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ICT-based extension services for smallholder farmers

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Abstract

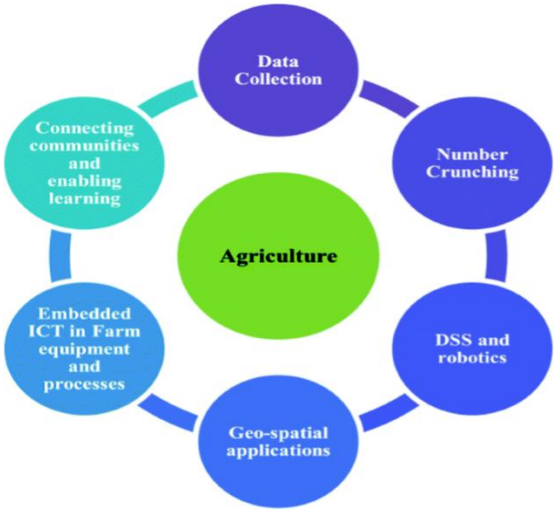
ICT-based extension services are transforming agricultural advisory systems by enabling timely, cost-effective, and scalable delivery of information to smallholder farmers. Digital tools such as mobile advisories, online platforms, and data-driven decision-support systems enhance access to weather, crop, and market information, improving farm-level decision-making. Evidence indicates that ICT-enabled extension increases technology adoption, raises productivity, and reduces production risks through early warnings and personalized recommendations. Integration of remote sensing, analytics, and interactive platforms supports location-specific and precision-oriented advisories. Digital extension also expands outreach to remote and underserved farming communities at lower operational costs. Despite challenges related to digital literacy, connectivity, and platform fragmentation, emerging opportunities in blended advisory models and advanced analytics offer viable pathways for improvement. Strengthening institutional coordination and user-centric design is essential for maximizing the impact of ICT-based extension on sustainable smallholder agriculture.

Keywords: *ICT-based extension, Smallholder farmers, Digital advisory services, Technology adoption, Decision support*

1. Introduction to ICT-Based Extension Services

Concept and scope of ICT in agricultural extension

Information and communication technologies (ICTs) in extension encompass mobile phones, internet platforms, decision-support systems, and data analytics used to deliver advisory services. ICT-based extension enables rapid dissemination of crop, weather, pest, and market information. Studies show that digital advisories can reduce information delays by over 60% and improve accuracy of farm decisions. The scope extends from simple SMS alerts to advanced platforms integrating remote sensing and artificial intelligence.



Importance for smallholder farming systems

Smallholder farmers often face constraints related to limited access to timely

information, extension personnel, and markets. ICT-based services address these gaps by offering low-cost, scalable, and personalized advisories. Evidence indicates that access to mobile-based extension increases technology adoption by 15–30% and enhances farm income through better input management and market timing. Digital inclusion strengthens resilience and supports informed decision-making at the farm level.

Evolution from conventional to digital extension

Extension systems have shifted from face-to-face and group meetings toward hybrid and fully digital models. Conventional methods required high operational costs and limited outreach, while ICT-enabled approaches expand coverage at reduced cost per farmer. Data suggest that digital extension can reach three to five times more farmers compared to traditional approaches, marking a structural transformation in advisory service delivery.

2. ICT Tools and Platforms in Extension

Mobile phones, apps, and SMS-based advisories

Mobile-based extension tools deliver real-time information on crop management, weather forecasts, pest alerts, and input use. SMS and smartphone applications provide low-cost and rapid communication, reaching farmers across diverse literacy levels. Empirical studies indicate that mobile advisories improve timely decision-making and can increase crop productivity by 10–20%. App-based platforms also support record keeping, input planning, and advisory customization based on crop stage and location.

Digital platforms, call centers, and social media

Digital platforms and agricultural call centers facilitate two-way communication between farmers and experts. Voice-based services and interactive helplines improve accessibility for farmers with limited digital literacy. Evidence shows that call center-based advisories resolve over 70% of farmer queries related to crop production and pest management. Social media groups and online communities enhance peer learning, rapid information exchange, and dissemination of best practices at scale.

