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Daily News Analysis

The Hindu Important News Articles & Editorial For UPSC CSE

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Edition : International Table of Contents

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Page 01 : GS 3 : Indian Economy / Prelims

India's Index of Industrial Production (IIP) is a key barometer of the country's economic health, reflecting changes in manufacturing, mining, and electricity generation. The latest data for October 2025 indicates that industrial growth has slipped to a 14-month low of just 0.4%, signalling stress in certain sectors of the economy and raising concerns about demand conditions, inventory cycles, and structural bottlenecks.

Growth in industrial activity slips to 14-month low of 0.4%

The Hindu Bureau
NEW DELHI

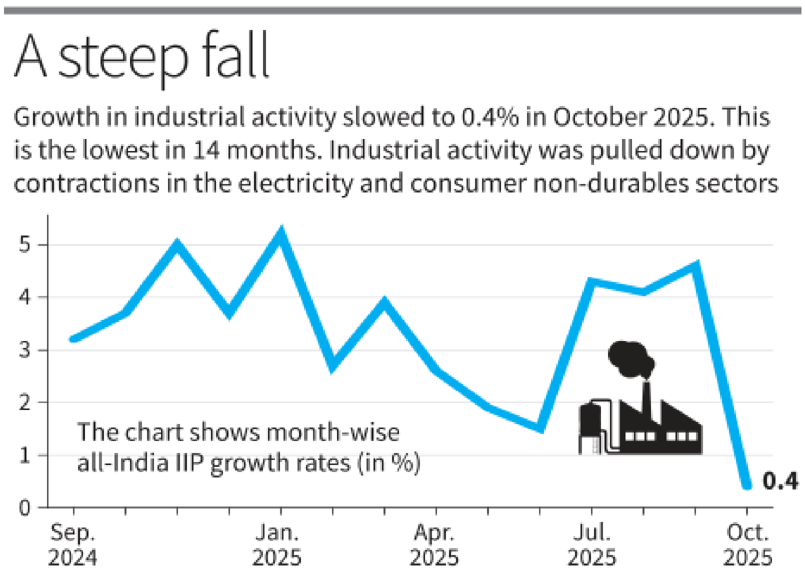
Growth in industrial activity slowed to a 14-month low of 0.4% in October 2025, pulled down by contractions in the electricity and consumer non-durables sector, as well as relatively slow growth in the manufacturing sector.

Data on the Index of Industrial Production (IIP) released by the Ministry of Statistics and Programme Implementation showed that growth in the index was last lower than the latest figures in August 2024, when it had come in at 0%.

The electricity sector contracted 6.9% in October 2025, compared with a growth of 2% in October last year. The consumer non-durables sector contracted 4.4% compared with a growth of 2.8% over the same period.

"Consumer goods registered negative growth, and the inventory factor would have played out," Madan Sabnavis, chief economist at the Bank of Baroda said.

"It was -0.5% for durables and -4.4% for non-durables. This would need to be monitored for the next two months where traction in a positive direction should be seen." Mr. Sabnavis added.



Key Analysis

1. Key Highlights of the IIP Data

- Overall growth: IIP growth fell to 0.4%, the lowest since August 2024 (0%).
- **Sector-wise performance:**
  - **Electricity:** Contracted sharply by –6.9% (last year +2%).
  - **Consumer non-durables:** Fell –4.4% (last year +2.8%).
  - **Consumer durables:** Slight contraction of –0.5%.
  - **Manufacturing:** Growth remained weak, pulling down the overall index.

2. Reasons Behind the Slowdown

a) Weak Consumer Demand

- Both durables and non-durables registered negative growth.
- Indicates tepid rural demand, possibly due to:
  - uneven monsoon,
  - high inflation in essentials,
  - reduced discretionary spending.

b) Inventory Adjustment Cycle

- As highlighted by Bank of Baroda Chief Economist Madan Sabnavis, inventory correction may be underway.
- Companies often reduce production temporarily when stocks have accumulated due to slower demand.

c) Contraction in Electricity Output

- A 6.9% decline in electricity generation suggests:
  - lower industrial usage,
  - mild weather reducing household consumption,
  - possible supply-side bottlenecks.

d) Moderation in Manufacturing Growth

- Manufacturing carries 77–78% weight in the IIP.
- Even small dips in manufacturing significantly drag the overall index.

3. Implications for the Economy

a) Growth Outlook

- A prolonged slowdown could affect:
  - GDP growth (IIP feeds into the real sector of the economy),
  - employment generation in manufacturing,
  - investment sentiment.

b) Policy Considerations

- Government may need to:
  - boost rural consumption (PM-KISAN, MNREGA allocations, food price stability),
  - support MSMEs through credit and infrastructure,
  - push supply-side reforms (PLI schemes, logistics improvements).

c) Need for Monitoring

- As experts noted, the next two months will be crucial.
- A revival in consumer goods output—especially during the post-festival season—will be a sign of demand stabilisation.

Conclusion

The slip in industrial growth to 0.4% reflects a combination of demand-side weakness, inventory correction, and sector-specific contractions—especially in electricity and consumer non-durables. While this does not necessarily indicate a structural downturn, it highlights the need for careful monitoring and targeted policy support. Ensuring momentum in manufacturing and reviving consumer demand will be essential for sustaining India's broader economic growth trajectory in the coming months.

UPSC Prelims Practice Question

Ques: The Index of Industrial Production (IIP) in India is released monthly by:

a) NITI Aayog

b) Ministry of Finance

c) Ministry of Statistics and Programme Implementation (MoSPI)

d) Department for Promotion of Industry and Internal Trade

Ans: c)

UPSC Mains Practice Question

Ques: Evaluate the effectiveness of recent government initiatives such as the Production Linked Incentive (PLI) scheme in addressing stagnation in India's manufacturing sector. **(150 Words)**

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Page 04 : GS 2 : International Relations

External Affairs Minister S. Jaishankar recently warned that the world remains inadequately prepared to handle the growing threat of bioterrorism. Speaking at an international conference marking 50 years of the Biological Weapons Convention (BWC), he stressed the dangers posed by non-state actors, the gaps in the existing global biosecurity framework, and the need to place the Global South at the centre of future strategies.
His remarks revive a crucial debate on biosecurity governance, especially after the vulnerabilities exposed during the COVID-19 pandemic.

