Artificial Intelligence and Machine Learning in Space Sector

For Prelims: Indian Space Research Organisation, Artificial Intelligence, Machine Learning, Gaganyaan, NISAR, SPADEX Experiment, Bharatiya Antariksh Station.

For Mains: Role of AI and ML in Diverse Space Applications, ISRO's Future Endeavors

Source: PIB

Why in News?

Recently, the Government of India highlighted the substantial strides made by the **Indian Space Research Organisation (ISRO)** in **integrating** Artificial Intelligence (AI) **and** Machine Learning (ML) within the realm of space exploration.

- This transformation has been a **strategic response to the rapid technological advancements** in these domains over the past few years.
- ISRO's ongoing projects, including the **Gaganyaan Program** have integrated AI solutions.

How AI and ML Assist in Diverse Space Applications?

- **Space Exploration and Robotics: AI-driven robots and rovers can navigate,** make decisions, and explore distant planets or asteroids without constant human intervention.
  - ML helps in **identifying celestial objects, terrain, and hazards** in images captured by space probes or satellites.
- **Satellite Operations:** ML algorithms **analyze satellite images to monitor changes in Earth's surface,** weather patterns, and environmental changes.
  - AI helps anticipate satellite component failures by **analyzing telemetry data**, enhancing maintenance scheduling and reducing downtime.
- **Spacecraft Systems:** AI systems **monitor the health of spacecraft components,** predicting potential failures and allowing proactive maintenance.
  - **ML algorithms optimize power, fuel, and other resources** for spacecraft operations during missions.
- **Data Analysis and Pattern Recognition**: AI analyzes vast amounts of astronomical data to discover new celestial bodies, understand cosmic phenomena and identify space debris in space.
  - ML helps in processing signals from deep space, **distinguishing between noise and potential communication or scientific data.**
- **Mission Planning and Decision Making:** AI models assess mission risks, **aiding in decision-making processes** by considering various factors and scenarios.
  - ML enables spacecraft to adapt to changing environments or unexpected situations in real-time.
- **Optical Communications Optimization: AI and ML** models refine optical communication systems, adapting to changing space conditions and maximizing data transmission rates, crucial for interplanetary missions.
- **Quantum Computing for Space Challenges:** AI has the potential to harness **quantum computing's potential to tackle complex calculations and cryptography**, enhancing

security and computational capabilities for space missions requiring high-level encryption or intricate simulations.

What AI and ML Projects are Underway in India's Space Sector?

- **AI and ML Projects:**
  - There are various projects and programmes in the domains of AI and ML being undertaken by the **Department of Space** are at different stages of feasibility studies and implementation. Major ones include:
    - **Launch vehicle and spacecrafts mission** trajectory design and autonomous operations;
    - **Launch vehicle and satellites health monitoring** and prediction from the telemetry data;
    - **Satellite Data Processing** for Resource mapping, weather prediction, disaster prediction, **geo-intelligence (object and change detection),** Precision agriculture, Agroforestry etc.
    - **Humanoid robots and chatbots**
    - **Space Robotics** and smart manufacturing in space.
- **ISRO's Future Endeavors:**
  - **Chandrayaan-4 Mission**: Planned by ISRO to bring back samples from the Moon within four years.
  - Bharatiya Antariksh Station **(India's Space Station):** The first module, capable of conducting experiments with robots, will launch by 2028.
  - **SPADEX Experiment:** Demonstrates autonomous docking capability between two spacecraft.
    - Involves launching connected satellites that separate, travel a distance, and then reconnect.
  - NISAR**: NASA-ISRO SAR (NISAR) is a Low Earth Orbit (LEO) observatory** being jointly developed by NASA and ISRO.
  - **Gaganyaan:** Gaganyaan mission aims to **send humans to space and return them safely to Earth**. The mission will consist of two unmanned flights and one manned flight, using the GSLV Mk III launch vehicle and a human-rated orbital module.

