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Friday, October 16, 2026



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IMPORTANT INSIGHTS

PFAS Contamination Across Indian Water Sources Raises Public Health Concerns and Exposes Critical Regulatory and Treatment Gaps

Recent Developments:

- Recent investigations have detected **per- and polyfluoroalkyl substances (PFAS)**, commonly called **forever chemicals**, in Indian groundwater, surface water and treated water, highlighting emerging threats to **water security and public health**.
- A **2025 research review** covering Gujarat, Maharashtra, Tamil Nadu and West Bengal identified PFAS contamination as a significant concern, although inconsistent monitoring prevents reliable nationwide assessment.
- India's **IS 10500:2012 drinking-water standard** does not prescribe PFAS-specific limits. The **Bureau of Indian Standards (BIS)** has initiated work on emerging contaminants, while scientific institutions are expanding analytical capabilities.

Understanding PFAS:

Definition and Characteristics:

- PFAS** constitute a large family of synthetic fluorinated chemicals used commercially since the **1940s**, characterised by highly stable **carbon-fluorine bonds**.
- Their properties include **thermal stability, resistance to degradation, water and oil repellency**, and surfactant behaviour, making them useful across industrial applications.
- PFAS include gases, liquids and polymers; their environmental persistence varies, and certain compounds remain in water, soil and living organisms for prolonged periods.

Major Sources and Applications:

- Consumer products:** Non-stick cookware, stain-resistant textiles, waterproof clothing, cosmetics and food-contact packaging.
- Industrial applications:** Electronics, semiconductor manufacturing, aerospace, automotive production, construction and metal processing.
- Firefighting foams:** Certain aqueous film-forming foams release PFAS around airports, military facilities and firefighting training locations.
- Environmental pathways:** Industrial effluents, landfill leachate, sewage sludge and contaminated wastewater transport PFAS into groundwater, rivers and agricultural ecosystems.

Evidence of PFAS Contamination in India:

Major Research Findings:

- 2025 multi-state review:** Research from Gujarat, Maharashtra, Tamil Nadu and West Bengal identified contamination concerns but highlighted inadequate sampling coverage and inconsistent analytical methods.
- IIT Madras study (2024):**
 - Researchers examined **14 water samples collected during 2022–2023**, including groundwater, surface water and different stages of a treatment facility.

- Groundwater near waste-disposal sites exhibited relatively high contamination, while measured concentrations of certain PFAS in treated water were **5%–103% higher** than corresponding raw-water concentrations.
- Researchers suggested that **precursor transformation** during treatment could explain some increases, requiring further investigation rather than establishing that treatment universally increases contamination.
- **February 2026 experimental study:** Exposure to a mixture of **24 PFAS compounds** was associated with delayed zebrafish hatching, impaired growth and altered cardiac function, providing experimental evidence of potential ecological toxicity.

Monitoring Limitations:

- Testing restricted to a few target compounds may overlook **unidentified PFAS and precursor substances**.
- Differences in sampling, detection limits and laboratory procedures obstruct comparisons across regions.
- Nationwide exposure estimates remain uncertain because **systematic, harmonised monitoring** is insufficient.

Environmental and Public Health Implications:

Ecological Consequences:

- **Persistence and mobility:** Several PFAS resist natural degradation and migrate through soil into aquifers, rivers and drinking-water sources.
- **Bioaccumulation:** Certain PFAS accumulate in fish, wildlife and biological tissues, potentially affecting aquatic food webs.
- **Ecotoxicity:** Experimental studies indicate possible developmental, reproductive and physiological disturbances in exposed organisms.

Human Health Risks:

- **Carcinogenicity:** The **International Agency for Research on Cancer (IARC)** classified **PFOA as carcinogenic to humans (Group 1)** and **PFOS as possibly carcinogenic (Group 2B)** in **2023**; the detailed monograph appeared in 2025.
- **Other health concerns:** Exposure to certain PFAS has been associated with altered cholesterol levels, immune responses, thyroid function and reproductive or developmental outcomes.
- **Immune effects:** Some PFAS exposures are associated with reduced antibody responses following vaccination.
- **Risk assessment:** Detecting PFAS does not automatically establish harm; actual risk depends on **chemical identity, concentration, exposure duration, route and population vulnerability**.

Challenges in Water Treatment:

Limitations of Conventional Technologies:

- Conventional **biological wastewater treatment** is generally ineffective at destroying highly persistent PFAS.
- Standard sedimentation, filtration and disinfection processes were not designed specifically to eliminate dissolved forever chemicals.
- Some **PFAS precursors** can transform into persistent terminal compounds during treatment, complicating assessments of removal efficiency.

Advanced Treatment Technologies:

- **Granular activated carbon:** Adsorbs several PFAS effectively, particularly longer-chain compounds, but requires timely replacement and safe disposal.
- **Ion-exchange resins:** Capture ionic PFAS through specialised materials, although operating costs and contaminated-resin management remain challenges.
- **Reverse osmosis and nanofiltration:** High-pressure membranes can remove many PFAS efficiently but require energy, maintenance and management of contaminated concentrate.
- **High-resolution mass spectrometry:** Enables broader identification of suspected and previously untargeted compounds, subject to stringent sampling and laboratory quality controls.

Regulatory Framework and Governance Challenges:

India's Existing Institutional Response:

- **Bureau of Indian Standards:** The revision of **IS 10500:2012** offers an opportunity to introduce scientifically justified PFAS drinking-water parameters.
- **Ministry of Environment, Forest and Climate Change:** India lacks a comprehensive PFAS-wide manufacturing prohibition, creating regulatory gaps across production, discharge and disposal.
- **CSIR–Indian Institute of Toxicology Research, Lucknow:** Participates in PFAS baseline-data development under a **UNEP-supported National Implementation Plan** and has developed analytical capabilities covering approximately **50 PFAS compounds**.
- **Central Pollution Control Board and State Pollution Control Boards:** Their existing pollution-control functions provide an institutional basis for strengthening industrial-effluent surveillance.

