.
- **Public Perception & Ethical Concerns:** Misconceptions about GM crops, cloning, and synthetic biology hinder adoption.

- **Unequal Regional Development:** Concentration of biotech hubs in select states; Northeastern and central states lag behind.

Government Initiatives

- **BioE3 Policy (2024):** Aims at $300 bn bioeconomy by 2030.
  - **Thematic Sectors:** High-value bio-based chemicals, biopolymers & enzymes, Smart proteins & functional foods, Precision biotherapeutics, Climate-resilient agriculture, Carbon capture & its utilisation, Marine and space research.
- **Biomanufacturing Infrastructure**: Mohali Biomanufacturing Institute, national network of **biofoundries and Bio-AI hubs**.
- **Global Biofuel Alliance:** Led by **India, Brazil, and United States**, it presents an opportunity for India to reduce costly oil imports, boost domestic biofuel production.
- **Sector specific schemes:** National Biopharma Mission; National Green Hydrogen Mission; SATAT and GOBARdhan scheme.
- **ISRO–DBT MoU**: Joint working group on **space biotech**; three DBT-backed experiments already conducted on the ISS.
- **BioE3 Challenge for Youth (2025–30)**: Monthly innovation calls on themes like microbes, molecules, and biomaterials.
- **International Engagement**: Collaboration with **52 countries**, expanding India's biotech diplomacy.

Way Forward

- **Regulatory Reforms**: Create a **single-window clearance system** for biotech products; strengthen biosafety and ethical oversight.
- **Capacity Building**: Expand biotech education, skill development, and promote entrepreneurship in Tier-II & Tier-III cities.
- **Funding Mechanisms**: Increase venture funding, public–private partnerships, and long-term R&D grants.
- **Global Integration**: Strengthen participation in global biotech alliances, standards, and supply chains.
- **Inclusive Growth**: Develop **state-level bioeconomy roadmaps** to ensure balanced regional participation.
- **Public Awareness**: Run campaigns on safety, benefits, and sustainability of bio-based products.

India's bioeconomy is not just an economic strategy but a pathway to **sustainability, innovation, and Atmanirbhar Bharat**. With strong policy support under the BioE3 framework, integration of biotechnology with AI and space science, and active participation from youth and startups, India has the potential to become a **global bioeconomy leader by 2030.**