Future Agriculture e-magazine

E-ISSN: 3048-4553 (Online)

https://futureagriculture.co.in/

Article Id: FA-40 **ISSUE- July, 2026 | Issue-2 pp. 83-93**

Popular Article

OPEN ACCESS

ICT-Based Approaches for Agricultural Knowledge Transfer

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Abstract

ICT-based approaches are transforming agricultural knowledge transfer by making information faster, more accessible, interactive, and personalized. Mobile phones, SMS, smartphone applications, social media, video platforms, interactive voice response, artificial intelligence, Internet of Things devices, remote sensing, and digital decision-support systems enable farmers to access timely information on crop production, weather, pests, diseases, irrigation, markets, and farm management. These technologies also facilitate two-way communication, allowing farmers to share field observations, photographs, and production challenges with extension professionals. Personalized and location-specific advisory services can improve decision-making and resource-use efficiency. Despite their potential, challenges such as digital illiteracy, poor connectivity, affordability, language barriers, misinformation, and data privacy require attention. Integrating ICT tools with human expertise, participatory approaches, and conventional extension can create inclusive, responsive, and farmer-centred agricultural knowledge systems.

Keywords: *ICT; Agricultural extension; Knowledge transfer; Digital advisory; Mobile technology; Artificial intelligence; Farmer empowerment.*

How to Site this article: Bannoth Jaswanth Naik, & Saren, P. (2026, July). ICT-based approaches for agricultural knowledge transfer. *Future Agriculture e-Magazine*, *(2)*, 83–93.

Introduction

Information and Communication Technologies (ICTs) have transformed the way agricultural knowledge is generated, accessed, exchanged, and applied. Traditional agricultural extension has relied mainly on personal visits, demonstrations, printed materials, radio, and group meetings. Although these approaches remain useful, ICTs provide new opportunities to reach larger numbers of farmers rapidly and continuously.

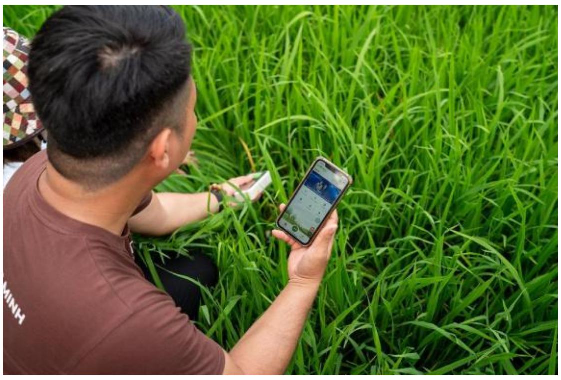
ICT-based agricultural knowledge transfer includes mobile phones, SMS, interactive voice response, smartphone applications, websites, social media, online learning platforms, video-based advisory services, geographic information systems, remote sensing, cloud computing, artificial intelligence, and Internet of Things technologies. The major strength of ICT-based extension is its ability to connect farmers with multiple sources of knowledge. Farmers can communicate with extension professionals, researchers, input suppliers, market actors, and other farmers without always needing physical meetings.

ICTs also enable two-way communication. Farmers can send photographs of diseased crops, report pest outbreaks, ask questions, receive weather alerts, compare market prices, and participate in online communities.

When combined with conventional extension, ICTs can make agricultural knowledge transfer faster, more interactive, location-specific, and farmer-centred. Their effectiveness, however, depends on digital literacy, connectivity, affordability, language accessibility, information quality, and trust.

Evolution of ICT in Agricultural Extension

The use of ICT in agriculture has developed gradually.



Radio and Television

Radio was among the earliest electronic communication technologies used for agricultural extension. Agricultural programmes provided information about crop production, livestock management, weather, markets, and government programmes.

Television later introduced visual demonstrations, making it easier to communicate production techniques.

Telephone-Based Extension

The expansion of mobile networks enabled direct communication between farmers and agricultural experts.

Farmers could call extension officers to discuss crop problems, weather conditions, livestock health, and production practices.

Internet-Based Extension

Internet connectivity created opportunities for websites, email, online agricultural databases, digital libraries, and discussion forums.

Smart ICT

Modern systems integrate mobile communication with artificial intelligence, sensors, cloud computing, remote sensing, and data analytics.

This transition has moved extension from simple information broadcasting toward **interactive and personalized knowledge systems**.

Mobile Phones for Knowledge Transfer

Mobile phones are among the most widely applicable ICT tools in agriculture.

Even basic phones can support agricultural communication through voice calls and SMS, while smartphones provide access to much more advanced services.

