Emerging ICTs and Their Potential in Revitalizing Small-Scale Agriculture in Africa

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ABSTRACT: Agriculture plays a vital role in the social and economic development of most African countries and is the main contributor to economic growth and stability. Small-scale agriculture and the harvesting of natural resources provide livelihoods for over 70% of the African population. However, most smallholders are resource-poor and face many challenges. Modern information and communication technologies (ICTs) have the potential to improve agricultural productivity by communicating knowledge and information to rural agricultural communities, providing capacity building, accessing markets and credit, restructuring of extension and scaling up inter-linkages of development interventions. This paper is based on an International Development Research Centre (IDRC) scoping study conducted in 2007 on ICTs and small-scale agriculture in Africa, which was carried out through a desk study, field observations, and individual and group interviews in Botswana, Ghana, Kenya and Uganda.

Resumen: La agricultura cumple una función vital en el desarrollo social y económico de casi todos los países de África, y es el sector que más aporta al crecimiento y a la estabilidad económicos del continente. La agricultura en pequeña escala y la recolección de productos derivados de los recursos naturales le permiten ganarse la vida a más del 70% de la población africana. Ahora bien, los pequeños agricultores disponen de pocos recursos y se enfrentan a muchos retos. Las modernas tecnologías de la información y la comunicación (las TIC) tienen la capacidad de mejorar la productividad agrícola porque comunican conocimientos e información a las comunidades agrícolas del sector rural, promueven el desarrollo de capacidades, dan acceso al mercado y al crédito, reestructuran la extensión rural, y expanden las interconexiones propias de las intervenciones del desarrollo. Este trabajo se basa en un estudio de posibilidades realizado en 2007 por el Centro Internacional de Investigaciones para el Desarrollo (IDRC, del inglés) sobre las TIC y la agricultura de menores recursos de África, en el que se hicieron un estudio de oficina, observaciones de campo, y entrevistas a individuos y a grupos en Botswana, Ghana, Kenia y Uganda.

Introduction

The agricultural sector has been described as the engine for economic growth and improved livelihoods in Africa (World Bank, 2006b; Diao et al., 2007). The majority of the population in Sub-Saharan Africa (SSA) lives in rural areas and depends directly or indirectly on agriculture (Diao et al., 2007). Agriculture contributes about 17% to the Gross Domestic Product (GDP) of many of these countries and accounts for 40% of their exports, apart from contributing to employment creation. According to the United Nations Development Programme (UNDP) (2005), about one-third of the continent’s population is malnourished. Africa is the only continent where food production is falling, which makes the challenge of attaining the Millennium Development Goals (MDGs) and the World Food Summit (WFS) goal to reduce the number of hungry people from 790 million to 400 million by 2015 even more daunting.

Most of the food grown in Africa is produced by smallholders. Small-scale agriculture and the harvesting of natural resources provide livelihoods for over 70% of the African population. Some 70–80% of this population lives in rural areas and farmers are predominantly women. Small-scale farmers have certain defining characteristics: they derive their livelihood from holdings of less than 2–5 hectares (usually less than 2 hectares) and typically own 10–20 head of livestock, although they may have less than 2 or none at all (Hirst et al., 1988). Small-scale farmers also tend to practice a mix of commercial and subsistence production (in crops and/or livestock). The family provides the majority of labour, while the farm provides the principle source of income (Narayanan and Gulati, 2002; Davis, 2006).

To improve productivity, these smallholders need access to improved technologies, best practices, and to appropriate, timely and comprehensive information and knowledge on production, value addition and markets.
The Food and Agriculture Organization of the United Nations (FAO) (2000) asserts that “information and knowledge play a key role in ensuring food security and sustainable development”. Thus, Information and Communication Technologies (ICTs) are considered to be cross-cutting drivers of change for rural and agricultural development, by connecting rural and remote communities, and improving healthcare, education and agricultural productivity (Richardson, 1997). ICTs can, for example, speed up the extension of development services, and can be instrumental in strengthening partnerships and in providing a framework for shared learning (Van Audenhove, 2003). A networked information economy helps to achieve competitiveness, and although it cannot in itself solve poverty, hunger and disease, it provides new avenues for cultural production, creates new economic opportunities, and facilitates the sharing and dissemination of scientific outputs and innovative linkages between farmers, scientists and other actors (Benkler, 2006). It is not surprising, therefore, that ICTs have led to increased use of a networked information environment and the development of platforms for better sharing and exchange of information and knowledge.

