Agriculture 4.0: The Next Farming Revolution

This editorial is based on "Agriculture 4.0: How urban farming is shaping the future of food security in smart cities" which was published in Hindu Business Line on 23/09/2024. The article brings into picture the role of Agriculture 4.0 in transforming urban and rural farming through smart technologies like IoT, vertical farming, and mobile apps. This innovation enhances food security, optimizes resource use, and boosts farmer incomes, positioning India as a leader in sustainable agriculture.

For Prelims: Agriculture 4.0, Internet of Things, Green Revolution, eNAM, Soil Health Card scheme, India Digital Ecosystem of Agriculture , National e-Governance Plan in Agriculture, National Mission on Horticulture, PM-KISAN Scheme, BharatNet project, Farmer Producer Organizations.

For Mains: Benefits of Agriculture 4.0, Key Roadblocks to Implementation of Agri 4.0 in India.

Agriculture 4.0 is revolutionizing **urban food production,** seamlessly **blending advanced technologies** with the growing demand for **local, sustainable food sources in cities.** This innovative approach transforms urban spaces into thriving agricultural hubs, utilizing smart technologies like the Internet of Things **(IoT),** vertical farming, **and** hydroponics.

In the Indian landscape, **Agriculture 4.0 is not just about high-tech urban farms**; it's about empowering farmers across the country with tools to make informed decisions, optimize resource use, and increase yields. As India aims to double farmers' income and ensure food security for its **1.4 billion people,** the adoption of Agriculture 4.0 practices **holds the potential to transform the agricultural sector,** making it more attractive to younger generations and **positioning India as a global leader in sustainable food production.**

What is Agriculture 4.0?

- **About:** Agriculture 4.0, also known as smart farming or digital farming, represents the **fourth major revolution in agricultural practices**, leveraging cutting-edge technologies to optimize food production and resource management.
  - This innovative approach integrates advanced digital technologies such as the **Internet of Things (IoT), artificial intelligence (AI), machine learning, big data analytics, robotics, and precision farming techniques** into traditional agricultural practices.
- **Other Key Agricultural Revolutions:**
  - **Agriculture 1.0:** The initial transition from hunting-gathering to settled agriculture, beginning around 10,000 BCE, marked by the domestication of plants and animals.
  - **Agriculture 2.0:** The **Industrial Revolution in agriculture** (18th-19th centuries), characterized by mechanization, improved crop rotation, and the use of chemical fertilizers and pesticides.
  - **Agriculture 3.0**: The Green Revolution **(mid-20th century),** featuring high-yielding crop

varieties, expanded irrigation, and increased use of synthetic fertilizers and pesticides to boost food production.

