

Information and Communications Technology (ICT) and Agricultural Extension in Developing Countries

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Information and communications technologies (ICTs) are rapidly growing in importance, even in agricultural and rural settings in lower- and middle-income countries where agriculture is primarily characterized by resource-poor, small-scale farmers and production systems. Although ICTs have the potential to revitalize agricultural extension in developing countries, evidence suggests that not all ICT-enabled extension approaches are equally effective in improving farmers' technology adoption, productivity, income, or welfare outcomes. More research is thus needed on how the growth in ICT use is affecting the performance of extension services.

Previous reviews have explored multiple dimensions of ICT contributions to developing-country agriculture. This review examines various pathways through which ICTs can affect outcomes from extension services. It also explores whether ICT-enabled extension can help researchers more rigorously evaluate and identify extension outcomes. These insights point to several lines of future policy-relevant research on ICT-enabled extension.

Our study focuses on a narrow class of ICT products and services: technologies related to mobile phones, services, and networks; portable devices; web-based portals, tools, and applications; and the data and information shared through these products and services via technologies as varied as interactive voice response (IVR) systems and satellite imagery. We do not consider more traditional ICTs such as radio and television programming. In addition, we focus on a core function of extension services—the promotion of productivity-enhancing agricultural technologies and practices—from which we examine the impacts of ICT-enabled extension on equity outcomes, such as changes in women's empowerment and decision-making within households; on behavioral outcomes, such as aspiration, risk, and ambiguity preferences; and on learning outcomes, such as awareness, knowledge, and learning externalities.

How ICTs in Extension Can Lead to Better Outcomes for Farmers

We see three distinct impact pathways through which ICT-enabled extension could produce outcomes related to productivity, welfare, equity, and sustainability (see figure below): (1) information effects, (2) learning effects, and (3) motivational effects on agents.

A conceptual model of ICT-enabled agricultural extension and advisory services

Information effects

ICTs improve farmers' access to information by reducing both dissemination costs for the extension provider and search costs for the farmer, by improving the timeliness or quality of information, or by reducing market and institutional barriers to information provision more broadly.

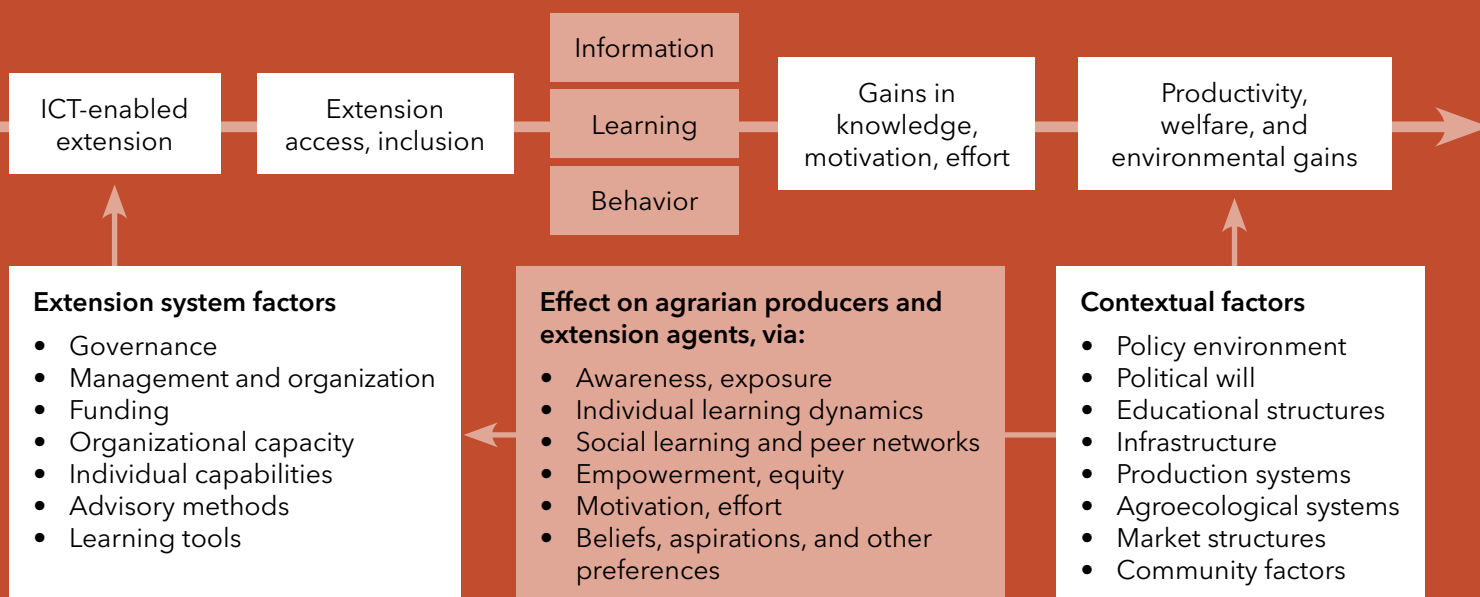
One example on information and gender demonstrates how ICT-enabled extension can affect information pathways in multiple and often complementary ways. Female farmers in developing countries generally have less access to extension services than their male counterparts. Most extension strategies targeting male heads of households assume that they will share the information they receive—but studies show that this is often not the case. In many

