Module 6: ICTS AS ENABLERS OF AGRICULTURAL INNOVATION SYSTEMS

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IN THIS MODULE

Overview. Research, extension, and advisory services are some of the most knowledge-intensive elements of agricultural innovation systems. They are also among the heaviest users of information communication technologies (ICTs). This module introduces ICT developments in the wider innovation and knowledge systems as well as explores drivers of ICT use in research and extension.

Topic Note 6.1: ICT in the Agricultural Research Process. This section spans the entire agricultural research process from engaging partners and stakeholders, through data collection and analysis, collaboration and knowledge access, publishing and dissemination, to feedback and interactions with rural and other end-user communities. In each of these areas, ICTs are making agricultural research more effective.

- **Advances in ICTs Increase the Utility of African Sites for Testing Varieties**
- **KAINet Kenya Knowledge Network Anchored in Partnerships and Collaboration**

Topic Note 6.2: Using ICT in Extension and Advisory Services. This note looks at ways ICTs are helping transform extension, including the emergence of public and private innovators and startups with business models built around ICT-enabled advisory services. It examines how traditional and new ICTs are being used to reach rural communities, enable the creation and sharing of rural communities' own knowledge, and support connections of rural communities to markets, institutions, and other sources of information and advice.

- **Farm Radio International Involves Men and Women Farmers**
- **E-Extension in the USA and Philippines**
- **TECA Uganda Exchange Group Offers Practical Advice for Smallholders**
- **Participatory Video and Internet Complement Extension in India**

Topic Note 6.3: E-learning as a Component of Agricultural Innovation Systems. Learning through ICTs can provide fresh approaches that are learner-centric, which engages producers and their communities in designing and implementing the learning experience. It can also make it easier to maintain quality by supporting feedback mechanisms and ensuring appropriate accreditation and certification processes. This note also explores some of the adaptations and strategies required for e-learning to succeed in rural areas of developing countries.

- **Lifelong Learning for Farmers in Tamil Nadu**
- **Innovative E-Learning for Farmers through Collaboration and Multi-Modal Outreach**

OVERVIEW

The traditional approach to fostering innovation in agriculture is often described as linear: Researchers develop an innovation such as a disease-resistant wheat variety, extension services advise farmers through demonstrations and other methods that a more disease-resistant variety is available, and farmers plant it. The problems with this approach have been widely acknowledged. It can encourage research and extension to act independently of one another and of farmers, to the extent that each group becomes relatively isolated. A linear approach can exclude other stakeholders in the agricultural sector such as universities, agribusiness, traders, and nongovernmental and civil society organizations. It does not reflect the many well-documented ways that agricultural innovation actually occurs, such as experimentation by individual farmers, informal networking among farm communities, private sector participation, collaboration among extension workers interested in a particular idea, collaboration between researchers and farmers, and the adaptation by all of these actors of knowledge and practices from domains outside agriculture.

A few decades ago, practitioners began to use the concept of innovation systems to explain noteworthy economic performance driven by a strong orientation to innovation in some developed countries.[1] An innovation system can be defined as "a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect their behavior and performance" (World Bank 2006). This thinking recognizes that interactions of people and ideas catalyze innovation and that innovation consists of generating, accessing, and putting knowledge into use (Hall 2006). It also recognizes the importance of institutions and policy in fostering innovation.

ICTs and Agricultural Innovation Systems

ICTs appear ideally suited to the task of enhanced interaction because they can expand communication, cooperation, and ultimately innovation among the growing array of actors in agriculture. ICTs, especially mobile phones, can and do drive participatory communication, including communication from those on the margins of traditional research-extension processes, and they are often the key instruments that organizations use to deliver services to larger numbers of rural people than they could reach before. ICTs are fundamental to the business models of the "infomediaries" and "brokers," public and private—extension agents, consultants, companies contracting farmers, and others—emerging to broker advice, knowledge, collaboration, and interaction among groups and communities throughout the agricultural sector.

Numerous electronic tools increase interaction among the actors involved in agriculture. On a macro level, e-Science (e-Research) draws on increasingly connected and extensive digital infrastructure to facilitate collaboration and knowledge exchange nationally, regionally, and globally. On a micro level, m-Agriculture, powered by increasingly affordable mobile digital devices such as phones, laptops, and sensors, connects millions of rural people to sources of information. In both cases, ICTs empower individuals and institutions to create, access, and use knowledge and to communicate in unprecedented ways. In agricultural extension and education, from universities to farmers' fields, ICTs facilitate learning.

ICT-Enabled Tools

As ICTs have developed and become more pervasive, they have become more relevant in agricultural innovation systems. The most pertinent developments for research, extension, and e-learning are reviewed briefly below.

First and foremost, the increased pervasiveness of telecommunication networks has enabled ICT to reach rural areas. Technologies that have long been applicable to poor agricultural communities have not been effective simply because they are difficult to get into the hands of rural users. Expanded telecommunications networks have increased the speed, reliability, and accuracy of information exchange—through text, voice, and applications—between farmers and other stakeholders. Low-bandwidth networks have also started to trickle into rural areas in developing countries, creating opportunities for farmers to connect with extension workers, agribusiness, researchers, and each other. For example, telecommunications networks have facilitated e-learning by liberating it from the classroom and from the need for the user to invest in anything other than a mobile phone. Power lines and power sources critical for the regular use of and upkeep of ICTs also continue to expand. (See Module 2 for more information on the growth of this infrastructure.)

Second, cloud computing services have immense potential to improve agricultural innovation systems. The advantage of cloud computing is that it offers pooled and elastic resources on demand over the Internet (Porcari 2009). More specifically, cloud computing has been described as "a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" (Mell and Grance 2009). Over the past few years, these services have created opportunities for data sharing initiatives that were once prohibitively expensive for most institutions to explore, let alone students conducting master's or doctoral research. They have also eased the data collection and aggregation process, which is critical for research, extension, and education.

For example, a website such as Amazon Web Services can be used to acquire a Windows or Linux server by specifying

1 See Freeman (1987) and Lundvall (1992).

how much processor, bandwidth, and storage capacity are needed. The required resource is made available immediately over the Internet, and the cost is based on how long the server is used. Cloud computing's elasticity and variable capacity make it possible to process very large datasets, which can also be shared with anybody with adequate connectivity (box 6.1).

BOX 6.1: Datasets on Amazon Web Services

Public Data Sets are a centralized repository on Amazon Web Services (AWS) for public data that can be seamlessly integrated into AWS cloud-based applications. AWS hosts the datasets at no charge for the community. As for all AWS services, users pay only for the computing and storage they use for their own applications.

Previously, large datasets such as those in the Human Genome Project and United States Census required hours or days to locate, download, customize, and analyze. Now anyone can access these data from their Amazon Elastic Compute Cloud (Amazon EC2) and start their computations within minutes. Users can also leverage the entire AWS ecosystem to collaborate easily with other AWS users. For example, users can produce or use prebuilt server images with tools and applications to analyze the data sets. Users can also discuss best practices and solutions in the dedicated Public Data Sets forum (http://aws.amazon.com/publicdatasets/).

Source: Authors.

Third, the movement toward open access and public involvement through online or mobile tools also favors agricultural innovation, not only in research institutions but more broadly among all participants in an innovation system. Governments, organizations, and even the private sector are sharing data and reports with the public and one another through ICT. As ICT has alleviated the difficulties inherent in interactions among people in dispersed locations, knowledge sharing and multistakeholder engagement are widely acknowledged to have increased. Research can involve more expert opinion and diversity (box 6.2). Advisory services can tap a much wider range of current expertise and provide advice in a much more targeted way to those who need it. With Internet access, e-learning can occur even in the absence of a formal distance education program, and web platforms such as agropedia, discussed in Topic Note 6.3, make it much easier to develop and transmit content for e-learning programs.

BOX 6.2: Social Media Support Research Project Review and Reporting

The System-wide Livestock Program of the Consultative Group for International Agricultural Research uses social tools to capture, record, and share discussions at its project review and planning meetings. A wiki was used to plan and report on meetings. A pre-meeting survey among participants was conducted using SurveyMonkey. Scientists in remote locations were brought in using the "webex" Internet conferencing system. During the meeting, all the resources prepared and shared were published online. The results of the intense "internal" small group discussions were recorded on video and shared on the project website. A key feature is the use of social "reporting" to share information that normally remains internal and closed.

Similarly, the Fodder Adoption Project organized an end-of-project meeting for project participants from Ethiopia, Syria, and Vietnam to draw lessons and share results. The organizers used web tools to document and share all the notes, contributions, and discussions at the meeting. By the end of the meeting, the wiki contained the essence of the workshop report (http://fodder-adoption-project.wikispaces.com/Final+Workshop). Video interviews recorded the group discussions (usually this tacit knowledge is lost) and a series of blog posts shared the meeting "live" with wider audiences.

In these cases, web applications directly contribute to research meeting organization, reporting, and dissemination. The tools are free or inexpensive. They require Internet connectivity (at a high speed if video is part of the package), some digital skills among meeting organizers and participants, a willingness among participants to embrace an extended digital toolkit and workflows, and an open attitude to sharing "internal" discussions more broadly.

Source: Author; see also http://vslp.org and http://fodderadoption.wordpress.com.

Finally, new forms of knowledge brokering have been made possible through ICT (image 6.1). Knowledge brokering has always been an integral part of agricultural innovation systems (box 6.3). The creation and passing of information

IMAGE 6.1: Specialized Knowledge on Farm Practices Can Result in Profitable Enterprise

Source: Dominic Sonsoni, World Bank.

between farmers and extension agents, farmers and researchers, and researchers and extension agencies, among others, is critical to innovation and increased productivity through adoption of better farming practices and technologies. Knowledge brokering is becoming a specialization—sometimes a profitable one.

On a more basic level, as digital literacy and the availability of ICTs increase, farmers, traders, and others in developing countries are offering information services for a small fee. This private activity can widen the availability of information in rural areas and reduce pressure on public extension agents, who are charged with getting timely and locally relevant information to farmers. Private sector involvement in advisory services has almost always been more successful than the involvement of public services with their very broad mandates, but until recently the high costs of such services limited private advisory initiatives. An issue that policy makers need to examine, however, is how public advisory services and other forms of knowledge brokering will meet the needs of rural people who are not linked into the innovation system through ICT, either because they cannot access it or do not yet know how to use it effectively.

KEY CHALLENGES AND ENABLERS

The topic notes and innovative practice summaries in this module demonstrate the potential for ICTs to enable agricultural innovation systems to develop and function more effectively, but enormous challenges in pursuing this agenda remain. Two key enablers—policy change and collective action (among research institutions, extension agents, governments, and farmers)—are critical to using ICTs such as mobile phones and the Internet in agriculture and enabling the many relatively small, scattered innovations in the agricultural sector to add up to major impacts. Policy change can spur development of the underlying infrastructure for ICT-enabled information sharing, and collective action, facilitated by digital tools, can push the agricultural agenda forward.

Just as roads are essential for rural development, digital connectivity is becoming essential for research, extension,

BOX 6.3: Innovation Brokers at the Heart of Networking and Communication in Agricultural Information Systems

Innovation brokers are teams of specialists that combine a strong background in agricultural science with knowledge of business, marketing, and/or the creation of innovation networks. Innovation brokers support linkages among actors in the agricultural innovation system and help farmer organizations and private firms manage projects. They teach courses on the management of innovation, assess the actors' innovation capabilities, propose actions to strengthen them, and may facilitate the implementation of the recommendations. Innovation brokers may also help governments and donors to develop their own innovation capabilities and to explore new instruments to foster innovation. NGOs, specialized service providers, or public organizations (including research or educational institutions) can play this role. Klerkx, Hall, and Leeuwis have concluded that "innovation brokerage roles are likely to become relevant in emerging economies and that public or donor investment in innovation brokerage may be needed to overcome inherent tensions regarding the neutrality and funding of such players in the innovation system."

Source: Adapted from World Bank 2012 and Klerkx, Hall, and Leeuwis 2009.

and e-learning. Connectivity does not depend on national policy alone; it is affected even by the policies prevailing in an institution. Researchers may want to disseminate results more widely and increase their usefulness, for example, but they can be inhibited by institutional information technology (IT) and intellectual property policies that limit opportunities to tap into the open access movement.[2] If national research systems do not digitize their research results and create repositories for them, other organizations are limited in their ability to access and share findings in a wider network. Extension programs, other agricultural services, and producers suffer the consequences. Appropriate institutional policies and general e-readiness are essential to build innovation cultures where ICTs thrive and are put to good use.

Even if all farmers in poor countries own phones, however, this connectivity will not ensure that extension agents and researchers will listen to what farmers have to say and adapt their programs accordingly. Nor will it guarantee that farmers can use any knowledge they may obtain; as Topic Note 6.3 indicates, farmers learn best when the information is carefully targeted to their needs and when multiple stakeholders provide incentives for learning (for example, in the form of a mobile phone for learning any time and any place, and a bank loan to put their new knowledge to use). Investments in agricultural innovation systems give particular attention to building the capacity to innovate (especially the capacity to share and use knowledge) and to the enabling environment that fosters innovation.

ICTs to facilitate communication and engage many stakeholders are fundamental to such an approach. Much stronger farmer representation and influence are also needed in the forums where research and program priorities are determined. Specific reforms and incentives are needed for service providers to become more accountable to clients, and ICTs can make a difference by strengthening feedback systems and accountability. ICTs can help people to learn the interactive skills (collaborating and negotiating, for example) that have proven critical in effective innovation systems, and they can help them to acquire agricultural and technical skills as well.

Building research networks, data repositories, and expert query systems and engaging in large data collection efforts require effective management and collaboration. In addition to committing resources, the right climate and culture must be created, including at senior management level, for collaborative planning, knowledge sharing, communication, cross-functional teams, and critical review of current information and communication systems.

ICTs are also fundamental to enabling advisory services to fulfill their primary role in an agricultural innovation system, which is to serve as a central node for knowledge sharing and innovation brokering (including brokering new partnerships). The nature of farmer engagement, two-way communication, information requirements, and the complexity of extension networks all make the design of advisory service programs critical to their ultimate success. In designing advisory programs that use ICTs, the basic requirements for developing an ICT service must be considered, including ICT policy, rural connectivity, and user fees; the information and communication needs of potential stakeholders; functional linkages; existing communication channels and knowledge sources; lessons related to previous information dissemination and networking efforts; farm diversity; and demographic, political, and environmental demands (image 6.2).

IMAGE 6.2: ICT Must Be Complemented by Other Inputs Like Improved Seedlings

Source: Dominic Sansoni, World Bank.

2 They may also be limited by inadequate policies on intellectual property. The urge to protect research results can be strong, especially if they represent a potential source of income for impoverished national research programs. Many public organizations, lacking expertise in intellectual property management and protection, opt for the most restrictive policy on information sharing, even though they recognize that it is detrimental to innovation (see World Bank 2012, Modules 6 and 7).

