VISIONIAS
INSPIRING INNOVATION

SCIENCE & TECHNOLOGY

MAINS 365

Classroom Study Material 2022

(September 2021- to June 2022)

www.visionias.in 8468022022, 9019066066

DELHI | JAIPUR | PUNE | HYDERABAD | AHMEDABAD | LUCKNOW | CHANDIGARH | GUWAHATI

SCIENCE AND TECHNOLOGY

Table of Contents

1. AWARENESS IN THE FIELDS OF IT, COMPUTERS, ROBOTICS ____ *4*
1.1. Emerging Technologies ____ **4**
1.1.1. National Strategy on Blockchain ____ 4
1.1.2. Non-Fungible Tokens (NFTs) ____ 6
1.1.3. Quantum Technology ____ 7
1.1.4. Artificial Intelligence ____ 10
1.1.5. 5G Technology ____ 11
1.1.6. Internet of Things ____ 12
1.1.7. Cyber-Physical Systems ____ 13
1.2. Developments in Information Technology ____ **14**
1.2.1. Net Neutrality ____ 14
1.2.2. Dark Net ____ 16
1.2.3. Virtual private network (VPN) ____ 17
1.2.4. Satellite Internet Services ____ 18
1.3. Other Technological Developments ____ **19**
1.3.1. Data Centres ____ 19
1.3.2. Geospatial Technology ____ 21
1.3.3. Additive Manufacturing ____ 23
2. AWARENESS IN THE FIELD OF Space ____ *25*
2.1. Gaganyaan ____ **27**
2.2. Chandrayaan-3 ____ **28**
2.3. Private Sector Participation in Space ____ **29**
2.4. Space Situational Awareness (SSA) ____ **30**
2.5. Space Debris ____ **31**
2.6. Black Holes ____ **32**
2.7. James Webb Space Telescope (JWST) ____ **34**
2.8. Parker Mission ____ **34**
2.9. Laser Interferometer Gravitational-Wave Observatory (LIGO) Project ____ **35**
3. AWARENESS IN THE FIELDS OF NANO-TECHNOLOGY, BIO-TECHNOLOGY AND ISSUES RELATING TO INTELLECTUAL PROPERTY RIGHTS ____ *37*
3.1. NanoTechnology ____ **37**
3.1.1. Liquid nano urea plant ____ 38
3.2. Biotechnology ____ **39**
3.2.1. Stem Cells ____ 40
3.2.2. Genome Sequencing ____ 41
3.2.3. Genetically Modified Crops ____ 42
3.2.4. DNA Technology (Use and Application) Regulation Bill, 2019 ____ 44
3.2.5. Synthetic Biology ____ 45
3.2.6. Xenotransplantation ____ 45
4. HEALTH ____ *47*
4.1. Traditional Medicine ____ **47**
4.2. World Malaria Report 2021 ____ **48**
4.3. Tuberculosis (TB) ____ **49**
4.4. One Health ____ **49**
4.5. Neglected Tropical Diseases ____ **51**
4.6. India's Vaccine Ecosystem ____ **52**
4.6.1. Self-amplifying messenger RNA (mRNA) vaccine ____ 53
4.7. Trans Fats ____ **54**
4.8. Rice Fortification ____ **55**
5. ACHIEVEMENTS OF INDIANS IN SCIENCE & TECHNOLOGY; INDIGENIZATION OF TECHNOLOGY AND DEVELOPING NEW TECHNOLOGY ____ *57*
5.1. Achievements of Indians in science & technology ____ **57**
5.1.1. Har Gobind Khorana ____ 57
5.1.2. Srinivasa Ramanujan ____ 57
5.2. Indigenization of technology and developing new technology ____ **58**
5.2.1. Solid Fuel Ducted Ramjet (SFDR) Technology ____ 58
5.2.2. Hyperloop System ____ 59
6. MISCELLANEOUS ____ *60*
6.1. Nobel Prize ____ **60**
6.1.1. The Nobel Prize in Physics 2021 ____ 60
6.1.2. Nobel Prize in Physiology or Medicine ____ 61
6.1.3. Nobel Prize in Chemistry ____ 61
6.2. Clean Technology ____ **63**
6.2.1. Green Hydrogen/ Green Ammonia Policy 63
6.2.2. Electric Vehicles ____ 67
6.3. Atomic/Nuclear Field advancements ____ **69**
6.3.1. European Organization for Nuclear Research (CERN) ____ 69
6.3.2. Neutrino Observatory ____ 71
6.3.3. Nuclear Fusion ____ 72
6.4. Solar flare and Geomagnetic Storm ____ **74**
6.5. Use of Technology in Agriculture ____ **75**
6.5.1. Drone Technology in Agriculture ____ 76
6.6. Scientific Social Responsibility Guidelines 2022 ____ **77**
6.7. Lithium-ion Battery ____ **78**

Previous Year Question

A reference sheet of syllabus-wise segregated previous year questions from 2013-2021 (for the Science and Technology Section) has been provided. In conjunction with the document, it will help in understanding the demand of the exam and developing a thought process for writing good answers.

A NOTE FOR THE STUDENTS

Dear Students,

- Precision of content in good answer is no longer a dispensable luxury, but a simple necessity. And the preparation to write a precise answer starts well before one picks up a pen and starts to formulate the answer. A good understanding of the topic asked along-with a ready set of data and examples assists one in approaching the most difficult of the questions.
- This is further assisted by a good presentation style, which depicts the information in an easy-to-understand manner.

In this context, we made few changes to the Mains 365 documents last year, which included

Topic at glance:
which gave a comprehensive view of the topic, connecting the current and static aspects along-with providing necessary data and facts.

Infographics:
Designed in a manner that they can be readily used in the answers

Previous years questions:
A QR code linked syllabus wise segregated list of previous years questions was added.

Along-with these, this year we have made few more additions to help you revise the topics and approach answers in a precise manner, these include:

Data banks:
have been designed and added in the articles to help you identify and revise the important datasets of the topics.

Appendix:
An appendix of key data and facts has been added at the end of the document to facilitate quick revision.

Weekly focus document list:
A QR code linked list of relevant Weekly focus documents has been added in the end of the document to ensure easiness in approaching these topics.

We hope that these additions will help you not only developing a comprehensive understanding of the topics but also provide the necessary inputs to write effective and well-presented answers.

Knowing is not enough: we must apply. Willing is not enough: we must do.

-Johann Wolfgang von Goethe

All the best!
Team VisionIAS

1. AWARENESS IN THE FIELDS OF IT, COMPUTERS, ROBOTICS

1.1. EMERGING TECHNOLOGIES

1.1.1. NATIONAL STRATEGY ON BLOCKCHAIN

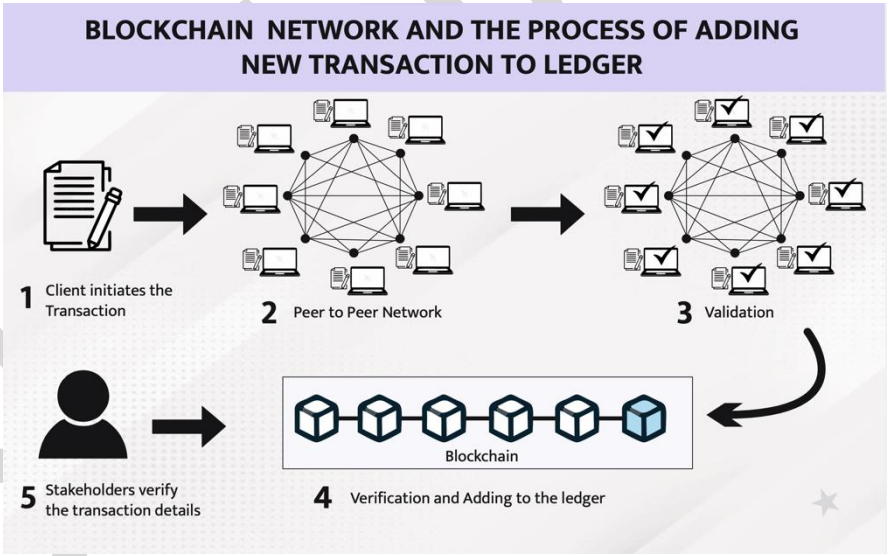
Why in news?

National Strategy on Blockchain has been formulated by the Ministry of Electronics & Information Technology (MeitY).

Blockchain Technology Overview

- Blockchain is a **distributed or decentralized ledger technology** which is an **amalgamation of various technologies** such as distributed systems, cryptography, etc.
- Data and transactions stored in blocks are **secured against tampering using cryptographic hash algorithms** and are validated and **verified through consensus** (consensus protocols) across nodes of the Blockchain network.

What is blockchain?	
A Database	A list of records / transaction, like a ledger, that keeps growing as more entries are added;
Which is Distributed	Copies of the entire database are stored on multiple computers on an network, syncing within minutes / seconds;
Adjustable Transparent	Records stored in the database may be made visible to relevant stakeholder without risk of alteration;
Highly Secure	Malicious actors (hackers) can no longer just attack one computer and change any records;
and Immutable	The mathematical algorithms make it impossible to changes / delete any data once recorded and accepted



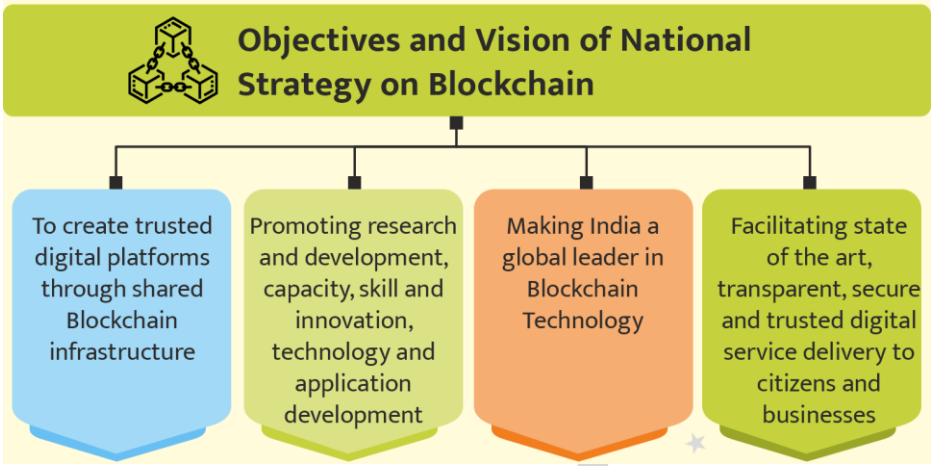
Significance of the technology

- **Decentralized mechanism:** Blockchain technology provides efficient distributed ledger storage mechanism.
- **Bringing transparency and efficiency** along with increasing processing speed and reducing cost.
- **Fraud prevention:** It is extremely difficult to get access to it, and if so, any piece of information can be easily recovered.
- **Applicability in diverse domains** such as education, governance, finance & banking, healthcare, logistics, cyber security, media, legal, power sector, etc.

Examples of potential applications

- **E-Governance:** Blockchain not only makes the underlying system more efficient but also brings trust, transparency, and accountability in the system.
  - This includes Property Record Management, Digital birth, death and education certificates Management etc.
  - For e.g., UAE through **Smart Dubai initiative** aims to become the first city fully powered by Blockchain.
- **Banking:** Blockchain can help in avoiding risk of payment losses involved in banking transactions, reduces cross-border transaction fees, corporate payments and remittances.
- **Supply Chain:** Blockchain can create a tamper proof record to check the real time information about product journey from place of origin to destination place improving the reliability and efficiency of the supply chain system.
- **Healthcare:** By establishing a secure chain of network blockchain can help in handling the patient records, consent forms, billings and public health monitoring.
- **E-Courts:** Data from multiple entities such as police, judiciary, legal department, etc. can be stored in a coordinated manner using Blockchain technology.

Strategies and Outcomes targeted for next 5 years: National Blockchain Framework



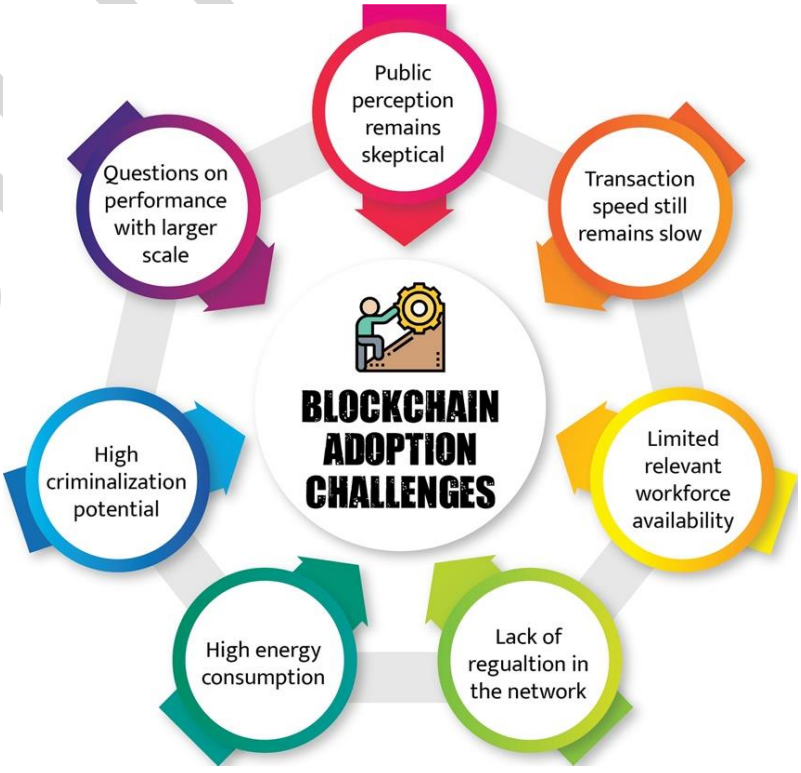
- **Need:** Reports predicts that by 2030, Blockchain would be used as a foundational technology for 30% of the global customer base.
- **Plan:** MeitY has initiated a project on design and development of a **National Blockchain Framework (NBF)** for creation of a shared Blockchain infrastructure and offering Blockchain as-a-Service (BaaS).

This framework comprises **following components** for a multi-pronged strategy:

- **Geographically distributed nodes** across the country, to enable citizen services at large scale and enable cross domain application development in health, agriculture, education, finance, etc.
- **To design and develop an indigenous Blockchain platform** incorporating identified best practices and advanced technological features.
- **Integration with important National Level Services** such as e-Pramaan and Digilocker.
- **Awareness Creation:** To sensitize the MSME/ Government departments/ judiciary and law enforcement agencies (LEAs) and like for boosting the adoption.
- **Policies & Regulations:** The existing regulations and policies would be updated as needed as NBF evolves and more experience is gained during the implementation.
- **Adoption Incentives:** Central and state Governments shall formulate their respective schemes and guidelines detailing out fiscal and non-fiscal incentives in this sector to enable large scale adoption of Blockchain in the country.
- **Human Resource Development:** Government has already started the **Future Skills Prime program** for upskilling and reskilling in emerging technologies including Blockchain in association with NASSCOM.
- **Multi-Institutional Approach:** involving various stakeholders from Government, premier academic & research institutions, startups, and industry is proposed to plan and implement NBF.
    - Further, **Blockchain Advisory Council** and **Steering Committee** shall be constituted to provide overall guidance.

Other prominent efforts in this direction

- **Centre of Excellence (CoE) in Blockchain technology** was established by NIC in association with **National Informatics Centre Services Inc.** (NICSI).
- **NITI Aayog** in collaboration with Gujarat Narmada Valley Fertilizers & Chemicals Limited (GNFC) has developed a Blockchain based system **for fertilizer subsidy**.



Related Information
Presidio Principles: Foundational Values for a decentralized future

- Presidio Principles were **released by World Economic Forum's** Global Blockchain Council and calls on **all actors to uphold these tenets** as they build blockchain applications.
- The Presidio Principles are **grouped into four broad pillars:**
  - Transparency & Accessibility (Right to information)
  - Privacy & Security (Right to data protection)
  - Accountability & Governance (Right to recourse)
  - Agency & Interoperability (Right to own and manage data)

1.1.2. NON-FUNGIBLE TOKENS (NFTS)

Why in news?

According to a recent report, India has the third most (after U.S. and Singapore) NFT companies headquartered in the world.

What are NFTs?

- An NFT, or a non-fungible token, is a **digital object** that can be a drawing, animation, piece of music, photo, or video **with a certificate of authenticity created by blockchain technology**.
  - NFT is a **unique proof of ownership** over something you can't usually hold in your hand — a piece of digital art, a digital coupon, maybe a video clip.
- The virtual object, which is actually a computer file, **can be exchanged or sold with its certificate.**
- "Tokenizing" these assets **allows them to be bought, sold, and traded more efficiently** while reducing the probability of fraud.
- NFTs can also be used to **represent people's identities, property rights, and more.**

Importance

It seeks to solve the problem of Ownership tracking, Value storage, and Decentralisation.

- **Monetisation:** Artists, musicians, influencers and sports franchises are using NFTs to monetise digital goods that have previously been cheap or free.
- **Authenticity:** Contemporary artists can now archive their collections through the blockchain and have NFTs to authenticate their works and ensure no fakes exist in the future.
- **Protecting intellectual property rights of Artisans:** who can use NFTs to verify their original work.

Conclusion

NFT marketplace is exploding, and surprisingly large amounts are being paid for NFT artwork. These prices, together with the uncertainty of a new technology, **raise potential legal liability issues for art creators, buyers, and marketplaces.**

There is **need for government to lay down framework to regulate cryptocurrency and other digital currencies** to avail its advantages which in the future would be profound.

1.1.3. QUANTUM TECHNOLOGY

QUANTUM TECHNOLOGY AT A GLANCE

An emerging field of physics and engineering powered by the principles defined by quantum mechanics which is a subfield of physics that explains the nature and behaviour of matter and energy on the atomic and subatomic level.

Potential applications of Quantum technology

- **Quantum Computing:** Qubits as its the basic unit of information instead of binary bits.
- **Quantum communication:** Uses quantum bits, typically photons of light, for transmitting data along optical cables.
- **Quantum simulation:** Specially designed quantum computer for simulating materials or chemical reactions of the physical world.
- **Quantum sensing and metrology:** Uses photons and electrons as highly sensitive sensors to measure of forces, gravitation, electric fields etc.

Significance of Quantum technology for India

- **Staying ahead of the disruption** and achieving a beginner's edge in this emerging field.
- **Preparing for tackling National security risks** posed by adversarial use of quantum computers.
- **Boosting Translational research.**
- **Fostering economic growth** by developing market for quantum R&D, software development, and equipment manufacturing.
- **Driving societal progress and improving the overall quality of life** enabled by applications of Quantum technology.
- **Encouraging entrepreneurship and start-up ecosystem development**

Measures taken in India to strengthen quantum industry

- **National Mission on Quantum Technologies & Applications (NMQTA)** with a total budget outlay of Rs 8000 Crore.
- **Quantum-Enabled Science and Technology (QuEST) initiative**
- **QSim – Quantum Computer Simulator Toolkit**
- **Quantum Frontier mission**
- **Setting up of dedicated labs and centres** like quantum computing laboratory and an AI centre at a military engineering institute at Mhow, Madhya Pradesh, Quantum Computing Applications Lab established by MeitY etc.

Constraints faced by India

- **Loosely built research ecosystem** with limited participation of private sector.
- **Small pool of skilled professionals in the field.**
- **Unstructured research** and absence of a common platform.
- **Absence of indigenous development of critical quantum components.**
- **Industry-academia gap** hindering translation of research into scalable applications.
- **Other issues:** Low patent applications, Lack of protocols for global governance, Low international collaborations etc.
- **Inherent Technological challenges:**
  - **Difficulty in achieving and maintaining quantum superposition and entanglement** long enough to complete a task is due to decoherence.
  - **Challenges in upscaling the number of qubits on a processor chip.**
  - **Need of special infrastructure**

Way forward

- **Creation of a dedicated quantum community** through Entrepreneurship, innovation, university courses, scholarships, training programmes etc.
- **Establishing dedicated centres for research.**
- **Setting priorities to safeguard national security** such as investing in post-quantum cryptography.
- **Effective coordination between the central and state governments.**
- **Focussing efforts on translating research into real-world applications.**
- **Facilitating International cooperation.**
- **Promoting domestic manufacturing facilities and units for development of quantum components.**
- **Revisit and rework National policies** like military doctrines, ethical guidelines etc.

1.1.3.1. QUANTUM KEY DISTRIBUTION

Why in News?

Scientists from DRDO and IIT Delhi successfully demonstrated a Quantum Key Distribution (QKD) link for a distance of 100 Km between Prayagraj and Vindhyachal in Uttar Pradesh.

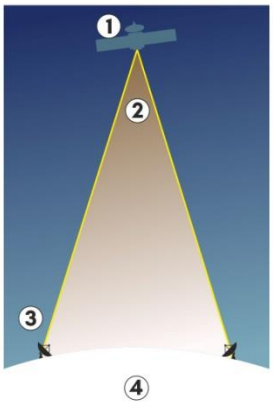
About Quantum Key Distribution (QKD)

- It is a secure **communication technology that uses quantum physics** to construct a cryptographic protocol.
- **In traditional cryptography,** the security is usually based on the fact that an **adversary is unable to solve a certain mathematical problem** while in QKD, **security is achieved through the laws of quantum physics.**
- **Two main categories of QKD** are prepare-and-measure protocols and Entanglement-based protocols.
    - **Prepare-and-measure protocols focus on measuring unknown quantum states.** This type of protocol can be used to detect eavesdropping, as well as how much data was potentially intercepted.
    - **Entanglement-based protocols focus around quantum states** in which two objects are linked together, forming a combined quantum state. In this method, if an eavesdropper accesses a previously trusted node and changes something, the other involved parties will know.

How does Quantum Key Distribution works?

Quantum key distribution allows user to agree on a way of transmitting their data without the worry that someone is listening in

1. Sender instructs satellite to generate 2 entangled photons of particular quantum state
2. Photons are beamed to both ground stations
3. Sender and receiver compare the quantum states of the photons to check if they have been intercepted. If not they use the photons to create a code to encrypt the date
4. Encrypted data can then be sent securely via conventional means



Advantage of QKD

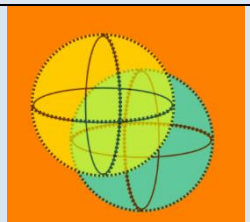
- It will **enable security agencies to plan a suitable quantum communication network** with indigenous technology backbone.
- **Quantum cryptography is considered as 'future-proof'** since no future advancements in the computational power can break quantum-cryptosystem.
- Secure communications are vital **for various civilian applications.**

Challenges in QKD

- **Transmission loss in optical fibres** in implementing QKD over long distances and at high communications rates.
- **Lower communication rate** (100,000 times less) **is another parameter where QKD falls short** compared to classical communications.
- It is currently **difficult to implement an ideal infrastructure for QKD.**

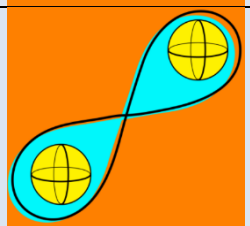
Quantum mechanics and related terms and concepts

- Quantum mechanics explains the **nature and behaviour of matter and energy on the atomic and subatomic level.**
- In physics, a **quantum is the smallest possible discrete unit of any physical property.** It usually refers to properties of atomic or subatomic particles, such as electrons, neutrinos and photons.



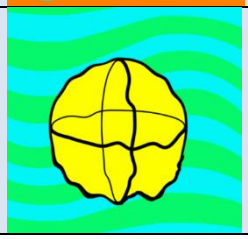
Superposition: In superposition, quantum particles are a combination of all possible states. They fluctuate until they are observed and measured.

- One way to picture the difference between binary position and superposition is to imagine a coin. Classical bits are measured by "flipping the coin" and getting heads or tails. However, if you were able to look at a coin and see both heads and tails at the same time, as well as every state in between, the coin would be in superposition.



Entanglement: It is the ability of quantum particles to correlate their measurement results with each other. When qubits are entangled, they form a single system and influence each other. Thus, measurements from one qubit can be used to draw conclusions about the others.

- By adding and entangling more qubits in a system, quantum computers can calculate exponentially more information and solve more complicated problems.



Decoherence: The interaction of qubits with their environment in ways that cause their quantum behavior to decay and ultimately disappear is called decoherence. Their quantum state is extremely fragile.

- The slightest vibration or change in temperature—disturbances known as "noise" in quantum-speak—can cause them to tumble out of superposition before their job has been properly done.

	Quantum supremacy: It's the point at which a quantum computer can complete a mathematical calculation that is demonstrably beyond the reach of even the most powerful supercomputer.

Related Information

National Supercomputing Mission (NSM)

- Launched in 2015 the mission aims at **establishing supercomputer facilities across 70 national research and academic institutions** and connecting them onto a National Knowledge Network (NKN).
- **Objective:**
  - To make India one of the **world leaders in Supercomputing** and to enhance India's capability in solving grand challenge problems of national and global relevance.
  - To **empower our scientists and researchers with state-of-the-art supercomputing facilities** and enable them to carry out cutting-edge research in their respective domains.
  - To **minimize redundancies and duplication of efforts,** and optimize investments in supercomputing.
  - To **attain global competitiveness and ensure self-reliance** in the strategic area of supercomputing technology.
- **First phase of NSM:** In the first phase of the NSM, parts for the supercomputers were imported and assembled in India.
- **Second phase of the NSM:** It involves increasing the speed of the supercomputer network in the country to 16 petaflops.
- **Third phase of the NSM:** This phase will take the speed of country's supercomputer network to 45 petaflops.

1.1.4. ARTIFICIAL INTELLIGENCE

ARTIFICIAL INTELLIGENCE (AI) AT A GLANCE

It is the branch of computer science concerned with making computers mimic human-like intelligence. AI enables a machine to perceive and respond to its changing environment.

Potential to boost national growth rate by 1.3% and add 1 trillion dollars by 2035 to India's economy.

India's Strength in AI: Large young population, Emerging startup ecosystem, India's "AI for All" strategy, India's digital footprint.

Benefits and applications of AI

- **Healthcare:** AI driven diagnostic, Early detection, drug research and discovery.
- **Education:** Automation of repetitive task, Practicals using AR/VR, Counselling sessions, Evaluation etc.
- **Agriculture:** AI enabled agricultural robotics, Predictive analysis, AI for intelligent spraying etc.
- **Manufacturing:** Quality checks, Prediction of equipment failure, Inventory management, real time changes in supply chain management etc.
- **Energy:** AI managed smart grids, Anti-theft technologies, Fault prediction, Energy efficient systems using Alexa, Google nest etc.
- **Financial services:** Personalised Banking, Fraud detection, Process automation etc.
- **Law enforcement:** Facial recognition, Speech recognition, Predictive analytics etc.

Challenges to AI adoption in India

- **Data security and privacy** issues.
- **Limited AI expertise.**
- **High implementation cost** resists numerous organizations to implement AI solutions.
- **Lack of AI and cloud computing infrastructure.**
- **Lack of integrity and ethics** with AI algorithms.

Initiatives taken

- **MeitY's FutureSkills PRIME** in collaboration with NASSCOM, for re-skilling/ up-skilling of IT professionals in 10 Emerging areas including AI.
- **National Strategy for Artificial Intelligence.**
- India is **founding member of the Global Partnership on Artificial Intelligence (GPAI).**
- **National Programme on Responsible Use of AI for Youth.**
- **'National AI Portal',** a repository of AI based initiatives.
- **Responsible AI for Social Empowerment (RAISE)** in 2020.

Way Forward

- **Applications and Infrastructure Development** with high computational power, large memory and storage space.
- **Regulations and Policy as** AI applications touch several aspects of human life.
- **Initiate a Programme to support R&D** and innovation with international cooperation.
- **Human Resource Development:** to reskill them for new type of jobs.

1.1.5. 5G TECHNOLOGY

5G TECHNOLOGY AT A GLANCE

Designed to address speed, latency, and utility issues of earlier/ current generation of mobile networks.

Enhanced throughput to handle more simultaneous connections at a time.

Works in 3 bands: low, mid and high frequency spectrum.

Significance of 5G technology for India

- **Economic growth:** 5G network rollout estimated to add $450 billion to the Indian economy.
- **High speed:** of about 10Gbps with having the cheap telecom data charges.
- **Creation of job:** in agriculture, health, education, infrastructure, and logistics.
- **Ease of doing** by bringing positive change in the governance of the country.
- **Self-reliance** in the direction of critical and modern technologies.

Challenges in implementation of 5G

- **Low fiberisation footprint:** Only 30% of India's telecom towers are connected by fibre connection.
- **Hardware challenge:** Indian communications service providers are mostly dependent on foreign telecom OEM.
- **High spectrum pricing:** Several times costlier than the global average).
- **Differences in 5G frequency bands:** as each one has its own advantages and limitations w.r.t. speed and coverage area.
- **Challenge to net neutrality:** due to network slicing (preferential or differential treatment).
- **Others:** Telcos issue (low average revenue per user, lack of skillset etc.), Consumer Constraints (Network coverage issue, Handset availability, data privacy etc.).

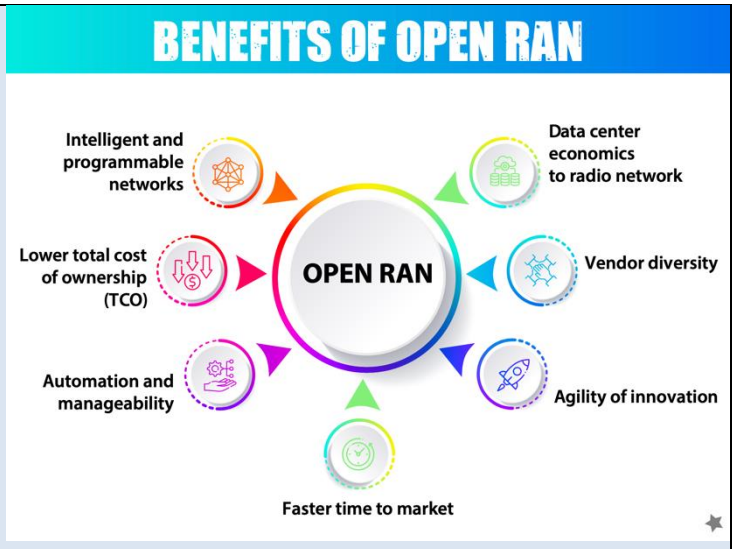
Steps taken by Government

- **A 5G High Level Forum was set up in 2017.**
- **Cellular Operators Association of India (COAI) formed 5G India Forum.**
- **'National Digital Communication Policy-2018** (NDCP-2018) also lays out objectives with respect to 5G services in India.

Way Ahead

- **Doubling of fibre connectivity:** from 30% for an efficient 5G launch and adoption.
- **Boost local 5G hardware manufacturing** at an unprecedented rate.
- **Rationalization of prices:** to make 5G services globally competitive.
- **Balanced allocation of bands** to enhance futuristic 5G technology applications.

Related News- Open Radio Access Network (ORAN)



- **Telecommunication Engineering Centre,** technical arm of DoT**,** and **telecom equipment maker VVDN Technologies** have signed a pact to set up 5G ORAN **to drive research innovation and domestic design and manufacturing.**
  - Pact will **facilitate registered start-ups, innovators and MSMEs** working in field of ORAN to get their product tested at existing lab of VVDN **for interoperability among Open RAN components**.
- RAN **provides the critical technology to connect users to the mobile network** over radio waves. It also acts as a bridge to access all the key applications on the web.
  - Current RAN technology is **provided as an integrated platform of both hardware and software.**
  - Therefore, it is **difficult to mix vendors for its different units**, and in most cases, they come from the same supplier.
- Idea of **Open RAN is to enable operators to mix and match components** from different vendors.
  - Open RAN **will create a multi-supplier RAN solution** that allows for the separation between hardware and software with open interfaces.

1.1.6. INTERNET OF THINGS

Why in news?

Recently, **Telecommunication Engineering Centre (TEC) released 'Code of Practice for securing consumer Internet of Things (IoT)'.**

Guidelines for securing consumer IoT

1. All IoT device **default passwords shall be unique per device** and/or require user to choose a password that follows best practices, during device provisioning.
2. **Disclosed vulnerabilities should be acted on in a timely manner.**
3. **Software components in IoT devices should be securely updateable**. Updates shall be timely and should not adversely impact the functioning of the device.
4. **Unused functionality should be disabled**; hardware should not unnecessarily expose access (e.g., unrequired ports both network and logical should be closed).
5. **Security-sensitive data,** including any remote management and control, **should be encrypted in transit,** appropriate to the properties of the technology and usage of the device.
6. In case the device collects or transmits **personal data,** such data **should be securely stored.**
7. **Installation and maintenance of IoT devices should employ minimal steps** and should follow security best practices on usability.

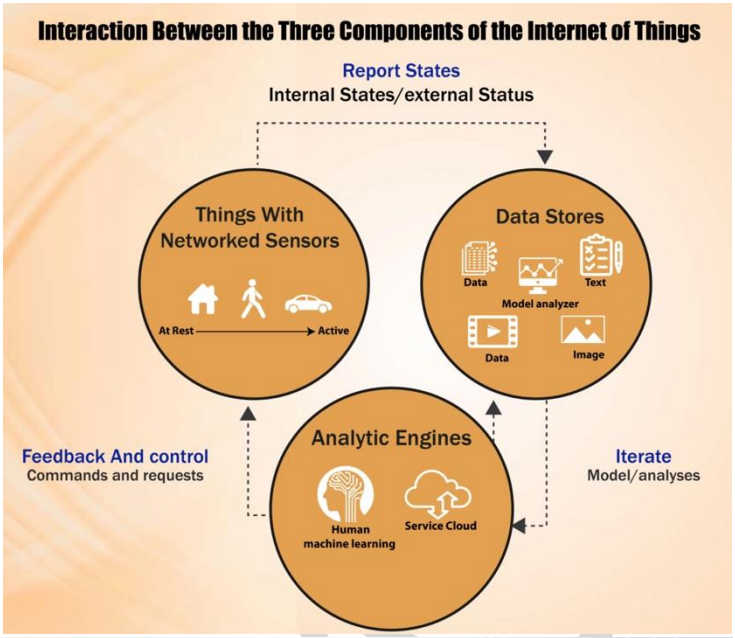
About Internet of Things (IoT)

- It is a **seamless connected network of embedded objects/ devices, with identifiers, in which Machine to Machine (M2M) communication without any human intervention is possible** using standard and interoperable communication protocols.
  - As per the projections, there may be **26.4 billion IoT devices in service globally by 2026**.
- An IoT ecosystem consists of **web-enabled smart devices use embedded systems, such as processors, sensors, and communication hardware,** to collect, send and act on data they acquire from their environments.
- Sometimes, **these devices communicate with other related devices** and act on the information they get from one another.
- The devices do most of the work without **human intervention, although people can interact with the devices**.

Significance of IoT

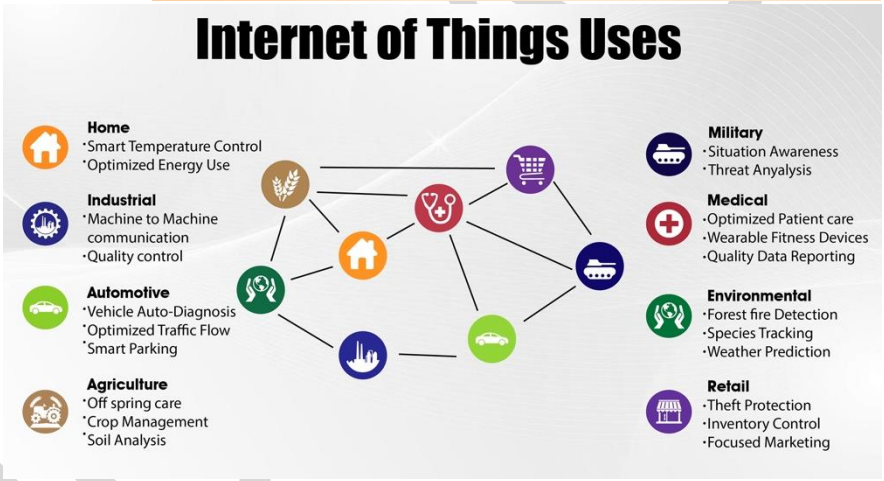
- **Automation and Control:** The machines can communicate with each other without the need for continuous human intervention.
- **Better monitoring of devices:** M2M communication helps to maintain transparency and leads to uniformity in the tasks and maintain the quality of service.
- **Improve efficiency:** The M2M interaction provides better efficiency; hence, accurate results can be obtained fast.