The International Development Research Centre (IDRC) has recognized the importance of small-scale agriculture in Africa and noted that relatively little attention had been paid to the potential benefits in the broader use of ICTs to small-scale agriculture. As a result, the IDRC commissioned a scoping study on ICTs and small-scale agriculture in Africa in 2007, to provide an overview of emerging issues and document on-going ICT initiatives. This paper reports on the scoping study and examines the challenges faced by small-scale farmers and the potential of emerging ICTs in revitalizing small-scale agriculture in Africa.

**Methodology**

The study was carried out through a desk review of secondary sources of information covering small-scale agriculture and a wide range of ICT-related experiences and initiatives. Primary data was collected through field visits to institutions in Botswana, Ghana, Kenya and Uganda. During the field visits, observations were made at sites where specific initiatives were being implemented. Individual and group interviews were held with key informants in the agricultural sector. Where it was not possible to have face-to-face interviews, a checklist was e-mailed to respondents and responses returned by e-mail, or interviews were conducted using telephone and Skype. Among the criteria used to select the countries to be visited was the presence of regional and national initiatives in a country. The study population comprised the technical staff of local, national, regional and international institutions and development partners working in the agricultural sector and applying ICTs in Africa. One major limitation of the study was its broad geographical coverage. The general focus for the study was rural Africa and in particular Sub-Saharan Africa. However, due to time and resource constraints, field visits did not cover Francophone West Africa and North Africa. In sum, 40 institutions and 66 respondents provided feedback; 62% of the respondents were male and 38% were female.

**Findings and Discussion**

Small-scale farmers in Africa face many problems that are often complex and multi-faceted. One of the most pronounced challenges facing small-scale farmers is farm size, which has been declining over time. As a result, rural people have insufficient land to make a living (Jayne, 2001). Some rural community members are landless or near landless, leading to major social and economic problems. The small size of their lands leads to diseconomies of scale, and since most small-scale farmers are resource-poor, they find it difficult to access affordable credit and inputs for their produce. Most of these farmers have little experience in produce marketing (Mukhwana, Nyongesa and Ogemah, 2005), and lack access to good and efficient markets (Arua, 2007). Typical problems faced by these farmers include very high transport and transactional costs, small inefficient markets, low agricultural productivity, low levels of irrigation and erratic rainfall, vulnerability to high seasonal and inter-annual fluctuations, high rates of evapo-transpiration and very slow adoption of new technologies. Problems of this nature make the smallholder farm ‘the global epicentre of extreme poverty’ (UNDP, 2005). Further, ‘of the roughly 850 million people living in chronic hunger, smallholder farmers constitute half’ (FAO, 2004, cited in UNDP, 2005). Consequently, they cannot re-invest and continue to face the demands of declining production and productivity.

National policies have not adequately addressed the needs of small-scale farmers. According to the Chief Executive Officer of Farm Africa (2002), often ‘there is a failure to listen to small-scale farmers and also a failure in government policy to support commitments to international development.’ The Economic Commission of Africa (ECA) (2006) cites problems of weak backward and forward linkages between agriculture and other sectors. In addition, small-scale farmers contend with inadequate subsidies and unfair trade (Karaan, 2006), limited access to animal and mechanical power, reduced availability of labour due to rural-urban migration, weak information systems, a poor regulatory framework that does not facilitate investment and specialization in new and high value products, inadequate market information and a lack of agricultural information (Kidane, Maetz and Dardel, 2006). Further challenges include low uptake of research products, counterproductive policies and insufficient investment in market infrastructure (Jones, 2006).
Other more systemic factors include conflicts and disasters (Bunders and Broerse, 1991), under-investment in rural areas, limited access to improved technologies, weak infrastructure, high production costs, the HIV/AIDS pandemic, loss of biodiversity, and dependency on foreign aid. Institutions in Africa also suffer from a lack of adequate systems and capacity to share and disseminate essential outputs to small-scale farmers (Madukwe, 2006; Richardson, 2006). Kidane, Maetz and Dardel (2006) also note that ‘unless SSA countries create conditions for smallholder farmers to improve their labour productivity through technological change and enhanced capital assets, and/or invest in the development of labour-saving technologies, it is difficult to envisage a significant production increase through area expansion’.