Bioterrorism a serious threat, world not ready: Jaishankar

Union Minister warns that 'non-state actors' can use biological agents; he says such threats cannot be handled in isolation, pitches for keeping Global South at the centre of strategies to tackle them

Kallol Bhattacherjee
NEW DELHI

The world is not yet "adequately prepared" to deal with the threat of bioterrorism, External Affairs Minister S. Jaishankar said here on Monday.

Speaking at a conference on 50 years of the Biological Weapons Convention (BWC), Mr. Jaishankar said "non-state actors" can resort to use of biological agents and that the Global South should be at the centre of preparations to deal with bioweapons.

"Bioterrorism is a serious concern that the international community has to be adequately prepared for. Yet the BWC still lacks basic institutional structures," said Mr. Jaishankar.

'No compliance system'

"It has no compliance system, it has no permanent technical body and no mechanism to track new scientific developments. These gaps must be bridged in order to strengthen confidence," said the Minister, calling for BWC's modernisation.

External Affairs Minister S. Jaishankar addressing a conference on the Biological Weapons Convention in New Delhi on Monday. PTI

India 'committed to non-proliferation of sensitive and dual-use goods and technologies'

He said India has proposed a National Implementation Framework that will cover "high-risk agents, oversight of dual-use research, domestic reporting and incident management".

Mr. Jaishankar said India is "committed to ensuring the non-proliferation of sensitive and dual-use goods and technologies", and this has been supported by India's strong legal and regulatory system.

Role of Global South

The Minister said biological threats cannot be handled by countries in isolation from international stakeholders and called for making the Global South central to BWC.

He described "unequal access to vaccines and medicines" as not just development issues but as "global risks".

"The Global South is the most vulnerable and has the most to gain from stronger biosecurity. It also has the most to contribute. Its voice must therefore shape the next 50 years of the BWC," said Mr. Jaishankar, who highlighted India's 'vaccine diplomacy' that took shape against the backdrop of the COVID-19 pandemic.

Key Issues Highlighted

1. Rising Threat of Bioterrorism

- The Minister underlined that **non-state actors may resort to biological agents**, making bioterrorism a real, not hypothetical, threat.
- Advances in biotechnology, gene editing and synthetic biology increase the **dual-use** risks of scientific research.

2. Weaknesses in the Biological Weapons Convention (BWC)

Jaishankar pointed out major gaps in the 1975 BWC, including:

- **No formal compliance mechanism**
- **No permanent technical body** to evaluate scientific advances
- **No structured system** to track emerging biological threats
- Lack of mechanisms to ensure **verification, monitoring, and enforcement**

These gaps weaken global trust and reduce the BWC's deterrence capacity.

3. India's Proposal: National Implementation Framework

India has proposed a comprehensive national framework focusing on:

- Regulation of high-risk agents
- Oversight of dual-use research
- Strong domestic reporting systems
- **Effective incident management mechanisms:** This aligns with India's long-standing support for **non-proliferation** and responsible science.

4. Need for Global South Leadership

Jaishankar argued that:

- The **Global South is the most vulnerable** to biological threats due to limited health infrastructure.
- Yet, it also has significant capabilities, as seen through India's **vaccine diplomacy** during COVID-19.
- Therefore, the Global South must **shape future biosecurity governance**, not remain a passive recipient.

5. Vaccine Inequality as a Security Issue

Calling unequal access to vaccines and medicines a **"global risk"**, Jaishankar linked public health to:

- Global security

- Resilience against pandemics

- Equitable global governance : This is a reminder that **biosecurity is not only a scientific issue but also a geopolitical and developmental challenge**.

Conclusion

S. Jaishankar's remarks highlight the urgent need for **modernising the Biological Weapons Convention**, strengthening global biosecurity, and ensuring that developing nations take a central role in shaping future strategies.

In an era where technological advances can be misused by non-state actors, and where global health systems remain uneven, **bioterrorism has emerged as a key 21st-century security threat**.

India's call for stronger institutional structures, verification mechanisms, and inclusive global leadership positions it as a responsible actor in global biosecurity governance.

UPSC Prelims Practice Question

Ques : Which of the following best describes "dual-use research of concern (DURC)" in biotechnology?

A. Research that has no civilian applications

B. Research that can be used for both beneficial and harmful purposes

C. Research conducted only by private laboratories

D. Research that focuses exclusively on vaccines

Ans: a)

UPSC Mains Practice Question

Ques : The rapid growth of biotechnology has created risks related to "dual-use research". Discuss the challenges and the need for stronger national and global bio-governance mechanisms. **(150 words)**

Page : 07 : GS 3 : Science and Tech / Prelims

The U.S.'s announcement of deploying a small nuclear reactor on the Moon under its Lunar Fission Surface Power Project marks a major shift in space technology. While nuclear energy promises high-density, reliable power for long-term human presence on the Moon and Mars, it also exposes significant legal, environmental, and geopolitical vulnerabilities. This development highlights the urgent need to modernise global space governance frameworks and rethink nuclear safety norms beyond Earth.

The science, technology, and pitfalls of using nuclear power in space

As the human presence in space expands, energy will become critical; while nuclear devices are forbidden, treaties are silent on nuclear propulsion for peaceful purposes; the Liability Convention addresses damage by space objects, but is not clear about accidents involving nuclear reactors

Shrawani Shagun

The US recently announced plans under its Lunar Fission Surface Power Project to deploy a small nuclear reactor on the moon by the early 2030s. It could be the first attempt to establish a permanent nuclear power source beyond earth orbit, signalling the start of a new era in space.

While solar energy can power some simple moon-based activities, it's constrained by the two-week-long lunar nights and the scarcity of sunlight at the poles. For a sustained moon and Mars presence, humans' energy independence thus becomes a critical enabler. This is also why the U.S.'s lunar nuclear programme is notable.


An artist's illustration of a future Artemis Base Camp operated by NASA. NASA

Promise of nuclear power

In conversations on this topic on the earth, nuclear power often features as an alternative that is compact, dense, and reliable.

Devices called radioisotope thermoelectric generators (RTGs) have powered the Voyager spacecrafts' odyssey through the solar system. They convert heat released by the slow decay of plutonium-238 nuclei into electricity, and are immune to dust and darkness. But RTGs only produce a few hundred watts of electric power, enough for instruments but insufficient for human habitats or industrial operations.

Compact fission reactors are the next leap. About the size of a shipping container, these reactors can generate tens to hundreds of kilowatts, and can power life support, laboratories, and manufacturing units.

The next leap on the demand side will be industrial operations like in-situ resource utilisation, which can convert Martian water ice into rocket fuel and oxygen, which need over 1 MW of continuous power. Sunlight alone can't reliably supply this magnitude beyond the earth's orbit. This is where nuclear power reactors are attractive.