- **Saves Money:** Optimum utilization of energy and resources can be achieved by adopting this technology and keeping the devices under surveillance.



Measures taken by the government to promote IoT

- **In 2015, Draft IoT Policy was formulated** with a vision to **develop connected and smart IoT based system** for our country's economy, society, environment, and global needs.
- **Smart City concept** and the **Digital India Program initiatives** to setup Digital Infrastructure in the country **would help boost the IoT industry**.
- **Centre of Excellence** for IoT was set up in **Bangalore by GoI and NASSCOM**.
    - **Also, Andhra Pradesh will become an IoT hub** with first-of-its-kind policy
- The government came up with the **National Digital Communications Policy (NDCP) 2018,** to satisfy the modern realities of the telecom such as 5G technology, IoT, M2M communication, etc.
- As per the **NDCP,** an eco-**system is to be created for 5 billion connected devices by 2022.**



Challenges of IoT: Data Breach (Personal data gets more exposed), **Dependence on technology** as it is mainly dependent on internet connection, **Complexity in operation, Security** (as IoT information is prone to attack by hackers), **issue of compatibility** in tagging and monitoring devices, **Lesser Employment of Menial Staff etc.**

Conclusion

In view of the anticipated growth of IoT devices, it is **important to ensure** that the IoT **comply to the safety and security standards and guidelines** in order to protect the users and the networks that connect IoT devices. However, it is one of the **fastest emerging technology**, providing **enormous beneficial opportunities for society, industry, and consumers** and it will continue to pick up as more people realize the potential of connected devices to keep them competitive.

1.1.7. CYBER-PHYSICAL SYSTEMS

Why in news?

Through National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS), **new and emerging technologies are being developed** at 25 Technology Innovation Hubs (TIHs) across the country.

About Cyber-physical system (CPS)

- It is an interdisciplinary field that **deals with the deployment of computer-based systems** that do things **in the physical world.**

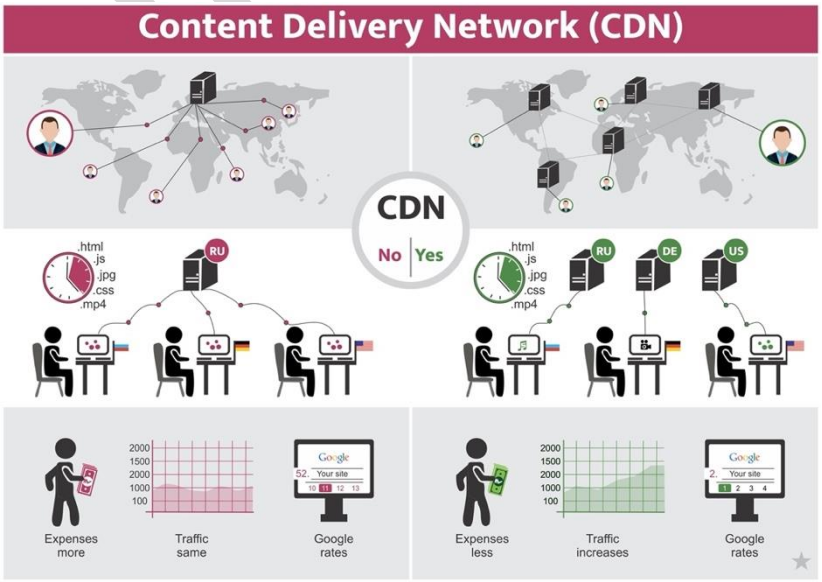
- It **integrates sensing, computation, control and networking into physical objects** and infrastructure, connecting them to the Internet and to each other.
- Examples of CPS are **Smart Grid Networks, Smart Transportation System, Enterprise Cloud Infrastructure,** Utility Service Infrastructure for Smart Cities, etc.
- **CPS and its associated technologies,** like AI, IoT, Machine Learning, Big Data Analytics, Robotics, Quantum Computing, Quantum Communication etc. play a **transformative role in almost every field of human endeavor in all sectors**.
- **Advantages of CPS technologies** include **enhanced security capabilities**, **Disaster Management** (next generation public safety communications, sensor networks etc.), **Energy** (smart power infrastructure), **Healthcare** (cost-effective, easy to-certify, and safe products), **Transportation** (Congestion control, traffic-based grid) etc.
- **Challenges in CPS:** Privacy issue, Data related challenges (information leakage, deliberate attacks etc.), Infrastructural and technological barriers etc.

About National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS)

- Mission aims **to create a strong foundation and a seamless ecosystem for Cyber Physical Systems (CPS) technologies** by coordinating and integrating nationwide efforts.
  - Approved in 2018, it is implemented by the **Department of Science & Technology (DST).**
- Mission is expected to **act as an engine of growth that would benefit national initiatives** in health, education, energy, environment, agriculture, strategic cum security, and industrial sectors, Industry 4.0, SMART Cities, SDGs etc.
- **Mission goals:**
  - Make India a leading player in CPS technologies.
  - Achieve translation of CPS technologies for societal and commercial use, nurture startups and increase in the job market.
  - Produce next generation technocrats in CPS technologies.
- **Four major activities of NM-ICPS:** Technology Development, Human Resource & Skill Development, Innovation, Entrepreneurship & Start-Up Ecosystem and International Collaborations.

1.2. DEVELOPMENTS IN INFORMATION TECHNOLOGY

1.2.1. NET NEUTRALITY



Why in News?

The **net neutrality debate has resurfaced in the country** as telecom operators are backing a proposal to regulate content delivery networks (CDN), which are used by global big tech companies to host data locally.

More on News

Telecom operators say that CDN, which were kept out of the TRAI's 2017 recommendations on net neutrality, need regulatory re-examination as **internet companies start to tie up with specific ISPs to deliver higher quality services to certain groups of customers.**

About Net Neutrality

- Net Neutrality is the idea that **Internet service providers (ISPs) should treat all data that travels over their networks fairly,** without improper discrimination in favour of particular apps, sites, or services.
- It means ensuring that all **end users are able to access the Internet content, applications and services at the same level of service quality, speed and price.**
- **Each country adopts different responses to the issue.**
  - Countries which have **taken no specific measures** e.g. Australia, Republic of Korea, New Zealand.
  - Countries that have adopted **light-touch regulatory measures** e.g. European Commission, Japan, UK.

- Countries that have taken or propose to take **specific legislative measures** e.g. Brazil, Chile, France, Netherlands, Singapore, USA (FCC rules).

- Mechanisms for establishing guidelines ensuring Net Neutrality **in India are at present mainly enforced by TRAI.**

TRAI on Net Neutrality

- TRAI has backed the basic principles of an open and free internet in its recommendations on Net Neutrality (2017).
- **Key highlights from TRAI recommendations**
  - **Discriminatory treatment of content is prohibited**.
  - Kept **content delivery networks (CDN) out of the regulation.**
  - **Internet of Things (IoT), as a class of services, is not excluded** from the scope of the restriction on non-discriminatory treatment. **However, critical IoT services**, which could include telemedicine, B2B services **will be automatically excluded.**
  - TRAI has also recommended a **watchdog along the lines of BARC India** for enforcing Net Neutrality.
  - I**nternational treaties, court orders, government order** on blocking certain sites **are exempt from these guidelines.**

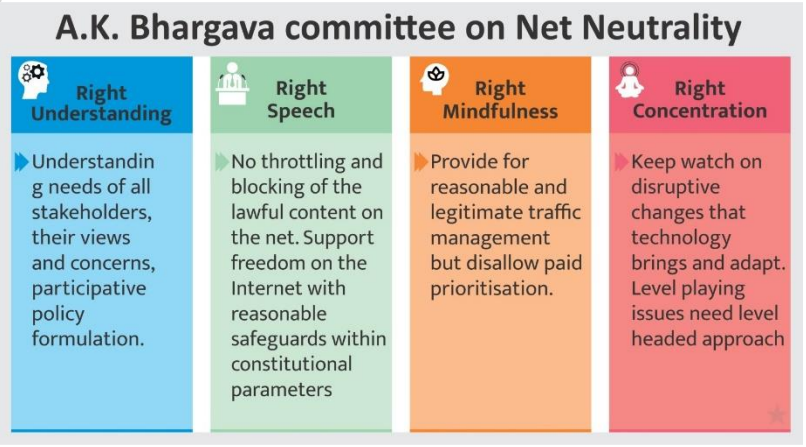
Why Net Neutrality is needed?

- **Unlocking Possibilities** by ensuring open and non-discriminatory access to the Internet.
- **Important component of open internet:** Where policies such as equal treatment of data and open web standards allow those on the Internet to easily communicate with each other without interference from a third party.
- **Level playing field:** Without net neutrality, ISPs can slow down the websites or services of small businesses that can't afford to pay for the so-called fast lanes.
- **Freedom of expression and free speech:** ISPs shouldn't be able to block content or slow down webpages just because they don't like them. With no net neutrality legislation, nothing stops them from censoring online content.
- **Supporting innovative ideas:** Net neutrality has enabled an ecosystem for creation of Google, Facebook, Twitter and countless other services. All these services had very humble beginnings. They started as a basic website with modest resources.

Arguments against Net Neutrality

- **Priority based services:** Data packets of different applications (e.g., a data packet carrying emergency service information versus another packet carrying video information etc.) need different type of treatment on the network.
- **Limited Bandwidth:** Unlike an infinite resource, the bandwidth of the Net is limited. If someone is using Skype or YouTube, he needs a lot of bandwidth and that too on priority. It can be argued that he should pay a higher price.
- **Illicit content:** Offensive, dangerous, and illegal content is accessible to everyone and difficult to remove. Removing net neutrality makes it easier for ISPs to filter dangerous content.
- **Lack of new infrastructure:** With net neutrality, large amounts of data are consumed without being paid for – this money could be used to expand the high-speed network to rural areas.

Way Forward

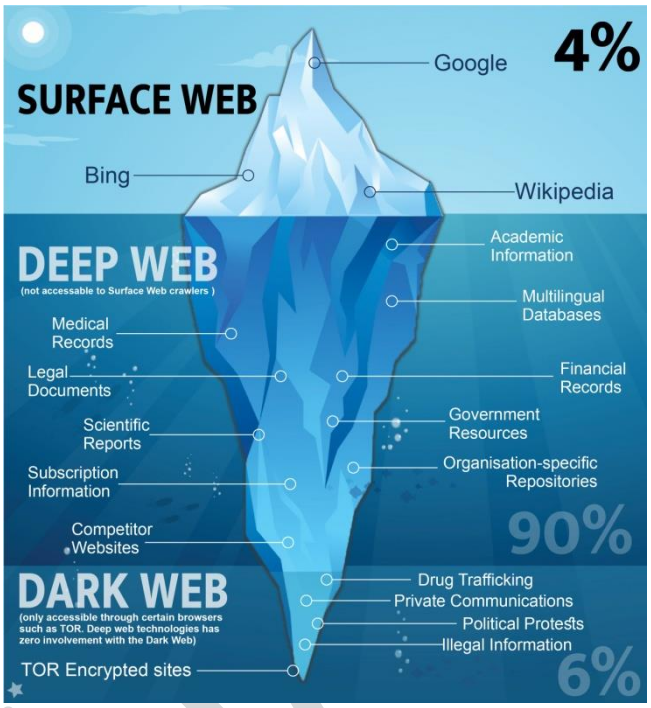


- **User rights on the Internet need to be ensured** so that ISPs do not restrict the ability of the user on the Internet.
- **ISPs should make adequate disclosures to the users about their traffic management policies,** tools and intervention practices to maintain transparency and allow users to make informed choices.
- **Prioritisation of government information in times of public crises certainly is important,** there needs to be more deliberation on the list of websites and URLs that Cellular Operators Association of India (COAI) will allow being zero-rated during emergency.
- **A.K. Bhargava committee (2015) on Net Neutrality** suggested some approach (see infographics) that should be followed.

1.2.2. DARK NET

Why in news?

Germany has shut down Russia-linked 'Hydra Market'- considered as world's **biggest and oldest DarkNet marketplace** of illegal items and services.



About DarkNet

- Also known as Dark Web, it is that **part of Internet which cannot be accessed through traditional search engines** like Google nor is it accessible by normal browsers like Chrome or Safari.
  - It **generally uses non-standard communication protocols** which make it inaccessible to internet service providers (ISPs) or government authorities.
  - **Content on Dark Net is encrypted and requires specific browser such as TOR** (The Onion Ring) browser to access those pages.
- **Dark Net itself is only a part of Deep Web** that is a broader concept, which includes sites that are protected by passwords.
  - **Part of internet that is readily available to general public** and searchable on standard search engines **is called as Surface Web.**

Uses of Dark Net

- **By journalists and citizens, working in oppressive regimes**, to communicate without any government censorship.
  - It was used by activists during the Arab Spring and is known to have been used by Chinese citizens.
- **By researchers and students** to do research on sensitive topics as it is known to have large virtual libraries.
- **By law enforcement agencies** for sting operations.
- **To access connect blocked** by local Internet service providers.
- **To maintain privacy** of sensitive communications or business plans.

Concerns over its use

- **Anonymity:** Because of their end-to-end encryption dark net offers a high degree of anonymity and thus it is near impossible to track.
- **Haven for illicit activity:** Malicious actors like cyber criminals, terrorists and state-sponsored spies use dark web for various activities like payment card fraud, illicit finance, selling banned drugs, etc.
- **Technical challenges to establish digital evidence in courts:** As most users are tracked in foreign countries, it offers multiple complexities and roadblocks in investigation.
- **Privacy and ethical concerns:** Decrypting communications to catch criminals has been opposed by activists as it would risk everyone's data present on the dark web.

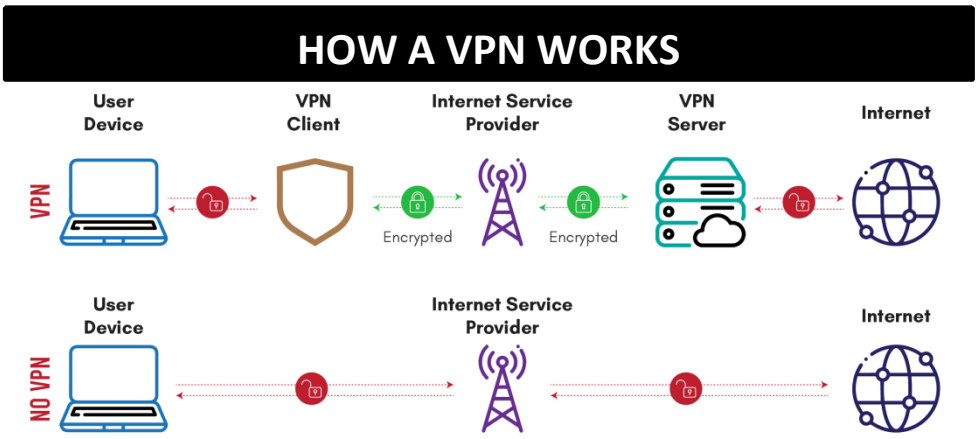
Steps that can be taken by India

- **International collaboration** in strengthening cyber security framework to deal with challenges posed by Dark Net.
- **Investment in research and development** and training and capacity building of personnel in the field of cyber security.
- **Amendment to the Information and Technology Act** and Evidence Act to deal with the new age cyber-crimes.
- **A code of criminal procedures** dealing with cyber-crime that would come under the Ministry of Home Affairs, which deals with policing issues

1.2.3. VIRTUAL PRIVATE NETWORK (VPN)

Why in news?

Recently, **Central government has asked VPN companies** to keep a record of their logs of customer information as directed by Indian Computer Emergency Response Team (CERT-In).



About Virtual Private Network (VPN)

- VPN is an **encrypted connection** over the Internet from a device to a network **in real time.**
- This **prevents unauthorized people from eavesdropping** on the traffic and allows the user to conduct work remotely.

Benefits of using VPN

- **Secure encryption:** VPN provides encrypted connection in real time. With the help of this online activities are hidden even on public networks.
- **Secure data transfer:** VPN services connect to private servers and use encryption methods to reduce the risk of data leakage.
- **Encryption of IP address:** This allows user to send and receive information online without the risk of anyone but user and the VPN provider seeing it.
- **Encryption of protocols**: VPN prevent from leaving traces, in the form of internet history, search history and cookies and prevents third parties from gaining access to confidential information.
- **Kill switch:** Sudden interruption in VPN connection interrupts secure connection terminate preselected programs, reducing the likelihood that data is compromised.

Issues associated with using VPNs

- **Data leaks**: A study showed that 72% of free VPNs embedded third-party trackers in their software. These trackers are used to gather data on your online activities.
- **Jurisdiction**: The country where your VPN is located affects how secure (based on local data laws) your VPN is.
- **Bypasses cybersecurity walls:** VPN services can bypass cyber security walls and allow criminals to remain anonymous online.
- **Commercial ramifications**: VPN has commercial ramifications for businesses like Netflix and other content providers that have geographical restrictions.

Way Forward

Asking VPN service providers to store user data may not be desirable, especially since the proposed Personal Data Protection Bill is yet to be passed by the Parliament.

The Centre can, however, take other measures to ensure that **cybercriminals do not hide behind a VPN platform** through a consultative process not just with VPN players but also with global law enforcement agencies.

Rules (like Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Rules, 2021) **can be framed that puts the onus on VPN service providers** for keeping their platforms safe.

About CERT-In guidelines & it analysis

- New directives, under **IT Act, 2000,** aim to deal with the **gaps that hinder the government in responding to certain cybercrime incidents**:
  - All cloud service providers and VPN providers will be required to **maintain a series of extensive customer information for at least five years**. Even after any cancellation or withdrawal of the registration.
  - **Data centre companies and cryptocurrency exchanges**, too, are asked to collect and store user data by CERT-In.

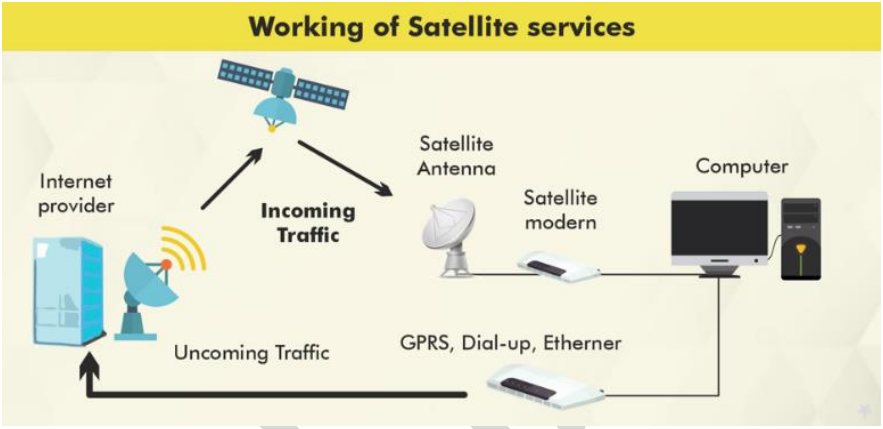
- **VPN companies will have to regularly report the cases around the 20 cyber security vulnerabilities** listed by CERT-In.

- **Concerns raised:**
  - **Against user privacy**: Adhering to CERT-In guidelines by VPN providers would go against the nature of their services to protect user privacy.
  - **Lack of technical means:** A 60-day compliance time to set up an online validation facility is a challenging task and will require significant engineering and architecting for a seamless onboarding experience.
  - **Additional cost:** small and medium enterprises that the government's mandate to keep logs of users for five years and verify the details, will significantly add to their costs.
  - **Against Ease of Doing Business.**

1.2.4. SATELLITE INTERNET SERVICES

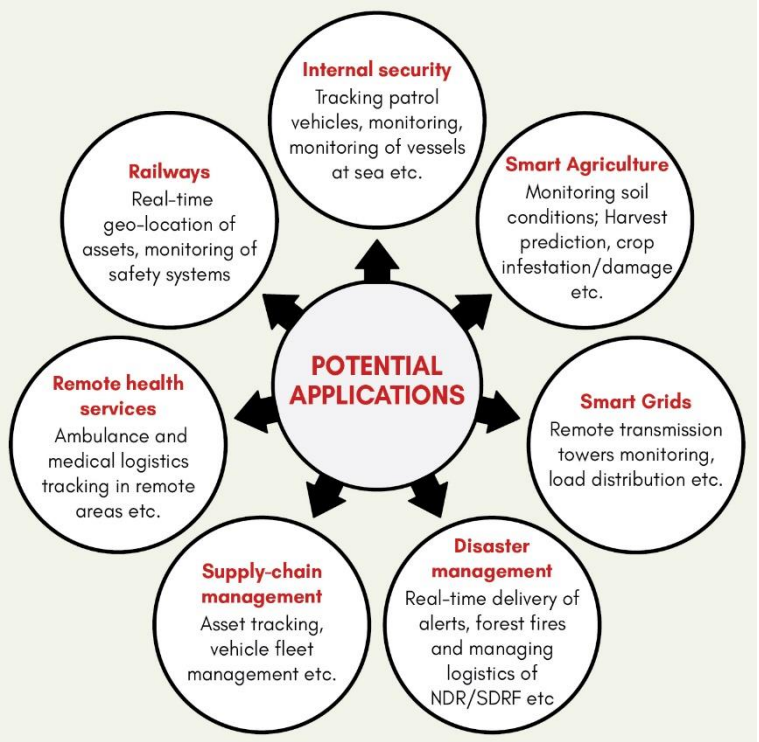
Why in News?

Recently, the government issued a public advisory to stop Starlink Internet Services from offering satellite-based services in India and asked citizens not to subscribe to it as it is not licensed in India.



What is Satellite Internet Service?

- Satellite Internet Services is a **wireless internet connection** which uses satellites in space to get an internet signal from the Internet Service Provider (ISP) to users.
- It operates using two way satellites which can be the geostationary satellites or satellites in **Low Earth Orbit (LEO)**.
- It is **different from satellite television** as Internet signals have to go **both ways** with a much **greater amount of bandwidth** to move all that data.

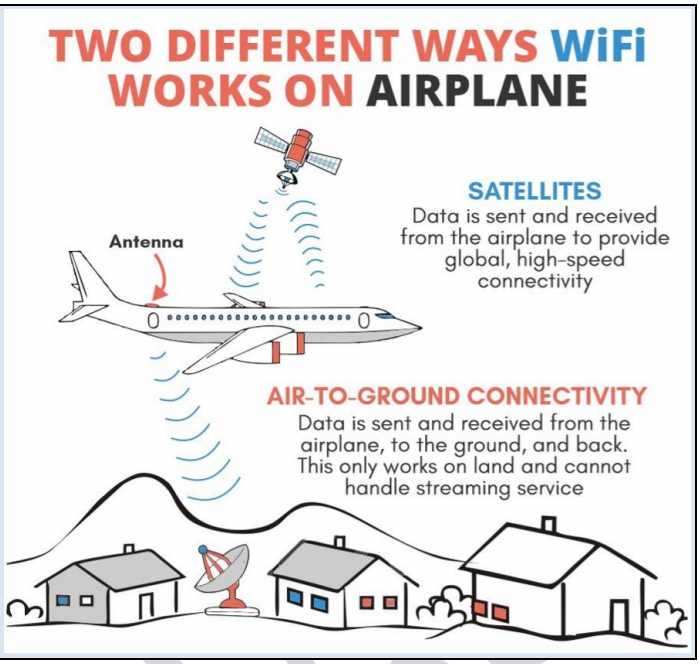


Benefits of Satellite Internet Services	Challenges in Satellite Internet Services
• **Cheap** and **easy internet** option for rural areas, hilly terrains, and islands for **Last Mile connectivity**. • **Faster than Digital Subscriber Line (DSL) connection** with continuously improving technology with present speeds reaching around **100 mbps**. • Can play a **significant role in emergency** or **disaster recovery** due to limited ground infrastructure.	• **Low Speed** and **High Latency** in comparison to fiber optic cables. • **High Cost** as compared to wireless cellular networks and others. • **Limitations of Bandwidth** with high impact of weather aberrations. • **Potential to damage spacecrafts/satellites** or interrupt higher satellites frequency because of its large satellite network need. • **Potential to increase** space junk • **Not compatible** for **VPN Services** (provides online privacy and anonymity).

Related News

In-flight Wi-Fi have a very few takers despite government's push

- Telecom Commission **had given its green signal to in-flight connectivity of Internet** and mobile communications on aircraft in Indian airspace in 2018.
  - Broadly, in-flight connectivity systems use two kinds of technologies: **Air-to-ground Wi-Fi and Satellite Wi-Fi** (refer to the infographics).
  - The in-flight Wi-Fi industry is expected to grow to be **worth $30 billion by 2035.**
- **Main reasons of failure of uptake**
  - Retrofitting antennas for Wi-Fi is **extremely costly.**
  - **Difficult to pass on the costs to the customers** in an extremely competitive market.
  - **Low passenger demand** because of COVID-19.



1.3. OTHER TECHNOLOGICAL DEVELOPMENTS

1.3.1. DATA CENTRES

Why in News?

Interest from companies such as Microsoft, Flipkart, Amazon Web Services etc. suggests that India is slowly becoming a favourable destination for corporations setting up data centres.

About Data Centres

- Data centre is **a dedicated secure space within a building / centralized location where computing and networking equipment is concentrated** for the purpose of collecting, storing, processing, distributing or allowing access to large amounts of data.
- **Key selection criteria:** Geographic location, favourable climatic conditions, availability of power, proximity to customers, fiber connectivity and real estate costs.

Data Centres in India

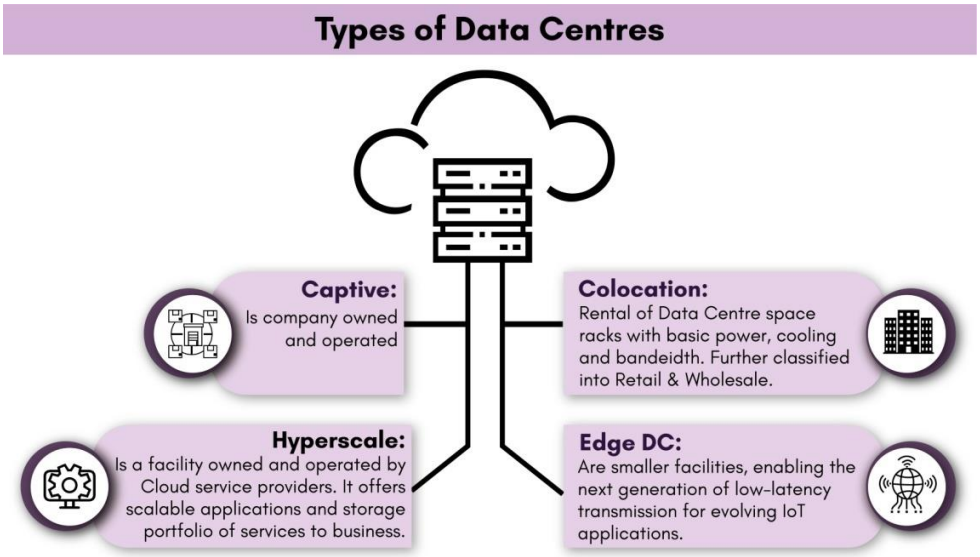
- **India's data centre industry has around 499 megawatts (MW) of critical information technology capacity,** of which seven cities account for 490 MW — Mumbai (Highest Capacity), Chennai, Bengaluru, Pune, Delhi NCR, Hyderabad, and Kolkata.
- As per Nasscom, India is expected to see **investments of around $4.5 billion by 2025.**
- **Demand drivers include** push to Digital India, COVID-19 induced demand, fairly stable geography, improved fiber connectivity, growing IT sector, adoption of cloud services etc.

Importance of Data Centres for India

- **Size of digital economy:** in India is estimated to grow from **$ 200 billion in 2017-18 to $ 1 trillion by 2025.**
- **Data localization provisions:** Presence of domestic data centres will allow companies to store critical personal data and sensitive personal information of Indian citizens within India.
- **High growth potential:** India's data centre market is set to play a key role in job creation, bring in foreign investment and contribute to the growth of the country's economy.
- **Meeting digital demands:** Indian Data Centre market has seen tremendous growth in the past decade, riding on the explosion of data through smartphones, social networking sites, ecommerce, digital entertainment, digital education, digital payments, and many other digital businesses / services.
- **Suitability for emerging technologies:** Data centres has the potential to fulfil the growth in data stimulated by adoption of emerging technologies such as quantum computing, artificial intelligence, internet of things etc.

Challenges in establishing Data Centres in India

- **Lack of a Data Protection Bill:** Unless the bill is in place and data protection laws are solid, some stakeholders, especially investors from overseas, could be hesitant to invest.
- **Locational Constraints:**
  - **Skill Availability** for advanced data centre construction and design remains a key challenge.
  - **Government Approvals** are a time-consuming process in India.
  - **Power and land constraints** i.e., availability of land in proximity to a power substation and fibre path, safe distance from residential plots, etc.



- **Carbon emissions**
  - **High Power Consumption** by data transmission networks is a major concern as thermal power accounts for around 60 per cent of its requirement.
  - **Global Pressure to Reduce Carbon Emissions**
- **Data centre security**
  - **Security Threats:** To the data centre facility from physical damages; safety of IT Infrastructure from attacks and network vulnerabilities.
  - **Growing Complexities in Data centre Environment:** may pose a variety of logical threats are emerging such as DDoS attacks, web application attacks, DNS infrastructure exploits etc.

Initiatives taken in India

- **Draft Data Centre policy by MeitY** to accelerate the growth in the projected Data Centre capacity in the country.
- National Informatics Centre (NIC) has set up **state-of-the-art National Data Centre at NIC Headquarters Delhi, Pune, Hyderabad, and Bhubaneswar** and 37 small Data Centres at various State Capitals to provide services to the Government at all levels.
- **States like Uttar Pradesh and Tamil Nadu have released their own data centre policy.**

Way forward

Draft Data Centre Policy, 2020 proposes following strategies that can help India become a Global Data centre hub

Ease of Doing Business Ecosystem	• **Providing Infrastructure Status** to the Data Centre Sector. • Setting up of **Pre-provisioned Data Centre Parks**. • Formulation of **Data Centre Incentivization Scheme**
Enabling a Favourable Ecosystem	• MeitY to work with Department of Telecommunications (DoT) to **facilitate robust and cost-effective connectivity** • Data centres to be **declared as an Essential Service.** • **Recognize Data centre as a separate category** under National Building Code.
Setting up Data centre SEZs	• Government to set up **at least four Data Centre Economic Zones (DCEZ) in the country** as a Central Sector Scheme.
Promote Indigenous Technology Development	• **Encourage use of indigenous hardware and software products** to reduce import burden. • **Promote R&D in Data Centre ecosystem** • Collaborate with Ministry of Skills Development and Entrepreneurship and leading academic institutes to impart **large scale trainings to workforce on Data Centre, Digital and Cloud technologies**.

1.3.2. GEOSPATIAL TECHNOLOGY

1.3.2.1. GEO-SPATIAL DATA

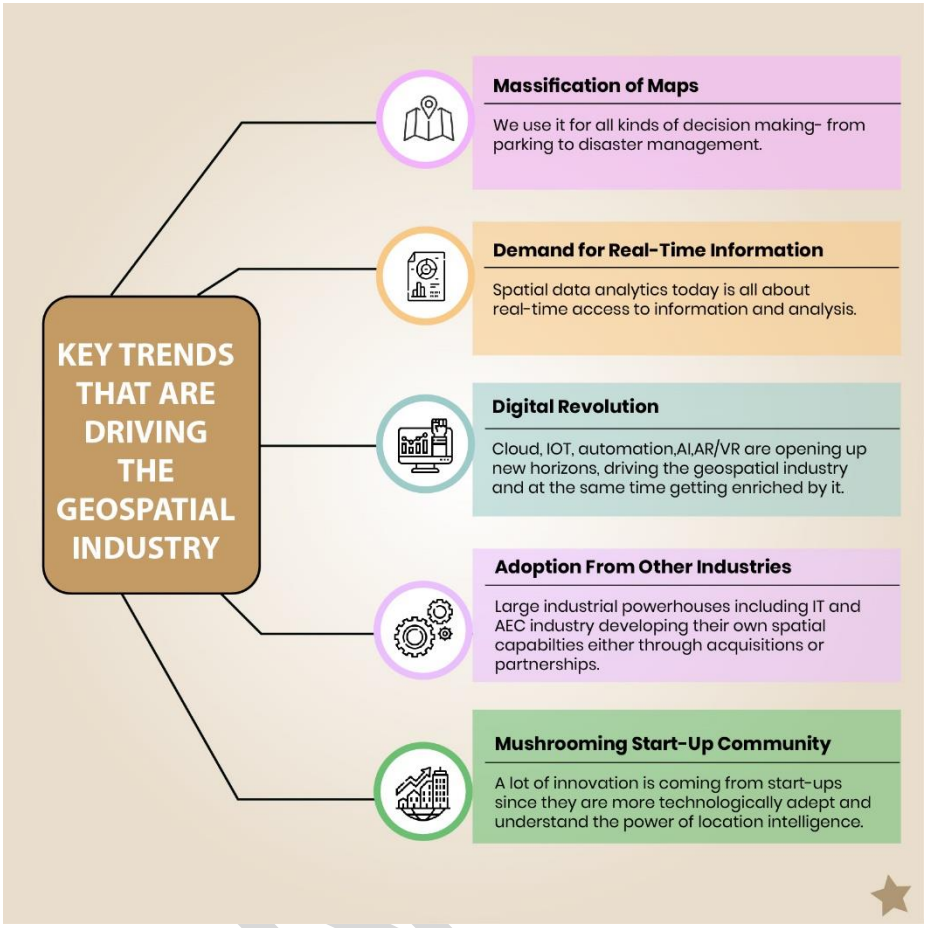
Why in News?

1st anniversary of the release of geospatial data was celebrated recently.

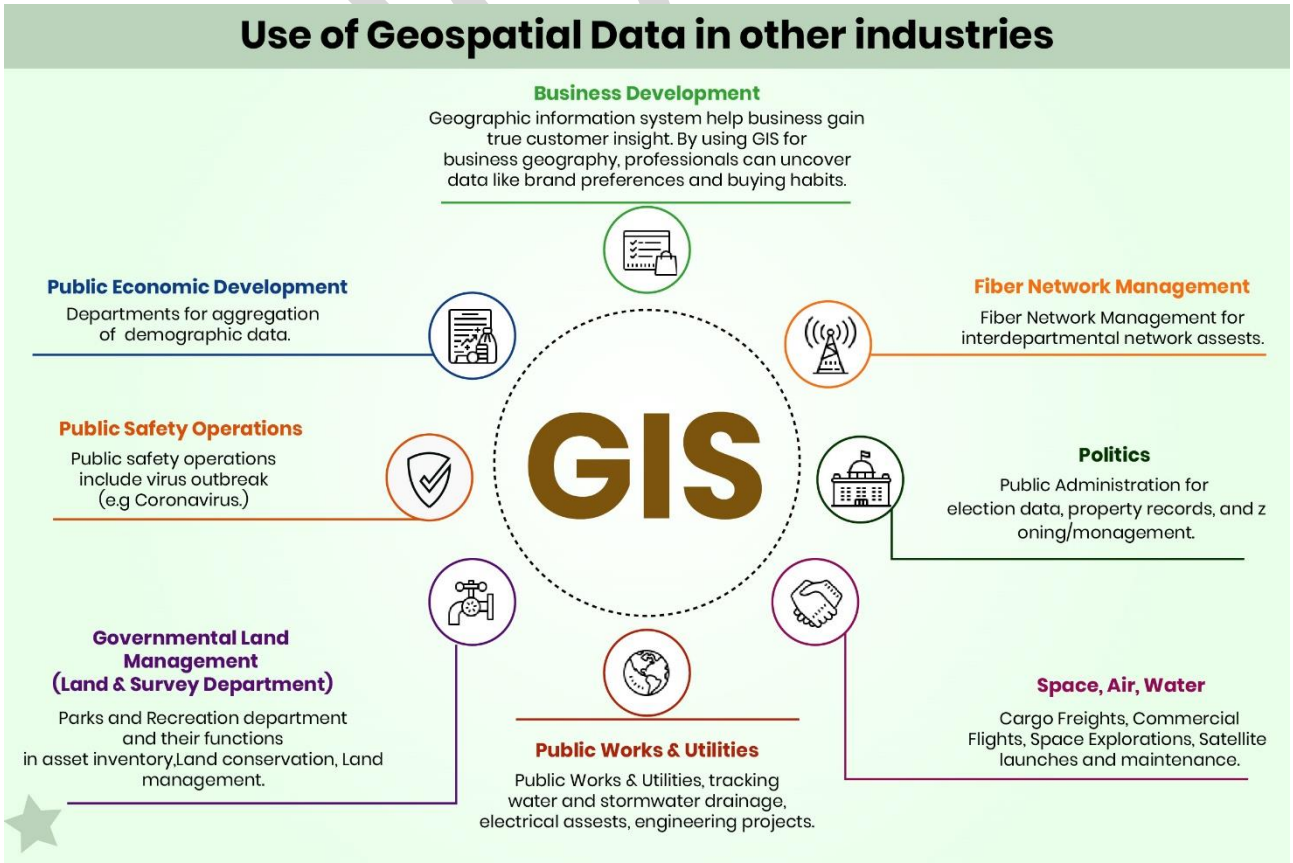
About Geo-Spatial Data

- Geospatial data (also known as "**spatial data**") is used to describe data about objects, events, or phenomena (man-made or natural) that have a location on the surface of the earth. At present, **80% of any data has a geo spatial component.**

- Examples include the location of a road, an earthquake event, malnutrition among children, or dynamic like a moving vehicle or pedestrian, the spread of an infectious disease etc.



