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Facilitating agricultural technology adoption among the poor: The role of service delivery through mobile phones

Heike Baumüller

List of Figures and Tables

Abstract

The use of mobile phones in poverty reduction and development has ignited much interest over the past decade. To take advantage of the rapid expansion of mobile phones in developing countries, businesses, government agencies and non-governmental organisations are increasingly turning their attention to the delivery of services through mobile phones in areas such as health, education and agriculture. This paper examines how such m-services could be and are already being used to facilitate agricultural technology adoption among farmers in developing countries, including accessing, using and generating income from new technologies. The paper argues that m-services could help to overcome some of the obstacles to technology adoption by facilitating access to information and learning, financial services, and input and output markets. Existing studies assessing the impacts of mobile phones already point to the potential benefits for poverty reduction and rural development. However, there is a risk that the poorest and marginalised may fall behind. Further research is needed to understand how their particular challenges could be addressed through m-services and other support activities, and how they might become active players in the demand for m-services. Such research will need to draw on various disciplines to allow for an analysis of the economic, social and biophysical dimensions of the users, farming contexts and technologies.

Keywords: mobile phones, m-services, agriculture, technology adoption, poverty

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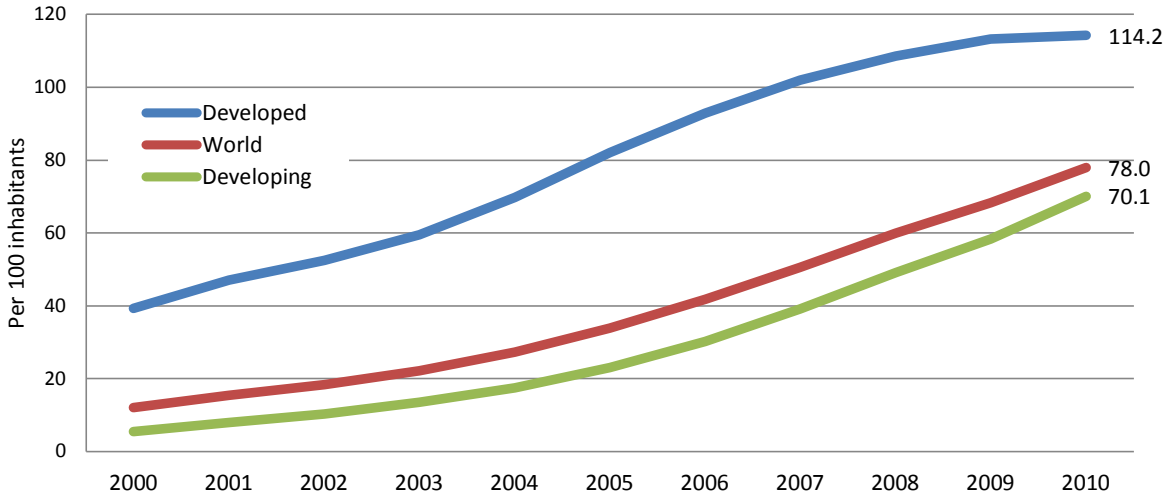
1 Introduction

The use of mobile phones in poverty reduction and rural development has ignited much interest over the past decade. Mobiles have become the most ubiquitous telecommunication technology in developing countries where subscription rates have soared from 250 million in 2000 to 4 billion a decade later (ITU 2010). By 2010, subscribers from developing countries accounted for around three quarters of the 5.4 million global subscriptions, up from a third in 2000 (ibid). This rapid growth was made possible through falling handset prices and calling rates, the introduction of pre-paid mobile phones packages and the expansion of networks into rural areas. While users in Africa initially included mainly male, educated, young, wealthy and urban populations, the share of poor, elderly and rural individuals has also been increasing (Aker & Mbiti 2010).

Despite the recent expansion, mobile telecommunication markets in developing countries continue to offer significant business opportunities. On average, subscription rates in 2010 were still lower than in industrialised countries (Figure 1) and phone sharing remains widespread, thus leaving significant room for growth. Mobile broadband usage is still very low, but expanding rapidly as the most widely used technology for accessing the internet in many developing countries. In response, businesses are aggressively moving into emerging markets. Mobile network operators such as Vodafone, Orange, Tigo and Bharti Airtel can now be found all over Africa while mobile phone manufacturers such as Nokia and Huawai are offering locally adapted mobile handsets.

Figure 1: Mobile cellular subscriptions per 100 inhabitants (2000-2010)



Source: ITU World Telecommunication /ICT Indicators database

As more and more people gain access to mobile phones (even if they do not own them), companies, government agencies and non-governmental organisations are turning their attention to the delivery of services through mobile phones (also referred to as 'm-services' in the context of this paper). The German business software company SAP, for instance, is piloting supply chain management systems for small producers in Ghana, Nokia and Reuters Thomson are delivering information services to mobile phones users in India, and Google is linking buyers and sellers through mobile and internet-based platforms in Uganda. In addition to international companies, smaller local businesses are also starting to deliver services in sectors such as health, education and agriculture, supported by emerging innovation hubs in several developing countries. In the longer term, many of these services are envisaged to function as self-sustaining enterprises that can also service the poor rather than having to rely on donor funding.