Mobile-based extension can deliver:

- Weather forecasts.
- Pest alerts.
- Disease information.
- Crop-management recommendations.
- Market prices.
- Input information.
- Government schemes.
- Training content.
- Expert consultations.

The portability of mobile phones allows farmers to access information directly from their farms.

SMS-Based Advisory Services

SMS is particularly useful where smartphones or high-speed internet are unavailable.

Agricultural organizations can send messages according to:

- Crop type.
- Location.
- Season.
- Growth stage.
- Weather conditions.

For example, farmers may receive reminders about sowing, fertilizer application, irrigation, pest monitoring, and harvesting.

SMS is inexpensive and simple, but its short format limits the amount of information that can be communicated.

Interactive Voice Response

Interactive Voice Response (IVR) systems provide agricultural information through telephone-based voice services.

Farmers can call a number and select a language or topic through keypad options.

IVR is particularly valuable for farmers with limited literacy because information is delivered through speech.

Voice-based services can include:

- Crop advisories.
- Livestock information.
- Weather updates.
- Market information.
- Pest alerts.
- Frequently asked questions.

Local-language IVR can significantly improve accessibility.

Smartphone Applications

Smartphone applications can provide multiple agricultural services through a single digital platform.

A comprehensive application may include:

- Crop calendars.
- Weather forecasts.
- Pest identification.
- Disease diagnosis.
- Fertilizer calculators.
- Irrigation recommendations.
- Market information.
- Farm records.
- Expert consultation.

GPS-enabled applications can also provide location-specific advisories.

For example, an application can combine a farmer's location with weather information to generate a crop-management recommendation.

Social Media as an Extension Tool

Social media platforms have become important channels for agricultural knowledge exchange.

Farmers can participate in digital communities where they share:

- Farm photographs.
- Production experiences.
- Pest observations.
- Machinery information.
- Market opportunities.
- Weather information.
- Successful practices.

Extension professionals can use these platforms to answer questions and distribute educational content.

Social media also allows rapid dissemination of emergency information such as disease outbreaks, severe weather warnings, or pest invasions.

However, misinformation can spread rapidly, making information verification essential.

WhatsApp-Based Extension

Messaging platforms can provide a practical bridge between farmers and extension personnel.

Farmers can send text messages, voice messages, photographs, and videos to extension groups.

An extension worker can review the information and respond with a recommendation.

Group-based communication also enables farmers to learn from one another.

The effectiveness of such systems depends on active moderation and reliable technical information.

Video-Based Agricultural Knowledge Transfer

Video provides an effective method for communicating practical agricultural technologies.

Videos can demonstrate:

- Seed treatment.
- Nursery management.
- Grafting.
- Pruning.
- Irrigation installation.
- Fertigation.
- Pest identification.
- Disease management.
- Harvesting.
- Post-harvest handling.

Visual learning is particularly useful when a practice involves a sequence of physical operations.

Short videos can be distributed through smartphones and social-media platforms, allowing farmers to watch them repeatedly.

Online Learning Platforms

Online learning platforms can provide structured agricultural education.

Farmers, students, extension workers, and rural entrepreneurs can access:

- Recorded lectures.
- Demonstration videos.
- Digital manuals.
- Online quizzes.
- Webinars.
- Expert discussions.
- Digital certificates.

Online learning can reduce geographical barriers and allow users to learn at their own pace.

Artificial Intelligence in Knowledge Transfer

Artificial intelligence is creating new opportunities for agricultural advisory systems.

AI can process large volumes of agricultural data and generate recommendations.

Potential applications include:

- Crop disease identification.
- Pest recognition.
- Weather interpretation.
- Irrigation scheduling.
- Fertilizer recommendations.
- Yield prediction.
- Crop selection.
- Farmer question answering.

AI chatbots can provide conversational advisory services in natural language.

For example, a farmer can ask:

"Why are the leaves of my crop turning yellow?"

The system can request additional information, analyse a photograph, consider environmental conditions, and provide possible explanations.

AI-generated advice should be appropriately validated, particularly where incorrect recommendations could cause significant crop or financial losses.

E-ISSN: 3048-4553 (Online)

Image-Based Agricultural Advisory

Smartphone cameras have created new possibilities for remote crop diagnosis.

Farmers can photograph:

- Leaf lesions.
- Insect pests.
- Fruit damage.
- Weed species.
- Nutrient-deficiency symptoms.
- Plant abnormalities.

Images can be sent to extension specialists or analysed using machine-learning models.