International Regulatory Context:

- The **Stockholm Convention on Persistent Organic Pollutants** controls selected PFAS, including PFOS, PFOA and PFHxS, through internationally agreed restrictions and exemptions.
- The **United States Environmental Protection Agency** has established drinking-water regulations for selected PFAS, illustrating a chemical-specific regulatory approach.
- International experience demonstrates the importance of combining **source restrictions, exposure monitoring and advanced treatment** rather than relying exclusively on end-of-pipe purification.

Water Management Initiatives and Their Relevance:

- **Namami Gange Programme:** Supports sewage infrastructure, river restoration and pollution abatement, providing potential institutional support for emerging-contaminant monitoring.
- **AMRUT:** Strengthens urban water supply, sewerage and wastewater infrastructure, although conventional infrastructure upgrades do not automatically ensure PFAS removal.
- **Swachh Bharat Mission–Urban:** Promotes sanitation and solid-waste management, helping address contamination pathways associated with unmanaged waste.
- **National River Conservation Plan:** Supports wastewater interception and treatment to improve river-water quality.
- **National Framework for Safe Reuse of Treated Water:** Encourages regulated wastewater reuse, making monitoring of persistent contaminants increasingly important.

Way Forward:

- **Precautionary regulation:** Develop interim, health-based PFAS limits using Indian exposure evidence and international scientific assessments.
- **National monitoring network:** Establish standardised testing across industrial clusters, landfill sites, drinking-water systems and vulnerable groundwater regions.
- **Polluter Pays Principle:** Strengthen industrial discharge controls, producer accountability and environmentally sound disposal of PFAS-containing waste.
- **Technology adoption:** Support affordable adsorption systems, membrane treatment, non-targeted analytical techniques and research into PFAS destruction.
- **Public health protection:** Prioritise high-exposure communities, publish accessible monitoring results and strengthen coordination among **BIS, CPCB, CSIR and public-health authorities**.

Value Addition for UPSC:

Constitutional and Legal Linkages:

- **Article 21:** The judicially recognised right to clean drinking water forms part of the **Right to Life**.
- **Article 48A:** Directs the State to protect and improve the environment.
- **Article 51A(g):** Establishes citizens' fundamental duty to protect the natural environment.
- **Environment (Protection) Act, 1986:** Provides a framework for environmental standards and regulatory intervention.
- **Water (Prevention and Control of Pollution) Act, 1974:** Establishes mechanisms for preventing and controlling water pollution.

Important Concepts and Examination Relevance:

- **GS Paper II:** Public health governance, institutional accountability and drinking-water regulation.
- **GS Paper III:** Environmental pollution, emerging contaminants, water security and technological solutions.
- **SDG 3 and SDG 6:** Good Health and Well-being; Clean Water and Sanitation.
- **Precautionary Principle:** Scientific uncertainty should not justify postponing proportionate measures against potentially serious environmental harm.
- **Polluter Pays Principle:** Pollution-control and remediation costs should be borne by responsible polluters.

Conclusion: PFAS contamination illustrates the growing challenge of **emerging chemical pollutants** in India's water-governance framework. Effective protection requires **science-based standards, coordinated monitoring, source-level pollution prevention, advanced treatment and transparent public accountability**.

Starlink's Proposed Indian Launch Highlights Satellite Internet Regulation, Digital Inclusion, Spectrum Allocation and National Security Challenges

Recent Developments:

- **Starlink**, operated by SpaceX, has emerged as a major contender in India's satellite broadband market. As of October 2026, the government has stated that Starlink, Reliance Jio's satellite communications arm and Bharti-backed OneWeb are undergoing regulatory processes, with spectrum assignment and security-related requirements remaining critical to commercial operations.
- In **April 2026**, the Telecom Regulatory Authority of India (TRAI) issued a consultation paper on satellite communication network authorisation and spectrum assignment, reflecting the continuing evolution of India's satellite communications framework.
- The debate highlights the need to balance **digital inclusion, competitive neutrality, national security and affordable connectivity**.

What Is Starlink?

Definition and Features:

- **Starlink** is a satellite-based broadband service developed by **SpaceX**, designed to provide high-speed, low-latency internet, particularly in remote, rural and underserved areas where terrestrial infrastructure is limited.
- It uses a large constellation of **low Earth orbit (LEO) satellites**, user terminals and ground infrastructure to transmit data between users and the wider internet.
- Unlike conventional broadband, satellite internet can provide connectivity without requiring fibre-optic cables or mobile towers at every service location.

How Does Satellite Internet Work?

Technical Architecture:

- **Space segment:** Satellites carry communication payloads that receive, process or relay data between user terminals, other satellites and ground stations.
- **Ground segment:** User terminals, antennas, modems and gateway stations connect satellite networks to users and terrestrial internet infrastructure.
- **Inter-satellite links:** Some LEO systems use optical links to transfer data directly between satellites, reducing dependence on ground gateways for certain routes.

Major Orbital Categories:

- **Geostationary Earth Orbit (GEO):** Located approximately **35,786 km** above the equator, GEO satellites offer extensive coverage but experience high latency, making them less suitable for some real-time applications.
- **Medium Earth Orbit (MEO):** Located between approximately **2,000 km and 35,786 km**, MEO systems offer intermediate latency and require suitable satellite arrangements for broad coverage.
- **Low Earth Orbit (LEO):** Extending up to approximately **2,000 km**, LEO satellites provide lower latency but cover smaller areas individually, requiring large constellations for extensive coverage.

