

Digital Divide in Agricultural Extension: Exploring ICT

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Abstract: Agriculture, as the backbone of many economies, has undergone significant transformation due to the integration of digital technologies. The adoption of information and communication technologies (ICT) in farming has facilitated better decision-making, improved productivity, and enhanced access to markets and advisory services. The digital divide in agriculture remains a pressing issue in many developing and emerging economies, where unequal access to information and communication technologies (ICTs) significantly influences productivity, income levels, and market participation. This study explores the relationship between farmers' socio-economic profiles—such as age, education, income level, farm size, and gender—and their access to and use of ICT tools like mobile phones, internet platforms, and agricultural applications. By analyzing how these profiles shape the adoption of digital technologies, this research highlights the structural barriers that restrict many farmers from benefiting from modern digital solutions. Findings indicate that younger, better-educated farmers are more likely to use ICT for accessing market information, weather forecasts, and extension services, whereas older and less-educated farmers often remain excluded. Addressing the digital divide in agriculture requires a multipronged approach that combines affordable digital infrastructure, capacity-building initiatives, and inclusive policies to ensure equitable participation in the digital agricultural ecosystem.

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INTRODUCTION

Agriculture is the backbone of many economies worldwide, providing food, employment, and raw materials for industries. However, the sector faces persistent challenges, including climate change, market fluctuations, and limited access to timely information. In recent decades, information and communication technologies (ICTs) have emerged as a powerful tool for bridging these gaps by improving farmers' access to agricultural knowledge, market prices, weather updates, and input suppliers. ICT in agriculture can take many forms, including mobile phone-based advisory services, internet platforms, social media groups, e-extension services, and decision-support systems. Despite the promise of ICT to transform agriculture and enhance productivity, its benefits are unevenly distributed among farming populations. This inequality in access and use of digital tools is referred to as the digital divide—a socio-economic phenomenon that continues to deepen existing disparities in rural areas. The digital divide in agriculture is multidimensional, encompassing access, affordability, skills, and utilization. Access refers to the availability of infrastructure such as mobile network coverage and internet connectivity. In many rural areas, connectivity remains patchy, slow, or prohibitively expensive, limiting farmers' ability to participate in digital initiatives. Affordability involves the cost of

devices, data plans, and digital services. Low-income farmers may prioritize immediate household needs over investing in smartphones or internet subscriptions. Beyond access and affordability, there is the question of digital literacy—the ability to use technology effectively. Farmers who lack education or training may struggle to navigate digital platforms, which often use technical language or are not available in local dialects. Thus, the digital divide is not simply about having or not having technology; it is about the ability to meaningfully engage with and benefit from it.

Farmers' socio-economic profiles significantly influence how they experience this digital divide. Research consistently shows that younger farmers are more likely to own smartphones, use social media, and adopt mobile-based advisory services compared to older farmers who may rely on traditional knowledge and word-of-mouth communication. Education also plays a critical role: literate and numerate farmers can interpret text-based messages, engage with online platforms, and make data-driven decisions, whereas illiterate farmers may depend on intermediaries or family members to access information. Gender is another factor, as women farmers often face systemic barriers, including lower ownership of digital devices, cultural restrictions, and time constraints, which limit their ability to engage with ICT tools. Farm size and income levels also

matter: larger-scale farmers often have greater financial capacity to invest in technology, while smallholder farmers may see ICT as a risk rather than an opportunity due to their limited resources.