situations, women may gather their information from informal networks, but when these networks are made up solely of women, they may all suffer from the same lack of information. Consequently, women often have less capacity to make effective use of the inputs and assets to which they do have access.

Improving women's access to ICTs and adapting the content to women's needs could close this information gap, producing multiple benefits:

- Providing women with alternative channels through which they can learn from others—peers as well as extension agents—about new agricultural technology and market opportunities
- Facilitating women's access to financial services such as credit or insurance
- Allowing women to overcome time constraints or constraints related to norms and culture that limit their participation in extension activities
- Allowing women to participate more fully in agricultural decisions in their households
- Enabling women to realize and express their distinct preferences for what is produced or consumed by the farm household

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Similarly, ICT-enabled extension can help close information gaps faced by other groups marginalized by age, remoteness, or other factors.

Learning effects

But using ICTs merely for information dissemination and training may not be enough to lead farmers to use new knowledge or to improve the quality of extension services provided. The pathway related to learning effects centers on the social and psychological dimensions of how individuals learn and on how learning affects their economic decision-making.

In the study of learning, the field of economics lags behind work in psychology, education, sociology, and anthropology. More research in economics is needed on issues such as the effects of information targeting, framing, aspirations, peer networks, role models, social incongruity, and other factors that affect both learning and economic decision-making about the present and future.

These lines of inquiry would allow for further investigation of the effects of different adult learning approaches used in extension systems. For example, experiential learning has been integrated into the farmer field school approach to agricultural extension, but there are virtually no rigorous evaluations of the impact of farmer field schools on farmers' behaviors, attitudes, and aspirations or on their adoption of new knowledge or technologies, their welfare, or other outcomes.

Effects on agents' motivation and behavior

The next pathway concerns how extension services, programs, and agents can use ICTs to improve their own knowledge, motivation, effort, and performance to increase farmers' access to extension and enhance the quality of service provided.

It can be difficult to monitor the performance of extension agents. Because policymakers hire extension agents to produce public goods and services for farmers and farm communities, the agents must be responsive to the needs of both the policymakers and the communities at the same time. One popular solution to this problem is community-based monitoring. Townhall-style meetings—where different stakeholders can share information and engage in facilitated Q&A sessions—has been found effective in some but not all contexts. Whether bottom-up or top-down, monitoring can have undesirable effects on

agents' motivation, however. In particular, when agents' performance is only partly observable, monitoring may cause them to shift efforts toward those tasks that are more easily monitored and away from other equally important but unobservable tasks.

Recent economic theory on an individual's motivation is grounded in a deep literature in the field of psychology: Individuals may be internally motivated in part by the very nature of their task or externally motivated by financial and nonfinancial rewards and recognition. If external and internal motivations draw agents in opposite directions, financial incentives may crowd out those individuals with higher internal motivation. On the other hand, financial incentives may also crowd in those individuals with lower internal motivation. The existing literature says little about how to enhance agents' internal motivations. If, for instance, agents are more motivated by those tasks that they perform well, providing them with a means to enhance performance (such as ICT tools) may induce greater efforts. Though there are some informative studies in this area, overall we know of few applications of these concepts to developing-country extension services in the economics literature.

Empirical Evidence and Evidence Gaps

Next we examine the evidence on the role and impact of ICTs on agricultural extension with respect to the three central elements in our model—information effects, individual and social learning effects, and behaviors—by looking at empirical studies in the economics literature as well as in other social science disciplines. We analyze these studies' breadth, depth, and scope; the research questions they pose; and the methods they apply.