In addressing these issues, many emerging technologies are being examined for their potential in transforming agricultural development in Africa. As outlined below, the use and application of modern ICTs could occupy a pivotal position in this line of engagement, especially in the context of small-scale agriculture. Suggestions from the respondents in the study tackled many of the problems highlighted above, including concentrating on high-value agricultural (HVA) products, focusing on improvement in productivity, considering the options for commercial agriculture, paying increased attention to new markets and marketing strategies, and increasing agricultural production through biotechnology. Some of the emerging ICTs that were identified include Geographic Information Systems (GIS) and decision support systems, mobile mapping and hand-held personal computers (personal digital assistants/PDAs), precision agriculture and mobile (cellular) phone applications, community radio stations, radio frequency identification tags, WorldSpace satellite radio, and more generally, access to the Internet and web-based applications.

**GIS-based Decision Support Systems** – A Geographical Information System (GIS) makes visual comparisons between different types of data possible. It helps to establish relationships between different data sets and is important in the production of maps, charts and additional information associated with coordinates and time. It also helps in the analysis of post harvest variation in crop yield measures, and provides a holistic view of the production system. In Africa, GIS has been applied in a number of initiatives. The International Livestock Research Institute (ILRI) has used GIS technology to map fences in its livestock-wildlife ecosystem initiative. In South Africa, the Gender, Agriculture and Rural Development in the Information Society (GenARDIS) project has used GIS applications in natural resources management in the Roobos tea lands and in exploring the spatial dynamics of gender in rural areas.

Mobile mapping is a component of GIS systems that enables the collection of field data, including unique geospatial time tags and attributes, for integrating into and/or updating a GIS (GIS Development, 2006).

**Handheld Personal Computer (HPC) or Personal Digital Assistants (PDAs)** – HPCs are small, light, and robust and have been used to provide access to information, mobile mapping and other data gathering tools (GIS Development, 2006). The International Small Group and Tree Planting Alliance (TIST) is training farmers involved in community-based reforestation projects in Kenya and Uganda to use PDAs and Global Positioning System (GPS) technology to gather reforestation data, which is then uploaded to an online database. In Tanzania, the Family Alliance for Development and Cooperation (FADECO) is using PDAs to access agricultural information, while Manobi in Senegal has developed a platform of services through which fishing professionals can access fishing-oriented or sea safety-oriented data and information using PDAs. This reduces the need for face-to-face contact and reduces telecommunication and transport costs.

**Mobile (Cellular) Phone Applications** – The cellular phone has provided market links for farmers and entrepreneurs. Growth in mobile phone usage in SSA has been explosive and now reaches more than a third of the population. This has reduced transaction costs, broadened trade networks and facilitated searches for employment (Guilain et al., 2006). Bertolini (2004) observes that the ‘telephone is the only ICT used (if any) by the majority of farmers in Africa’. Some of the respondents in the study considered cellular phone applications, such as the Short Message Service (SMS), to be one of the most important emerging ICT applications in Africa.

In Kenya, the National Agricultural and Livestock Extension Programme (NALEP) recently launched a telephony information service, the National Farmers Information Service (NAFIS), which provides extension information to farmers in English and Kiswahili using audio format (NALEP, 2008). Other cellular phone applications include the provision of market information and electronic trading platforms, where farmers and traders access information on commodities being sold, their prices and the identity of their buyers and extension messages, such as Tradenet.biz. In Senegal, women are using telecentres linked to the Internet via mobile phones to access market prices (Hafkin and Odame, 2002). The mobile phone is also used as an electronic money transfer channel. For instance, the M-Pesa service in Kenya is an affordable and speedy option for money transfer from one person to another, using SMS. In essence, the phone subscription acts as a bank account and a debit card and is being used in the agricultural sector to pay farm workers and purchase farm inputs.

Mobile phone technology can also support other voice, image and video applications. In Kenya, the Kenya Agricultural Commodity Exchange (KACE) is collaborating with a local company to offer market information through Interactive Voice Response (IVR), a service that uses voice mail for information delivery. In Senegal, farmers can subscribe to real-time information...
on agricultural and fish prices via their cell phones. Likewise, fishermen in Ghana and in other parts of the continent are using mobile phones to communicate information on where to fish and to obtain information on prevailing weather conditions and prices. Farmers, however, experience challenges with mobile phones due to lack of infrastructure such as the electricity needed to charge phones.