The relevance of ICT in agriculture extends beyond productivity gains. Digital platforms enable farmers to bypass intermediaries and access markets directly, securing better prices for their produce. Weather and pest alerts allow for timely decision-making, reducing losses and improving food security. Moreover, ICT has the potential to make agricultural extension services more inclusive, reaching farmers in remote areas who were previously neglected. However, without deliberate efforts to close the digital divide, these benefits risk being concentrated among a privileged subset of farmers, exacerbating rural inequalities. Policymakers, technology developers, and development agencies must therefore work collaboratively to ensure that digital innovations are designed with inclusivity in mind, considering the diverse needs and capacities of different farming communities. Addressing the digital divide requires not only infrastructure investment but also capacitybuilding initiatives. Training programs on digital literacy can empower farmers to use ICT tools confidently, while localized content in native languages can make platforms more accessible. Public-private partnerships can help subsidize the cost of devices and data services, making them affordable for smallholder farmers. Furthermore, involving farmers in the design and testing of digital tools ensures that these solutions are user-friendly and contextually relevant. Ultimately, the goal is to create an enabling environment where ICT is not a luxury but a practical tool that every farmer—regardless of age, gender, or income—can leverage to improve their livelihoods.

CONCEPT OF DIGITAL DIVIDE

The term digital divide refers to the gap between individuals, households, communities, or regions that have access to modern information and communication technologies (ICTs) and those that do not. This divide is not limited to physical access to devices like computers, smartphones, or internet connectivity, but also includes differences in the skills and ability to use these technologies effectively. In other words, the digital divide represents both a technological gap and a knowledge gap. People on the “connected” side of the divide can access information quickly, communicate more efficiently, and participate in economic, educational, and social opportunities created by digital technology. Those on the “disconnected” side are left behind, which often worsens existing socio-economic

inequalities. In the context of agriculture, the digital divide has critical implications. Farmers with access to digital tools can receive timely weather forecasts, learn about new farming techniques, find better markets for their produce, and connect with agricultural experts through mobile or online platforms. Farmers without access remain dependent on traditional sources of information, which are often slow, unreliable, or unavailable altogether. This divide is influenced by several factors, including income level, education, geographical location, gender, and age. Rural areas, where agriculture is dominant, are more likely to have poor digital infrastructure compared to urban areas, widening the gap even further.

Moreover, the digital divide is not only about access but also about meaningful use. Even when farmers have mobile phones or internet access, they may lack the digital literacy skills needed to navigate apps, interpret data, or use online platforms effectively. Some may face language barriers if digital content is not provided in their native language. Others may be discouraged by the cost of devices, data plans, or service subscriptions. Therefore, bridging the digital divide requires addressing affordability, availability, awareness, and ability—ensuring that people not only have the tools but also the knowledge and confidence to use them to improve their livelihoods.

CURRENT ICT INFRASTRUCTURE AND ACCESS IN RURAL AREAS

The state of ICT infrastructure in rural areas has improved significantly over the past decade, yet large gaps remain when compared to urban centers. Mobile phone penetration has grown rapidly, with many rural households now owning at least a basic feature phone, and in some regions, smartphones are becoming increasingly common. This expansion has been driven by lower device costs, competitive mobile network providers, and government initiatives aimed at promoting rural connectivity. However, despite these gains, rural internet penetration is still relatively low in many developing countries. Broadband infrastructure often remains limited, with patchy network coverage and slower internet speeds, making it difficult for farmers to access rich digital content such as videos, mobile applications, and online platforms for learning or marketing their produce. Electricity access also plays a major role in ICT adoption. Many rural areas still face irregular or limited power supply, which directly affects the ability to charge mobile devices or run computers. In regions where electricity is unreliable, the cost of alternative power sources, such as solar chargers or generators, adds another barrier for farmers. Even

where infrastructure exists, affordability continues to be a major challenge. The cost of mobile data plans, smartphones, and digital services often consumes a large share of rural household income, discouraging regular use of ICT tools. Another important issue is the availability of locally relevant content and services. Many ICT-based agricultural platforms are designed in dominant languages or require a high level of literacy, which excludes a significant portion of smallholder farmers. As a result, even in areas where connectivity is available, adoption rates may remain low. Moreover, rural women often face additional social and cultural barriers to accessing ICT infrastructure, such as lower ownership of mobile phones and limited control over household resources. Despite these challenges, the trend is moving toward improved access. Governments and private telecom companies are investing in expanding network coverage to underserved regions, often through public-private partnerships. Digital agriculture projects, e-extension platforms, and mobile-based advisory services are being piloted in many countries to close the information gap. Community information centers, mobile kiosks, and rural ICT hubs are also emerging as shared solutions to improve affordability and access. However, to fully bridge the gap, these efforts must be scaled up and tailored to the unique needs of rural populations, ensuring that infrastructure is not only available but also affordable, reliable, and inclusive.