Given that agricultural innovation systems are generally quite complex and diverse, it is often challenging to identify who has been excluded or which targets have been missed. As agricultural innovation systems become more digitally engaged, there are growing opportunities to use ICTs to monitor them, track the interventions of numerous stakeholders in multiple processes, and evaluate innovation system performance more effectively. Good monitoring and evaluation design, effective use of the data collected, and emerging analysis, reporting, and visualization tools yield better insights into what agricultural innovation systems produce, who uses and benefits from the products of innovation systems, and where the challenges are.

Finally, not all of the ICTs available for agricultural information systems will work in rural areas. Analyzing the technical capacity (infrastructure, connectivity, accessibility, affordability, equipment) as well as staff capabilities (in software development, IT understanding) in line departments, local government offices, or research centers are two critical prerequisites to implementing effective technical services. Public-private partnerships can be forged, particularly for commercially oriented extension or e-learning (see IPS "Lifelong Learning for Farmers in Tamil Nadu" in Topic Note 6.3), to improve telecommunications infrastructure, identify sustainable business models, and aid in capacity building and training. Box 6.4 reviews areas that require attention when using ICT in agricultural innovation systems (AIS).

ORGANIZATION OF THIS MODULE

This module focuses specifically on how ICT can be used in three major, interrelated components of agricultural innovation systems, especially to build innovation capacity and

BOX 6.4: Key Considerations When Using ICT in AIS

Policies. Generate or adapt institutional and national strategies and policies to make the introduction of ICT innovations more frequent and more effective.

Institutions. Adapt organizational structures at all levels to accommodate changes in ICT systems and information management processes, develop new incentive structures to encourage all innovation actors to contribute novel outputs or to stimulate collaboration, and develop innovative business models, particularly where they relate to mobile devices and telecommunications.

Individuals. Develop and diversify the skills and competencies of all stakeholders in applying ICTs for innovation. Invest in the skills of new intermediaries, such as innovation brokers, who specialize in linking actors and resources to foster innovation and often rely on ICTs to do so.

Content. Stimulate open access to the increasing volume of outputs of agricultural research so that all can benefit. Develop and comply with coherent standards that continue to improve the interoperability and exchange of data among stakeholders.

Processes. Use ICTs to facilitate and open up inclusive multi-actor processes in which knowledge flows and can be put to use by different stakeholders. Facilitation will be needed at various levels to bridge divides and gaps in access to ICTs and in institutional strength.

Technologies. Invest in greater connectivity, data and information generation and handling capacity, hardware, software, and improved human-computer interfaces that have been purposefully designed to enable innovation. Ensure that rural ICT infrastructure and connectivity are enhanced. Specific actions are needed to overcome barriers to technology use, such as culture, language, and gender. A recurring challenge is the fast-moving pace of change and development in the technologies.

Monitoring and evaluation. Develop new and improved tools and approaches to assess information and knowledge interventions more effectively.

Capacities. Invest in the technical and organizational capacities of individuals and institutions so they appreciate and use ICTs as tools to enhance knowledge creation, transformation, and innovation. These capacities are more than just technical; appropriate mindsets and incentives are essential to encourage information and knowledge to flow.

Source: Authors.

foster an environment in which innovation occurs more readily: research and knowledge sharing systems, advisory services, and e-learning. Each of these components is discussed in a topic note.

Topic Note 6.1 focuses on the use of ICTs in research for agricultural development. Investments in infrastructure and digital research collaboration, along with rapid developments in mobile devices and connectivity in rural areas, are changing information and knowledge flows. This note focuses on general research processes rather than specific applications, describing how ICTs are altering research collaboration and data collection, analysis, storage, and dissemination. For example, the note describes efforts by individuals and research organizations to make formal and informal research outputs (peer-reviewed journal articles and unpublished literature) freely and openly available on the Internet using low-cost technologies.

Topic Note 6.2 describes how ICTs are benefiting agricultural extension and advisory services. Many countries are reassessing the organization, mandates, and partnerships of their agricultural advisory services to reach farmers and other clients more effectively. "Extension" is no longer a public employee traveling among villages to deliver technologies to farmers. This note is organized around broad functions of ICTs in supporting this new notion of advisory services: the need to provide localized, customized, and highly accessible information; the need to archive and provide reference information for a wide array of actors in the sector (from fertilizer application rates to quality standards for food processors and exporters); the need to facilitate networks (local, regional, global) for collaborative, interdisciplinary approaches to problem solving and research diversification through shared knowledge bases, online forums, and collaborative spaces; and the need to empower and "give voice" to rural communities.

Topic Note 6.3 focuses on electronic learning, especially its potential for building capacity in extension providers and in producers. E-learning potentially enables any actor in the innovation system to reach large numbers of producers, involving them as partners and adult learners in designing and implementing the learning experience. The use of ICTs such as mobile phones makes it possible for learning to occur without classrooms or fixed schedules, although face-to-face interaction and incentives for using the new knowledge are important for e-learning to succeed.

Topic Note 6.1: ICT IN THE AGRICULTURAL RESEARCH PROCESS

TRENDS AND ISSUES

This note discusses the entry points for ICT to be used in agricultural research for development. Agricultural research is a key part of any innovation system. As with other components of an innovation system, in agricultural research successful innovation depends on a number of variables. Particularly important variables are the partnerships surrounding the research process, the level of accountability shared by the partners, and the purpose, quality, and intensity of the research in which the partners are concerned.

In dramatic and well-documented ways, the effects of ICT have permeated the agricultural research process and the partnerships that define, sustain, and direct it toward development goals. For example, ICTs are making agricultural research more inclusive and at the same time more focused on development goals, because they change how, where, and to whom information flows. Information can flow in many directions; it can be highly dispersed and accessible, and it can be highly targeted, location specific, and location aware (Ballantyne, Maru, and Porcari 2010).

ICTs are becoming integral to the mechanics of the research process. They are also associated with the collaborative context in which the research process unfolds, and they are critical to the communication and accessibility of the data, information, and knowledge that researchers and their partners create.

These technologies offer new potential to developing country institutions, national research centers, and networks to participate in a worldwide digital knowledge economy (Kirsop, Arunchalam, and Chan 2007). Open repositories and Web 2.0 tools create opportunities for the more digitally connected stakeholder groups in research agencies and academia to generate, capture, store, analyze, and share virtually the entire range of research content, such as theses, data, images, researcher profiles, and so on. These technologies have also created more informal ways of communicating research outputs.

COLLABORATING IN THE RESEARCH PROCESS

The need for collaboration cuts across the entire research process, from the conceptualization of a research program to the application of the results. In agricultural research for

BOX 6.5: ICTs Engage Stakeholders in Formulating an Ambitious Research Program

In the summer of 2010, four international agricultural research centers in the Consultative Group for International Agricultural Research came together with partners to develop an innovative, inclusive research program on livestock and fish. Before the program could be developed, a very wide range of stakeholders (governments, funders, extension, research, the private sector) participated in extensive consultations, not only in person but online. Their efforts were supported by a wiki to enable documents and other resources to be shared in a transparent, efficient, and cost-effective manner; a blog where assumptions and questions were posed and comments received; and several online surveys developed using the SurveyMonkey tool. The process and documentation were fully open. All documents, presentations, and interviews were publicly available.

Fostering broad and deep engagement among numerous stakeholders to develop a very large research program is not a simple or brief task. For this particular program, the e-consultation began in July 2010 and consisted of eight rounds of questions, each focused on a different aspect of the proposed research. The initial proposal emerged after five rounds of consultation, each including a survey (a series of statements with which participants were invited to agree or disagree) and an opportunity to submit open-ended comments. Three more phases of the e-consultation followed in February 2011. During this time, revisions to the initial proposal based on an external review were shared and tested in public through the e-consultation forum.

Between July 2010 and March 2011, the various e-consultation tools and resources were viewed more than 25,000 times. The organizers received 465 comments and other feedback on questions and surveys. The consultations raised a number of concerns and suggestions that were instrumental in strengthening the proposed program throughout its development.

Source: Program proposal (http://livestockfish.wordpress.com).

development, for example, priorities are often based on the needs of small-scale farmers with very limited resources. ICTs are making it easier for research organizations to link with these stakeholders and document and understand their needs, thus enhancing the relevance and effectiveness of their research. ICTs also make it possible to consult a much wider and more dispersed network of stakeholders (such as producer groups, technical experts, private sector, research administrators, and policy makers) prior to developing a research program (box 6.5).

An integral part of "who to include in the collaborative research process" is "where to do the research." The local nature of agriculture, from the environment's effect on crops and biodiversity or the social and cultural norms that influence the agricultural sector (for example, in one location women are quite active as small-scale farmers and traders; in another, they never work alone in the field and are forbidden from selling produce to strangers), suggests that it is usually necessary to pick locations appropriate to the locale in which the results are to be applied.

Here again, ICTs have proven quite useful making these links. For example, in developing new varieties with specific traits needed by small-scale farmers (such as drought tolerance or resistance to a particular disease), plant breeders have relied for years on ICTs to collect, analyze, and validate data to identify field testing sites that are representative of conditions in small-scale farmers' fields (see IPS "Advances in ICTs Increase the Utility of African Sites to Test Varieties" in this topic note). In Tanzania, researchers have added to their capacity to track and monitor the development of cassava mosaic disease and cassava brown streak disease because ICTs offer a means of cooperating with the distant farming communities whose crops represent the front lines in these pandemics (box 6.6).

Communication in agricultural research is traditionally dominated by a focus on the dissemination of "end-results"—by publishing journal articles or otherwise reporting on results. To make research more relevant, open, and accessible, ICTs are used in some organizations to enhance knowledge sharing much earlier in the research process, during program formulation, design, and as part of ongoing planning and review (box 6.7). Increasingly, researchers are using digital social media tools, which are easy to access and use, to extend and open up communication and knowledge sharing throughout the research process.

To disseminate information on such approaches and tools, the Consultative Group for International Agricultural Research (CGIAR) has assembled a Knowledge Sharing Toolkit (http://www.kstoolkit.org) in conjunction with FAO, the KM4Dev Community, and UNICEF. The toolkit consists of knowledge sharing tools and methods to promote collaboration through each stage of the research project cycle. Online tools include collaboration platforms, wikis, blogs,

BOX 6.6: Rural Tanzanians Update Researchers on Spreading Cassava Diseases

Pandemics of cassava mosaic disease and cassava brown streak disease are reaching East and Central Africa. The costs of sending researchers to monitor disease development are high. Yearly visits have barely kept pace with these spreading diseases, yet early warnings of new outbreaks and greater community involvement in their control would considerably slow their progress through Africa.

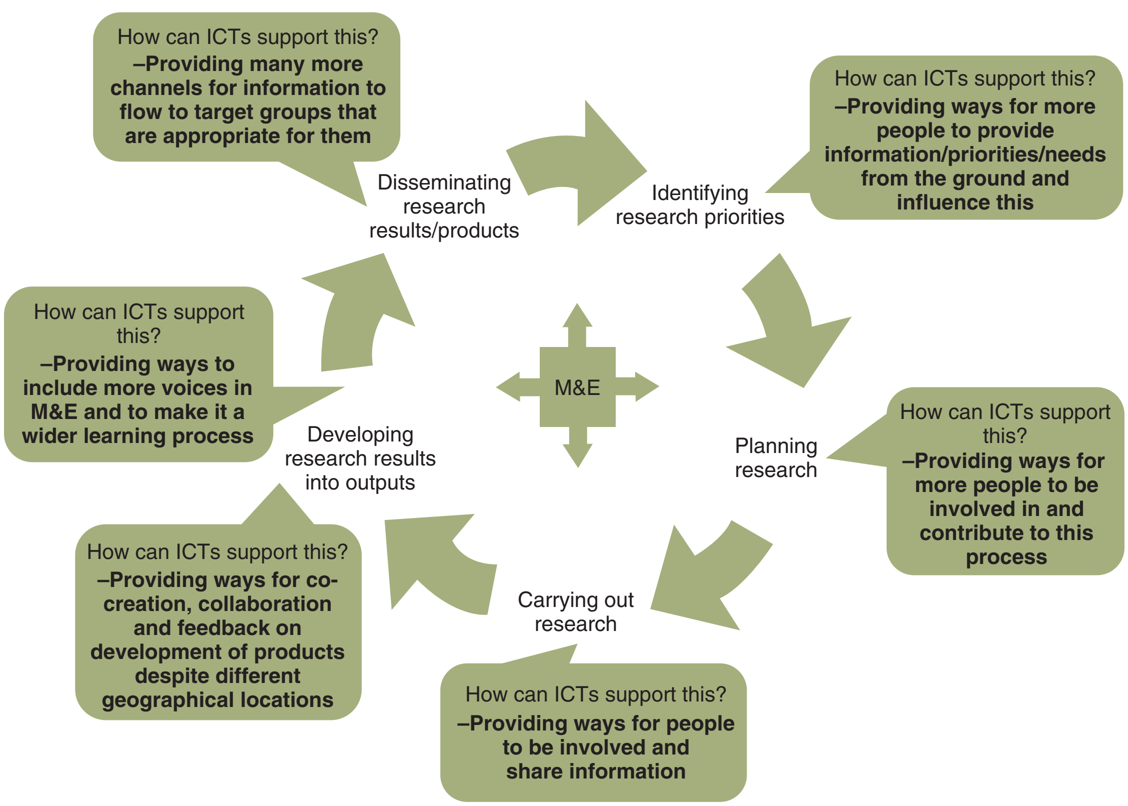
The Digital Early Warning Network (DEWN) provided training and mobile phones to farmers in northwestern Tanzania so that they could recognize symptoms of the two diseases and text their findings to researchers. Information obtained from farmers was used to generate maps. One of the most significant findings was that brown streak disease reported by farmers was confirmed by researchers' visits to two districts where it had not previously been reported. This finding allowed project teams to concentrate disease mitigation efforts on these areas.

DEWN has provided an innovative, informative, and relatively cheap means of involving communities in monitoring and maintaining the health of their crops. Research has been enriched and cost-effectively extended through greater connectivity with the voices and knowledge of farming communities. DEWN was primarily piloted by the Lake Zone Agricultural Research Institute in Tanzania with the International Institute of Tropical Agriculture.

Source: Adapted from http://r4dreview.org/2011/04/dewn-a-novel-surveillance-system/.

photo sharing, podcasting, Google documents, discussion forums, intranets, content management systems and instant messaging. Each tool is described, with links to relevant resources and suggestions for use, on the website. Figure 6.1 illustrates how the CGIAR ICT-KM Program (http://ictkm.cgiar.org) perceives the relationship between the research cycle and different knowledge sharing and collaboration tools highlighted above.

