

Digital Transformation in Agriculture: Learnings from Extension Advisory Services

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Introduction

A few months back, on a field visit to a milk cooperative in Haryana, I watched a young dairy farmer photograph her cow's swollen udder on her phone and send it straight to the local para-vet on WhatsApp - before I had even finished my cup of tea at the society office. A decade ago, that same query would have meant a bumpy tractor ride to the block office, or days of guesswork while the animal suffered quietly in the shed. That small moment illustrates, better than any policy note could, how far the delivery of agricultural knowledge has moved in a single generation, and why the phrase "digital extension" has stopped being a slogan and become a working reality on the ground.

For decades, our extension machinery ran on a stretched, almost heroic model - a single extension worker trying to reach thousands of farmers through field visits, demonstration plots, and the occasional training camp. It worked, after a fashion, but it was slow, costly to scale, and it buckled the moment a problem turned urgent: a sudden pest flare-up, an unseasonal hailstorm, or a cow going off her feed overnight. Chronic underfunding and a heavy reliance on printed pamphlets and face-to-face meetings meant the system simply could not keep pace with how fast farm-level problems now surface (Travis et al., 2004). Layer on top of this the fact that women make up close to 43 percent of the agricultural workforce in developing countries yet have historically had far thinner access to extension contact than men, and the structural cracks in the conventional model become impossible to ignore.

Conceptual Basis of Digital Extension Advisory Systems

Extension science has always rested on a fairly simple premise: knowledge generated in research stations is of little value until it reaches the farmer in a form she can actually use. What has changed is not this premise but the mechanism of transfer. Chowdhury et al. (2014) describe this shift as a move away from a purely top-down, agent-mediated model toward a more networked one, where public extension agencies function less as sole information gatekeepers and more as coordinators within a wider ecosystem of digital tools, private players, and farmer collectives. Producer organisations and cooperatives, in this sense, are not incidental to the story; they have long served as the institutional scaffolding through which new practices and technologies are absorbed at the village level (Rondot & Collion, 2001), and it is precisely this scaffolding that digital platforms are now being layered onto rather than replacing.

Mobile telephony forms the backbone of this transition. Programmes such as mKisan built on this foundation by sending SMS advisories in local languages on weather, pests, and market prices, quietly becoming one of the largest farmer-advisory networks the country has run (Naika et al., 2021). Mobile-based weather and climate advisory tools, in particular, have shown measurable value for smallholders who must make sowing, spraying, and irrigation decisions under considerable climatic uncertainty (Caine et al., 2015). What is easy to overlook is how much of this same architecture has since been adapted specifically for animal husbandry, where the unit of advisory delivery is not a plot of land but an individual animal with its own health and productivity history.

ICT-Enabled Advisory Tools in Indian Agriculture and Dairying

The e-GOPALA application, developed by the National Dairy Development Board and inaugurated in September 2020, was built as a single-window platform where a farmer can obtain a ration formulated from locally available feed ingredients, follow ethno-veterinary protocols for roughly two dozen common ailments such as mastitis and indigestion, and receive alerts before an animal is due for vaccination, pregnancy diagnosis, or calving - now offered in twelve Indian languages, so that language is no longer the barrier it once was (Ministry of Fisheries, Animal Husbandry and Dairying, 2023; National Dairy Development Board [NDDB], 2021).

Behind the scenes, the sector has quietly digitised its own operational plumbing as well. The Automatic Milk Collection System records the quantity, fat content, and quality of milk at the collection point itself, calculates the farmer's payment instantly, and dispatches an SMS confirmation - a facility that today covers more than 26,000 dairy cooperative societies and reaches roughly 17.3 lakh milk producers. Running alongside this is the "Pashu Aadhaar" scheme under the National Digital Livestock Mission, which has already tagged over 35 crore animals with a unique identity number, converting what used to be a handwritten cooperative register into searchable, animal-specific data (Drishti IAS, 2026). For an extension scientist, this is not a minor administrative convenience; it is the difference between advising an entire village on aggregate averages and advising an individual farmer based on the verified health record of her own animal. At a broader scale, precision agriculture technologies - encompassing remote

sensing, GIS-based soil mapping, and sensor-driven irrigation - are following a comparable trajectory of moving advisory decisions from generalised recommendations toward site- and animal-specific ones (Getahun et al., 2024).