- The mechanization of tasks like planting, harvesting, and irrigation during Agriculture 3.0 **laid the groundwork for future advancements in agricultural automation, including the use of robotics.**
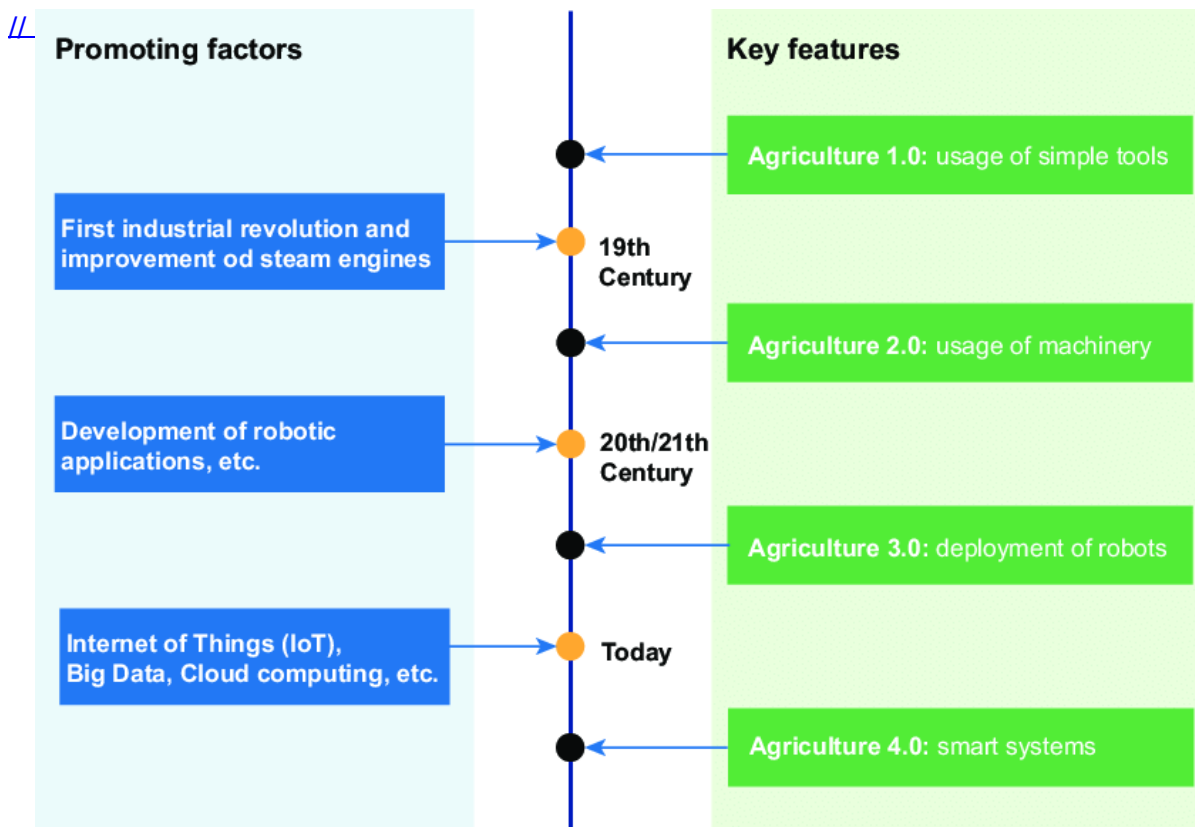
What are the Benefits of Agriculture 4.0?

- **Increased Crop Yields and Productivity:** Agriculture 4.0 technologies significantly boost crop yields through precision farming techniques.
  - For instance, **the use of IoT sensors** and data analytics enables farmers to optimize inputs like **water, fertilizers, and pesticides** based on real-time soil and plant conditions.
  - In India, the adoption of precision agriculture techniques has led to yield increases of up to **30% in some crops.**
  - A notable example is the partnership between **Microsoft and ICRISAT,** which developed an AI-powered sowing app that **increased groundnut yields by 30% in Andhra Pradesh.**
- **Resource Efficiency and Sustainability:** Agriculture 4.0 promotes **sustainable farming practices by optimizing resource use.**
  - Smart irrigation systems, for example, can reduce water consumption by up to **50% compared to traditional methods.**
  - In water-stressed regions of India, drip irrigation coupled with IoT sensors has shown remarkable results.
  - The **Tamil Nadu Precision Farming Project** demonstrated water savings of 40-50%.
    - Furthermore, **precision application of fertilizer**s guided by soil health data and crop requirements has led to a reduction in fertilizer use by 15-20%.
- **Climate Resilience and Risk Mitigation:** Advanced weather forecasting and early warning systems integral to Agriculture 4.0 help farmers adapt to climate change and mitigate risks.

- For instance, the **CRIDA's 'Meghdoot' app provides location, crop, and livestock-specific weather-based agro-advisories** to Indian farmers.
- This technology has been crucial in helping farmers make informed decisions about planting, harvesting, and pest control, reducing crop losses due to extreme weather events.
- **Supply Chain Optimization and Market Access:** Agriculture 4.0 technologies are **revolutionizing agricultural supply chains, r**educing post-harvest losses and improving market access for farmers.
  - Blockchain-based supply chain solutions, for example, enhance traceability and transparency, building trust among consumers and fetching better prices for farmers.
  - In India, the [eNAM (Electronic National Agriculture Market) platform,](#) which leverages digital technology to connect farmers with buyers across the country, has enrolled over **1.69 crore farmers.**
- **Data-Driven Decision Making and Predictive Analytics**:The integration of big data and AI in agriculture enables predictive analytics, helping farmers and policymakers make informed decisions.
  - For instance, **satellite imagery** combined with **machine learning algorithms** can predict crop yields months before harvest with over **90% accuracy.**
  - In India, the **FASAL project (Forecasting Agricultural output using Space, Agrometeorology and Land based observations)** uses such technologies to provide pre-harvest crop estimates for major crops, aiding in national food security planning.
- **Democratization of Agricultural Knowledge**: Agriculture 4.0 is making expert agricultural knowledge more accessible to smallholder farmers through mobile apps and AI-powered chatbots.
  - In India, platforms like **Kisan Suvidha and IFFCO Kisan** have reached millions of farmers, providing them with personalized advice on crop management, pest control, and market prices.
  - Agritech startup **DeHaat's** revenue is likely to grow by over 80% on sales of farm inputs to farmers.

