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GROUND WATER CRISIS

SYLLABUS:

GS 1 > Geography > Resource geography > water

REFERENCE NEWS:

- In India, the groundwater serves as the primary foundation of agricultural activity and drinking water supply, meeting nearly **62% of irrigation needs, 85% of rural consumption, and 50% of urban demand** (Source: PIB).
- **Rapid population growth, agrarian intensification, industrial expansion, and urbanisation** have collectively intensified pressure on groundwater systems in the country. In this context, the adoption of scientifically informed and sustainable groundwater management practices has become imperative.

WHAT IS GROUNDWATER?

- Groundwater is water that **exists underground in saturated zones beneath the land surface**.
- It maintains water levels in many rivers and streams, and it strongly influences the habitats of wetlands for plants and animals.
- It fills the pores and fractures in underground materials such as sand, gravel, and other rock. **This layer where water is held in appreciable amount is called an aquifer.** The upper surface of the saturated zone is called the **water table.**

INDIA'S GROUNDWATER SCENARIO:

The hydro-geological setting of ground water in India can be divided into two:

- **Hard-rock Aquifers of Peninsular India**:
  - Cover **65%** of India's aquifer area, mostly in central peninsular regions.
  - Have **limited groundwater storage** due to **hard-rock formations**.
  - Water levels drop rapidly after a 2-6 meter decline, with poor permeability limiting recharge, making these aquifers vulnerable to drying out.
- **Alluvial Aquifers of the Indo-Gangetic Plains**:
  - Found in the Gangetic and Indus plains of Northern India with **significant storage capacity.**
  - Critical for fresh water supply but face risks of irreversible overexploitation due to excessive extraction and low recharge rates.

