Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 06, Issue: 05 (SEP-OCT, 2026)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Will AI Replace the Extension Worker, or Empower the Extension Worker?

Shubham Gaurav[1] and *Tuhani Akhtar[2]
[1]PhD Research Scholar, Department of Agricultural Extension Education, Bihar Agricultural University, Sabour, Bihar, India
[2]PhD Research Scholar, Department of Agricultural Extension, Assam Agricultural University, Jorhat, India
*Corresponding Author's email: tuhaniakhtar212@gmail.com

A farmer standing at the edge of a field, unsure whether to irrigate today or wait. A few fields away, another farmer is watching their crop closely, worried it might be showing the first signs of a pest attack. Somewhere else, someone is trying to decide whether it's worth the trip to the market this week, or whether prices might rise if they wait a few more days. For generations, the answers to these questions came from experience, from neighbours, or when things got serious from a visit to the local extension worker. That system, built on field visits, farmer meetings, and word of mouth, has served agriculture for decades. It still does, in most parts of the world. But something is changing. Increasingly, that same farmer might reach for a smartphone instead of waiting for a visit. Weather alerts, pest warnings, and market prices can now arrive as a notification rather than a conversation. Sensors buried in the soil can report moisture levels before a plant even shows signs of stress. This raises an interesting question worth sitting with: if information can reach a farmer instantly, predict problems before they occur, and offer farm-specific advice, what will the agricultural extension system of the future actually look like? That's what this article sets out to explore not through speculation, but through the evidence currently available on how AI, IoT, and digital platforms are already reshaping extension services, and where the technology still has a long way to go.

What Is Digital Agricultural Extension?

Before going further, it helps to unpack some of the terms that get thrown around in this space. Digital extension simply means delivering agricultural advice and information through digital tools apps, SMS, websites rather than relying solely on in-person visits. Mobile-based extension is a subset of this: using phones, often even basic ones via SMS, to reach farmers directly, no matter how remote their location. AI-driven agricultural advisories go a step further. Instead of just delivering static information, artificial intelligence can analyse patterns in data — weather, soil, crop history and generate advice tailored to a specific farm or situation. IoT-enabled farming (the Internet of Things) refers to networks of small, connected sensors placed in fields that continuously collect data on things like soil moisture or temperature and send it back for analysis. Put together, these tools support what researchers call data-driven decision-making using real information from the field, rather than general assumptions, to guide farming choices. Agricultural extension services are increasingly being reshaped by artificial intelligence, IoT, and mobile platforms, which together aim to deliver real-time advisories, predictive analytics, and precision farming support (Subeesh & Mehta, 2021; Dujali et al., 2025; Priya et al., 2025). These tools are reported to improve information dissemination, decision-making accuracy, and resource management though, as we'll see, significant adoption barriers remain (Ibrahim, 2023; Priya et al., 2025).

The Smartphone as the New Extension Tool

Of all the digital tools available, the humble smartphone and even simpler technology like SMS has arguably had the most immediate impact on extension delivery. Mobile applications, SMS-based advisories, and web platforms have become primary channels for getting timely agricultural knowledge directly into farmers' hands (Bunkar et al., 2024; Singh et al., 2023; Priya et al., 2025). Instead of waiting for a scheduled visit, a farmer can receive location-specific advice on pest management, an updated weather forecast, or current market prices, often within minutes of the information becoming available. This isn't just a convenience the evidence suggests it makes a measurable difference. In some interventions, these mobile and SMS-based tools have been associated with productivity improvements of roughly 20–30% (Bunkar et al., 2024; Priya et al., 2025). That's a meaningful gain, though it's worth remembering these figures come from specific interventions and contexts rather than representing a universal guarantee for every farmer who adopts a mobile advisory tool. The core advantage here is speed and reach. A single well-designed SMS advisory system can, in principle, notify thousands of farmers about an approaching weather event on the same day something that would be logistically impossible through field visits alone.