FIGURE 6.1: Knowledge Sharing and Collaboration Tools in the Research Cycle



Source: Manning-Thomas 2009.
Note: M&E = monitoring and evaluation.

BOX 6.7: Web-Based Tools Facilitate Research Collaboration

The last few years have seen the emergence of many web-based collaboration tools and approaches, frequently described as "Web 2.0" or "social media." The key features of such tools are that they are web-based, free or very low cost, and very easy to use; they encourage interactions between people; and they offer ways to integrate different types of information from different perspectives.

These tools are used by the Nile Basin Development Challenge (http://www.nilebdc.org) in Ethiopia. This initiative is funded by the CGIAR Challenge Program on Water and Food to work with numerous national partners and a group of international centers to improve the resilience of rural livelihoods in the Ethiopian highlands. Web-based applications are used in the project to support interaction and sharing among the project team members and to communicate messages to wider audiences and stakeholders:

- The project has a shared wiki space where project members document activities and plans. This space has been used, for example, to share meeting agendas and reports, discuss issues, and share files.
- The project has a private conversation space on Yammer (https://www.yammer.com/), a social networking site for corporate purposes, where project members share updates, questions, and announcements.
- The project has a DSpace (http://www.dspace.org/) document repository where all public reports and resources from the projects are indexed and made accessible.
- A blog is used as a website with regular stories and updates from the project.
- Updates and news are spread across social networking sites like Facebook and Twitter.
- The project uses social media tools like Flickr to share photos, slideshare to publish presentations and posters online, and Blip.tv to publish video and film.

Such a web-based approach also requires complementary face-to-face, print, and offline tools and approaches to really engage with the rural communities "on the ground."

Source: Author; see also http://www.nilebdc.org/.

COLLECTING AND ANALYZING RESEARCH DATA

ICT is widely used to collect data, with the choice of technology depending on the kind of data needed. Surveys can be administered electronically. Information from online research collaboration can be recorded and analyzed using a variety of ICT tools. Mobile devices of all kinds record research data—smartphones, mobile phones using short messaging service (SMS) text messages, personal data assistants (PDAs), Global Positioning System (GPS) units, and specially designed equipment to measure indicators of soil nutrient levels, among others. Electromagnetic and photographic data are recorded by sensors in satellites and aircraft and on the ground. Small transmitters are used to collect, store, and send data, including data from radio-frequency identification (RFID) tags (Munyua 2007).

Mobile technology has also created opportunities for crowdsourcing farmers. Rather than perform data collection by hand or through paper surveys, researchers can collect data through SMS. Data on pest outbreaks, for example, can be recorded by asking farmers to text information to a premium number. Scientists and governments are able to monitor farming activities and local problems remotely and to predict regional and national challenges with greater certainty. SMS and other mobile devices have also eased data entry. Paper surveys, which require enormous amounts of labor after the initial data are collected, are being replaced with devices connected to software packages that automatically transfer the data to databases and statistical programs. iFormBuilder is an innovative application that collects rural survey data (http://www.iformbuilder.com).

In addition to collecting primary data, researchers often rely on secondary data to complete their analyses. For example, several organizations offer archival geographic information system (GIS) data, including remote sensing data, at increasingly better resolutions and sometimes free of charge.[3] Other organizations (public and private) offer data sequences of crop genomes. In the future, as biotechnology and agriculture increasingly overlap, results of nanotechnology applications in agricultural production and food processing and packaging[4] will increasingly be

3 See Stanford University's Library and Academic Information Resources ("Websites for Digital GIS Data," http://library.stanford.edu/depts/gis/web.html) and the CGIAR Consortium for Spatial Information ("What is CGIAR-CSI?" http://csi.cgiar.org/WhtIsCGIAR_CSI.asp).

4 For examples related to nanotechnology, see the National Institute of Food and Agriculture (http://www.nifa.usda.gov/nanotechnology.cfm).

collected and shared through the ICT (Interagency Working Group on Manufacturing R&D, Committee on Technology, National Science and Technology Council 2008).

The use of ICT to analyze research data appears virtually universal, although some research systems are limited by the infrastructure and applications available to them. Options range from custom software developed for a particular research project or organization to more generic packages such as GenStat Discovery Edition (http://www.vsni.co.uk/software/genstat-discovery/), a version of the widely used GenStat software for statistical analysis that is available free of charge to noncommercial users in developing countries.

One chief impediment to the wider use of analytical software in research for development is the lack of funding. The 13th edition of GenStat costs about US$ 330, for instance, but other software, especially for sophisticated genomic and proteomic analyses, may be even more costly, especially for public research programs in developing countries. Reducing the costs of ICTs for data analysis is critical in enabling poorer institutions to participate more fully and meaningfully in the innovation system.

Some of the most innovative current uses of ICT in data analysis are in modeling, simulation, visualization, and cloud computing (do Prado, Barreto Luiz, and Chaib Filho 2010; Li and Zhao 2010; Hori, Kawashima, and Yamazaki 2010).[5] For instance, ICTs are vital for developing models of crop performance in environments where yields are reduced by climate stress and increasing climatic variability. Such models offer an important means of evaluating the potential for new cultivars to adapt to climate stress and climate change and to assess food import needs and export potential.

Another example involves researchers at the Medical College of Wisconsin Biotechnology and Bioengineering Center in Milwaukee, who recently developed free tools for analyzing virtual proteomics data ("Cloud Computing Lowers Cost of Protein Research," 2009). The tools are used in combination with other free software and Amazon's cloud computing service, giving researchers access to considerably more computing power than they may have at their own institutions. Proteomics—the study of proteins expressed by an organism—has numerous applications in plant breeding research, such as improving the understanding of how plants respond to disease—but until recently few research institutions in developing countries have been able to afford the ICT infrastructure to analyze proteomics data.

5 For examples related to geospatial, precision, and sensor technologies, see the National Institute of Food and Agriculture (http://www.nifa.usda.gov/ProgViewRelated.cfm?prnum=16198&lkid=4).

MAKING DATA AND INFORMATION ACCESSIBLE

A primary output of the research process is knowledge, typically encapsulated in reports, manuals, articles, maps, data files, and interactive video and audio media. The transition from print to digital information formats is one of the most striking transformations in agricultural research. New storage technology, particularly the availability of storage in the cloud, is making the storage and sharing of data and other information far less expensive.

Organizing and providing access to its information and data resources are among the most useful investments that an agricultural research institution can make. Complete, easy to access, open repositories or archives of research outputs are becoming a standard to which research institutes aspire. The concept is based on the use of free software such as DSpace (http://www.dspace.org/) or ePrints (http://www.eprints.org/) that allows an organization to set up a repository of its documents and outputs. These repositories allow content to be uploaded and made accessible in full; they also allow the metadata to be harvested and shared using open standards. As the collections grow, they become permanently accessible indices of an institution's research and nodes in a globally searchable knowledge base for agriculture.

Alongside these repositories, many related specialized systems focus on, for example, theses or academic learning materials, specific subject areas (aquaculture, forestry, and so on), or national aggregations of data from different sources. Parallel systems facilitate the curation, sharing, and sometimes analysis of data in various forms (box 6.8). All of these systems build on basic connectivity and ICT infrastructure, both within institutions and outside them through the adoption of applications that enable global sharing and aggregation, harvesting, and distributed management of data.

BOX 6.8: Dataverse: An Open Application for Storing and Analyzing Data

Dataverse is an open application to publish, share, reference, extract, and analyze research data. It makes data available to others and allows them to replicate work by other researchers. Developed by the Institute for Quantitative Social Science at Harvard University, the software can be freely downloaded for local use, or data can be hosted by the project. Dataverse is used by the International Food Policy Research Institute to archive and make its data accessible, for example.

Source: Authors; see also http://thedata.org/home and http://dvn.iq.harvard.edu/dvn/dv/IFPRI.

A number of examples of data storage and sharing follow, and many more could be cited. They are similar in several ways. First, they use open standards and common taxonomies that allow metadata to be shared across organizations and systems. Second, they are often based on free or low-cost specialized applications provided by third parties. Third, they depend on the distributed actions of organizations and initiatives that are working toward common objectives and are committed to making information and data widely accessible through the Internet. Fourth, they have chosen to use systems that not only store content but curate and index content in ways that add value to this public good. Finally, they all rely on increasing (remote) storage and connectivity capacities.

Research institutes and other agricultural entities participating in research projects or dissemination projects usually select a single approach to organize their research electronically. These forms of organization include subject, national, regional, institutional, and crowdsourcing approaches or a variety therein. Selecting a manner in which to organize repositories is critical to its user and management friendliness.

Subject Approaches

Avano (http://www.ifremer.fr/avano/) harvests electronic resources related to the marine and aquatic sciences. It provides access to almost 300,000 resources from almost 300 repositories and other archives worldwide. It is operated by a group of information professionals who agreed to use open repositories and standards and to allow their resources to be harvested.

The Global Forest Information System (GFIS, http://www.gfis.net) is a collaborative initiative that allows forest-related information to be shared easily through a single gateway. GFIS is an open system to which information providers, using agreed information exchange standards, may contribute content. Similar to Avano, GFIS is organized by the global forest community. It depends on the adoption of open tools and content by its many collaborators. It uses RSS (really simple syndication) as the primary device to aggregate and re-present content acquired from different sources.

The System-wide Information Network for Genetic Resources (SINGER, http://singer.cgiar.org), developed by the agricultural research centers of the CGIAR and their partners, is an extensive collection of information about the genetic resources conserved by SINGER members. These collections hold more than half a million samples of the world's major food crops, forage crops, and forest species and are an essential resource for plant breeding and biodiversity conservation worldwide.

National Approaches, Pioneered and Partnered with Ministries

The Government of India in partnership with the World Bank began funding the National Agricultural Innovation Project (NAIP) in India in 2006 (http://www.naip.icar.org.in/index.html). Led by the Indian Council of Agricultural Research, this six-year project aims to quicken the pace of agricultural development by exploring and applying agricultural innovation in collaboration with a variety of public and private stakeholders. NAIP has established over 50 research alliances between public organizations, commercial enterprise, and farmers, focusing applied research initiatives on technological innovation in poor rural areas. The project and its partnerships have led to a wide expansion in stakeholder engagement, more frequent monitoring and evaluation of technological outcomes, and improved knowledge brokering.

The project component most relevant to this module focuses on the management of change and information in the national agricultural research service. This component seeks to strengthen the use of ICT for research and technological innovation, increase public awareness of ICT, experiment

IMAGE 6.3: Open Access to Genetic Information Can Improve Yields Worldwide

Source: Edwin Huffman, World Bank.

with e-learning models, and open opportunities for stakeholder collaboration and exchange using electronic tools and web platforms. The project has connected over 300 institutions on the web, working toward building an enormous ICT network for agricultural research and dissemination. The project is also developing a central portal for the network, which will serve as the platform for knowledge building and sharing. This central portal will maintain 42 open-sourced and subscription-based agricultural libraries. Formal links between libraries in the national research system and other agricultural libraries will be forged. This project component also includes virtual classroom development (source: http://www.naip.icar.org.in/index.html).

Brazil's national agricultural research system, EMBRAPA (the Brazilian Agricultural Research Corporation), recently contributed 470,000 bibliographic records to WorldCat, "the world's largest library catalog" (http://www.worldcat.org/), reflecting the scale and publishing power of this research system. EMBRAPA also maintains substantial repositories of its research outputs in full text: The ALICE repository (http://www.alice.cnptia.embrapa.br/) provides full access to formal research outputs in the form of book chapters, articles in indexed journals, articles in proceedings, theses and dissertations, technical notes, and so on. This resource is complemented by the Infoteca-e (http://www.infoteca.cnptia.embrapa.br/), which collects and provides access to more practical information on technologies produced by EMBRAPA. This information is intended for farmers, extensionists, agricultural technicians, students and teachers from rural schools, cooperatives, and others concerned relatively directly with agricultural production.

In Jordan, the National Center of Agricultural Research and Extension, the Ministry of Agriculture, and FAO have joined forces to set up a National Agricultural Information System portal (http://nais-jordan.gov.jo/Pages/Index.aspx?CMSId=8) that provides updates and news as well as access to full-text reports and publications.

Regional Approaches

Similar in concept in that it seeks to link local project actors, the International Fund for Agricultural Development (IFAD) in Asia joined with the International Development Research Centre to use ICTs to support learning and networking across a number of IFAD-supported development projects. ENRAP (http://www.enrap.org)[6] was formed to promote knowledge sharing and networking between IFAD projects located in the Asia-Pacific region.[7] ENRAP worked in the area of knowledge networking and Internet applications at the local, national, and international levels.

The project, which ended in 2010, was designed to bring the benefits of global information resources to IFAD-supported rural development projects in Asia and the Pacific. It aimed to increase effective use of the Internet and electronic communication by project staff and, ultimately, by project communities. The project focused especially on methods and practical solutions to foster participation at the grassroots level. Local electronic newsletters, agricultural market information dissemination, and shared electronic libraries are examples of ENRAP-supported activities.

The first phase of ENRAP began with an emphasis on ICTs, but subsequent phases focused more on the knowledge/content that needed to be shared. Attention was given to building capacities in knowledge production, especially the use of digital video as a supplement and alternative to written documentation of project experiences.

Institutional Approaches

In Chile, the digital library of the Fundación para la Innovación Agraria (Foundation for Agricultural Innovation) (http://bibliotecadigital.innovacionagraria.cl/) incorporates new ICTs to manage and diffuse public information. It assembles information on all the reports and publications, photos, videos, and presentations produced by the foundation.

In 2009, the International Livestock Research Institute (ILRI) set up an open repository of its research outputs (http://mahider.ilri.org). ILRI used free DSpace software to develop the repository, and in the first 18 months, some 4,500 outputs were included in the service. Since the system uses open standards, the contents are harvested across the Internet and can be reused in other services—Google Scholar, the CGIAR Virtual Library, FAO's AGRIS (http://agris.fao.org), and so on. The same platform is being used to develop a shared service across several CGIAR centers and initiatives.

In Uganda, Makerere University has established a "scholarly digital library" (http://dspace.mak.ac.ug/) with the full text of reports and theses, including those of its agriculture and veterinary sciences faculties.

A final example comes from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). ICRISAT conducts

6 Originally Electronic Networking for Rural Asia Pacific.

7 Similar projects exist in Africa, Latin America, and the Middle East.

genomics research to enhance the efficiency and effectiveness of crop improvement. In the course of this work, it learned that the rate-limiting step in genomics was no longer data generation but the speed at which data were captured, validated, analyzed, and turned into useful knowledge. ICRISAT initiated its Global Theme on Biotechnology, a program that focuses on building and sharing the ICT tools to accelerate these stages of research. The program develops information systems for data capture, storage, retrieval, and dissemination.

