(A No. 161) Digital Extension and Ai-Based Agro-Advisory Systems in Indian Agriculture

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ABSTRACT

Agricultural extension in India stands at a crossroads. While the institutional network of public, private and civil society organizations continue to expand. The ability of traditional systems to deliver timely and context-specific information remains limited. Declining extension worker to farmer ratios, irregular field visits, fragmented knowledge flows and climate-induced production uncertainties have intensified the need for stronger, faster and more responsive advisory mechanisms. At the same time, farmers increasingly seek real time solutions to manage unpredictable weather events, pest outbreaks, input price volatility and market risks

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The rapid growth of ICTs, mobile internet penetration and digital services has created fertile ground for the emergence of digital extension systems. Over the past decade, these systems have evolved from simple information-delivery models to sophisticated advisory ecosystems powered by big data analytics, remote sensing and AI. This transformation is reshaping not only how information is disseminated but also how knowledge is produced, validated and used in everyday farm decision-making.

1. The Changing Context of Agricultural Extension

India's agricultural extension system has long struggled with structural limitations. The public extension network is overstretched, with a single extension worker catering to over a thousand farmers in many districts (Reddy, 2018). Traditional extension methods-farm visits, demonstrations, training programmes are time intensive, reach only a fraction of the farming population, and often fail to address time-sensitive challenges. The lack of real time communication weakens feedback loops between farmers and extension staff, resulting in generic advisories that may not match local conditions.

Moreover, Indian agriculture now operates in a highly dynamic environment. Frequent climatic shocks, shifting market demands, labour shortages, and the need for sustainable intensification demand continuous knowledge updates. These emerging complexities have created an urgent need for digital approaches that complement human-led extension and provide timely insights at scale.

2. The Emergence of Digital Extension in India

Digital extension encompasses ICT based tools and platforms used to deliver agricultural information and advisory services. These include mobile apps, SMS and voice based advisories, WhatsApp groups, YouTube channels, digital dashboards, tele-advisories and satellite-supported monitoring systems.

Digital tools have expanded the outreach of extension by:

- Enabling two-way farmer–expert interactions;

- Removing geographical barriers;
- Supporting instant sharing of photos, videos, and location-specific problems;
- Providing access to knowledge on demand.

Farmers can now receive pest alerts, weather forecasts, market information, and cropping advisories directly on their mobile phones. Extension personnel also use digital tools for monitoring cropping conditions, generating advisories and maintaining records. Digital extension has thus moved beyond information provision to become an interactive, participatory and data-enabled system.

3. AI-Based Agro-Advisory Systems: The Next Frontier

Artificial intelligence has accelerated the shift toward predictive, personalized and scalable advisory systems. AI-driven tools integrate diverse datasets including satellite imagery, automated weather station data, crop images, soil health records and historical trends to generate granular, actionable recommendations.

3.1 Pest and Disease Diagnosis

AI-based apps such as NPSS, Plantix employ machine learning models trained on millions of images to diagnose pests and diseases with high accuracy. These tools help farmers identify field problems instantly and access recommended solutions without waiting for expert visits.

3.2 Predictive Agro-Advisories

Research institutions like ICAR and ICRISAT have developed AI models that forecast pest outbreaks such as Fall Armyworm and pod borer based on weather parameters and vegetation indices. These predictive advisories shift extension from reactive responses to preventive actions.

3.3 AI-Enhanced Weather Intelligence

The Ministry of Agriculture's initiative to broadcast AI-generated monsoon forecasts through m-Kisan represents a landmark step. Using models such as Google NeuralGCM and ECMWF-AIFS, the system provides village-level rainfall predictions that support sowing, irrigation and risk planning.

3.4 Market and Crop Management Tools

AI tools analyse price trends, crop patterns and supply chain data to guide farmers on market timing, crop selection and input management. AI-driven irrigation and nutrient models recommend optimal schedules, improving water and fertilizer use efficiency.

3.5 AI Chatbots and Virtual Assistants

Chatbots like KrishiGPT and emerging tools like MausamGPT allow farmers to interact in local languages, ask questions freely and receive real time answers enhancing accessibility and democratizing advisory services.

4. Opportunities and Emerging Impacts

Digital and AI-based advisory systems are beginning to show measurable impacts across regions. Farmers using digital advisories report improvements in productivity, reduction in input costs and better risk preparedness (Tripathi & Pandey, 2024). Studies show that digital platforms enhance early disease detection, improve crop scheduling, support timely irrigation, and strengthen market participation.

For extension systems, digital and AI tools provide:

- Enhanced monitoring capabilities;
- Real-time field insights;
- Improved coordination across institutions;
- Data-driven planning and evaluation.

For policymakers, AI-generated analytics help visualize hotspots, understand cropping trends, and design targeted interventions. Digital extension also strengthens together knowledge exchanges by enabling farmer communities to learn from one another through videos, social media and interactive platforms.

5. Challenges and Concerns

Despite their promise, digital and AI-driven advisory systems face critical challenges:

Digital Divide

Not all farmers have access to smartphones, broadband connectivity or digital literacy. This inequality risks leaving behind smallholders, women farmers, and marginalized communities.

Data Quality and Model Accuracy

AI recommendations depend on high-quality datasets. In many regions, data are fragmented,

outdated or missing, leading to context-insensitive advisories.

Privacy and Ethical Concerns

The collection and use of farm-level data raise concerns about data privacy, ownership and potential misuse. Clear regulatory frameworks are urgently needed.

Overdependence on Technology

Excessive reliance on digital tools may weaken human-farmer relationships central to effective extension practice.

Localization Challenges

AI systems developed in controlled settings may not fully capture the socio-economic and agro-ecological diversity of Indian farms.

Implications for Extension and Advisory Services

The rise of digital and AI-based advisory systems has significant implications for extension:

- **Extension personnel** must be trained in digital skills to use, interpret and validate AI outputs.
- **Institutions** must adopt data governance frameworks ensuring transparency, sharing and privacy.
- **Policies** need to integrate digital advisories within existing extension structures not as standalone systems.
- **Farmers** require capacity-building programmes to use digital tools effectively.
- **Research organizations** must ensure AI tools are calibrated to local conditions through field validation.

Most importantly, extension must adopt a hybrid model combining AI-driven insights with human experience, contextual understanding and participatory approaches.

Conclusions

Digital extension and AI-based agro-advisory systems are reshaping the future of agricultural extension in India. They offer unprecedented opportunities to deliver timely, precise and scalable advisories that can enhance resilience, productivity and sustainability. However, the success of these innovations depends on addressing digital inequities, ensuring data ethics, building institutional capacities, and integrating technology with traditional extension approaches. India must move toward a balanced and inclusive extension ecosystem where digital innovations strengthen-not replace human-centered advisory services. Such a hybrid, collaborative model holds the greatest potential for empowering farmers and making Indian agriculture more resilient to emerging climatic and market challenges.

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