From Reactive to Predictive Extension

Perhaps the most interesting shift underway is not just about *speed* of information, but about its *timing*. Traditional extension has generally been reactive. A farmer notices something wrong yellowing leaves, wilting, visible insects and seeks advice. The response is essentially: *"Your crop has a pest problem here is what you should do about it."* AI-driven extension aims to flip this sequence. Instead of waiting for a problem to appear, predictive systems analyse weather patterns, crop stage, and field conditions to estimate the *likelihood* of a problem before it happens. The message becomes something closer to: *"Based on current weather, crop stage, and field conditions, there is a high probability of a pest outbreak in the coming days here is what preventive action you can take."* This shift from reactive to predictive advice relies on AI-driven advisory systems combined with IoT-based monitoring, which use predictive models to anticipate crop disease and pest outbreaks (Bunkar et al., 2024; Ibrahim, 2023; Priya et al., 2025). According to the available evidence, these systems can improve decision-making accuracy by up to 40% in some contexts (Priya et al., 2025). That's a genuinely significant claim but it's also one worth treating with appropriate caution. "Up to 40%" describes a reported ceiling in certain studies, not a guaranteed outcome across every crop, region, or farming system. Predictive tools are only as good as the data feeding them, and their accuracy will vary depending on local conditions and how well the underlying models have been trained. Still, the underlying logic is compelling: preventing a pest outbreak is almost always cheaper and less damaging than responding to one after it has already taken hold.

IoT: When the Farm Starts Talking

If AI is the "brain" behind predictive extension, the Internet of Things (IoT) is often the "senses" the network of small sensors quietly collecting data from the field itself. In simple terms, IoT sensors are small devices placed in or around a farm that continuously measure specific conditions soil moisture, temperature, humidity, or even early indicators of crop stress and transmit that data, often wirelessly, to a system that can analyse it. Rather than a farmer or extension worker having to physically check each field, sensors can provide a continuous stream of real-time information. This matters because so many farming decisions when to irrigate, when a crop might be under stress, whether conditions are becoming favourable for disease depend on timely information. A sensor network can flag a drop in soil moisture the same day it happens, rather than days later when the crop shows visible signs of water stress. Combined with AI and IoT-based monitoring more broadly, this kind of sensing supports disease prediction and irrigation management in ways that extend an extension worker's reach well beyond what field visits alone could achieve (Ibrahim, 2023; Sharma & Shivandu, 2024).

GIS and Remote Sensing: Extension from Above

Traditionally, agricultural advice has often been delivered at the level of a village or district one general recommendation covering many different farms, soils, and microclimates, even though conditions can vary considerably from one field to the next. Geographic Information Systems (GIS) and remote sensing are changing that. GIS allows extension agents to map and analyse spatial data soil types, land use, crop patterns across a landscape. Remote sensing, often using satellite or aerial imagery, adds another layer by capturing information about crop health, soil conditions, and land use over large areas without anyone having to physically visit every plot. Together, these tools enable extension agents to tailor recommendations to the specific soil and crop conditions of individual farms, rather than relying on a single blanket recommendation for an entire region (Bunkar et al., 2024; Byamukama et al., 2025). In practical terms, this represents a shift from "one recommendation for a village" toward "more precise recommendations for different farms and fields" — a move toward genuinely personalised extension advice.

The Future Extension Worker: Replaced or Empowered?

This is probably the question on the mind of many extension professionals reading about these technologies: will AI eventually replace agricultural extension workers? Based on the available evidence, the more accurate answer is: not replace — but reshape. AI and digital tools are genuinely good at certain things. They can process large volumes of data quickly, generate timely advisories at scale, identify patterns across many farms that a single human observer might miss, and support diagnosis and prediction for issues like pest outbreaks or irrigation needs (Bunkar et al., 2024; Ibrahim, 2023; Priya et al., 2025). They can also help extension services reach far more farmers than field visits alone ever could. But there's a great deal that these tools still cannot do — and may never fully replicate. Extension work has always been about more than transferring information. It involves building trust, drawing on deep local knowledge of specific communities and conditions, effective communication, understanding the social dynamics that influence whether a farmer actually adopts a recommendation, encouraging genuine behaviour change, running hands-on demonstrations, and sustaining long-term community engagement. These are fundamentally human skills, rooted in relationships built over years, not something a predictive model can substitute for. The most realistic and evidence-supported vision, then, is not *"AI instead of the extension worker,"* but *"the extension worker plus AI."* Technology can handle the data-heavy, repetitive, and time-sensitive parts of the job, freeing human extension professionals to focus on the relationship-building and judgment-based work that genuinely requires a human presence.

Beyond AI: Blockchain, AR/VR, and Digital Twins

Alongside AI, IoT, and GIS, several other emerging technologies are being discussed as part of the future of agricultural extension. It's important to note that many of these remain **emerging or conceptual** rather than widely implemented — they represent directions the field is exploring, not established current practice.

