

Artificial Intelligence in Indian Agriculture: Transforming Crop Management and Enhancing Farmer Livelihoods

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Artificial Intelligence (AI) is changing the face of agriculture across the globe, and India—with its varied agro-ecological zones and predominantly small-holder farming systems—could really stand to benefit from this opportunity. Using AI through machine-learning algorithms, computer vision, remote sensing, and IoT devices can make resource management more efficient, forecasting for pest and disease outbreaks, doing the otherwise manual tasks, and improving the supply chain. In essence, this article takes a look back at the development of AI in Indian agriculture, core applications and representative case studies thereof; assesses the opportunities and challenges; and looks toward a future where scaling up AI is done to build a more resilient and rewarding farm enterprise.

1. Evolution of AI in Indian Agriculture

Since the early 2010s, India's public and private sectors have invested in digital agricultural

initiatives—ranging from soil health cards to mobile advisory platforms. However, the integration of AI began in earnest after 2018, fuelled by three converging trends:

- **Data Proliferation:** Satellite imagery, weather station networks, and subsidized smartphones have generated vast agro-climatic and farm-level datasets.



- **Computing Advances:** Cloud-based platforms and edge

computing devices now enable real-time model training and inference, even in rural settings.

- **Policy Support:** The Government of India's Digital Agriculture Mission and initiatives such as eNAM (National Agriculture Market) have created frameworks for data sharing and commercialization of digital solutions.

Early pilots focused on simple decision-support—crop advisories via SMS—evolved into sophisticated AI-driven platforms capable of generating

field-specific recommendations for irrigation scheduling, nutrient management, and market linkages.

2. Key AI Applications in the Field

AI's versatility has yielded a spectrum of use cases across the cropping cycle:

2.1 Precision Crop Monitoring

Computer-vision algorithms, deployed on drones or tractor-mounted cameras, automatically detect foliar diseases, nutrient deficiencies, and weed infestations. For example, convolutional neural networks can classify images of rice paddies with over 90% accuracy for blast disease, triggering targeted fungicide sprays only where needed.

2.2 Yield Prediction and Resource Optimization

Machine-learning models ingest multispectral satellite data (e.g., NDVI time-series), local weather forecasts, and soil maps to predict crop yields at district or even individual-field levels. Accurate forecasts allow cooperatives and agribusinesses to plan procurement, storage, and logistics, reducing post-harvest losses by up to 15%.

2.3 Automated Machinery and Robotics

Robotics start-ups in India are developing AI-enabled robots for tasks such as seeding, weeding, and harvesting. Vision-guided weeders, for instance, use deep learning to distinguish crops from weeds and mechanically uproot the latter, cutting herbicide use by 60%. Automated transplanters and harvesters are still nascent but hold promise for labour-short districts.

2.4 Smart Irrigation and Water Management

AI-powered controllers integrate soil-moisture sensors, local evapotranspiration data, and weather

forecasts to optimize irrigation schedules. Trials in Maharashtra and Karnataka have demonstrated water savings of 20–30% without yield penalties, crucial in water-stressed regions.

2.5 Supply-Chain and Market Intelligence

Natural language processing (NLP) algorithms scrape wholesale market websites to forecast price trends, enabling farmers to decide when and where to sell. Some platforms provide personalized market alerts, helping smallholders capture better margins—an average of ₹200–₹500 extra per metric ton of produce.

3. Illustrative Case Studies

3.1 Fasal: AI-Driven Crop Advisory in Punjab

Fasal, a Bengaluru-based agritech startup, combines IoT weather stations, field sensors, and satellite imagery. Its AI engine delivers crop-specific advisories—on fungicide spray timing or irrigation—to over 200,000 farmers in Punjab. Independent evaluations report a 12% yield increase for wheat and a 15% reduction in input costs within two seasons.

3.2 Microsoft-IARI Partnership on Pest Forecasting

In partnership with the Indian Agricultural Research Institute (IARI), Microsoft's Azure AI Lab developed machine-learning models that predict locust swarm movements and potato blight outbreaks. By integrating real-time satellite imagery with historical outbreak data, the system provides seven-day advance warnings, allowing state agencies to mobilize control measures faster.