The program also develops software based on open-source technologies; this software is all in the public domain (http://www.icrisat.org/bt-software-downloads.htm). Applications have been downloaded several hundred times by users from other institutions. For example, a Library Information Management System (LIMS) facilitates molecular genotyping through modules that make it possible to track samples, schedule jobs, generate reports, and perform other tasks. LIMS has been adopted by other research facilities and customized by a private sector partner. Information is shared through ICRISAT's Integrated Crop Resources Information System (ICRIS). Available on the Internet with password-protected access, the database provides genotype, marker, and phenotype information. An integrated decision support system, iMAS, has also been developed to facilitate marker-assisted plant breeding by integrating freely available quality software needed for designing experiments, mapping quantitative trait loci,[8] and providing decision guidelines to help users interpret results.

Crowdsourcing Approaches

Researchers and others are not just sitting back and waiting for others to provide tools to share data and information. Researchers with access to the Internet are making their own specialized literature bases available online (box 6.9). They are also assembling them into quite sophisticated resources that become new research products in their own right. An example is WikiGenes (http://www.wikigenes.org). This collaborative knowledge resource for the life sciences is based on the general wiki idea but employs specifically developed technology to serve as a rigorous scientific tool. The project provides a platform for the scientific community to collect, communicate, and evaluate knowledge about genes, chemicals, diseases, and other biomedical concepts in a bottom-up process.

8 A preliminary step in identifying and sequencing the genes related to variations in physical characteristics of an organism arising from the interactions of multiple genes and/or interactions between genes and the environment in which they are expressed.

Such open collaboration is possible only because of the Internet and the way it allows distributed systems for the aggregation, review, and dissemination of knowledge and, most important, the active support of a large community (Hoffmann 2008). Tools like this one are a form of "expert crowdsourcing" online.

Crowdsourcing through ICT can also be effective in research projects that involve rural inhabitants. Asking farmers to send information via mobile phone can be an effective way of gathering data with reduced costs and labor. In areas where mobile phones are ubiquitous, it also allows for increased participation from a variety of farmers or farmer groups.

BOX 6.9: Mendeley: ICT to Expand the Literature Base

Mendeley is a free online reference manager and academic social network through which researchers organize their research, collaborate with others, and discover the latest research in their areas. With Internet connectivity, scientists can manage their personal research profiles and presence and co-create a literature base on a subject or around an event. For example, researchers at the International Food Policy Research Institute have started to use this service to collate, share, and track research information around specific projects and events, such as the 2011 conference on agriculture, nutrition, and health (http://2020conference.ifpri.info/knowledge-fair/literature-hub).

Source: Authors; see also http://www.mendeley.com/.

Preferential Access Schemes for Research in Developing Countries

Despite increases in Internet access and connectivity, developing-country researchers continue to face barriers in gaining access to scientific publications and literature. This is particularly significant for journal articles and other publications published through commercial channels where subscriptions are required.

In recent years, commercial publishers have begun to provide free or inexpensive access to some developing countries through initiatives like AGORA (Access to Global Online Research in Agriculture, http://www.aginternetwork.org/), which provides free or very low-cost access to 2,400 journals on food, agriculture, and related sciences to institutions in 107 countries (image 6.4); PERI (the Programme for the Enhancement of Research Information, http://www.inasp.info/peri/), which supports the efforts of developing-country institutions to get together in

IMAGE 6.4: AGORA Provides Access to Agricultural Research Literature

Source: A screenshot of the AGORA homepage.

investments in information literacy are needed to maximize the use of these tools. Scientists may rely on their traditional information-seeking strategies and remain unaware of new electronic resources. Their parent organizations need to encourage the use of e-resources and provide appropriate bandwidth and training.

Gaining Access to Private Sector Innovation and Research

Initiatives like CIARD (box 6.10) are important to make publicly funded research results accessible (see image 6.5). It is quite another challenge to gain access to the results of research financed by private companies, which in total spend more on research than the public sector. Because companies operate for profit and need to recover their R&D investment, they seek intellectual property rights for their innovations, which typically prevent public access and, at times, collaboration.

consortia to pay for heavily discounted subscriptions; and TEEAL (The Essential Electronic Agricultural Library, http://www.teeal.org/), which provides a package of content that institutions can run on their own networks.

Although Internet connectivity gives scientists access to the resources provided, evidence shows that significant

Some systems permit research results from private firms to be shared. Innovations covered by patent rights allow the patent holder 20 years to exploit the commercial potential of the patented innovation, in exchange for publicly disclosing the innovation in a patent database. This practice is meant to enable other researchers to build on the initial innovation. The largest searchable patent databases include PATENTSCOPE

BOX 6.10: Driving Developing County Access: The CIARD Initiative

Public knowledge and research results have limited impact on agricultural and rural development when they are not easily or widely accessible. The Coherence in Information for Agricultural Research for Development (CIARD, http://www.ciard.net/) initiative, pioneered by FAO, the Global Forum on Agricultural Research, the CGIAR, and other partner organizations, aims to change this by increasing the awareness of how new ICTs and associated institutional changes expand options to manage and present information differently and economically. CIARD's vision, "to make public domain agricultural research information and knowledge truly accessible to all," reflects the transformational effects of ICT in agricultural development. CIARD partners coordinate their efforts, promote common formats for information sharing and exchange, and adopt open information systems approaches. CIARD projects, like KAINet in Kenya, focus on three priority areas:

- Making content accessible through open content, open systems, and common international standards.
- Empowering individuals with awareness and skills and encouraging institutions to be self-sufficient through ownership of their information.
- Advocating better investments through policies that improve access to information, coordinated approaches, and evidence of benefits.

The explanation and the routes for implementation of the CIARD agenda as a whole are available at the CIARD website and in print.

Source: http://www.ciard.net/.

IMAGE 6.5: Accessing Private Sector Research Could Have Wide Impacts on Poor Agriculture

Source: Jonathon Ernst, World Bank.

from the World Intellectual Property Organization, with close to 2 million international patent applications (http://www.wipo.int/pctdb/en/). The United States Patent Office database (http://patft.uspto.gov/) and esp@cenet, the European Patent Office database, offer 60 million patent documents from over 80 countries. For a recent review of patent databases, see http://patentlibrarian.blogspot.com/2010/02/patent-database-review.html; for a more general discussion of IP and related issues in agricultural research, see the work of the CGIAR Systemwide Program on Collective Action and Property Rights (CAPRI, http://www.capri.cgiar.org/).

Initiatives like the African Agriculture Technology Foundation (http://www.aatf-africa.org/), the International Service for the Acquisition of Agri-biotech Applications (http://www.isaaa.org/), and Public Intellectual Property Resources for Agriculture enable developing countries to maximize access to promising technologies and innovations developed by the private sector. Such efforts are built on smart access to relevant developments in the private sector, insights into local research interests, and brokering between the various parties.

LESSONS LEARNED

Increasingly, ICTs such as computers, mobile phones, other devices, and e-mail are standard tools of the trade for individual researchers, scientists, and the people they work with. As part of a personal research toolkit or dashboard, ICTs are essential to the delivery of today's research. Lessons learned in using these technologies for agricultural research are summarized here; the discussion also highlights the key enablers for designing and implementing ICT-enriched research initiatives.

First, ensure that each researcher has basic levels of e-literacy and ICT access. It is critical to convince managers and funders that ICTs are "basic" to research, not just desirable add-ons. Beyond the level of the individual scientist or researcher, many opportunities for using ICT in research require significant institutional investments to have a real impact on research itself or the targets of research.

The lack of systematic investment in ICTs by research institutions and their funders often holds researchers back from adopting and using ICTs (FARA 2009; Balaji 2009; GCARD 2009; RUFORUM 2009; Karanja 2006; Kashorda and Waema 2009; and UNCTAD 2010). Like funding for agricultural research more generally, investments in ICT for agricultural research are vital to increase and should be at the forefront of the agricultural research discussion. Thinking carefully about how ICT might contribute to research projects is critical to tapping the wide range of opportunities available throughout the research process.

Unfortunately, beyond the use of ICTs for everyday communication and Internet access, research institutions may offer few incentives to undertake ICT-enabled research that deviates from traditional paths and uses newer ICTs, especially if that research involves gaining access to proprietary information and ICT tools (or even paying fees for ICT services). This lack of incentives represents a major challenge to using ICT for agricultural research, especially in rural areas where difficulties like the lack of electricity and weak telecommunications connections abound.

As for open access to research products, low investment in technical infrastructure, in sustaining research capacity, and in research itself have left many countries on the margins of global digital society and innovation, most notably in sub-Saharan Africa (RUFORUM 2009; Karanja 2006; Kashorda and Waema 2009). Their marginalization renders them less aware of and able to adopt the international standards and methodologies required to participate in open digital information sharing. In this context, the efforts made by organizations to overcome institutional inertia, join together, and develop collective and accessible research information repositories and services are immensely important. Although each institution will have its own priorities and constraints, all can subscribe to common approaches.

An additional major challenge in research is for organizations and individuals to truly grasp the emerging possibilities and be willing to use them. One aspect of this challenge is awareness: Which of all the possible tools and investments will work best, and where? Who has the skills to make them work? What "fallout," positive and negative, will the organization experience if they are used? What is the best portfolio of ICT-related investments for my particular set of individual, project, or institutional goals and challenges? The use of new ICTs is also a risky and change-making business. Just adopting a new tool can trigger major changes in workflows, procedures, processes, culture, and hierarchy that force a wider assessment of business processes. Legacy IT systems as well as institutional processes and power relations are often threatened.

Finally, moving beyond "ICT-assisted and connected" research to "ICT-enabled and transformed innovation" is a challenge for even the smartest, best-funded scientific institute. A research organization that has been transformed through ICT needs people and leadership with skills to develop a vision for e-research and align ICT investments to research and innovation processes, ensure that staff acquire the necessary skills, redesign institutional processes, adopt open standards and access to knowledge, change staff mindsets, give staff access to ICT toolsets, invest in technological infrastructure and networks, and innovate and experiment—among other needs. Devising and developing the optimal ICT investment portfolio for a national research institute or network is a major challenge.

INNOVATIVE PRACTICE SUMMARY
Advances in ICTs Increase the Utility of African Sites for Testing Varieties

Widespread use of higher-yielding and stress-resistant varieties throughout Africa has been frustrated by the variability of African growing conditions, the difficulty of selecting appropriate sites to test new cultivars, and the challenges of matching new cultivars to suitable growing environments across the continent. Innovations may be tested, but they are not tested in ways that make it more likely that they will be useful to farmers, so they are not adopted.

Africa Trial Sites (http://africats.org/) is a portal that enables national and international research organizations to electronically pool their extensive information on trial sites and provides numerous tools (based on ICT advances in bioinformatics, GIS, and data management) that help farmers, plant breeders, and agronomists to evaluate new varieties more efficiently in the field and gain more useful data from field trials. For some time much of the data from field trials—representing an enormous investment of research resources over several decades—resided on the shelves of research institutions and was difficult to assemble, analyze on a large scale, and put to use.

Users can search the website for trial sites and data by country, design trials to evaluate cultivars, obtain tools to manage trials (from developing a budget to estimating water stress during the growing season), analyze trial data, view results of spatial analyses, examine data on an interactive Google map, and report results online. They can also rank varieties and add comments about their performance at a given site. The website allows the analysis of climate data for any point in Africa as well as climate similarity comparisons between trial sites and other areas of Africa. Finally, the site includes links to resources such as websites of the participating centers, from which anyone can request seed from breeders and genebank curators.

The combination of African trial site data and interactive data analysis tools has made valuable information much more widely available and useful for the agricultural research, development, and extension community. Results for cultivars tested in Africa are rarely available online. Participants' data will significantly expand knowledge of which cultivars are suited to which environments (especially environments subject to stress from diseases, pests, or environmental factors). International agricultural research centers are beginning to use the trial sites in a climate adaptation research program, drawing in national partners, and they are using Africats.org to standardize their trial site information.

INNOVATIVE PRACTICE SUMMARY
KAINet Kenya Knowledge Network Anchored in Partnerships and Collaboration

The Kenya Agricultural Information Network (KAINet, http://www.kainet.or.ke) project, supported by FAO, encourages and assists Kenyan agricultural organizations to capture and share information in a series of repositories. The network, launched in 2009 and supported by the Ministry of Agriculture, provides training and support. The network's website allows researchers to query the resources of all member institutions at once. The repositories include around 4,000 full-text digital documents generated by the institutions, with around 40,000 metadata records that conform to international coherence standards to facilitate access and sharing. The network is guided by a national stakeholder forum, a board of trustees, and a network management committee.

Like the thematic services Avano and GFIS mentioned earlier, KAINet relies on distributed action by different organizations, their compliance with standards, and sufficient connectivity for the harvesting and virtual querying of the databases. The collaboration between national institutions and international partners ensured the effective use of national resources and leveraged knowledge of international best practices.

An important aspect of KAINet is that it is integrated into national and institutional policies and strategies. Its outputs and resources, such as the institutional and national repositories of agricultural information, complement national and global initiatives aimed at sharing information. Its training programs support the development of human capacity in information and communication management.

Experiences with KAINet have been carefully documented. Among the lessons and enabling factors that emerged, piloting the network with a limited number of national institutions allowed the partners to learn and devise workable solutions before expanding the network. The management and steering committees played important roles in promoting the network, involving the management of partner institutions in its development, and guiding project activities. Linking the project to the priorities and plans of partner institutions added credibility to KAINet, ensuring that it would enhance existing work and not remain an isolated initiative. The initial planning and partnership-building phase was critical for success, because it provided an understanding of the institutions' information and communication management needs and helped partners develop a basis for collaboration.

The development of adequate capacities in information and communication management (including physical infrastructure) was essential to develop open repositories, and these capacities should preferably be built early in a networking project. Because networking contacts were the basis of collaboration and project operations, telephone and e-mail groups were essential for constant communication among partners.

Topic Note 6.2: USING ICT IN EXTENSION AND ADVISORY SERVICES

TRENDS AND ISSUES

Rural people must be able to respond productively to the opportunities and challenges of economic and technological change, including those that can improve agricultural productivity and food security. Innovation is more successful when producers can communicate with and be heard by their peers, local authorities, and institutions. Producers also require relevant knowledge and information, including technical, scientific, economic, social, and cultural information. To be useful, that information must be available to users in appropriate languages and formats. At the same time, it must be current and communicated through appropriate channels.

This topic note outlines key issues involved in using ICTs to convey demands for rural advisory services and deliver those services effectively. Although there is convincing evidence that ICTs can revitalize research-extension interactions in ways that respond to farmers' demands, the use of ICTs is merely one element in the wider transformation of a traditional, top-down, technology-driven extension system into one that is more pluralistic, decentralized, farmer led, and market driven (and thus more effective within the innovation system). Part of the role of ICTs is to contribute to the many reforms that are urgently needed to empower and support small-scale farmers as developing countries seek to respond successfully to food security, market development, and climate change challenges (Christoplos 2010).