Key Case Studies Related to Agriculture 4.0:

- **Pramod Gautam**: A former automobile engineer, Pramod switched to farming on his 26-acre land in 2006.
  - Facing initial challenges with crops and labor, he adopted modern farm equipment and shifted to horticulture. Today, Pramod runs a successful dal mill and horticulture business, generating a turnover of Rs. 1 crore annually.
- **Sachin Kale**: A mechanical engineer turned farmer, Sachin left his high-paying job in 2013 to set up an innovative clean energy farm.
  - He now runs his own company, helping over 137 farmers with contract farming and generating a turnover of Rs. 2 crore.
- **Harish Dhandev:** Harish left a government job to pursue Aloe Vera farming in Rajasthan. Using digital platforms and market research, he scaled his business to 100 acres, now earning between Rs. 1.5 to 2 crore annually.
- **Vishwanath Bobade:** A farmer from drought-prone Beed, Maharashtra, Vishwanath earned Rs. 7 lakh from one acre through multi-cropping and efficient farming techniques like drip irrigation.
- **Rajiv Bittu:** A chartered accountant who turned to farming, Rajiv implemented modern techniques like drip irrigation and mulching. His diversified crop strategy on leased land now earns him Rs. 15-16 lakh annually.

These cases highlight how innovation, technology, and smart farming methods are transforming agriculture in India, aligning with the principles of Agriculture 4.0.

What are the Key Roadblocks to Implementation of Agri 4.0 in India?

- **Limited Digital Infrastructure and Connectivity:** Despite rapid improvements, India's [rural digital infrastructure](#) remains a significant barrier to Agriculture 4.0 adoption.
  - Out of approximately **5.97 lakh villages in India**, it is estimated that around **25,067 villages** lack mobile and internet connectivity.
  - The Digital India initiative has made strides, but the last-mile connectivity challenge

persists.

- This digital divide hinders the deployment of IoT devices and real-time data transmission crucial for precision agriculture.
- In states like **Bihar and Jharkhand**, where connectivity is particularly poor, farmers struggle to access even basic digital agricultural services, limiting the potential impact of Agriculture 4.0 technologies.

- **Small and Fragmented Landholdings**: India's agricultural landscape is dominated by **small and marginal farmers**, with an **average landholding size of just 1.08 hectares.**
  - This fragmentation makes it challenging to implement large-scale technological solutions cost-effectively.
  - For example, precision farming equipment like **GPS-guided tractors or drones** for crop monitoring become economically unviable for individual smallholders.
  - This **fragmentation not only increases the per-acre cost of technology adoptio** n but also complicates data collection and analysis at scale, reducing the effectiveness of big data-driven agriculture solutions.
- **Limited Financial Resources and Access to Credit:** The high initial investment required for **Agriculture 4.0 technologies** poses a significant barrier for many Indian farmers.
  - According to the **National Financial Inclusion Survey 2016-17, T**he annual income of rural households was **₹ 96,708.**
  - While schemes like the [Kisan Credit Card](#) have improved credit access, the adoption of high-tech farming solutions remains low.
- **Lack of Awareness and Digital Literacy:** Majority of Indian farmers lack awareness about Agriculture 4.0 technologies and the digital literacy required to use them effectively.
  - As of 2023, **only 30% of Indian farmers** have adopted some form of digital technology in their agricultural practices.
  - The **digital literacy rate in rural India stands at just 25%.**
  - This knowledge gap hinders the adoption of even basic digital agricultural services.
- **Inadequate Data Infrastructure and Standards:** The lack of standardized, high-quality agricultural data is a major roadblock for Agriculture 4.0 in India.
  - While initiatives like the [Soil Health Card scheme](#) have generated vast amounts of data, the integration and effective use of this data remain challenges.
  - The **absence of a unified agricultural data platform** hampers the development of AI and ML models crucial for precision agriculture.
- **Environmental and Socio-Economic Disparities**: India's diverse agro-climatic zones and socio-economic disparities pose unique challenges to the uniform implementation of Agriculture 4.0.
  - **Technologies that work well in irrigated regions of Punjab or Haryana may not be suitable for rain-fed areas in central India.**
  - For instance, while precision irrigation technologies can show water savings of up to 50% in some areas, their applicability in rain-fed regions, which constitute **51% of India's net sown area,** is limited.
  - Similarly, the **success of agri-tech startups is often concentrated in more developed agricultural belts,** creating a technology adoption gap between progressive and marginalized farming communities.

