Q-6. How can India achieve energy independence through clean technology by 2047? How can biotechnology play a crucial role in this endeavour?

India, the world's **third-largest energy** consumer, aims for **energy independence by 2047**, This requires reducing dependence on fossil fuel imports and promoting sustainable clean energy solutions.

Pathways through Clean Technology

- **Renewable Energy Expansion** – Scaling up solar (ISA)- (OSOWOG) initiative
- **Electrification of Transport – FAME India Scheme (**Faster Adoption and Manufacturing of Electric Vehicles) in India.
- **Green Hydrogen Mission** – Target of **5 MMT by 2030**, useful for decarbonizing refineries, fertilizer, and steel sectors.
- **Energy Efficiency** – Smart grids (National Smart Grid Mission (NSGM) , efficient appliances(**Standards and Labelling Program**).
- **Nuclear & Fusion Research** – Reliable baseload clean energy to complement renewables.

Role of Biotechnology in Energy Independence

- **Biofuels (Ethanol & Biodiesel)**
  - 20% ethanol blending target by 2025–26 reduces crude imports.
- **Algal Biofuels**
  - Microalgae can yield high oil content, offering a renewable alternative to petroleum.
- **Genetically Engineered Crops**
  - Energy crops (e.g. high-biomass sorghum) optimized for biofuel yield.
- **Industrial Biotechnology**
  - Bio-refineries convert agricultural and municipal waste into fuels, chemicals, and power, promoting a circular economy.

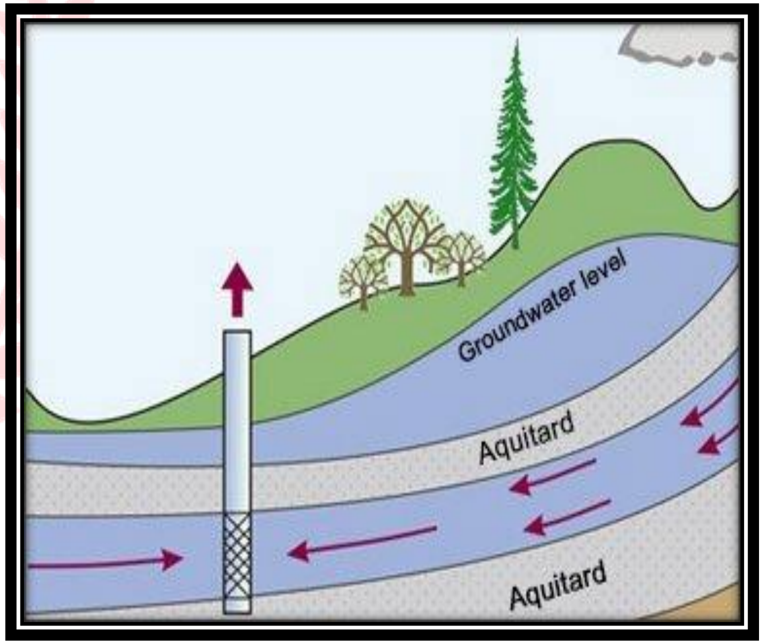
By combining **clean technologies (solar, hydrogen, EVs)** with **biotechnology-driven solutions (biofuels, biogas, bio-refineries)**, India can cut fossil fuel imports and achieve **energy independence by 2047**, while ensuring sustainability and rural livelihood generation.

Q-13. Examine the factors responsible for depleting groundwater in India. What are the steps taken by the government to mitigate such depletion of groundwater?

lifeline of India's agriculture, drinking water supply, and industries, yet it faces rapid depletion. According to the **Central Ground Water Board (CGWB)**-60% of districts face either over-exploitation or critical stress.

Factors Responsible

- **Over-extraction for Irrigation** – About **85% of India's groundwater is used for agriculture**; water-intensive crops like rice, sugarcane, and wheat worsen depletion.
- **Unregulated Pumping** – Free/subsidized electricity encourages uncontrolled pumping through borewells.
- **Monsoon Dependency** – Erratic rainfall and failed monsoons reduce recharge opportunities.



Urbanization & Industrialization – Rapid growth increases **domestic and industrial** demand, while concretization lowers recharge.