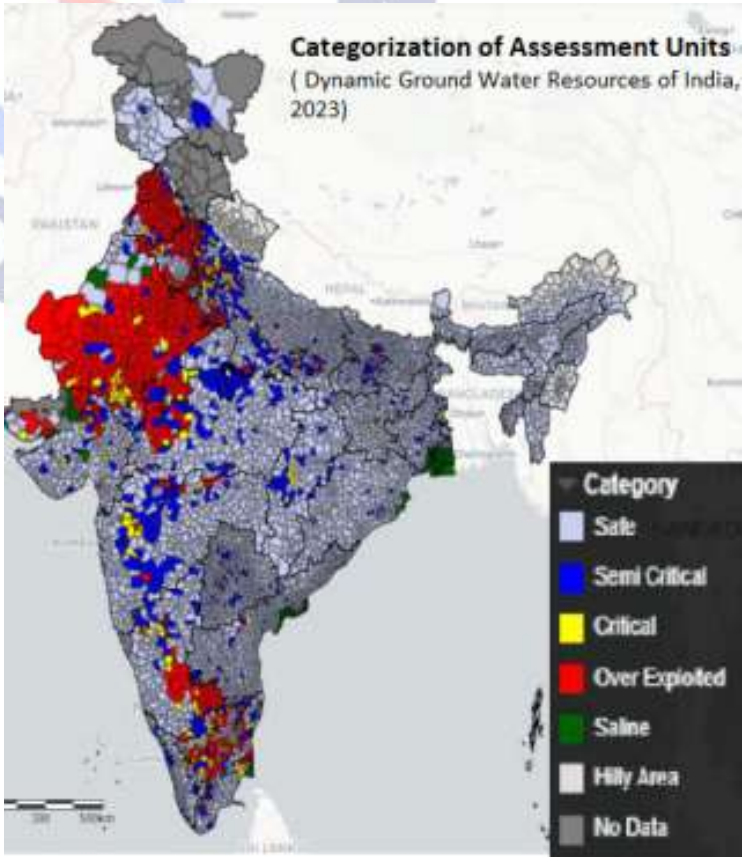
GROUND WATER AVAILABILITY

- As per the **2023 Dynamic Ground Water Resource Assessment Report** released by the Central Ground Water Board (CGWB), the total annual groundwater recharge for the entire country is **449.08 billion cubic meters (BCM)**, marking an increase of 11.48 BCM compared to the previous year (2022).
  - **Annual Extractable Groundwater Resources: 407.21 BCM**
  - **Annual Groundwater Extraction: 241.34 BCM**, indicating a stage of groundwater extraction of approximately **59.23%** across the country.
- **Rainfall contributes about 61%** of the total annual groundwater recharge, with the remaining **39%** coming from other sources like canal seepage, return flow from irrigation, and recharge from water conservation structures (Source: Vikaspedia, 2023 Dynamic Groundwater Resources Assessment)

INDIA AS A GROUND WATER ECONOMY:

- India is a groundwater economy. **UNESCO 'World Water Development Report' 2020 states that** India is the largest extractor of groundwater in the world.
- **India uses 25% of all groundwater extracted globally.** (Source: UNESCO, *World Water Development Report* 2020).
- **Groundwater is one of the most important water sources in India:**
  - **Overall, some 60% of the irrigated land in India is supported primarily by groundwater** supplies and approximately **90 million rural households are directly dependent on groundwater irrigation.**
  - **Over 80% of the rural and urban domestic water supplies** are met through groundwater.
  - **About 90% of the groundwater extracted is used by irrigation.**

(Sources: Ministry of Water Resources, Central Ground Water Board, Groundwater Yearbook 2022-23)



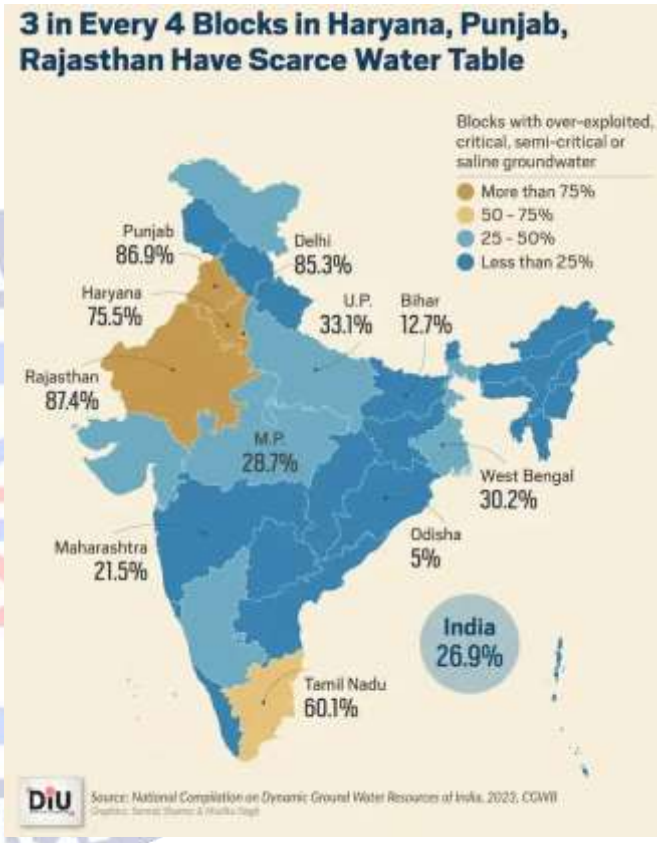
GROUND WATER CRISIS

- Experts believe that **India is fast moving towards a crisis of ground water overuse and contamination.**
- As per the 2023 Dynamic Ground Water Resource Assessment Report, out of the total 6,553 assessment units across the country, **736 units (approximately 11%)** have been categorized as **'Over-exploited.'** Additionally, when combined with the **'critical' and 'semi-critical'** categories, these concerning categories account for more than **35%** of the total assessed units.

- **Groundwater overexploitation** occurs when extraction exceeds recharge over time. Although surface water is more abundant, **groundwater's decentralized availability** makes it the primary source for agriculture and drinking water in India.
- **Northern and eastern India** are major hotspots of groundwater depletion.
- **India is the world's largest consumer of groundwater**, withdrawing around **230 billion cubic meters annually for irrigation alone**, according to the Central Ground Water Board (CGWB). This excessive usage, combined with inadequate replenishment, is causing groundwater levels to plummet across the country.