What are the Recent Government Initiatives Related to Digitalisation of Agriculture?

- [India Digital Ecosystem of Agriculture](#) (IDEA): A framework designed to create a federated farmers' database to enable innovative agri-focused solutions. It integrates scheme databases for effective planning to increase farmers' income and boost sectoral efficiency.
- [National e-Governance Plan in Agriculture](#) **(NeGP-A):** Supports state projects using technologies like AI, ML, robotics, drones, data analytics, and blockchain to modernize agriculture.
- [Sub Mission on Agricultural Mechanization](#) (SMAM): Focuses on providing farm mechanization to small and marginal farmers through custom hiring centers, high-tech equipment hubs, and capacity building.
- **e-NAM**: A pan-India digital trading portal connecting Agricultural Produce Market Committees (APMCs) to create a unified market for agricultural commodities, benefiting farmers, traders, and

FPOs.

- **PM-KISAN Scheme**: Transfers funds directly to farmers' bank accounts via Direct Benefit Transfer (DBT). Farmers can self-register and access information through the PM-KISAN Mobile App.
- **AGMARKNET:** A G2C e-governance portal providing agricultural marketing-related information, including daily prices and arrivals of commodities in agricultural markets.
- **Agriculture Infrastructure Fund (AIF):** Provides financial assistance for post-harvest management and community farming assets, offering interest subvention and credit guarantees.
- **National Mission on Horticulture (HORTNET):** Promotes e-Governance in horticulture by offering a web-enabled system for financial assistance, ensuring transparency in the process.
- **National Project on Soil Health and Fertility**: Issues soil health cards through a digital portal for farmers to track nutrient deficiencies and improve fertilization practices.
- **Kisan Suvidha Mobile App:** Disseminates crucial information on weather, market prices, plant protection, input dealers, and more to help farmers make informed decisions.

What Strategies can be Adopted to Effectively Implement Agriculture 4.0 in India?

- **Public-Private Partnerships for Digital Infrastructure:** Leveraging public-private partnerships can accelerate the development of digital infrastructure in rural areas.
  - The BharatNet project can be expedited by involving private telecom operators in last-mile connectivity and can be linked to **CSCs (Common Service Centres)**.
  - Expanding this model can significantly improve rural internet connectivity.
  - These partnerships can focus on **creating Wi-Fi hotspots in village centers and providing subsidized data plans for agricultural use**, making digital agriculture services more accessible to farmers.
- **Farmer Producer Organizations (FPOs) for Technology Adoption:** Promoting and strengthening Farmer Producer Organizations can overcome the challenges posed by small landholdings.
  - The government's target to form **10,000 new FPOs by 2024** provides an excellent opportunity to introduce Agriculture 4.0 technologies at scale.
    - In the Union budget 2024-25 the government proposed increasing the allocation for FPOs by about 30%, **from ₹450 crore for 2023-24 to ₹581.67 crore for 2024-25**
  - The success of **FPOs like Sahyadri Farms in Maharashtra,** which has helped small farmers adopt precision farming techniques, demonstrates the potential of this approach.
- **Customized Financial Products and Digital Literacy Programs:** Developing tailored financial products for Agriculture 4.0 technology adoption, coupled with digital literacy programs, can address both financial and knowledge gaps.
  - **Banks and fintech companies** can offer low-interest loans or pay-per-use models for agri-tech solutions.
  - Expanding programs like the Pradhan Mantri Gramin Digital Saksharta Abhiyan **(PMGDISHA)** with a specific focus on digital agriculture can enhance farmers' ability to use these technologies effectively.
- **Standardization of Agricultural Data and Open Data Platforms:** Establishing a standardized framework for agricultural data collection, storage, and sharing is crucial for the effective implementation of Agriculture 4.0.
  - The **India Digital Ecosystem of Agriculture (IDEA) framework** can be fast-tracked to create a unified, open-source platform for agricultural data.
  - Implementing **blockchain technology for data integrity and traceability,** as demonstrated by the Coffee Board of India's **blockchain-based marketplace pilot**, can enhance trust and transparency in the agricultural data ecosystem.
- **Regulatory Sandbox for Agri-Tech Innovations:** Creating a regulatory sandbox for agricultural technologies can foster innovation while ensuring safety and efficacy.
  - This approach allows for **controlled testing of new technologies in real-world conditions** before full-scale implementation.
  - For example, the **recent liberalization of drone regulations for agriculture** can be extended to create designated zones for testing advanced drone applications in precision