Breadth, depth, and scope of existing studies

Prior studies address only a narrow range of extension services and ICTs. Most studies made use of mobile services that are viable on feature phones, such as prerecorded voice messages, call center services, IVR systems, and SMS systems. Few studies investigated the use of smartphone apps or other more advanced ICT approaches to providing extension services.

In addition, these studies focused on a limited range of outcomes, such as farmers' knowledge acquisition and technology adoption. Consequently, there is so far little evidence on how ICT-enabled extension affects productivity, profitability, environmental conservation, or sustainable agriculture.

This lack of evidence limits our ability to extract lessons on the design of ICT-enabled agricultural extension. This is not so much a negative reflection on the evidence as it is an incentive for further research.

Research questions

Many studies examine the information effects of ICT-enabled extension, but fewer delve into the learning and behavioral effects. This may simply reflect the direct and obvious importance of the information pathway relative to other pathways, or it may reflect the slow evolution of agriculture and resource economics toward research on learning and behavior.

A number of studies explore the gender dimensions of ICT-enabled extension. These studies address, among other things, the prevalence of women's ICT ownership, access, and use, focusing primarily on mobile phones. They highlight the potential for ICTs to either exacerbate or remedy inequalities already identified in the literature on gender in extension. Several studies have made innovative attempts to compare how different ICT channels amplify informational messages to women. Far less frequent, however, are studies of the impacts of ICT-enabled extension on women's empowerment, allocation of resources within households, and other topics that lie at the foundation of gender analysis.

Although ICTs hold promise for social learning, as they are generally networked technologies that become more useful as more people use them, few studies have been

conducted in this area. Additionally, few studies have examined the use of ICT-enabled extension to improve extension agents' performance or to better communicate farmers' demand for extension services. Finally, we note the absence of studies on the cost-effectiveness of ICT-enabled extension services.

Methodological rigor

To understand the impacts of ICT-enabled extension, it is vital to use methods that can credibly identify cause-and-effect relationships between ICT-enabled extension approaches and the outcomes of interest. Unfortunately, most of the studies we reviewed are hampered by methodological limitations.

New methods in economics, however, offer the potential for new lines of research. Experimental methods can be applied with relative ease to evaluating ICT-enabled extension: ICTs provide a diverse set of convenient, low-cost, consistent, and measurable treatments with which investigators can experiment. A more difficult challenge in these experimental designs is measuring the "spillover effects" of ICT-enabled extension approaches. Researchers must disentangle whether individuals' choices are directly influenced by their peers' choices or by the fact that they and their peers face similar conditions. Because social learning is likely to be fertile ground for ICT applications for extension, spillover effects will need to be incorporated more explicitly in studies.



Directions for Future Research

Though future research on this topic will always likely be highly sensitive to context and approach, it is clear that ICTs are potentially significant to the performance and impact of agricultural extension and advisory services.

ICT-enabled extension offers exciting opportunities for innovations that go beyond mobile phone-based information services and videos on farming practices. One clear gap in the literature concerns the potential of ICTs to leverage social networks for agricultural extension and the potential of big data to better target information to users. Another promising avenue for future research is the use of ICTs to increase agent monitoring—as a way to boost motivation and performance—including evaluating the effectiveness of increased monitoring. A final challenge is how to translate evidence from program evaluations into policy choices, given the paucity of comparable cross-country data, information, and analysis.

But as researchers begin designing new studies, three caveats should be kept in mind:

1. Agricultural development is not merely about adoption and yield effects. It is also important to investigate other

processes that underpin agricultural development—learning dynamics and behavior change—building on insights and methods used in psychology, education, sociology, and anthropology.

2. Much greater rigor and systematic exploration of heterogeneity, by gender and other axes of exclusion, are needed in the study and evaluation of ICT-enabled extension.
3. Studies or evaluations must be able to clearly identify cause and effect and to rigorously analyze the effectiveness—and cost-effectiveness—of ICT-enabled extension approaches. This means that extension evaluation should be taken far more seriously than it is in the existing literature.

In summary, agricultural extension and advisory services are widely recognized as important components of agricultural development strategies. Assembling an ever-increasing body of relevant, timely, and credible evidence on what works in ICT-enabled extension—and for whom—will be important to informing decisionmakers at the local, regional, and global levels.

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