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Role of ICTs in Agricultural Extension and Rural Development

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INTRODUCTION

Information and Communication Technologies (ICTs) have become a key instrument of change in agriculture and rural development around the globe. The tools range from simple equipment, such as mobile phones, radio, television, satellite communication, to complex systems such as information systems (e.g. Geographic Information Systems (GIS), remote sensing) and to sophisticated tools involving the use of artificial intelligence and machine learning-based decision support systems. In agricultural extension, the application of ICTs has made the flow of information between research, extension workers, input suppliers, markets and farmers more rapid and effective. Extension services relied more on personal contact which was time-consuming and reach was limited. The gaps have been bridged somewhat through ICT enabling real time communication, broader coverage, and easier access to scientific and market information at the village level. They are particularly important in contexts such as India where smallholder farmers experience gaps in information and knowledge in the face of complex, heterogeneous agro-climatic conditions where ICTs are thus key instruments of agricultural knowledge systems. They enhance the efficiency of extension and enable farmers to make better-informed decisions as they provide more timely, accurate, and relevant information with sustainable agriculture and rural development hinging on them.

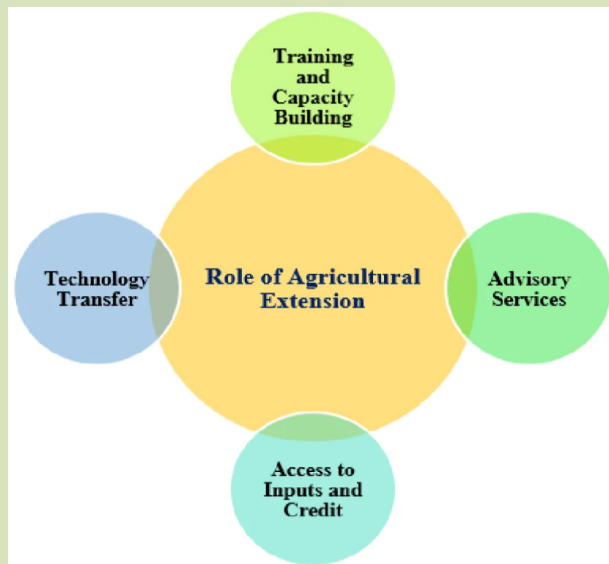
ICTs in Agricultural Extension Services

ICTs have become an integral part of the delivery of agricultural extension services, with the previous

function of supplementing other extension activities now being reversed. They facilitate timely, demand-driven and location-specific advisories that enhance the delivery effectiveness of extension services. Mobile technologies (SMS, voice messages, smartphone applications) are also enabling large-scale dissemination of information on crop management, pest and disease control, irrigation and weather information at low cost and time. Digital solutions and web portals enable farmers and experts to engage through online queries, video conferencing and e-learning, eliminating distance. Besides, ICT-based decision support systems merge soil, weather, crop and market information to provide tailor-made, evidence-based advice. This transition has enabled extension systems to become more efficient, interactive, and farmer-oriented, resulting in better decisions at the farm level.

Key functions of ICTs in Agricultural Extension Services

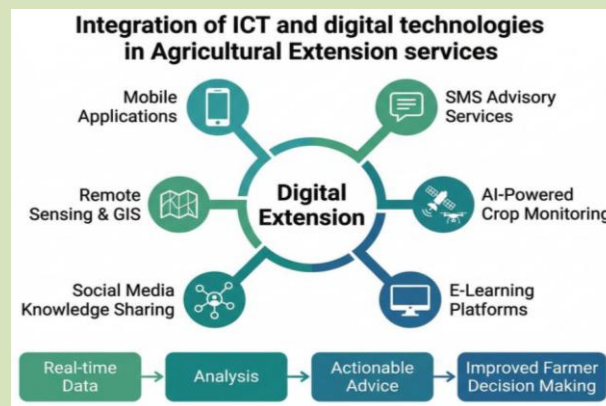
- Timely, location-specific and user-customized agriculture advisories were provided to the farmers
- Real-time information on crops, pests and diseases, irrigation, and weather is available.
- Enable farmers and extension agents to communicate directly using digital medium
- Support for interactive learning through mobile applications, Web learning, SMS notifications, video conferencing
- Soil, weather, crop, and market system data are integrated to aid in decision making
- The extension services could be extended to a large number of farmers at less cost and time.