On Mars, reactors buried beneath the regolith could take advantage of the natural shielding to protect equipment and inhabitants from cosmic radiation while producing large amounts of energy. The idea of deploying such reactors on the moon itself is lucrative, where they can help maintain warm habitats for explorers, process ice for water and rocket fuel, and recharge batteries for surface mobility vehicles.

Incremental advances in nuclear power have enabled new technologies that were once confined to science fiction. Beyond RTGs, there is now nuclear thermal propulsion, where a propellant is heated by nuclear decay and expelled from nozzles. The DRACO programme in the U.S. will test this technology in lunar orbit by 2026.

If it works, the trips to Mars could become several months shorter, slashing crew exposure to galactic cosmic rays.In nuclear electric propulsion, reactor-generated electricity ionises a propellant, offering years of efficient thrust for deep-space probes and cargo missions.

Legal vacuum

The international framework for nuclear power in space is based on the 1992 United Nations Principles Relevant to the Use of Nuclear Power Sources in Outer Space (UNGA Resolution 47/68). These Principles impose several procedural and safety obligations on launching states for systems used to generate electricity.

Three Principles in particular are relevant. No. 3 mandates nuclear power sources to be designed and built to prevent the release of radioactive materials in both normal and emergency conditions. No. 4 requires rigorous pre-launch safety analyses to make sure the probability of accidental release is acceptably low. No. 7 further aligns with existing space treaties by requiring prompt and clear emergency notification to any potentially affected state in the event of a malfunction or reentry involving radioactive materials.

However, this framework is limited. The Principles address only RTGs and fission reactors intended for electricity generation, and not nuclear thermal/electric propulsion systems. And while they call for safety assessments, they don't establish binding technical standards for reactor design, operational limits, and end-of-life disposal.

Crucially, as a General Assembly resolution, the Principles are non-binding, meaning they offer guidance but no enforcement mechanism. This leaves significant governance gaps. Among other possibilities, states can begin testing compact fission and propulsion reactors capable of operating far beyond the earth orbit without being compelled to address safety.

Beyond those Principles, the Outer Space Treaty, the Liability Convention, and the Nuclear Non-Proliferation Treaty together only offer partial coverage. For instance, even if they are all considered together, there are no binding protocols to prevent radioactive contamination of celestial bodies or to govern reactors jettisoned at the end of a mission.

On Mars, reactors buried beneath the regolith could take advantage of the natural shielding to protect inhabitants from cosmic radiation. The idea of deploying such reactors on the moon is lucrative, where they can keep habitats warm, process ice for water and rocket fuel, and recharge batteries for surface mobility vehicles

Without such protocols, nuclear contamination could irreversibly alter pristine extraterrestrial environments long before humankind fully understands them. The tension between safety and international access is also paramount. As the European Space Agency's special advisor for political affairs Kai-Uwe Schrogl has noted: "Establishing 'safety zones' around nuclear power plants on celestial bodies must not lead to national appropriation or the restriction of freedom of use for other actors."

Responsible race

As the human presence in the solar system expands, energy will become critical and energy sources will become strategic.

For now, while the Outer Space Treaty forbids countries from placing weapons of mass destruction in earth orbit, it's silent on nuclear propulsion for peaceful purposes.

The Liability Convention addresses damage caused by space objects but isn't clear about accidents involving nuclear reactors in cis-lunar space or beyond.

For these reasons, we need to update the legal framework posthaste to match countries' technological capabilities or risk accidents that could have long-lasting consequences across state boundaries.

In fact, if such an accident does occur, the promising nuclear dawn will quickly devolve into a nuclear twilight, if not a second Cold War.

India's moment

India itself stands at a strategic inflection point. An alliance of the Indian Space Research Organisation (ISRO) and the Department of Atomic Energy could be powerful. A domestically developed space reactor could power lunar operations in permanently shadowed craters, enable continuous in-situ resource utilisation on Mars, and overall demonstrate India's leadership in deep-space innovation.

But both in India and around the world, a responsible nuclear future needs to begin with reform. The UN's 1992 Principles should be updated to explicitly include propulsion reactors, establish safety benchmarks, and define end-of-life disposal standards. The UN Committee on the Peaceful Uses of Outer Space needs to adopt binding environmental protocols to govern safe launches, preventing contamination, and disposing of nuclear systems.

To this end a multilateral oversight mechanism modelled on the International Atomic Energy Agency could certify designs, verify compliance, and enhance transparency.

This said, technology alone can't secure our future. Without a coherent legal and ethical framework, efforts to expand nuclear technologies in space could give way to conflict.

India in particular can help by championing safe nuclear practices, and do for space energy what it once did for non-aligned diplomacy: shape norms for a multipolar era by balancing ambition with restraint.

(Shrawani Shagun is a researcher focusing on environmental sustainability and space governance. shrawani.shagun@gmail.com)

Key Analysis

1. Why Nuclear Power in Space?

a. Limitations of Solar Power

- Lunar nights last 14 Earth days, creating long periods of darkness.
- Polar regions receive very little sunlight.
- On Mars, dust storms and distance from the Sun reduce solar efficiency.

b. RTGs: Existing but Limited Systems

- RTGs (Radioisotope Thermoelectric Generators) powered missions like Voyager.
- They convert heat from plutonium-238 decay into electricity.
- But they generate only a few hundred watts, insufficient for habitats or industrial use.

c. Compact Fission Reactors: The New Frontier

- Small reactors, about the size of a shipping container, can produce tens to hundreds of kilowatts.
- Ideal for:
    - Life-support systems
    - Lunar habitats
    - Research labs
    - Manufacturing
    - In-situ resource utilisation (ISRU) such as converting lunar/Martian ice into fuel

d. Advanced Nuclear Propulsion

- **Nuclear Thermal Propulsion (NTP):** Heats a propellant using nuclear decay → expels through nozzles → faster Mars missions. The U.S. DRACO mission will test this by 2026.
- **Nuclear Electric Propulsion (NEP):** Reactor-generated electricity ionises propellant → long-duration deep-space missions.

These technologies collectively promise faster travel, higher payload capacity, and sustained presence in deep space.