In the context of rural advisory services that support innovation, ICTs have four broad functions. First, they need to deliver or provide access to information. They should address the need for localized and customized information—adapted to rural users in a comprehensible format and appropriate language—to give small-scale producers as well as providers of advisory services adequate, timely access to technical and marketing information, as well as information or support on new technologies and good farming practices (image 6.6). It is not just a matter of getting information out. A key aim is to

IMAGE 6.6: Matching ICT to the Diverse Needs of Farmers Is Critical

Source: Neil Palmer, CIAT.

give rural people the facilities and skills to find the information and answers they need.

Second, they need to organize the knowledge base. ICTs should help document and store information for future use. In many cases, information and knowledge on technologies and good practices is available only in hard copy or in people's heads, and data are incomplete, scarce, or inaccurate. Local and indigenous knowledge is often transmitted orally, records are often unavailable, and information is dispersed only to nearby family and friends. As with research, all this knowledge needs to be documented and organized for reuse. The challenge is evident from the scattered nature of the information, its multiple "formats," and the general lack of attention to documentation and learning in this area. While researchers are rewarded for publishing, extension workers, advisors, and farmers are motivated to deliver "practical" results; documentation is only a potential by-product.

Third, ICTs need to connect people and networks. ICTs can facilitate networking—locally, regionally, and globally—thus leading to collaborative and interdisciplinary approaches to problem solving and research based on shared knowledge and collaboration (Nyirenda-Jere 2010). Many NGOs, research organizations, and national ministries have used ICTs to improve access to technologies and knowledge in their rural advisory services, by means of rural telecenters, community knowledge workers, online networks, and various types of forums. They also need to focus on ways to empower rural communities to connect with one another, not just to the outside world. Facilitating linkages between market actors, extension, and smallholders along value chains is also essential.

Fourth, ICTs need to empower rural communities. ICTs should help farming communities "gain a voice" so that they can convey their needs and demands, negotiate better deals with other actors in value chains, and generally get practical benefits from the services intended for them (and otherwise avoid being exploited). A key element is to use ICTs to give rural people the skills and tools to tell their own stories, in their own words and languages, in ways that reach and influence others (see Module 8 on farmer organizations for additional information on ICT and collective action).

Throughout the developing world, ICTs are being integrated into classic rural advisory services, through radio, SMS, television, video, Internet, libraries, the media, and mobile services. Advice and information provided via ICTs is becoming more varied, covering specific technologies and practices; climate change mitigation and adaptation; disaster management; early warning of drought, floods, and diseases; price information; political empowerment; natural resource management; production efficiency; and market access. It is not a one-way flow: ICTs open up new channels for farmers to document and share experiences with each other and with experts (IICD 2006).

Some of the likely trends in the use of ICTs for rural advisory services over the coming years include (Ballantyne 2009)

- Many advisory services will be privatized as the agricultural sector becomes more commercial, as other actors step into this arena, and as clients are willing to pay.[9]

9 As discussed in Module 3 of the *Agricultural Innovation Systems Investment Sourcebook* (World Bank 2012): "The private sector increasingly finances extension services for specific objectives and/or value chains. Contracting public extension workers for specific tasks is a common practice among NGOs as well as specific commodity development programs, such as the program for cashew production in Mozambique. Some export commodity chains finance extension services through a government-instituted export levy, as in Mozambique and Tanzania. The private sector also finances extension services directly, as is the case with large tobacco companies in Malawi and Mozambique. Many of these arrangements are in transition to become systems of cost-sharing with farmers, first by assuring effective demand for relatively costly services and eventually by having farmers fully finance extension services, as a complement to services they already provide one another (F2F extension)."

Some services—for small-scale producers and natural resource management, for example, which excite less interest from commercial providers—will continue as public services.

- ICTs, including devices and software, will become more available, much cheaper, and more affordable or even cost-free (open-source software is one example), even in rural areas.
- Connectivity will become more pervasive and more mobile. More devices will be "smart" and capable of performing multiple operations.
- Farmers and rural communities will be regarded as much less "passive" consumers of advice and information; through ICTs as well as other developments, they are becoming active participants in formal rural knowledge and innovation systems.
- Traditional public advisory services will be challenged and bypassed by the emergence of new actors with alternative ICT-based business models. Increasingly, these new actors rely on ICTs to provide their comparative advantage. To be relevant and competitive in such situations, public extension services need to reinvent or transform themselves, with strategic use of ICTs as part of the change process.
- There will be much experimentation and innovation by governments, NGOs, the private sector, and new infomediaries to develop and test ICT-based services and business models to better reach or engage with rural communities. The challenge will be to scale these out to reach specific target groups or broad groups of marginal communities.

The more complex and dynamic interactions characteristic of innovation systems, including the interactions fostered through ICT, will require new skills, both technical and entrepreneurial, to be acquired by farmers as well as advisory service providers (Swanson and Rajalahti 2010). In some instances, ICTs themselves can enable farmers and service providers to attain these skills; in others, special capacity-building efforts will be needed. This discussion is beyond the scope of this topic note, but helpful information is available (see World Bank 2012, especially Module 4).

In the remainder of this note, the discussion of ICTs in advisory services contains examples and innovative practice summaries that illustrate practical strategies for integrating farmers' demands into advisory services and give an idea of their relative strengths and weaknesses. The examples and practice summaries also illustrate some of the social and economic outcomes that can arise when ICTs support the wider webs of communication that characterize effective innovation systems.

ICTS FOR EXTENSION AND ADVISORY SERVICES

ICT has great potential to transform the way public extension is organized and delivered—including interactions with farmers. It is also an entry point for nontraditional actors who see advisory services as an area of intervention and for giving greater emphasis to subjects traditionally deficient in extension services. ICT can also increase women's access to advisory services.

Some developing countries have moved quickly to enable farmers to interact in real time (or close to it) with advisory services through ICT. Until ICTs offered farmers a channel for communicating directly with distant technicians and experts, many farmers could wait months or years for an extension worker to provide technical advice, and often that advice did not address their immediate concerns (image 6.7). The following examples highlight some of the ICT applications that advisory services have used to improve their interactions and technical knowledge sharing with farmers in developing countries. These applications include web services like "ask the expert," mobile messaging for advice, radio programs to disseminate technical information, and video. Many of these endeavors are fairly new, limiting practitioners' ability to analyze their effectiveness.

IMAGE 6.7: Timely Advisory Services Improve the Effectiveness of Other Technologies

Source: Thomas Sennett, World Bank.

Informing the Extension Agent

Two recent projects improve extension agents' ability to respond to farmers' needs by improving the quality and relevance of information available to both groups. The first was launched in Egypt and the second in Uganda.

Egypt launched a Virtual Extension and Research Communication Network (VERCON) in 2000 to develop and strengthen links among the research and extension components of the national agricultural knowledge and information system. By improving research-extension linkages, the initiative aimed to improve advisory services for Egyptian farmers, especially resource-poor farmers (see http://www.fao.org/sd/2001/KN1007_en.htm).

VERCON-Egypt introduced and tested several innovative communication tools. One of the most useful tools is the Farmers' Problems Database, created explicitly to address farmer's problems. The web interface enables extension agents to pose questions on behalf of farmers seeking solutions to agricultural problems; they can also examine answers to questions already posed to researchers. Content is classified into four main categories of problems: production, administration, environment, and marketing.

The online database and tracking system enable farmers' questions to flow from provincial extension centers to the national extension directorate and research system. Farmers approach extension centers with problems, and if they cannot be solved using online resources such as extension bulletins or agricultural expert systems, the extension agent develops a full description of the problem and his/her proposed solution, which is forwarded to a specialized researcher who provides advice to address it (Beltagy et al. 2009). The problems and solutions are added to the online database to assist other users of the network who face similar problems.

Aside from addressing farmers' problems, the system provides valuable information to track farmers' problems, including their incidence and significance. The system makes farmers' problems more visible and quantifiable for research planners, and chronic problems can be addressed in research projects. Since 2006, over 10,000 problems and their solutions accumulated in the interactive database, and over 26,000 farmers benefited from the system (FAO 2008).

In Uganda, the Grameen Foundation's Community Knowledge Worker Initiative established a distributed network of intermediaries, called Community Knowledge Workers (CKWs), who used mobile devices to collect and disseminate information to improve the livelihoods of smallholder farmers. The idea was to extend the reach of centralized expertise and transmit farmers' concerns more clearly. Via mobile phones, CKWs provide information on three-day weather forecasts, seasonal forecasts, good farming and husbandry practices, input supplies, and markets. The subject matter for each of these topics comes from expert partner institutions like the Uganda National Agro-Inputs Dealers' Association and Uganda's National Agricultural Research Organisation.

Early findings indicate that women and poorer farmers are frequent users of the service and that farmers generally act on the information they receive. Even so, CKWs require intensive training in mobile technologies, agricultural information, survey techniques, and business skills to be effective.[10] (For more detailed information on this initiative, see IPS "Community Knowledge Worker Initiative in Uganda" in Module 4 and "Community Knowledge Workers in Uganda Link Farmers and Experts to Cope with Risk" in Module 11.)

Using Radio and Video to Reach Rural Farmers

Among the various communications media available, even the most novel and technically sophisticated alternatives, radio remains the most pervasive, inexpensive, popular, and socioculturally appropriate means of communication in many parts of the developing world. Radio is still the only medium for disseminating information rapidly to large and remote audiences, including critical information about markets, weather, crops, livestock production, and natural resource protection. Video has also made substantial impact in convincing farmers to try new technologies; its images and demonstrations make information easier to understand and apply.

Rural radio is distinctive from urban radio and most national radio networks in that it is directed specifically to a rural audience and its distinctive information needs, often including authentic stories and experiences from communities and successful farmers. Rural radio can motivate farmers, promote the exchange of views, and draw their attention to new agricultural production ideas and techniques. Communities actively plan the production of broadcasts, making them an expression of community life and concerns rather than treating communities as passive listeners. (For examples, see box 6.11 and IPS "Farm Radio International" in this topic note.)

10 See http://www.grameenfoundation.applab.org/applab-blog/2010/05/20/community-knowledge-worker-pilot-report-and-program-launch/.

BOX 6.11: Rural Radio Lets Listeners Speak

A villager's story, recorded in a rural radio program about bushfires:

> *My uncle once told me how a bushfire burnt his field: "That bushfire was angry—it charged like a herd of elephants, destroying everything! Even came near to our home!"*
>
> *I said, "Don't be scared. With the right words, a good hunter can stop a herd of charging elephants. We too can stop bushfires with the right words."*
>
> *"What words?"*
>
> *"Let's unite."*
>
> *"Let's unite?"*
>
> *"If the entire village gets organized to fight bushfires, you'll never be afraid of bushfires again!"*

Rural radio programs serve a variety of purposes, such as promoting an anti-bushfire campaign in Chad. Whether produced at the local, regional, or national level, such radio programs are most effective when made with audience participation, in local languages, and taking into account cultural traditions. Rural radio programming, besides spreading agricultural information, can fulfill other important functions: It can stimulate a regular discussion and debate among the people involved in agricultural development, provide a forum where rural communities can express their views, and can even be a powerful means of investigation for decision-makers, helping them to approach local agricultural development in appropriate ways.

Source: FAO n.d.

Rural radio producers must know the rudiments of agriculture, be familiar with farmers' agricultural problems, and have a good general understanding of rural life to ensure that their programming is relevant to their audience. Production teams are taught to work with farmers and, to the extent possible, organize broadcasts directly from the field in open-air gatherings in which entire villages or communities participate.

Program content is generated through participatory discussions with community representatives and presented in languages and formats to which the audience relates socially and culturally. For every rural radio project, the starting point should be a participatory needs assessment to evaluate not only the material needs of communities that will benefit from the project but the perceptions, expectations, and commitments that community members can bring to the initiative.

Radio overcomes some of the most challenging issues related to using ICT in advisory services:

- ***Accessibility.*** Radios are relatively cheap to produce and distribute and do not need electricity or special skills to operate. They can also be shared by groups of listeners. It should be mentioned, however, that a key challenge to reaching female farmers through radio is ownership. Often men own the radio and choose the programs to listen to, which may not be relevant for women farmers. Radio programs should target women (although ensuring women's access to radios in the household may not be so easy).
- ***Literacy and language barriers.*** Radio requires no reading and speaks the language of the community it intends to reach.
- ***Geographic coverage.*** Radio can easily and simultaneously reach large numbers of isolated communities over vast geographic areas.
- ***Local focus.*** Radio can focus on local issues in local languages. The United Nations Development Programme notes that in Latin America, for example, most radio programs are locally or nationally produced, whereas only 30 percent of television programming comes from the region.

New ICT has benefited radio by offering better and cheaper means of recording, mixing, editing, and transmitting (for example, the digital audio recorder, audio editing on computers, and the electronic transmittal of sound programs as attachments) (image 6.8). Development practitioners increasingly recognize the potential for combining radio with new Internet-based ICTs, given that the new ICTs are still limited in some areas by the lack of telecommunications infrastructure and reach only a small number of people in developing countries.

Like radio, video has the advantage of attracting people's curiosity, and it appears to be an especially convincing medium when it captures familiar people or situations (as does local participation in radio broadcasts). Advances in ICT have made video much easier and less costly to produce and disseminate. Like radio, video does not demand literacy, and it suits the narrative culture that prevails in most developing countries. Images can make it easier for viewers with little education to understand complex topics. An additional benefit is that video can foster social cohesion in agricultural

IMAGE 6.8: New Technologies Have Allowed for More Innovative Radio Programs

Source: Farm Radio International.

communities by featuring the actions and voices of marginalized groups (Lie and Mandler 2009).

Through videos developed in collaboration with farmers, the Africa Rice Center (http://www.africarice.org/) has widely disseminated information about rice productivity and marketing opportunities (van Mele, Wanvoeke, and Zossou 2010). The Africa Rice videos stimulate learning and experimentation in rice production from field to market. A series of 11 videos in more than 30 African languages on producing, processing, and marketing rice were produced and widely shared with local radio stations and farmer organizations across Africa. These videos have reached more than 500 organizations and probably hundreds of thousands of farmers; it is likely that they continue to be copied and distributed more widely, but this spontaneous diffusion and any resulting innovation are difficult to monitor and evaluate.