Integration of ICT and Digital Technologies in Agricultural Extension Services

The convergence of ICTs with other digital technologies is ushering a new era in which agricultural extension services are able to deliver agricultural information and advisories to its clientele with high efficiency. What were once traditional methods based on field visits and meetings face-to-face are now supplemented by the quicker and efficient use of digital media tools. These products provide timely, accurate and location-specific information to enable better decisions on the farm. Innovative extension systems such as mobile services, SMS alerts, WhatsApp groups, web portals, or digital advisory platforms are being employed to provide up-to-date information on production related issues like crop production, pest and disease management, irrigation, weather prediction, and market information. Also, video conferencing and virtual trainings facilitate real-time engagement among farmers, scientists, and extension agents. This

overcomes physical barriers such as distance, and enhances the latency and quality of knowledge sharing. In general, the integration of ICTs has led to extension services being more effective, inclusive and responsive to farmer needs, which has led to increased productivity and sustainable agriculture development.



ICTs and Rural Development Transformation

ICTs have enabled profound change in rural development by facilitating delivery of services (education, healthcare, governance, financial systems, and market linkages) among other things. Rural areas have traditionally been subjected to problems such as remoteness, inadequate infrastructure, and weak institutional support, and ICTs are helping to break through these barriers by enhancing digital inclusion and linking rural dwellers to national and global information grids. In governance too, ICT-enabled platform like the e-governance portals, Direct Benefit Transfer (DBT) mode have brought in transparency, minimised leakages and made Government benefits delivery timely. Mobile banking, Unified Payments Interface (UPI), digital wallets among others have also

enhanced financial inclusion, making financial services increasingly accessible. In education, ICTs facilitate online learning, digital classrooms and educational broadcasting, leading to increased literacy and skill development among rural youth. Besides, ICT-based entrepreneurship has created/expanded new livelihood avenues in areas like agri-services, digital marketing, ICT maintenance, rural e-commerce etc, offering incomes beyond the confines of traditional agriculture.

Key Points

- Increases access to education, healthcare, finance and governance services
- Advocates digital inclusion in rural and remote areas
- Contributes to greater transparency in government schemes through DBT and e-governance mechanisms
- Promotes financial inclusion through UPI, mobile banking and digital wallets
- Provides aid to rural education through digital classrooms and online learning
- Generates new avenues for livelihoods and rural entrepreneurship

Major ICT Tools and Technologies in Agriculture

Today, agricultural extension and rural development systems are making use of a variety of ICT tools for information dissemination, monitoring, analysis and advisory services. Mobile technology has been the most widely embraced tool because it is the most affordable, accessible and convenient to use in rural communities. Smartphones, in particular, have revolutionized access to agricultural information, enabling farmers to receive real-time information on weather, market prices, crop advisories and pest

management through mobile apps. In addition, radio and television continue to be relevant especially in distant areas where internet access is also very weak, community radio has a significant role to play in transmitting localized agriculture information in regional languages. Web-based services and agriculture portals provide farmers, extension service providers and researchers with comprehensive information about crop production methods, research results, and government policies. Novel tools, such as GIS and remote sensing, enable the spatial analysis of soil, water, crops, and climate which may be useful for precision agriculture and disaster management. Granular computing (GrC) is a useful technique for analyses of crop regions' agricultural environments. Novel computing paradigms (e.g., quantum, hyperdimensional) and technologies (e.g., Internet of Things) Hold promise to revolutionize further the way agricultural systems can be monitored and managed. Emerging methods and tools including artificial intelligence, machine learning, and big data are further improving prediction modeling, pest forecasting, yield computations and automated advisory systems.