Regulatory Framework Governing Starlink in India:

Telecommunications Regulation:

- **Telecommunications Act, 2023:** Provides the principal statutory framework for telecommunications authorisation and permits administrative assignment of spectrum for specified satellite-based services listed in its First Schedule.
- **Department of Telecommunications (DoT):** Oversees service authorisation, spectrum assignment, technical compliance and security-related conditions. Starlink's operations require the applicable authorisations and permissions before commercial launch.
- **TRAI Act, 1997:** Establishes the regulatory authority responsible for recommendations and regulatory functions concerning telecommunications, including licensing frameworks, spectrum-related matters and competition.
- **Indian Telegraph Act, 1885:** Historically governed telecommunications licensing under Section 4. The current framework must be understood alongside the transition to the Telecommunications Act, 2023, rather than treating the older legislation as the sole governing law.

Space, Data and Security Regulation:

- **Indian Space Policy, 2023 and IN-SPaCE:** Provide the broader framework for private-sector participation in space activities, including applicable authorisation and coordination requirements. Telecommunications service permissions remain distinct from space-sector authorisations.
- **Information Technology Act, 2000 and Digital Personal Data Protection Act, 2023:** Form part of India's broader legal framework for information security and personal-data protection, subject to applicable provisions and implementation requirements.
- **National security requirements:** Satellite operators must comply with applicable government directions, lawful interception and monitoring requirements, subscriber verification rules and other security conditions.

Why Has Starlink's Commercial Launch Faced Delays?

Key Regulatory and Operational Issues:

- **Spectrum assignment:** Administrative allocation is permitted under the Telecommunications Act, 2023, but the applicable charges, conditions and assignment framework remain important regulatory issues.
- **Security clearances:** Authorities must assess network architecture, data routing, user verification, lawful access and potential misuse of satellite connectivity.
- **Technical compliance:** Satellite operations require compliance with applicable frequency coordination, interference-management and gateway requirements.
- **Competition concerns:** Traditional telecom operators and satellite broadband providers differ in infrastructure costs, spectrum requirements, coverage models and service economics, making regulatory neutrality important.
- **Regulatory clarification:** TRAI's 2026 consultation on satellite communication network authorisation and spectrum assignment demonstrates that aspects of the wider framework continue to evolve.

Advantages of Starlink for India:

Developmental and Strategic Benefits:

- **Rural connectivity:** Satellite broadband can connect remote villages, islands, mountainous regions and border areas where terrestrial networks are difficult or expensive to deploy.

- **Economic empowerment:** Reliable connectivity can support digital education, telemedicine, agricultural technology, e-commerce and access to online public services.
- **Disaster resilience:** Satellite networks can provide alternative communication channels when floods, earthquakes, cyclones or other emergencies disrupt terrestrial infrastructure.
- **Strategic connectivity:** Satellite communication can strengthen communications in geographically isolated areas, including remote infrastructure and maritime locations, subject to applicable security restrictions.
- **Digital inclusion:** Satellite broadband can complement **Digital India** and **BharatNet**, extending connectivity to areas where conventional networks remain inadequate.

Concerns Associated with Starlink's Entry:

Affordability and Market Competition:

- **High costs:** User terminals, installation and subscription charges may make the service unaffordable for many rural households, limiting immediate mass-market adoption.
- **Unequal access:** Initial demand may be concentrated among businesses, institutions and affluent customers rather than low-income communities with limited connectivity.
- **Competitive neutrality:** Policymakers must ensure that spectrum charges, authorisation conditions and security requirements are transparent and applied fairly across eligible operators.

Security and Technological Risks:

- **Unlawful use:** Portable satellite terminals may be misused for unauthorised communication, illegal activities or operations in restricted areas.
- **Data governance:** Foreign-controlled network infrastructure raises questions about data routing, lawful access, cybersecurity and compliance with Indian law.
- **Interference and orbital congestion:** Large satellite constellations require effective frequency coordination, orbital management and measures to reduce harmful interference and space debris.

Way Forward:

- **Transparent regulation:** Establish predictable authorisation procedures, clearly defined security conditions and consistent spectrum-assignment rules.
- **Affordable access:** Encourage suitable pricing models, targeted support and partnerships with public institutions to extend services to underserved communities.
- **Complementary infrastructure:** Treat satellite broadband as a supplement to fibre, mobile networks and BharatNet rather than a universal replacement for terrestrial connectivity.
- **Strong security safeguards:** Enforce subscriber verification, lawful monitoring, cybersecurity standards and appropriate domestic data-governance requirements.
- **Competition and accountability:** Ensure a level playing field for domestic and foreign providers while protecting consumers, innovation and national interests.

Value Addition for UPSC:

Constitutional, Policy and Examination Linkages:

- **Article 19(1)(a):** Freedom of speech and expression provides an important constitutional context for internet access, subject to constitutionally valid restrictions.
- **Digital India:** Seeks to improve digital infrastructure, service delivery and digital empowerment.

- **BharatNet:** Aims to provide broadband connectivity to gram panchayats, primarily through rural digital infrastructure.
- **International Telecommunication Union (ITU):** Coordinates international radio-frequency use and satellite-orbit resources to reduce harmful interference.
- **GS Paper II:** Governance, regulatory institutions, digital inclusion and public-policy implementation.
- **GS Paper III:** Science and technology, space technology, cybersecurity, infrastructure and economic competition.

Conclusion: Starlink can help narrow India's digital divide by connecting underserved regions, but its benefits depend on **affordability, transparent regulation, fair competition and robust national-security safeguards**. Satellite broadband should complement India's terrestrial networks while expanding equitable access to digital opportunities.