Deforestation & Land-use Change – Loss of forests reduces natural infiltration of rainwater.

Climate Change – Rising temperatures increase evapotranspiration and reduce effective recharge.

Inefficient Water Use – Flood irrigation and wastage in domestic/industrial sectors intensify stress

Government Measures

- **Atal Bhujal Yojana (2019)** – A World Bank-assisted program promoting **community-led groundwater** management in water-stressed areas.
- **Jal Shakti Abhiyan** – Campaign for rainwater harvesting, watershed management, and aquifer recharge.
- **Mission Amrit Sarovar(rejuvenating 75 water bodies in each district of the country) & Catch the Rain Campaign** – Focus on rejuvenating water bodies to aid recharge.

Groundwater depletion in India is driven by **human overuse and natural variability**.

community participation, efficient irrigation, crop diversification, and strict regulation

Q-17. Mineral resources are fundamental to the country's economy and these are exploited by mining. Why is mining considered an environmental hazard? Explain the remedial measures required to reduce the environmental hazard due to mining.

- Mineral resources are vital for industrialization, infrastructure, and economic growth, but **mining activities cause serious environmental challenges**.

Mining- an Environmental Hazard

- **Land Degradation** – Open-pit and surface mining destroy landscapes, leading to loss of topsoil and agricultural land.
- **Air Pollution** – Blasting, drilling, and transport release dust and particulate matter, causing respiratory issues.
- **Water Pollution** – Acid mine drainage and **heavy metal** contamination pollute rivers and groundwater.
- **Loss of Biodiversity** – Habitat destruction displaces flora and fauna, threatening endangered species.
- **Health Hazards** – Workers and nearby communities face **silicosis,** lung diseases, and exposure to toxic substances.

Remedial Measures

- **Enforce strict rules & monitoring** – Ex: EIA clearance before mining.
- **Use eco-friendly mining methods** – Example: Controlled blasting in iron ore mines to reduce dust.
- **Dispose of mining waste safely** – Example: Scientific tailing ponds in copper mines of Rajasthan.
- **Involve local communities** – Example: CSR activities by Coal India Ltd. for tribal welfare in Jharkhand.
- **Use renewable energy in mining** – Example: Solar-powered mining trucks.

Mining is essential, **balancing economic growth with environmental protection** requires **sustainable mining & strong regulation to** minimize ecological damage while meeting developmental needs.

Q- 18. Write a review on India's climate commitments under the Paris Agreement (2015) and mention how these have been further strengthened in COP26 (2021). In this direction, how has the first Nationally Determined Contribution intended by India been updated in 2022?

a legally binding international treaty to address climate change by reducing global greenhouse gas emissions

to limit global temperature increases to well below 2°C, preferably to 1.5°C, above pre-industrial levels

Under the Paris Agreement, India submitted its **first Nationally Determined Contribution (NDC) in 2015**, pledging to:

- **Reduce Emission Intensity** – Lower GDP's emission intensity by **33–35% from 2005 levels by 2030**.
- **Increase Non-fossil Fuel Share** – Achieve **40% of installed electricity capacity from non-fossil sources by 2030.**
- **Create Carbon Sink** – Add **2.5–3 billion tonnes of CO_2 equivalent** through additional forest and tree cover.

Strengthening Commitments at COP26 (Glasgow, 2021)