REASONS FOR THE CRISIS:

- **Groundwater energy nexus:**
  - **Subsidized or free electricity for agriculture** in many states, such as **Punjab and Haryana**, leads to unmetered groundwater pumps and flat-rate tariffs. This has resulted in inefficient and excessive groundwater use, contributing to a significant depletion of water tables. According to a **report by the World Bank,** around **90% of groundwater extraction** in these states is linked to subsidized electricity.
  - Also, **according to the CGWB**, northern states such as **Punjab, Haryana, and Rajasthan** are among the most affected, largely due to intensive agricultural activities and irrigation needs.
  - In Punjab, for instance, the **groundwater level is dropping by about 1 to 1.2 meters per year** in some districts.



- **Green revolution and inapt cropping patterns:**
  - Over **80% of India's net irrigated area** added since the Green Revolution relies on groundwater (World Bank).
  - Government incentives, like higher **MSPs for water-intensive crops** (e.g., rice, sugarcane), push farmers to grow them in water-stressed regions like Punjab, leading to severe groundwater depletion.
- **Inadequate regulations:**
  - Currently, **the Easement Act, 1882 provides every landowner with the right to collect and dispose, within his own limits**, all water under the land and on the surface. This makes it difficult to regulate extraction of ground water as it is owned by the person to whom the land belongs.
- **Lack of uniformity in regulation**
  - **Water falls under the State List of the Constitution**. This implies that state legislative assemblies can make laws on the subject.

- **Hence there is no uniformity in the laws across the country.** Also, the central government can only make recommendations to the states in matters related to groundwater.

- **Fragmented institutional arrangement:**
  - **Multiple ministries**, including Jal Shakti, Rural Development, and Environment, along with **institutions** like the Central Water Commission (CWC), Central Ground Water Board (CGWB), Central Ground Water Authority (CGWA), and Central Pollution Control Board (CPCB), manage groundwater. However, they often **operate independently**, leading to a lack of coordination in groundwater management.
- **Pollution:**
  - **Groundwater Pollution:** Contaminants like **arsenic, nitrate, fluoride, and salinity** can pollute groundwater through both natural and human activities. A recent study by the National Remote Sensing Centre (NRSC) highlighted severe **fluoride contamination**, especially in regions like Rajasthan, where it poses serious health risks such as skeletal fluorosis.
    - The **2024 Annual Groundwater Quality Report** by the Central Ground Water Board (CGWB) underscores a worsening groundwater crisis across the country. Over **20% of samples** from 440 districts contained **unsafe nitrate levels from fertiliser overuse and septic leakage.**
    - **Fluoride** exceeded limits in **9%** of samples, driving dental and skeletal fluorosis in Rajasthan, Andhra Pradesh, and Telangana. **Uranium** concentrations above 100 ppb were found in Punjab, Andhra Pradesh, and Rajasthan, while **iron** contamination affected over 13% of samples, posing gastrointestinal and developmental health hazards.
  - **Natural Causes:** In certain areas, rocks with mineral compounds naturally leach contaminants like arsenic into groundwater. This is a major issue in India. For instance, **Arsenic** in parts of Punjab and Bihar breached the WHO's 10 µg/L limit, heightening cancer and neurological risks (Source: **2024 Annual Groundwater Quality Report)**.
  - **Anthropogenic Causes:** Human activities such as discharge of untreated effluents, landfills, chemical-laden agricultural runoff, and over-extraction contribute significantly to groundwater pollution.
- **Climate Change:**
  - Changes in rainfall patterns, intensity, and temperature affect groundwater replenishment, with climate change acting as a force multiplier by reducing infiltration and recharge.
- **Inaccurate Estimation:**
  - The current method using 15,640 wells struggles to accurately assess groundwater, not fully accounting for rising urban/rural use or climate change impacts.
- **Urbanization and Industrialization:**
  - The **rapid growth of cities and industries** has increased the demand for water, putting further strain on groundwater resources.
  - For instance, according to the World Bank, **India's urban population is expected to double by 2050.**

IMPACT OF GROUNDWATER DEPLETION/CRISIS:

- **On Individuals**:
  - Reduced groundwater availability can cause potable water shortages and eventually lead to droughts.