**Community Radio Stations** – Radio is an important mechanism for disseminating knowledge and information in different languages and formats (Girard, 2003; Illbudo, 2003; Bobbili et al., 2006), especially to poor people (Harris, 2004). Kweku’s (2006) findings indicate that radio is the most highly used media in accessing development and agricultural information. Following the liberalization of airwaves in most African countries, there has been a mushrooming of radio stations, many of which facilitate agricultural marketing and dissemination of market information. In Zambia, the Radio Farm Forum (RFF), a government initiative, has shown that radio is important in addressing the common needs and problems of resource-deficient rural farmers by giving them an opportunity to listen to a radio discussion programme on agricultural problems and techniques (Bobbili et al., 2006). The convergence of ICTs, such as the Internet with rural radio, can provide powerful support to help harness and communicate knowledge for development. KACE for example has developed Soko Hewani (supermarket on air) that uses FM radio and cellular phones to connect to an electronic trading floor.

WorldSpace satellite radio enables rural communities to download development content where there is no Internet connectivity. It has been used by non-governmental organizations (NGOs) in Africa, to upload and download agricultural and development content.

In recent years, the United Nations Educational, Scientific and Cultural Organization (UNESCO) has provided support to a number of community radio stations in Africa. The Panos Institute of West Africa (PIWA) produces and distributes programmes through a website that is a cost effective alternative to shipping CD-ROMs, cassettes and mail. It also provides training and technical assistance to radio stations. Radio stations are able to upload and download programmes free-of-charge in ten Francophone West African countries (Attias and DeFlander, 2003). The Technical Centre for Agricultural and Rural Cooperation (CTA) also gives support to national and regional African, Caribbean and Pacific (ACP) rural radio producers. Support ranges from developing curricula to providing training in how to produce rural radio packs on agriculture. Other development agencies that support rural radio programmes include the FAO and Farm Radio International.

**Radio Frequency Identification (RFID)** – RFID can be used to capture data on individual livestock that is then transmitted to a central database as part of a repository of information for livestock farmers, state veterinary services and health authorities. RFID has been used in Botswana, Namibia and South Africa for livestock identification purposes under the livestock information trace back system in compliance with new regulations required by the European Union.

**Internet and Web-Based Applications** – The Internet, e-mail, websites and web-based applications are becoming increasingly important in sharing and disseminating agricultural information and there are many ongoing web-based application initiatives in Africa. The FAO and partners are implementing e-Agriculture, an initiative aimed at the intersection of agricultural informatics, agricultural development and entrepreneurship, focusing on agricultural services, technology dissemination and information delivered through the Internet. e-Agriculture is intended to promote the integration of agricultural stakeholders and technology with multimedia, knowledge and culture, and aims to improve communication and learning processes (FAO, 2006).

In Uganda, the Agricultural Research and Extension Network (ARENET) uses a web portal to provide information services and a question-and-answer service to small-scale farmers. Internet cafes, telecentres, information kiosks, and market information centres have attracted the attention of rural information brokers who disseminate agricultural information on the web. Also in Uganda, the Collecting and Exchange of Local Agricultural Content (CELAC) project has developed a web-based platform that facilitates the sharing of local agricultural knowledge using various ICTs. The project targets female farmers and has established resource centres with ICT facilities for farmers to ask agriculture-related questions using Yahoo and Skype and to engage in conferencing. In Kenya, the government is establishing digital villages that will make it possible for rural communities to access government services and development information and knowledge, including agriculture.

**Precision Agriculture (PA)** – PA has been described as the ‘next great revolution in agriculture.’ PA is also known as ‘precision farming, information-intensive agriculture, prescription farming, [and] target farming’ (Srinivasan, 2006). Taylor and Whelan (2005) define PA as ‘an integrated information and production-based farming system that is designed to increase long-term, site-specific and whole farm production efficiency, productivity and profitability, while minimizing unintended impacts on wildlife and the environment.’ PA has ‘the ability to manage land by the square meter instead of the square mile’ (Rasher, 2001). It adapts to variability: spatial — changes across farm; temporal — season to season; and predictive — difference between predicted and actual results (Wikipedia, 2006).

Through PA, local situations can be assessed to enable a farmer to optimize use and vary the rate of inputs, such as fertilizer, across a field based on the need identified by GPS guided grid sampling. Satellite positioning and navigation have played a catalytic role in the evolu-
tion of PA. The technology encompasses four key information technologies, namely location determination (via GPS), GIS, computer-guided controllers for variable rate application (VRA) of crop inputs, and sensing technologies for automated data collection and mapping. Among the four, GPS and GIS have been more widely established and used (Swinton and Lowenberg-DeBoer, 2001). PA has been used to increase yields for row crops, hay production, pasture management, animal grazing and other agricultural activities (GIS Development, 2006; Jarfe and Werner, 2006). PA also has the inherent capacity to provide an effective forum for disseminating research and experience and for assessing natural resources variability such as soil and landscape variability, weather forecasting and remote sensing.