Blockchain. This is a technology for creating secure, tamper-resistant digital records. In an agricultural context, it's being explored for supply-chain transparency — tracking a product from farm to market — and for maintaining data integrity and traceability (Byamukama et al., 2025; Priya et al., 2025). Early discussions suggest it could enhance traceability across agricultural supply chains (Ahmad et al., 2024), though, as later sections will show, actual field-tested evidence for this remains limited.

Augmented Reality (AR) and Virtual Reality (VR). These technologies create immersive digital environments — AR overlays digital information onto the real world, while VR creates a fully simulated environment. In extension, they're being discussed as tools for immersive training, allowing farmers and extension agents to learn through interactive demonstration and simulated environments rather than only through static materials (Miller et al., 2025; Byamukama et al., 2025).

Digital twins. A digital twin is essentially a virtual, data-driven replica of a real farm or field — a model that mirrors real-world conditions using continuously updated data. The idea is that farmers or advisors could test different management decisions virtually before applying them in the real field. Digital twins are discussed as part of the next phase of data-driven farming systems, alongside advanced algorithms and next-generation connectivity such as 6G (Kumari et al., 2025; Taha et al., 2025; Sharma & Shivandu, 2024).

Edge AI. Rather than sending all data to a distant server for processing, edge AI refers to running AI computations locally closer to the sensor or device itself, in the field. This is meant to support faster, more real-time decisions, since there's less delay involved in transmitting and processing data remotely (Miller et al., 2025; Byamukama et al., 2025).

It's worth being clear: while these technologies are actively discussed in current research, they are, for the most part, still emerging frontiers rather than established, widely adopted tools in everyday extension practice.

What Could the Extension Office of the Future Look Like?

Imagine a farmer opening a mobile application on their phone. The app already knows their crop, their field, and their location. It pulls in updated weather data showing a shift in conditions over the coming days. Soil sensors placed in the field report current moisture levels. In the background, an AI system analyses all of this information together. Within moments, the farmer receives a specific, location-based advisory perhaps a recommendation to delay irrigation by two days, or a warning about conditions that favour a particular pest. Meanwhile, on the other end, an extension worker looks at a dashboard summarising dozens of farms in their area, immediately seeing which ones show conditions that need closer attention. The same platform might also display current market prices, helping the farmer decide when to sell. This kind of integrated, farm-specific system represents where the underlying technologies AI, IoT, mobile platforms, GIS are collectively heading. But it's important to underline: this is a plausible future scenario built from combining current research directions, not a description of a system that is already widely operating today.

The Digital Divide: Who Might Be Left Behind?

For all the promise of these technologies, there's a serious and often underdiscussed limitation: not every farmer has equal access to them. The scale of this gap is significant. Approximately 37% of the global population lacks internet access, and this shortfall is particularly pronounced in rural areas, precisely where agricultural extension is often needed most (Priya et al., 2025; Ahmad et al., 2024). Even where connectivity exists, limited digital literacy among farmers and extension agents can constrain how effectively these tools are actually used (Ibrahim, 2023; Dujali et al., 2025; Priya et al., 2025). Beyond connectivity and skills, there are structural barriers: high infrastructure costs, poor rural connectivity, and unreliable electricity all hinder the scalability of digital extension tools, particularly in developing regions (Miller et al., 2025; Byamukama et al., 2025). And access isn't distributed evenly even within communities socioeconomic inequalities disproportionately affect the access that women and other marginalized groups have to digital extension tools (Byamukama et al., 2025). This leads to a statement worth taking seriously: a digital extension system can only be as inclusive as the connectivity, skills, and access of the farmers it is designed to serve. Technological progress in this space does not automatically translate into inclusive progress that requires deliberate effort.

AI Needs Human Trust

There's another dimension to this that's easy to overlook amid the excitement about new technology: even where AI-driven advisories are technically available and accurate, farmers won't necessarily adopt them automatically. Trust plays a central role. A farmer is more likely to act on a recommendation they understand, that has been locally validated, and that comes through some form of human interaction or endorsement, rather than an unexplained notification from an unfamiliar app. Transparency about how a recommendation was generated, simplicity in how it's communicated, sensitivity to cultural and local context, and visible demonstration of real benefits all influence whether farmers actually change their practices based on digital advice. This points to something important about the nature of extension itself: it has never been simply about transferring information from one party to another. It has always also been about building relationships and confidence and that human element doesn't disappear just because the information now arrives via a smartphone rather than a field visit.