Impact and Benefits of ICT Integration

- Sustainable enhancement of agricultural productivity and efficiency
- Better decisions on crop selection, use of inputs, irrigation, and pest management
- Increases resource-use efficiency and minimizes waste of inputs
- Diminishes dependence on middlemen for market information
- Enhances the farmers' bargaining power and price realization

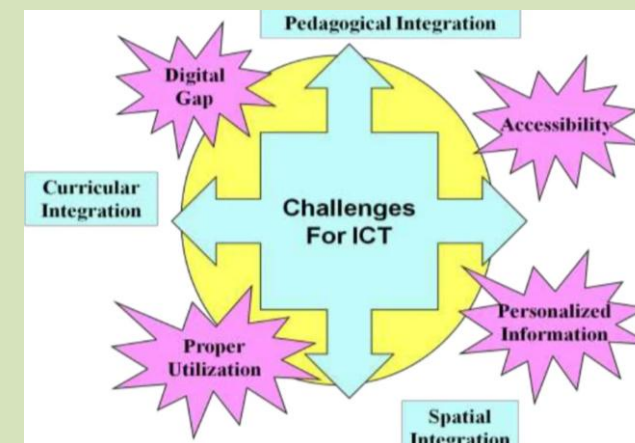
- Delivers early warning of extreme weather, pests and climate risks
- Climate variability resilience enhancement and crop losses reduction
- Fosters access to knowledge, and participation in development programmes
- Rural growth, inclusive growth, and farmer empowerment are promoted
- Bridge the information gap between rural and urban through knowledge democratization.

Modern ICT Tools & Techniques	
Tools: Tools are something you use to do a job.	Techniques: Techniques are procedures used to accomplish specific activity or task.
Computer, Laptops, Internet, Websites, Web Portals	E-mail, Internet Telephony (VoIP), Wi-Fi
Mobile phone, Smart phones, Tablets, Call Centers	Whats App, Face book, twitter
Interactive whiteboards	GPRS, USSD Technology, SMS, Conference Calling
Touch Screen Systems, Information Kiosks	E-learning
Expert Systems,	Teleconferencing, Video conferencing
Interactive Voice Response Systems	GIS, Remote Sensing Technology
Digital TV, Scanners, Personal Digital Entertainment Devices	Streaming media Podcasts, Vodcasts, Blogs

Challenges in ICT Adoption in Rural Areas

While much has been achieved, the integration of ICTs into rural agricultural systems remains challenging both structurally and functionally. Among the constraints, the most pressing one is the digital divide, manifested as unequal access to internet connectivity, electricity, and digital devices, especially in underserved rural regions. Inadequate infrastructure is an additional barrier to maximize the use of extension services based on or using ICT. Another significant obstacle is the poor digital literacy of farmers, which needed for them to make sense of and access high-quality digital information and services relevant to farm decision-making.

Language too is a barrier to effectiveness, as much of the digital content is either not available in local language, or is farmer is not culturally adapted. The expensive nature of frontier technologies, such as precision farming tools, artificial intelligence (AI)-based systems, and sensor technologies, also renders them inaccessible to small and marginal farmers. Resistance to technological change, lack of trust in digital platforms, and inadequate training and extension services also retard the adoption of ICTs. Collectively, these issues constrain the ability of ICTs to completely revolutionize rural agricultural systems and inclusive digital development.



CONCLUSION

By facilitating more rapid, cost-effective and inclusive communication, ICT dramatically reshaped agricultural extension systems and rural development models. They have deepened the integration of research institutes with farming communities, enhanced access to markets and services and played a major role in rural socio-economic development. Yet to exploit the full potential of the ICTs, there are still challenges to be tackled in terms of infrastructure,

digital literacy, affordability and localization of content. With further strengthening of digital infrastructure and capacity, ICT is anticipated to increasingly play a major role in the future of sustainable agriculture and rural development. The introduction of new technologies such as artificial intelligence, big data analytics and Internet of Things (IoT) will accelerate this transformation and help making agriculture more intelligent, efficient and resilient.