- Polluted groundwater can result in health issues such as **Hepatitis, Fluorosis, Itai-Itai disease, and Arsenic poisoning**. Notably, fluoride contamination, as highlighted in a recent study by the NRSC, poses severe health risks, including **skeletal fluorosis and accelerated dental decay.'**
- **For instance,** a **study conducted in Bihar**, published in *Nature Scientific Reports* in 2021, reveals that **elevated blood arsenic levels make 1 in 100 individuals highly vulnerable to cancer**, including cancers of the skin, kidney, liver, bladder, and lungs, as well as other secondary cancer types.

- **On Agriculture**:
  - **Over-dependence**: India heavily relies on groundwater for agriculture, so any change in its quantity or quality can severely affect **crop production and productivity.**
  - **Decreasing Farmer Income**: Water scarcity forces farmers to **invest more in deeper wells or purchasing water**, reducing profits. This is a significant factor in the increasing number of farmer suicides in India.
  - **Increasing Pest Attacks**: Groundwater depletion can lead to pest infestations, as seen in Harchandpur village, Haryana, where a drop in groundwater led to **a rise in termite attacks.** The lack of water allows termites to thrive, forcing farmers to shift from growing pulses to more water-intensive crops like mustard and wheat, which are less susceptible to termite damage.

Case study:
Punjab: The Breadbasket Running Dry
Punjab, producing ~20% of India's wheat and 12% of its rice, is facing rapid groundwater depletion—NASA estimates ~54 km^3/year loss in north India. Government-backed rice cultivation in Punjab's semi-arid climate, reliant on groundwater irrigation, has severely overexploited aquifers.