3.3 RoboWeed: Autonomous Weeding Robot in Karnataka

A consortium led by a Mysuru university prototyped RoboWeed, a solar-powered, AI-driven weeder. Equipped with stereo cameras and a deep neural network trained on thousands of plant images, RoboWeed operates at 0.8 ha/day, removing 95% of weeds while reducing herbicide use by 70%. Pilot farmers reported 18% higher yields in maize plots.

4. Benefits and Co-Benefits

AI adoption in agriculture generates a cascade of advantages:

- **Increased Productivity:** Precise interventions yield 10–20% yield gains across major cereals and horticultural crops.
- **Cost Savings:** Optimized input use—a fertilizer, pesticides, water—lowers production costs by 15–30%.
- **Environmental Sustainability:** Reduced agrochemical runoff, lower greenhouse-gas emissions from tractors (via smart dispatch), and water-use efficiency contribute to eco-friendly farming.
- **Risk Mitigation:** Early warning systems for pests, diseases, or extreme weather events strengthen climate resilience, reducing crop-failure risk by up to 25%.
- **Empowerment of Smallholders:** Accessible AI services—via voice, regional languages, and low-bandwidth apps—democratize advanced agronomic advice, particularly for marginal farmers.

5. Challenges and Barriers to Scale

Despite these successes, several hurdles impede widespread AI adoption:

- **Digital Divide:** Only 45% of India's farmers currently have reliable internet access in the field, limiting real-time data transmission.
- **Affordability:** High costs of smart sensors, drones, and farm robots remain prohibitive for smallholders without aggregators or cooperatives.
- **Data Quality and Privacy:** Inconsistent data standards across platforms, and concerns over ownership and misuse of farmer data, create trust deficits.
- **Skill Gaps:** Effective use of AI tools requires digital literacy and agronomic understanding; extension services are yet to be fully equipped for such training.
- **Regulatory Ambiguity:** Lack of clear guidelines on AI model validation, liability for mispredictions, and standards for agritech products slows institutional procurement.

6. Policy Recommendations and Enabling Ecosystems

To unlock AI's full potential in Indian agriculture, a multi-pronged approach is necessary:

1. **Infrastructure Investments:** Expand rural broadband and 5G pilots in agri-clusters; subsidize solar-powered IoT nodes.
2. **Subsidy Reforms:** Offer capital-grant support for sensor kits, drones, and AI-enabled machinery, particularly under schemes like FPO strengthening or agri-start-up funds.
3. **Data Trust Frameworks:** Establish public-private data collaboratives with clear data-governance norms, ensuring farmers' rights and incentivizing secure data sharing.

4. Capacity Building: Revamp Krishi Vigyan

Kendras (KVKs) and agricultural universities to include AI-in-agriculture modules and hands-on training.

5. Standardization and Certification: Introduce national standards for agritech products—sensor accuracy, AI-model benchmarks, cybersecurity—to build farmer and institutional trust.

7. Personal Opinion

Artificial intelligence, when applied in agriculture, cannot be a silver bullet for technology because it requires a thoughtful marriage of traditional knowledge and extension support. In my opinion, the greatest gains will come from hybrid models where community-level aggregator services pool resources for AI infrastructure, and local agronomists interpret AI outputs in the cultural and ecological context of the particular area. It remains imperative for policymakers to emphasize decentralization in farmer-owned data platforms and treat incentivizing the co-design of AI tools among its end users as a priority to earn relevance and nurture ownership.

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Conclusion

Using AI technologies in Indian agriculture opens up a range of transformations, from being precise about monitoring the health of crops to testing variations in the machinery and market levels of intelligence. From a more practical perspective, pilots such as Fasal advisory network, the Microsoft-IARI pest forecasts, and RoboWeed's autonomous weeder application have shown improvements to yields, reduction of costs, and positive environmental impacts. However, issues such as digital access, affordability, data governance, and capacity building need to be tackled via policy measures, a collaboration between the private and public sectors, and community engagement. This ecosystem nurtures a balance between state-of-the-art AI and grassroots-level participation, turning India into the stage for the second Green Revolution—a data-driven, resilient, and inclusive one where sustainable livelihoods are guaranteed to millions of smallholders in the coming decades.

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