- **The two main types of geospatial data are vector data and raster data (refer infographic).**
  - **Vector Data:** It uses geometric shapes to show the location and shape of geographic features. Points, lines and polygons can represent things like cities, roads and waterways. Vector data is scalable, has small file sizes and ideal for depicting boundaries.
  - **Raster Data:** It represents data through a digital image such a scanned map or photograph. It also includes aerial and satellite imagery. Raster data uses a cell-based format called stair-stepping to record data as pixels or grids with an image. Spatial analysis depends heavily on raster datasets.



1.3.3. ADDITIVE MANUFACTURING

Why in News?

National Strategy on Additive Manufacturing was released by the Ministry of Electronics & Information Technology (MeitY).

About Additive Manufacturing (AM)/ 3D printing

- **Definition:** AM is a process in which a **three-dimensional object is built from a computer-aided design (CAD) model, usually by successively adding** materials in a layer-by-layer fashion.
- **Application:** AM market globally focused on the sectors including automotive, consumer products, medical, business machines, aerospace, government/military, academic and others.
- **Drivers of the AM Market:** new and improved technologies, financial support from governments, large application area, rapid product development at a low cost, and ease of development of custom products.
- **Traditional vs. AM:** Unlike AM, traditional manufacturing methods, by contrast, are subtractive in nature.
  - Subtractive manufacturing **involves removing parts of a block of material** (Ex: Cutting Wood) to create the desired shape.

Potential Impact of Additive Manufacturing

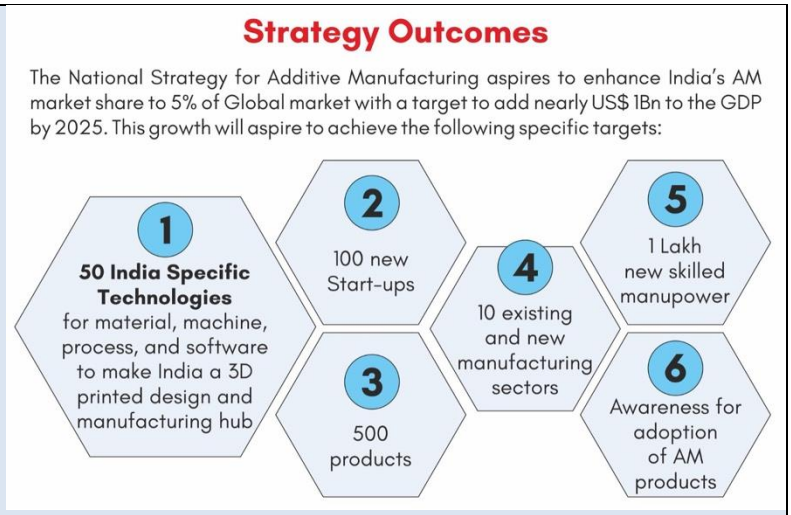
- **Economic Competitiveness**
  - **Supply Chains** could become more responsive due to on-demand manufacturing.
  - **Increase in GVA:** by development of new technology-driven industries and jobs.
- **Environmental impact:** AM facilitates more energy and resource efficient development to alleviate carbon footprint and increases its energy security.
- **Innovation Diffusion:** It allows for removing design constraints thereby boosting innovation in the product development process.
- **Patient specific medical care:** AM has the potential to fabricate biomedical implants, prosthetics, skin/tissues and intricate organs and medicals devices quickly and cost effectively.
- **Military Superiority:** In place of storing important stocks, our military entities will only require adequate AM facility and important raw materials to help the manufacturing process even in the operationally difficult places.

Initiatives taken in India

- **Establishment of 3D printing Manufacturing Lab** at National Institute of Electronics & Information Technology, Aurangabad.
- Under Atal Innovation Mission, **Atal Tinkering Labs have been set up,** where do-it-yourself (DIY) kits on latest technologies like 3D Printers, Robotics, Miniaturized electronics are installed through government financial support.
- **Several states** (Gujarat, Andhra Pradesh etc.) have **collaborated with foreign universities** to set up 3D printing Labs.
- **Department of Heavy Industries collaborated with Wipro** to build India's first industrial grade 3D printer.
- Despite these efforts, **India's share** in the **global additive manufacturing ecosystem remains at 3%-5%.**

National Strategy for Additive Manufacturing

- It aims **to inspire an effective strategy on AM, maximizing economic benefits** from future growth opportunities, while minimizing risks and mitigating associated challenges.
- **Key goals envisaged are:**
  - Position India as a global hub for AM.
  - Protect India's AM intellectual properties.
- **Key Objectives are:**
  - **Encourage domestic manufacturing** across the value-chain.
  - **Reduce import dependency.**
  - Encourage global market leaders to **establish global bases for manufacturing AM** components and sub-assemblies in India.
  - **Strengthen India's collaborations with global AM organizations** and Innovation and Research Centres.
  - Establish a **"National Centre on AM"** for harnessing AM transformation.
  - **Promote Innovation and Research infrastructure.**
  - **National network of Industrial MakerSpaces and FabLabs** (similar to Kerala's Maker village) may be developed **for encouraging community participation** to promote the horizontal exchange of knowledge.
- **Focus sectors are** Electronics, Aerospace, Defence, Automotive, Medical Devices, Capital Goods, Consumer goods, Construction and Architecture etc.



2. AWARENESS IN THE FIELD OF SPACE

INDIA'S SPACE SECTOR AT A GLANCE

Indian Space Research Organisation has till now carried out 100+ spacecraft missions, 75+ launch missions with a remarkable feat of launching 104 satellites into orbit in

Efforts have been taken to encourage Space Exploration like Indian National Space, Promotion & Authorization Centre (IN-SPACE) and Space Activities Bill.

Changing approach of India's space exploration activities to factor in predominance of security concerns from countries like China and to raise India's international profile.

Benefits of Space Exploration

Research & Innovation

- Applications in everyday life ranging from solar panels to a global search-and-rescue system
- Experiments conducted over International Space Station helps betterment of public health and safety
- Space mining provides a near-infinite supply of the precious and scarce resources such as lithium, cobalt etc.
- Studies of the Martian environment helps in **understanding Climate change over Earth.**
- **Attracts young people** to careers in science, technology, engineering and mathematics

Culture & Inspiration

- **Fulfil people's curiosity** about Universe
- Affect humanity's **appreciation of life's uniqueness on Earth**

Means to address global challenges

- Contribute to **trust building and diplomacy between nations**
- International preparedness for **protecting the Earth from catastrophic events.**

Emerging Challenges

- **Militarisation and Weaponization of space**
- **Cyberattacks on space assets**
- **Increased Space traffic & Debris**
- **Ethical concerns over space-based data collection** due to the dual use nature of satellites
- **Polarisation of space reach and formation of oligopoly** due to increasing Space Privatisation
- **Ecocide i.e.,** mass damage and destruction of space ecosystem
- **Irresponsible manufacturing of space objects**
- **Uneven distribution of benefits** of space exploration
- **Obsolete space laws** with lack of dispute settlement mechanism and state centric nature

Regulation of outer space activities

- **United Nations Committee on the Peaceful Uses of Outer Space** (UNCOPUOS) for debating issues of international space law and policy
- **Five international treaties under UNCOPUOS forms the basis of space law:**
  - The Outer Space Treaty, 1967
  - The Rescue Agreement, 1968
  - The Liability Convention,1972
  - The Registration Convention, 1975
  - The Moon Agreement, 1979

Way forward

- **Devising new norms and rules for space** addressing emerging issues
- **Fostering International Cooperation** on International Code of Conduct for Outer Space Activities, Prevention of Arms Race in Outer Space and Space2030
- **Leadership role must be played by India** in forming a comprehensive regime for use of outer space and by actively engaging with existing forums and deliberations over peaceful use of outer space.
- **Recognising Intellectual Property (IP) in space to** ensure active participation of private entities.
- **More rational and organised approach is needed** in the space research.

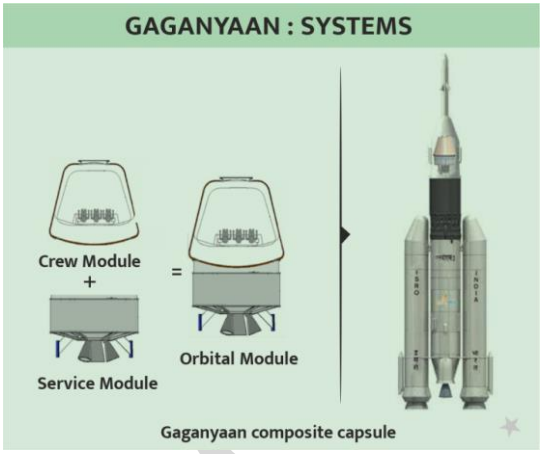
DEVELOPMENTAL ROLE OF INDIAN SPACE RESERACH ORGANISATION

Agriculture	ISRO technology is being used to carry out crop production forecasts for major crops and to improve crop condition and productivity by using remote sensing satellites data.
Rural Development	ISRO has launched Village Resource Centres (VRCs) to provide space based services directly to rural areas like Telemedicine, Tele-education, Panchayat planning, marketing information etc.
Resource management	ISRO through Earth Observatory satellites provides for effective management of natural resources.
Railway sector	Applications of space technology are realised in guarding unmanned railway crossings, detecting obstructive objects on rail tracks to avoid train accidents etc.
Education	EDUSAT provided connectivity to schools, colleges and higher levels of education and also supported non-formal education including development communication
Disaster Management	Using geoportals like Bhuvan to address various aspects of natural disasters, using space based inputs.
Navigation with Indian Constellation (Navic)	It is an independent regional navigation satellite system developed and maintained by India. Applications include in maritime field, mobile phones, Defence etc.
Infrastructure development	ISRO is contributing by offering Satellite Imaging and other Space Technology applications for better accomplishment of infrastructural projects.
Urban Development	High resolution satellite data provides accurate information on current landuse practices in a city or town.
Medical Management	ISRO had been providing liquid oxygen on a large scale to several state governments from their own manufacturing facilities or from the existing stock during the COVID pandemic.
Land use Planning	ISRO's Desertification and land degradation Atlas presents state-wise desertification and land degradation status maps depicting land use, process of degradation and severity level.

2.1. GAGANYAAN

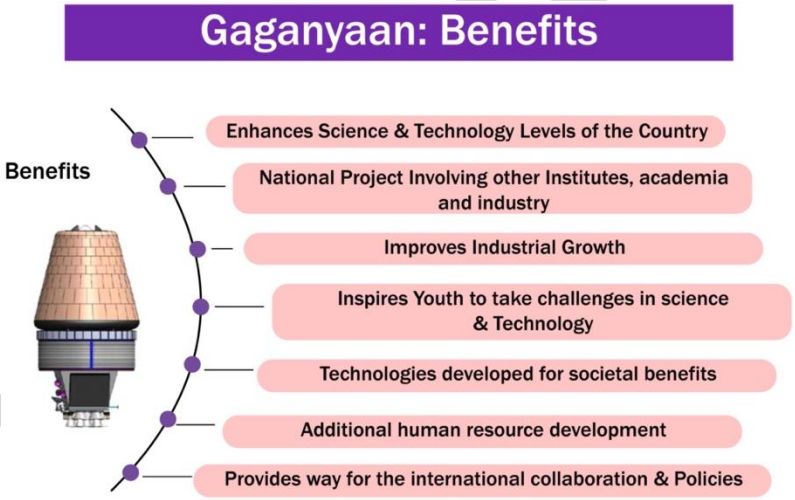
Why in news?

Indian Space Research Organisation (ISRO) plans to launch Gaganyaan before Independence Day in 2022.



About Gaganyaan

- The **word 'Gaganyaan'** is derived from **Sanskrit,** meaning **'sky-vehicle'**. Programme envisages **undertaking the demonstration of indigenous capability** to undertake human spaceflight to Low Earth Orbit (LEO).
- As part of this programme, **two unmanned missions and one manned mission will be carried out**.
- The **major new technologies required** for Gaganyaan programme are as follows:
  - **Human rated launch vehicle**
  - **Crew escape systems**
  - **Habitable orbital module**
  - **Life support system**
  - **Crew selection and training and associated crew management activities**



Technical Challenges

- **Hostile environment:** The 'Gaganyaan' has **to create an atmosphere like Earth inside a small volume** and ensure that is adequate maintained throughout the mission.
- **Gravity field:** Transitioning from one gravity field to another has impact on the physical bodies. It affects hand- eye and head-eye coordination.
- **Isolation:** Due to isolation, one may encounter depression, fatigue, sleep disorder and psychiatric disorders.
- **Radiation:** In space stations, astronauts receive over ten times the radiation than what people are subjected to on Earth. **Radiation exposure may increase the risk of cancer. It can also damage the central nervous system.**
- **Launch escape system:** Anything may go wrong during the prelaunch, launch and post launch phase including the explosion of rocket into a fireball. Launch escape systems safety features must be built to minimize the losses.
- **Re-entry and Recovery:** The spacecraft's re-entry into the atmosphere must be very precise, even the slightest deviation could lead into a disaster.

Conclusion

The Gaganyaan mission could **propel India** to the **centre of human space exploration.** The manned missions will push India further in **exploration beyond Earth's orbit as** countries are eager to control the next space race, which has the **potential to trigger major changes in the global order.**

Related News
Maiden launch of Small Satellite Launch Vehicle (SSLV) was delayed recently.
About SSLV

- It has been **designed to meet "Launch on Demand" requirements.**
- It is a **three stage all solid vehicle** with capability to launch up to **500 kg satellite mass into 500 km low earth orbit.**
- It is the **smallest vehicle at 110-ton mass at ISRO.**
- It aims to **cater to the market for the launch of small satellites into Earth's low orbits** that has emerged in recent years to cater to the need of developing countries, universities for small satellites, and private corporations.

- **New Space India Limited (NSIL), a PSU, will be the sole nodal agency** responsible for providing end-to-end SSLV Launch services.

Advantage of SSLV

- **Reduced turnaround time** (take only 72 hours to integrate, unlike the 70 days taken now).
- **Cost effective** (cost will be only around Rs 30 crore).
- **Multiple satellite mounting options** for nano, micro and small satellites.

2.2. CHANDRAYAAN-3

Why in News?

Minister of State for Atomic Energy and Space, in a written reply to Lok Sabha, stated that Chandrayaan-3 is scheduled for launch in August 2022.

About Chandrayaan-3

- Chandrayaan-3 is a **follow-on mission to Chandrayaan-2** and is meant **to demonstrate lunar landing and roving capability.**
- Chandrayaan-3 will carry only a modified lander and rover and **will use the orbiter of the Chandrayaan 2 mission** to communicate with the earth.
- **Scientific payloads that are being carried on-board are:**
  - **Lander:** Langmuir probe, Chandra's Surface Thermo Physical Experiment (ChaSTE) and Instrument for Lunar seismic activity (ILSA).
  - **Rover payloads are** Alpha Particle X-Ray Spectrometer (APXS) and Laser Induced Breakdown spectroscope (LIBS).
- Chandrayaan-3 lander is planned to perform an **in-situ experiment of surface and sub-surface measurements of temperature.**
  - It is meant to help understand the thermal exchange and physical properties of the uppermost Lunar soil.

Why lunar missions?

- In the coming years, **several countries are planning to launch their lunar missions.**
  - **Other lunar missions:** Artemis (NASA), Volatiles Investigating Polar Exploration Rover (NASA), Korea Pathfinder Lunar Orbiter (South Korea)
- **Reasons for renewed interest**
  - **Economic:** Helium-3 (an isotope of the element helium) is abundant on the Moon, but rare on Earth. It is a potential fuel for nuclear fusion.
  - **Base for future space exploration:** It is the best place to test how life reacts to harsh conditions of space.
  - **To study Earth:** Moon and Earth share a common past, studying it will reveal how earth's early past.

India's Lunar missions

- India's Lunar exploration journey began with a maiden mission **Chandrayaan-1 in 2008 and a second mission in 2019.**
  - While the 2008 mission was a success, the 2019 mission Chandrayaan-2 failed to land successfully on the Lunar surface.
- Around 2024-25, India and Japan are expected to **launch a joint Lunar Polar Exploration Mission.**
  - This probe is meant to land at the Lunar South pole with a rover.

About Chandrayaan-1 and 2

	Chandrayaan-1	Chandrayaan-2
About	• **India's first mission** to Moon. • It carried 11 scientific instruments built in India, USA, UK, Germany, Sweden, and Bulgaria.	• **Second lunar exploration mission** with following basic components- **Orbiter, Lander (called Vikram), band Rover (called Pragyan).** • Though mission **spacecraft failed its soft landing on the Moon's surface, its Orbiter continued to successfully collect and relay** crucial insights about the Moon.

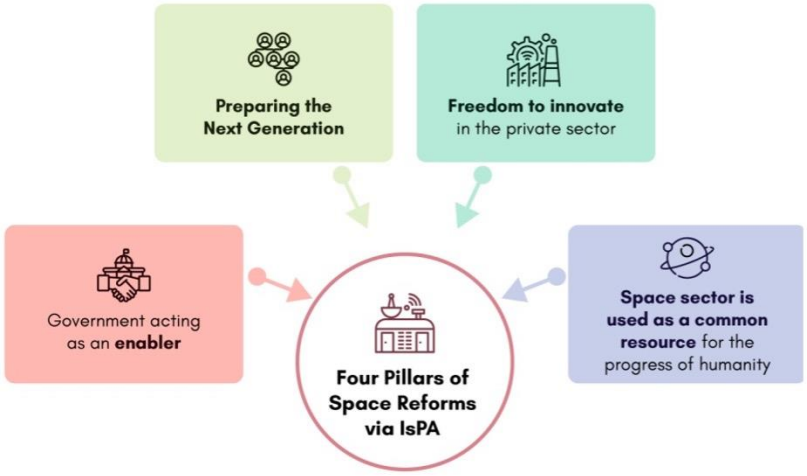
Objective	• To **conduct chemical and mineralogical mapping of the entire lunar surface** for distribution of mineral and chemical elements.
	• To **prepare a three-dimensional atlas** of both near and far side of the moon.
		• **Primary objective:** To demonstrate the ability to soft-land on the lunar surface and operate a robotic rover on the surface.
		• **Scientific Objectives**
		  ○ Moon provides the best linkage to Earth's early history.
		  ○ Evidence for water molecules discovered by Chandrayaan-1 requires further studies.

		○ It will also study new rock types with unique chemical composition.
Major Findings	• **Detected water in vapour form** in trace amounts, • **Confirmed the Ocean Magma Hypothesis** i.e., the moon was once completely in molten state, • **Detected x-ray signals** during weak solar flares thus indicating presence of magnesium, aluminum, silicon and calcium on lunar surface, • **Detection of new spinel-rich rock type** on lunar far-side.	• Detected unambiguous **presence of hydroxyl and water molecules** on the Moon with the precision of differentiating between the two. • Detected **solar proton events** due to high intensity solar flares. • **Imaged Sarabhai crater** on the Moon. • **Detection of Argon-40** in the lunar exosphere.

2.3. PRIVATE SECTOR PARTICIPATION IN SPACE

Why in news?

The Prime Minister recently **launched the Indian Space Association (ISpA)**, an industry body consisting of various stakeholders of the Indian space domain.



More about news

- The industry association will act as an **independent and a "single-window" agency** for enabling the opening up of the space sector to start-ups and the private sector.
- ISpA will also work towards **building global linkages** for the Indian space industry to bring in **critical technology and investments** into the country to create more high-skill jobs.

The gamut of Space activities envisaged to be taken up by private sector

- **Production of components and subsystems** of **a launch vehicle**, launch vehicle **integration and testing** which is meant for space launch.
- **Production of components of a spacecraft**, spacecraft Integration and testing for the purpose of space launches.
- **Space launch of spacecraft** on board a launch vehicle and establishment/ operation of **launch infrastructure.**
- Providing **space-based services** including operation, control and station keeping of spacecraft by establishing and operation of **ground segment/ stations.**
- Development of **space-based applications** using satellite data and rolling out of commercial services.

Status of India's Space industry

- **Driven by public sector:** India's space programme is one of the well-developed in the world and is driven by a state-owned agency ISRO.
- **High economic potential:** The current global space economy is estimated at US$ 360 billion, with India accounting for ~2%. The Indian space sector is **projected to reach US$ 50 billion** over next 5 years.
- **Limited participation in satellite and ground-based services:** In the global space market, rocket and satellite launch services, an area in which ISRO specializes, amount to only 5% share. Satellite-based services and ground-based systems account for the remaining 95%.

Need for private sector participation

- **Growing demand**: ISRO alone can't cater to the rising demand for space-based applications and services within India.
- **To enable ISRO to fulfil its strategic objectives**: Private sector participation will allow ISRO to focus more on strategic programmes like R&D activities, exploration missions and human spaceflight programme.
- **Increase India's share in global space market**.
- **To secure our space capabilities and make them more robust**: by distributing them across many different satellites and spacecraft.

- **To expand satellite-based services:** Private sector can facilitate development of a cost-effective product or a service, thus creating large base of new consumers.
- **To achieve our geopolitical objectives:** Given the current geopolitical situation of the country and security threats, growth in the space sector can help the country gain leverage over others.
- **Other factors** include attracting innovation and cutting-edge technology, enhanced competitiveness, creation of job opportunities, realising vision of Aatmanirbhar Bharat and reducing dependence on taxpayer's money.

Challenges associated with Private Sector participation

- **Conflicts of interest:** As ISRO is both a regulator and an operator, this conflict of interest is likely to manifest during dispute resolution between private players and ISRO entities.
- **Procedural hurdles:** Companies have often cited multiplicity of approvals and procedural ambiguity as barriers to start operations in India.
- **Lack of clarity on level of private involvement:** Given that government still considers some domains in space too crucial for national interest to allow private participation.
- **Absence of coherent policy:** that could provide support and guidelines to technology manufacturing businesses, including tax rebates etc.
- **Limited technological advancements:** Most IP is owned ISRO and that has hindered the technological advancements of Indian companies.

Concerns related to Private sector participation

- **Monopolistic trends:** Space technology is expensive and needs heavy investment. This kind of lucrative power is available only with selected rich corporates, thus can lead to monopolization of the sector.
- **Social welfare may take a backseat:** ISRO always worked on applications like remote sensing, tracking of land use, resource mapping etc., enhancing social welfare. However, private companies will have more profitable interests than developing solutions.

Recent steps taken for private sector participation

- To enhance utilization and maximize benefits from the space assets, it has been proposed to change the approach from **"Supply Based Model" to "Demand Based Model".**
- **IN-SPACe was created** to **encourage, promote and hand hold** the private sector for their participation in Space Sector.
- **New Space India Limited (NSIL)** is the commercial arm of ISRO and primarily responsible for enabling Indian industries to take up high-tech, space-related activities.

Charting the road ahead

- **Regulatory clarity:** to ensure compliance with India's international obligations, ensuring safety, covering liabilities and standardization. Improved regulatory environment would mean fewer barriers of entry for private firms.
- **Independent regulator:** Creating an independent regulator can help in instilling confidence among private players.
- **Incubator and Grant Programs:** that support the sector during this initial R&D phase will greatly improve entrepreneurship and investor participation, as well as increase the success rate of these start-ups
- **Incentives to private companies:** Opening up of ISRO's testing facilities to the private sector will reduce cost and increase incentives for firms to build operational spacecraft.
- **FDI reforms:** Government can consider more liberal FDI rules for the sector to encourage both domestic as well as international funding.

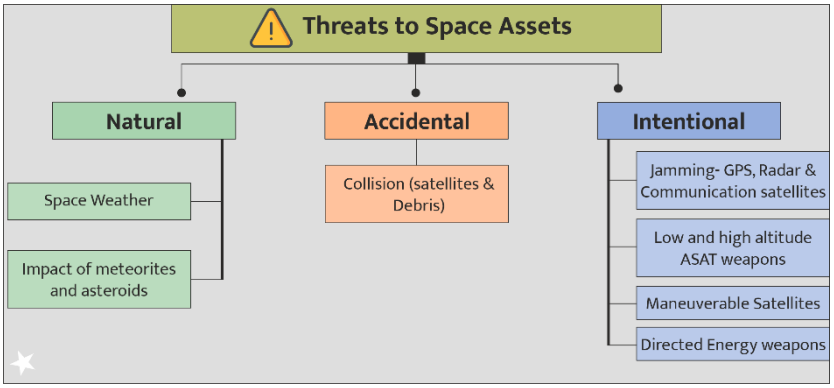
2.4. SPACE SITUATIONAL AWARENESS (SSA)

Why in News?

India, US finalise signing of new Space Situational Awareness arrangement

What is SSA?

SSA is the practice of **tracking objects** in space**, identifying** them, **establishing their orbits,**



understanding the environment they're operating in, and **predicting their future positions and threats** to their operations.

Importance of SSA for India

- **To ensure security of space assets:** SSA can help in **debris tracking, collision avoidance**, Prediction and monitoring of **threats** (refer infographic) and **Satellite anomaly detection.**
- **Space superiority:** SSA also helps in providing **information regarding adversary's activities** in space which will enable decision makers to **gain and maintain space superiority.**
- **Dramatic rise in number of space objects**: The number of objects in space is **increasing exponentially,** heightening the risk of collisions between space objects.
  - Currently there are more than 19,000 objects on orbit of which only 2216 are active satellites.

Steps taken in the light of importance of SSA

- **ISRO has set up a Directorate of Space Situational Awareness and Management (SSAM)** aiming at protecting high valued space assets from space debris close approaches and collisions.
- **A control centre is being established at Bengaluru** to systematically carryout all activities related to SSAM such as protection of Indian Space assets, tracking data of inactive satellites and enabling research activities.
- **Global cooperation:** India is an active member of Inter-Agency Debris Coordination Committee (IADC) and engages in several initiatives with North American Aerospace Defense Command (NORAD).
- **Multi Object Tracking Radar (MOTR):** Currently used for proximity analysis, but when used in conjunction with a dedicated Command Centre, it could drastically improve the observation accuracy of space assets.

2.5. SPACE DEBRIS

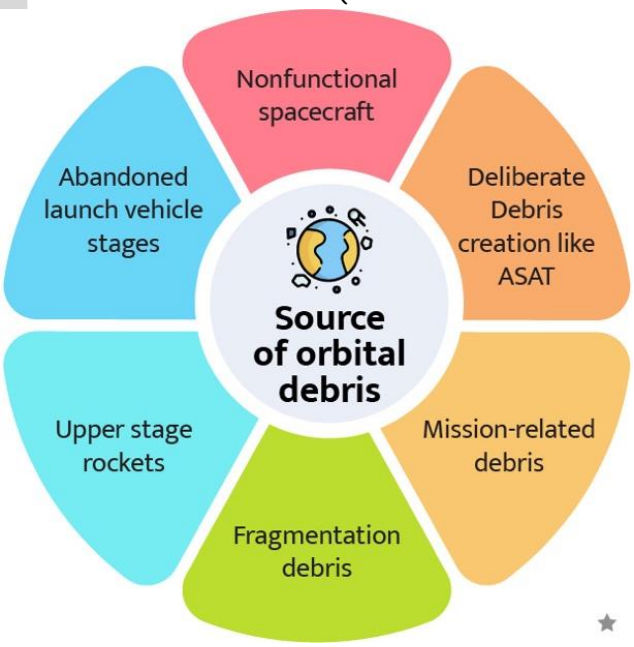
Why in News?

Indian Space Research Organisation (ISRO) is building up its orbital debris tracking capability by deploying new radars and optical telescopes under the Network for Space Objects Tracking and Analysis (NETRA) project.

About Space Debris

- Space debris encompasses **both natural meteoroid and artificial** (human-made) orbital debris. Meteoroids are in orbit about the sun, while most artificial debris is in orbit about the Earth (hence the term "orbital" debris).

Risks associated with space debris



- **In-orbit risks:** The rising number of space debris increases the potential danger to all space vehicles, especially to ones with humans aboard the International Space Station (ISS).
- **Kessler Syndrome:** It is a scenario in which the density of objects in LEO is high enough that collisions between objects could cause a cascade where each collision generates space debris that increases the likelihood of further collisions.
- **Increases Cost:** Satellite operators in the geostationary orbit have estimated that protective and mitigation measures account for about 5-10% of mission costs and for LEO the cost is even higher.
- **Interference with Scientific and other observations:** Space debris also disrupts reception of radio telescope and distorts photographs from ground-based telescopes affecting the accuracy of scientific results obtained.
- **Affect Air travel:** Space debris may lead to significant problems for spaceflight around Earth (higher risk for objects orbiting at an altitude of around 1,000 kilometres).

Strategies to Tackle Space Debris

- **Preventive measures:**
  - Spacecraft and orbital stages should be **designed not to release debris** during normal operations.
  - Missions should estimate and **limit the probability of accidental collision** during the orbital lifetime.
  - Avoidance maneuvers for spacecraft/co-ordination of launch windows should be considered.
  - **Move satellites in higher orbits** (particularly GEO), which are too far away to re-enter the atmosphere, into a graveyard orbit well outside the region used by active satellites.
- **Removal procedures:** To reduce the number and mass of objects on orbit, reduce the probability and severity of on orbit hypervelocity collisions following techniques can be considered-
  - **Space tether:** will make the debris object move close enough to the upper atmosphere that after release from the tether, spirals and burns up.
  - **Lasers:** This method is used to slowing objects using high powered lasers fired from Earth, so that they move out of orbit.
  - **Space tugs:** A space tug is actually a spacecraft that is used to move multiple pieces of debris to disposal orbits in GEO.
- **ISRO is working on a Self-Eating rocket** based on materials for casings of Rockets that can burn up along with motors at final stage, helping in mitigating the problem of space debris

Way forward

- **Extensive research and discussion:** to have a complete understanding of the problems and its associated solution.
- **Make mitigation guideline binding:** International bodies such as UNCOPUOS could take the responsibility of creating an internationally binding law.
- **Encourage States to**
  - Ratify and implement existing space treaties
  - Develop domestic legislation and build capacity in space law
  - Adopt internationally accepted best practices
- **Limit future launches**: Multi-mission satellites can significantly reduce the number of potential launches in the future.
- **Space Information Networks (SIN):** It can accommodate many more commercial and governmental contenders to address the limited orbital resources issue while fulfilling the requirements of the services of every country.

Global Initiatives by Space agencies to tackle Space Debris

- **Inter-Agency Space Debris Coordination Committee's (IADC)** Space Debris Mitigation Guidelines.
- **UN Committee on the Peaceful Uses of Outer Space (COPUOS)** deal with issue of liability for damage caused by space objects.
- **Japan's Aerospace Exploration Agency (JAXA) and the European Space Agency (ESA)** have partnered with start-ups to help with removal of space debris.
- **Remove DEBRIS (UK)** has tested two different technologies for removing space debris: **capture with a net or capture with a harpoon.**

2.6. BLACK HOLES

Why in News?

The black hole at the centre of Milky Way was photographed for the first time.

About Black Holes

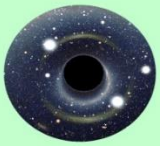
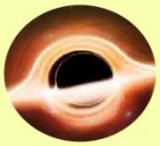
- A black hole is a place in space where **gravity pulls so much that even light cannot get out.** The gravity is so strong because matter has been squeezed into a tiny space.
- **This can happen when a star is dying** (our sun will never turn into a black hole as it is not big enough to make a black hole).
- Because no light can get out, **people can't see black holes.** They are invisible.
- Black holes **do not go around in space eating stars, moons, and planets.** Earth will not fall into a black hole because no black hole is close enough to the solar system for Earth to do that.
- **2020 Nobel Prize in Physics** was awarded to Roger Penrose, Reinhard Genzel, and Andrea Ghez **for a study associated with black holes.**

General Theory of Relativity

- This theory was proposed by **Albert Einstein in 1915.**
- Essentially, it's **a theory of gravity** whose basic idea is that instead of being an invisible force that attracts objects to one another, **gravity is a curving or warping of space.** The more massive an object, the more it warps the space around it.
- **In 2016, the discovery of gravitational waves** was another confirmation of general relativity.

Detection of Black Holes

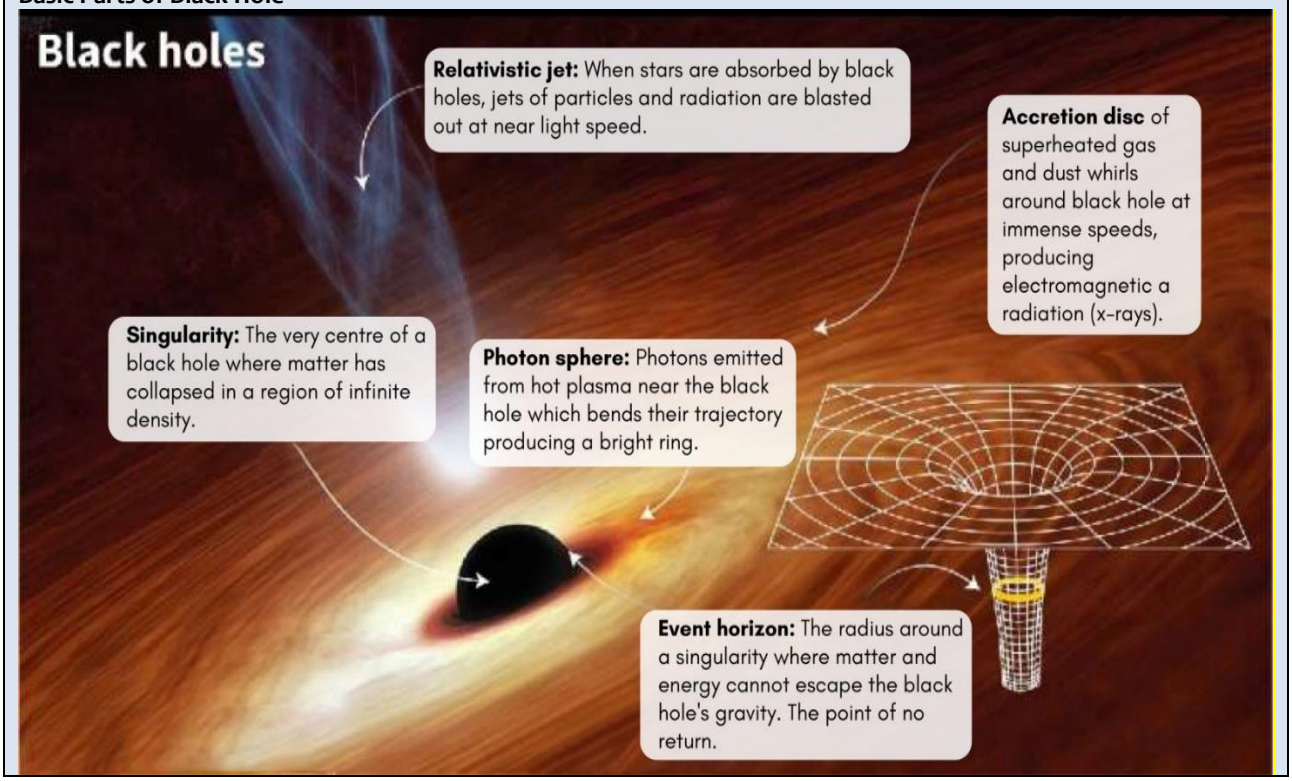
- They **cannot be directly observed** because they themselves do not emit or radiate light, or any other electromagnetic waves that can be detected by instruments built by human beings.
- But the **area just outside the boundary of the black hole** (Event Horizon), which has vast amounts of gas, clouds and plasma swirling violently, **emit all kinds of radiations, including even visible light.**
- Hence, the presence of black holes **can be inferred by detecting their effect on other matter nearby them.**

Tiny Black Holes	Stellar Black Holes	Supermassive Black Holes
		
● As small as just one atom. ● These black holes are very tiny but have the mass of a large mountain. ●These black holes were formed when the universe began.	●Its mass can be up to 20 times more than the mass of the sun. ●There may be many, many stellar mass black holes in Earth's galaxy (the Milky Way) ●They were formed when the center of a very big star falls in upon itself, or collapses. ●When this happens, it causes a supernova (supernova is an exploding star that blasts part of the star into space)	●These black holes have masses that are more than 1 million suns together. ●Supermassive black holes were made at the same time as the galaxy they are in.