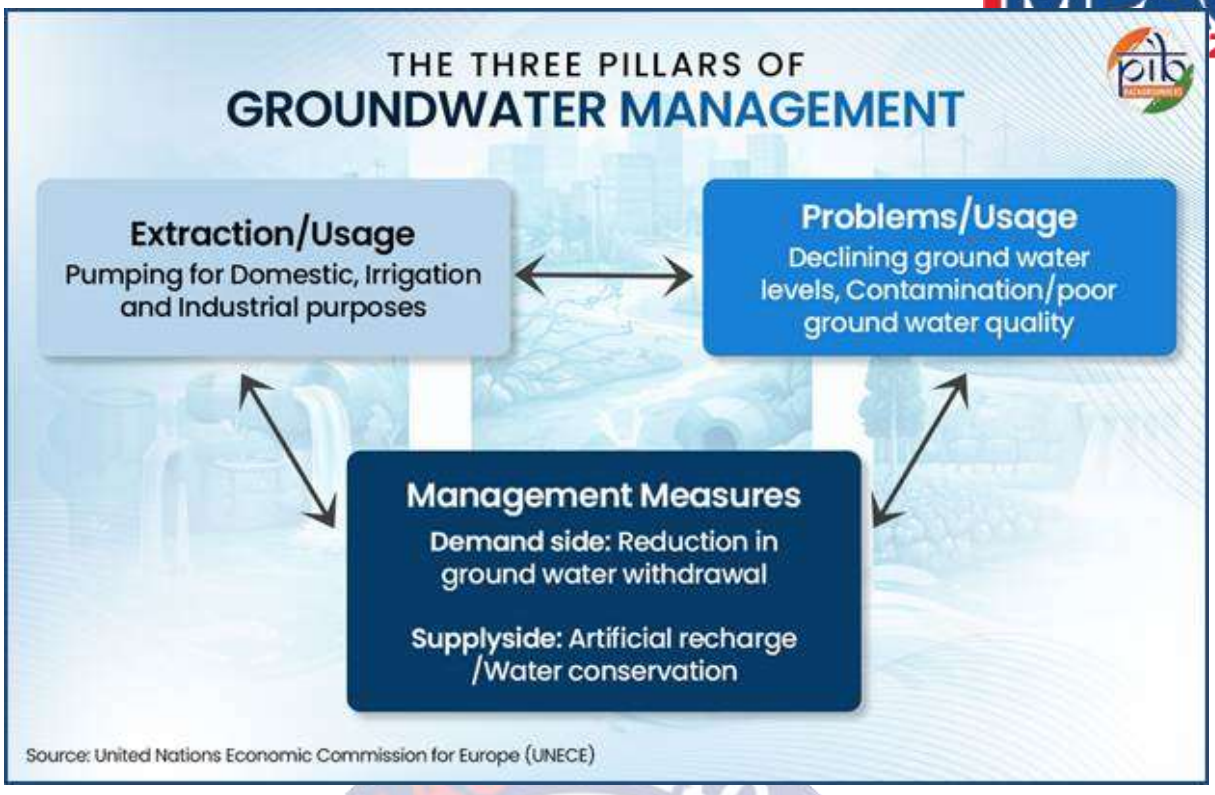
- **On Economy**:
  - By 2030, India's water demand is projected to be **twice the available supply**, leading to severe water scarcity for millions and potentially causing a **6% loss in GDP.**(source: NITI Aayog's 2018 Composite Water Management Index (CWMI) report)
  - Also, according to a report by **NITI Aayog**, **21 major cities, including Delhi and Bengaluru**, are projected to **run out of groundwater by 2030.**
- **On Society**:
  - Groundwater depletion can cause **land subsidence**, forcing relocations. **Jakarta**, for example, is sinking due to excessive groundwater extraction, prompting Indonesia to move its capital to East Kalimantan.
  - Water scarcity disproportionately affects the poor and vulnerable, increasing their costs and exposing them to greater risks of contagious diseases like **Cholera and Hepatitis**, thereby deepening poverty and widening societal inequalities.
- **On Environment and Ecology**:
  - **Reduced Water Flow**: Groundwater depletion prevents water from replenishing lakes, rivers, and seas, leading to declining water levels and negatively affecting aquatic life and ecosystems.
  - **Loss of Soil Moisture**: The depletion leads to loss of soil moisture, making soil less cohesive and more prone to erosion, contributing to desertification.
  - **Impact on Air Quality**: As soil cohesion decreases, more dust is released into the air, worsening air quality. This is particularly evident in **New Delhi,** where desertification around the Northern Aravallis and Sutlej-Yamuna plains contributes to severe air pollution.

Government Initiatives Related to Groundwater Management:

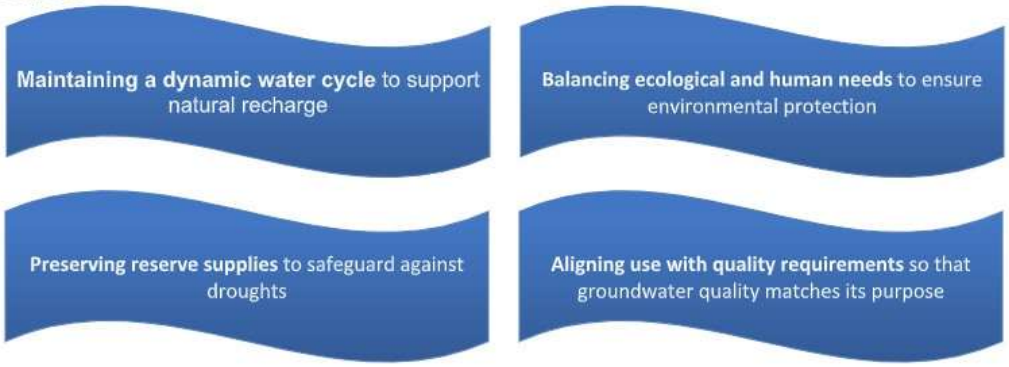
- **Atal Bhujal Yojana (ABY / Atal Jal):** Promotes **community-led, demand-side groundwater management** in **7 water-stressed States**, using outcome-based incentives and digital monitoring to improve aquifer sustainability.
- **National Aquifer Mapping and Management Programme (NAQUIM):** Scientifically maps aquifers and supports **aquifer-specific management**; **NAQUIM 2.0** provides **high-resolution, Panchayat-level groundwater data** for local planning.
- **Pradhan Mantri Krishi Sinchayee Yojana (PMKSY):** Enhances irrigation access and promotes **"more crop per drop"** through micro-irrigation and improved water-use efficiency, reducing pressure on groundwater.
- **Master Plan for Artificial Recharge to Groundwater (2020):** Identifies **terrain-specific recharge interventions** nationwide, targeting **~1.42 crore recharge structures** with a potential recharge of **185 BCM**.
- **Jal Shakti Abhiyan – Catch the Rain (JSA: CTR):** Nationwide campaign encouraging **rainwater harvesting**, water body rejuvenation, and **revival of defunct borewells** for groundwater recharge.
- **Jal Sanchay Jan Bhagidari (JSJB):** Launched in 2024 under JSA: CTR to promote **localised artificial recharge** through borewell recharge, recharge shafts, and aquifer recharge structures.
- **Mission Amrit Sarovar:** Focuses on **creation and rejuvenation of ponds** (minimum 1 acre) to enhance **natural groundwater recharge** and local water security.
- **India–Groundwater Resource Estimation System (IN-GRES):** Government-developed software enabling **dynamic annual groundwater assessments** to support data-driven planning.
- **Model Groundwater (Regulation and Management) Bill:** Provides a **regulatory framework** for sustainable groundwater use; **adopted by 21 States/UTs**, with continued central facilitation for wider adoption.

WAY FORWARD:

- **Groundwater as a Common Pool Resource**: Legislative reforms, including amendments to the *Easement Act*, are essential to treat groundwater as a shared resource. The *Model Groundwater Bill* offers potential for equitable access and sustainable use.
- **Institutional Reform – National Water Commission:** Implement *Mihir Shah Committee*'s recommendation to merge CGWB and CWC into a unified **National Water Commission (NWC)** with multidisciplinary expertise in hydrology, hydrogeology, meteorology, river ecology, agronomy, environmental economics, and participatory management.
- **Groundwater Management - Elements and Priorities:**



- As per the United Nations Educational, Scientific and Cultural Organization (UNESCO), effective groundwater management needs 4 key priorities to ensure sustainable and balanced use of groundwater resources:



- **National Groundwater Pollution Control Framework**: Establish a dedicated framework defining agency responsibilities, empowering CGWB with statutory regulatory authority to tackle contamination.
- **Community Water Management**: Scale up models like Andhra Pradesh's aquifer management and borewell-sharing for equitable distribution, integrating local governance in decision-making.
- **Integrated Technological & Traditional Practices**: Adopt a two-pronged approach—technological measures (e.g., groundwater recharge injection, micro-irrigation, drip systems) alongside traditional water harvesting and conservation practices.
- **Address Over-Exploitation in Agriculture**: Limit excessive withdrawals by rationalising agricultural electricity subsidies and rationing power supply; promote crop diversification (e.g., maize uses one-third the water of paddy); train farmers in water conservation practices; incentivise efficient irrigation as per *CWMI* recommendations.
- **Modernised Monitoring Infrastructure**: Deploy real-time sensors, remote sensing, and open-access data platforms; integrate groundwater quality monitoring with **HMIS** and public health surveillance for early warning.