The videos appear to have had a tangible impact on the livelihoods of rural women. Because the videos featured women, they reached more women, who were more likely to apply what they learned (Africa Rice Center 2009). For example, women who saw the video on parboiling rice improved their parboiling techniques and marketed their rice through new outlets. Others developed a better relationship with the NGO that showed the video, formed producer groups, and gained assistance from the NGO in obtaining credit to purchase inputs for improving rice production. The NGO, in turn, recognized the effectiveness of the video format and began to use more visual aids in its work with women. The fact that the videos showcased women's expertise and innovation convinced some male researchers that they should work more with women farmers. Giving a voice to women and other marginalized groups in this manner and involving them in the development and dissemination of agricultural technology may be an effective means of promoting greater social inclusion. To see the rice videos, visit Africa Rice Center (http://www.warda.org/warda/guide-video.asp).

Making Information Accessible through Mobile Phones and Internet

Colombia's Ministry of Agriculture and Rural Development, in collaboration with partners, facilitates AGRONET, the National Agricultural Information and Communication Network of Colombia (www.agronet.gov.co). AGRONET is a network of agricultural information providers that have adopted a common platform to standardize and integrate resources to offer value-added information and communication services for the agricultural sector using modern and traditional ICTs.

To send relevant information to producers, AGRONET develops user profiles based on a needs assessment and users' particular productive activities. AGRONET introduces new methods and improved workflows to provide content systemically and takes advantage of mobile technologies to reach a growing number of rural users. Through SMS, producers receive updates on AGRONET's platform, including changes in its databases and other news and events pertinent to agriculture. The ministry plans to expand the service to reach 160,000 producers in 2011 with context-specific information on agricultural markets, inputs and supplies, weather alerts, and other subjects. Over the medium term, AGRONET plans to provide a greater wealth of content and information services to producers by adding capacity in digital television.

The government's efforts to reduce the digital divide through public-private partnerships and growing broadband penetration in rural municipalities catalyzed the development of AGRONET's innovative, value-added information services. An assessment by Colombia's e-Government Program ranked the ministry first in online information provision.

In Uganda, ARENET (Agricultural Research Extension Network) is a web portal (http://www.arenet.or.ug/index.php) created to strengthen the links between the National Agricultural Research System and the National Agricultural Advisory Services program and its related extension service providers. The portal provides access to practical and technical agricultural information from national and international sources. Users can post questions and problems through the system to experts at research institutes and in local government, and ARENET makes it possible for farming communities, researchers, extension agents, and the private sector to communicate among themselves and to share their knowledge and experience. The site uses English but may include other local languages in the future.

The question-and-answer module of the website is divided into categories such as livestock, agricultural engineering, and forestry, and it lists the most viewed and recently posted questions. There is also a page from which various technical publications can be downloaded. Questioners are advised that their query should receive an answer within three days. The discussion forum section is not yet operational. Like many Internet information sites at present, this site will be more valuable for large-scale farmers than for smallholders.

Plans are well advanced for an ambitious ICT platform to improve Uganda's research capabilities and the way it delivers extension services. The National Agricultural Advisory Services and the National Agricultural Research Organisation will be supported by this program, which, among other things, will allow feedback from farmer organizations and other users of the services. One important aim is to change the culture of the research organizations to one of accountability, transparency, and competence. This transformation should have obvious benefits to the clients.

ICTS THAT PRESERVE FARMERS' KNOWLEDGE

ICTs—some of which, like radio, have been available for some time, and others, such as digital video, which are relatively new to rural areas—bring farmers' views and voices into agricultural advisory and research services. ICTs are invaluable for eliciting and preserving local knowledge, such as knowledge of the medicinal traits of plants or traditional erosion control practices. The following sections illustrate how rural people in a range of settings have benefited from and enriched advisory services through greater participation and knowledge sharing mediated by ICTs.

Using ICT to Share and Elicit Local Knowledge

Many organizations and governments see ICTs as tools that bring information and modernity to rural areas. They help get messages "out." Undoubtedly they extend the reach of extension and advisory services, but they can become one-way pipelines, pushing information to uninterested communities. A more inclusive approach uses ICTs to empower rural people to document their own knowledge so it can be shared with other communities and with extension. This empowering approach is more challenging as it depends on the capacities of the communities and their willingness to share their knowledge. For their part, proponents of the approach must be willing to use ICTs to enable changes that cannot be defined before the work is underway. The approach will involve some loss of control and very probably unexpected impacts.

People will use a system for sharing information, including agricultural information, if the content is adapted to local needs, sourced appropriately, and presented suitably. In Costa Rica, a national team conducted a participatory rural communication appraisal in selected regions to engage farmer organizations in sharing their knowledge. In the Brunca region, for example, livestock production dominates agriculture, and farmers identified livestock diseases as an important concern. One participant, a woman farmer, was famous for her knowledge of how to cure sick cows. The organization decided that the best way to document her knowledge was to film her. The videos could be shown at the local livestock auction and remain available digitally on the national PLATICAR ("talk") web platform.[11]

In other regions where the participatory method was used, it elicited information and knowledge on other themes. Farmer organizations producing tuber crops decided to prepare radio programs that were broadcast and then archived in PLATICAR. For rice producers, information sheets were developed on each of many rice varieties in Costa Rica.

The participatory approach that led to the choice of the most knowledgeable person was the innovation that enabled farmers to recognize that their own local and traditional knowledge was most appropriate for their needs. The innovative decision was to select the best medium for sharing this knowledge, as well as the place and time where it would be shared most effectively. The fact that the information is digitally preserved

11 Plataforma de Tecnología, Información y Comunicación Agropecuaria y Rural (Platform for Agricultural and Rural Information and Communication).

means that it can be archived and available through PLATICAR. The team that led the participatory process was the key enabler, because it built trust among stakeholders and brokered the sharing of personal knowledge that could benefit the whole group.

IMAGE 6.9: Farmer-Led Documentation Processes Can Use Digital Tools in Place of Paper

Source: Charlotte Kesl, World Bank.

Documenting and Mobilizing Indigenous Knowledge

A related information-sharing effort documents indigenous knowledge (image 6.9). As experienced farmers migrate to urban areas, as the local farming population ages, or as climate change and social upheavals uproot agricultural communities, much knowledge can be lost. This knowledge is worth preserving simply for its cultural value, but it is also instrumental in aiding researchers and extension workers to develop and adapt technology and practices for local conditions (and could help communities recover from natural disasters and conflicts).

In Bolivia, the CARENAS project started in 2003 in the Department of Santa Cruz to strengthen rural communication for sustainable natural resource management and rural development. Representatives of municipalities, farmer associations, and NGOs participated in intensive training for one month in communication methods and techniques, the use of ICTs, and the production and use of multimedia materials in the field. The 21 people who passed the course became local audiovisual specialists, who engaged in a participatory process with advisory service workers and farm communities to elicit farmers' traditional knowledge and integrate it with technical knowledge. Based on this interaction, the audiovisual specialists produced draft videos, which were validated through focus group discussions, interviews, and farmer-extension meetings. The videos were then shown to the communities and, after participatory evaluation, final versions were produced. They were distributed to 25 communities in 11 municipalities (see http://www.fao.org/tc/tcdm/italy/op_bol034_en.asp?lang=en). The videos, which demonstrated such techniques as repairing drainage ditches using nets and vegetative cover, recycling organic waste, and building compost latrines, eventually formed part of a training package consisting of printed guides for trainers and booklets for farmers.

In South Asia, in an effort to increase their impact, organizations working with rural communities in Bangladesh and India embarked on a process of Farmer Led Documentation and Knowledge Sharing.[12] Farmer-led documentation is defined as an empowering process in which local communities take the lead role in the documentation process. The results are used by community members for learning within the community (internal learning) and exchange between communities (horizontal sharing) and communities, development agents, and policymakers (vertical sharing).[13] This process of engaging with farmers to document their knowledge and experiences showed that a "people-led development process does not only help increase yields or conserve the local biodiversity; it can also help farmers to get access to the resources they need and can contribute to strengthening local organizations, networks, and alliances. Most important of all, it leads to empowerment."

ICTS TO MONITOR AND EVALUATE AGRICULTURAL INTERVENTIONS

Monitoring and evaluating outcomes of research results (such as new varieties and management practices), the construction of agricultural infrastructure (often involving contractors), or the impacts from extension programs or new technologies in a decentralized rural setting can greatly benefit from

12 See http://www.misereor.org/fileadmin/redaktion/MISEREOR_Strengthening_people-led_development.pdf.

13 The farmer-led documentation approach was promoted by Participatory Ecological Land Use Management (PELUM), Promoting Local Innovations (PROLINNOVA), and OXFAM Novib. See www.prolinnova.net/fld.php.

ICT. ICT can transform monitoring and evaluation, which are often afterthoughts in agricultural interventions because of the difficulties associated with analyzing impact. Monitoring and evaluation are expensive (entailing the costs of traveling, producing materials, hiring experts, analyzing data), especially for poorly resourced public agencies. It is often a challenge to measure impact accurately because so many variables cannot be controlled (including unanticipated changes in weather, conflict, natural disasters, or community or farmer health). ICT can address some of these challenges by reducing the paper trail, increasing farmers' responses (and the diversity of respondents), improving remote observation, and expanding data accuracy. (See also Module 13 on governance.)

Monitoring and Evaluating Agricultural Interventions and Research

India has pioneered the use of ICT in many agricultural interventions and is often at the forefront of technological innovation for smallholder farming. To track research being conducted in India, the Indian Agricultural Statistics Research Institute developed the Project Information and Management System for the Indian Council of Agricultural Research. The data management system was created to prevent duplication between research projects, monitor research initiatives and their progress more effectively, evaluate research outcomes, and contribute to smoother management processes. By generating online software, the Indian Council of Agricultural Research has the ability to monitor and evaluate research projects at national and state levels simultaneously. Users involved in research projects can upload information on new projects and update information as the project moves forward. Users can also browse through projects, which helps to spur innovation and creative thinking while preventing overlap. Research directors and managers can then manage and monitor agricultural interventions and research remotely and with fewer costs. In addition, the management system can hold research data and final reports. For more information on how the system works, visit the tutorial at http://pimsicar.iasri.res.in/.

In another project, which monitored drought vulnerability, local participants played key roles in validating and evaluating the effectiveness of the information provided. The Virtual Academy for the Semi Arid Tropics (VASAT) (http://www.icrisat.org/vasat) uses components such as PC-equipped rural information centers, community radio, and mobile telephony in conjunction with human-centered efforts to anticipate and monitor the effect of drought at the micro level. Since 2005–06, activities under this initiative have taken place in Niger and in India. In both locations, rural organizations established community-based information centers with international support. The focus was on helping rural communities anticipate drought and to help them develop and arrive at decisions that can mitigate the impact of drought when it occurs.

In the VASAT initiative, a blend of remote sensing and agrometeorology techniques was used to develop highly localized, village-by-village forecasts of drought vulnerability. These forecasts were presented as simple color-coded maps of the locality (a cluster of adjoining villages). Red/amber indicated severe vulnerability to drought (including drinking water scarcity), whereas green indicated that business as usual could continue. Yellow indicated that the village needed to give attention to altering their cropping pattern and pay attention to fodder supplies. Developed for the coming season from global and regional rainfall forecasts, these maps and a set of recommended actions are shared with rural communities through the information centers. Every village has at least one individual who is trained in reading the vulnerability maps.

Analyses of the effects of this intervention reveal that after two seasons, a large number of individuals started to use the color-coded maps as reliable information resources. In 2009 in India, a particularly serious drought was forecast at the micro level although not at the aggregate level. Rural families prepared for the anticipated drought by storing fodder and not sowing water-intensive crops such as rice. Through these actions, they mitigated the effects of the ensuing drought, which was serious, lasting more than halfway into the season. Using ICT to monitor weather patterns as well as farmers' responses helps VASAT determine the correlation between the two. In this intervention, it was significant that women were key actors in absorbing and relaying information about vulnerability to drought. They were also meticulous data providers for experts to refine or correct the vulnerability forecasts.

Pajat (http://www.pajatman.com/), a company founded in 2009 and financed by the Finnish Funding Agency for Technology and Innovation among others, has also pioneered ICT for monitoring and evaluation. The POIMapper, using GPS-enabled mobile phones, can collect data and photos with digitized links to location. Numeric or text data can be uploaded to a central database through cellular or bandwidth networks. Data collected for a particular intervention can be mapped on a computer; multiple datasets can be layered to create more informative maps. This tool can be used to monitor a variety of projects, including projects to develop infrastructure such as wells or to manage forests (see the forestry module). It may also be used to monitor the effects of agricultural interventions by mapping data on increases or declines in crop yields or frequencies of livestock disease. (See IPS "PoiMapper in Kenya" for more information in Module 15.)

In Africa, organizations have used mobile phones to collect information from farmers about how they can improve their programs, as illustrated in box 6.12.

BOX 6.12: Mobile Phones as Tools for Farmer Surveys and Feedback

Voice of the Farmer (VoF) is a pilot project testing a structured approach to obtain broad-based, low-cost, and frequent feedback from farmers in Kenya, Tanzania, and Uganda, using mobile phone technology. The pilot was conducted between January 2010 and March 2011 by Synovate Panafrica, with funding from the Bill and Melinda Gates Foundation.

The approach was designed to help organizations collect a steady supply of empirical, actionable data more rapidly and cost-effectively. Feedback from target constituencies enables organizations to assess whether they need to change their activities and approach to better meet their constituents' needs. In the shortest possible time, findings can be available to participating organizations through an online portal.

How has VoF been used? Some organizations used VoF data to monitor progress in implementing projects. Others used the surveys to help guide the content of products they planned to develop. One organization used VoF to get a better idea of how to focus its monitoring and evaluation surveys. Another used VoF primarily for quick marketing surveys to receive timely feedback on new products and services. Experience with the pilot project indicates that VoF has potential as an efficient, low-cost solution meeting a number of needs in private, public, and civil society organizations.

Source: Authors; see also http://www.synovate.com/contact/africa/.

LESSONS LEARNED

Despite the benefits of using ICT in agricultural advisory and extension services, many challenges remain. Lessons from the examples herein and Innovative Practice Summaries are relevant to many projects that use ICT to improve advisory services. These lessons and their potential solutions are discussed below.

Because advisory services are one of the most direct lines to poor farmers, it is critical to determine the main objective of services and the most appropriate ways to use ICT to meet them. If the primary aim is to get information to farmers, then multiple channels and media should be used to reach many groups. The quality and relevance of the content/advice to be provided is also important, as is the level of community "connectivity" to the providers' messages. Conversely, if the aim is to maximize farmer-to-farmer documentation and sharing, then the emphasis is likely to be much more on capacity building and issues of culture, language, and various forms of literacy.

The technological component of an ICT for advisory services should be developed locally, in collaboration with users, and drawing on local, national, and international content as appropriate. Attention should be focused on what the technology needs to deliver, not its capabilities.