Importance of studying Black Holes

- Black holes are **laboratories for testing fundamental theories** that explain how the Universe works on the largest and the smallest scales.
- **Enhances the understanding of gravitational force** which can be useful for the Global Positioning Satellites to make them accurate to more than a few metres.

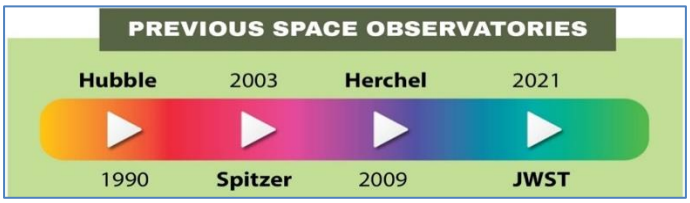
Basic Parts of Black Hole



2.7. JAMES WEBB SPACE TELESCOPE (JWST)

Why in news?

NASA's James Webb Space Telescope (JWST) delivered deepest infrared image of Universe yet.



About James Webb Space Telescope (JWST)

- It is NASA's **infrared flagship observatory.**
- It is an international collaboration between **NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA).**
- **Mission goals are**
  - **Search for first galaxies** or luminous objects formed after Big Bang.
  - **Determine how galaxies evolved.**
  - **Observe stars formation** from the first stages to formation of planetary systems.
  - **Measure physical and chemical properties of planetary systems,** including our own Solar System, and investigate potential for life in those systems.
- **JWST is placed in Sun-Earth Lagrange Point 2 (L2).**
  - Lagrange points are **positions in space where objects sent there tend to stay put** as gravitational forces of a two-body system (like Sun and Earth) equal the force required for a small object to move with them.
- **Scientific instruments on JWST:** Near Infrared Camera, Near Infrared Spectrograph, Mid Infrared Instrument and Fine Guidance Sensors/Near Infrared Imager and Slitless Spectrograph.
- The **JWST is being considered as the successor** of the Hubble Space Telescope (HST).

	Hubble	Webb	Herschel Space Observatory
Distance from Earth	507 Km	1.5 million Km at Second Sun-Earth Lagrange point	Second Sun-Earth Lagrange point
Primary Mirror Diameter	2.4 M	6.5 M	3.5 M
Searching for	Young Galaxies (12.5 billion years ago)	New Born Galaxies (13.5 billion years ago)	Most actively star-forming galaxies
Serviceable	Yes	No	No
Wavelengths	Visible, UV, Part of near-infrared	Near and mid infrared	Far-infrared and submillimeter

2.8. PARKER MISSION

Why in news?

NASA's Parker Solar Probe (PSP) has now flown through the Sun's upper atmosphere – the corona – and sampled particles and magnetic fields there.

About PSP

- Launched in 2018, the PSP is part of **NASA's Living with a Star program** to explore aspects of the Sun-Earth system that directly affect life and society.
- It became **the first spacecraft in history to touch the Sun** (uses a carbon-composite shield to withstand high temperatures).

Relevance of the PSP mission

- **Deeper insights into sun's evolution:** Touching the very stuff the Sun is made of will help scientists **uncover critical information about our star, the Sun, and its influence on the solar system.** This in turn, can also expand our knowledge on other stars in the universe.
- **Predicting extreme weather events:** The PSP can help Scientists in forecasting solar storms and other major space weather events
  - Solar storms can rattle Earth's magnetic field. In the process, communications may be disrupted, satellites can be knocked offline, and power grids will be vulnerable to electrical surges.

- **Unravelling secrets in Corona:** In Corona some key processes take place that currently defy explanation. For example,
  - The temperature of the Sun at its **photosphere is roughly 6,000 degree C** but within **the corona** it can reach a staggering **million degrees or more**.
  - It's also within this region that the **outward flow of charged particles** - electrons, protons, and heavy ions - suddenly **gets accelerated into a supersonic wind.**

Achievements

- In 2019, Parker discovered that **magnetic zig-zag structures in the solar wind,** called **switchbacks,** are plentiful **close to the Sun.**
- In April, 2021, the PSP crossed the **outer edge of the corona** termed the **Alfvén critical boundary,** a point that marks the end of solar atmosphere and beginning of the solar wind.
- It should eventually get to **within 7 million km** (4 million miles) of the **photosphere in 2025.**

Some other solar missions: NASA's Heliophysics Missions, European Space Agency's Solar Orbiter, India's Aditya-L1 mission.

2.9. LASER INTERFEROMETER GRAVITATIONAL-WAVE OBSERVATORY (LIGO) PROJECT

Why in News?

Hingoli revenue department (Maharashtra) has handed over land for Laser Interferometer Gravitational-Wave Observatory (LIGO) project **for setting up a laboratory** along with some other related infrastructure.

More on News

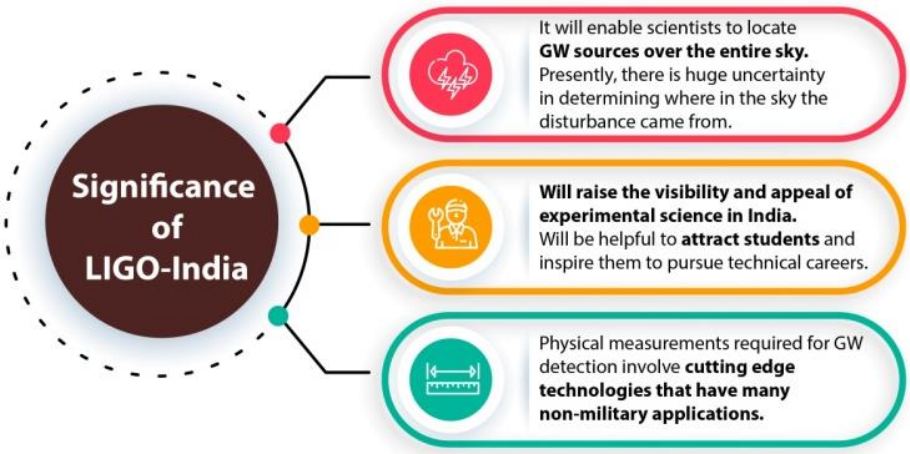
- In 2016, **central government had given approval to LIGO-India** (a Joint India-US detector) for research on gravitational waves.
- Technology being developed includes **design and fabrication of ultra-stable laser, quantum measurement techniques,** handling of complex control system for enforcing precision control, large-scale ultra-high vacuum technology, **data analysis and machine learning.**
- Project will be funded by **Department of Atomic Energy (DAE) and Department of Science and Technology (DST).**

About Gravitational Waves

- They are **'ripples' in space-time** travelling at speed of light caused by some of most violent and energetic processes in Universe.
- They carry with them **information about their cataclysmic origins, as well as invaluable clues to nature of gravity itself.**
- **They are created when**
  - objects move at very high acceleration,
  - a star explodes asymmetrically (called a supernova),
  - two big stars orbit each other,
  - two black holes orbit each other and merge

About LIGO

- It was **designed for direct detection of gravitational waves** predicted by Einstein's General Theory of Relativity.
- It is **being operated at two sites in US** (Washington and Louisiana).



- Also, there are **3 LIGO's sisters' facilities** in Italy, Germany and Japan **and LIGO- India.**

- Data LIGO collects may have **far-reaching effects on many areas of physics including gravitation, relativity, astrophysics, cosmology, particle physics,** and nuclear physics.
- **It is different from other observatories as**
  - **LIGO is blind:** Unlike optical or radio telescopes, LIGO does not see electromagnetic radiation (e.g., visible light, radio waves, microwaves) as gravitational waves are not part of the electromagnetic spectrum.
  - **LIGO isn't round** and can't point to specific locations in space: Since LIGO doesn't need to collect light from stars, it doesn't need to be round or dish-shaped.

Significance of detection of Gravitational Waves by LIGO

- Information that **Gravitational waves can provide**
  - Gravitational waves will provide **a test of Einstein's theory of general relativity under extreme conditions of gravity** where it has never before been tested.

  - They will also give more **information about the unimaginably dense form of matter** that makes up neutron stars.
  - Gravitational waves will also **tell us about how many objects like black holes and neutron stars exist** in the Universe.
  - They will give us insight into **what happens during some of the Universe's most violent explosions.**

3. AWARENESS IN THE FIELDS OF NANO-TECHNOLOGY, BIO-TECHNOLOGY AND ISSUES RELATING TO INTELLECTUAL PROPERTY RIGHTS

3.1. NANOTECHNOLOGY

NANOTECHNOLOGY AT A GLANCE

It is the study of materials which are in nanoscale range (size scale range of 1 to 100nm).

Conversion to nanoscale results in alteration of its physicochemical, biological, mechanical, optical, electronic, etc. properties

India among top five nations in terms of scientific publications in nanotechnology.

Applications of Nanotechnology

- **Energy storage, production, and conversion:** Carbon nanotubes, Nanocatalysts for hydrogen generation etc.
- **Agricultural productivity enhancement:** Nanoporous zeolites, Fertilisers, herbicide delivery; Nanosensors for monitoring.
- **Water treatment and remediation:** Nanomembranes for water purification, Magnetic nanoparticles etc.
- **Drug delivery systems:** Nanocapsules for slow and sustained drug release systems.
- **Food processing and storage:** Nanocomposites for plastic film coatings used in food packaging, Antimicrobial nanoemulsions etc.
- **Vector and pest detection and control:** Nanoparticles for new pesticides, insecticides, and insect repellents

Challenges related to Nanotechnology

- **Impact on Health:** Nanoparticles might be able to disrupt cellular, enzymatic and other organ related functions.
- **Environmental concern:** nanoparticles might form a new class of non-biodegradable pollutants.
- **Lack of information** on the nature and characteristics of nanomaterials, insufficient methods for detecting and measuring nanomaterials etc.
- **Scarcity of skilled manpower.**
- **Ethical consequences:** For instance, nanotechnology may be used in warfare, may invade people's privacy etc.
- **High costs for acquisitions of IPR,** nanotechnology infrastructure etc

Initiatives taken in India

- **9th Five-Year Plan first time promoted research** in nano materials.
- In 2007 **Mission on Nano Science and Technology** (Nano Mission) was launched.
- **Nanoelectronics Innovation Council** set up by MeitY.
- **Indian Nanoelectronics Users Programme (INUP)** by MeitY for undertaking research and skill development.
- **National Task Force for regulatory framework roadmap.**

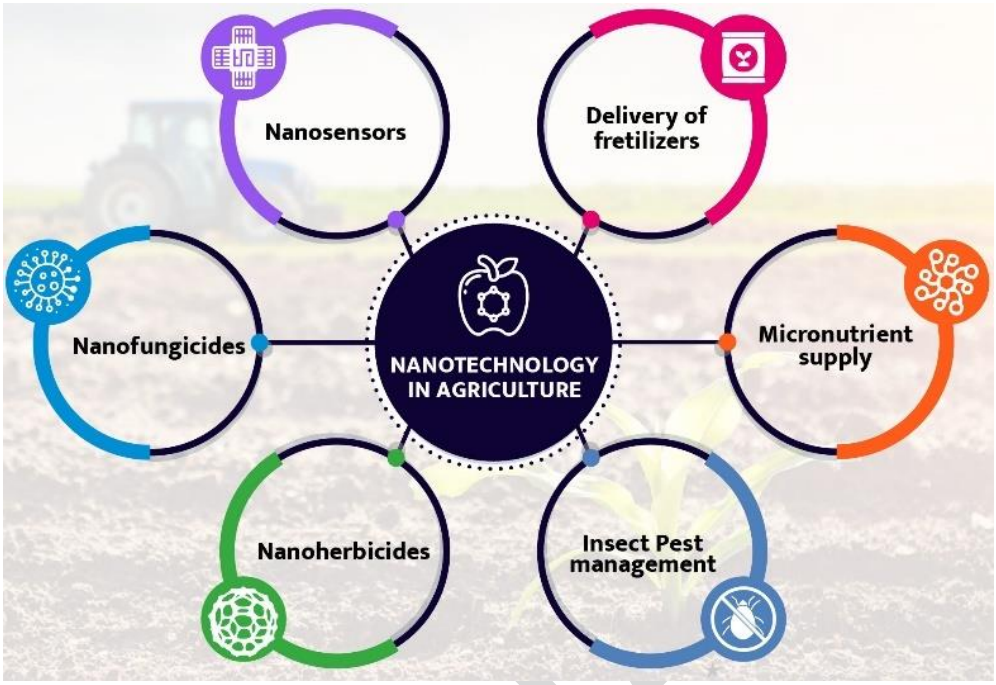
Way Forward

- **Enacting new regulations** for responsible nanotechnology governance.
- **Establishing a regulatory body** to foresee the safe development and commercialisation of products.
- **Labelling of nano-based products** to enable people make an informed choice.
- **Infrastructure development** for basic research and human resource development.
- **Coordination with various international/ inter-governmental organizations** for development of standards, safe lab practices and risk governance.

3.1.1. LIQUID NANO UREA PLANT

Why in News?

Prime Minister **inaugurated** the country's first liquid nano urea plant at Kalol (Gujarat)



About Liquid Nano Urea

- It is a **patented chemical nitrogen fertiliser** developed by IFFCO's Nano Biotechnology Research Centre at Kalol with nano nitrogen particles (from 20-50 nm).
  - **It is world's first nano urea (liquid) plant.**
- It is **sprayed directly on the leaves** of plants and gets **absorbed by the stomata**- pores found on the epidermis of leaves.

Benefits of Nano urea

- **Improved agricultural produce** with **reduced urea consumption** as the efficiency of liquid nano urea is as high as 85-90% in comparison to 25% of conventional urea.
- **Significant reduction in urea imports,** government subsidies and logistics cost.
- **Reduced soil, water and air pollution** from urea, improving quality of underground water and reduction in global warming.
- **Higher shelf life** as no issue of caking on coming into contact with moisture.

Related News

- Recently, **Scientists used Machine Learning** to predict the match of pairs of metals that can form **bimetallic nanoalloys**.
- **Nano alloys,** also called core-shell nanocluster alloys, are **alloys with one metal forming core and another stays on surface as a shell.**
  - The formation depends on the **cohesive energy difference, atomic radius difference, surface energy difference** and **electronegativity of the two atoms**.
- Nanoalloys can have other configurations as well such as **homogeneously mixed alloy** and **cluster-in-cluster**.
- **Potential applications:** Biomedicine, catalysts in biofuels and fuel cells, mobile devices, batteries etc.

3.2. BIOTECHNOLOGY

BIOTECHNOLOGY AT A GLANCE

Area of biology that uses living processes, organisms, or systems to manufacture products or technology intended to improve quality of human life.

Biotechnology Branches: Blue (marine and aquatic application), Green (agriculture processes), Red (medical), White (industrial).

India among top 12 destinations globally. Estimated to increase to USD100 billion by FY 2025.

5

Five major segments in India: Bio-pharma, Bio-services, Bio-agri, Bio-industrial, and Bioinformatics.

Growth Drivers in India: Growing population, rising public health expenditure, skilled human capital, Enhanced policy, and infrastructure support etc.

Significance

- **Food security:** More productive and drought resistant crops, tolerant of other stress like pest, insect etc.
- **Tackling diseases:** finding solutions to Corona/Zika virus, antibiotic-resistant bacteria.
- **Bioenergy:** use of bioethanol and biodiesels.
- **Advancement in drugs:** Better innovation and cost effective drugs.
- **Biofortification to improve nutritional quality** of food crops.
- **Animal Biotechnology:** To improve the productivity of livestock.
- **Bioremediation:** To consume and break down environmental pollutants).
- **Stem cell therapy.**

Challenges

- **Low R&D:** 0.67 per cent of GDP.
- **Intellectual Property Right regime**
  - **Section 3(d) of the Patents (Amendment) Act, 2005:** strict standards thereby dampeing foreign investment.
  - **Compulsory licensing:** allows government power to suspend a patent in times of health emergencies.
- **Lack of Marketisation:** Most of the early research funding runs out before marketisation phase.
- **Lack of public awareness** about modern tools of biotechnology.
- **Less Lucrative** as number and quality of jobs offered is less.
- **Lack of Regulatory mechanism.**

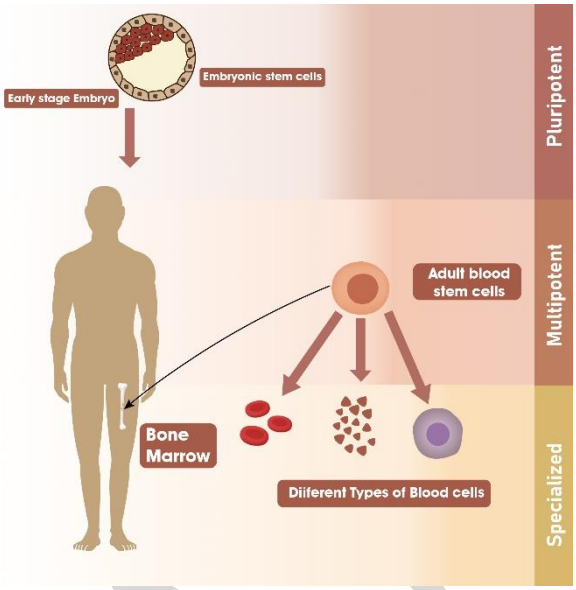
Initiatives taken

- **Higher Budget allocation (2022-23)** for developing basic infrastructure, genetic engineering, agriculture biotechnology, training skilled professionals etc.
- **100% FDI under the automatic route** for greenfield projects.
- **Biotechnology Parks and Incubators** across the country.
- **Atal Jai Anusandhan Biotech Mission** by DBT.

Way Ahead

- **Increase in investment towards R&D and building human capital.**
- **Collaboration between government and industry** for improving IP regime.
- **Funding Mechanism for national importance ideas.**
- **Strategic Road Map for industry-based R&D.**
- **Ecosystem of innovation** in which scientists, innovators and future entrepreneurs could be nurtured.
- **Extending Reach to other fields of study.**

3.2.1. STEM CELLS



Why in News?

Recently, a US patient became the First woman reported to be cured of HIV after stem cell transplant (SCT).

About stem cells

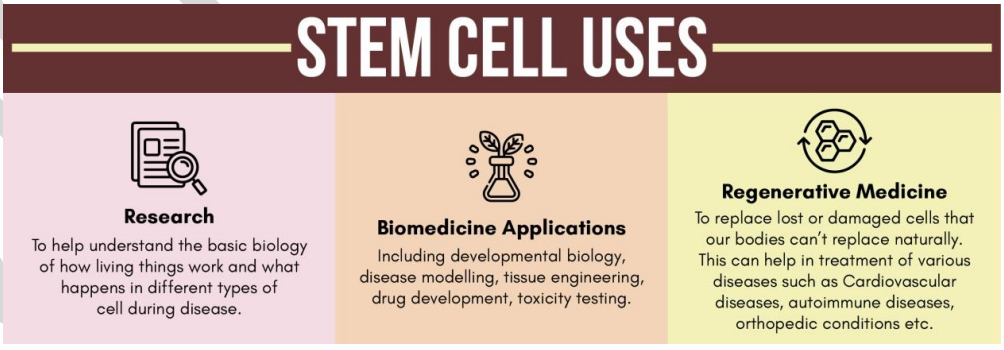
- Stem cells are **special human cells that are able to develop into many different cell types.** Stem cells provide new cells for the body as it grows and replaces specialized cells that are damaged or lost.
- They **have two unique properties** that enable them to do this:
  - They **can divide repeatedly** to produce new cells.
  - As they divide, they **can change into the other types of cells** that make up the body.
- Based on the cell type/tissue of origin, **stem cells are classified as-**
  - **Somatic Stem Cells (SSCs) also known as Adult Stem Cells:** They have limited capacity of differentiation and may be multipotent or unipotent.
  - **Embryonic Stem Cells' (ESCs)** are pluripotent, which mean they can change into any cell in the body.
    - ✓ Pluripotent stem cells can also be generated in lab and the products thus generated are referred as Induced Pluripotent Stem Cells (iPSCs).

About Stem Cell Therapy (SCT)

- SCT, also known as regenerative medicine and bone marrow transplant, **promotes the repair response of diseased, dysfunctional or injured tissue** using stem cells or their derivatives.
  - Lab grown stem cells are **manipulated to specialize into specific types of cells,** such as heart muscle cells, blood cells or nerve cells.
  - The specialized cells can then be implanted.
- **Two of the most common types of stem cell transplants** are:
  - **Autologous transplantation** uses the patient's **own stem cells.**
  - **Allogeneic transplantation** where stem cells come **from donor.**

Challenges related to stem cell technology

- **Safety of the patient:** Immune rejection of donor cells by the host immune system post-transplantation is a primary concern.
- **Ethical concerns:** Use of embryos for creating human embryonic stem cell lines may lead to commoditization of human cells and tissues.



- **Limited technology:** To generate large quantities of stem cells. Also, therapies using these avenues are largely new and much more research and testing is needed.
- **Other Concerns:** Challenges related to gene editing/modification, potential danger of tumorigenicity (it is the tendency for cultured cells to give rise to either benign or malignant growing tumors) of stem cells, possible risk of contamination and genomic changes etc.

Way Forward

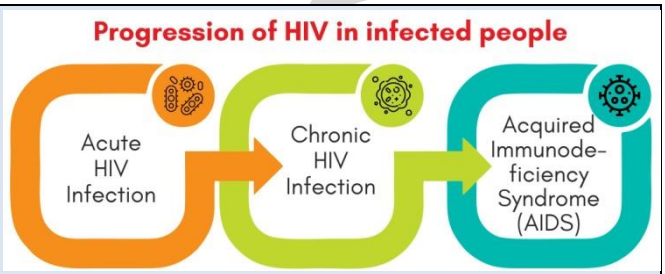
- **Better regulation** for basic, clinical research and product development based on categories of research and level of manipulation.
- **Informed consent for trials:** Researchers should describe the risks and prospective benefits in a realistic and easily understandable manner with potential participants.

- **Scientific considerations:** Appropriate measures should be taken to ensure that the stem cell derived product is safe for human application.
- **Addressing ethical dilemma** by developing guidelines (like India's **National Guidelines for Stem Cell Research**) for various stakeholders that comprehensively addresses permissible and impermissible categories of stem cell research.

Status in India

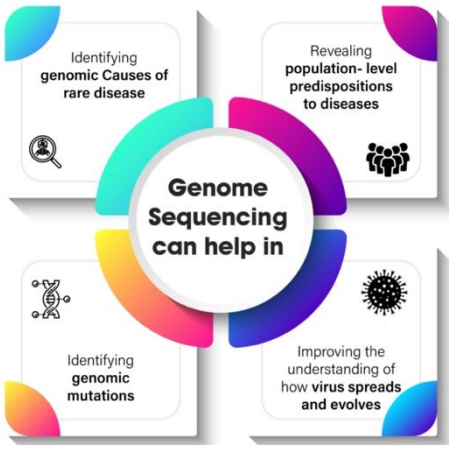
- Stem cells and their derivatives **fall under definition of 'Drug' as per the Drugs and Cosmetics Act 1940 and** are categorized as 'Investigational New Drug (IND)' or 'Investigational New Entity (INE)' when used for clinical application.
- **Regulated by National Guidelines for Stem Cell Research- 2017:** As per these guidelines, **only bone marrow/hematopoietic SCT for blood disorders is permitted** and use of stem cells all other conditions has to be done only under purview of clinical trials in compliance with National Guidelines for Stem Cell Research 2017.
- Some hospitals providing SCT in India are **AIIMs, New Delhi, Tata Memorial Centre, Mumbai** etc.

About HIV



- HIV is a virus that attacks the **body's immune system.** If not treated, it can lead to **AIDS.**
- It **targets the immune system and weakens people's defence** against many infections and some types of cancer.
- HIV infections may be caused by **one of two retroviruses, HIV-1 or HIV-2** and HIV-1 is more prevalent worldwide.
- HIV in **infected people progress in three stages** (see infographic) in the absence of effective medicine.
- **Treatment:** it can be **managed (not cured)** by treatment regimens composed of a **combination of three or more antiretroviral drugs**.
- In India, **there were estimated 23.48 lakh People Living with HIV (PLHIV)** in 2019.
  - **Mizoram was estimated to have the highest adult HIV prevalence** followed by Nagaland and Manipur.
- **Initiatives taken by government**
  - National AIDS Control Organization (NACO) to oversee policies related to HIV and AIDS- It is the **nodal organization for National AIDS response.**
  - National AIDS Control Program (1992) is being implemented as a comprehensive programme for prevention and control of HIV/AIDS in India.
    - Also, over time, the focus of NACO has **shifted from raising awareness to behavior change,** from a national response to a more decentralized response and to **increasing involvement of NGOs and networks of PLHIV**.
  - HIV & AIDS (Prevention and Control) Act, 2017 to address discrimination against PLHIV.
  - National Strategic Plan 2017-24 and Mission SAMPARK for tracing under ART services.
  - Training and sensitization programmes for various stakeholders.

3.2.2. GENOME SEQUENCING



Why in News?

In recently published research, an international team described the **first-ever sequencing of a complete human genome.**

About Genome sequencing

- Genome sequencing means **deciphering the exact order of base pairs** in an individual.
- **A genome is an organism's complete set of DNA.** It includes all chromosomes, which houses DNA, and genes (specific sections of DNA).
- Human genome contains about 3 billion base pairs that spell out the **instructions for making and maintaining a human being.**

Challenges in scaling up genome sequencing projects

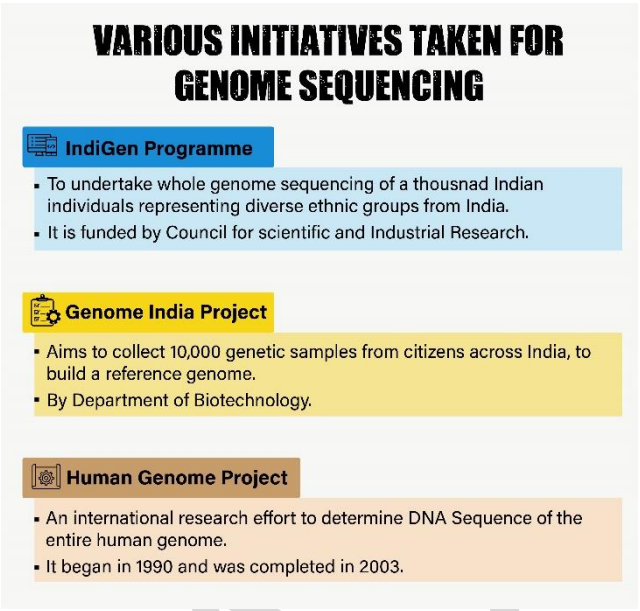
- **Technological issues:** Like selection of analytical software tools, the speedup of the overall procedure using High-performance computing technology, data storage solutions.
- **Financial issues:** Because of limited financial resources, genetics projects are not as big a priority as national security and social welfare.

- **Legal issues:** Data privacy bill is yet to be passed. Anonymity of the data and questions of its possible use and misuse would need to be addressed.

Way ahead

While India, led by the CSIR, first sequenced an Indian genome in 2009, it is only now its laboratories have been **able to scale up whole-genome sequencing** and offer them to the public.

Funding in the technology has been the major obstacle for in scaling up this project. To overcome such challenges **India should also go for private funding of science projects.**

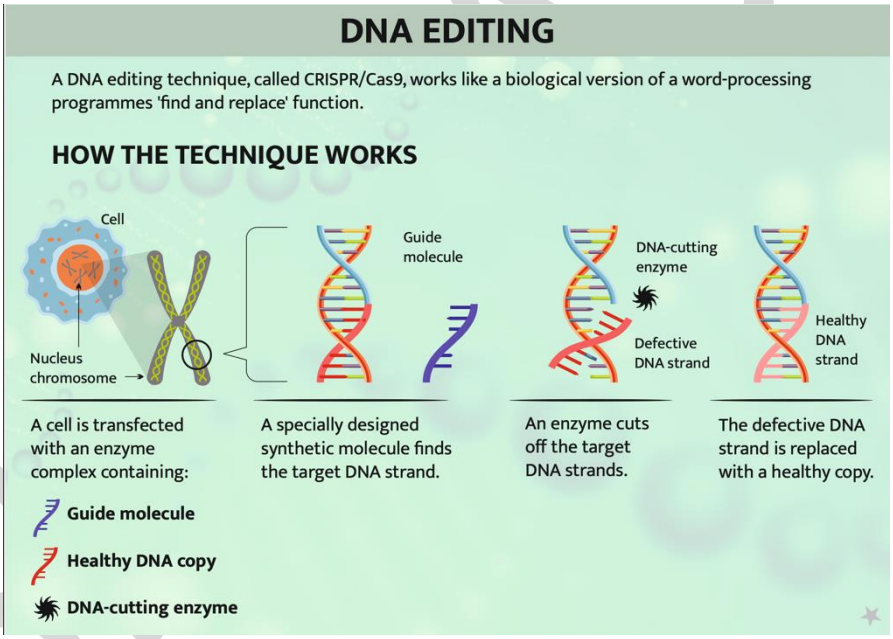


3.2.3. GENETICALLY MODIFIED CROPS

Why in news?

Recently the Department of Biotechnology (DBT) issued **Guidelines for Safety Assessment of Genome Edited Plants, 2022** easing norms for research into genetically modified (GM) crops.

Guidelines for Safety Assessment of Genome Edited Plants, 2022



- Currently, in India, all activities related to Genetically Engineered organisms (GE organisms) or cells and hazardous microorganisms and products thereof are regulated under **Manufacture, Use, Import, Export and Storage of Hazardous Microorganisms/ Genetically Engineered Organisms or Cells, Rules, 1989.**
- DBT issued guidelines for the **development and sustainable use of genome editing technologies** in India, specifying the biosafety and/or environmental safety concerns, and describing the regulatory pathways to be adopted while undertaking the genome editing of plants.
    - Guidelines **exempt researchers who use gene-editing technology** to modify the genome of the plant **from seeking approvals from the Genetic Engineering Appraisal Committee (GEAC).**

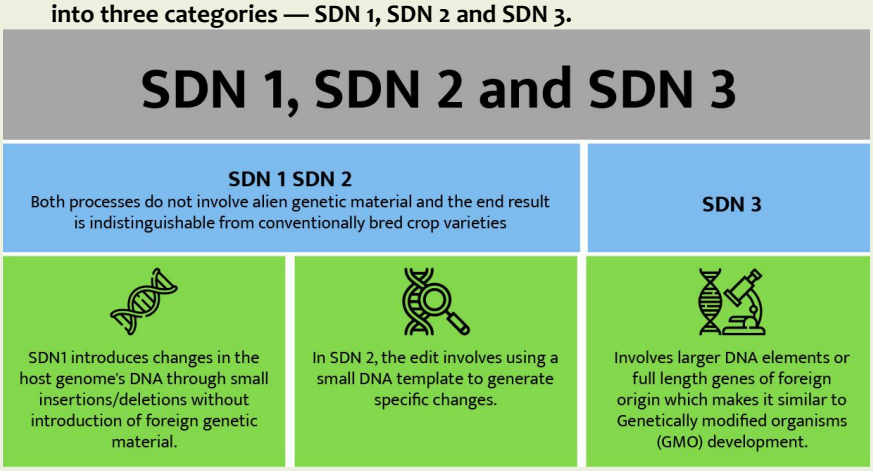
Overall policy framework for GM Crops

- Rules governing the handling of GMOs and products thereof **were notified in 1989 under Environment Protection Act 1986 (EPA) and guidelines issued later.**
    - **Ministry of Environment and Forests (MoEF) and the Department of Biotechnology (DBT)** are responsible for implementation of the regulations.
- **Genetic Engineering Appraisal Committee (GEAC)** is responsible for approving commercial cultivation of GM crops as well as the manufacture, import and selling of processed foods made from GM ingredients.
    - GM food imports require approvals under two laws: **EPA and the Food Safety and Standards Act of 2006.**
- **Codex Alimentarius Commission (Codex):** It is the joint FAO/WHO intergovernmental body responsible for developing the standards, codes of practice, guidelines and recommendations that constitute the Codex Alimentarius, meaning the international food code.
    - Codex developed principles for the human health risk analysis of GM foods in 2003.