- **Targeted Remediation & Health Interventions**: Install arsenic/fluoride removal systems in high-risk areas; expand piped safe water coverage; run awareness campaigns on safe water usage.
- **Urban & Industrial Waste Management Reforms**: Mandate **Zero Liquid Discharge (ZLD)** for industries, strictly regulate landfills, and enforce penalties for illegal discharges to prevent aquifer contamination.
- **Agrochemical Reform**: Promote organic and balanced fertiliser use; regulate pesticide application to reduce nitrate contamination; encourage sustainable nutrient management.
- **Citizen-Centric Groundwater Governance**: Empower panchayats, water user groups, and schools in groundwater testing, monitoring, and advocacy to ensure community-driven conservation.

BEST PRACTICE:

- **Mazhapolima Initiative, Kerala:** It is an **artificial groundwater recharge program.** Under this initiative, employees of 100 NGOs received training to install roof water harvesting systems. **In the rainy season, the rooftop rain water is led through pipes with sand filter at the end, to open dug well to replenish the aquifer.** The intervention gives subsidies to poorer households especially in overexploited groundwater blocks and in areas of high salinity.
- **'Bhungroo'- Ground Water Injection Well**: Bhungroo' is a water management system in Gujarat that injects and stores excess rainfall water underground. This water is then used for irrigation during summers

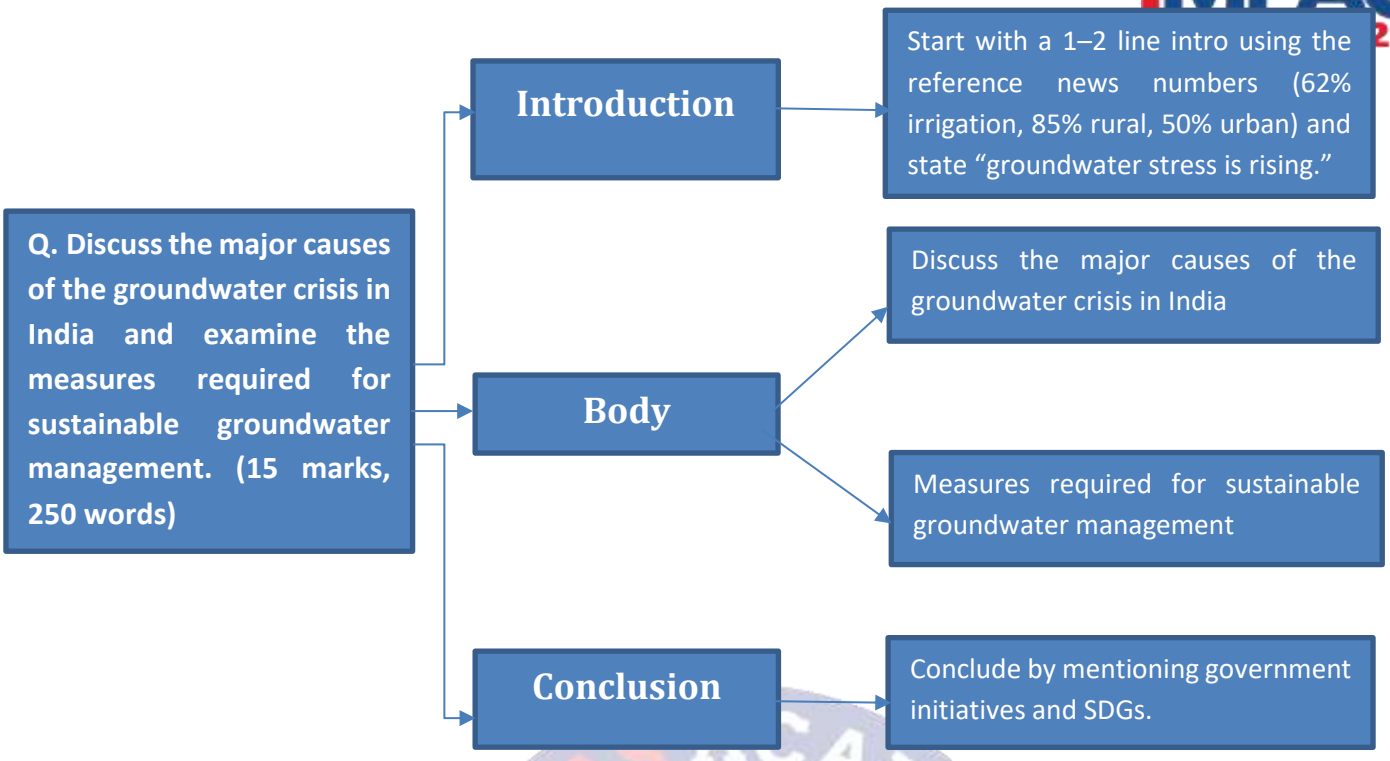
CONCLUSION:

- Groundwater is central to India's water security but faces severe stress from over extraction, pollution, and climate variability. Ensuring its sustainability demands a shift towards **aquifer-based, science-driven, and community-led governance**, supported by effective regulation and demand management. Such an approach is vital for achieving **SDG 6 (Clean Water and Sanitation)**, strengthening urban and ecological resilience under **SDG 11**, and promoting **SDG 12 (Responsible Consumption and Production)**.

PRACTICE QUESTION:

Q. Discuss the major causes of the groundwater crisis in India and examine the measures required for sustainable groundwater management. (15 marks, 250 words)

APPROACH:



MODEL ANSWER:

Groundwater forms the backbone of India's water security, meeting **nearly 62% of irrigation needs, 85% of rural drinking water demand, and 50% of urban consumption** (PIB). However, rapid population growth, agrarian intensification, industrial expansion, and urbanisation have placed unprecedented pressure on groundwater systems, making sustainable management imperative.

Major Causes of the Groundwater Crisis in India:

1. Over-extraction driven by agriculture

- About **90% of groundwater extraction is used for irrigation**.
- Subsidised or free electricity encourages unmetered pumping, especially in Punjab, Haryana, and Rajasthan.
- Water-intensive cropping patterns (paddy, sugarcane) in semi-arid regions aggravate depletion.

2. Policy and regulatory gaps

- The **Easement Act, 1882** links groundwater ownership to land, limiting regulation.
- Water being a **State subject** leads to fragmented and non-uniform laws.

3. Hydro-geological vulnerability

- Hard-rock aquifers of peninsular India have limited storage and poor recharge.
- Even alluvial aquifers of the Indo-Gangetic plains face risks of irreversible over-exploitation.

4. Pollution and quality degradation

- Arsenic, fluoride, nitrate, and uranium contamination from natural and anthropogenic sources.
- Over 20% of groundwater samples show unsafe nitrate levels (CGWB, 2024).

5. Climate change and urbanisation

- Erratic rainfall reduces recharge.
- Rapid urban and industrial growth increases groundwater dependence.

Measures Required for Sustainable Groundwater Management:

1. Aquifer-based and science-driven planning

- Use high-resolution aquifer mapping and data-based extraction limits.

2. Demand-side management in agriculture

- Rationalise power subsidies, promote micro-irrigation, and encourage crop diversification.

3. Strengthening regulation and institutions

- Implement the **Model Groundwater (Regulation and Management) Bill** uniformly.
- Improve coordination among groundwater institutions.

4. Recharge and conservation

- Promote rainwater harvesting, recharge structures, and pond rejuvenation through national programmes.

5. Community participation

- Scale up community-led water management and local water budgeting.

India's groundwater crisis calls for a transition towards **aquifer-based, science-driven and community-led governance**, reinforced through initiatives such as **Atal Bhujal Yojana, NAQUIM, Jal Shakti Abhiyan–Catch the Rain, Mission Amrit Sarovar and the Model Groundwater Bill**. Effective implementation of these measures will be critical for securing **SDG 6 (Clean Water and Sanitation)**, enhancing urban and ecological resilience under **SDG 11**, and promoting sustainable water use aligned with **SDG 12 (Responsible Consumption and Production)**.