7. Deep-Tech Revolution in Agriculture - Geography

The World Economic Forum, in collaboration with stakeholders from both industry and academia, has launched a new insights report 'Shaping the Deep-Tech Revolution in Agriculture'

Introduction - Agriculture at a Crossroads

Global Context - The world's agricultural systems are under immense pressure due to climate change, population growth, and natural resource degradation. Rising demand for food and shrinking arable land call for technological disruption to ensure productivity and sustainability.

India's Context - India, home to nearly 18% of the global population but only 2.4% of the world's land, faces the dual challenge of feeding a large population and sustaining agricultural livelihoods amid erratic monsoons, soil degradation, and water stress.

Emerging Solution - The World Economic Forum's Artificial Intelligence for Agriculture Initiative (AI4AI) identifies deep technologies—including AI, robotics, CRISPR, nanotech, and remote sensing—as catalysts to transform global agriculture, including India's agri-economy.

About the Report and Initiative

Released by - World Economic Forum (WEF) under its Artificial Intelligence for Agriculture Initiative (AI4AI).

Established in - 2021 to enable governments, startups, and research institutions to harness emerging technologies for sustainable, inclusive, and resilient agriculture.

Objective - To accelerate the use of AI and other deep-tech tools for transforming agricultural productivity, improving supply chain transparency, and addressing environmental and socio-economic challenges.

Seven Deep-Tech Domains for Agricultural Transformation

The report identifies seven critical "deep-tech" domains that can revolutionise modern agriculture -

1. Generative Artificial Intelligence (AI) - Uses large-language models (LLMs) and predictive analytics to assist farmers in -

1. Pest and disease forecasting.
2. Yield and labour optimisation.
3. Farm management and decision support systems.

Example - AI-based virtual assistants providing real-time, local-language advisories on weather and crop planning.

2. Computer Vision - Utilises real-time imaging and video analytics for -

1. Detecting pest attacks and plant diseases.
2. Monitoring growth and grading produce.
3. Sorting, packaging, and quality assurance.

Applications - Drones equipped with multispectral cameras can diagnose crop stress or nutrient deficiency across large farms.

3. Edge Internet of Things (IoT) - Involves on-farm sensors and connected devices that process data locally, enabling -

1. Smart irrigation and fertigation.
2. On-site pest control.
3. Remote area farm management where connectivity is weak.

Advantage - Reduces data latency, improves precision, and supports resource efficiency in small and marginal farms.

4. Satellite-Enabled Remote Sensing - Employs Earth observation data to monitor -

1. Soil health, crop status, and moisture levels.
2. Weather anomalies, flood/drought patterns, and yield forecasting.
3. Supply chain risks and market linkages.

India already integrates this in Pradhan Mantri Fasal Bima Yojana (PMFBY) for damage assessment and insurance transparency.

5. Robotics and Autonomous Systems (Including Drones) - Focuses on automating labour-intensive activities like -

1. Sowing, weeding, spraying, and harvesting.
2. Swarm robotics for large field operations.

Benefits - Reduces labour dependency, ensures precision, and increases efficiency in large-scale and aging farming contexts.

6. CRISPR / Gene Editing - Employs CRISPR-Cas9 and other genome-editing technologies to -

1. Develop climate-resilient, drought-tolerant, and disease-resistant crop varieties.
2. Accelerate crop breeding cycles compared to conventional methods.

Example - ICAR-developed CRISPR rice variety tolerant to drought and salinity, with higher yields and lower methane emissions.

7. Nanotechnology

Enables precision input delivery -

1. Nano-fertilisers and nano-pesticides allow targeted release at plant root zones.
2. Reduces input waste, improves absorption, and minimises environmental contamination.

Future use - Nano-sensors for soil nutrient detection and nano-packaging to extend produce shelf life.

Key Concerns Highlighted

Rural–Urban Migration - Rising migration reduces agricultural labour availability, creating a need for automation and robotics.

Climate Extremes - Erratic rainfall, droughts, and floods increasingly affect crop yield stability.

Natural Resource Degradation - Overuse of fertilisers and water has reduced soil organic carbon and depleted aquifers. Overexploitation of resources threatens long-term agricultural sustainability.

