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From agents to algorithms: a four-pillar assessment of the journey to ai-based advisory for climate-resilient smallholder agriculture

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Abstract

Agricultural information delivery in the Global South has moved through three technological waves over fifty years. Training-and-Visit (T&V) and demonstration trials dominated the 1970s-1980s. Digital extension followed in the 2000s through SMS, IVR, and apps. A new era has begun: over 60 AI-based extension tools are operational or piloted across India and sub-Saharan Africa. This study compares the three systems on what they deliver to smallholders, and asks where AI must be redesigned to avoid past exclusion.

Conventional extension reaches a fraction of farmers; digital systems risk reproducing exclusion at lower marginal cost. Public coverage is thin: under 10 % of Indian agricultural households reached a government extension worker in 2018–19, and 13 % of Malawian farmers received Lead Farmer advice over two years. Lead-farmer and contact-farmer models are widely critiqued for elite capture, with information rents accruing to richer, male, better-connected farmers. A survey of 2,068 smallholders in Bihar and Odisha exposes the digital divide. Mobile-phone endowment is 86 % among men, 39 % among women. Online-payment competence differs by a factor of 7.5. About 99 % have never received digital training. Latent demand is high: 77.8 % want to learn.

The study assesses the journey across four pillars: effectiveness (SCAR: speed, cost, accuracy, reach); inclusivity; trust and developer-farmer feedback; and farmer agency and data sovereignty. Methods combine a 40-tool review, the Bihar-Odisha survey, and 82 gender-balanced interviews in India, Sri Lanka, Kenya, and Malawi. Cost per farmer falls from US\$30 (conventional) to US\$3 (digital) to US\$0.30 (AI). Site-specific accuracy remains weak. Exclusion has shifted from social elite capture to digital, now algorithmic. The feedback loop closes in real time for the first time. Three insights converge. Extension officers certify AI advice they cannot verify, eroding trust. Agritech founders cite cost-per-active-user, not reach, as the binding constraint, depending on philanthropy to serve smallholders. Farmers value AI most when an extension agent or village-level woman entrepreneur mediates between them and the algorithm. Investment must shift from devices to in-village, voice-first, women-targeted skills training, embedded in hybrid models pairing AI with trusted human agents. Climate-resilient farming requires not just better information, but more equitable access.

Keywords: Artificial intelligence, climate-resilient agriculture, digital extension, gender gap, smallholder farmers

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