During implementation, the roles and responsibilities of the various actors need to be defined. Accountability improves when participants are aware of what is expected from them in terms of their roles and their commitments of human and financial resources and time. This clarity is especially important for national advisory services, where stakeholders are diverse and systems are decentralized. Regular face-to-face meetings are also crucial to capitalize on information exchange and stimulate new ways of working together and sharing lessons learned.

Any technology used for advisory services must be user-friendly, accessible, and serve farmers' needs quickly and sufficiently. Trust, useful information and knowledge, and appropriate support are critical to user sustainability. Part of ensuring sustainability is engaging in proper prior analysis and involvement of end users. These steps will help providers determine whether the users can pay for the service and, if so, how much; understand the culture surrounding the use of technology in a given location; identify social and political challenges that may arise during implementation; and determine what kinds of applications will serve users best based on their agrarian activities.

Special efforts have to be made to guarantee that both men and women participate in and benefit from information and communications for advisory services. The opportunities offered by information technologies can significantly enhance information provision to rural women in developing countries. Without equal access to information, women are at a disadvantage in making informed choices about what to produce and when to sell their products. While ICT certainly improves these circumstances, availability of an ICT device does not necessarily imply equitable access. More often than not, ICT devices (radios, phones) remain under the control of men, preventing women from tapping knowledge and information relevant to their needs. Gender-disaggregated data, monitoring, evaluation, and better targeting will improve these outcomes.

INNOVATIVE PRACTICE SUMMARY
Farm Radio International Involves Men and Women Farmers

Radio is used to spread knowledge of improved farming and land management practices, but farmers do not necessarily adopt them. Farm Radio International, a Canadian NGO funded by the Bill and Melinda Gates Foundation, has created a new model of radio broadcasting that seeks to overcome some of these challenges to adoption.

Farm Radio International partners with 360 radio stations in 39 African countries and reaches more than 200 million smallholders in more than 100 African languages. It offers a number of services but primarily develops Participatory Radio Campaigns, theme-based radio programs that continue for four to six months. Themes range from livestock husbandry to farmer innovation, soil conservation, and issues specific to rural women (such as maternal health, farm implements designed for women, and women's land rights).[14]

The most innovative aspect of the Participatory Radio Campaigns is the broad base of farmer participation. First, men and women farmers help to develop the scripts, and a number of communities are invited to participate during implementation and evaluation (image 6.10). Second, programs are broadcast on a consistent schedule to keep farmers engaged. Third, Participatory Radio Campaigns feature voice response systems and call-in options that have proven remarkably successful in retaining listeners. The information elicited in this way helps extension staff and local NGOs identify the challenges, understand the perspectives, and gain the knowledge associated with a given community or area. Finally, women farmers are regularly

IMAGE 6.10: Women Can More Easily Participate in Rural Radio Interviews

Source: Farm Radio International.

included in the broadcasts and participatory aspects of the programs, improving their visibility and importance in the local agricultural supply chain.

Empirical evidence of impact, which is currently lacking for many applications of ICTs in agriculture, is available for the Participatory Radio Campaigns. In 90 communities across five countries, about 4,500 farm households (1,988 women and 2,452 men in total) were randomly selected and surveyed through questionnaires. Key informant interviews and site observations were also used to assess overall impact. The communities were split into three categories: (1) communities that participated actively in broadcasts and program design, (2) communities that listened to broadcasts without active participation, and (3) control communities (or those that did not have network radio signals to listen to the programs).

Thirty-six percent of active listening communities adopted improved farming practices, and 21 percent of passive listening communities adopted. Women from active listening communities were much more likely to adopt the practices covered in the radio programs (almost as likely as male listeners) than women in passive listening communities. These adoption rates are higher than those from many other radio programs, demonstrating that participatory radio is more effective than programs that do not engage farmers directly. More men than women listen to and have access to radio programs (table 6.1), although when women have no radio in the household, they access radio elsewhere.

14 See http://farmradio.org/english/radio-scripts/gender.asp.

TABLE 6.1: Radio Access and Frequency of Listening in the Household (%)

	MEN	WOMEN
Radios in the household	84	68
Access to radio (both inside and outside of the home)	96	89
Frequency of listening (at least once/week)	95	86

Source: Farm Radio International Participatory Radio Campaign Evaluation Report 2011 (unpublished).

Participatory Radio Campaigns take approximately 12–18 months to design, distribute, and evaluate. For themed packages, costs range from US$ 25,000–50,000. For the whole process, including training and assessment, costs can range from US$ 80,000 to US$ 200,000, depending on the country and other factors. To put these figures into perspective, it is useful to know that if a campaign reaches 1 million farm families, the cost lies somewhere between US$ 0.08 and US$ 0.20 per listening family. Given the adoption rates cited earlier, costs per adopter range from US$ 0.20 to US$ 1.00. These costs are relatively small in light of the relatively high adoption rates and resulting productivity increases.

INNOVATIVE PRACTICE SUMMARY
E-Extension in the USA and Philippines

This summary looks at how electronic advisory services are being implemented in the United States and the Philippines. Both programs use ICTs to increase the expertise available in the national advisory service and transmit that expertise to a much larger audience—while learning from that audience in the process.

United States: ICTs to Co-Create and Deliver Extension and Educational Knowledge

In 2001, the United States government decided to transform the way its Cooperative Extension System fulfilled its mission through technology. The program that became known as "eXtension" was approved as a national initiative in 2004 and fully launched in 2007. By definition, eXtension is the product of new and emerging technologies. The program aims to become a national, Internet-based information and education network; provide accurate, up-to-date information for use anytime, anywhere; use technology and new organizational processes such as communities of practice; enhance the accessibility, quality, breadth, and depth of information provided to the public; foster collaboration within the Cooperative Extension System; and reduce duplication. It is an integral part of the Cooperative Extension System and complements and reinforces other extension activities.

Through the Internet, eXtension provides 24/7 access to objective, science-based information from land-grant universities and partners. One of eXtension's most notable features is "Ask an Expert," which puts people in touch with experts in universities across the country. In addition to those resources, eXtension's communities of practice connect extension professionals throughout the country to collaborate in developing new content and web services. eXtension has transformed extension's traditional teaching role by offering a wide range of virtual learning and skill-development activities and events on its website. Through social networks and media (including blogs), the communities of practice expand the reach of extension and engage with new users.

The eXtension websites are a useful resource for those seeking to develop similar programs in other countries. They offer a wealth of information on the approach and the tools used (http://www.extension.org and http://about.extension.org).

Philippines: ICTs Power Advisory Service for Agriculture, Fisheries, and Natural Resources

The Philippines launched its e-Extension Program in December 2007. The lead organization—the Agricultural Training Institute—relies on collaboration with various organizational units within the Department of Agriculture. The goal of e-Extension is to integrate and harmonize ICT-based delivery of advisory services for agriculture, fisheries, and natural resources and to use its network of institutions to provide a more efficient alternative to a traditional extension system. e-Extension can be thought of as an electronic, interactive bridge where farmers, fishers, and other stakeholders meet and interact to enhance the productivity, profitability, and global competitiveness of the agricultural sector. The benefits of the approach are expected to include empowered stakeholders, who have alternative means of acquiring new knowledge and skills related to farming and fishing technologies; reduced costs of education and training; more optimal use of resources; enhanced delivery of programs and services; and an organized repository of information, harmonized across related initiatives.

The main program components are e-Learning and e-Farming; an e-Trading component is available as well. e-Learning courses are available online and can also be delivered to small groups. Blended courses offer computer-based instruction backstopped with field activities and face-to-face interaction between learners and experts. Learners also have the opportunity to interact through online discussion forums. Online they also have access to a wide array of free digital resources to increase the knowledge gained through coursework and obtain additional information to make decisions about their agricultural enterprises. Media for school radio programs are available as well. The e-Learning courses are designed to be highly interactive. Photos, video, games, and puzzles also help to sustain interest.

e-Farming uses ICTs to deliver farm and business advisory services. It provides technical assistance to farmers to increase the profitability of their enterprises and facilitates the exchange of information among traders and investors in agriculture and fisheries. Its Farmers' Contact Center caters to farmers' concerns through voice, text, e-mail, and other online communication formats such as instant messaging and online forums.

e-Trading is a service for online trading and for information on market trends, investments, market prices, inventories of producers and suppliers, and other information, initially available through the PhilAgribiz Centers of the Department of Agriculture. For more information, see http://e-extension.gov.ph/ and http://www.ati.da.gov.ph/.

INNOVATIVE PRACTICE SUMMARY
TECA Uganda Exchange Group Offers Practical Advice for Smallholders

The TECA web platform (http://www.fao.org/teca/) includes online resources, discussion forums, and query/response services that offer practical information on technologies and practices that will help small-scale producers. The platform, which is a medium for FAO technical units, partners, and projects to document and share successful technologies and good practices, is also a tool that supports further development, testing, adaptation, sharing, and adoption of technologies for small-scale farmers.

The central TECA platform on the FAO server permits information sharing at the global level in English, French, and Spanish. A local version on the partner organization's server contains modules provided by FAO for information sharing and exchange within a national agricultural innovation system; the modules can be adapted to local languages and specific information needs. For example, the TECA Uganda Exchange Group, piloted in 2010, currently has more than 300 members from public and private advisory services, NGOs, research, the private sector, farmer groups, government, and universities (including some student members).

Since its establishment, the group has had very positive feedback. Members have shared their experiences and created their own informal networks. An active group facilitator, fully dedicated to the group, has been central to its success. The facilitator must increase awareness of the platform among potential users, bring individuals together and identify their common interests, initiate discussions, motivate members to contribute, identify experts, and provide technical assistance. The facilitator needs support from IT as well as contacts who can gain visibility for the platform. Although TECA is designed as an online forum, personal gatherings proved essential to establish a vibrant online community (the kind of interaction will require funding for meetings, phone calls, transport, and other items that facilitate personal interaction). Another major lesson is that students are a very important and active group of participants; introducing them to the idea of knowledge management, is a key asset for their future work in agriculture.

INNOVATIVE PRACTICE SUMMARY
Participatory Video and Internet Complement Extension in India

Digital Green (http://www.digitalgreen.org/) started with the support of Microsoft Research in India. It disseminates targeted agricultural information to small-scale and marginal farmers in India through digital video. The system includes a database of digital videos produced by farmers and experts. The topics vary, and they are sequenced in ways that enable farmers progressively to become better farmers. Unlike some systems that expect ICT alone to deliver useful knowledge to marginal farmers, Digital Green works with existing, people-based extension systems to amplify their effectiveness. The videos provide a point of focus, but it is people and social dynamics that ultimately make Digital Green work. Local social networks are tapped to connect farmers with experts; the thrill of appearing "on TV" motivates farmers. Although Digital Green requires the support of a grassroots-level extension system and other partners, it is effective because its content is relevant and it maintains a local presence. This local presence makes it possible to connect with farmers on a sustained basis. Key aspects of the model include the following:

- ***Digital video.*** Digital Green relies on recent advances in digital videography, including low-cost camcorders and

PC solutions for editing digital video, which have greatly reduced the costs of developing local video content.

- ***Mediation.*** Videotaped demonstrations are not a complete extension solution. They lack the interactivity that is the hallmark of good extension. Digital Green relies on a local facilitator, whose role is to pause or repeat video to engage the audience in discussion and capture farmers' feedback.
- ***Partnerships.*** Digital Green emphasizes the development and delivery of digital content to improve the cost-effectiveness of organizations involved in agricultural research and/or extension. As noted, the goal is to strengthen existing institutions and groups, not to create new ones.
- ***Community-based content.*** Content must be relevant to local conditions (crops, climates, soils, farming practices, and so on). The use of video provides opportunities to customize materials. When videos feature farmers' fellow villagers, farmers often instantly connect with the message. Digital Green has an open model to disseminate content, so it is freely available to everyone to use.
- ***Beyond connectivity.*** To be successful and sustainable, Digital Green operates in environments with limited infrastructure and financial resources. High-bandwidth Internet connections are not necessary, since one option for receiving the video content is DVD.
- ***Feedback.*** By enabling anyone to be a content producer and consumer, Digital Green gives even isolated communities a voice. Other types of audio- and video-based mechanisms are used to support reporting and to build trust among virtual communities of participants.

The Digital Green approach is underpinned by various technological innovations (http://www.digitalgreen.org/tech). For example, its COCO (Connect Online, Connect Offline) software supports data tracking for organizations with sizable field operations, even where Internet service is intermittent and/or poor. COCO, a standalone application in the Internet browser, requires no additional desktop software installation or maintenance. It has an open-source, customizable framework and can be used without support from professional IT or engineering staff. Digital Green's Analytics System provides day-to-day business intelligence on field operations, performance targets, and basic measures of returns on investment relevant to an organization (see http://analytics.digitalgreen.org).

Topic Note 6.3: E-LEARNING AS A COMPONENT OF AGRICULTURAL INNOVATION SYSTEMS

TRENDS AND ISSUES

Learning—formal and informal—is central to all innovation systems, including those for agriculture, and in sustaining the capacity to innovate over the long term. Formal learning consists of specific courses of study of varied length and complexity in the educational system. This system develops the skilled experts who contribute to agricultural innovation (the varied research disciplines and areas of technical expertise, innovation brokers, as well as developers of food processing systems and standards, financial and risk management instruments, rural infrastructure, IT systems—the list is as extensive as the agricultural innovation system is comprehensive). Outside of this context, informal learning occurs through the varied interactions in an agricultural innovation system and is particularly important in agricultural extension (FAO 2003). The role of agricultural education and training in an innovation system is discussed in detail in Module 2 of World Bank (2012). This topic note focuses on the role of e-learning, particularly in extension interactions.

With the advent of radio, ICTs opened new channels for learning that proliferated rapidly as the range of ICTs expanded to include computers, the Internet and their applications (CD-ROMs, e-mail, websites, multimedia, and so forth). Learning delivered through the newer ICTs was termed "e-learning," and its potential to facilitate "distance learning" and "distance education" (instruction and learning outside the traditional classroom setting) was recognized immediately (image 6.11).

The World Bank defines e-learning as "the use of electronic technologies to deliver, facilitate, and enhance both formal and informal learning and knowledge sharing at any time, any place, and at any pace."[15] E-learning can widen the inclusiveness of the agricultural innovation system by bringing elements of traditional learning and mentoring to a wider

15 See http://go.worldbank.org/3IVXTNIW20.

IMAGE 6.11: E-learning Creates Opportunities for Rural Participation

Source: Curt Carnemark, World Bank.

audience and further empowering people through learning communities.

In theory, e-learning enables governments, agricultural advisory services, NGOs, farmer organizations, private companies—in fact, any actor in the innovation system—to reach large numbers of producers. Content can be updated quickly and accommodate rapidly changing needs. E-learning can also provide fresh approaches that are learner-centric, engaging producers and their communities as partners and adult learners in designing and implementing the learning experience. In addition, e-learning can make it easier to maintain quality by supporting feedback mechanisms and ensuring appropriate accreditation and certification processes.