PM announced the **Panchamrit targets (five nectar elements):**

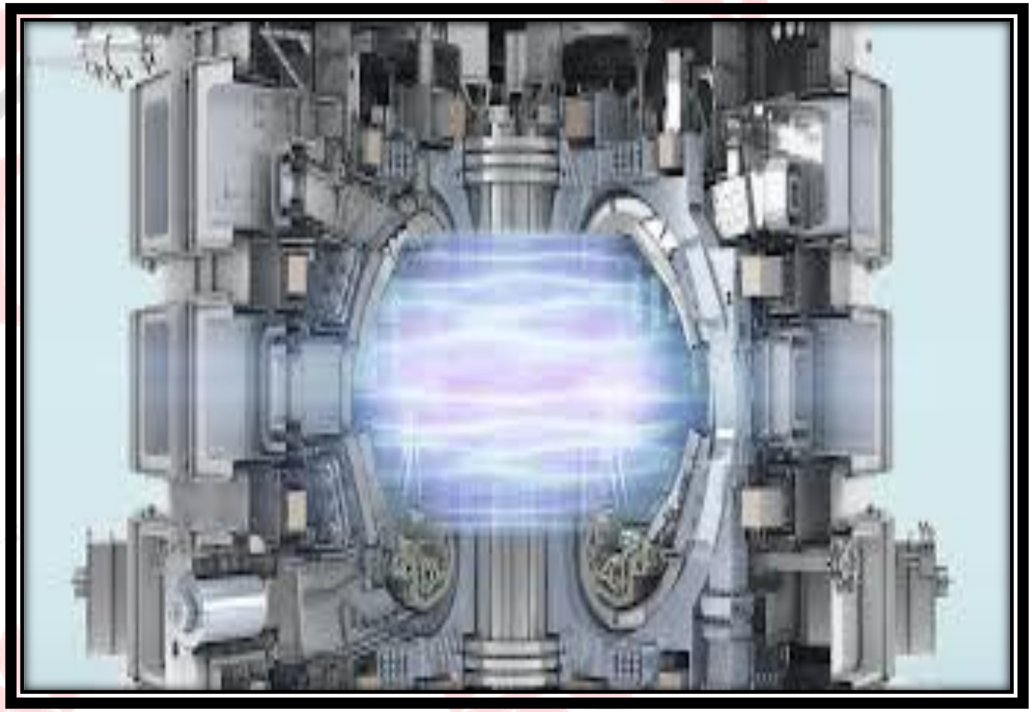
- **500 GW non-fossil capacity** by 2030.
- **50% of energy needs** from renewables by 2030.
- **Reduce total projected carbon emissions by 1 billion tonnes** by 2030.
- **Reduce carbon intensity of GDP by 45%** from 2005 levels by 2030.
- **Achieve Net Zero by 2070.**

Updated NDC (2022 Submission)

- India formally updated its NDC in August 2022:
- **Emission Intensity Reduction**: Enhanced target to **45% reduction by 2030** (from 2005 levels).
- **Non-fossil Fuel Share**: Raise share of non-fossil-based energy to **50% of installed capacity by 2030**.
- Retained commitment to carbon sink creation.

India's climate pathway shows a **progressive strengthening** of commitments—from **modest targets** in 2015 to ambitious net-zero and renewable expansion goals in 2021–22. This reflects India's balancing act between **development needs and climate responsibility**.

Q-5. The fusion energy programme in India has steadily evolved over the past few decades. Mention India's contributions to the international fusion energy project – International Thermonuclear Experimental Reactor (ITER). What will be the implications of the success of this project for the future of global energy?



Key contributions:

- The **Cryostat**, the world's largest stainless-steel vacuum chamber, designed and manufactured by Larsen & Toubro.
- **Cooling water systems** and **in-vessel shielding modules** **(used to protect components inside a fusion reactor or other nuclear system from intense neutron radiation).**
- **Power supply systems** such as high-voltage, high-current converters for plasma heating.
- **Diagnostics and instrumentation** for monitoring plasma behavior.

  Institutions like the Institute for Plasma Research (IPR), BARC, and Indian industry have played a pivotal role in design, fabrication, and quality assurance.

Implications of ITER's Success:

- **Abundant Clean Energy:** Fusion uses deuterium and tritium, ensuring an almost inexhaustible fuel supply with zero greenhouse gas emissions.

  Safe Nuclear Power: Unlike fission, fusion poses no meltdown risk and produces only short-lived radioactive waste.

- **Energy Security:** Reduces dependence on fossil fuels and enhances global energy diversification.

- **Global Climate Commitments:** Provides a pathway for nations to meet decarbonization goals.

India's active role in ITER reflects its scientific and industrial maturity. If successful, ITER could usher in a new era of sustainable, safe, and virtually limitless energy, transforming the global energy landscape.

Q-15. How does nanotechnology offer significant advancements in the field of agriculture? How can this technology help to uplift the socio-economic status of farmers?