- **Significance of the move**
  - **Aligns India's regulatory framework** with other mega food-producing countries.
  - **Encourages product development and commercialization** to help raise farmer's income.
  - **Speed up crop genetic development** through a faster breeding process

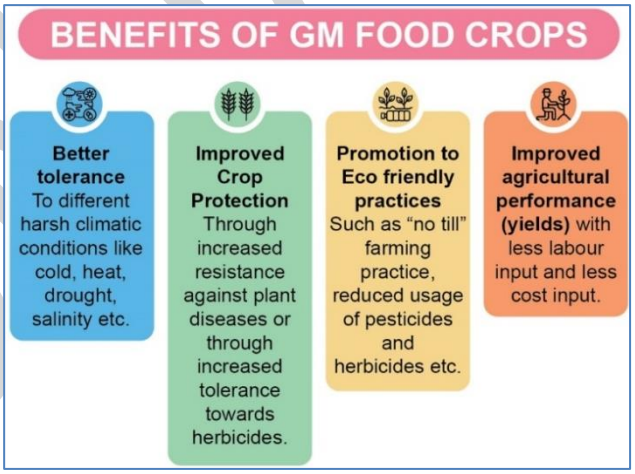
About Site directed nuclease (SDN)

- SDN refers to the **practice of cleaving DNA strands** to affect the subsequent genome editing.
- **Depending on the nature of the edit** that is carried out, the process is **divided into three categories — SDN 1, SDN 2 and SDN 3.**



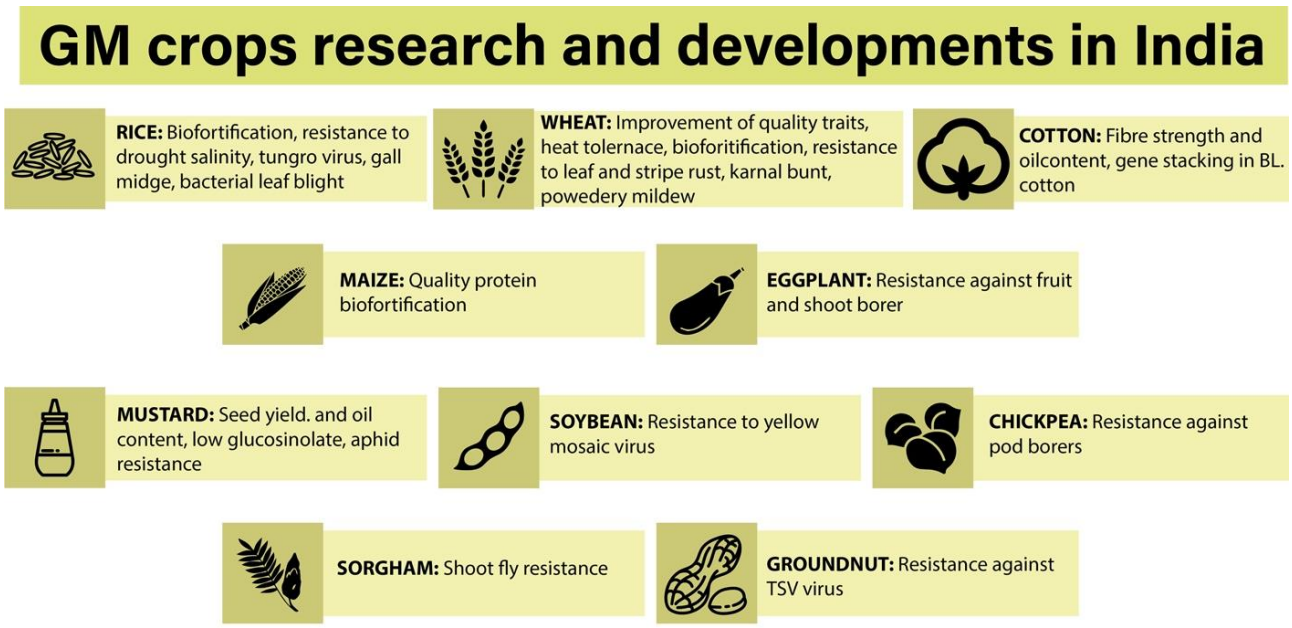
GM crops and technology

- GM technology involves **direct manipulation of DNA of many organisms,** including plants, bacteria, and animals to alter the desired characteristics.
- In plants it involves introducing a gene from a different species or genus to **alter the desired characteristics**.
- There are several **approaches to genome editing** like Clustered regularly interspaced short palindromic repeats (CRISPR)- associated protein 9 (Cas9) and Site-Directed Nuclease (SDN) etc.
  - **Non-Transgenic Gene Editing** uses gene editing tools to directly tweak the plant's own genes and does not involve inserting any foreign DNA.
- BT-cotton is **only GM crop approved for commercial cultivation** in 2002 by the Government of India.



Concerns with GM crops

- **Bio-safety of human and animal health:** Risk of toxicity, due to the nature of the product or the changes in the metabolism and the composition of the organisms resulting from gene transfer.
- **Environmental concerns:** Since a GMO is artificially created, its breeding with the other crops in the natural ecosystem can result in genetic contamination.
  - GM technology could also allow the transfer of genes from one crop to another, creating super weeds which might be immune to common control methods.
- **Economic concerns**: Yields of GM crops (as found with Bt Cotton experience) have turned out to be false.
- **Ecological concerns**: GM crops could lead to erosion of biodiversity and pollute gene pools of endangered plant species.
- **Ethical concerns**: Unregulated use of GM technology in crop can lead to corporate dominance in agriculture.



Way forward

- **Awareness and information** on GM crops such as keeping biosafety data out of the public domain needs to be increased to take informed decisions.
- **Government roadmap** for ensuring food security without jeopardising the biodiversity and compromising with the safety of human health.
- **Capacity building** in GM research agenda and development with science based consistent regulatory policy.
- **Robust clinical trials** need to be contingent on robust demonstration of safety and efficacy.
- Adherence to the principles of **Cartagena Protocol on Biosafety** which is an integral part of the Convention of Biological Diversity.

3.2.4. DNA TECHNOLOGY (USE AND APPLICATION) REGULATION BILL, 2019

Why in news?

Recently, Government informed the Rajya Sabha that the draft DNA Technology (Use and Application) Regulation Bill, 2019 is under consideration with provision to set up DNA data banks across the country to store DNA profiles.

About DNA Technology (Use and Application) Regulation Bill, 2019

- Bill **provides for the regulation of use of DNA technology** for establishing the identity of certain persons.
- **Key provisions of the Bill**
  - **Regulation of use of DNA technology** for establishing the identity of certain persons including offenders, victims, suspects and undertrials.
  - **DNA testing is allowed only in respect of matters listed in the Schedule to the Bill** like offences under Indian Penal Code 1860, civil matters such as paternity suits, etc.
  - **Consent for collection of DNA** will be required as per provisions of the bill.
  - **Establishment of a National DNA Data Bank,** Regional DNA Data Banks and also a DNA regulatory board.
  - Establishment of a DNA Regulatory Board to supervise the DNA Data Banks and laboratories.
  - **Penal provisions for offences** like unauthorised disclosure, obtaining, use and access of DNA samples, destruction, alteration, contamination or tampering with biological evidence etc.

Concerns raised against the bill

- **Sensitive information:** DNA profiles can reveal extremely sensitive information of an individual that can be misused to specifically target individuals and their families.
- **Weak Consent Clause:** Magistrate can easily override it consent thereby making consent perfunctory. There is no guidance on the grounds and reasons of when the magistrate can override consent.

- **Violation of the fundamental right to privacy** with its provisions for retention of DN, storing DNA profiles in Data bank etc.
- **Absence of robust data protection legislation**, which raises concerns regarding security of a huge number of DNA profiles that will be placed with the National DNA Data bank and its regional centres.

Way Forward

- **Parliamentary Standing Committee on Science and Technology has suggested the following:**
  - **Independent scrutiny must be done** of the proposals to destroy biological samples and remove DNA profiles from the database.
  - If a person has been found innocent his **DNA profile has to be removed immediately** from the data bank.
- India first needs **laws to protect privacy and personal data** and also sample collection has to be carefully defined and purpose based.
- **DATA banks and laboratories** should have **highest possible levels of cyber security** to prevent Cyber security breaches.

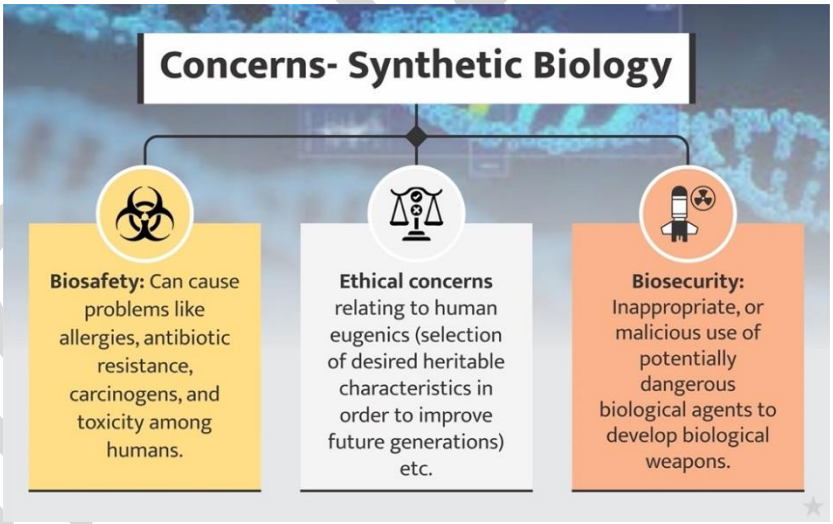
3.2.5. SYNTHETIC BIOLOGY

Why in News?

A draft foresight paper on synthetic biology by Department of Biotechnology has **stressed the need for a national policy** that can consolidate India's stand on the issue.

About Synthetic Biology

- **Synthetic biology refers to** design, re-design and fabrication of biological components and systems that do not already exist in the natural world.
- **Potential applications** are biofuels, bioremediation, biosensors, health (biosensor-based diagnostics, engineered bacteria to target specific pathogens etc.), Food fortifications etc.
- **Status of regulation in India:**
  - **Parliament is yet to clear Biotechnology Regulatory Authority of India Bill, 2013,** that had provisions for regulating research around genetic engineering that could have also encompassed synthetic biology.
  - Regulations on **GM food crops**.
  - Earlier, as part of 12th Five-Year Plan, a **task force on systems biology and synthetic biology research in 2011** was set up.



3.2.6. XENOTRANSPLANTATION

Why in News?

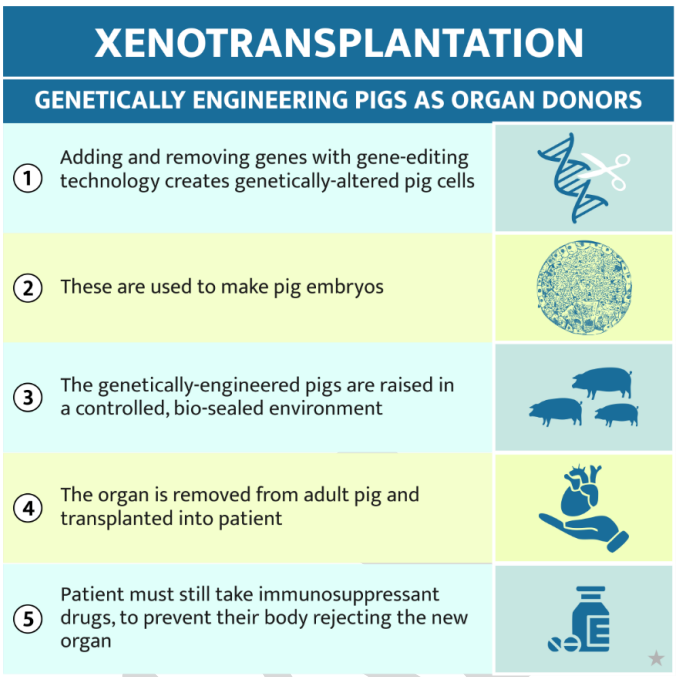
Recently, doctors **transplanted the heart from a genetically modified pig to a patient,** a highly experimental surgery to use animal organs for life-saving transplants.

About Xenotransplantation

- **It involves** the transplantation, implantation, or **infusion into a human recipient of live cells, tissues, or organs from a nonhuman animal source.**
- **Pigs are increasingly being used** for this, **as their organs are anatomically similar to those of humans** and are more tuned for genetic engineering.

Benefits of Xenotransplantation

- It could potentially provide an **unlimited supply of cells, tissues, and organs** for humans. It could **bridge the organ shortage gap.**
- It would make it **possible to alleviate graft rejection by modifying donor tissue** through genetic engineering, thereby making the outcome less dependent on recipient treatment with immunosuppressive agents.
- Xenotransplantation has the **potential to bring significant cost savings** and existing organizations for procurement and sharing of organs from deceased donors will become obsolete.



Concerns raised

- **Medical implications:** Even well-matched human donor organs can be rejected after they are transplanted - and with animal organs the danger is likely to be higher.
- **Cross-species infection:** of undetected or unidentified animal infectious agents to patients that could, in turn, be transmitted to the general public.
- **Animal rights:** many animal rights groups oppose modifying genes of animals for such transplants.
- **Religion:** Some faiths have strict rules on animals, making such transplants difficult for patients.
- **Ethical issues:** Difficulties of informed consent, Clinical trials over humans as the technology is still emerging etc.

Conclusion

Xenotransplantation could be the answer for thousands of patients who will require transplants and innovative treatments for previously untreated conditions, however there is need to proceed with caution to ensure the safe development of this potentially life-saving technology.

4. HEALTH

4.1. TRADITIONAL MEDICINE

Why in news?

Recently, WHO Director-General laid the foundation stone for world's first and only **Global Centre for Traditional Medicine (GCTM) at Jamnagar in Gujarat.**

About traditional medicine

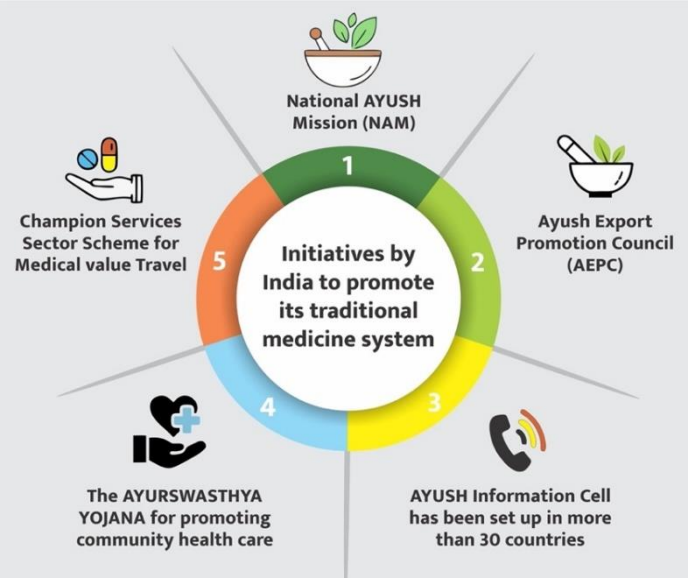
- It is the **sum total of the knowledge, skill, and practices** based on the theories, beliefs, and experiences **indigenous** to different cultures, whether explicable or not, used in the maintenance of health as well as in the **prevention, diagnosis, improvement or treatment of physical and mental illness.**
- **Major traditional and complementary medicines(T&CM) in India include:** Ayurveda, Yoga, Siddha, Unani, Sowa-Rigpa, Naturopathy etc.

Advantages of mainstreaming T&CM

- **Less capital intensive:** Relatively low levels of technological inputs are required for T&CM making it more affordable to poor people.
- **Enhancing the accessibility to public health facilities:** Proportion of Ayush doctors in some of the poorest part of the country is high. This in turn could enhance the accessibility of health facilities in remote areas.
- **Holistic approach to treatment:** In Ayurveda, a human being is seen as a combination of body, mind, soul and senses. So, to treat any illness, the system takes all four into account and treats the patient more holistically.
- **Improving doctor to patient ratio:** In India, the **ratio of the doctor-patient is about 1:1400** if we consider only allopathic doctors; the ratio will come to 1:800 if the AYUSH practitioners are added. This is **much better than the WHO recommendation of 1:1000**.
- **Effective in managing chronic diseases:** Scientific studies of several TM/CAM therapies show that their use is effective, e.g., for HIV/AIDS and cancer patients.

Challenges in mainstreaming T&CM

- **Unregulated:** Traditional Medicine products are unregulated in many countries, and therefore many of the concerns about the risks for consumers relate to the safety and quality of medicinal products.
- **Skewed financing:** In Budget 2020-21, the Ministry of Health and Family Welfare (MoHFW) was allocated ₹ 86,200.65 crore whereas the Ministry of AYUSH was allocated only ₹ Rs 3,050 crore.
    - Such skewed financing would naturally create a gap between AYUSH and Allopathy in terms of research, education, training, etc.



- **Low acceptance of AYUSH:** National Sample Survey in 2014 indicates that only 6.9% of patients seeking outpatient care opted for AYUSH. In the case of hospitalised care, the proportion is less than 1%.
- **State subject:** Health being a state subject adds an extra layer of complexity to any national level initiative.

Way ahead

- **Bridging the financing gap:** Equal emphasis should be given to both AYUSH as well as Allopathy system. PPP could also be utilised to ensuring adequate funding of both the system.
- **Developing international standards & guidelines:** These would help promote the safety, efficacy and quality of T&CM by expanding the knowledge base and providing guidance on regulatory and quality assurance standards.

- **Integration into national health system:** Its proper integration into national health systems will enable consumers to have a wider choice when they wish to use such services.
    - In this direction, **in 2020,** the Central Council of Indian Medicine amended Indian Medicine Central Council (Post Graduate Ayurveda Education) Regulations, 2016, to include the regulation to **allow the PG students of Ayurveda to practise58 types of general surgery.**

4.2. WORLD MALARIA REPORT 2021

Why in news?

Recently, the **World Health Organization (WHO) has released the World Malaria Report 2021** that assesses the actions taken by states in response to Malaria in the backdrop of COVID 19 pandemic.

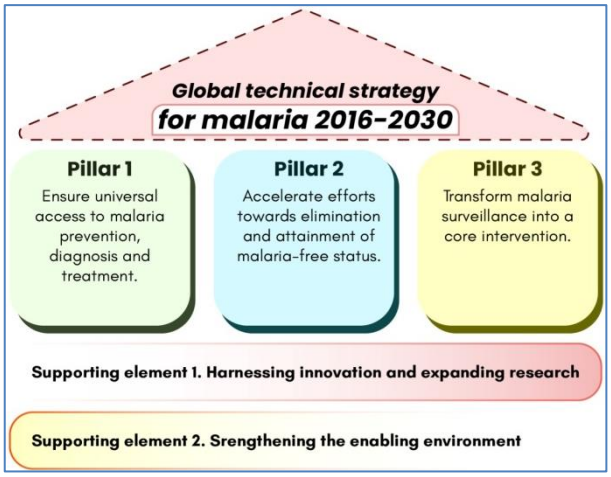
Key findings of the report

- **Malaria cases and deaths**
    - An estimated **241 million malaria cases** were **reported in 2020** in 85 malaria-endemic countries, increasing from 227 million in 2019.
    - **Sub-Saharan Africa** accounts for about 95% of all cases and 96% of deaths in 2020.
    - **Malaria deaths increased by 12% globally** in 2020 compared with 2019.
- **India related findings**
    - India accounted for **83% of cases** in the **WHO South-East Asia Region**.
    - **India was the only high-burden country to record progress** by sustaining a reduction in malaria burden between 2019 and 2020.
- **Globally, 40 countries and territories** have now been granted a **malaria-free certification from WHO** – including, most recently, China, El Salvador, Argentina and Uzbekistan.

About Malaria

- It is a life-threatening **mosquito borne blood disease** caused by **plasmodium parasites and** spread through the bites of infected **female Anopheles mosquitoes**.
- It is **preventable as well as curable**.
- **Malaria Vaccine**
    - WHO has recommended broad use of the **RTS, S/AS01 (RTS,S) malaria vaccine** among children living in regions with moderate to high P. falciparum malaria transmission.
    - Known by its **brand name Mosquirix**, this recombinant protein vaccine has been shown to significantly **reduce malaria, and deadly severe malaria** among young children, and also reduced the overall hospital admissions.

Measures taken to eliminate Malaria



- **WHO Global Malaria Programme (GMP):** guided by the Global technical strategy (GTS) for malaria 2016–2030 adopted by the World Health Assembly in 2015.
- **Malaria Elimination Research Alliance (MERA)-India:** working to eliminate malaria from India by 2030.
- **E-2025 initiative:** Under this, WHO has identified group of 25 countries with the potential to eradicate malaria by 2025.
- **High Burden to High Impact (HBHI) initiative:** In 2019, WHO has initiated the HBHI initiative in 11 high malaria burden countries, including **India** (West Bengal and Jharkhand, Chhattisgarh, and Madhya Pradesh).
- **National Strategic Plan for Malaria Elimination (2017-22):** It gives year wise elimination targets in various parts of the country depending upon the endemicity of malaria in the next 5 years.
- **Ministerial Declaration on Accelerating and Sustaining Malaria Elimination in South-East Asia Region (SEAR):** India is a signatory to it.
- **National Task Force on Malaria Elimination:** to promote intersectoral cooperation and engagement of all stakeholders.

Related News

CRISPR-based system developed to safely restrain mosquito vectors via sterilization

- New **precision-guided sterile insect technique (pgSIT) alters genes in Aedes aegypti**, the species responsible for spreading malaria, dengue, chikungunya and Zika.

- This technology could be **implemented by deploying eggs of sterile males and flightless females at target locations** where mosquito-borne disease spread is occurring.
- **Superiority of pgSIT**
  - pgSIT is designed as a **much more precise** (for gene alteration) **and scalable technology** since it uses CRISPR not radiation or chemicals.
  - Unlike 'gene drive' the pgSIT **system is self-limiting and is not predicted to persist or spread in the environment.**
    - ✓ **"Gene drive"** systems could **suppress disease vectors by passing desired genetic alterations indefinitely from one generation to the next**

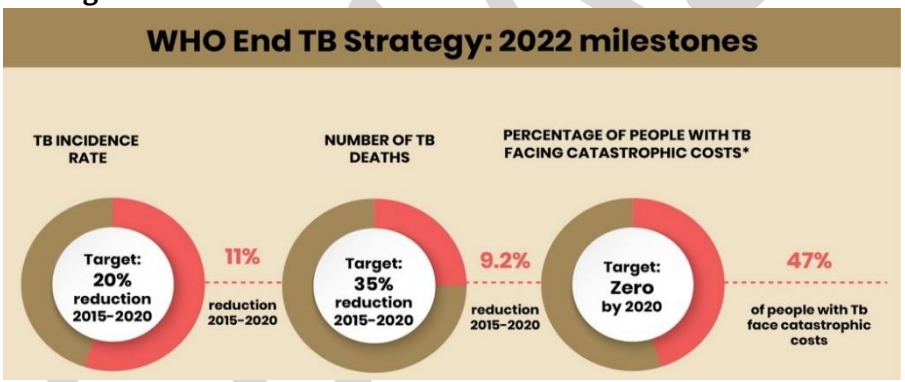
4.3. TUBERCULOSIS (TB)

Why in News?

Global tuberculosis (TB) report 2021 released by World Health Organization (WHO).

Key highlights of the report

- **TB deaths rise for the first time in more than a decade** due to COVID-19 pandemic. A **total of 1.5 million people died** from TB in 2020 (including 214 000 people with HIV).
- In 2020, **30 high TB burden countries accounted for 86% of new TB cases.** Eight countries account for two thirds of the total, with **India leading the count.**
- **A large number of cases went undetected** due to highly curtailed access to diagnostics and restrictions imposed to contain the pandemic.
  - **India contributed the biggest drop in detection of new cases** (41% of the total undetected cases).



- Global TB **targets are off track** (refer infographic).

About Tuberculosis (TB)

- TB is caused by **bacillus Mycobacterium tuberculosis,** which is spread when people who are sick with TB expel bacteria into the air.
- It **typically affects the lungs** (pulmonary TB) but can affect other sites.

Initiatives taken to fight TB

- **National Strategic Plan for Tuberculosis Elimination** (2017 - 2025) a framework to guide the activities of all stakeholders whose work is relevant to TB elimination in India.
- **Revised National Tuberculosis Control Program (RNTCP):** It has been renamed as "National Tuberculosis Elimination Program (NTEP)" to accelerate momentum towards eliminating Tuberculosis in the country by 2025.
- **Early accurate diagnosis** being done using techniques like Ziehl-Neelsen acid-fast staining /Fluorescence Microscopy, Cartridge Based Nucleic Acid Amplification Test (CBNAAT) / Line Probe Assay (LPA)/ TrueNAT.
- **On-line notification** of TB patients **through the NIKSHAY portal.**

4.4. ONE HEALTH

Why in news?

Department of Animal Husbandry and Dairying (AHD) launched 'One Health' pilot project in Uttarakhand.

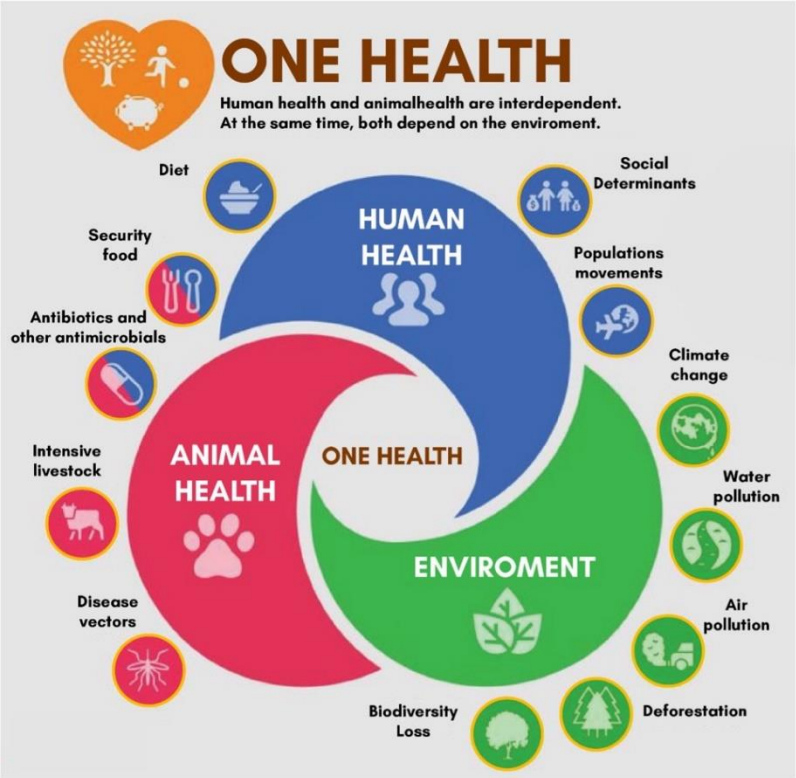
- **Some of the key activities to be undertaken as part of the pilot project** include institutionalizing the mechanism for data collection on disease outbreaks, prevalence, management, and integration of the data with the digital architecture of the National Digital Livestock Mission.

About One Health

- One Health is understood as a **collaborative, multisectoral, and trans-disciplinary approach** to achieve optimal health and well-being outcomes **recognizing the interconnections between people, animals, plants, and their shared environment.**

- One Health issues include **zoonotic diseases, antimicrobial resistance, environmental contamination,** and other health threats shared by people, animals, and the environment.

- The overarching purpose is to encourage **collaborations in research and sharing of knowledge at multiple levels across various disciplines** like human health, animal health, plants, soil, environmental and ecosystem health in ways that improve, protect and defend the health of all species.
- **Global initiatives**
  - **The Pilanesberg Resolution, 2001:** to consider potential wildlife health impacts in development projects.
  - **One World-One Health:** introduced in 2007 along with 12 recommendations **(the Manhattan Principles)** that focused on establishing a more holistic approach to preventing epidemic disease and maintaining ecosystem integrity.



One Health facts

- **People's Health**
  - 60% of pathogens that cause human diseases like Covid-19 originate from domestic animals or wildlife.
  - 75% of emerging human pathogens are of animal origin.
  - 80% of pathogens that are of bioterrorism concern originate in animals.
- **Food Security**
  - More than 70% additional animal protein will be needed to feed the world by 2050.
  - More than 20% of global animal production losses are linked to animal diseases.
- **Environment**
  - Humans and their livestock are more likely to encounter wildlife (this may increase the transmission of diseases) when more than 25% of an original forest cover is lost.
  - Human actions have severely altered 75% of terrestrial environments and 66% of marine environments.
- **Economy**
  - Animal diseases pose a direct threat to the **incomes of rural communities that depend on livestock production.**

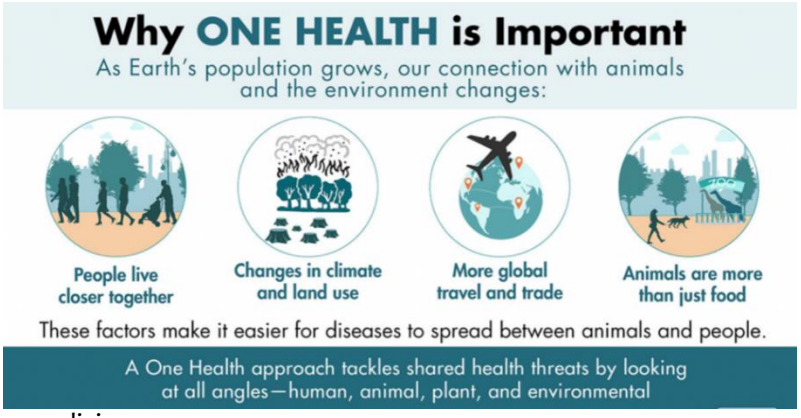
Challenges in adoption of One Health Strategy

- **Difficulty in coordination:** There is relatively limited practical guidance and understanding on how to foster and sustain cross-sector collaborations (including coordination for mobilisation of financial resources).
- **Lack of awareness:** Mostly One Health strategy is seen as a governmental endeavour. Awareness about this concept among common people is very less.
- **Systemic issues:** Most nations do not have institutions whose primary missions are animal disease surveillance, control, and prevention.
  - Also, only few qualified veterinarians are pursuing careers in livestock and wildlife health, probably because limited jobs are available.

Way ahead

- **Consensus building:** Cultivate champions in different sectors who can agree on common objectives that promotes innovation, adaptation, and flexibility in terms of political, financial, and administrative accountability.
- **Establishing international institution:** An international body that would work for creating a global network of qualified individuals working to share information with respect to various dimensions of One Health.

- **Mainstreaming One Health:** Success is likely if One Health initiatives are institutionalised in existing structures and not championed by novel structures outside of mainstream systems.
- **Adequate funding for animal health programme:** Currently, human health is vastly better funded compared with animal health. This needs to be addressed by creating more schools of veterinary medicine.

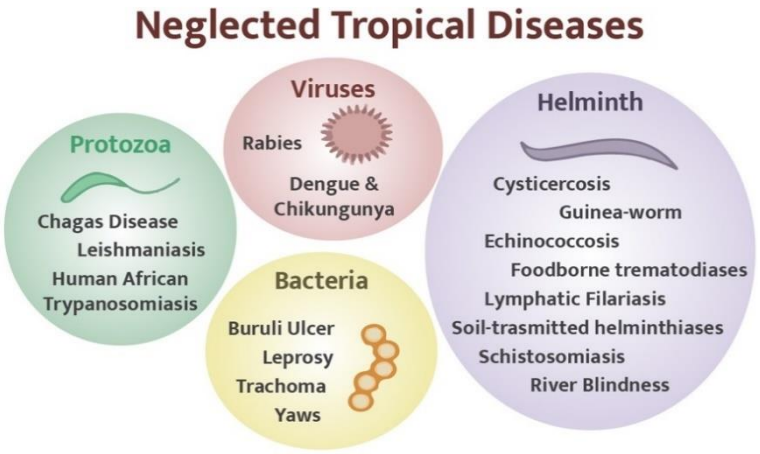


- **Education:** Engaging One Health concept into the medical school curricula would ensure medical students see One Health as an essential component in the context of public health and infectious diseases.

4.5. NEGLECTED TROPICAL DISEASES

Why in News?

Neglected Tropical Diseases (NTD) Day 2022 with theme of Achieving health equity to end the neglect of poverty-related diseases was celebrated on January 30.



About Neglected Tropical Diseases (NTD)

- NTDs refer to around **20 medically diverse, communicable diseases** that are most common among marginalised communities in the developing regions of **Africa, Asia and the Americas**. They are prevalent in tropical areas.
- **Populations living in poverty, without adequate sanitation** and in close contact with infectious vectors and domestic animals and livestock are those worst affected.
- India experiences the **world's largest absolute burden of at least 11 major NTD**, though India has already **eliminated several NTDs, including guinea worm, trachoma, and yaws.**

Impact of NTDs

- **Affecting the world's poorest people:** NTDs overload already stretched health systems in developing countries, and some of them can lead to catastrophic expenditures and can reduce individual productivity.
- **On children's health:** Some disease impair physical and cognitive development amongst children as infection leads to malnutrition, cognitive impairment, stunted growth, and the inability to attend school.
- **On Women's Health:** Some diseases with cutaneous manifestations are disfiguring, particularly for women, because they delay health-seeking behaviour, diagnosis and treatment.
  - They **affect women's social health** (by promoting exclusion and stigma) and **economic health** (by affecting women's ability to work).

Challenges in tackling NTD

- **Lack of prioritized efforts:** because NTDs are characterized by little attention from policy-makers, lack of priority within health strategies, inadequate research, limited resource allocation and few interventions.
- **Non availability of treatments:** For many NTDs, there are no vaccines or simple tests to ensure timely diagnosis and treatment, and treatments can be toxic, ineffective, and costly.
- **Prevalence of Social stigma:** along with the social displacement of people affected by NTDs.

Way forward

- **Resource mobilization, public–private partnerships and community mobilization** are important and must be prioritized.

- **Effective surveillance and monitoring** are urgently needed, together with an evaluation system for tracking progress on a regular basis.
- **Regular briefing of the media** can increase community involvement in elimination programmes, reduce stigma and discrimination.
- Development of **community-based programmes for the rehabilitation of disabled persons** and their reintegration into their communities.

4.6. INDIA'S VACCINE ECOSYSTEM

4.6.1. SELF-AMPLIFYING MESSENGER RNA (MRNA) VACCINE

Why in News?

A Self-amplifying messenger RNA (mRNA) vaccine showed promising results against COVID-19.

Related Information
Breakthrough Infection

- **When someone who is vaccinated** with either a primary series or a primary series plus a booster dose **gets infected with the virus that causes COVID-19**, it is referred to as a "vaccine breakthrough infection.

About mRNA vaccine

- Both **DNA and RNA are types of Nucleic acid vaccines** (also known as gene-based vaccines).
- **Unlike conventional vaccines** that inject a weakened form of a virus or bacteria into the body, **RNA vaccines use part of virus' own genes to stimulate an immune response.**
- **A conventional mRNA vaccine,** such as those from Pfizer and Moderna, **uses mRNA that encodes the spike protein of the coronavirus.**
  - **mRNA vaccines teach cells how to make copies of the spike protein** that triggers an immune response inside human bodies, when actual infection takes place.
- A self-amplifying mRNA vaccine is an **improvement over the traditional mRNA** as it **encodes four extra proteins in addition to the vaccine antigen,** and these enable amplification of original strand of RNA once inside the cell.
- **Advantage of self-amplifying mRNA vaccine** over conventional mRNA vaccine: making storage easy, minimizing dose of RNA and lowering the cost of vaccines.
- **Advantages of RNA vaccines: Safe and non-infectious** as they are not made with pathogen particles or inactivated pathogen, **can generate a stronger type of immunity, Can be produced more rapidly etc.**

Other types of Vaccines

- **Live Attenuated Virus (LAV):**
  - **Uses a weakened (or attenuated) form of the germ** that causes a disease.
  - Because these vaccines are so similar to the natural infection that they help prevent, they **create a strong and long-lasting immune response.**
  - Used in case of **Measles, Rubella (MMR combined vaccine), Tuberculosis, Rotavirus, Oral Polio Vaccine(OPV), Yellow fever etc.**
- **Inactivated vaccines:**
  - Uses the **killed version of the germ** that causes a disease.
  - These vaccines usually **don't provide immunity that's as strong as live vaccines** so several doses over time (booster shots) is needed to get ongoing immunity against diseases.
  - **Used in case of Polio (IPV), Pertussis, Hepatitis A etc.**
- **Subunit and Recombinant vaccines**
  - Use **only part of a target pathogen** like its protein, sugar, or capsid (a casing around the germ) presenting it as an antigen on its own to provoke a response from the immune system.
  - It can also be created via genetic engineering. **The end result of this approach is a recombinant vaccine:** the immune system will recognize the expressed protein and provide future protection against the target virus.
  - **Used in case of Haemophilius Influenza type B(Hib). The Hepatitis B** vaccine currently used in the United States is a recombinant vaccine.
- **Conjugate vaccines**
  - **Similar to recombinant vaccines** but are made using pieces from the coats of bacteria. These coats are chemically linked to a carrier protein, and the combination is used as a vaccine.
  - Conjugate vaccines are used to create **a more powerful, combined immune response:** typically the "piece" of bacteria being presented would not generate a strong immune response on its own, while the carrier protein would.
  - The vaccines **currently in use for children against pneumococcal bacterial infections** are made using this technique.

Challenges with vaccines development in case of Pandemics

- Before a vaccine is available the **pandemic will probably have peaked and declined.**
- As soon as a vaccine is approved, **it's going to be needed in vast quantities.**
- **In case of a pandemic, countries also have to compete with each other for medicines. The challenge is to make sure the vaccine gets to all those who need it.**
- Because pandemics tend to hit hardest those countries that have the most fragile and underfunded healthcare systems, there is **an inherent imbalance between need and purchasing power** when it comes to vaccines.

- **Toxoid vaccines**
  - Uses a **toxin (harmful product) made by the germ** that causes a disease.
  - They create immunity to the parts of the germ that cause a disease instead of the germ itself.
  - Booster shots are needed to get ongoing protection against diseases.
  - **Used in case of Tetanus and Diphtheria.**

4.7. TRANS FATS

Why in news?

WHO released the third progress report on Global trans-fat elimination 2021 titled 'Countdown to 2023'.