Note

- During the past 9 months of the **financial year 2023-24**, the government stated that startups in the space sector within the country have garnered **private investments exceeding 1,000 crore rupees.**

What are Major Challenges Related to AI and ML in the Space Sector?

- **Computational Limitations:** Spacecraft have **limited computational power and memory, making it challenging to run complex AI algorithms**. ML models need to be optimized to run efficiently in these resource-constrained environments.
- **Robustness and Reliability:** Space environments are **harsh, with high levels of radiation and extreme temperatures,** which can affect the hardware and software components of AI systems. Ensuring the reliability and robustness of AI algorithms in such conditions is crucial.
- **Training Data Limitations**: Gathering training data for AI models specific to space missions can be challenging due to the **limited number of past missions or situations to learn from.**
- **Ethical and Legal Considerations**: As AI becomes more prevalent in space missions, ethical and legal concerns arise, such as the **responsibility for AI decisions, data privacy**, and **potential conflicts between AI-driven decisions and human judgment.**

Way Forward

- **Edge Computing and Onboard Processing:** Focus on **onboard processing and edge computing** to minimize data transmission delays and reliance on Earth-based computational resources.
  - This **allows spacecraft to process data and make decisions autonomously**, reducing dependency on constant communication with Earth.
- **Interdisciplinary Collaboration:** Encourage collaboration between **space agencies, researchers, and industries** to combine expertise from various fields such as astronomy, computer science, materials science, and robotics.
  - This interdisciplinary approach fosters innovation and comprehensive problem-solving.
- **Ethical Frameworks and Governance:** Developing **global ethical frameworks and governance guidelines specific to AI and ML in space that** address issues like AI decision-making, accountability, data privacy, and adherence to international space laws.

UPSC Civil Services Examination, Previous Year Question (PYQ)

Prelims

Q. Consider the following statements: (2016)

The Mangalyaan launched by ISRO

1. is also called the Mars Orbiter Mission
2. made India the second country to have a spacecraft orbit the Mars after USA
3. made India the only country to be successful in making its spacecraft orbit the Mars in its very first attempt

Which of the statements given above is/are correct?

(a) 1 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans: (c)

Mains

Q. What is India's plan to have its own space station and how will it benefit our space programme? **(2019)**

Dharavi Revamp in Turmoil

Source: TH

Why in News?

Recently, the **Dharavi Redevelopment Project (DRP),** an initiative to rebuild Asia's largest slum **Dharavi,** has sparked heated controversies due to allegations of favoritism towards the winning bidder for the project.

- A **Special Purpose Vehicle (SPV)** named **Dharavi Redevelopment Project Pvt Ltd (DRPPL)** has been established for this project.

What is the Dharavi Redevelopment Project?

- In **2004,** the state government formed the **Dharavi Redevelopment Authority** under the **Slum Redevelopment Authority (SRA)** with the goal of making **Mumbai a slum-free city.**
- The initiative addresses the persistent urban challenge of **slum redevelopment** in **Mumbai**, a city with a significant slum population.
- The redevelopment plan aims for an **integrated development approach** encompassing residential, commercial, and industrial aspects.
- This project highlights the public-private partnership **aspect** in addressing urban redevelopment challenges.
- The redevelopment plan's **floor space index** of over **4** indicates a **significant intensity of land use**, emphasizing the **multi-dimensional nature** of the project.

What is Dharavi?

- **Dharavi** is the **biggest slum cluster of Asia** that lies on prime property right in the middle of Mumbai.
- It is spread over **300 hectares**, of which the **state government** has notified **240 hectares** for the project.
- It was founded in **1882** at the time of the **British Raj.**

What is a Special Purpose Vehicle (SPV)?