Funding Uncertainty After DAY-NULM Ends Threatens Urban Livelihood Support and Social Protection for India's Poor

Recent Developments:

- At least **five states**—**Tamil Nadu, Karnataka, Maharashtra, Madhya Pradesh and Tripura**— have raised concerns with the Union Government regarding financial support for urban livelihood programmes, warning that uncertainty could disrupt assistance to vulnerable urban households.
- The **Deendayal Antyodaya Yojana–National Urban Livelihoods Mission (DAY-NULM)** ended on **30 September 2024**, after a decade of implementation. Its successor pilot, **Deendayal Jan Aajeevika Yojana–Shehri (DJAY-S)**, concluded on **31 December 2025**, leaving questions about the continuity of a comprehensive urban livelihood framework.
- According to the Ministry of Housing and Urban Affairs, DAY-NULM had formed **10,02,545 self-help groups**, provided skill training to **15,42,952 candidates**, and established **1,995 shelters** with capacity for approximately **1.41 lakh beds** by September 2024.

About DAY-NULM:

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Evolution and Objectives:

- **DAY-NULM** was a centrally sponsored scheme implemented by the Ministry of Housing and Urban Affairs to reduce the **economic, social and residential vulnerabilities** of the urban poor through sustainable livelihoods, financial inclusion and community mobilisation.
- It evolved from the **Swarna Jayanti Shahari Rozgar Yojana (SJSRY)**, introduced in 1997, and was restructured into the National Urban Livelihoods Mission in September 2013, subsequently operating under the Deendayal Antyodaya Yojana framework.
- The mission sought to enable urban poor households to access wage employment, self-employment, institutional credit, skill development and essential support services.

Key Features:

- **Self-help groups:** Organised urban poor women into savings-and-credit-based groups and federations to strengthen collective action, financial independence and community participation.

- **Financial assistance:** Supported eligible groups through revolving funds, bank linkages and interest subsidies, helping members access institutional credit and establish micro-enterprises.
- **Skill development:** Provided market-oriented training and placement assistance to improve employability and enable sustainable earnings.
- **Self-employment:** Encouraged individual and group enterprises through credit facilitation, entrepreneurship development and financial inclusion.
- **Urban homelessness:** Supported permanent shelters equipped with essential services for vulnerable homeless populations.
- **Street-vendor support:** Promoted vendor-friendly urban planning, access to credit, market development and livelihood opportunities.

Understanding DJAY-S:

Purpose and Target Groups:

- **Deendayal Jan Aajeevika Yojana–Shehari (DJAY-S)** was introduced as a pilot programme from **1 October 2024** to develop a successor approach to urban poverty alleviation.
- The pilot focused on six vulnerable occupational groups, including **construction workers, transport workers, gig workers, waste workers, domestic workers and care workers**.
- Its approach sought to combine livelihood development, financial assistance, skill enhancement, social protection and stronger community institutions, reflecting the changing composition of the urban informal workforce.

Major Concerns Arising from the Transition:

Funding and Administrative Uncertainty:

- **Funding uncertainty:** States have reported inadequate clarity over continued central assistance, outstanding financial requirements and the resources needed to maintain existing programme activities.
- **State-level financial pressure:** Tamil Nadu, Karnataka, Maharashtra, Madhya Pradesh and Tripura have raised concerns about funds for self-help groups, staff salaries, revolving funds and interest subsidies.
- **Staff continuity:** Delays in decisions on administrative expenditure may disrupt field-level implementation, beneficiary assistance and the functioning of community institutions.
- **Uneven implementation:** States with weaker fiscal capacity may find it more difficult to maintain livelihood support, potentially widening regional disparities in urban welfare delivery.

Risks to Livelihoods and Social Protection:

- **Disruption of self-help groups:** Reduced financial and administrative support may weaken savings, internal lending, bank linkages and collective livelihood activities developed over the previous decade.
- **Loss of institutional credit:** Interruptions in interest subsidies and credit facilitation may constrain working capital and micro-enterprise expansion among low-income households.
- **Reduced employment opportunities:** Discontinuity in skill training and placement support could affect workers dependent on formal assistance to enter or improve their employment.
- **Weakening of community institutions:** Self-help groups and their federations require sustained capacity-building and financial support to remain effective channels for service delivery and social mobilisation.

Government's Position and Related Schemes:

Existing Support Mechanisms:

- The Ministry has indicated that experiences from the DJAY-S pilot are being used to explore approaches for a future urban livelihood programme, although the precise long-term framework requires clarification.
- Existing community institutions can be connected with other programmes, including **Pradhan Mantri Awas Yojana–Urban, Swachh Bharat Mission–Urban, AMRUT and PM Surya Ghar: Muft Bijli Yojana**, wherever their objectives and eligibility conditions align.
- **PM SVANidhi**, a separate Central Sector Scheme, provides collateral-free working-capital loans to eligible street vendors. Its lending period was extended to **March 2030** under the 2025 restructuring, offering a continuing avenue of support for this specific occupational group.
- Convergence with other schemes can preserve selected benefits, but it cannot automatically replace the comprehensive livelihood, institutional-development and social-protection functions of DAY-NULM.

Way Forward:

Policy and Institutional Reforms:

- **Ensure funding continuity:** The Union Government should communicate the future programme's design, implementation timeline and financing arrangements, while clarifying the settlement of eligible committed liabilities.
- **Provide transitional assistance:** Dedicated support should protect essential staff, self-help group activities, beneficiary services and community institutions until a successor framework becomes operational.
- **Strengthen Centre–State coordination:** Clearly defined responsibilities, predictable fund-release schedules and transparent reporting mechanisms can reduce implementation uncertainty.
- **Institutionalise scheme convergence:** Urban self-help groups should be linked with municipal services, waste management, food processing, housing, renewable energy and other suitable livelihood opportunities.
- **Adopt an inclusive framework:** Future policy should combine broad-based urban poverty alleviation with targeted assistance for vulnerable informal-sector workers, including gig workers, domestic workers and waste workers.
- **Monitor outcomes:** Indicators covering household income, access to institutional credit, enterprise survival, employment, social-security coverage and women's participation should guide programme evaluation.