Table 1. Select ICT-Based Advisory Tools Relevant to Indian Agriculture and Dairying

Platform / Initiative	Implementing Body	Core Advisory Function	Notable Reach or Feature
mKisan	Ministry of Agriculture, GoI	SMS-based weather, pest, and market advisories in local languages	One of the largest farmer SMS networks in the country
e-GOPAL A	National Dairy Development Board	Ration balancing, ethno-veterinary guidance, vaccination/calving alerts	Available in 12 Indian languages
Automatic Milk Collection System (AMCS)	NDDB / Dairy Cooperatives	Digitised milk testing, instant fat-based payment, SMS receipts	Covers 26,000+ societies, ~17.3 lakh producers
Pashu Aadhaar / NDLM	Dept. of Animal Husbandry & Dairying	Unique 12-digit animal ID linked to health & breeding records	Over 35 crore animals tagged
Digital Green	Digital Green (NGO), multi-country	Participatory farmer-to-farmer training videos	Documented gains in practice adoption among smallholders
Precision agriculture tools	Public research & private agri-tech	Remote sensing, GIS-based soil and crop monitoring	Site-specific input and irrigation recommendations

Source: Compiled by the author from Khatri et al. (2024), Naika et al. (2021), Olumola (2015), Getahun et al. (2024), NDDB (2021), Ministry of Fisheries, Animal Husbandry and Dairying, Government of India (2023), and Drishti IAS (2026).

4. Constraints and Limiting Factors in Adoption

It would be misleading to present this transition as an unqualified success story. Every time I visit a Krishi Vigyan Kendra cluster in a remote district, the same pattern plays out - a handful of younger, comparatively better-off farmers use these applications with ease, while a much larger group, often

older, often women, is still waiting for someone to visit them in person. This is not incidental; it reflects what the literature terms the digital divide, manifesting as poor smartphone ownership, patchy internet connectivity, and unreliable electricity, precisely in the regions where advisory support is needed most. Gender and socioeconomic disparities sharpen this gap further, since women and smallholders remain disproportionately excluded from the benefits that ICT-enabled advisory services promise (Bhat et al., 2024; Khatri et al., 2024). Digital literacy constitutes a related but distinct constraint - owning a device is not equivalent to trusting an application enough to act on its recommendation, and extension personnel themselves frequently require reorientation before they can guide farmers through these tools with any confidence.

Table 2. Constraints to ICT-Based Extension and Corresponding Mitigation Strategies

Constraint	Manifestation at the Field Level	Suggested Mitigation
Connectivity and infrastructure deficits	Weak network signal, frequent power interruptions in remote villages	Prioritise rural broadband expansion and offline-capable applications in extension planning
Low digital literacy	Farmers possess devices but hesitate to act on app-based advisories	Structured, hands-on training camps conducted jointly by KVKs and dairy cooperatives
Gender disparity in access	Women farmers less likely to own or independently control a device	Women-focused digital literacy drives with content in regional dialects
Cost of devices and data	Smallholders defer device upgrades or data subscription	Subsidised data bundles linked specifically to recognised agricultural applications
Limited contextual relevance	Generic advisories disregarded when not locally applicable	Development of hyper-local, crop- and breed-specific advisory content

Source: Compiled by the author, drawing on constraints discussed in Khatri et al. (2024) and Bhat et al. (2024).

5. Emerging Frontiers in Digital Extension

The next phase of this transition is unlikely to be defined merely by pushing a larger volume of information through a handset; it will be defined by making that information progressively more predictive and personalised.

Artificial intelligence is already being trialled for early disease-outbreak alerts and yield forecasting, while blockchain-based systems are being piloted to strengthen transparency and traceability across agricultural and dairy supply chains, from the point of milk production to the point of consumption. Augmented and virtual reality tools remain at an early stage of adoption within Indian extension systems but hold considerable promise for immersive training that more closely approximates hands-on field demonstration than a conventional video lecture. None of these advances, however, will deliver their intended benefit unless the more fundamental gaps - connectivity, digital literacy, and farmer trust - are addressed concurrently, since even a technically sophisticated predictive model is of limited use to a farmer who cannot access it in the first place.

6. Conclusion and Way Forward

Having observed both the promise and the limitations of these tools at close quarters over several years, my assessment is that digital technology is unlikely to substitute for the human extension worker; rather, it is steadily redefining the nature of that role. The extension functionary of the near future will need to combine domain expertise with a working fluency in digital tools, alongside a continued advocacy role that ensures the farmer situated at the furthest end of the delivery chain is not the one excluded from the benefits of “smart” agriculture. Sustained investment in rural connectivity, structured capacity-building for both farmers and extension staff, and deliberate attention to gender-equitable access will determine whether this digital transformation translates into genuinely inclusive agricultural development.

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