2. The Legal Vacuum: Governance Gaps

a. 1992 UN Principles on Nuclear Power in Space

These principles require:

- Safety in design (No. 3)
- Pre-launch risk assessment (No. 4)
- Emergency notification (No. 7)

Limitations:

- Non-binding (General Assembly resolution)
- Apply only to RTGs and electricity-producing reactors
- Silent on nuclear propulsion systems
- No standards for disposal, shielding, or accident management

b. Limitations of Existing Treaties

- **Outer Space Treaty (1967):** bans nuclear weapons in orbit but silent on peaceful nuclear propulsion.
- **Liability Convention (1972):** unclear about damage caused by nuclear reactors in deep space or cis-lunar space.
- **NPT:** deals with nuclear weapons, not space reactors.

c. Environmental and Ethical Concerns

- Lack of protocols could lead to:
    - Radioactive contamination of pristine celestial environments
    - Restriction of other nations' access through "safety zones"
    - Inequitable exploitation of extraterrestrial resources

This creates tension between scientific progress and environmental stewardship.

3. Strategic and Geopolitical Implications

a. Nuclear Power as a Strategic Asset

- As space becomes contested, energy will become a **strategic determinant** of influence.
- Countries with compact space reactors will dominate lunar operations, ISRU, and deep-space missions.

b. Risk of a Nuclear Space Race

- Without updated treaties, unchecked nuclear deployment may lead to:
    - Accidents
    - Contamination
    - Escalation reminiscent of the Cold War

c. Need for Multilateral Oversight

A body similar to the **International Atomic Energy Agency (IAEA)** could certify designs and monitor compliance to ensure transparency.

4. India's Strategic Moment

a. Technological Potential

A collaboration between:

- ISRO
- Department of Atomic Energy (DAE)

could enable:

- Indigenous space reactors
- Powering Indian lunar bases
- Enabling ISRU on Mars
- Advancing nuclear propulsion research

b. India as a Norm-Setter

India historically shaped non-aligned norms.

Now, India can:

- Lead global efforts for safe, equitable nuclear use in space
- Push for updated UN principles
- Promote environmental protocols
- Balance ambition with ethical responsibility

This aligns with India's vision of a **multipolar, rules-based outer space order**.

Conclusion

The shift towards nuclear power in space marks a transformative moment in human exploration. While nuclear systems offer unmatched power for lunar bases, Mars missions, and deep-space propulsion, they also expose significant legal, environmental, and geopolitical gaps. Without modernised treaties, binding safety standards, and international monitoring, the world risks accidents that could trigger distrust, conflict, and a new space-based nuclear rivalry.

For India, this moment combines technological opportunity with diplomatic responsibility. By championing safe, transparent, and equitable nuclear practices, India can help shape a secure and sustainable future for humanity's expansion into space.

UPSC Prelims Practice Question

Ques: Nuclear Thermal Propulsion (NTP) differs from Nuclear Electric Propulsion (NEP) in which of the following ways?

A. NTP directly heats the propellant; NEP ionises the propellant using reactor-generated electricity

B. NTP is only for satellites; NEP is only for human missions

C. NTP uses solar energy; NEP uses nuclear energy

D. Both are identical except for reactor size

Ans: A)

UPSC Mains Practice Question

Ques : Evaluate the scientific and technological benefits of using nuclear power for long-duration lunar and Martian missions. Also highlight the associated risks. **(250 words)**

Page 10 : GS 3 : Environment

India today faces a serious environmental challenge where pollution of **air, water, and soil** threatens public health and ecological stability. Traditional cleanup technologies are expensive and energy-intensive. Against this backdrop, **bioremediation** — the use of microorganisms and plants to detoxify polluted environments — is emerging as a sustainable, cost-effective alternative. With rapid industrialisation and increasing waste loads, bioremediation is gaining strategic relevance for India's developmental and environmental goals.

Why does India need bioremediation?

What are the two different types of bioremediation? How is traditional microbiology combined with cutting-edge biotechnology? Has the government initiated schemes to further bioremediation programmes? What are some of the challenges the country faces with respect to adoption of such technologies?

EXPLAINER

Shambhavi Naik

The story so far:

Human waste is leading to a world where access to clean air, water and soil is becoming increasingly difficult. The solution is two-pronged – reduce waste and clean up the waste already made.

What is bioremediation?

Bioremediation literally means "restoring life through biology." It harnesses microorganisms such as bacteria, fungi, algae and plants to sequester or transform toxic substances such as oil, pesticides, plastics, or heavy metals. These organisms metabolise these pollutants as food, breaking them down into harmless by-products such as water, carbon dioxide, or organic acids. In some cases, they can convert toxic metals into less dangerous forms that no longer leach into the soil or groundwater.

There are two broad types of bioremediation – in situ bioremediation, where treatment happens directly at the contaminated site such as when oil-eating bacteria is sprayed on an ocean spill; or ex situ bioremediation, where contaminated soil or water is removed, treated in a controlled facility, and returned once cleaned.

Modern bioremediation combines traditional microbiology with cutting-edge biotechnology. New biotechnologies are enabling humans to gain unprecedented insight into biology, allowing them to identify biomolecules with useful characteristics. These technologies also allow humans to replicate biomolecules under desired conditions of use, such as in sewage plants or agricultural lands. For example, genetically modified (GM) microbes are designed to degrade tough chemicals like plastics or oil residues that natural species struggle with.

Why does India need it?

India's rapid industrialisation has come at a heavy environmental cost. Although pollution has been reducing, rivers such as the Ganga and Yamuna receive untreated sewage and industrial effluents daily. Oil leaks, pesticide residues, and heavy-metal contamination threaten both ecosystems and public health.

Traditional clean-up technologies are expensive, energy-intensive, and often create secondary pollution. Bioremediation offers a cheaper, scalable, and sustainable alternative, especially in a country where vast stretches of land and water are affected but resources for remediation are limited. Moreover, India's diverse biodiversity is a huge advantage. Indigenous microbes adapted to local conditions, such as high temperatures or salinity, can outperform imported strains.

New methods: Garbage being dumped in the Mittanaganahalli landfill in Bengaluru in 2024. FILE PHOTO

Where does India stand today?

Bioremediation is gaining traction in India, though still largely in pilot phases. The Department of Biotechnology (DBT) has supported several projects through its Clean Technology Programme, encouraging partnerships between universities, public research institutions, and industries.

The CSIR-National Environmental Engineering Research Institute has a mandate to propose and implement programmes related to bioremediation. Researchers at the Indian Institute of Technology have experimented with a nanocomposite material synthesised from cotton that can be used to mop up oil spills and others have identified bacteria that can consume toxic pollutants in soils.