Value Addition for UPSC:

Constitutional and Governance Linkages:

- **Article 14:** Equality before the law provides a constitutional basis for equitable and non-discriminatory access to public welfare measures.
- **Article 21:** The right to life has been interpreted by the judiciary to encompass dignified living, with implications for vulnerable urban populations.
- **Article 38:** Directs the State to promote social welfare and reduce inequalities.
- **Article 39(a):** Emphasises adequate means of livelihood for men and women.
- **Article 41:** Addresses the State's responsibility to make effective provision for work and public assistance within its economic capacity and development.
- **Article 243W and the Twelfth Schedule:** Provide the constitutional framework for municipal functions, including urban poverty alleviation.

Examination Relevance:

- **General Studies Paper II:** Welfare schemes, implementation challenges, Centre–State relations, social justice and institutional accountability.
- **General Studies Paper III:** Employment generation, financial inclusion, informal-sector livelihoods and inclusive urban development.
- **Sustainable Development Goals 1, 5, 8 and 11:** No Poverty, Gender Equality, Decent Work and Economic Growth, and Sustainable Cities and Communities.

Conclusion: The transition from DAY-NULM to a successor urban livelihood framework must protect the community institutions, financial linkages and employment opportunities built over a decade. **Predictable funding, policy clarity and effective Centre–State coordination** are essential to prevent administrative discontinuity from undermining the social and economic security of the urban poor.

UN Global AI Initiative Advances Farmer-Centric Agricultural Technology and Strengthens India's Digital Agriculture Ecosystem

Recent Developments:

- The **second meeting of the United Nations Global Initiative on AI for Agri-Food Systems (GI-AI4FS)** was held on **10 October 2026** alongside the India Mobile Congress 2026 in New Delhi. It was jointly hosted by the Telecommunication Engineering Centre under the Department of Telecommunications and the Indian Council of Agricultural Research.
- Coordinated by the **International Telecommunication Union (ITU)** with the Food and Agriculture Organization, International Fund for Agricultural Development and World Food Programme, the initiative promotes **trustworthy, interoperable and farmer-centric artificial intelligence (AI)**.
- The meeting followed an international AI hackathon held on 8–9 October 2026 and focused on responsible AI applications, common standards, international cooperation and practical agricultural innovations.
- India's digital agriculture ecosystem is expanding through **AgriStack, Kisan e-Mitra, the National Pest Surveillance System and Bharat-VISTAAR**. Notably, Bharat-VISTAAR moved beyond the proposal stage when its first phase was launched in March 2026.

Global Initiative on AI for Agri-Food Systems:***Objectives and significance:***

- **GI-AI4FS** is a United Nations-backed multilateral initiative that promotes the application of AI and the Internet of Things (IoT) across agricultural and food systems.
- Its objectives include developing interoperable digital solutions, strengthening international cooperation on AI governance and standards, building institutional capacity, and accelerating farmer-oriented innovations.
- It supports **Sustainable Development Goal 2 (Zero Hunger)** and **Sustainable Development Goal 12 (Responsible Consumption and Production)** by encouraging productive, resilient and resource-efficient food systems.
- India's participation strengthens its potential role in shaping **inclusive AI governance and digital public infrastructure**, particularly for developing countries facing climate risks, fragmented landholdings and limited agricultural technology access.

Applications of AI in Indian Agriculture:

Productivity, climate resilience and resource efficiency:

- **Precision farming:** AI combines satellite imagery, global positioning systems, drones and field sensors to generate farm-specific recommendations. Targeted application of water, fertilisers and pesticides can reduce input costs, minimise environmental damage and improve productivity.
- **Climate-responsive advisories:** AI-based weather models use historical and real-time meteorological data to improve localised rainfall and monsoon forecasts. During the Kharif 2025 pilot, forecasts reached **3.88 crore farmers across 13 states**, while surveys indicated that 31–52% of respondents adjusted land preparation or sowing decisions.
- **Smart irrigation:** Sensor-based systems monitor soil moisture and automate irrigation. A Farm Again initiative in Tamil Nadu demonstrated the potential of indigenous solar-powered sensors to double coconut yields while saving water and reducing emissions.
- **Pest and disease surveillance:** Image recognition can identify crop diseases and pests from photographs, enabling timely interventions and reducing avoidable crop losses. The **National Pest Surveillance System (NPSS)** supports 66 crops and more than 432 pest types, providing advisories to over 10,000 agricultural extension workers.
- **Crop insurance:** Technology-based yield estimation under **YES-TECH**, geotagged crop photographs through **CROPIC**, and weather information through the **WINDS** platform can improve crop-loss assessment, transparency and insurance-claim settlement under the Pradhan Mantri Fasal Bima Yojana.
- **Market intelligence:** AI can analyse price movements, arrivals and regional demand using information from **e-NAM** and **AGMARKET**. Better market intelligence can help farmers choose appropriate selling times and locations, reducing distress sales and improving price realisation.

India's Digital Agriculture Initiatives:

Digital Public Infrastructure and advisory services:

- **Digital Agriculture Mission:** Approved in 2024 with an outlay of ₹2,817 crore, the mission aims to establish a comprehensive digital foundation for agricultural services using verified farmer, land and crop data.
- **AgriStack:** It creates digital Farmer IDs linked to relevant agricultural records and supports the Digital Crop Survey. By 27 November 2025, more than **7.63 crore Farmer IDs** had been generated against a target of 11 crore by 2026–27; the crop survey covered more than 23.5 crore plots during Rabi 2024–25.
- **Krishi Decision Support System:** It integrates satellite imagery, weather, soil, water and crop information to support digital crop mapping, yield estimation, drought monitoring and evidence-based policy decisions.
- **Bharat-VISTAAR:** The **Virtually Integrated System to Access Agricultural Resources** is a multilingual, AI-powered platform launched in March 2026. It integrates agricultural information and scientific practices developed by the Indian Council of Agricultural Research to provide personalised advice on crop management, weather, market prices, pests and diseases, and soil health.
- **Kisan e-Mitra:** This voice-enabled AI chatbot answers queries about government schemes, including the Pradhan Mantri Kisan Samman Nidhi and crop insurance. By December 2025, it had answered over **93 lakh queries** and was handling more than 8,000 queries daily in 11 regional languages.
- **Soil resource mapping:** The Soil and Land Use Survey of India is undertaking village-level soil mapping at a resolution of 1:10,000. Approximately 29 million hectares had been mapped against a target of 142 million hectares, supporting scientific land-use planning and sustainable agriculture.
- **Agri-tech start-ups:** Under the Rashtriya Krishi Vikas Yojana, eligible start-ups receive support of up to ₹5 lakh at the idea stage and ₹25 lakh at the seed stage. A total of 2,282 start-ups received financial and technical assistance between financial years 2019–20 and 2025–26.