BARRIERS TO ICT ADOPTION AND USAGE AMONG RURAL FARMERS

Despite the growing presence of digital technologies in agriculture, rural farmers face numerous obstacles that hinder the full adoption and effective use of ICT. One of the most significant barriers is limited infrastructure. Many rural areas still suffer from poor network coverage, unreliable internet connectivity, and irregular electricity supply, all of which make it difficult for farmers to consistently use digital platforms. Even when infrastructure is available, it is often of lower quality than in urban areas, leading to slow internet speeds and frequent service interruptions. This discourages farmers from relying on ICT for critical decision-making. Affordability is another major constraint. The cost of smartphones, computers, mobile data packages, and subscription-based services can be prohibitively high for smallholder farmers, many of whom operate on very thin profit margins. When household income is low, digital investments are often seen as non-essential compared to immediate needs like food, healthcare, and farm inputs. Additionally, the ongoing cost of maintaining devices—repairs, charging, and

upgrading to newer technology—adds to the financial burden, reducing farmers' willingness to adopt ICT. A further challenge is low digital literacy and technical skills. Many rural farmers lack the knowledge and confidence to use digital devices or navigate agricultural apps effectively. In regions with high illiteracy rates, text-based platforms become inaccessible, and farmers must rely on intermediaries to interpret digital information, which reduces the timeliness and reliability of communication. Language barriers also play a role, as many ICT platforms are designed in official or global languages rather than local dialects. Without proper training and localized content, technology adoption remains slow. Cultural and social factors also influence ICT uptake. In some rural communities, there is skepticism or mistrust toward new technologies, especially among older farmers who are more comfortable with traditional methods. Gender disparities further complicate the situation, as women often face restricted access to mobile devices due to cultural norms, limited decisionmaking power within households, and competing domestic responsibilities. This leads to a gendered digital divide that prevents women farmers from benefiting equally from ICT innovations.

Lastly, there is the issue of relevance and usability of ICT solutions. Some digital platforms are not tailored to the specific needs of smallholder farmers, offering generic information that may not align with local cropping patterns, climate conditions, or market realities. When farmers perceive that ICT tools do not provide practical or actionable advice, they are less likely to continue using them. This lack of contextualization reduces trust in technology and limits its potential impact on farming practices and productivity.

POLICY AND PROGRAMMATIC INTERVENTIONS FOR DIGITAL INCLUSION IN AGRICULTURE

Bridging the digital divide in agriculture requires a combination of policy frameworks and targeted programs that address infrastructure gaps, affordability, and capacity building. Governments play a crucial role in creating an enabling environment for rural connectivity by investing in rural ICT infrastructure, such as expanding broadband networks, improving mobile coverage, and subsidizing electricity access for remote farming communities. Public-private partnerships (PPPs) have proven effective in this regard, as they leverage the expertise and resources of telecommunications companies while aligning with national development goals. For example, universal service funds can be