Startups are also entering the space. Firms like Biotech Consortium India Limited (BCIL) and Econirmal Biotech offer microbial formulations for soil and wastewater treatment.

However, widespread adoption faces challenges such as a lack of site-specific knowledge and the complex nature of pollutants, and a lack of unified bioremediation standards.

What are other countries doing?

Japan integrates microbial and plant-based cleanup systems into its urban waste strategy. The European Union funds cross-country projects that use microbes to tackle oil spills and restore mining sites. China has made bioremediation a priority under its soil pollution control framework, using genetically improved bacteria to restore industrial wastelands.

The opportunities for India are immense. Bioremediation can help restore rivers, reclaim land, and clean industrial sites, while creating jobs in biotechnology, environmental consulting, and waste management. It can also integrate with the government's Swachh Bharat Mission, Namami Gange, and other green technology initiatives.

What are the risks?

The introduction of genetically modified organisms into open environments need to be strictly monitored to prevent unintended ecological effects. Inadequate testing or poor containment can create fresh problems while solving old ones. Public engagement will be necessary to allow the smooth adoption of new technologies. India will need new biosafety guidelines, certification systems, and trained personnel to scale this technology responsibly.

What next?

First, there is a need to develop national standards for bioremediation protocols and microbial applications. Second, building regional bioremediation hubs linking universities, industries, and local governments would enable better understanding of local issues and identifying appropriate technologies for their resolution. Finally, public engagement would raise awareness that microbes can be allies, not threats, in environmental restoration.

Shambhavi Naik is chairperson, Takshashila Institution's Health & Life Sciences Policy.

THE GIST

- India's rapid industrialisation has come at a heavy environmental cost. Although pollution has been reducing, rivers such as the Ganga and Yamuna receive untreated sewage and industrial effluents daily.
- Bioremediation can help restore rivers, reclaim land, and clean industrial sites, while creating jobs in biotechnology, environmental consulting, and waste management.
- The introduction of genetically modified organisms into open environments need to be strictly monitored to prevent unintended ecological effects.

Why does India need bioremediation?

1. **Heavy Pollution Load:** Rivers like the **Ganga and Yamuna** still receive untreated sewage and industrial waste. Heavy metals, pesticides, oil spills, and plastic contamination are widespread.

2. **Limitations of Conventional Methods:** Mechanical and chemical cleanup methods are costly, generate secondary pollution, and are often unfeasible for India's large polluted areas.

3. **Environmental & Public Health Risk:** Polluted soil and water directly affect agriculture, drinking water, and overall ecosystem functioning.

4. **India's Biodiversity Advantage:** Indigenous bacteria and fungi adapted to **local temperature, soil, and salinity** conditions offer effective and cheaper solutions than imported strains.

What is Bioremediation?

Bioremediation means **restoring life using biological agents**. Microorganisms such as bacteria, fungi, algae and certain plants **metabolise toxic pollutants** and convert them into harmless substances like water, CO_2, or organic acids.

Types of Bioremediation

1. **In situ Bioremediation**
   - Treatment is done *directly at the contaminated site*.
   - Example: spraying oil-degrading bacteria on marine oil spills.
2. **Ex situ Bioremediation**
   - Contaminated soil/water is removed and treated in a controlled facility before being returned.
   - Useful when site conditions are unsuitable for direct treatment.

How traditional microbiology merges with modern biotechnology

- **Genetic engineering** allows creation of microbes that can degrade complex pollutants (plastics, oil residues).
- **Nanotechnology** enables better oil spill absorption (e.g., cotton-based nanocomposite developed by IITs).
- **High-throughput sequencing** helps identify microbial strains suited for local contamination.
- **Biomolecule replication technologies** allow large-scale production of microbial formulations for sewage plants and agriculture.

Thus, new-age biotechnology enhances the efficiency, stability, and survival of microbes in real-world conditions.

Government Initiatives to Promote Bioremediation

1. Department of Biotechnology (DBT) – Clean Technology Programme

- Supports R&D in microbial remediation.
- Funds collaborations between universities, CSIR labs, and industries.

2. CSIR – NEERI

- National mandate to develop and deploy bioremediation projects.
- Works on oil spill cleanup, heavy metal removal, composting processes.

3. IIT-led Research

- Development of nanocomposites for oil adsorption.
- Discovery of indigenous bacteria capable of degrading toxic pollutants.

4. Start-ups and Industry Support

- Firms like **BCIL** and **Econirmal Biotech** commercialise microbial solutions for wastewater and soil treatment.

5. Integration with Flagship Missions

- Potential synergy with:
  - **Swachh Bharat Mission**
  - **Namami Gange**
  - **National Mission on Clean Ganga (NMCG)**
  - **Waste-to-Wealth Mission**

However, most initiatives are still in **pilot or limited adoption** stages.

Challenges in Adoption of Bioremediation in India

1. **Lack of Site-Specific Data:** Pollution varies across regions; microbial solutions must be customised.
2. **Complex Pollutant Mix:** Many contaminated sites contain **multiple pollutants**, making single-microbe solutions insufficient.
3. **Regulatory Gaps:** No **unified national standards** for bioremediation processes or microbial application.
4. **Biosafety Concerns:** Especially with **genetically modified microbes** — risks of ecological imbalance or gene transfer.

5. **Low Public Awareness:** Misconceptions about microbes hinder acceptance of microbial technologies.

6. **Infrastructure and Skilled Manpower:** Limited facilities for large-scale production, testing, and ecological monitoring.

Global Best Practices

- **Japan:** Uses integrated plant-microbe cleanup systems in urban waste management.
- **European Union:** Funds cross-nation microbial restoration of oil spills and mining sites.
- **China:** Prioritises remediation under its soil pollution law; uses genetically enhanced bacterial strains in industrial zones.

These models show how bioremediation can be scaled nationally when backed by standards, funding, and monitoring.

Conclusion

Bioremediation offers India a powerful tool to address its legacy pollution while ensuring sustainability and low-cost remediation. With its rich microbial diversity and growing biotechnology ecosystem, India is uniquely positioned to lead in this domain. However, to unlock its full potential, the country must establish national bioremediation standards, invest in regional hubs, strengthen biosafety regulations, and enhance public awareness. If implemented responsibly, bioremediation can become a key pillar of India's environmental restoration and green growth strategy.