IMPACT AI framework:

The *Future Farming in India: AI Playbook for Agriculture*, released in October 2025, presents a three-pillar framework for scaling responsible AI adoption.

- **Enable:** Establish supportive policies, clear AI strategies, data-sharing frameworks and digital infrastructure.
- **Create:** Promote collaboration among start-ups, technology providers, agricultural research institutions and the private sector to develop and validate locally relevant solutions.
- **Deliver:** Integrate AI into agricultural extension services, strengthen last-mile access and use farmers' feedback to improve solutions.

Challenges of AI Adoption in Agriculture:

- **Smallholder data gap and algorithmic bias:** Small and marginal holdings account for approximately 86% of India's operational landholdings. Models trained on large, mechanised farms may produce inaccurate recommendations for fragmented, multi-cropped and rain-dependent Indian farms.
- **Digital divide and affordability:** Limited connectivity, digital literacy, reliable electricity and access to smartphones can prevent smallholders from benefiting. High initial costs of sensors, drones and automated machinery may concentrate gains among wealthier farmers.
- **Data privacy and sovereignty:** Unregulated access to farm-level, landholding and financial data could enable discriminatory credit scoring, exploitative pricing and excessive corporate control over agricultural information.
- **Land-record inconsistencies:** Inaccurate or outdated cadastral maps, unresolved tenancy disputes and incomplete land-title records can undermine the reliability of digital farmer databases and targeted service delivery.
- **Trust deficit:** Farmers may hesitate to replace established practices with algorithmic advice, particularly when recommendations are difficult to understand or lack local field validation.
- **Environmental costs:** Energy-intensive data centres and the growing volume of electronic waste may increase emissions, consume water and contaminate soil or groundwater if equipment is improperly discarded.
- **Interoperability and accountability:** Disconnected platforms, incompatible datasets and unclear responsibility for incorrect recommendations can reduce the effectiveness of digital agricultural services.

Measures to Promote Inclusive AI-Driven Agriculture:

- **Farming-as-a-Service:** Expand Custom Hiring Centres, Farmer Producer Organisations and drone services so smallholders can rent AI-enabled equipment on a pay-per-use basis rather than purchase costly machinery. Women's self-help groups can also be supported as service providers.
- **Phyigital agricultural extension:** Combine digital advisories with human assistance through Krishi Vigyan Kendras, agricultural extension workers and community resource persons such as Krishi Sakhis. Local validation and demonstrations can strengthen trust and overcome digital-literacy barriers.
- **Farmer-centric data governance:** Apply consent-based data-sharing principles, purpose limitation, secure access controls and grievance redressal to agricultural platforms. Farmers should have meaningful control over how their data is accessed and used.
- **Inclusive digital infrastructure:** Improve rural connectivity, local-language interfaces, offline access and assisted digital services, while ensuring that traditional extension services remain available.
- **Reliable and accountable AI:** Validate models across different agro-climatic zones and cropping systems, disclose uncertainty and establish mechanisms for correcting harmful or inaccurate recommendations.
- **Capacity building and innovation:** Train extension workers to interpret AI outputs, support locally developed agricultural technologies and expand affordable access to research, finance and markets.

- **International cooperation:** Use GI-AI4FS to share validated tools, open-source models, technical standards and best practices for agricultural data governance, while respecting national priorities and local farming conditions.

Conclusion:

AI can make Indian agriculture more **productive, climate-resilient, resource-efficient and market-oriented**. However, technological deployment alone cannot ensure inclusive development. Reliable data, affordable access, farmer consent, human-centred extension and environmental safeguards are essential to prevent digital exclusion and ensure that smallholders benefit from agricultural innovation.

Value Addition for UPSC:

- **GS Paper III:** Agriculture, technology in agriculture, crop insurance, food security, inclusive growth and environmental sustainability.
- **GS Paper II:** Digital governance, international institutions, public service delivery and accountability.
- **Key concept: Digital Public Infrastructure for Agriculture** combines trusted digital identities, interoperable datasets and accessible services to improve agricultural decision-making.
- **Analytical perspective:** AI should complement farmers' knowledge and public agricultural extension rather than replace them; its success should be measured through improved farm incomes, reduced risk, resource conservation and equitable access.
- **Potential Mains question:** *Discuss the opportunities and challenges associated with the use of artificial intelligence in Indian agriculture. Suggest measures to ensure that AI-driven agricultural transformation remains inclusive and sustainable. (250 words)*

JOSH Campaign Mobilises Youth Networks to Strengthen Community Participation in India's Fight Against Tuberculosis and Accelerate Grassroots Elimination

Recent Developments:

- On 8 October 2026, the Ministry of Health and Family Welfare launched **JOSH (Joint Squad for Health)** teams under the TB Mukht Bharat Abhiyaan at Bharat Mandapam, New Delhi. The first phase covers **55 districts across 11 states** and brings together MY Bharat volunteers, National Cadet Corps cadets and designated government officers.
- Each team comprises 5 MY Bharat volunteers and 5 National Cadet Corps cadets, led by a designated Class-I officer at the block or ward level. The teams promote symptom awareness, early diagnosis, treatment adherence and stigma reduction through community outreach.
- The campaign builds on India's progress in tuberculosis control. According to the **World Health Organization's Global Tuberculosis Report 2025**, India's estimated TB incidence declined by **21% between 2015 and 2024**, while treatment coverage reached 92% in 2024. The government also reported a treatment success rate of 90%.
- In 2026, **67,933 Gram Panchayats across 697 districts** were recognised as TB-free, highlighting the growing role of local institutions and community participation.