The Biggest Research Gap: Long-Term Evidence

Amid all the promising figures 20–30% productivity gains here, up to 40% improved decision accuracy there. There's a critical caveat that deserves equal attention: much of this evidence comes from short-term studies. An evidence-coverage analysis across different areas of AI-driven agricultural extension illustrates this clearly:

Sub-topic	Field Trials	Long-Term Impact	Equity & Access	Interoperability
Mobile & SMS advisory	8	2	6	3
AI predictive analytics	5	1	2	2
IoT sensor networks	7	1	3	4
Blockchain integration	GAP	GAP	1	1
AR/VR farmer training	1	GAP	1	GAP

A few patterns stand out. Mobile and SMS advisory tools have the most field-trial evidence (8 studies) but still only 2 studies examining long-term impact. AI predictive analytics and IoT sensor networks show a similar pattern a reasonable number of field trials, but very little evidence of what happens beyond the initial pilot phase. Blockchain integration in extension settings has essentially no field-trial or long-term evidence at all, and AR/VR farmer training has only a single field trial with no long-term studies identified. The most striking gap overall is the near-total absence of long-term impact assessments, with only one or two studies addressing sustained outcomes across the entire field (Ibrahim, 2023; Priya et al., 2025). This gap exists largely because most research to date consists of short-term pilot projects rather than multi-year field deployments, leaving policymakers without solid evidence on whether reported productivity gains actually persist or fade over time (Xu et al., 2023; Sharma & Shivandu, 2024). Blockchain and AR/VR applications, in particular, remain the least evidenced frontiers, with much of the current discussion still largely conceptual rather than empirically tested in real extension settings (Byamukama et al., 2025).

In short: the early results are promising, but agricultural extension like any field needs to see whether these promising early numbers hold up over years, not just weeks or months.

What Should Be Done Next?

For researchers:

- Conduct multi-year field trials rather than relying primarily on short pilot studies.
- Evaluate real-world adoption patterns, not just technical performance.
- Study long-term outcomes to see whether early productivity gains are sustained.
- Examine interoperability between different digital tools and platforms.
- Assess equity and inclusion outcomes as a core part of any evaluation, not an afterthought.

For extension organizations:

- Train extension personnel in digital skills so they can effectively use and explain these tools.
- Combine digital tools with continued face-to-face extension rather than treating them as a full substitute.
- Develop content in local languages to ensure genuine accessibility.
- Strengthen digital infrastructure to support reliable tool use in the field.

For policymakers:

- Invest in improving rural connectivity, particularly in underserved regions.
- Take active steps to reduce the digital divide rather than assuming it will close on its own.
- Develop responsible AI policies suited to agricultural contexts.
- Support the development of affordable digital technologies for smallholder farmers.
- Protect farmer data and privacy as digital tools collect increasing amounts of farm-level information.

For farmers:

- Use digital advisories as decision-support tools one input among several, not the sole basis for major decisions.
- Combine digital information with local knowledge and expert advice.

Verify critical recommendations, especially before making significant farm investments or decisions.

Conclusion: Extension Is Changing, But Its Purpose Remains the Same

The tools of agricultural extension have changed many times over the decades from printed leaflets and radio broadcasts to field days and farmer meetings. What we're witnessing now is simply the next chapter in that evolution: field visits and printed materials giving way, in part, to smartphones, AI-driven advisories, IoT sensors, and eventually more immersive technologies still finding their footing. But it's worth stepping back and remembering what none of this technology changes. The fundamental purpose of agricultural extension has always been the same: **to help farmers make better decisions and improve their livelihoods.** The evidence gathered so far suggests real, meaningful promise faster information, more precise recommendations, and early signs of measurable productivity gains. But it also shows real limitations: a persistent digital divide, a lack of long-term evidence, and technologies like blockchain and AR/VR that remain more conceptual than proven in practice. Both sides of that picture deserve equal weight. The future of agricultural extension is unlikely to be about technology replacing people. It's more likely to be about technology helping people extension workers and farmers alike reach further, understand needs more precisely, and deliver timely, relevant knowledge to the people who depend on it most.