Key highlights of the report

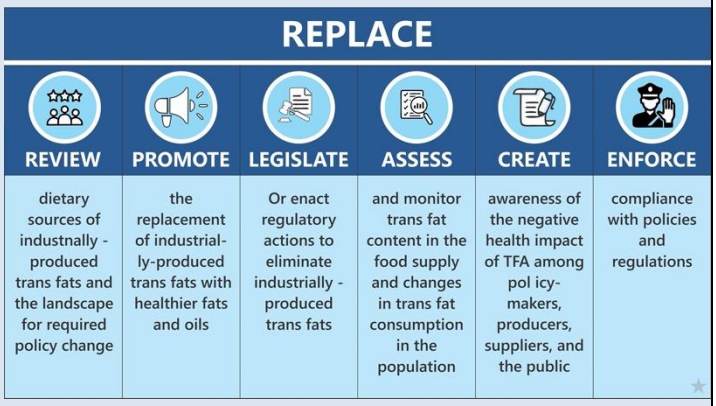
- **Progress in efforts worldwide:** Mandatory Trans Fatty Acids (TFA) elimination policies are currently in effect in 57 countries.
- **Best performers:** India and the Philippines became the first and second lower-middle-income countries to pass a best-practice policy.
- **Challenges to TFA policy-making** faced by countries over the past year were resource and capacity constraints due to the COVID-19 pandemic.

About Trans Fatty Acid (TFA)

- Trans fat, or trans-fatty acids, are **unsaturated fatty acids** that come from either natural or industrial sources
  - **Naturally occurring trans-fat** come from ruminants (cows and sheep).
  - **Industrially produced trans-fat** (have a longer shelf life and are cheaper) are found in hardened vegetable fats such as margarine and are often present in snack foods, baked goods and fried foods.
- **Health Impacts:** Intake of TFA is associated with **increased risk of heart attacks and death from coronary heart disease.**
  - Approximately **540,000 deaths each year globally and 60,000 in India** can be attributed to intake of industrially produced TFA.

Steps taken by WHO to eliminate Trans Fats from food supplies

- WHO launched a comprehensive plan **to eliminate industrially-produced artificial trans fats from the global food supply by 2023 called REPLACE.**
- **Additional resources to support country actions:** This includes six REPLACE implementation modules and a live policy tracking map – the **TFA Country Score Card**– to monitor global progress towards the 2023 target.
- **TFA indicator** (one of the indicators in the WHO Triple Billion Indicators to improve health of billions by 2023) that records whether countries have adopted WHO best-practice policies for eliminating industrially produced TFA.
- **WHO Certification Programme for Trans Fat Elimination:** to recognize countries that have eliminated industrially produced TFA from their national food supplies.

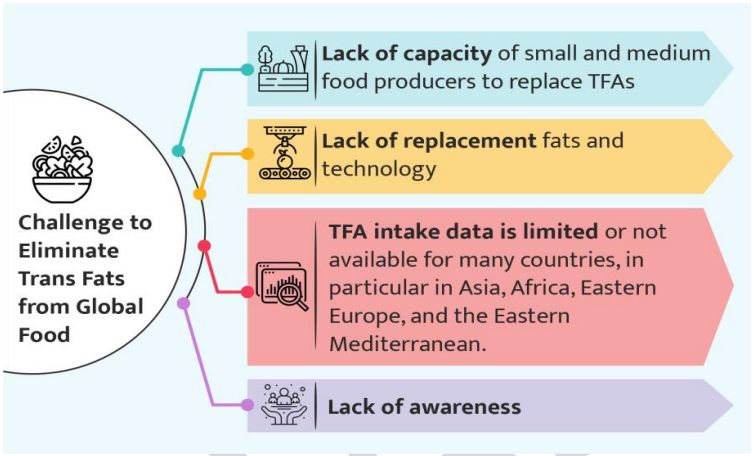


Following steps have been taken by India in recent times for TFA elimination:

- **Goal setting:** In 2018, India called for action to make the country TFA free by 2022, a year ahead of the WHO global target of 2023.
- **Labelling of TFA:** Food establishments can display the "Trans Fat Free" logo in their outlets and on their food products based on the minimum limits of TFA.
- **Behaviour Change Communication:** Multilingual Mass media campaign, "Heart Attack Rewind" was launched to create a demand for healthier alternatives to Partially hydrogenated oils.
- **Technology adoption:** Nudging Food businesses to adopt technologies to eliminate TFA in the food chain.
- **Capacity Building:** Strengthening Laboratories and Surveillance to provide a baseline so as to strategize the next steps for implementation of the regulation.

What more can be done in India?

- **Capacity building and additional technical assistance to Small and Medium Food enterprises** to produce healthier and cost-effective alternatives to TFAs.
- **Mandatory labelling of TFA and saturated fat content** for all edible oils and food products.
- **FSSAI will need to pursue local governments to improve surveillance,** inspection of food premises, sampling of food products, regular training of officers, upgradation of food labs, etc.
- **Civil society organisations should play an important role** in informing the public, providing support for draft legislation/ regulation and monitoring implementation.



Conclusion

As more and more countries regulate TFA, food manufacturers can reformulate products in for sale in multiple countries. This can reduce research and development costs, and allow easier trade between countries and within regions.

4.8. RICE FORTIFICATION

Why in news?

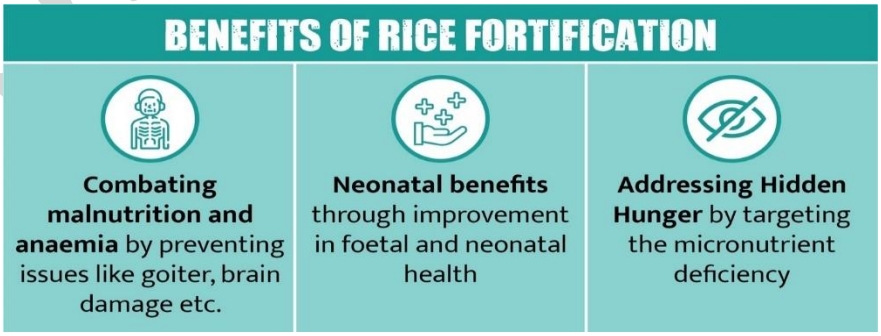
Recently, **Department of Food and Public Distribution has issued Standard Operating Procedure (SOP)** to maintain desired quality standards for implementation of 'Rice Fortification'.

About rice fortification

- Rice fortification is a process of adding micronutrients like **Iron, Folic Acid and Vitamin B12 to rice.**
- **Various technologies** are available to add micronutrients to regular rice, such as **dusting, coating and extrusion.**
- In India, **rice is fortified using extrusion technology** in which **milled rice is pulverized and mixed with a premix** containing vitamins and minerals.

About food fortification

- **Fortification means deliberately increasing the content of essential micronutrients** in a food to improve the nutritional quality of food and to provide public health benefit with minimal risk to health.
- Fortification has been **particularly successful for iodized salt as** 71 percent of the world's population has access to iodized salt.
- Other common examples of fortification include **adding B Vitamins, Iron, and/or Zinc to wheat flour and adding Vitamin A to cooking oil and sugar.**
- In India, **wheat flour and rice are fortified with Iron, Vitamin B12andFolic Acid, Milk and Edible Oil with Vitamins A and D** and **Double Fortified Salt with Iodine and Iron** to reduce the high burden of micronutrient malnutrition in India.
  - Food fortification is regulated under **Food Safety Standards (Fortification of Foods) Regulation, 2018.**



Steps towards fortification in India

- It **began in the 1950s** with vegetable oil fortification and salt iodization. Other commodities such as rice and wheat flour were finally **introduced in the 2000s.**
- India's **10th, 11th ,12th Five Year Plans, POSHAN Abhiyan** (National Nutrition Mission) and **Anaemia-Mukt Bharat Mission** recommend food fortification as an important strategy to tackle micronutrient malnutrition.

Related News

Ministry of Health and Family Welfare releases 3rd State Food Safety Index (SFSI)

- The index was prepared by FSSAI **to galvanize States to work towards ensuring safe food for citizens.**
- **Top states/UT on SFSI Index:** Large States (Gujarat), Small States (Goa), UTs (J&K).

- In 2016, FSSAI had come out with **regulations on fortification for staples** like wheat flour, maida, rice, double fortified salt, milk and oil.
- **Other Steps taken by FSSAI include:**
  - A dedicated unit called the **Food Fortification Resource Centre has been set up** for all **end-to-end technical and advocacy support** to both States/UTs as well as the open market.
  - Contributed towards various **capacity building trainings and developed Information Education & Communication (IEC) material** specifically for **POSHAN Maah.**
  - Further, one of the key messages in the **Eat Right India movement** is consumption of fortified foods.
- In 2019, **Centrally Sponsored Pilot Scheme** on **'Fortification of Rice and its Distribution under Public Distribution System'** was approved for a period of three years with focus on 15 districts.
  - Government has also decided to scale up the scheme to cover the **Integrated Child Development Scheme (ICDS) and Mid-Day Meal (MDM) scheme** in 'aspirational districts'.

Concerns with Rice fortification

- **Lead to excess iron:** As per recent report, consumption of iron-fortified foods by people with Thalassemia, Sickle-cell anaemia, TB etc **can lead to reduced immunity and dysfunctionality of organs**.
- **Adulteration:** It is found that 'plastic-rice' has been mixed with normal rice in the name of fortification, which caused abdominal discomfort, gastritis, diarrhoea and nausea to consumers.
- **Improper labelling**: There have been instances of distributing fortified food without proper labelling and warning about its adverse impact on people with sickle-cell anaemia and Thalassemia.
- **Removes people's choice of foods, or autonomy,** and could even be unethical if the risk of other morbidities is increased.
- **Difficult to withdraw**: Mandatory fortification will create markets that will be hard to withdraw when we have achieved the target. These foods can then contribute to nutrient overdoses.

Way forward

- **Dietary diversity**: including fruits, vegetables are more cost-effective way to fight nutritional deficiency than fortification. Food and rice fortification should thus be viewed as a complementary strategy.
- **Targeted fortification**: The rice fortification must be chosen carefully, as well as target the population at risk of inadequacy without creating excessive intake for other subgroups of the population.
- **Information and monitoring**: Fortification of rice must be applied thoughtfully, its effects monitored diligently, and the public informed effectively about its role in dietary intake through appropriate labelling and consumer education.

5. ACHIEVEMENTS OF INDIANS IN SCIENCE & TECHNOLOGY; INDIGENIZATION OF TECHNOLOGY AND DEVELOPING NEW TECHNOLOGY

5.1. ACHIEVEMENTS OF INDIANS IN SCIENCE & TECHNOLOGY

5.1.1. HAR GOBIND KHORANA

Why in News?

Recently, Har Gobind Khorana's 100th birth anniversary was celebrated.

About Har Gobind Khorana

- He was **born in Raipur village of Multan district** (Pakistan). He later **became naturalised citizen of US.**
  - In 1969, he was **awarded Padma Vibhushan.**
- His **early training was in chemistry** but later he started applying chemistry to solve problems in biology, **starting field of chemical biology.**

Major Achievements

- **1968 Nobel Prize for Physiology or Medicine** (shared with Nirenberg and Holley) **for interpretation of genetic code** and its function in protein synthesis.
  - He **proved that genetic code consists of 64 different three-letter words**, which told the cell where to begin reading the code and where to stop.
- **Constructed the world's first synthetic gene** paving the way for further advancements in the field of genetic engineering and biotechnology.
- He **investigated mutations in rhodopsin** that are associated with retinitis pigmentosa, which causes night blindness.
  - Rhodopsin is a **light-sensitive protein found in the retina** of the vertebrate eye.
- **Contributed to the science of polymerase chain reaction (PCR) tests**, used to detect genetic material from a specific organism, like a virus.
- **Discovered structure of transfer-RNA,** or tRNA (small RNA molecule that participates in protein synthesis).

5.1.2. SRINIVASA RAMANUJAN

Why in News?

For the year 2021, **Ramanujan Prize for Young Mathematician** has been facilitated upon **Professor Neena Gupta,** for her outstanding work in **affine algebraic geometry and commutative algebra.**

About Ramanujan

- Srinivasa Ramanujan was born on **December 22, 1887** in the town of **Erode, Tamil Nadu.**
  - His **birth anniversary on 22 December is celebrated as National Mathematics Day** to honour the achievements of the legendary mathematician.
- He received his degree from Cambridge in 1916 and went on to **publish several brilliant papers on his subject with the help of his professor GH Hardy of Trinity College, Cambridge University.**
- Ramanujan was elected to the **London Mathematical Society in 1917** and was elected a **Fellow of the Royal Society for his excellent work on Elliptic Functions and the theory of numbers.**

Ramanujan's Work

- Ramanujan made priceless contributions to several mathematical concepts like **infinite series, continued fractions, number theory and mathematical analysis.**
- He introduced a summation in **1918,** now known as the **Ramanujan sum** which is currently used in **signal processing, i.e., analysing, modifying and synthesising periodically repetitive signals such as speech, music, DNA sequences etc.**
- In his famous **letter to Hardy in 1919,** he introduced the **"mock theta functions"** which are **used today in 'String Theory' in theoretical physics.**
- He is also credited for his work in **'Modular functions'** which are used to **reveal properties of Black Holes by astrophysicists.**
- He discovered **Hardy Ramanujan number i.e., 1729** which is the smallest number which can be expressed as the sum of two cubes in two different ways- $1729 = 1^3 + 12^3 = 9^3 + 10^3$.

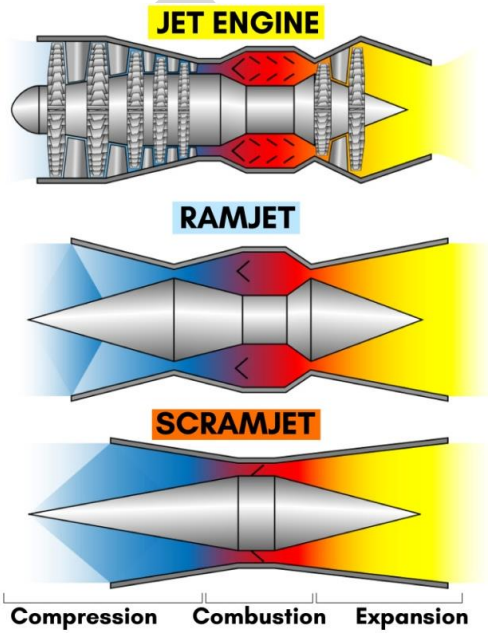
- He was also **the first Indian to be elected a Fellow of the Trinity College.**
- Ramanujan **died at the young age of 32** owing to deteriorating health on April 26, 1920.
- In 1976 George E. Andrews found Ramanujan's notes written during his last few years in England. Prof. Andrews, along with Bruce C. Berndt went on to compile the contents of this lost notebook into a **five-volume book entitled Ramanujan's Lost Notebook.**
- Robert Kanigel also wrote a book about him called **'The Man Who Knew Infinity'** and a **movie of the same name** premiered in **2015**.

5.2. INDIGENIZATION OF TECHNOLOGY AND DEVELOPING NEW TECHNOLOGY

5.2.1. SOLID FUEL DUCTED RAMJET (SFDR) TECHNOLOGY

Why in news?

Recently, DRDO successfully **flight tested SFDR booster at the Integrated Test Range (ITR),** Chandipur off the coast of Odisha.



About SFDR

- The first flight of SFDR, developed under a **joint Indo-Russian R&D project,** was tested in 2018. It had achieved the **speed of Mach 3.**
- It is a **missile propulsion system** that includes a **thrust modulated ducted rocket** with a reduced smoke nozzle-less missile booster.
    - The system **utilises a solid fuelled air-breathing Ramjet Engine.** Unlike solid-propellant rockets, the Ramjet takes up oxygen from the atmosphere during flight. Thus, it is **light in weight** and can **carry more fuel.**
    - The missile can hit the air targets in the **ranges from 70 - 340 km.**
- **Significance:**
    - It **enables the missile to intercept aerial threats** at very long range at supersonic speeds and high accuracy.
    - It will help to develop **long-range air-to-air missiles.** However, the technology can also be applied to surface-to-air missiles.
    - Air-to-air missiles which use SFDR technology can **achieve longer ranges as they do not require oxidisers.**

Difference between Ramjet, Scramjet and Dual Mode Ramjet (DMRJ)

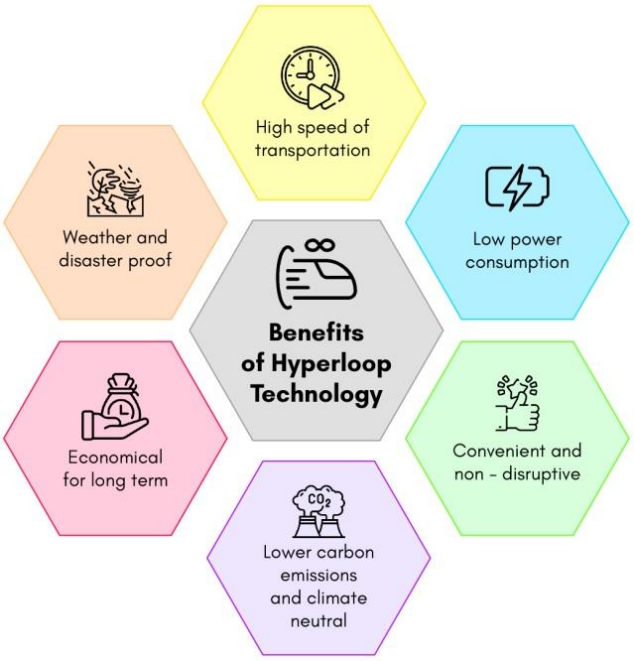
- Ramjet, Scramjet and DMRJ are the **three concepts of air-breathing engines** which are being developed by various space agencies.

Ramjet	Scramjet (Supersonic combustion ramjet)	Dual Mode Ramjet (DMRJ)
• Air-breathing **jet engine** that uses the **vehicle's forward motion to compress incoming air for combustion** without a rotating compressor. • Work **most efficiently** at **supersonic speeds around Mach 3** (three times the speed of sound) and can **operate up to speeds of Mach 6.** • Efficiency starts to drop when the vehicle reaches hypersonic speeds. • Does **not have any turbines** unlike the turbojet engines (jet engines).	• Improvement over the ramjet engine as it **efficiently operates at hypersonic speeds** and allows **supersonic combustion.** • Uses **Hydrogen as fuel** and the **Oxygen from the atmospheric air** as the oxidiser. • Both ramjets and scramjets have **no moving parts, only an inlet,** a **combustor** that consists of a fuel injector and a **flame holder,** and **a nozzle.**	• **Type of jet engine** where a ramjet transforms into scramjet **over Mach 4-8 range.** • It can efficiently operate both in **subsonic and supersonic combustor modes.**

5.2.2. HYPERLOOP SYSTEM

Why in news?

Indian railways is collaborating with IIT Madras Team (**Avishkar Hyperloop)** for the development of 'indigenous' Hyperloop system.



About Hyperloop system

- The Hyperloop is **a new mode of transportation** other than road, rail, water and air.
- It works on a technology that utilizes **magnetic levitation in low-pressure tubes** to transport both, goods and people at airplane-like speed **up to 1200 kilometers per hour**.
- Hyperloop aims to remove the two things that slow down regular vehicles: friction and air resistance.
    - For Friction, the pod hovers above its track, like a magnetic levitation train and tube is used to reduce air resistance.

Challenges in Hyperloop Technology

- **High initial cost**: The investment to have the system in place is very high
- **Vibration and jostling**: High speed of capsule may cause dizziness to the passengers travelling due to vibration and jostling.
- **Low transport capacity**: A conventional train can transport 1000 passengers from A to B in about 20 min, for the same number of passengers, Hyperloop needs almost one hour due to low passenger capacity.

Conclusion

There are several barriers to a hyperloop revolution across the globe, and a variety of political and economic concerns, among others, need to be addressed in development of system. But still, commercial hyperloop transport systems will surely become a reality and may even become as widespread as cars, trains and planes.

6. MISCELLANEOUS

6.1. NOBEL PRIZE

Why in news?

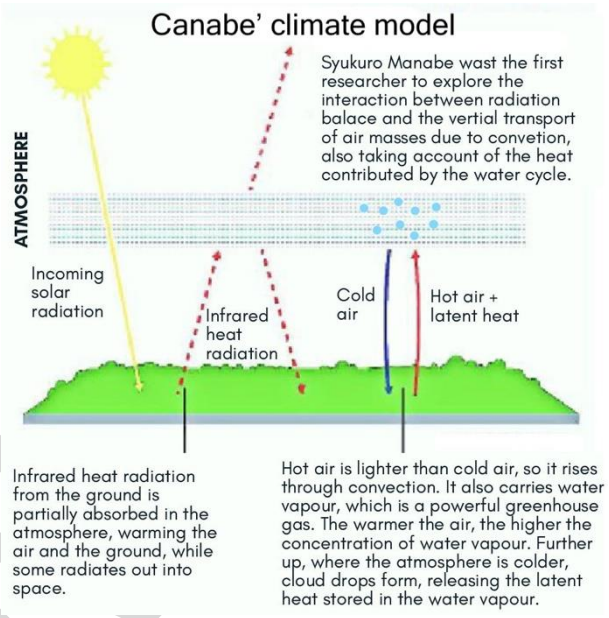
The Nobel Assembly and the Royal Swedish Academy of Science have **announced the winners** of Medicine, Physics and Chemistry **Nobel** for the year 2021.

6.1.1. THE NOBEL PRIZE IN PHYSICS 2021

Prize awarded for: Ground-breaking contributions to our understanding of **complex physical systems.**

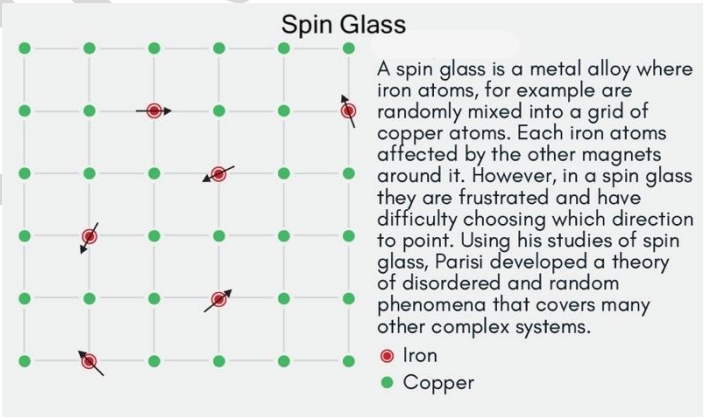
Awardees

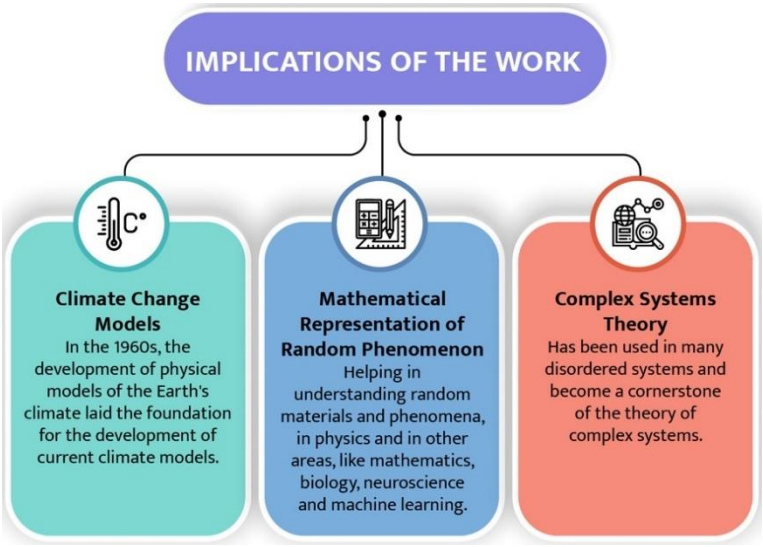
- One half of the prize was awarded to **Syukuro Manabe and Klaus Hasselmann for their work in the physical modeling of Earth's climate,** quantifying variability and reliably predicting global warming.
- Second half was awarded to **Giorgio Parisi for the discovery of the interplay of disorder and fluctuations in physical systems** from atomic to planetary scales.



About complex physical systems and the work of Nobel laurates

- **Complex systems** are characterised by **randomness and disorder** and are difficult to understand.
  - They can be difficult to **describe mathematically** – they may have an enormous number of components or be governed by chance.
  - The Prize recognises **new methods** for describing them and predicting their **long-term behaviour.**
  - The **Earth's climate** is one of many examples of complex systems.
- **Syukuro Manabe** demonstrated how **increased levels of carbon dioxide** in the atmosphere lead to **increased temperatures** at the surface of the Earth**.**
- **Giorgio Parisi** discovered **hidden patterns** in disordered complex materials with his **spin glass experiments (refer infographic).** With this, he discovered hidden structures within the systems and represented them mathematically.





6.1.2. NOBEL PRIZE IN PHYSIOLOGY OR MEDICINE

Prize awarded for: discoveries of **receptors for temperature and touch.**

Awardees

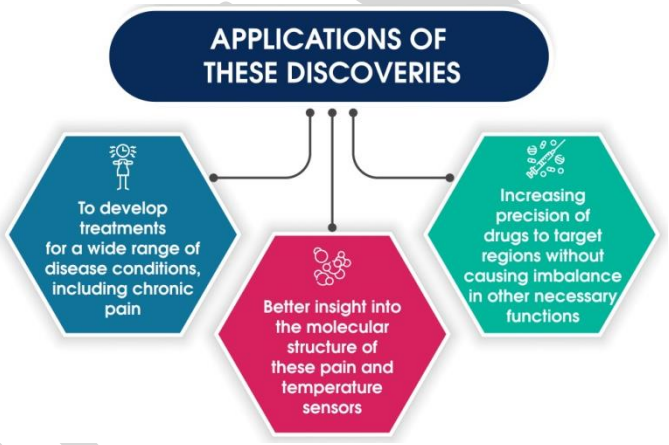
The 2021 Nobel Prize in Physiology or Medicine was jointly awarded to **David Julius and Ardem Patapoutian.**

About the receptors

- In the human body, all the molecules are **not sensitive to heat or mechanical pressure.** Only very specific are, and it is their job to **relay this signal to the nervous system,** which then triggers an appropriate response.

Work of David Julius and his team

- David Julius utilized **capsaicin, a pungent compound from chili peppers** that induces a burning sensation, to identify a **sensor in the nerve-endings** of the skin that responds to heat.
- He and his team looked for a **gene that could induce a response** to capsaicin in cells that usually wouldn't react to it. They found one in a **novel ion channel protein, later called TRPV1**, where TRP stands for **transient receptor potential**, and VR1 is **vanilloid receptor1**.
    - They were part of a **super family of TRP,** and it was found that TRPV1 was activated when **temperatures were greater than 40 degrees Celsius**, which is close to the body's pain threshold.



Work of Ardem Patapoutian and his team

- Ardem Patapoutian used **pressure-sensitive cells** to discover a **novel class** of sensors that respond to **mechanical stimuli in the skin and internal organs.**
- Patapoutian and his colleagues identified **72 potential genes** that could encode an ion channel receptor and **trigger sensitivity** to mechanical force, and it emerged that one of them coded for a **novel ion channel protein, called Piezo1**.
    - Via Piezo1, a **second gene** was discovered and named **Piezo2.** Sensory neurons were found to express **high levels of Piezo2** and further studies firmly established that Piezo1 and Piezo2 are ion channels that are directly activated by the **exertion of pressure on cell membranes.**
    - Later it was demonstrated that the Piezo2 ion channel is essential for the **sense of touch.** Moreover, Piezo2 was shown to play a key role in **proprioception as well as regulate blood pressure, respiration, and urinary bladder control.**

Both David Julius and Ardem Patapoutian also identified another **new receptor called TRPM8,** a receptor that is activated by cold.

6.1.3. NOBEL PRIZE IN CHEMISTRY

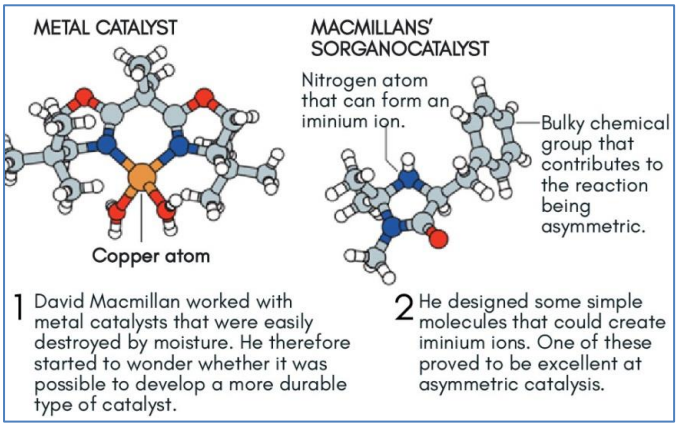
Prize awarded for: development of a precise **new tool for molecular construction:** organocatalysis.

Awardees

The Nobel Prize in Chemistry 2021 was awarded to **Benjamin List and David MacMillan.**

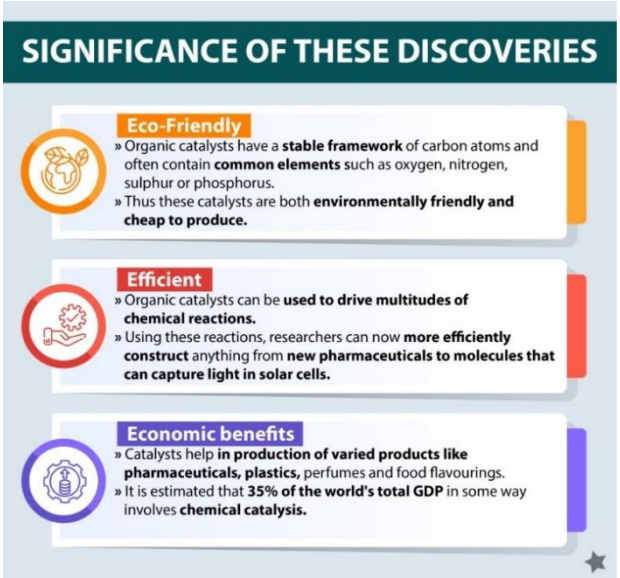
About Catalysts, catalysis and organocatalysis and the work of Nobel laurates

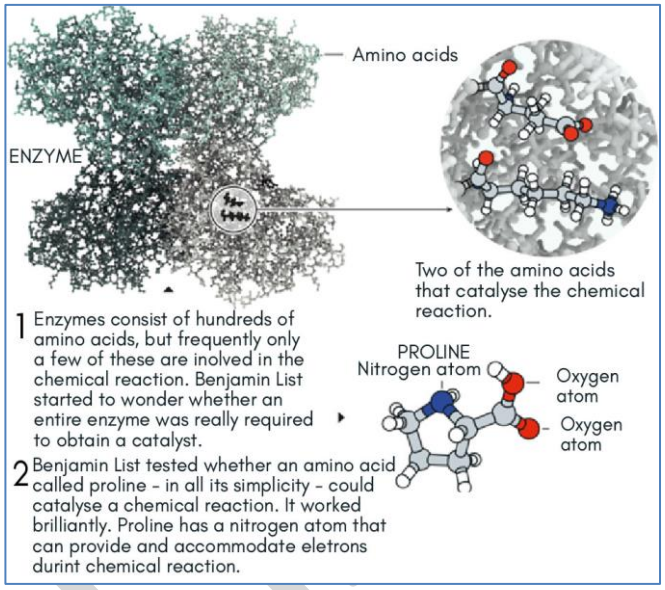
- Catalysts are substances that **control and accelerate chemical reactions,** without becoming part of the final product.



- For example, catalysts in catalytic converters of cars **transform toxic substances** in exhaust fumes to **harmless molecules.**

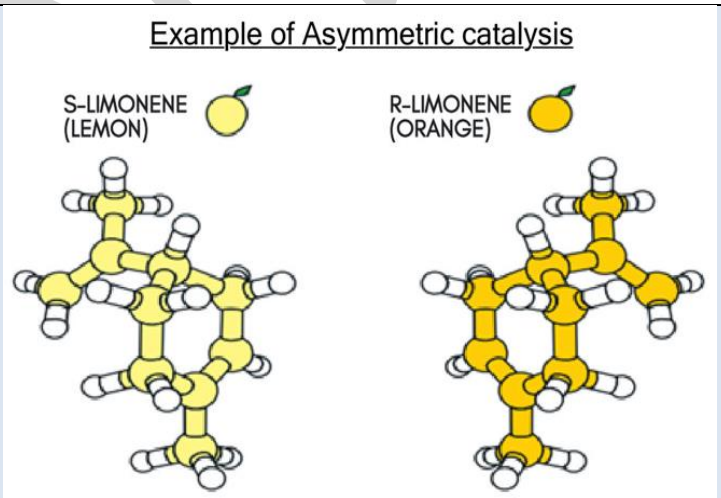
- Researchers long believed that there were, in principle, **just two types of catalysts available: metals,** mainly heavier metals; and **enzymes, naturally occurring** heavy molecules that facilitate all life-supporting biochemical processes.
- Benjamin List and David MacMillan, independent of each other, developed a **third type of catalysis**. It is called **asymmetric organocatalysis** and builds upon small organic molecules.





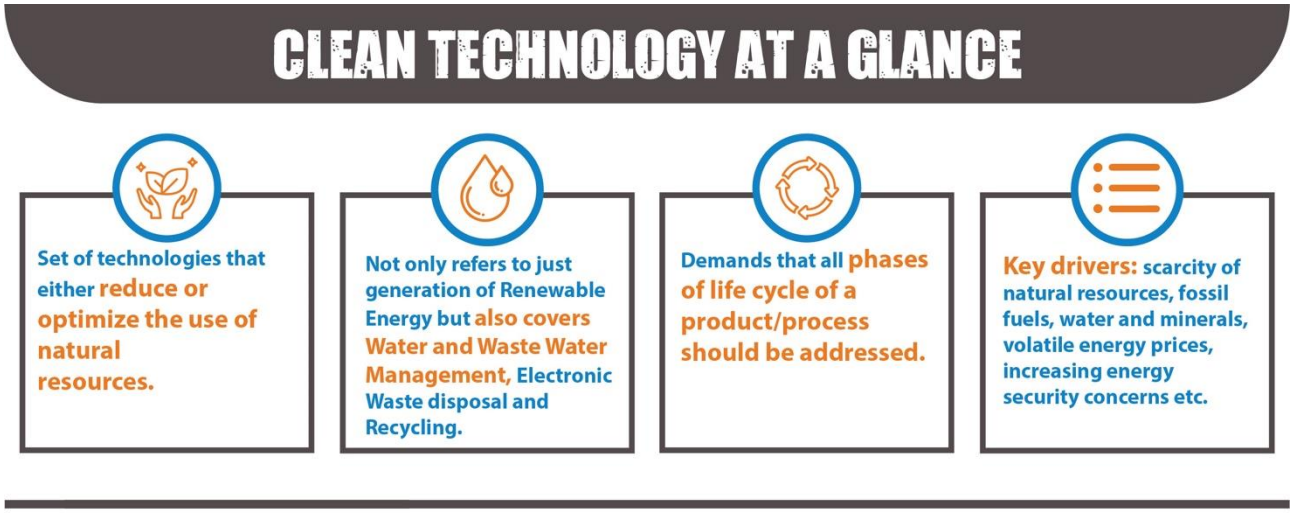
Asymmetric Catalysis

During chemical construction a situation often arises in which two molecules can form, which – just like our hands – are **each other's mirror image**. Chemists often **just want one of these mirror images,** particularly when producing pharmaceuticals, but it has been difficult to **find efficient methods** for doing this.



- List and MacMillan discovered that by using a natural compound like an amino acid as a catalyst, they were obtaining **only one specific mirror image** of the end-product. This was later named **asymmetric catalysis.**
- They experimented with **simple organic compounds**. Organic compounds are **mostly naturally-occurring substances,** built around a framework of carbon atoms and usually containing hydrogen, oxygen, nitrogen, sulphur, or phosphorus.
  - Life-supporting chemicals like **proteins,** which **are long chains of amino acids** (carbon compounds containing nitrogen and oxygen) are organic.