Case Studies from India

1. CRISPR Rice by ICAR - Developed rice variety tolerates salinity and drought. Achieves higher yields with lower methane emissions. Demonstrates India's growing leadership in gene-editing research for food security.

2. PM Fasal Bima Yojana (PMFBY) - Integrates remote sensing, drones, and mobile apps for quicker, more transparent crop damage assessment. Enhances insurance claim accuracy and reduces farmer distress.

Government of India Initiatives Supporting Deep-Tech in Agriculture

1. India Digital Ecosystem of Agriculture (IDEA) - A framework for creating a federated farmer database. Enables data-driven innovation, integrating AI, IoT, and blockchain for efficient agri-governance.

2. National e-Governance Plan in Agriculture (NeGP-A) - Supports states and UTs in implementing AI, ML, drones, robotics, blockchain, and data analytics for modernising agriculture. Focus - Decision support systems, agri-forecasting, and smart farming.

3. National Agriculture Market (e-NAM) - A pan-India electronic trading platform connecting APMC mandis. Promotes price transparency, market integration, and direct farmer-to-trader linkages. Now includes online payment, quality testing, and logistics modules.

4.ICAR Mobile Apps and Digital Advisory Systems - Over 100 mobile apps offering expert advice on crop cultivation, livestock management, and natural resource conservation. Examples - Pusa Krishi, Kisan Suvidha, and AgriApp for region-specific guidance.

5.Kisan e-Mitra - A voice-based, AI-powered chatbot designed to assist farmers with queries on government schemes, especially PM-KISAN. Supports vernacular languages, improving inclusivity in rural digital services.

6.National Pest Surveillance System - Uses AI and ML to predict pest outbreaks, supporting timely intervention to minimise crop loss due to climate-induced infestations.

7.NaMo Drone Didi Scheme (2023–26) - A Central Sector Scheme promoting drone-based precision

agriculture. Objectives - Enhance operational efficiency, reduce input costs, and empower rural women entrepreneurs through drone training and leasing.

Promotion of Precision Farming

Under Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), promotes -

1. Drip irrigation and fertigation systems.
2. Efficient water and fertiliser use at root zones.
3. Integration with IoT for smart irrigation scheduling.

Soil Health Card Scheme - Offers farmers customised fertiliser recommendations based on scientific soil testing. Reduces nutrient misuse, boosts soil fertility, and supports sustainable input management.

Broader Implications and Benefits of Deep-Tech Adoption

1. Productivity Enhancement - Predictive analytics, robotics, and precision inputs can raise yields by 15–25% while reducing costs.

2. Climate Resilience - Technologies like CRISPR, remote sensing, and IoT enable climate-smart agriculture, improving adaptability to weather extremes.

3. Resource Efficiency - Nano and IoT technologies reduce water and fertiliser use, conserving critical resources.

4. Inclusive Growth - AI chatbots, mobile platforms, and drone programs democratise access to information and technology for smallholders.

5. Sustainability - Reduced chemical dependency, better soil management, and optimised energy use ensure long-term environmental balance.

Challenges Ahead

Data Privacy and Ownership - Farmers' data must be protected under frameworks like the Digital Personal Data Protection Act, 2023.

Digital Divide - Need for better connectivity and infrastructure in rural areas.

High Cost of Adoption - Smallholders require financial incentives and capacity building.

Skill Gaps - Upskilling rural youth for handling drones, sensors, and data analytics is essential.

Conclusion - Deep-Tech for Future-Ready Farming

The AI4AI report makes it clear - traditional methods alone cannot ensure future food security. Deep technologies—AI, IoT, gene editing, robotics, and nanotech—represent the next agricultural revolution (AgriTech 4.0). When combined with inclusive policy frameworks, digital infrastructure, and farmer empowerment, these innovations can -

1. Enhance productivity and resilience.
2. Conserve natural resources.
3. Create a sustainable, digitally empowered agricultural ecosystem.

In the words of the report, deep-tech will "future-proof farming"—making agriculture not only smarter and more productive, but also climate-resilient and sustainable for generations to come.

Source - https - //www.thehindubusinessline.com/economy/agri-business/world-economic-forums-report-identifies-7-deep-tech-domains-to-drive-agri-transformation/article70252384.ece