References

1. Ahmad, A., Liew, A. X. W., Venturini, F., Kalogeras, A. P., Candiani, A., Di Benedetto, G., Ajibola, S., Cartujo, P., Romero, P., Lykoudi, A., Grandis, M., Xouris, C., Lo Bianco, R., Doddy, I., Elegbede, I., Labate, G., Moral, L. G. D., & Martos, V. M. (2024). AI can empower agriculture for global food security: challenges and prospects in developing nations. *Frontiers in Artificial Intelligence, 7*. https://doi.org/10.3389/frai.2024.1328530
2. Aijaz, N., Lan, H., Raza, T., Yaqub, M., Iqbal, R., & Pathan, M. S. (2025). Artificial Intelligence in Agriculture: Advancing Crop Productivity and Sustainability. *Journal of Agriculture and Food Research*. https://doi.org/10.1016/j.jafr.2025.101762
3. Bunkar, R. C., R., A. K., Kumar, K., Sadangi, B., Gupta, B. S., Saikanth, D. R. K., & Shukla, A. (2024). A Review on Levering Technology for Sustainable Development in Agricultural Extension Program. *Archives of Current Research International*. https://doi.org/10.9734/acri/2024/v24i5731
4. Byamukama, W., Ssemakula, E., Ssekandi, J., Shaman, A., Businge, P., Kalibwani, R., Atukunda, C., & Turyasingura, B. (2025). A Review of ICT Integration in Agricultural Extension Services. A Global Perspective. *East African Journal of Interdisciplinary Studies*. https://doi.org/10.37284/eajis.8.1.3023
5. Dujali, I. L., Inutan, S. M. B., Bacus, M. S., Quijano-Pagutayao, A., & Sarita, V. B. (2025). Transforming Agricultural Extension in the Digital Age: A Review of ICT-Based Approaches and Innovations. *International Journal of Research and Scientific Innovation*. https://doi.org/10.51244/ijrsi.2025.12030064

6. Fountas, S., Espejo-García, B., Kasimati, A., & Darra, N. (2020). The Future of Digital Agriculture: Technologies and Opportunities. *IT Professional, 22*, 24-28. https://doi.org/10.1109/mitp.2019.2963412
7. Ibrahim, U. (2023). Artificial Intelligence in Agricultural Extension for Sustainable Development. *International Journal of Applied and Scientific Research*. https://doi.org/10.59890/ijasr.v1i3.740
8. Kumari, K., Nafchi, A. M., Mirzaee, S., & Abdalla, A. (2025). AI-Driven Future Farming: Achieving Climate-Smart and Sustainable Agriculture. *AgriEngineering*. https://doi.org/10.3390/agriengineering7030089
9. Miller, T., Mikiciuk, G., Durlik, I., Mikiciuk, M., Łobodzińska, A., & Śnieg, M. (2025). The IoT and AI in Agriculture: The Time Is Now—A Systematic Review of Smart Sensing Technologies. *Sensors (Basel, Switzerland), 25*. https://doi.org/10.3390/s25123583
10. Priya, N., Patil, S. S., Vishwakarma, S. K., Saikanth, D. R. K., Mishra, I., Tripathi, S., Pathak, A., & Shastri, S. (2025). Digital Innovations in Extension Education: A Review of Emerging Technologies and their Impact on Agricultural Knowledge Dissemination. *Journal of Experimental Agriculture International*. https://doi.org/10.9734/jeai/2025/v47i53430
11. Sharma, K., & Shivandu, S. K. (2024). Integrating Artificial Intelligence and Internet of Things (IoT) for Enhanced Crop Monitoring and Management in Precision Agriculture. *Sensors International*. https://doi.org/10.1016/j.sintl.2024.100292
12. Singh, N. K., Sunitha, N., Tripathi, G., Saikanth, D. R. K., Sharma, A., Jose, A. E., & Mary, M. (2023). Impact of Digital Technologies in Agricultural Extension. *Asian Journal of Agricultural Extension, Economics & Sociology*. https://doi.org/10.9734/ajaees/2023/v41i92127
13. Subeesh, A., & Mehta, C. R. (2021). Automation and digitization of agriculture using artificial intelligence and internet of things. *Artificial Intelligence in Agriculture*. https://doi.org/10.1016/j.aiia.2021.11.004
14. Taha, M. F., Mao, H., Zhang, Z., Elmasry, G., Awad, M. A., Abdalla, A., Mousa, S., Elwakeel, A. E., & Elsherbiny, O. (2025). Emerging Technologies for Precision Crop Management Towards Agriculture 5.0: A Comprehensive Overview. *Agriculture*. https://doi.org/10.3390/agriculture15060582
15. Xu, Z., Adeyemi, A., Catalan, E. S., Kogut, A., & Guzman, C. (2023). A scoping review on technology applications in agricultural extension. *PLOS ONE, 18*. https://doi.org/10.1371/journal.pone.0292877