PA has been unevenly adopted in developed countries, and is virtually unknown in Africa, except in South Africa, Mauritius, Sudan and Zimbabwe. The Mauritius Sugar Industry Research Institute (MSIRI) has adopted PA at an experimental level in sugar cane production. The result has been improved management of cane loading operations, avoidance of overloading and over-spilling, improved transport scheduling of trucks and verification of contractual work (Autrey, Ramasamy and Ng Kee Kwong, 2006; Jhoty and Autrey, 1998). Farmers in South Africa are using an aspect of PA for irrigation using ground water, and this has ensured a sustainable and efficient system based on soil type, soil water capacity, potential yield and topography (Dennis and Nell, 2006). In Sudan, an international company is working with ASBNACO -a Sudan-based company that manages the Agadi Farm -and the Arab Authority for Agricultural Investment and Development (AAAID), to introduce the use of an autosteer tractor, fitted with a GPS satellite guidance system that controls tractor steering. This has helped improve farm productivity while conserving the environment and has reduced planting time on the farm by 60%.

Due to the high levels of investment required, most PA applications have been undertaken on large-scale farms, where labour is more expensive but land and capital are less costly. Although PA has been adopted by some small-scale farmers who use it routinely, a key limiting factor of this technology is the funding required for the high-tech farming applications, which is beyond the financial reach of most African small-scale farmers (AAAID, 2006; Howcroft, 2006). The use of PA by Zimbabwe's Nemakonde Agricultural Development Company (NADC) provides various sophisticated agricultural services including differential GPS land mapping, soil sampling and variable application of soil nutrients and lime. In addition, more accurate information was available to guide decisions made by local agronomy services, such as fertilizer recommendations (Nell, Maine and Basson, 2006).

Distance Learning – As mentioned above, distance education modules on farming practices can be delivered using audio/radio, web-based means, CD-ROM, video and print format. The use of these different media has been promoted under the Collaborative Electronic Records Project (CERP) (Pye et al., 2003). In Burkina Faso, the Manegbzanga Association has introduced Agriflash, which provides TV viewers with content on agriculture-related topics.

Conclusion

Interest in ICTs has grown steadily in Africa but weak ICT policies and poor implementation capacity are among the biggest obstacles to wider use (Guislain et al., 2006). May, Karugia andNdokweni (2007) add that one of the key factors affecting the use of ICTs in agriculture is inappropriate ICT policies, especially those that address rural communities and rural development. Sustainability is another key requirement for the use of ICTs, yet according to Kalusopa (2005), most ICT initiatives were project-based, and were disjointed and uncoordinated. The further use of ICTs calls for good ICT infrastructure, adequate ICT skills, good and affordable connectivity, and appropriate ICT policies (Maru, 2004; Richardson, 2006). In addition, there is a need for high bandwidth (Heeks, 2007).

Despite these challenges, there has been a massive rollout of basic information communication infrastructure in Africa. This has been spurred in part by the introduction of cellular technology, which has reduced subscriber costs. African governments have also continued to support ICT initiatives in under-served areas by offering incentives to the lowest competitive bidders for infrastructure provision. A number of countries are also making use of universal access funds that are meant to develop disadvantaged areas (World Bank, 2006a).

Findings of the present study have shown that radio stations and the cellular phone have become important tools in improving small-scale agriculture in rural areas. The Internet and web-based applications are becoming increasingly important in the sharing and dissemination of agricultural information and knowledge and the marketing of goods and services. The livelihoods of farmers could be enhanced through adoption of modern technologies such as PA, online markets and the application of appropriate ICTs in information and knowledge dissemination. Respondents of the study suggested the creation of ‘one-stop centres’ for training and for linking farmers to markets, and restructured extension services that target farmer groups to improve agricultural production and assist in the exchange of knowledge and information. However, the study established that there is low capacity and usage of ICTs and the ICT infrastructure in rural areas is a major problem. These challenges and their causes need to be addressed if ICTs are to benefit the small-scale farmer in Africa.
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