Understanding Tuberculosis:

Nature and transmission:

- **Tuberculosis (TB)** is an infectious disease caused by *Mycobacterium tuberculosis*. It primarily affects the lungs and spreads through the air when an infectious person coughs, speaks or sneezes.
- **Latent TB infection:** The bacteria remain in the body without causing active disease or making the person infectious. Some infected individuals may develop active TB later, particularly when immunity weakens.
- **Active TB:** The bacteria multiply and cause clinical illness, with symptoms such as persistent cough, fever, night sweats, weight loss and, sometimes, blood in sputum.
- **Pulmonary and extrapulmonary TB:** Pulmonary TB affects the lungs, while extrapulmonary TB affects other organs, including lymph nodes, bones, kidneys and the central nervous system. Infectiousness depends on the site of disease and clinical circumstances.
- **Drug-resistant TB:** Rifampicin-resistant and multidrug-resistant TB require specialised treatment. Multidrug-resistant TB is resistant to at least isoniazid and rifampicin, making early drug-susceptibility testing essential.

India's Strategy for TB Elimination:

National Tuberculosis Elimination Programme:

- The **National Tuberculosis Elimination Programme (NTEP)** operates under the National Health Mission and follows a comprehensive approach involving early detection, quality-assured treatment, preventive therapy and strengthened health systems.
- India set **2025 as its national target** for eliminating TB, ahead of the United Nations Sustainable Development Goal target of ending the global TB epidemic by 2030. The 2025 deadline was an ambitious national objective, not an achieved elimination milestone.
- The strategy has increasingly shifted from facility-based treatment towards **Jan Bhagidari**, or public participation, involving elected representatives, frontline workers, civil society, educational institutions and private healthcare providers.
- India's molecular diagnostic network, digital patient-management platform and direct benefit transfer mechanisms support case notification, treatment monitoring and nutritional assistance.

Major government initiatives:

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- **TB Mukh Bharat Abhiyaan and Ni-kshay Mitra:** These initiatives mobilise communities and individual supporters to provide supplementary nutritional and social support to people receiving TB treatment.
- **Ni-kshay Poshan Yojana:** This scheme provides nutritional financial assistance to notified TB patients. The monthly assistance was increased to **₹1,000 in 2024**, strengthening support during treatment.
- **Shorter BPALM regimen:** The six-month, all-oral regimen combines bedaquiline, pretomanid, linezolid and moxifloxacin for eligible patients with drug-resistant TB. It can reduce treatment duration compared with longer regimens, subject to clinical eligibility and national guidelines.
- **Technology-enabled screening:** Handheld digital chest X-rays with artificial intelligence support, molecular tests such as CBNAAT and Truenat, and digital tools help identify cases and improve access to diagnosis.
- **TB-free Panchayat initiative:** Local governments and communities are encouraged to improve awareness, screening, treatment adherence and preventive interventions, making TB control a decentralised public-health responsibility.

Challenges to TB Elimination:

Health-system and social barriers:

- **Under-notification in the private sector:** Patients frequently seek care from private providers, and incomplete reporting can leave diagnosed cases outside the national surveillance system. Irrational antibiotic prescriptions and delayed molecular testing may postpone appropriate treatment and contribute to drug resistance.
- **Undernutrition and poverty:** Undernutrition increases susceptibility to TB, while illness can reduce household income and worsen food insecurity. Daily-wage workers and vulnerable families may struggle to maintain adequate nutrition and complete treatment without social support.
- **Stigma and delayed diagnosis:** Fear of discrimination, social exclusion and marital or employment consequences can discourage people from disclosing symptoms or seeking timely care. Women and economically dependent individuals may face particular barriers.
- **Geographical and last-mile gaps:** Remote tribal settlements, hilly regions and areas affected by conflict can face shortages of diagnostic facilities, difficult specimen transport and delays in treatment initiation.
- **Drug resistance and adherence:** Incomplete treatment, inappropriate prescriptions and delayed identification of resistance can complicate disease management and increase treatment costs.
- **Persistent transmission:** Undetected infectious cases, crowded housing, poor ventilation and limited preventive treatment allow transmission to continue even when treatment coverage improves.
- **Social protection gaps:** Patients may experience income loss, nutritional insecurity and residual lung impairment after clinical recovery, creating a need for sustained rehabilitation and support.

Measures Needed to Accelerate Elimination:

- **Strengthen JOSH and community mobilisation:** Use youth networks to identify symptoms, correct misconceptions, encourage voluntary screening and support treatment adherence. Community outreach should protect patient confidentiality and avoid discriminatory labelling.
- **Expand targeted TB preventive treatment:** Screen household contacts and other eligible high-risk groups, rule out active disease and provide preventive treatment according to national guidelines. Preventive therapy should be accompanied by follow-up and counselling.
- **Integrate private healthcare providers:** Improve real-time notification through Ni-kshay, promote standard treatment protocols, strengthen drug-dispensation monitoring and facilitate referrals for molecular diagnosis and drug-resistance testing.
- **Decentralise quality-assured diagnosis:** Expand access to molecular testing through public health facilities, including Ayushman Arogya Mandirs where appropriate, while strengthening sample transport, maintenance and trained personnel.
- **Improve airborne infection control:** Promote adequate ventilation, cough etiquette, appropriate respiratory protection and infection-control practices in healthcare facilities, prisons, shelters and other crowded settings.
- **Strengthen nutrition and social protection:** Ensure timely nutritional assistance, food support, counselling and livelihood assistance for vulnerable patients. Rehabilitation services should address persistent respiratory disability after treatment.
- **Use data for targeted interventions:** Combine surveillance, screening outcomes and local disease patterns to prioritise high-burden communities, monitor treatment outcomes and identify gaps in access.
- **Address social determinants:** Improve nutrition, housing, sanitation and access to affordable healthcare, as medical treatment alone cannot eliminate the socioeconomic conditions that sustain TB transmission.