Use of remote sensing and data-driven tools

Remote sensing, geographic information systems, and data analytics enable precision advisory services. Satellite imagery and sensor-based data support monitoring of crop health, soil moisture, and weather variability. Research demonstrates that data-driven advisories can reduce input misuse by 20–30% and improve yield forecasting accuracy. Integration of analytics with extension platforms strengthens proactive and location-specific farm management support.

3. Role of ICTs in Knowledge Delivery and Decision Support

Timely access to weather, market, and crop information

ICT-based extension systems enable rapid dissemination of weather forecasts, price trends, and crop advisories. Real-time alerts on rainfall, temperature extremes, and pest outbreaks support proactive farm decisions. Evidence indicates that timely weather and market information can reduce crop losses by 15–25% and improve price realization through informed marketing. Digital delivery minimizes information asymmetry and shortens response time during critical crop stages.

Personalized and location-specific advisories

Digital platforms use geo-referencing, crop models, and farmer databases to generate tailored recommendations. Location-specific advisories improve relevance by accounting for soil type, climate, and crop growth stage. Studies report that personalized advisories enhance technology adoption and increase input-use efficiency by nearly 20%. Targeted messaging reduces blanket recommendations and supports precision-oriented farm management.

Enhancing farmer learning and feedback mechanisms

ICT tools strengthen learning through multimedia content, interactive modules, and peer-to-peer exchanges. Video-based advisories and virtual discussions improve comprehension and retention of technical information. Feedback mechanisms allow farmers to share field observations, enabling adaptive refinement of advisories. Evaluations show that interactive digital learning improves knowledge retention rates by over 30% compared to one-way communication models.

4. Impact of ICT-Based Extension on Smallholder Farmers

Technology adoption and productivity enhancement

ICT-based extension accelerates awareness and uptake of improved crop varieties, management practices, and farm innovations. Digital advisories reduce information gaps and support timely adoption decisions. Empirical assessments show that farmers using ICT-enabled services record productivity gains of 10–25% due to better crop management and optimized input use. Enhanced access to technical guidance strengthens decision accuracy across cropping cycles.

Cost reduction and risk management

Digital extension services lower transaction and information search costs by minimizing dependence on physical visits. Access to early warnings on weather variability and pest outbreaks supports preventive action and reduces yield losses. Evidence indicates that ICT-based advisories can cut production costs by 15–30% and improve risk mitigation through informed input timing and diversification strategies.

Inclusion, outreach, and scalability

ICT platforms expand extension reach to remote and resource-constrained farmers at a low marginal cost. Mobile and voice-based services improve accessibility across gender and age groups. Studies demonstrate that digital extension models can reach several times more farmers than conventional approaches, supporting scalable and inclusive dissemination of agricultural knowledge.

5. Challenges, Opportunities, and Way Forward

Key challenges in ICT-based extension

ICT-based extension faces constraints related to digital literacy gaps, uneven connectivity, and limited access to smart devices. Studies indicate that nearly one-third of smallholder farmers experience difficulty in interpreting digital advisories without facilitation. Data privacy concerns, fragmented platforms, and lack of interoperability also reduce efficiency. Insufficient localization of content affects relevance and trust in advisory outputs.

Emerging opportunities for strengthening digital extension

Rapid expansion of mobile networks, declining data costs, and growth of analytics-based platforms create strong opportunities for digital extension. Integration of artificial intelligence, remote sensing, and big data enables predictive advisories with higher precision. Evidence shows that blended extension models combining digital tools with human support

improve adoption rates by over 25% compared to standalone digital systems.

Strategic way forward

Future strategies should emphasize user-centric design, capacity building, and institutional coordination. Strengthening digital skills, ensuring content localization, and promoting open data standards can enhance effectiveness. Policy support for integrated ICT ecosystems and continuous impact assessment will improve scalability, reliability, and long-term sustainability of digital extension services.

Conclusion

ICT-based extension enhances smallholder farming by improving information access, accelerating technology adoption, reducing risks, lowering costs, and enabling inclusive, scalable, and data-driven advisory systems that support sustainable agricultural development.

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