UPSC Mains Practice Question

Ques : Why does India need bioremediation? Discuss the key challenges in adopting bioremediation technologies in the country. **(150 words)**

Page 10 : GS 3 : Geography

Rare Earth Elements (REEs) are the backbone of modern strategic technologies — from electric vehicles and wind turbines to missiles, radars, and smartphones. With China dominating both production and processing, disruptions in global REE supply chains have turned REEs into a **geo-economic and geopolitical weapon**. In this context, India's recent approval of a ₹7,280-crore scheme for domestic rare earth permanent magnet (REPM) manufacturing signals a major step towards **strategic autonomy and technological security**.

Can India become self-reliant in REE production?

How is China using its dominance over rare earth elements as a geopolitical strategy?

V. Nivedita

The story so far:

The Union Cabinet has approved a ₹7,280-crore scheme to manufacture rare earth permanent magnets domestically. The scheme would facilitate the creation of integrated Rare Earth Permanent Magnet (REPM) manufacturing facilities, involving the conversion of rare earth oxides to metals, metals to alloys, and alloys to finished REPMs. This announcement comes at a time when China's export controls are squeezing global supply chains.

What is extent of China's dominance?

Rare earth elements (REEs), a group of 17 minerals, are crucial for their high density, melting point and conductivity. They are moderately abundant, but hard to extract economically and sustainably. China built global supremacy in this sector by controlling 90% of global REE processing and 70% of production, despite holding only 30% of global reserves. In April, China imposed export restrictions on seven rare earth elements and finished magnets, in a bid to counter the trade war. This hit many sectors, especially the automobile sector. "EV makers are the worst hit," said Pranay Kotasthane, deputy director of Takshashila Institution.

Though China's controls come amid a broader reshaping of global trade due to U.S. President Donald Trump's tariffs, they are not new. In 2009, Beijing imposed export quotas on REEs which was scrapped after it lost a World Trade Organisation case brought by the U.S. and others in 2015. "China realised that this is something which it can play in order to achieve its geopolitical, geostrategic and geoeconomic objectives. They played the same playbook in 2020 while restricting the export of graphite. In 2021, they started an export licensing plan in which they started restricting the supplies to certain industries," Dr. Ram Singh, Professor (IB), Head (CDOE), Indian Institute of Foreign Trade, explained.

Why is India focusing on REEs?

India's focus on REEs is driven by its ambitions in electric mobility, renewable energy, electronics manufacturing and defence. These industries depend heavily on rare earth magnets and components.

The country imported over 53,000 metric tonnes of REE magnets in FY 2024-25, despite having 8% of the world's REE reserves – mainly in monazite sands across Andhra Pradesh, Odisha, Tamil Nadu and Kerala. Yet, India produces less than 1% of global output. To fix this, the government launched the ₹16,300 crore National Critical Mineral Mission in January, with a total outlay of ₹34,300 crore spread over seven years, to achieve self-reliance. The mission focuses on exploration, processing, and recycling minerals like lithium, cobalt, and rare earths. To boost domestic production, the government has auctioned new mining blocks and is inviting private companies to participate in exploration and processing. "This sector was closed to the private sector until August 2023 and hence this is a new domain. China's restrictions will help generate interest among private players," Mr. Kotasthane said. However, he points out that only a handful of exploration licences were handed out. "The stumbling block is government regulations and control. Deregulating all segments of this supply chain, fast-tracking environmental regulations, and funding exploration projects to reduce information asymmetry is crucial," he said.

Dr. Singh cautioned that India still lacks refining infrastructure, skilled labour and innovation capacity. He also pointed out that domestic manufacturing would take years to take off given the long gestation period.

"The good thing is that India isn't in a particularly bad position," Mr. Kotasthane said, pointing out that India's monazite sands have several light rare earths, including Neodymium, which are used in magnets. "Several companies have plans to substantially increase capacity in the rare earth magnet recycling space from end-of-life electronic devices and appliances," he added.

THE GIST

- Rare earth elements (REEs), a group of 17 minerals, are crucial for their high density, melting point and conductivity.
- India's focus on REEs is driven by its ambitions in electric mobility, renewable energy, electronics manufacturing and defence. These industries depend heavily on rare earth magnets and components.
- To boost domestic production, the government has auctioned new mining blocks and is inviting private companies to participate in exploration and processing.

1. What is the extent of China's dominance?

China's power in the REE market stems from **near-monopoly control**, not just in mining but across the entire value chain.

China's dominance by numbers

- **90% of global REE processing**
- **70% of global production**
- Only **30% of world reserves**, yet controls the market due to integrated infrastructure, subsidies, and early investments.

Why is this dominance significant?

- REEs like neodymium, praseodymium, dysprosium, terbium are essential for **high-performance permanent magnets** used in EVs, drones, jets, satellites, and critical defence systems.
- China's processing capacity gives it leverage even when other nations mine REEs.

2. How is China weaponising REEs geopolitically?

China uses REEs as a **strategic tool** to gain leverage in global politics and trade.

A. Export restrictions as coercive tools

- **2024:** Beijing imposed export controls on seven REEs and rare earth magnets, hitting global EV and electronics supply chains.
- **2009–2015:** Export quotas restricted supplies until the WTO struck them down.
- **2020 onwards:**
  - Restricted **graphite exports**.
  - Introduced **export licensing**, selectively controlling supply to specific industries.

This strategy mirrors China's broader political goals:

- Countering US tariffs and geopolitical pressure.
- Signalling dominance in supply chains critical for green technology manufacturing.
- Using "chokepoint power" to influence global manufacturers.

B. Strategic Playbook

China's consistent behaviour shows a pattern:

- Create dependence by dominating processing.
- Use that dependence for **geoeconomic and geostrategic leverage**.

Thus, REEs have become an instrument of Chinese statecraft.

3. Why is India prioritising REEs?

India's push is driven by its ambitions in:

- **Electric mobility (EVs)**

- **Renewable energy (wind turbines)**
- **Electronics manufacturing**
- **Defence and aerospace**
- **Atmanirbhar Bharat in critical technologies**

India's current REE landscape

- **8% of global reserves**, mainly in monazite sands in AP, Odisha, TN, and Kerala.
- Yet **less than 1% of global production**.
- Imported **53,000+ metric tonnes** of REE magnets in FY 2024-25.

This gap between resource availability and domestic capacity highlights the urgency of self-reliance.

4. Recent Indian initiatives

A. ₹7,280-crore scheme for Rare Earth Permanent Magnets (REPMs)

- Focus on **integrated domestic capacity**:
  oxides → metals → alloys → finished magnets.
- Reduces import dependence on magnets used in EVs, electronics, defence.