Nanotechnology is the science and application of matter at the nanoscale (dimension between approximately 1 and 100 nanometers)

Advancements in Agriculture

- **Nano-fertilizers**
  - Release nutrients in a **controlled and targeted manner**, minimizing losses and increasing crop yield.
  - **Example: Nano Urea**
- **Nano-pesticides**
  - Deliver pesticides precisely at target sites, reducing excess use, environmental pollution, and pest resistance.
- **Soil and Water Management**
  - **Nano sensors** detect soil pH, moisture, and nutrient deficiencies in real time.
- **Post-harvest Management**
  - Nano-coatings on fruits and vegetables extend shelf life and reduce post-harvest losses.
  - Nano-packaging prevents microbial growth, ensuring safe food supply.

Socio-economic Benefits for Farmers

- **Higher Productivity** – Improved input efficiency leads to better yields per hectare, raising farm income.
- **Reduced Costs** – Precise delivery of fertilizers and pesticides lowers input expenditure.
- **Sustainability** – Less chemical runoff protects soil and water, ensuring long-term fertility.
- **Market Competitiveness** – Longer shelf life and better-quality crops fetch higher market prices.
- **Employment & Rural Innovation** – Adoption of nanotech-based Agri-products can generate new industries, boosting rural economy.

Nanotechnology has the potential to **revolutionize Indian agriculture** by making it more productive, sustainable, and cost-effective & it can significantly **uplift the socio-economic status of farmers** and contribute to food and livelihood security.

Q-16. India aims to become a semiconductor manufacturing hub. What are the challenges faced by the semiconductor industry in India? Mention the salient features of the India Semiconductor Mission.

semiconductor is a material whose electrical conductivity lies **between that of a conductor (like copper)** and an **insulator (like rubber)**.

Challenges of Semiconductor Industry in India

- **Capital-Intensive Nature**
  Setting up a fabrication plant (fab) requires huge **investment,** making it a high-risk sector.
- **Lack of Ecosystem**
  India has strong **chip design capability** but weak in manufacturing, packaging, testing, and supply-chain infrastructure.
- **High Dependence on Imports**
  Raw materials like silicon wafers largely imported (China, Taiwan, and South Korea).

Power and Water Requirements

- Semiconductor fabs require **uninterrupted power and ultra-pure water**, which are infrastructural challenges in India.

Skilled Manpower Shortage

- Lack of trained semiconductor engineers and technicians for high-end manufacturing.

Geopolitical and Supply Chain Risks

- Heavy global dependence on Taiwan, USA, Japan, and South Korea creates strategic vulnerabilities.

Salient Features ISM

- **Focus Areas** – Semiconductor fabrication(Silica-SiO_2), design, assembly, testing, packaging.
- **Public–Private Partnership** – Encourages global players to invest in India.
- Promotes domestic startups and R&D in **chip design. (ex: Mindgrove Technologies)**
- **Reduce dependence on imports** and strengthen India's role in the **global electronics supply chain**.

While challenges of capital, ecosystem, and technology persist, the **India Semiconductor Mission** is a step towards **self-reliance (Atmanirbhar Bharat)** in electronics and aims to make India a **global hub for semiconductors** in the next decade.

Q-7. What is Carbon Capture, Utilization and Storage (CCUS)? What is the potential role of CCUS in tackling climate change?

(CCUS) refers to a set of technologies that capture carbon dioxide (CO_2) emissions.

Role of CCUS in Tackling Climate Change

- **Reducing Industrial Emissions** – CCUS helps capture CO_2 from steel, cement, and fertilizer industries . **Ex: Alberta Carbon Trunk Line in Canada, Reliance Industries Jamnagar Project**
- **Cleaner Power Generation** – Old coal power plants can use CCUS to cut emissions while moving towards renewable energy.
- **Negative Emissions with BECCS** – Using bio-energy with CCUS can remove CO_2 from the air, helping meet climate goals.
- **Enhanced Oil Recovery (EOR)** – Captured CO_2 can be injected into oil fields to get more oil and store CO_2 safely underground.
- **Carbon Circular Economy** – Captured CO_2 can be reused in making fuels, plastics, and building materials, reducing use of fresh fossil resources.

CCUS is not suffice but it is a **critical bridging technology** in the global climate strategy. Along with **renewable energy and lifestyle changes**, CCUS can help India and the world achieve **Net Zero targets.**

THANKS FOR WATCHING