- A special purpose vehicle is a separate legal entity which has all the attributes of a corporation such as owning assets, capacity to and get sued etc.
- A **SPV,** also known as a **special purpose entity (SPE),** is like a **separate company** created by a main company to protect against financial risks.
- Even if the main company faces **bankruptcy,** the SPV's independent legal status ensures that its obligations remain secure.
  - This is why an **SPV** is often referred to as a **bankruptcy-remote entity.**
- An **SPV** can be employed to take on a **risky project**, lessening any potential financial harm to the main company and its investors.
- Venture capitalists use SPVs to gather funds and invest in a startup.

What are the Recent Initiatives Related to Urban Development?

- **Atal Mission for Urban Rejuvenation and Urban Transformation (AMRUT)**
- **Pradhan Mantri Awas Yojana-Urban (PMAY-U)**
- **Climate Smart Cities Assessment Framework 2.0**
- **TULIP-The Urban Learning Internship Program**
- **Atmanirbhar Bharat Abhiyan (Self-Reliant India)**

UPSC Civil Services Examination, Previous Year Questions (PYQs)

Mains

Q. Do government's schemes for up-lifting vulnerable and backward communities by protecting required social resources for them, lead to their exclusion in establishing businesses in urban economies? **(2014)**

Indian Forest and Wood Certification Scheme

Source: PIB

Why in News?

Recently, the Ministry of Environment, Forests and Climate Change (MoEFCC) has launched the **Indian Forest & Wood Certification Scheme (IFWCS)**, offering **voluntary third-party certification** designed to promote sustainable forest management and agroforestry in the country.

What is the Indian Forest & Wood Certification Scheme (IFWCS)?

- **Objective:**
  - IFWCS aims to offer an **alternative to private foreign certification agencies** that have been operating in India. It seeks to ensure greater integrity, transparency, and credibility in certifying sustainable forest management and wood-based products.
- **Certification Scope:**
  - The scheme covers **three main areas for certification:**
    - Sustainable forest management.
    - Sustainable management of trees outside forests (like plantations).
    - Chain of custody, which guarantees the traceability of forest products throughout their supply chain, ensuring ethical sourcing and handling.
- **Nodal Agencies:**
  - The scheme will be overseen by the **Indian Forest and Wood Certification Council,** which will act as a multistakeholder advisory body.
  - **Indian Institute of Forest Management, Bhopal** will act as the scheme operating agency and will be responsible for overall management of the Scheme.
  - The **National Accreditation Board for Certification Bodies under the** Quality Council of India will accredit the certification bodies which will carry out independent audits and assess adherence of various entities on the standards prescribed under the scheme.
- **Trees Outside Forests Standard:**
  - A separate Trees Outside Forests Standard is **now introduced** as a part of the Scheme.
    - 'Trees outside Forests' means trees growing outside recorded and notified forests, in farm lands of an individual farmers or group of small farmers or plantation area on private land of institutions and industries, etc. and include all **trees on the hedges and bunds, trees in different models of agroforestry, silvo-pastoralism, urban and rural forestry** systems and block plantations.
- **Benefits:**
  - The certification is expected to enhance trust and transparency in processes related to **forest management and wood-based products.**
  - The IFWCS can provide **market incentives to various entities** that adhere to **responsible forest management** and agroforestry practices in their operations.
  - This includes state forest departments, individual farmers, or **Farmer Producer Organizations** engaged in **agroforestry and farm forestry**, as well as other wood-based industries in the value chain.
- **Global Context**:
  - The launch of IFWCS aligns with global efforts to address deforestation concerns. The scheme's objective resonates with the pledge made by over 100 countries at the **Glasgow climate change conference in 2021** to halt and reverse **Deforestation** by 2030.

What are the Other Recent Announcements Related to Forest Management?