used to support network expansion in low-profit rural areas, ensuring that connectivity reaches even the most marginalized farming populations. Another key intervention is affordability and access to devices. Policymakers can introduce subsidies or low-interest credit schemes to help smallholder farmers purchase smartphones, solar chargers, and data bundles at reduced costs. In addition, governments and NGOs can establish community ICT hubs or telecenters where farmers can access digital tools collectively, reducing the financial burden on individual households. These shared facilities can also serve as platforms for agricultural training, information dissemination, and farmer-to-farmer knowledge exchange. Digital literacy and capacity building are equally important. Programs aimed at training farmers in the use of mobile applications, digital marketing platforms, and e-extension services can empower them to integrate technology into their daily farming practices. Training initiatives should be inclusive, gender-sensitive, and designed in local languages to ensure participation from women and marginalized groups. Extension agents can be equipped with tablets and mobile apps to provide farmers with real-time information on weather, pest outbreaks, and market prices, making digital engagement more practical and relevant. Additionally, localized and farmer-centered content development is a vital programmatic strategy. Policymakers should encourage the creation of ICT platforms that offer region-specific advice on crop selection, soil health, irrigation practices, and market trends. Incorporating interactive features such as voice messages, chatbots, or call-in options helps overcome literacy barriers and enhances usability for farmers with limited education.

Finally, data protection and inclusive policy frameworks are critical to building trust among rural farmers. Clear regulations on data privacy, transparent pricing for digital services, and policies that prevent monopolistic practices in the ICT sector ensure that farmers benefit fairly from digital innovations. Collaboration between governments, private sector players, research institutions, and farmer organizations is necessary to develop sustainable models for digital inclusion. By combining infrastructure development, financial support, education, and tailored content, policy and programmatic interventions can transform ICT from a privilege into a powerful tool for equitable agricultural development.

IMPACT OF DIGITAL DIVIDE ON RURAL FARMING COMMUNITIES

The digital divide has far-reaching consequences for rural farming communities, affecting productivity, income, and overall well-being. Farmers without access to digital tools are often unable to receive timely weather forecasts, pest and disease alerts, or information on improved farming techniques. This lack of real-time information increases vulnerability to crop failures and reduces the ability to respond effectively to climate variability. In contrast, digitally connected farmers can plan planting and harvesting schedules more accurately, adopt better input management practices, and minimize losses, leading to higher productivity. Economically, the digital divide limits farmers' ability to access markets and secure fair prices for their produce. Farmers who lack access to mobile platforms or online marketplaces often remain dependent on middlemen, who may offer low prices for their products. This reduces profit margins and traps farmers in cycles of poverty. On the other hand, farmers with access to ICT can compare prices across markets, negotiate better deals, and connect with buyers directly, increasing their income and bargaining power. The inability to leverage digital financial services, such as mobile banking and online credit platforms, also prevents many rural farmers from accessing affordable loans for purchasing inputs or expanding their farms. Socially, the digital divide deepens existing inequalities within farming communities. Younger, educated, and relatively wealthier farmers tend to adopt ICT faster, leaving behind older, less educated, and poorer farmers who lack the means or skills to engage with digital tools. This creates a knowledge gap where some farmers benefit from new opportunities while others are excluded from innovations that could improve their livelihoods. Gender disparities are particularly concerning—women farmers are disproportionately affected by limited access to devices and information, which reduces their ability to make informed decisions and participate equally in agricultural value chains. In the long run, the persistence of the digital divide slows rural development and perpetuates poverty. Communities that remain disconnected are less likely to benefit from government support programs delivered through digital platforms, less able to adopt climate-smart agriculture practices, and less competitive in a globalized market. This not only affects individual farmers but also has broader implications for national food security, rural employment, and economic growth. Bridging the digital divide is therefore critical for inclusive agricultural transformation and sustainable rural development.

CONCLUSION

The exploration of farmers' profiles and ICT use reveals that the digital divide in agriculture is both a technological and socio-economic challenge. While ICT has immense potential to transform farming practices, its uneven adoption highlights deep-seated issues related to access, education, gender, and affordability. Bridging this gap will require a comprehensive approach that combines infrastructure development, digital literacy training, financial support mechanisms, and inclusive policies. By tailoring ICT solutions to the specific needs of diverse farmer groups, stakeholders can foster greater participation in the digital economy, enhance agricultural productivity, and promote rural development. Closing the digital divide is not merely about technology—it is about ensuring equity, empowerment, and resilience in the agricultural sector.

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