6.2. CLEAN TECHNOLOGY



6.2.1. GREEN HYDROGEN/ GREEN AMMONIA POLICY

Why in News?

Ministry of Power notified Green Hydrogen/Green Policy recently.

Key highlights of the policy

- Green Hydrogen / Ammonia manufacturers may **purchase renewable power from power exchange or set up RE capacity themselves.**

- Benefit of **Renewable Purchase Obligation (RPO) will be granted** to the hydrogen/Ammonia manufacturer.
- **Waiver of inter-state transmission charges for a period of 25 years** will be allowed to selected manufacturers.
- Manufacturers and RE plant shall be given **connectivity to the grid on priority basis.**
- Manufacturers will be allowed to **set up bunkers near Ports** for storage of Green Ammonia for export / use by shipping.
- **Single portal** for carrying out all the activities including statutory clearances will be set up.

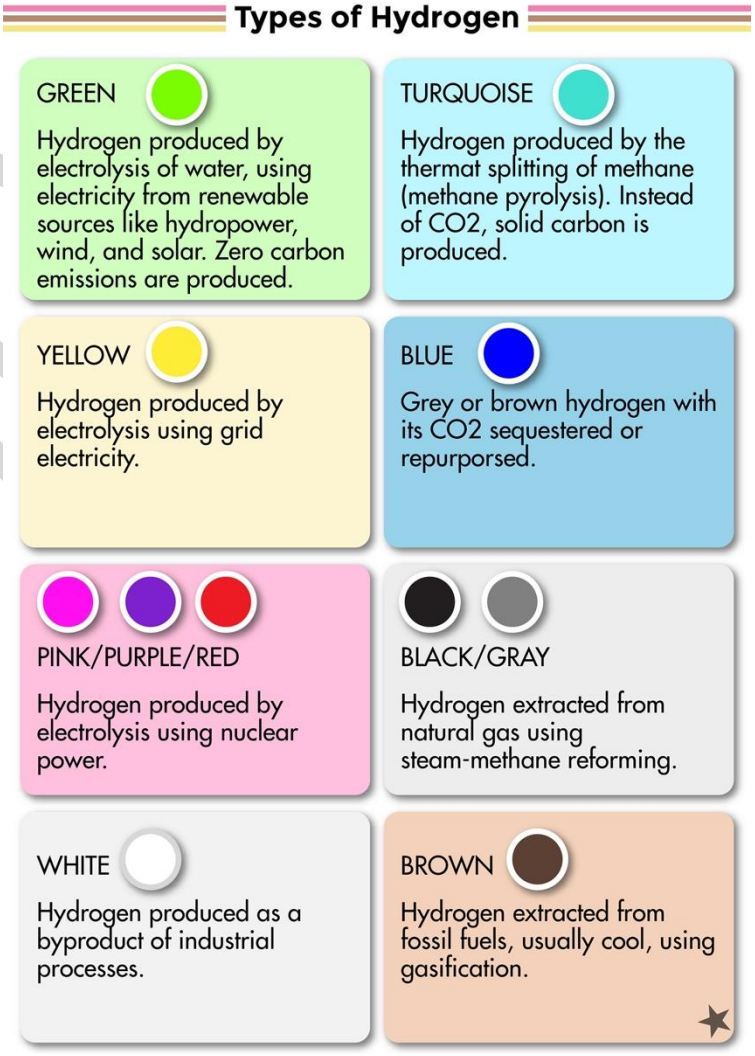
About Green Hydrogen and Green Ammonia

Green hydrogen and green ammonia refer to production of these fuels (hydrogen and ammonia) **by using power from renewable energy (RE).**

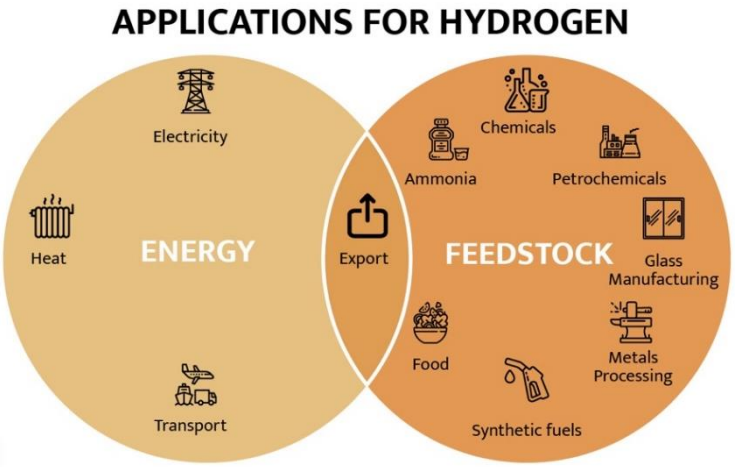
Green Ammonia is ammonia produced using power from renewable energy. It is among the three categories of Ammonia which include Blue and Brown Ammonia as well.

Benefits of using Green Hydrogen Energy

- **Clean source of energy:** It can decarbonize a range of sectors including iron and steel, chemicals, and transportation.
- **Potential to transform transportation:** as a direct replacement of fossil fuels.
- **Channelizing renewable energy:** Renewable energy that cannot be stored or used by the grid can be channelled to produce hydrogen.
- **Hydrogen FCEV (Fuel cell electric vehicles) are better in comparison to Battery electric vehicles:** with a refuelling time of just five minutes, compared to 30-45 minutes charging for a BEV (Battery electric vehicles).
    - This also has the **potential to reduce India's demand for rare earth minerals** that are used in the manufacturing of batteries for electric vehicles.
- **Reducing India's CAD:** India imports 85% of its oil and 53% of its gas demand. Green hydrogen has the potential reduce import dependency on fossil fuels and thus CAD.



- **Global manufacturing hub**: Quad group eyes India as a global manufacturing hub for green hydrogen outside the influence of China.
- **Addressing uncertainty:** Hydrogen finds special resonance in India, given the uncertainty in global energy markets.



Challenges

- **Process of extracting green hydrogen is energy-intensive:** Hydrogen is not found freely as it exists only combined with other elements and has to be extracted from naturally occurring compounds like water.
- **High Cost**- The technology used in production and use of hydrogen like carbon capture and storage (CCS) and hydrogen fuel cell **technology are at nascent stage** and are expensive which in turn increases the cost of production of hydrogen.
- **High R&D requirement:** The commercial usage of hydrogen as a fuel and in industries requires mammoth investment in R&D.
- **Multiple regulatory authorities**: Ministry of Road Transport and Highways regulates vehicle's fuel carrier specification, MNRE regulates renewable energy sources and Petroleum and Explosives Safety Organisation regulates explosive substances, storage and fuel station's specifications.
- **Issues in transporting hydrogen:** Hydrogen in gaseous form is highly inflammable. Also, hydrogen lacks smell, which makes any leak detection almost impossible.

Initiatives taken by India

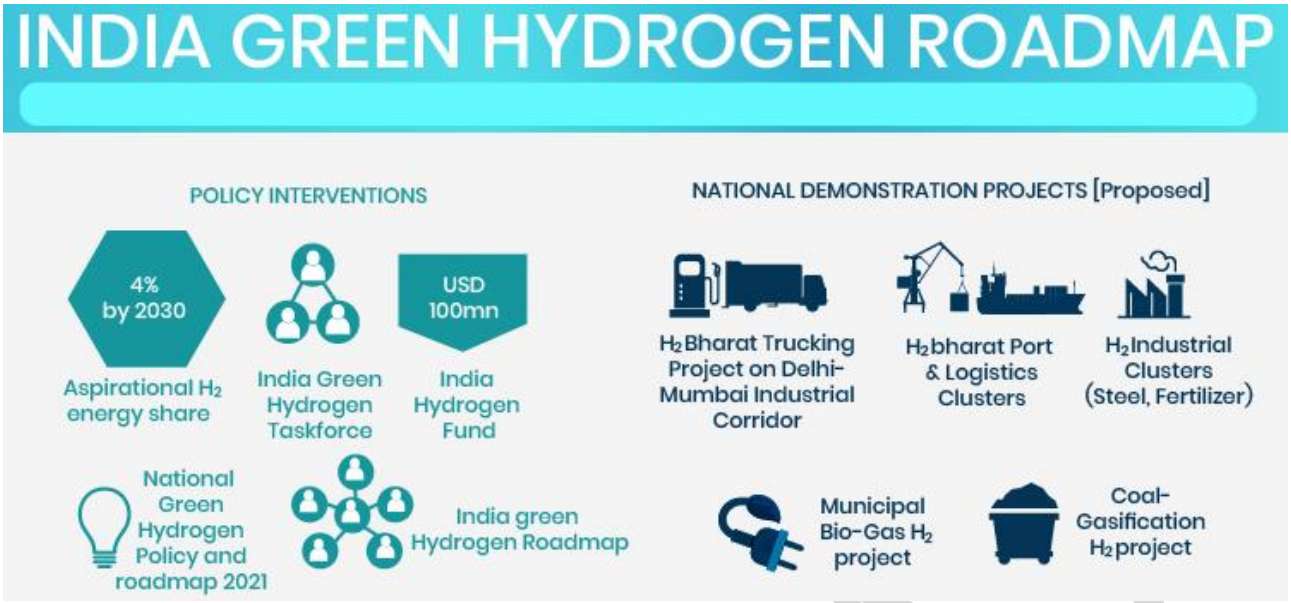
- **National Hydrogen Energy Mission was** formally announced in the Union budget for 2020-21.
- **National Hydrogen Energy roadmap (2006)** for the long-term public and private efforts for hydrogen energy development.
- **Hydrogen and Fuel cell program** by Department of Science and Technology.
- Indian Institute of Science has developed **biomass gasification-based hydrogen generation technology.**
- Delhi became the first Indian city to operate buses running on **hydrogen spiked compressed natural gas (H-CNG).**
- As a supporting regulatory framework, the **Ministry of Road Transport and Highways** issued a notification **proposing amendments to the Central Motor Vehicles Rules,** 1989, to include safety evaluation standards for hydrogen fuel cell-based vehicles.

About National Hydrogen Energy Mission

- The mission emphasizes on **generating hydrogen from green power resources (known as green hydrogen)** and enabling its commercial use.
- **Major activities envisaged under the mission include:**
  - Creating volumes and infrastructure;
  - Demonstrations in niche applications (including for transport, industry);
  - Goal-oriented Research & Development;
  - Facilitative policy support; and
  - Putting in place a robust framework for standards and regulations for hydrogen technologies.
- In line with **National Hydrogen Mission**, GAIL has commenced India's **first-of-its-kind project of mixing hydrogen into the natural gas system** to establish the techno-commercial feasibility of **blending hydrogen in City Gas Distribution (CGD) network**.

Way forward

- **State level actions:** and policy making related to Green Hydrogen to complement efforts at the national-level.
- **Capacity building and skill development:** across the ecosystem including government, industry, and academia addressing technology related challenges.
- **Adequate financial mechanisms** such as viability gap funding, PLI schemes, reduction or exemption of tax and duties should be encouraged to promote production.
- **Encouraging Electrolyser Manufacturing:** Identify and invest in research, development, and commercialization of low-cost electrolyser technologies that require minimum rare earth metals.
- **Early-stage R&D** to enable technologies that reduces the cost of costs of manufacturing electrolyser components, using advanced techniques such as additive manufacturing.



Related News: Coal Based Hydrogen

Why In News?

Recently, the **Ministry of Coal** constituted a **Task Force and Expert Committee to prepare the roadmap for Coal based Hydrogen production.**

What is Coal based Hydrogen?

- Coal is one of the important sources of **hydrogen making (Brown Hydrogen)** apart from **Natural Gas (Grey hydrogen)** and **renewable energy (Green Hydrogen) through electrolysis**. In case of renewable energy (Green Hydrogen) surplus solar power is used to electrolyze water into hydrogen and oxygen.
- The **partial oxidation process** is used to **produce hydrogen from coal**, which means some air is added to the coal, which generates carbon dioxide gas through traditional combustion.

How does the picture look for India in this sector?

- In India, Hydrogen demand could **increase 5-fold by 2050**, with use in industry being the major driver.
- In industry, **steel and ammonia will drive growth in hydrogen demand**, followed by refineries and methanol.
- By 2030, costs of hydrogen from renewables will fall more than 50% and will start to compete with hydrogen produced from fossil fuels.
- **Almost 100% of Hydrogen produced in India is through Natural Gas** (Grey Hydrogen).

In this context, pursuing Coal based hydrogen could enable following for India-

Benefits of Coal Based Hydrogen	Challenges of Coal Based Hydrogen
• Since India has the world's fourth-largest coal reserves, **Cost of Hydrogen produced from coal can be cheaper and less sensitive to production** through electrolysis and Natural Gas respectively. • Effective way to **develop clean energy**.	• As current technology hydrogen is made primarily from fossil fuel reformation, this would lead to a **higher rate of carbon dioxide emissions**. • **Safety and storage** problem. • **Issue of building much-needed infrastructure** and developing consumer markets (that is, hydrogen fuel cell vehicles) for a truly clean future fuel.

Road Ahead

The clean hydrogen has the potential to be traded as a new commodity. A lot of work will be required to lay down standards for large-scale use of hydrogen besides framing safety regulations. **India should be proactive in developing and deploying hydrogen technologies,** to indigenize manufacturing and maximize domestic benefits, and introduce penalty on carbon dioxide emission.

6.2.2. ELECTRIC VEHICLES

ELECTRIC VEHICLES AT A GLANCE

Operates on an electric motor, instead of an internal-combustion engine and use a battery pack to store electrical energy.

While some EVs used lead acid or nickel metal hydride batteries, standard for modern EV is now considered to be lithium-ion batteries.

EV market is estimated to be a US$ 7 billion opportunity in India by 2025.

Need/Opportunities for EV push

- **To minimise GHG emissions** as transport sector in India is second largest source of CO_2 emissions.
- **To reduce crude oil import bill**.
- **To meet Paris agreement goals.**
- **Rising motorization rates:** National target of achieving 30% EV sales penetration by 2030).
- Economic opportunities from **New EV related** startups and also intertest from conventional vehicle manufacturers

Challenges in the EV ecosystem

- **Policymakers and Regulators:** No mandate for EV adoption in FAME/State policies, Regulatory uncertainty in charging infrastructure.
- **EV component:** Limited suppliers, Lack of focus on skill development, Availability of limited financing options.
- **Consumers:** High upfront cost, High charging time, Limited availability of charging infrastructure, Limited financing options.
- **Others:** No mandate for DISCOMs to develop charging infrastructure, no mandate for financial institutions to provide funding for EVs.

Initiatives taken

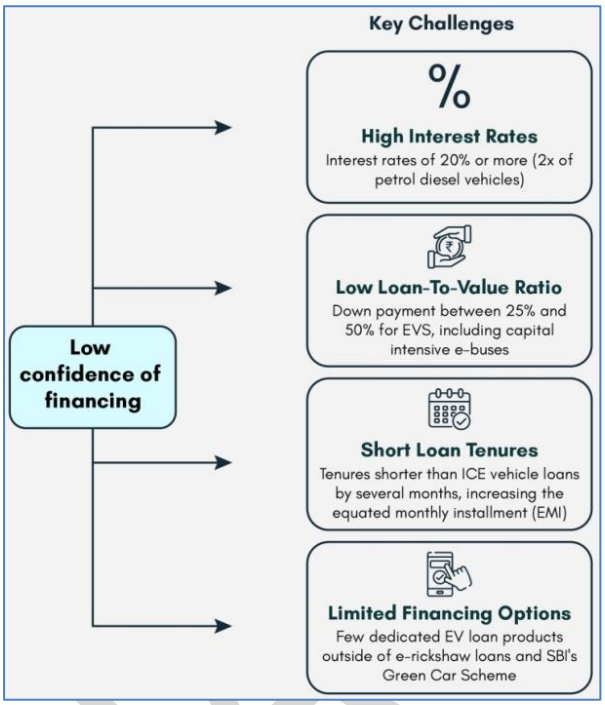
- India launched **E-Amrit portal** (at COP26 Summit) as a one-stop destination for all information on EVs.
- **National Electric Mobility Mission Plan** 2020
- **Draft battery swapping policy** by NITI Aayog.
- **FAME/ FAME II** Scheme
- **Production Linked Incentive** for Advanced Chemistry Cell Battery Storage scheme.
- **States announcing EV policies.**
- Ministry of Power **guidelines on EV charging infrastructure.**
- **ISRO has commercialized** indigenously developed **lithium ion battery technology**

Way Forward

- **Phased Manufacturing Program,** Aatma Nirbhar Bharat to strengthen the battery manufacturing.
- **Active participation of DISCOMs** in planning for EV charging infrastructure.
- **Need policy guidance** on standardization of battery for EVs.
- **Dedicated tariffs and incentives** for EV to encourage adoption.
- **Creation of non-financial incentives** such as priority lanes, reserved parking for better response from consumers.

Why in News?

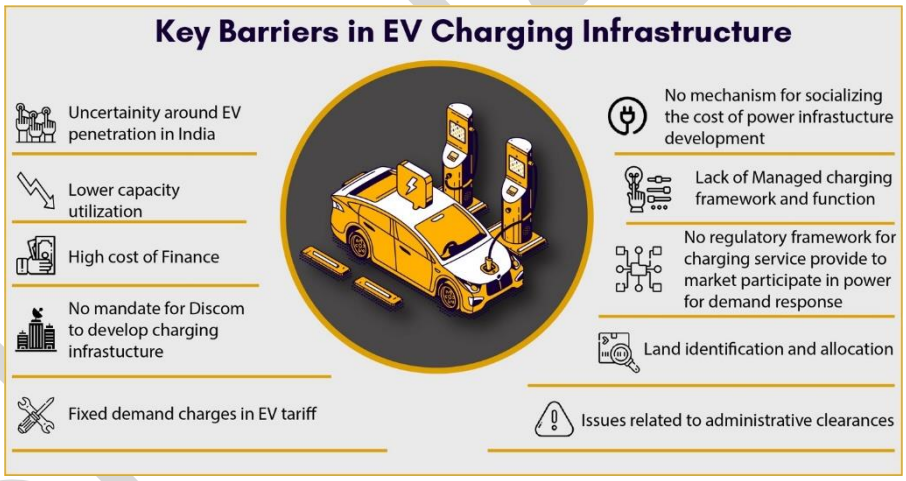
NITI Aayog, Rocky Mountain Institute (RMI), and RMI India released Banking on Electric Vehicles in India report.



Key highlights of the report

- Report provides considerations and recommendations to inform the inclusion of Electric Vehicles (EVs) in the Reserve Bank of India's (RBI's) priority-sector lending (PSL) guidelines.
- **Inclusion in PSL guidelines will**
  - **Increase investor confidence** by providing an additional market signal that complements central and state governments' existing planning and policies.
  - **Institutionalizing the importance of EVs** in India's financial industry
  - **Ensure a swift and equitable transition** by guiding Financial Institutions to increase credit penetration in credit-deficient segments and use cases.

Way forward for uptake of electric mobility in India



- **Phased Manufacturing Program, AatmaNirbhar Bharat,** and incentives announced by several states in their EV policy should be leveraged **to strengthen the battery manufacturing** in medium to long run.
- **Discoms need to actively participate in planning for EV charging infrastructure** because of their inherited capability of existing infrastructure, existing consumer base and superior technical skills.
- **Need policy guidance on standardization of battery for EVs,** and strategies to address huge upfront capital requirement **for a massive uptake of battery swapping business model.**
- **Financial Institutions should be encouraged** to extend their lending facility to electric mobility sector.
- **Creation of non-financial incentives** such as priority lanes, reserved parking for EV only vehicle, EV Purchase subsidy over and above FAME II subsidy etc. **for better response from consumers.**
- **Online portal and single window clearance system** for availing clearances and subsidies/rebate in transparent manner.

6.2.2.1. BATTERY SWAPPING TECHNOLOGY

Why in news?

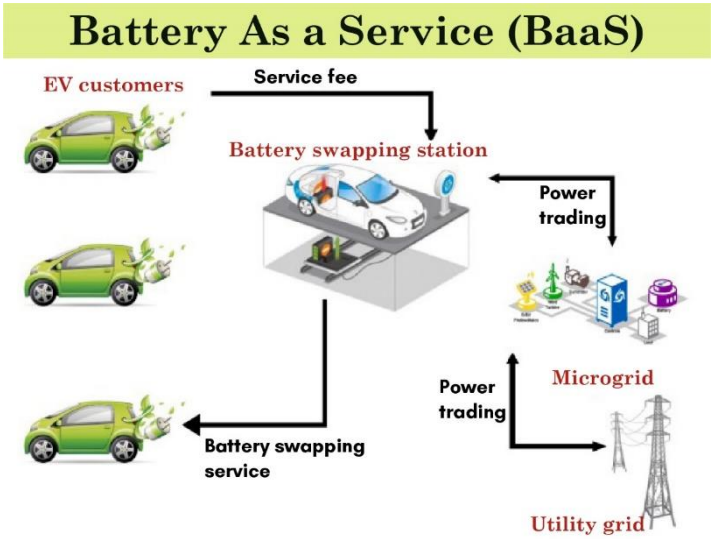
NITI Aayog released Draft Battery Swapping Policy for the comments of Stakeholders**.**

About Battery swapping

- It involves exchanging discharged batteries for charged ones, delinking the vehicle and fuel and hence, reducing the upfront cost of the vehicles.
- **Benefits of battery swapping:**
  - Electric two and three-wheeler having high consumer base in India have **removable batteries**.
  - Quick replenishment of battery charge **eliminates EV drivers' wait time.**

- Swapped batteries can be charged via slow **charging in a controlled environment** to prolong the battery life.
- **Lower upfront cost of EVs**, given that battery leasing will replace battery ownership

- **Disadvantages:**
  - Swap batteries having **lower range**.
  - **Supply chain constraints** with increase in demand of batteries.
  - **All EVs do not have removable batteries**.



Highlights of the policy

- **Phases of policy:**
  - **1st phase** proposes to **prioritise setting up battery-swapping networks in metropolitan cities** with a population above 40-lakh (per Census 2011).
  - **In 2nd phase**, all **major cities such as State capitals, UT headquarters and those with a population of over 5 lakh.**
- Vehicles with swappable batteries will be **sold without a battery**.
- **Any individual or entity is free to set up** a battery swapping station at any location.
- Swappable batteries will be **equipped with advanced features** such as IoT-based battery monitoring systems, remote monitoring etc, to ensure battery safety and security of assets.
- **Bureau of Energy Efficiency (BEE)** will be responsible for the **implementation** of battery-swapping networks across the country.

Related News
EV Fires

- **Amid increasing instances of fires in Electric Vehicle (EV),** Centre has formed a panel to formulate procedures on battery certification and quality control.
  - Move is a bid **to deter such incidents from reoccurring,** which could put off potential EV buyers.
- **Reasons for fire** may include **manufacturing defects, external damage, faulty charging** or faults in the deployment in the battery management system, which could result in these batteries becoming a fire risk.
  - **Different types of batteries** are available to power EVs such as Li-ion, Solid state, Nickel-Metal Hydride etc.
  - However, **Li-ion batteries are most preferred** because of their **high power-to-weight ratio, high energy efficiency, low self-discharge etc.**
- **Steps Taken for Battery Safety**
  - Bureau of Indian Standard (BIS) formulated **performance standards for EV Batteries.**
  - **Constitution of a Probe Committee** to look into fire incidents reasons.
  - **Regenerative braking** to increase its range by recovering energy.
  - **Re-use of EV batteries** in factories and home energy battery storage systems.

6.3. ATOMIC/NUCLEAR FIELD ADVANCEMENTS

6.3.1. EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

Why in news?

Large Hadron Collider (LHC) was restarted after a 3-year shutdown.

Significance of CERN

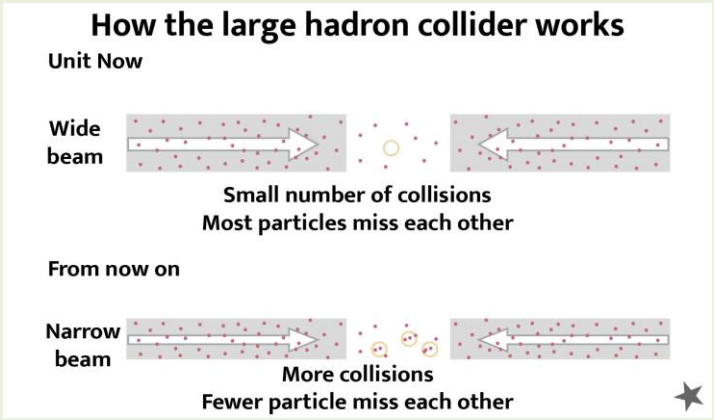
- **Fundamental research**-CERN's flagship accelerator is the LHC which during 2010-2013 brought proof of the existence of the long-sought Higgs boson particle (existence of this particle was predicted by Standard Model).
- **Advancing the frontiers of technology:** CERN also plays a vital role in developing the technologies of tomorrow.
  - **World Wide Web (WWW):** It is the best-known CERN technology. It was invented to allow an ever-increasing number of scientists to share information.

- **The Grid:** Grid harnesses the power of computers around the world. It has been developed at CERN to process the vast amounts of data collected by the LHC experiments.

- **Other technological spin off:** CERN is contributing to a **better planet,** with novel and more efficient technologies like
  - **Industry 4.0,** increasing automation and efficiency
  - Cultural heritage through **art restoration**
  - Developing technologies expected to have **significant impact in the future**

About the Large Hadron Collider (LHC)

- It is the **world's largest and most powerful particle accelerator.** It first started up in **2008** and remains the latest addition to CERN's accelerator complex.
  - LHC is **part of the CERN.**
- It consists of **ring of superconducting magnets** with a number of accelerating structures to boost the energy of the particles along the way.
- Inside the accelerator, **two high-energy particle beams travel at close to the speed of light before they are made to collide**.
- **There are four particle detectors to** record the tracks left by debris from the collisions.



Benefits to India as an associate member of CERN

- **Accessibility to scientific data:** As an Associate member India can access to all data generated at CERN. As there are many experiments in CERN, there will be plenty of information available.
- **Influencing policy:** India's associate membership status ensures India has a larger say in decisions regarding scientific policy formulation and experiments at the highest levels.
- **Access to research facilities:** Indian scientists are eligible to apply for staff appointments at CERN. Indian graduate and doctoral students can attend different educational programmes and workshops held by CERN.
- **Benefits for Indian Industry:** Indian industry can bid for CERN contracts, allowing for industrial cooperation in scientific research.
- **Full membership:** India also has the option of applying to become a full member after two years. Full membership will grant India the right to vote.

Conclusion

It is expected that the upgraded LHC may find an unknown fifth force of nature and the Dark Matter that makes up most of the Universe, this would bring a paradigm shift for understanding the origin and evolution of the Universe. As India has been important part of this experiment, any new discovery would also further enhance the image of India in the field scientific milieu.

Related News
10 years of Higgs Boson
About Higgs Boson

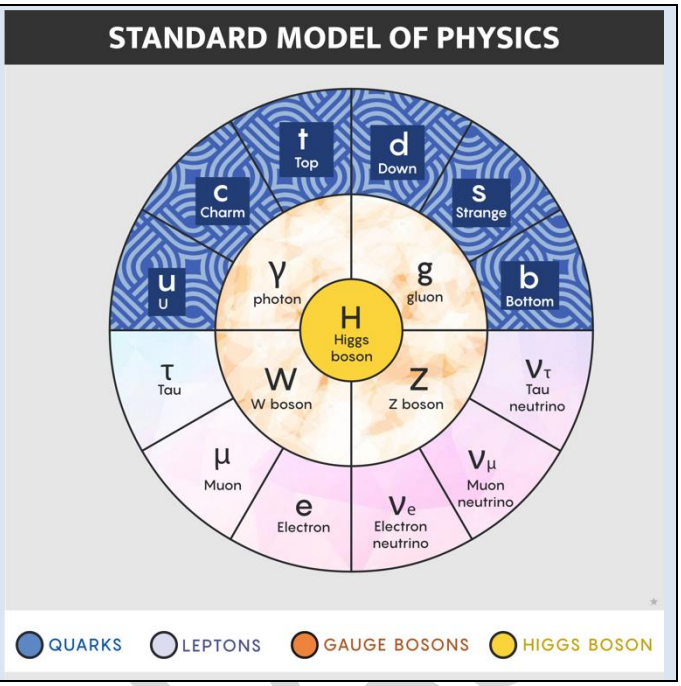
- Scientists refer to the Higgs boson as the **'God Particle', because it is one that is responsible for creation.**
  - It was first **predicted by Peter Higgs in 1960's.**
- Higgs boson is the **fundamental particle associated with the Higgs field**, a field that gives mass to other fundamental particles such as electrons and quarks.
  - **All matter is made up of atoms**; if you split open an atom you find **electrons, protons and neutrons**.
  - **In proton or neutron you will find** sub-sub-atomic particles — **quarks, leptons and bosons.**
  - Quarks and leptons have mass, but **bosons are a sort of a force.**

Significance of Higgs Boson

- It would help to understand as to **why elementary or fundamental particles** (smallest building blocks of nature) **have mass.**
- Higgs boson have **confirmed predictions of standard model of particle physics.**

- It is a set of mathematical formulae and measurements **describing fundamental particles and their interactions.**
- It contains **12 fundamental matter particles** categorised as **quarks and leptons and three forces that govern the behavior of matter: electromagnetism, the strong and weak nuclear forces.**

- **New technologies are continuously being developed** from particle accelerators such as the LHC, despite their primary goal of searching for particles like the Higgs boson.
- Higgs boson can also **help in finding signs of dark matter**.
  - Dark matter is the **matter that does not absorb, reflect, or emit light,** making it extremely hard to spot.



6.3.2. NEUTRINO OBSERVATORY

Why in News?

Tamil Nadu government has **filed an affidavit** in the Supreme Court stating that it would not permit the proposed **India based Neutrino observatory (INO)** at **Bodi West Hills in Theni district.**

About Neutrinos

- Neutrinos are **tiny, neutral, elementary particles which interact with matter via the weak force.** The weakness of this force gives neutrinos the property that **matter is almost transparent to them.**
- Neutrinos hold the key to several important and fundamental **questions on the origin of the Universe and the energy production in stars.**
- Another possible application of neutrinos is **its role in detailed investigation of the structure of the Earth** from core onwards.

About India based Neutrino observatory (INO)

- **INO will observe neutrinos produced in the atmosphere of the Earth.** The site identified is in Bodi West Hills, in Theni district, Tamil Nadu.
- Project is a multi-institutional effort aimed at building a world-class **underground laboratory for non-accelerator based high energy and nuclear physics research in India.**
- It is **jointly funded** by Dept. of Atomic Energy and the Dept. of Science and Technology.

Why neutrino observatories are located underground?

- **It is impossible to detect neutrinos on the surface of the Earth.** This is the reason most neutrino observatories are located deep inside the Earth's surface.
  - **One of the earliest laboratories in the world** to detect neutrinos was located **at Kolar Gold Field mines in India.**
- There are two types of underground laboratories: **either located in a mine or in a road tunnel.**
- **There are now four major laboratories around the world:** in Sudbury in Canada, Kamioka in Japan, under the Gran Sasso Mountains in Italy and in Soudan mines in the USA.

- **Project includes:**
  - **Construction of an underground laboratory** and associated surface facilities at Pottipuram in Bodi West hills. The underground laboratory will consist of a large cavern and several smaller caverns.
  - **Construction of an Iron Calorimeter (ICAL) detector** for studying neutrinos. It will be a magnetized ICAL, which will be the heaviest one made by any country.
  - **Setting up of an Inter Institutional Centre for High Energy Physics** (IICHEP) at Madurai, for the operation and maintenance of the underground laboratory, human resource development etc.
- INO has **no strategic or defence applications**. Its operation **involves no radioactivity release** or toxic emissions.
- However, there is controversy surrounding the project as **activists say the observatory will have devastating impacts on the local biosphere and people's health.**

Significance of INO Project

- Primary goal is the **study of neutrinos from various natural and laboratory sources** using an ICAL detector.
- It will **tell more about the properties of neutrino particles.** The aim is to make precision measurements of the parameters related to neutrino oscillations.
- INO will have an **impact on the emerging high energy physics scenario** in the country. It will host other experiments such as the neutrino-less double beta decay and the search for dark matter.
- Over the long term INO is expected to develop into **a world class underground science laboratory straddling many fields** like physics, biology, geology and allied engineering fields.
- **Students of science and technology** within the country will have the **opportunity to involve themselves in research involving cutting science and technology.**

Affidavit by TN raised following concerns over INO Project

- **Tunnelling work** would create the problems like construction waste material, rock bust, and roof collapse movement in the eco-fragile area.
- **Biodiversity impact as** the region harbours **many endemic species**.
- The area is a significant **watershed and catchment zone** for the rivers Sambhal and Kottakudi, and **supports livelihoods** in five districts of Tamilnadu.
- The project area links **Periyar Tiger Reserve** in Kerala with **Srivilliputhur Meghamalai** Tiger Reserve. Quarrying and construction activities will **upset wild animals** which use the **corridor for seasonal migrations**.

6.3.3. NUCLEAR FUSION

Why in News?

Scientists in the UK have managed to produce the largest amount of energy so far from a nuclear fusion reaction.

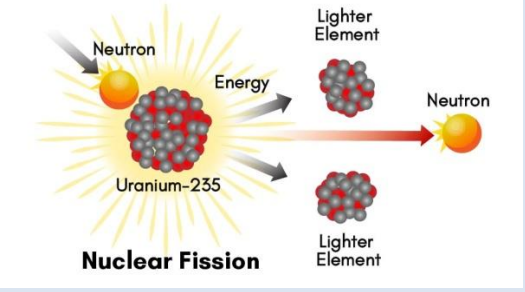
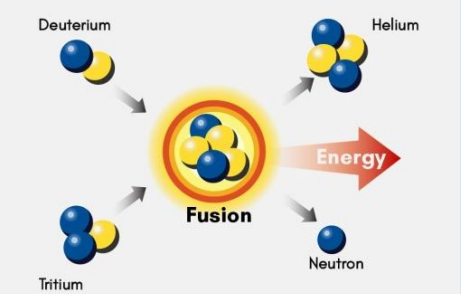
More on News

- A team at the Joint European Torus (JET) facility near Oxford in central England generated **59 megajoules of sustained fusion energy in a machine called a tokamak**.
- All **current nuclear reactors are based on the fission** process.

Tokamak

- Inside a tokamak, the energy produced through the fusion is **absorbed as heat in the walls of the vessel**, which will be used by a fusion power plant to produce steam and then electricity by way of turbines and generators.
- The device uses **magnetic fields** to contain and control the hot plasma, which enables the fusion between **deuterium and tritium nuclei** to produce great amounts of energy.
  - **Plasma** is an ionized state of matter similar to a gas. A gas becomes plasma at extreme temperatures.
- The **machine has been designed** specifically to:
  - **Produce 500 MW of fusion power**
  - **Demonstrate the integrated operation of technologies for a fusion power plant** such as heating, control, diagnostics, cryogenics and remote maintenance.
  - **Achieve a deuterium-tritium plasma** in which the **reaction is sustained for a long duration** through internal heating
  - **Test tritium breeding**: Since the world supply of tritium is not sufficient to cover the needs of future power plants.

Difference between Nuclear fission or fusion

Criteria	Nuclear Fission	Nuclear Fusion
Energy release through	Splitting of a heavy, unstable nucleus into two lighter nuclei	Combining of two light nuclei
Process		

Fuel	Uranium and plutonium	Atoms of Tritium and Deuterium (isotopes of hydrogen)
Amount of energy produced	Lesser than that in nuclear fusion	Several times greater than fission
Waste generated	Highly radioactive fission products	Produces **no high activity/long-lived radioactive waste**. The burnt fuel in a fusion reactor is helium, an inert gas.
Operational life	Additional neutrons released can initiate a Chain reaction sustaining fission reactions for longer durations	Difficult to sustain for long periods of time due to the tremendous amount of pressure and temperature needed

Advantage of Nuclear Fusion

- **Much more energy** (as much as four times) is released in the fusion process than in fission.
- Fusion **doesn't emit harmful toxins** like carbon dioxide or other greenhouse gases into the atmosphere. Its **major by-product is helium:** an inert, non-toxic gas.
- **No risk of meltdown** as it is difficult to reach and maintain the precise conditions necessary for fusion.
- **Limited risk of proliferation** as fusion doesn't employ fissile materials like uranium and plutonium (Radioactive tritium is neither a fissile nor a fissionable material).
- **Fusion fuels are widely available** and nearly inexhaustible.
- Produces much **less radioactive waste compared to fission.**

Challenges faced in fusion process

- Fusion is **possible only at very high temperatures,** of the order of a few hundred million degrees Celsius.
- At such high temperatures, **matter exists only in the plasma state, which has a tendency to expand very fast**, and is extremely difficult to handle and work with.
- **Fusion reactions are not easily controlled,** and it is expensive to create the needed conditions for a fusion reaction.