B. National Critical Mineral Mission (2024)

- Total outlay: **₹34,300 crore** over seven years.
- Focus areas:
  - Exploration
  - Processing
  - Refining
  - Recycling
- Covers minerals like lithium, cobalt, REEs.

C. Opening the sector to private players (post–August 2023)

- Earlier heavily regulated and state monopolised.

- New auction of mining blocks to encourage private exploration.

D. Recycling push

- Several Indian companies are scaling up **rare earth magnet recycling** from e-waste.

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5. Can India become self-reliant in REE production?

Strengths

1. **Large monazite reserves** with key light REEs like neodymium.
2. **Government support** through schemes, missions, and deregulation.
3. **Growing industrial demand**, which makes investment viable.
4. **Increasing interest from private sector**, driven by China's tightening controls.
5. Potential in **recycling technologies**, reducing pressure on mining.

Limitations

1. **Lack of processing and refining infrastructure** — the biggest bottleneck.
2. **Insufficient skilled manpower**, R&D capabilities, and technology for advanced separation.
3. **Regulatory hurdles and environmental clearances** slow down exploration.
4. **Long gestation period** — processing facilities take 5–7 years to become fully operational.
5. **Limited exploration licences** handed out so far; early stage ecosystem.

Realistic assessment

India **can** become self-reliant in REEs, but this will be a **medium to long-term process** (7–15 years), requiring:

- Full supply-chain deregulation
- Massive investment in refining
- R&D partnerships
- Faster environmental and exploration approvals

- Development of high-end magnet manufacturing capacity

India is **not starting from zero**, but self-reliance will demand sustained political, financial, and technological commitment.

Conclusion

China's near-monopoly over rare earths has turned REEs into a geopolitical pressure tool, shaping global supply chains and strategic industries. India, with significant reserves and rising technological ambitions, has recognised the urgency of building domestic capacity. The new magnet manufacturing scheme and the National Critical Mineral Mission represent critical steps towards strategic autonomy. However, achieving self-reliance will require overcoming structural challenges in refining capacity, regulatory bottlenecks, and technological know-how. If implemented effectively, India can gradually emerge as a reliable global player in REE production, reducing vulnerability and strengthening its position in the evolving global order.

UPSC Mains Practice Question

Ques : Can India become self-reliant in Rare Earth Elements (REEs)? Discuss in the context of China's geopolitical use of its dominance over REEs. **(150 Words)**

Page : 08 : Editorial Analysis

The new action plan on AMR needs a shot in the arm

Dr. Abdul Ghafur

is Senior Consultant in Infectious Diseases, Apollo Hospital, Chennai, and Coordinator, Chennai Declaration on Antimicrobial Resistance (AMR)

India's new National Action Plan on Antimicrobial Resistance (NAP-AMR 2.0) – (2025-29) – has been released at a time when Antimicrobial Resistance (AMR) is affecting human health, veterinary practices, aquaculture, agriculture, waste systems and the entire food chain. Antibiotic residues, resistant organisms and environmental discharge connect these sectors in powerful ways. AMR does not remain confined to hospitals. It moves through soil, water, livestock, markets and food systems, making it a true One Health challenge. Therefore, any national plan must be matched by real and coordinated action across all levels of governance.

The evolution, from the first action plan

The first National Action Plan on AMR, launched in 2017, was a significant step forward. It brought AMR into national consciousness, encouraged multi-sectoral participation, improved laboratory networks, expanded national surveillance and supported stewardship. It also placed AMR firmly within a One Health framework, recognising the links between human health, animal health and the environment.

Despite this progress, implementation during the first plan period remained limited at the State level. Only a small group of States – Kerala, Madhya Pradesh, Delhi, Andhra Pradesh, Gujarat, Sikkim and Punjab – developed formal State Action Plans, and only a few moved meaningfully into execution. The majority continued to rely on fragmented activities within individual sectors; State-wide, multisectoral One Health structures did not take shape in most parts of the country.

This slow uptake was not due to a shortage of national effort, but because the major determinants of AMR fall under State jurisdiction. Health administration, hospital functioning, pharmacy regulation, veterinary oversight, agricultural antibiotic practices, food-chain monitoring and waste governance are controlled by State departments. National guidance alone cannot create uniform implementation when the operational levers sit elsewhere.

India's broader public health experience shows that real progress happens only when the Centre and States work within a structured, mutually accountable system. The National Tuberculosis Elimination Programme is a clear example: its achievements arise from regular joint reviews, shared monitoring missions and clearly defined roles across levels of government. The National Health Mission follows similar principles, where coordinated planning, dedicated funding signals and periodic performance assessments enable States to turn national priorities into on-ground action. The NAP-AMR 2.0 represents a more mature and implementation-oriented framework when compared with the first plan. It moves beyond broad intent and outlines clearer timelines, responsibilities and resource planning. An important advancement is the recognition that India cannot address AMR without meaningful participation from the private sector, which delivers a major proportion of health care and veterinary services. The plan also strengthens its scientific base by placing greater emphasis on innovation – rapid diagnostics, point-of-care tools, alternatives to antibiotics and improved environmental monitoring.

It deepens its One Health perspective, giving more attention to food-system pathways, waste management and environmental contamination. Surveillance structures are more integrated across human, veterinary, agricultural and environmental sectors, creating a harmonised national approach.

In terms of governance, the NAP-AMR 2.0 introduces a higher level of national oversight by placing intersectoral supervision under NITI Aayog through a dedicated Coordination and Monitoring Committee. It repeatedly stresses that every State and Union Territory should establish State AMR Cells and prepare State Action Plans aligned with the national framework, supported by a national dashboard for progress reporting. These developments signal that AMR is evolving from a technical health issue to a national development priority requiring multi-departmental engagement.

> The success of the National Action Plan on Antimicrobial Resistance (NAP-AMR 2.0) depends on how effectively national and State systems work together

Where the new plan falls short

Despite these important developments and the stronger emphasis on State-level implementation, the fundamental weakness of the first plan remains unchanged. The plan stresses that States must develop AMR Action Plans and establish AMR Cells, but it does not create any mechanism to ensure that they do so. There is no formal Centre-State AMR platform, no joint review mechanism, no statutory requirement for States to notify or implement their plans and no financial pathway – such as NHM-linked incentives – that could anchor sustained State commitment. In a federal system where the key determinants of AMR – health services, veterinary oversight, agricultural antibiotic use, food-chain safety and waste regulation – lie almost entirely within State jurisdiction, this is the pivotal gap. Without a structured method for political engagement, administrative follow-through and shared accountability, even a well-designed national plan risks remaining a technical document rather than a functional national programme.