agriculture.
  - The success of **India's regulatory sandbox for fintech** can serve as a model, allowing agri-tech startups to test their innovations in controlled environments.
- **Localized Agri-Tech Solutions through Krishi Vigyan Kendras (KVKs):** Leveraging the network of **Krishi Vigyan Kendras (KVKs)** to develop and disseminate localized agri-tech solutions can address the challenge of diverse agro-climatic conditions.
  - KVKs can serve as **hubs for demonstrating and customizing Agriculture 4.0** technologies for specific local needs.
- **Integration of Agriculture 4.0 in Agricultural Education:** Updating agricultural education curricula to include **Agriculture 4.0 technologies** can create a skilled workforce to drive innovation and adoption.
  - This can be achieved by integrating courses on precision agriculture, IoT in farming, and agricultural data analytics into existing agricultural degree programs.
  - Collaborations with tech companies, like the partnership between Microsoft and ICAR**can bring industry expertise into agricultural education**, preparing the next generation of tech-savvy agricultural professionals.

Conclusion

Agriculture 4.0 is transforming Indian farming by integrating advanced technologies to **enhance productivity**, sustainability, and resilience. However, addressing challenges like limited digital infrastructure, small landholdings, and financial constraints is crucial for widespread adoption. With strategic public-private partnerships and localized solutions, Agriculture 4.0 can revolutionize India's agricultural landscape, **ensuring food security and empowering farmers.**

__Drishti Mains Question:__

Examine the potential of Agriculture 4.0 in addressing the challenges of food security and sustainable farming in India. How can emerging technologies be integrated with traditional agricultural practices to achieve these goals?

UPSC Civil Services Examination, Previous Year Question (PYQ)

Prelims:

Q. In the context of India's preparation for Climate -Smart Agriculture, consider the following statements: (2021)

1. The 'Climate-Smart Village' approach in India is a part of a project led by the Climate Change, Agriculture and Food Security (CCAFS), an international research programme.
2. The project of CCAFS is carried out under Consultative Group on International Agricultural Research (CGIAR) headquartered in France.
3. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India is one of the CGIAR's research centres.

Which of the statements given above are correct?

(a) 1 and 2 only

(b) 2 and 3 only

(c) 1 and 3 only

(d) 1, 2 and 3

Ans: (d)

Q. Consider the following pairs: (2014)

Programme/Project Ministry

1. Drought-Prone Area Programme Ministry of Agriculture

2. Desert Development Programme Ministry of Environment and Forests

3. National Watershed Development Project for Rainfed Areas Ministry of Rural Development

Which of the above pairs is/are correctly matched?

(a) 1 and 2 only

(b) 3 only

(c) 1, 2 and 3

(d) None

Ans: (d)

Q. In India, which of the following can be considered as public investment in agriculture? (2020)

1. Fixing Minimum Support Price for agricultural produce of all crops
2. Computerization of Primary Agricultural Credit Societies
3. Social Capital development
4. Free electricity supply to farmers
5. Waiver of agricultural loans by the banking system
6. Setting up of cold storage facilities by the governments

Select the correct answer using the code given below:

(a) 1, 2 and 5 only

(b) 1, 3, 4 and 5 only

(c) 2, 3 and 6 only

(d) 1, 2, 3, 4, 5 and 6

Ans: (c)

Mains:

Q. Given the vulnerability of Indian agriculture to vagaries of nature, discuss the need for crop insurance and bring out the salient features of the Pradhan Mantri Fasal Bima Yojana (PMFBY). **(2016)**

Q. Explain various types of revolutions, took place in Agriculture after Independence in India. How these revolutions have helped in poverty alleviation and food security in India? **(2017)**