Conclusion:

The JOSH campaign strengthens India's shift towards a **community-led, prevention-oriented and technology-enabled TB response**. However, declining incidence and improved treatment coverage do not mean that

transmission has ended. Sustained progress requires early diagnosis, preventive treatment, reliable private-sector notification, adequate nutrition, stigma-free care and stronger last-mile health services. A TB-free India depends on combining medical interventions with community ownership and social protection.

Value Addition for UPSC:

- **GS Paper II:** Public health, government interventions, decentralised governance, civil society and public service delivery.
- **GS Paper III:** Science and technology in healthcare, artificial intelligence in diagnostics and inclusive development.
- **Important distinction:** **TB infection is not the same as active TB disease;** preventive treatment aims to reduce progression from infection to disease, while active TB requires an appropriate treatment regimen.
- **Policy insight:** TB elimination requires a continuum of care—screening, diagnosis, treatment, preventive therapy, nutritional support and post-treatment rehabilitation.
- **Potential Mains question:** *India's progress towards tuberculosis elimination requires a whole-of-society approach beyond clinical treatment. Discuss the role of community mobilisation, preventive care and social protection in achieving this objective. (250 words)*



QUESTIONS

1. With reference to environmental monitoring of persistent industrial pollutants across major Indian river systems and coastal zones, consider the following spatial trajectories:

- (1) Industrial effluent containing PFAS released in the upper catchment of the Ganga basin moves seaward towards the Sundarbans delta.
- (2) Runoff carrying aqueous film-forming foams (AFFF) from coastal military airbases in Tamil Nadu drains toward the Coromandel Coast.
- (3) Leachate from unlined landfills along the Western Ghats can migrate westward through short, fast-flowing rivers directly into the Arabian Sea.

In terms of maritime discharge from North to South along the Bay of Bengal coast, what is the correct spatial sequence of these potential receiving discharge zones?

- (A) Sundarbans Delta → Coromandel Coast
- (B) Coromandel Coast → Sundarbans Delta
- (C) Malabar Coast → Coromandel Coast
- (D) Sundarbans Delta → Konkan Coast

2. With reference to Low Earth Orbit (LEO) satellite broadband networks like Starlink compared to Geostationary Earth Orbit (GEO) communications, consider the following statements:

- (1) LEO satellites operate at altitudes below 2,000 km, resulting in significantly lower signal propagation latency compared to GEO satellites stationed at approximately 35,786 km.—
- (2) Inter-satellite optical links (laser ISLs) enable LEO constellations to route data across space without relying on ground gateway stations for every intermediate hop.
- (3) Due to their high orbital altitude, individual LEO satellites provide larger geographical coverage footprints than GEO satellites, requiring fewer total satellites for global coverage.
- (4) Administrative assignment of spectrum for satellite-based services is permissible under the provisions of the Telecommunications Act, 2023 in India.

How many of the above statements are correct?

- (A) 1 and 4 only
- (B) 1, 2 and 4 only
- (C) 2 and 3 only
- (D) 2, 3 and 4 only

3. With reference to urban poverty alleviation and informal workforce welfare frameworks in India, consider the following statements:

- (1) Under the 74th Constitutional Amendment Act, 1992, "Urban poverty alleviation" is explicitly listed as a functional subject under the Twelfth Schedule (Article 243W).
- (2) The Deendayal Jan Aajeevika Yojana–Shehri (DJAY-S) pilot explicitly targeted informal occupational categories including gig workers, waste pickers, and care workers.
- (3) PM SVANidhi is implemented as a Centrally Sponsored Scheme where capital deployment and interest subsidies are shared on a 60:40 ratio between the Centre and States.

(4) Article 39(a) of the Constitution of India directs the State to secure that citizens, men and women equally, have the right to an adequate means of livelihood.

How many of the above statements are correct?

- (A) 1 and 3 only
- (B) 2, 3 and 4 only
- (C) 2 and 4 only
- (D) 1, 2 and 4 only

4. Consider the following statements:

Statement 1: Unregulated commercial access to granular farm-level and financial data generated through digital agriculture platforms poses significant data privacy and economic sovereignty risks for farmers.

Statement 2: Consent-based data governance frameworks and purpose-limitation protocols prevent third-party entities from exploiting agricultural data for predatory credit scoring or manipulative price setting.

Which one of the following is correct in respect of the above statements?

- (A) Both Statement 1 and Statement 2 are correct, and Statement 2 is the correct explanation for Statement 1.
- (B) Both Statement 1 and Statement 2 are correct, but Statement 2 is NOT the correct explanation for Statement 1.
- (C) Statement 1 is correct, but Statement 2 is incorrect.
- (D) Statement 1 is incorrect, but Statement 2 is correct.

5. Consider the following pharmaceutical drugs:

- (1) Bedaquiline
- (2) Pretomanid
- (3) Linezolid
- (4) Moxifloxacin
- (5) Artemisinin

How many of the above anti-microbial drugs are core components of the shorter, all-oral BPaLM regimen used for treating drug-resistant Tuberculosis?

- (A) Only two
- (B) Only three
- (C) Only four
- (D) All five

ANSWER KEY

1 – Answer (A), 2 – Answer (B), 3 – Answer (D), 4 – Answer (B), 5 – Answer (C)



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