Image-based advisory can reduce the time between problem detection and technical consultation.

Internet of Things

The Internet of Things connects agricultural devices and sensors to communication networks.

Sensors can measure:

- Soil moisture.
- Temperature.
- Relative humidity.
- Soil electrical conductivity.
- Leaf wetness.
- Water level.
- Greenhouse conditions.

Data can be transmitted to a cloud platform and converted into alerts.

For example, a soil-moisture sensor can trigger an irrigation notification when moisture falls below a predefined threshold.

IoT therefore changes agricultural extension from periodic advisory to continuous monitoring.

Remote Sensing and Satellite-Based Knowledge

Satellite imagery can provide information about agricultural conditions over large geographical areas.

Remote sensing can help identify:

- Crop stress.
- Drought.
- Flooding.
- Vegetation changes.
- Water stress.
- Crop growth patterns.

Extension agencies can use this information to identify areas requiring field-level investigation.

Satellite-based information can also support regional crop monitoring and early-warning systems.

Drone-Based Knowledge Transfer

Drones provide high-resolution information from agricultural fields and orchards.

Multispectral and thermal cameras can identify variations in crop condition that may not be easily visible from the ground.

Drones can support:

- Crop health assessment.
- Pest monitoring.
- Disease surveillance.
- Irrigation assessment.

- Canopy analysis.
- Mapping.

The information can be converted into maps and shared with farmers and extension professionals.

Digital Weather Advisory

Weather information is one of the most valuable forms of agricultural knowledge.

ICT systems can combine weather forecasts with crop information to deliver specific recommendations.

Farmers may receive alerts regarding:

- Heavy rainfall.
- Heat waves.
- Frost.
- Strong winds.
- Drought.
- High humidity.
- Storms.

Weather advisories can help farmers decide when to irrigate, spray, sow, harvest, or protect crops.

Market Information Systems

ICTs also support knowledge transfer related to agricultural markets.

Digital platforms can provide:

- Market prices.
- Buyer information.
- Demand trends.
- Transportation services.
- Storage information.
- Processing opportunities.

Access to timely market information can improve farmers' bargaining capacity and help them make better marketing decisions.

Digital Farmer Communities

Online communities facilitate peer-to-peer learning.

Farmers can share experiences about:

- Crop varieties.
- Farm machinery.
- Pest management.
- Irrigation.
- Marketing.
- Processing.
- Storage.

Such communities can complement formal extension by creating continuous learning networks.

Extension personnel can participate as moderators and information validators.

Multilingual ICT-Based Extension

Language strongly influences the effectiveness of agricultural communication.

ICT platforms can provide information in regional languages through:

- Local-language applications.
- Voice messages.
- IVR.
- Subtitled videos.
- Speech recognition.
- Language translation.

Artificial intelligence may further improve the ability of advisory systems to communicate in multiple languages.

Personalized Knowledge Transfer

A major advantage of ICT is the possibility of personalized information.

Traditional extension often provides the same recommendation to large groups of farmers. Digital systems can use farmer-specific information to tailor advice.

Farmer information	Personalized knowledge
Crop	Crop-specific advisory
Location	Local weather information
Soil	Nutrient recommendation
Growth stage	Stage-specific management
Pest occurrence	Targeted pest alert
Weather	Irrigation or spraying advice
Farm history	Customized recommendations

Personalization can improve the relevance of agricultural information.

Digital Decision-Support Systems

Decision-support systems combine multiple sources of information to help farmers make management decisions.

A digital platform can integrate:

- Soil data.
- Weather data.
- Crop stage.
- Pest observations.
- Market information.
- Historical farm records.

The system can then provide recommendations or alerts.

These platforms can help farmers shift from reactive decision-making to preventive and predictive management.

ICT for Farmer Training

ICTs can support continuous farmer education.

Training materials can be distributed through:

- Mobile applications.
- Video platforms.
- Online courses.
- Webinars.
- Digital manuals.
- Podcasts.
- Voice messages.

Farmers can access training materials according to their availability rather than waiting for scheduled extension programmes.

ICT and Women Farmers

ICTs can improve access to agricultural information for women who may face mobility, time, or social barriers to attending conventional extension activities.

Mobile advisory services, voice messages, women's digital groups, and online training can provide flexible learning opportunities.

However, gender differences in phone ownership, digital literacy, and internet access must be addressed.

ICT and Rural Youth

Young people can play an important role in digital agriculture.

ICT-based extension can support youth in areas such as:

- Precision agriculture.
- Farm entrepreneurship.
- Digital marketing.
- Drone services.
- Agricultural machinery.
- E-commerce.
- Food processing.
- Agritech startups.