- **National Working Plan Code 2023:**
    - The MoEFCC has released the "National Working Plan Code-2023" for scientific management of forests and evolving new approaches in July 2023.
        - National Working Plan Code which **was first adopted in 2004** with a subsequent amendment in 2014 brought uniformity and acted as the guiding principle for the preparation of the working plan **for scientific management of different forest divisions of our country.**
        - The **"Indian Forest Management Standard (IFMS)"** which is a part of this code, takes into account the diverse forest ecosystem in our country, while trying to bring in uniformity in management.
- Green Credit Program (GCP) **and Ecomark Scheme:**
    - The MoEFCC under **LiFE (Lifestyle for Environment' movement)**, has introduced the GCP and the Ecomark Scheme in October 2023.
        - **GCP** is an innovative market-based mechanism designed **to incentivize voluntary environmental actions** across diverse sectors, by various stakeholders like individuals, communities, private sector industries. The **Indian Council of Forestry Research and Education (ICFRE) serves as the GCP Administrator,** responsible for program implementation, management, monitoring, and operation.
        - **Ecomark Scheme** provides accreditation and labelling for household and consumer products that **meet specific environmental criteria** while maintaining quality standards as per Indian norms.
            - The **Central Pollution Control Board** administers the Ecomark Scheme in partnership with **Bureau of Indian Standards (BIS),** which is the national body for standards and certification.

Night Vision in Animals

Animals **navigate darkness using a complex mix of eye structures and light-sensitive cells.** Unlike humans, many animals can detect light waves that escape our notice.

- Among vertebrates, there are two key types of light-sensitive cells: rods and cones. Rods work great in low light (like night vision), while cones handle daylight and colors.
- Day-active creatures have more **cone cells for sharper images** but may struggle in dim light. Whereas, nocturnal animals mainly rely on **rod cells in their retinas**, packed with a light-sensitive pigment called **rhodopsin.** This pigment helps them see better in the dark by regenerating slowly when light is scarce.

Climate Finance

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CLIMATE FINANCE

Climate finance refers to local, national or transnational financing—drawn from public/ private/alternative sources of financing—to support mitigation and adaptation actions against climate change.

PRINCIPLES OF CLIMATE FINANCE

- Polluter Pays
- Common but Differentiated Responsibility and Respective Capability (CBDR–RC)

Multilateral Climate Funds Coordinated by UNFCCC

- **Global Environment Facility (GEF):** Operating entity of financial mechanism (1994)
- **Kyoto Protocol (2001):**
  - **Adaptation Fund (AF):** Gives developing countries full ownership of adaptation projects
  - **Clean Development Mechanism (CDM):** To carry out emission-reduction projects in developing nations
- **Green Climate Fund (GCF):** estd. - 2010 (COP 16)
  - Funds under it - **Least Developed Countries Fund (LDCF)** and **Special Climate Change Fund (SCCF)**
- **Long-Term Climate Finance:**
  - **Cancun Agreements (2010):** Mobilize and provide scaled-up funds in short and long term
  - **Paris Agreement (2015):** Developed nations agreed to establish new collective goal of at least $100 billion/year by 2025
- **Loss and Damage Fund (2023) (COP27 & COP28):** Financial assistance to nations most vulnerable and impacted by effects of climate change

Climate Investment Funds (CIFs) under World Bank

- Clean Technology Fund
- Strategic Climate Fund

INDIA'S INITIATIVES REGARDING CLIMATE FINANCE	
Fund	**Objective**
▌ **National Adaptation Fund for Climate Change** (NAFCC) (2015) ▌ **National Clean Energy Fund** (2010-11) ▌ **National Adaptation Fund** (2014) ▌ **Intended Nationally Determined Contributions** (INDCs) (2015) ▌ **Climate Change Finance Unit (2011)**	▌ For vulnerable Indian states ▌ Advancing clean energy (started with initial carbon tax on industrial coal use) ▌ Bridging gap between required and available funds ▌ Nationally binding targets adopted under UNFCCC ▌ Leads on global climate finance issues

Challenges to Climate Finance

- Gap between national needs and climate finance under NDCs
- Least Developed Countries receive much less approved funding in per-capita terms from the multilateral climate funds
- Slow rate of approvals
- Failure in securing viability-gap funding

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