Over the years, scientists have been able to draw up the plan for a fusion nuclear reactor. It is called ITER (International Thermonuclear Experimental Reactor).

About ITER (International Thermonuclear Experimental Reactor)

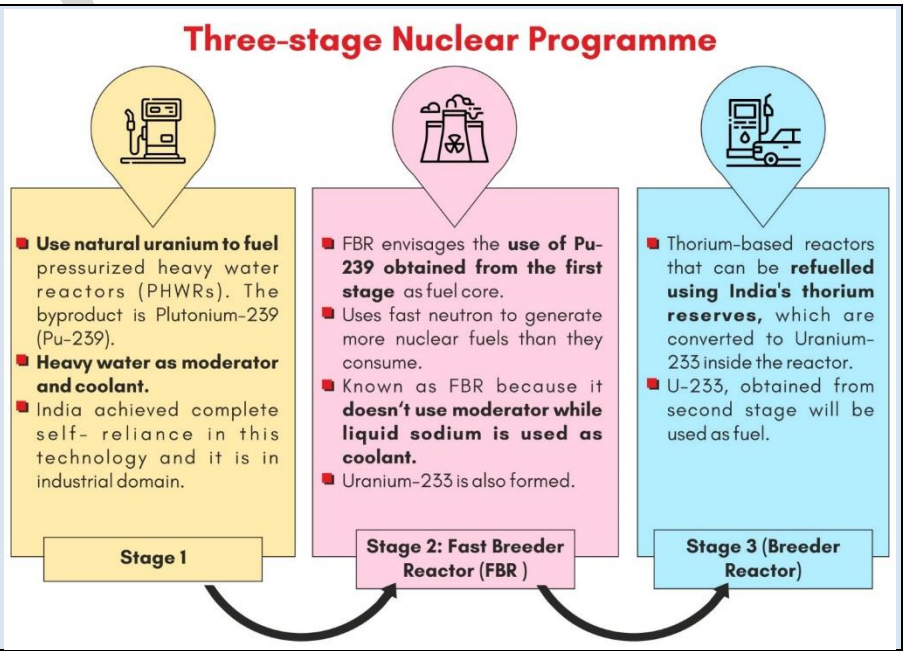
- Launched in 1985, ITER is an **experimental fusion reactor facility** currently under construction in Cadarache, south of France.
- It aims to prove the feasibility of **nuclear fusion as a future source of energy** and build the world's largest **tokamak** through an international collaboration**.**
- **ITER Members:** Signatories to the ITER Agreement include **China**, the **European Union**, **India**, **Japan**, **Korea**, **Russia** and **US**.
- **India's contribution:** India is responsible for delivery of cryostat, in-wall shielding, cooling water system, cryogenic system, heating systems, Diagnostic Neutral Beam System, power supplies and some diagnostics.
  - **ITER-India (**under Dept. of Atomic Energy **)is the Indian domestic agency.**

Related News

Recently, government announced that India will have 9 nuclear reactors by 2024.

More on News

- There are **presently 22 reactors with a total capacity of 6780 MW** in operation.
  - As on December 2021, share of Nuclear energy in **total Installed generation capacity stands at 1.7%.**
- Indian Nuclear Power Generation **envisages a Three Stage Programme.**
- India is currently on the **second stage (FBR) of its ambitious nuclear program.**



Need for nuclear development in India

- **Energy security:** Nuclear security, by providing provide a large scale of electricity generation, is an important component of achieving energy security.
- **Less impact on climate:** Nuclear reactors do not produce greenhouse gases like power plants using coal and, therefore, can increase electricity generation without contributing to climate change.
- **Replacing conventional energy resources:** Increased share of nuclear power in the Indian energy mix will help diminish the reliance on conventional coal based energy plants.
- **Continuous supply of electricity:** They can provide a steady supply of electricity because unlike solar and wind power sources, nuclear plants can operate when there is no sun or wind.
- **Nuclear Energy and Foreign Policy Nexus:** Nuclear energy plays a substantial role in the formation of bilateral relations among nations.

Challenges

- **Uranium contamination** of ground water due to Mining.
- **Purity of Uranium:** In comparison to world occurrences, uranium deposits established in India are mostly of low-grade.
- **Anti-nuclear protests:** Following the 2011 Fukushima nuclear disaster in Japan, populations around proposed Indian Nuclear power plant sites have launched protests.
- **Syncing with foreign players:** Engaging with foreign suppliers means dealing with problems of capacity, queued bookings and uncertainty.
- **Other Issues:** Factors such as problems on land acquisition, rehabilitation/resettlement of affected persons, reserve forest/tiger sanctuary locations, socio-political issues, public consensus, etc.

Way forward

Certain steps need to be taken to ensure the safety and security of using nuclear power. This includes:

- Ensure maintenance of the skills base.
- Maintain continued effective safety regulation.
- Foster progress on facilities for waste disposal and management must be given serious consideration.
- Maintain and reinforce international non-proliferation arrangements.

6.4. SOLAR FLARE AND GEOMAGNETIC STORM

Why in news?

Recently, sun emitted a large solar flare that was **observed by NASA's Solar Dynamics Observatory. (SDO).**

About Solar Flares

Solar flare classification	Associated X-ray flux - I (W/m^2)	Possible effects on Earth
B	$I < 1E\text{-}06$	none
C	$1E\text{-}06 \leq I < 1E\text{-}05$	Possible effects on space missions.
M	$1E\text{-}05 \leq I < 1E\text{-}04$	Blackout in radio transmissions and possible damages in astronauts outside spacecraft.
X	$I \geq 1E\text{-}04$	Damage to satellites, communication systems, power distribution stations and electronic equipment

- **Solar flares** are a sudden explosion of energy **caused by reorganizing of magnetic field lines near sunspots.**
- In a solar flare, **energy stored in the sun's magnetic structures is converted into light and heat energy.** This causes the emission of high energy x-ray radiation and highly accelerated charged particles to leave the sun's surface.
    - Sometimes solar flares **also cause hot plasma to be ejected from the Sun,** causing a solar storm **called Coronal Mass Ejection (CME).**
    - These Coronal Mass Ejections (CME) when collide with the Earth cause **geomagnetic storm** (GMS).
- GMS is a **disturbance in the earth's magnetosphere,** which is the area around the planet controlled by its magnetic field.
    - Earth's magnetosphere protects its inhabitants from most of the particles emitted by the sun.
    - It is **caused by massive exchange of energy from the solar wind into the space environment** surrounding the Earth.
    - GMS are **categorised between G1 and G5,** the **latter being the strongest**
- **Impacts of solar flare and GMS:**
    - Triggers intense lights in the sky, called **Auroras.**
    - **Damage satellite electronics** and expose astronauts and high-altitude pilots to increased levels of radiation.
    - Voltage surges due to altered magnetic activity can **affect power supply on earth** and cause outages.
    - Can hit **operations of space-dependent services** like **global positioning system (GPS), high-frequency radio broadcasts,** and satellite communications.

Related Terms:

- **Sunspots** are areas that **appear dark on the surface of the Sun** and are cooler than other parts of the Sun's surface influenced by the magnetic flux of the sun.
- **Plasma** is the highly ionised gas present on the sun, while corona is the outermost part of the sun's atmosphere.
- **A magnetosphere** is that area of space, around a planet, that is **controlled by the planet's magnetic field.**
- Auroras are caused by the **interaction of energetic particles** (electrons and protons) of the solar wind **with atoms of the upper atmosphere** occurring primarily in high latitudes of both hemispheres.
    - Auroras in the Northern Hemisphere are called **aurora borealis, aurora polaris, or northern lights,** and in the Southern Hemisphere **aurora australis, or southern lights**.

6.5. USE OF TECHNOLOGY IN AGRICULTURE

AGRICULTURE AND TECHNOLOGY AT A GLANCE

Drivers of Agricultural technology growth in India

Increasing population, increasing average income and globalization effects increase demand for quantity, quality and nutritious food, and variety of food.

To build an agriculture and food system that is efficient, environmentally sustainable, equitable, and able to link farms with consumers.

India is the third-largest nation in terms of funding received and start-ups in the agritech space. Agritech is projected to grow to a $30-$35 billion market by 2025.

Applications of technology in Agriculture

- **Crop and soil monitoring** (where companies are leveraging sensors and internet of things, or IoT-based technologies.
- **Predictive and agricultural analysis** (where artificial intelligence and machine learning, tools are used to predict the optimal time to sow seeds or to raise alert about possible pest attacks)
- **Real-time data analytics** to build an efficient and smart supply chain

Schemes/Initiatives

- **National e-Governance Plan in Agriculture (NeGPA)** for timely access to agriculture related information through ICT use.
- **AI-Sowing App** developed in collaboration with International Crops Research Institute for the Semi-arid Tropics (ICRISAT).
- **ISRO's Geo-platform, Bhuvan**, provides valuable data on the plantation, pest surveillance and weather.
- Krishi Vigyan Kendras (KVKs) mandated with **Technology Assessment and Demonstration for its Application and Capacity Development (TADA-CD).**
- **Agristack**, a unified platform for provision for end-to-end services.
- Promotion of **Kisan Drones** for crop assessment, digitization of land records, spraying of insecticides and nutrients.

Constraints

- **High transaction cost** because of small farm holdings, shortage of power and infrastructure, insufficient human capital investments.
- **Surplus Agricultural labour and farmer's reluctance** to invest in tech solutions **due to lack the skills and knowledge**
- Public as well as private sector **investment in agri R&D is low.**
- **Regional imbalances** in credit disbursement.
- **Hilly and rolling topography** with mixed cropping and integrated farming.

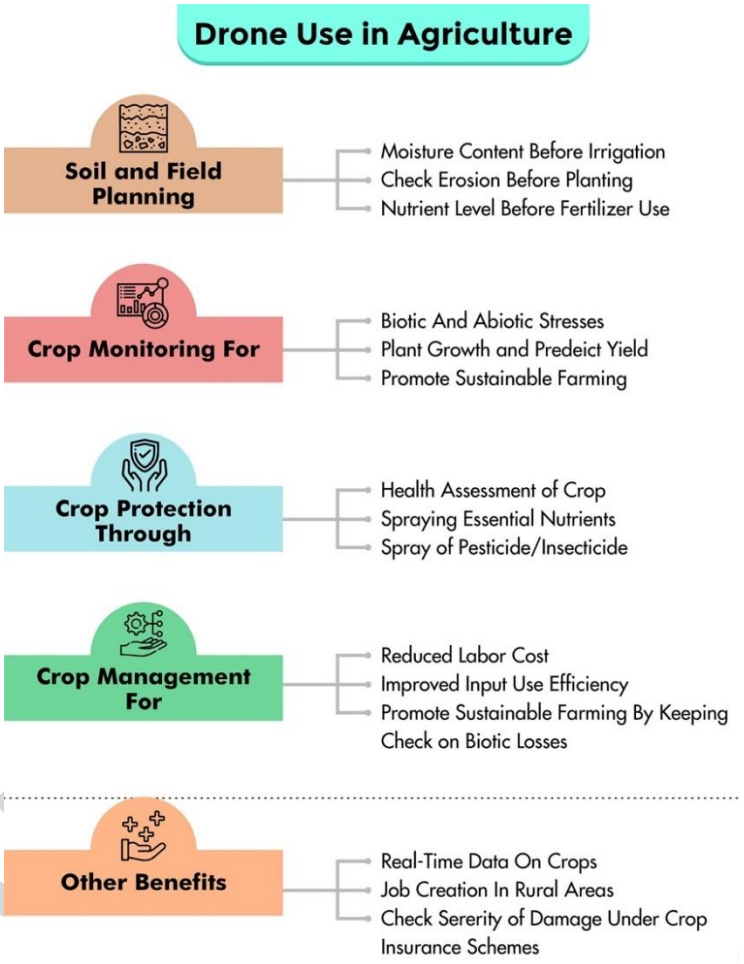
Way Ahead

- Review regulations constraining the adoption of technologies.
- Innovative financial arrangements and micro-loans might be required to increase adoption.
- Support digital entrepreneurship ecosystems for innovative agri focused solutions.
- Bring awareness on digital and hi-tech services to farmers.
- Indigenous Research and Development to roll out farmer-friendly and location specific agricultural machinery.
- Encouraging farm mechanization through Agriculture Machine Banks at district level for leasing of farm equipment.

6.5.1. DRONE TECHNOLOGY IN AGRICULTURE

Why in News?

Recently, the Union Agriculture Minister released the **Standard Operating Procedure** (SOP) **for use of Drone in Pesticide Application** for Crop Protection and for spraying Soil and Crop Nutrients.



Major Provisions of the SOPs

- It covers instructions on **pre, post and during operation, emergency handling plan** for effective and safe operations of drones.
- The SOP covers important aspects of **Pesticide application** and drones can be used in Agricultural, Forestry, Non-Cropped Areas, etc.

Potential of Drone Technology use in Agriculture

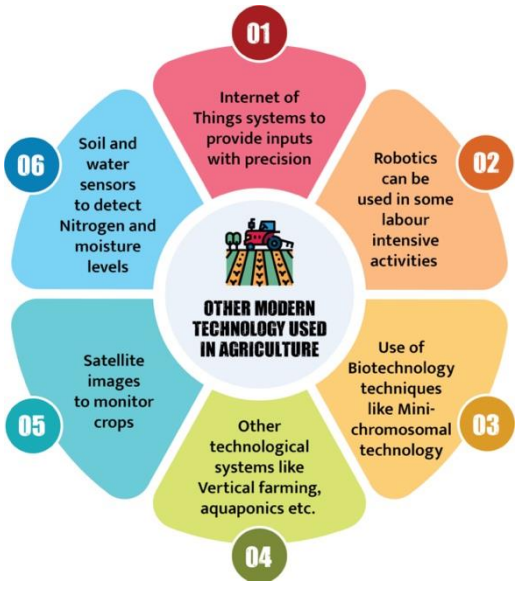
- Finding use in many fields, it holds potential to **modernize the routine manual agriculture** activities as well by **linking with AI, machine learning (ML)** etc.
- It will also help in **finding solutions to:**
  - **Addressing Increasing food demand** with world population predicted to reach 9 billion by 2050;
  - **React faster to pest invasions**. E.g., in 2020, drones were used in fight against the attack on crops by swarms of locusts in India.
  - **Help in Smart Agriculture** through direct communication between drones and other agricultural equipment.

Why use drones for spraying pesticides?

- Being toxic in nature (Biocides), the Conventional pesticide use methods carry issues like:
  - **High Labor Cost, Lower spray uniformity** and **excessive application.**
  - **Health and environment risks** on **Oral, respiratory or dermal** (by skin) contact; pollution of soil and water.
- Drones use can **help address most of these issues.**

Challenges

- **Unviable Commercial Operation** due to small and scattered landholding. E.g. According to the Agriculture Census (2015-16), around 86% farmers in India hold land less than 5 acres.
- **Limited Flight time and range** of Drones due to relatively high payloads (20-60 minutes).
- **High Initial costs** of drones with maintenance issues.
- **Connectivity issues** in rural areas for online coverage.
- **Knowledge and skill issues** as it needs specialized skills and knowledge from farmer to utilize drone inputs,
- **Concerns over misuse of drones** to infringe privacy and security (especially in border areas).
- **Weather dependence** with difficulties to operate in windy or rainy weather.



Way Forward

Drone Rules, 2021, SOPs and **PLI scheme for drones** would benefit all sectors including agriculture.

The **Indian Council of Agricultural Research** (ICAR) is already working on **SENSAGRI, SENsor based Smart AGRIculture** to develop indigenous prototype for drone based crop and soil health monitoring system.

We should further expand the **scope of research** to study the quality of its operations and **fine-tune telecom, skill,** and **other policies/initiatives** to address the challenges of connectivity and skills among others.

6.6. SCIENTIFIC SOCIAL RESPONSIBILITY GUIDELINES 2022

Why in news?

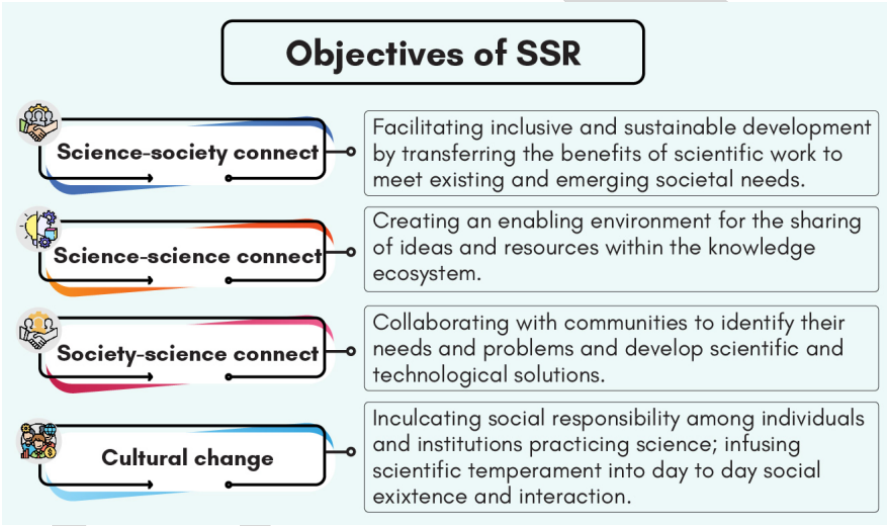
Recently, **Department of Science and Technology (DST)** has released Scientific Social Responsibility Guidelines 2022.

About Scientific Social Responsibility (SSR)

- It is defined as the **ethical obligation of knowledge workers** in all fields of science and technology **to voluntarily contribute their knowledge and resources** to the widest spectrum of stakeholders in society, in a spirit of service and conscious reciprocity.

About SSR Guidelines 2022

- All Central Government Ministries and State Governments would **plan and strategize their SSR** in accordance with their respective mandates.
- Every knowledge institution would **prepare its implementation plan in consultation with Anchor Scientific Institution (ASI)** for achieving its SSR goals and prepare its SSR code of conduct.
- Every knowledge worker is expected to **contribute at least ten person-days in a year towards SSR over and above their regular work** except those in administration or are involved directly in the management of SSR implementation.
- There should be an **SSR assessment cell in each institution** to periodically assess institutional projects and individual activities and each knowledge institution would publish an annual SSR report.
- SSR activities and projects of a knowledge institution **would not be outsourced or subcontracted.**



Need of SSR Guidelines

- **Social welfare:** SSR facilitate the integration of science and society and build synergy among the stakeholders thereby ensuring transfer of scientific knowledge for the benefit of society.
- **Attitudinal change:** in the mindset and the work style of the scientific community, thereby enhancing the social outreach of our scientific community.
- **Self-reliance:** SSR has the potential to fundamentally transform society by improving the lives of our citizens towards building a self-reliant nation.

- **Sustainable development:** SSR would strengthen the existing initiatives of the government such as transformation of Aspirational Districts, Make in India, Swachh Bharat and Digital India towards achieving inclusive growth and sustainable development.
- **Access to and sharing of resource and knowledge:** Despite making a good progress in Science Technology and Innovation (STI), the transfer of scientific knowledge and its benefits to society remains an area of concern.

Conclusion

Thus, SSR guidelines envision a scientific ecosystem with systematically evolved interconnections among stakeholders to create two-way engagement among science and society in the pursuit of a more driven scientific community building a self-reliant nation.

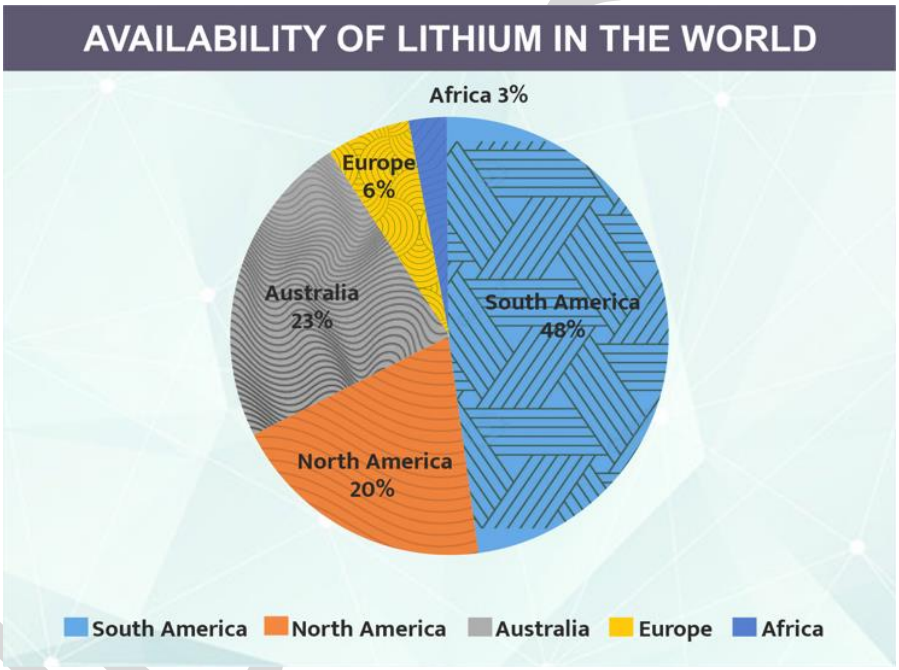
6.7. LITHIUM-ION BATTERY

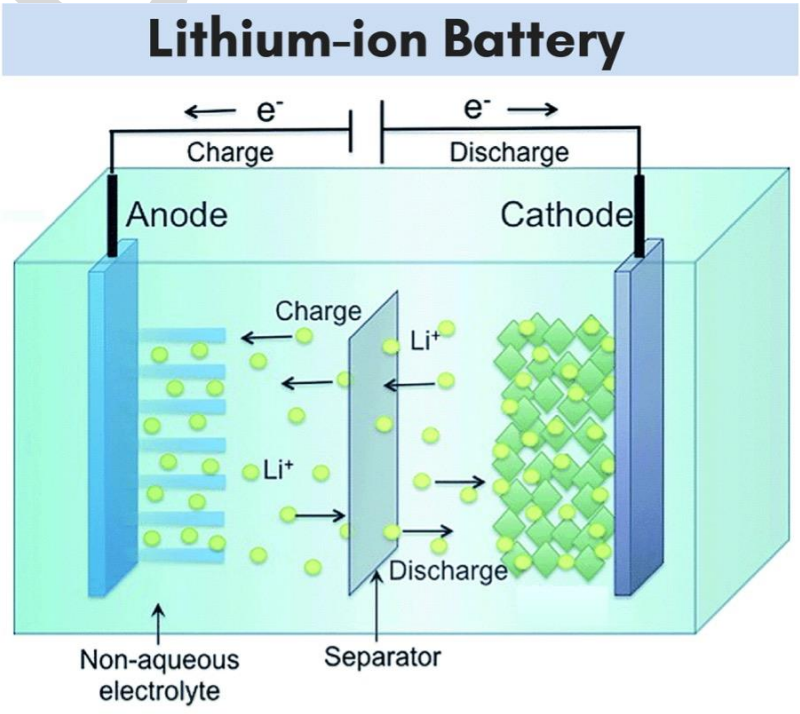
Why in news?

Recently Union Government has constituted an expert panel to probe the recent series of battery explosions in electric vehicles (EVs).

About Lithium-Ion batteries

- A lithium-ion battery is a **type of rechargeable battery** that is charged and discharged by lithium ions moving between the negative (anode) and positive (cathode) electrodes.
- Their **applications include consumer electronics such as** smartphones and PCs, industrial robots, production equipment and automobiles.





Advantages of lithium-ion battery

- **High specific charge density:** the parameter for detecting the amount of charge a battery can supply, at a particular time period.
- **High voltage**: Lithium-ion battery provides 3 to 3.5 volts, which is 3 times higher than Nickel Cadmium (Ni-Cd) batteries and enough to be used for various purposes.
- **High energy density:** It is light weight and has high energy density i.e., stores more energy per unit of weight.
- **Low self-discharge**: hence can be used even after batteries are non-operational for some period of time.
- **Applicability:** Due to high-power densities, lithium-ion batteries are used in everyday electronic products such as semi-conductors, laptops, smartphones, and electric vehicles.

Disadvantages and concerns of Lithium-ion batteries

- **Thermal runaway**: It occurs due to melting of the electrolyte, high operational temperature, poor quality of the battery cells and battery pack assemblies, and lack of active cells assemblies, which leads to catching fire.

Steps taken for Lithium-ion batteries in India

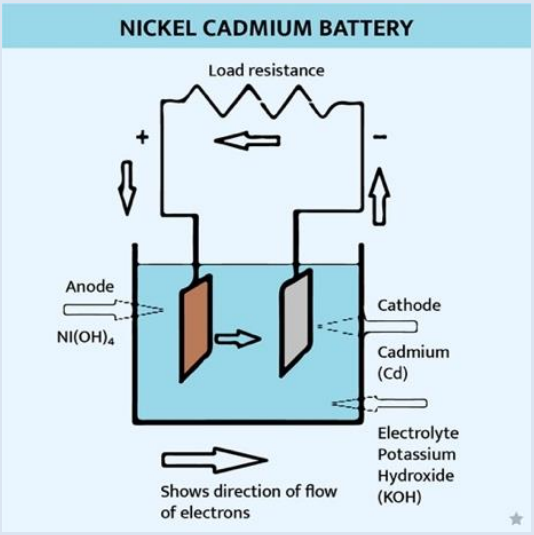
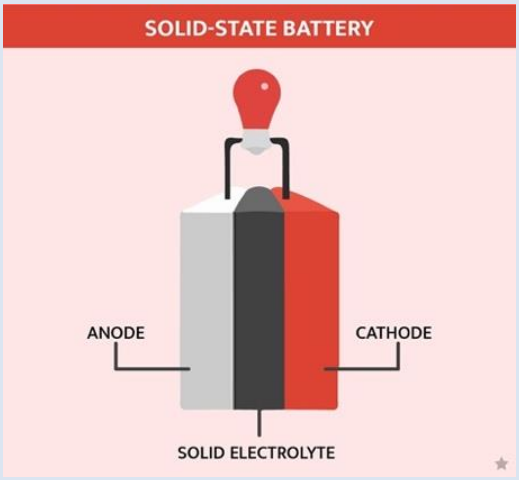
- **National Mission on Transformative Mobility**: to encourage **domestic Lithium-Ion Cell manufacturing** and EV components.
- **ISRO and BHEL agreement:** to develop low-cost lithium-ion batteries.
- **Lithium triangle nations**: India is focusing on **'Lithium Triangle' nations Argentina, Bolivia and Chile** for **joint manufacturing and facilitating the process of acquiring Lithium.**

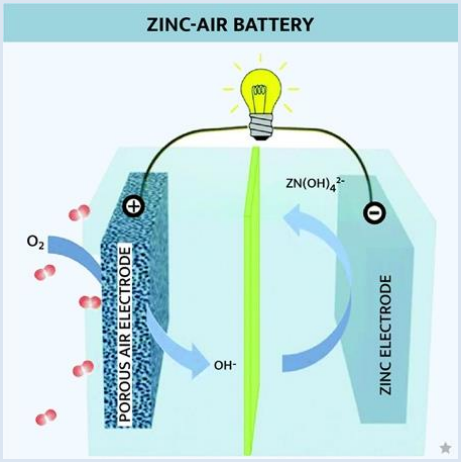
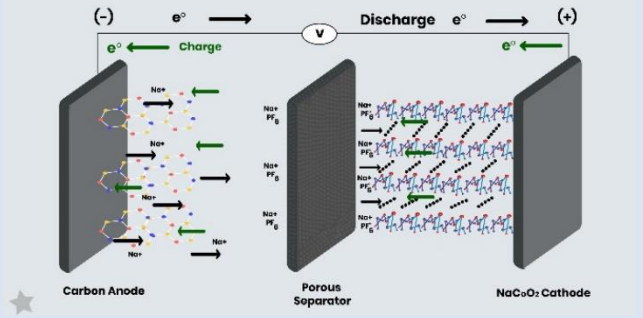
- **Less stability**: More the energy density less the stability of the batteries.
- **High reactivity**: Lithium metal is extremely reactive and can potentially short-circuit the cell.
- **Unavailability of lithium**: Battery-grade lithium is less available in India and the country is dependent on import of Li-ion battery cells from China, South Korea, or western Europe.
- **Fragility:** Li-ion is fragile and it needs a protective circuit to keep it running safely.

Way forward

- **Battery thermal management (BMS):** Strong and smart BMS monitors the temperature of the entire battery pack and each cell closely and active cooling system is triggered when temperature reach the maximum levels.
- **Avoid overcharging**: A battery can instigate formation of dendrites which can hinder battery longevity and cause short circuit. Hence overcharging to be avoided.
- **Store and charge in specified temperature**: Follow manufacturer specifications to store and charge batteries. Generally, it is safe to charge between 32° and 113° F and discharge between -40° and 131° F.

Comparison of Lithium-ion battery with other battery types

Nickel-cadmium battery	• **Prone to memory effect** that can cause a battery to lose electrical storage area, while **Lithium-ion batteries are not.** • Can be **stored or used for up to 5 years as compared to 2-3 years for** Lithium-ion batteries. • **Nearly four times less energy density** than that of lithium-ion cells. • Can offer **more than 1,000 charge and discharge cycles**, while Lithium-ion batteries offers between 300 and 500 charge and discharge cycles. • Have a **higher rate of self-discharge than lithium-ion batteries.** • **Li-ion batteries do not contain toxic cadmium**, which makes them easier to dispose of than Ni-Cd batteries.	
Solid-state battery	• **Replaces the polymer separator used in lithium-ion batteries with a solid-state separator**, which is more energy-dense. • **Lowers charging time and improve life by eliminating the need to have lithium diffuse** into the carbon particles as in conventional lithium-ion cells. • Solid-state **batteries can hold up to 50% more energy that their lithium-ion counterparts.** • Solid state battery is new technology and **till now perfect material for a solid electrolyte has been difficult to be found.**	

Zinc-air battery	• Unlike Li-ion batteries, in **zinc-air batteries only anode replacement is required rather than the entire battery.** • **Zinc is extensively available and this would naturally reduce reliance on countries like China or South Korea** for Li-ion battery cells, reducing imports. • **Zinc air batteries are less expensive** than Li-ion batteries. • **Zinc air batteries are water-based,** have a longer shelf-life and have ahigh turnaround efficiency.	
Sodium-ion battery	• **As compared to Lithium-ion battery, Sodium-ion battery replaces the polymer separator** used in lithium-ion batteries with a solid-state separator, which is more energy-dense. • **It also lowers charging time and improve life** by eliminating the need to have lithium diffuse into the carbon particles as in conventional lithium-ion cells.	

WEEKLY FOCUS

Science and Technology

TOPIC	DESCRIPTION	LEARN MORE
 5G Technology Challenges and Opportunities	5G Technology is one of the lynchpins in the emerging parlance of 4th Industrial Revolution as it drastically alters economy and the life around us. The omnipresence of this technology also brings in a geopolitical dimension to this debate. The multi-dimensional impact of this technology necessitates adoption of a progressive, open but cautious approach for a country like India given the developments in relation to China and United States.	
 Clean Coal Technologies	Coal is regarded as the dirtiest energy resource with the highest carbon emission coefficient, but it plays a vital role in electricity generation worldwide. Given the importance of coal in the global energy framework, and the difficulty in phasing out its use, at least in the foreseeable future, the development of clean coal technologies (CCTs) has been pressed as an appropriate way to achieve both coal-driven energy production and environmental protection.	
 AI and National Security	Artificial intelligence (AI) is a rapidly growing field of technology that is capturing the attention of commercial investors, defense intellectuals, policymakers, and international competitors alike. Recently, developments like increased use of AI in cyberattacks and growth of hybrid warfare techniques have showcased how AI can potentially affect National Security. AI presents many opportunities vis-à-vis National Security along the challenges. In this context, it becomes important for India to keep pace with the integration of technological growth and defence.	
 Data-Driven Innovations and Privacy	Data is the new oil and data-driven innovations are the new sources of growth. However, the story is incomplete without talking about the privacy of data generators. This document explains various types of data, their usage and the inter-relationships that exist between innovation and privacy. Further, it also provides an insight into how a middle path can be identified that can protect data privacy while promoting the culture of data-driven innovations.	

 Space Exploration: Changing dynamics & pathway to the future	Space exploration has played an important role for countries with regard to their economies and security. With the sector experiencing substantial growth, the need for collaboration in the sector has also increased. India being an emerging power in the sector can play a vital role in creating and enabling space collaboration.	
 Cryptocurrency: A tool of Economic Empowerment or a Regulatory Nightmare?	Cryptocurrency is having its best year yet in 2021; becoming more popular, mainstream, and accessible. But, is there a future for cryptocurrency in India? In what form cryptocurrency would be acceptable to Indian lawmakers and regulators remains to be seen. Discussing the basics of cryptocurrency, the document puts light on their role in economic empowerment of the masses and the path ahead to overcome the emerging regulatory challenges due to their increased usage.	
 Universal Immunisation Towards A Healthier And A Safer World	The recently launched global immunisation agenda aims for a world where everyone, everywhere, at every age, fully benefits from vaccines for good health and well-being. The document provides an insight into the science of how a vaccine activates immune system of our body and protects us against deadly diseases. Going ahead, it discusses why universal immunisation across the globe is the need of hour and assesses India's progress in this direction.	
 India's Vaccination Drives: Strategy, Obstacles and Opportunities	Launching the most awaited COVID vaccine, India started its journey on the road to recovery from a pandemic that has unprecedently disrupted and taken lives. India is now also the fastest country in the world to achieve the 100 million vaccination mark. This document takes us through the story of India becoming the global leader in vaccine manufacturing and analyses the success stories, existing bottlenecks in the system and the potential opportunities. It also delves into the ongoing debate over the efficacy of vaccine diplomacy as pursued by India.	
 Quantum Technology in India: Exploring the possibilities ahead	We are at the dawn of a new era, the age of quantum technology. A new generation of quantum technologies will cut across most of the emerging technologies we know today, empowering many of them while threatening the security of others. This document explains different aspects of quantum technologies, including the way they work, their inevitable impact at both the technological and social level, the actions governments and technology firms are taking to incorporate them into their programs and infrastructure and its prospects for India.	

8 IN TOP 10 SELECTIONS IN CSE 2021

from various programs of VisionIAS

CIVIL SERVICES EXAMINATION 2020

1 AIR

SHUBHAM KUMAR

2 AIR

ANKITA AGARWAL

3 AIR

GAMINI SINGLA

4 AIR

AISHWARYA VERMA

5 AIR

UTKARSH DWIVEDI

6 AIR

YAKSH CHAUDHARY

7 AIR

SAMYAK S JAIN

8 AIR

ISHITA RATHI

9 AIR

PREETAM KUMAR

YOU CAN BE NEXT

DELHI

HEAD OFFICE Apsara Arcade, 1/8-B, 1st Floor, Near Gate 6, Karol Bagh Metro Station

+91 8468022022, +91 9019066066

Mukherjee Nagar Centre

635, Opp. Signature View Apartments, Banda Bahadur Marg, Mukherjee Nagar

JAIPUR 9001949244 | **HYDERABAD** 9000104133 | **PUNE** 8007500096 | **AHMEDABAD** 9909447040 | **LUCKNOW** 8468022022 | **CHANDIGARH** 8468022022 | **GUWAHATI** 8468022022

/c/VisionIASdelhi /vision_ias /visionias_upsc /VisionIAS_UPSC