Youth participation can strengthen rural innovation and employment.

ICT for Livestock Extension

ICT-based knowledge transfer is also useful in livestock production.

Farmers can receive information about:

- Animal nutrition.
- Vaccination schedules.
- Disease prevention.
- Breeding.
- Housing.
- Fodder management.
- Milk production.

Mobile applications and digital records can help farmers monitor individual animals and maintain health information.

ICT for Fisheries and Allied Activities

Digital extension can also support fisheries and aquaculture.

Advisories may include:

- Water-quality monitoring.
- Fish feeding.
- Disease management.
- Weather alerts.
- Market prices.
- Pond management.

Sensors can provide real-time information about water temperature, dissolved oxygen, pH, and other parameters.

Benefits of ICT-Based Knowledge Transfer

ICT-based agricultural extension can provide several advantages:

- Rapid dissemination of information.
- Wider geographical coverage.
- Continuous access.
- Lower communication costs.
- Personalized recommendations.
- Two-way interaction.
- Multimedia learning.
- Faster emergency alerts.
- Better documentation.
- Improved farmer connectivity.

Challenges and Limitations

Despite significant potential, ICT adoption is constrained by several factors.

Digital Divide

Farmers may have unequal access to smartphones, computers, internet services, and electricity.

Digital Literacy

Some users may require training before they can effectively use digital platforms.

Connectivity

Weak network coverage can limit digital services in remote locations.

Affordability

Data costs, smartphones, sensors, and digital subscriptions can create financial barriers.

Information Quality

Incorrect or unverified information can lead to poor agricultural decisions.

Language Barriers

Many platforms are not available in local languages.

Data Privacy

Digital systems may collect farm, location, production, and financial information. Appropriate data-protection measures are therefore necessary.

Role of Extension Professionals

ICT does not eliminate the need for agricultural extension professionals. Instead, it expands their capabilities.

Extension professionals can act as:

- Digital facilitators.

- Content developers.
- Information validators.
- Online trainers.
- Data interpreters.
- Community moderators.
- Technology trainers.

Human expertise remains essential for complex agricultural problems that cannot be reliably solved through automated systems alone.

Digital Literacy and Capacity Building

Farmers need appropriate training to use ICT effectively.

Digital-literacy programmes should teach farmers how to:

1. Use agricultural applications.
2. Search for reliable information.
3. Identify trustworthy sources.
4. Upload clear crop photographs.
5. Interpret weather advisories.
6. Participate in digital groups.
7. Protect personal information.
8. Verify recommendations before adoption.

Training should be practical, local-language based, and adapted to farmers' digital experience.

Integrated ICT Extension Model

An effective ICT-based extension system should combine multiple technologies.

For example:

Farmer → Smartphone → Crop photograph → AI screening → Extension expert → Validated recommendation → Farmer feedback

Similarly:

Sensor → Cloud platform → Data analysis → Alert → Farmer → Extension support

Such integrated systems can create continuous communication between agricultural fields and knowledge institutions.

Future Prospects

Future agricultural knowledge-transfer systems are likely to combine artificial intelligence, IoT, satellite imagery, mobile applications, voice technology, digital farmer records, and online communities.

AI assistants may provide real-time multilingual advisory services, while IoT sensors and remote sensing may supply continuous information about crop conditions.

Digital twins and predictive analytics could eventually allow extension systems to simulate different management decisions before farmers implement them.

The most effective future systems will combine digital technologies with conventional extension methods rather than replacing human interaction completely.

Practical

ICT Tool	Knowledge-transfer application	Major advantage
SMS	Alerts and reminders	Simple and accessible
IVR	Voice advisory	Useful for low-literacy users
Mobile apps	Crop management	Personalized information
Social media	Farmer communities	Rapid communication
Video	Practical demonstrations	Visual learning
AI	Diagnosis and advisory	Automated support
IoT	Field monitoring	Real-time information
Drones	Crop assessment	High-resolution data

Satellites	Regional monitoring	Large-area coverage
Online platforms	Training	Continuous learning
Digital markets	Price information	Better marketing decisions

Conclusion

ICT-based approaches are transforming agricultural knowledge transfer by making information more accessible, rapid, interactive, personalized, and data-driven. Mobile phones, SMS, IVR, smartphone applications, social media, video platforms, artificial intelligence, IoT sensors, remote sensing, drones, and digital decision-support systems provide multiple pathways for connecting farmers with agricultural knowledge.

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