These qualities make e-learning especially attractive to extension, especially for expanding extension workers' and farmers' knowledge and skills. Efforts in extension education have long been challenged by the use of a formal didactic framework that expects students to fit with the established courses (Kroma 2003). Public sector extension has suffered from declining investments, the high proportion of farmers in relation to trained extension workers, and the need to incorporate adult learning strategies and indigenous knowledge into their activities (World Bank 2012).

ICTs (and e-learning) may make it possible to surmount some of these barriers to effective extension training and outreach in developing countries, but significant adaptations will be needed. E-learning originated in a postindustrial setting among a relatively well-educated population with reasonably good infrastructure for accessing digital services. Investments in digital content for e-learning were an agreed priority that resulted in the development of a host of advanced platforms and applications for learners and facilitators/teachers.

The innovative practice summaries in this topic note indicate some of the adaptations and strategies required for e-learning to succeed in rural areas of developing countries, especially communities with limited literacy (digital and otherwise) and access to digital resources. Both examples come from India. The first summary describes an e-learning initiative in which farmers use mobile phones to gain specific skills that enable them to benefit more substantially from services such as commercial banking and extension advice. The second describes the development of a web-based platform called agropedia for storing and sharing agricultural information in a range of formats and languages. The platform, which incorporates Web 2.0 elements such as wikis, blogs, and commentary spaces, provides much-needed content for e-learning for farmers and extension workers. Through these features and multiple access points (including mobile phones and landlines), the platform connects researchers, extension personnel, and farmers in various information-sharing and e-learning activities.

LESSONS LEARNED

The experiences summarized here offer important social and technical perspectives on e-learning for rural people and extension workers in developing countries. ICTs can facilitate a learner-centric process if they are adapted carefully to the particular social, economic, and political context (including constraints on learners' time and travel). A multistakeholder partnership is essential for promoting learning among the farming community through ICTs, and agricultural institutions need to produce more extension-oriented digital content. Content for e-learning must be highly granular for rapid uptake and must be linked to specific learning outcomes. E-learning does not require the complex online workflows associated with standard learning management systems, but a priority in promoting e-learning in agricultural innovation systems is to build ICT capacity in personnel at all levels of agricultural education, training, and extension.

Finally, ICTs and virtual interactions are not sufficient to form cohesive learning communities. Peer-to-peer contact significantly improves learning, and mobile phones can provide useful support. In the lifelong learning for farmers initiative, for example, mobilization, social capital, and social networking played a major role. The use of ICTs for learning influenced development outcomes because the learning experience was tailored to women's cognitive social capital and reinforced by links with commercial banks.

INNOVATIVE PRACTICE SUMMARY
Lifelong Learning for Farmers in Tamil Nadu

Lifelong Learning for Farmers (L3F) (http://www.col.org/progServ/programmes/livelihoods/L3farmers/Pages/default.aspx) is an application of Open and Distance Learning for Development by Commonwealth of Learning (COL) in Commonwealth countries (Balasubramanian and Daniel 2010). Banks, universities, and marketing agencies are the partners in the L3F initiative. Using open and distance learning and ICT, the initiative aims to strengthen the self-directed learning process among men and women in the farming community and create linkages between various stakeholders. The objective is to facilitate the enhancement of skills and knowledge of farmers in partnership with financial institutions and research institutions. L3F is based on the following premises:

- Unexploitative, mutually reinforcing contractual relationships between rural producers and the formal public and private sector will promote rural entrepreneurship.
- Learning and extension can be a self-sustaining process in which secondary stakeholders support L3F within a win-win framework. For instance, by blending rural credit with appropriate capacity building, rural credit will perform much better in terms of productivity, returns, and nonperforming asset levels. Such gains will lead financial institutions to support L3F.
- Capacity building will also enlarge the market for bank credit among small-scale and marginal farmers and among other marginalized groups of the rural poor, particularly women. Modern ICTs can play a major role in supporting capacity building, which in turn would enhance the market for such technologies.

The rural poor stand to gain in this process, along with the participating financial institutions, research institutions, and ICT companies. In addition to using ICTs to build capacity, financial institutions can use them to reduce the transaction costs of lending. Integrating these functions can improve the likelihood that the L3F process will be replicable and sustainable.

Integrating Mobile Phone-Based Learning and Credit for Women Livestock Producers

VIDIYAL, an Indian NGO, uses L3F to promote community banking among 5,000 women organized into self-help groups (SHGs). During 2008, nearly 300 women from the SHGs became partners and decided to build their capacity through open and distance learning related to various aspects of sheep and goat production. As poor laborers, most of the women felt that attending classes or watching multimedia materials restricted their ability to work and attend to household chores. They asked VIDIYAL and COL to explore the use of mobile phone as a learning tool, because they would not need to be confined to any particular place or time during the learning process.

Through face-to-face and computer-based learning, COL and VIDIYAL encouraged the women to develop a business proposal for rearing sheep and goats. They developed a business proposal in which each member would obtain credit for buying nine female goats, one buck, and one mobile phone. The local bank agreed to the proposal and sanctioned a loan of US$ 270,000. The credit and the legal ownership of the assets are in the names of the participating women.

The 300 women bought simple mobile phones, and VIDIYAL entered an agreement with IKSL, one of India's major mobile network operators, to send audio messages to the women's phones free of charge and enable free calls among group members. The company felt that this strategy would enhance its mobile service in the long run.

VIDIYAL and some of the participating women were trained in developing audio content for mobile phone-based learning (image 6.12). Learning materials are prepared within the broad principles of open and distance learning to meet learners' time and geographical constraints. VIDIYAL developed the materials in consultation with the Tamil Nadu Veterinary and Animal Sciences University and contextualized them to the local culture and dialects.

The learning materials convey information in granular fashion—in short, concise messages. Three to five audio messages are sent to participating women every day. Each message runs for 60 seconds.

IMAGE 6.12: Women Use Mobile Phones to Learn Better Goat Production Techniques

Source: Commonwealth of Learning.

Women preferred to receive the messages in the mornings while going to work or performing their household tasks—for example, while grazing the livestock. The women reported that they learned and practiced the messages and recorded them in their diaries. Illiterate women sought the help of literate family members to record the messages. Most of the respondents' families supported their learning objective, which benefited the entire family by expanding their knowledge base in relation to small livestock production.

Other multimedia learning materials were shown during SHG meetings and telecast through local satellite channels run by the SHGs. Once a week, SHG members met and shared experiences. The horizontal and vertical transfer of knowledge has encouraged self-directed learning among the members (Balasubramanian, Umar, and Kanwar 2010).

Preliminary Impacts

An important contribution of L3F is that is establishes links between research and education institutions, extension organizations, and the primary stakeholders. The participatory preparation of learning materials fosters intensive interaction between all of these groups. A consortium of agricultural and veterinary universities supports the farmers' and women's groups in developing business plans and providing learning materials on seed, animals, and other subjects. The women's association assesses the problems in a particular area, aggregates the queries, and sends them through video e-mails to the universities. Designated professors in the universities provide answers through video e-mails that are stored in a digital library for farmers and others to access easily. Similarly, the FAQ system used in mobile phone-based learning is linked to the universities, research institutions, and extension organizations.

In this learning process, information flows both ways as farmers contribute their informal learning and tacit knowledge to the other partners. Through mobile phones and computers, the students and researchers interact with SHG members (farmers and women) to understand their indigenous knowledge. SHG members participate in university research by managing research plots, providing data, and in analyzing results. Undergraduate and graduate students undergo field training under the supervision of the women farmers. Universities use the distance learning materials developed by women's groups and farmer groups as reference materials for diploma courses in agriculture and horticulture.

The social capital and capacity building accumulated through L3F and the interaction it induces have led to some interesting results. Around 5,000 women and men are involved in structured learning courses through mobile phone. During 2009–11, commercial banks extended approximately US$ 1 million in credit to 2,000 L3F participants. Over the same period, the total turnover of the supported enterprises was US$ 3.14 million. The higher rate of credit repayment among L3F participants encourages support from the banks (COL 2010). Studies by COL indicate that the quality of the sheep and goat enterprises operated by L3F participants is significantly better than those of nonparticipants in the same region (Balasubramanian and Daniel 2010).

Learning through Interactive Voice Educational System

Recognizing the potential of mobile phone-based learning, COL asked the University of British Columbia to develop an audio-based Learning Management System and Learning Content Management System. The university created a prototype called Learning through Interactive Voice Educational System, which not only enables audio-based learning materials to be automated but helps process the tests, feedback, and responses through appropriate databases (Vuong et al. 2010). This system should improve quality assessment and certification in an informal learning environment.

INNOVATIVE PRACTICE SUMMARY
Innovative E-Learning for Farmers through Collaboration and Multi-Modal Outreach

The apparent limited availability of digital content relating to agricultural extension reduces the opportunity to build sustainable, digitally mediated services that bring new benefits to farmers and increase the reach of extension personnel (for example, see Balaji 2009). This gap could be overcome by developing a content aggregation system that receives and provides information in multiple modes, especially through the Internet and voice/text messaging on mobile phones.

Such information could be generated using standard validation procedures in research and education or captured from transactions (such as query response services involving farmers and experts). The same arrangement could provide additional training support to field-based stakeholders in agriculture, especially farmers. The core principle here is multi-modality in access to information and training/learning support services.

The Consortium for Agricultural Knowledge Management: Resources for E-Learning

A key initiative under the World Bank-funded National Agricultural Innovation Project in India is the Consortium for Agricultural Knowledge Management, which has been active since 2008. The initiative is built around an advanced online content aggregation system called agropedia (http://agropedia.net), which delivers and exchanges information through a web portal and mobile phone networks accessible to phones with limited or no data capability. Agropedia also provides a subsidiary platform to support online learning for agricultural extension (http://www.agrilore.org).

Agropedia was designed to overcome the paucity of useful agricultural extension information in the web space. Online discussions can be set up to support queries or validation. The platform incorporates Web 2.0 elements such as wikis, blogs, and commentary spaces and receives material in digital formats including text, still images, audio, and video. A highly targeted search engine allows users to search for content in multiple Indian languages, overcoming a serious challenge in using ICTs for development. Agropedia is already linked to the principal website of the Indian Council of Agricultural Research (http://www.icar.org.in).

Agricultural extension workers can use the agropedia platform to create their own groups of contact farmers or peers, facilitating e-learning. These groups can be sent timed SMS/text messages and voice messages, enabling specific interest groups to receive specific messages and not broadcasts. A farmer or a practitioner in the field can raise a query via voice or text. A virtual call center built into agropedia receives the query and passes it to appropriate extension workers and experts. In this way, trust and/or interest-based messaging networks can be formed and sustained.

Agropedia is an example of how a highly integrated platform can use multiple approaches to connect a spectrum of stakeholders, including research experts validating information, extension personnel in farm research stations and in the field, and farmers. Field-based producers do not need computers to connect to experts and extension personnel. Farmers with advanced practical knowledge and skills are in a position to share their tips and messages with a much wider community and can participate in discussions related to validation of particular pieces of information.

Agropedia has the equivalent of about 10,000 pages of material on 10 important crops in four languages and has close to 2,000 registered expert users. During two cultivation seasons in 2009–10, the consortium organized mobile phone contacts with about 27,000 farmers in four language regions and conducted 2.2 million SMS/voice transactions through 687 specific messages. Analysis revealed that farmers in general prefer voice as the transaction medium and that the preferred length of voice messages is about 36 seconds maximum.

The consortium is continuing into its second phase. An analysis of costs and efforts in the first phase (January 2009 to September 2010) revealed that university-based extension personnel could participate in the second phase without requiring additional staff. Since mobile phone and platform-hosting costs are low in India compared to the rest of the world, the analysis concluded that the effort can be mainstreamed as a regular activity in a typical agricultural university. The serious challenge is to strengthen ICT capacity among specialists and personnel at all levels, ranging from researchers to field-level extension workers.

Adapting the E-Learning Approach for Farmers

An important activity for the consortium is to use e-learning methods to help farmers adapt their crop management practices to cope with drought. This activity was pursued by the Adarsha Mahila Samaikhya (AMS), a community-based, all-women federation of microcredit groups (south central India) and ICRISAT, which led the agropedia consortium in 2008–10. The AMS has a membership of about 7,400 women (June 2011); almost 70 percent come from households that are below the official poverty line.

ICRISAT helped the AMS set up the basic infrastructure connecting the AMS rural operations hub to the Internet, using a low-cost landline. A number of AMS activists were trained in IT. ICRISAT research scholars functioned as trainers and remotely supported extension-related queries from farmers. The scholars escalated queries to senior scientists of ICRISAT if needed. Several AMS women activists were trained in the basics of reporting problems related to crop cultivation, using a blend of online/e-learning and direct contact.

ICRISAT scientists and scholars realized that the e-learning methods were originally designed for the classroom milieu and needed to be adapted to new learners with limited or no classroom experience. Based on advice from COL, ICRISAT developed modules based on granules of instruction (see the previous practice summary; the modules can be viewed in English at http://www.icrisat.org/vasat).

Twenty minutes was set as the maximum amount of time that a farmer would have to attain a learning outcome. Learning outcomes were defined accordingly (for example, a learning outcome in this context would be to recognize a visible symptom of a plant disease). Women farmers were trained in facilitation to help other farmers state their field problems with greater clarity. Together, these skills were developed in a group of 30 farmers using internet chat first, bolstered by regular contact sessions. Eight hours of instruction were required over four weeks on average.

Preliminary Results

The results were encouraging. With an untrained interlocutor, a farm problem received a solution from a subject matter specialist in an average of 26 hours, since the specialist needed to keep going back to the farmer for more information. With a trained interlocutor, the average time taken to identify a solution dropped to less than two hours, because the interlocutor was able to elicit important supplementary information (on rainfall, fertilizer and irrigation applications, crop variety, and so forth). With the same number of extension personnel, more problems could be resolved in the field owing to the improved skills that women interlocutors mastered through e-learning. Key granules with photos were translated by the activists into the local language (Telugu) and issued as pamphlets for distribution among the interested farmers. Over a period of two years, 15 of 30 trained activists received higher-level recognition in the form of certificates from the Indian National Virtual Academy for Rural Prosperity.

Taking this experience into account, agropedia designers developed a repository of agricultural learning objects for use in extension (http://www.agrilore.org). Three open and distance learning institutions—Indira Gandhi National Open University, Maharashtra State Open University, and the Open and Distance Learning Directorate of Tamil Nadu Agricultural University are populating this repository with about 500 granules relating to horticulture. They use this information to deliver certificate-oriented learning services to 5,000 farmers in three linguistic regions. This effort is also supported by the World Bank-financed National Agricultural Innovation Project as a separate activity.

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