The AMR policy cannot succeed through guidance alone. Unless India builds a mechanism that brings the Centre and the States into a common implementation framework, the NAP-AMR 2.0 will struggle to convert national intent into measurable national outcomes.

The need for a coordinated mechanism

To make the NAP-AMR 2.0 effective, India needs a clear architecture that brings political leadership, senior administrators and sectoral departments from all States into a unified system. A national-State AMR council, chaired by the Union Health Minister and guided by NITI Aayog, could provide the platform for regular review, joint decision-making and coordinated problem-solving across human health, veterinary sectors, agriculture, aquaculture, food systems and environmental regulation.

State engagement would also strengthen if the Union Government formally requested each State to prepare and notify its AMR Action Plan, with timelines and annual reviews. Experience from the National Health Mission (NHM) and tuberculosis (TB) programmes shows that high-level communication, especially through Chief Secretaries, can significantly shift administrative attention.

Financial mechanisms should follow. Even modest conditional grants under the NHM can drive improvements in surveillance, stewardship, infection control and laboratory strengthening. When funding signals priority, States respond with administrative energy and policy focus.

The NAP-AMR 2.0 provides the scientific and strategic foundation India needs. But its success will depend entirely on how effectively national and State systems work together. AMR is driven by real-world practices along the entire One Health continuum – from hospitals and farms to markets, food chains and wastewater systems. Without strong State participation, national plans cannot have national impact.

India has an opportunity now to build a coordinated and accountable Centre-State model for AMR control. If such a system is established, the country can achieve measurable progress and set an international example. Without it, even the most well-crafted national plan may remain a document of intentions rather than a framework for action. With stronger coordination, political commitment and sustained support across States and sectors, the NAP-AMR 2.0 can become a turning point in India's AMR journey.

GS-2: Social Justice

UPSC Mains Practice Question : India's National Action Plan on Antimicrobial Resistance (NAP-AMR 2.0) marks progress but still lacks the structural mechanisms required for effective implementation. Discuss." **(250 words)**

Context :

Antimicrobial Resistance (AMR) has emerged as one of the most serious global health threats of the 21st century. In India, AMR is no longer confined to hospitals; it spreads across **soil, water, livestock, aquaculture, agriculture, waste systems, and food chains**, making it a true **One Health** challenge. Against this backdrop, India has released its updated **National Action Plan on AMR (NAP-AMR 2.0)** for 2025-29. While the plan builds on earlier gains and adopts a more coordinated, surveillance-oriented approach, its success ultimately hinges on robust State-level action and Centre–State cooperation.

Background: Evolution from NAP-AMR 1.0 (2017)

The first National Action Plan (2017–2021) made important strides:

- Brought AMR into national discourse
- Encouraged multi-sector participation
- Strengthened laboratory networks & surveillance
- Integrated a **One Health** perspective
- Supported antimicrobial stewardship

However, the major limitation was **weak implementation at the State level**. Only a handful of States — Kerala, MP, Delhi, AP, Gujarat, Sikkim, Punjab — created formal State AMR Plans, and even fewer implemented them. Most States continued fragmented, sector-wise activities without coordinated AMR governance.

This was not due to weak national guidance, but because **the key drivers of AMR—health, veterinary services, food safety, agriculture, pharmacy regulation, and waste management—are State subjects**.

What NAP-AMR 2.0 Brings to the Table

The new plan is more **implementation-oriented** with clearer timelines and responsibilities. Key improvements include:

1. Stronger One Health Integration

- More focus on food systems, livestock, aquaculture
- Environmental contamination and waste pathways
- Integrated surveillance across human, animal, agriculture and environmental sectors

2. Private Sector Inclusion

Recognises that India's health care and veterinary care are heavily private-sector-driven; therefore, engagement with private stakeholders is essential.

3. Emphasis on Innovation

- Rapid diagnostics
- Point-of-care tools
- Alternatives to antibiotics

- Improved environmental monitoring

4. Centralised Oversight

- NITI Aayog to run a **Coordination and Monitoring Committee** for intersectoral supervision
- Encourages each State/UT to create **State AMR Cells**
- National dashboard for monitoring progress

NAP-AMR 2.0 signifies that AMR is no longer just a health issue but a **national development priority** requiring cross-departmental engagement.

Where NAP-AMR 2.0 Falls Short

Despite progress, the core weakness remains **unchanged**: The plan **urges** States to act but **does not mandate or enforce** State-level action.

Key gaps:

1. **No formal Centre–State AMR platform** – Unlike TB or NHM frameworks, there is no statutory mechanism for joint review.
2. **No mandatory requirement** for States to:
   - Establish AMR Cells
   - Notify State Action Plans
   - Undertake periodic monitoring
3. **No dedicated funding mechanism:** No NHM-linked incentives or conditional grants. Without financial signals, States may deprioritise AMR
4. **Lack of accountability systems** – No measurable performance metrics tied to State responsibilities

Given that AMR drivers lie largely in State jurisdiction, this is a **critical structural gap**.

What India Needs: A Robust Centre–State Architecture

To make NAP-AMR 2.0 effective, the article suggests the following:

1. A National–State AMR Council

Chaired by the Union Health Minister and guided by NITI Aayog, to ensure:

- Regular joint reviews
- Shared monitoring
- Cross-department coordination
- High-level inter-ministerial engagement

2. Mandatory State Action Plans

- Centre should formally request States to notify their plans

- Chief Secretaries' involvement can drive administrative attention

3. Financial Incentives

- NHM-linked conditional grants
- Funding for surveillance, stewardship, diagnostics, and labs
- States respond when priorities are backed by money

4. Strong accountability & political commitment

AMR must be treated like TB elimination or immunisation — requiring political ownership, system-wide coordination, and continuous monitoring.

Conclusion

India's NAP-AMR 2.0 is scientifically sound and strategically strong, but its success hinges on **State-level engagement**. AMR is shaped by everyday practices — prescription patterns, farm antibiotic use, food chain safety, wastewater management — all of which lie in State jurisdiction. Without a structured, accountable Centre–State coordination mechanism, even the best-designed plan will remain a statement of intent.

If India builds a joint governance system supported by clear roles, financial pathways and political leadership, NAP-AMR 2.0 could become a transformative milestone in India's battle against AMR. Otherwise, it risks becoming another well-written but poorly implemented national document.