Developers are increasingly making use of new technology trends (Bughin et al. 2011) to develop and deliver such m-services, complementing existing mobile technologies such as SMS and voice calls. The growth of cloud computing, for instance, allows for the storage of large amounts of audio, text or image data which can then be accessed through searchable databases. Also, through 'distributed co-creation' mobiles and other information and communication technologies (ICTs) help to engage users to improve service delivery, such as mobile phone surveys among farmers to report on the performance of agricultural extension services. Moreover, the so-called 'Internet of things', where sensors and actuators are linked through networks, are slowly finding applications in his area, such as crop insurance pay-outs via mobile phones triggered by weather sensors.

This paper explores the emergence and impact of mobile phones and m-services in the area of agriculture. It examines how m-services could be and are already being used to facilitate agricultural technology adoption among farmers in developing countries, including accessing, using and generating income from the technologies. The paper argues that such services could help to overcome some of the constraints to agricultural technology adoption faced by poor farmers, including access to information and learning, financial services, and input and output markets. The paper goes on to review existing evidence on the impacts of mobiles and related services in developing countries and assesses the particular challenges for the poorest and marginalised to benefit from mobile phones and m-services.

2 Agricultural technology adoption

2.1 Definitions and theory

The paper focuses on the adoption of new agricultural technologies and diffusion of these technologies among communities. In this context, agricultural technologies include both physical objects such as seeds or fertilizer, as well as new farming methods. The technology may not be new as such, but novel to the farmer. Thus, following Rogers (2003), a new technology (or innovation) is defined as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (p.12). Rogers (2003) identifies two characteristics of innovations (from the perspective of the farmer) that best explain different adoption rates, i.e. the perceived *relative advantage* of using the technology vis-à-vis the technology it supersedes, and its perceived *compatibility* with existing values, needs and experiences (Rogers 2003). In addition, Rogers notes that innovations are more likely to be adopted if they are less complex, lend themselves to trialling and whose results are observable to others.

Adoption of a technology may be measured by "both the timing and extent of new technology utilization by individuals" (Sunding & Zilberman 2001, p.229). *Diffusion*, in turn, is defined as "the process in which an innovation is communicated through certain channels over time among the members of a social system" (Rogers 2003, p.5). The timing of adoption and diffusion can be split into three levels, i.e. the decision process of the farmer whether to adopt or not (or to abandon a technology once adopted), the innovativeness of the farmer in terms of when to adopt in the diffusion process, and the rate at which a technology is adopted in the system (Rogers 2003). The extent of adoption can be measured by intensity of cultivation e.g. in terms of number of farmers, total area, area within farms or harvest (CIMMYT 1993).

Two main strands of technology adoption research have emerged (Marra et al. 2003). Sociologists have traditionally focused on the characteristics of the adopters, their perceptions of the innovation, adoption rates and communication channels in the decision process. Zvi Griliches' seminal study of the diffusion of hybrid corn in Iowa was one of the first economic studies in this area which shifted the emphasis towards economic variables as the most important determinants of technology adoption (Griliches 1957). Since the 1960s and in particular since the publication of the Griliches

studies, S-shaped diffusion curves have become widely used (Sunding & Zilberman 2001). According to this theory, innovations are first adopted by a few early adopters. Then adoption rates accelerate as the majority adopts the technology before it gradually slows again as fewer and fewer remaining individuals adopt the innovation (the so-called 'laggards') (Rogers 2003). In this context, diffusion studies have focused on the differences between early and late adopters, the perceived attributes of an innovation that affect its rate of adoption and why a critical mass of early adopters is needed for an innovation to become widespread (ibid).

Experience has shown that a new technology may not be appropriate in every context, but rather its suitability depends on how well it fits the particular farming context (CIMMYT 1993). However, much of the focus of the adoption literature has been on the individual farmers (e.g. the attitude or personality of the farmers or their socio-economic characteristics, such as wealth, landholding or education) and the characteristics of the technologies, rather than the context in which technology adoption and diffusion takes place (CIMMYT 1993; Marra et al. 2003). Similarly, during the Green Revolution only limited attention was paid to the complexity and diversity of the farmer's physical, economic and social environment while more recently attention has been shifting towards a focus on farming systems (Barker et al. 1985).

It is also important to note that the adoption process is a dynamic one, not only in terms of the diffusion of new technologies over time and space, but also from the perspective of the individual farmer. As a result, the willingness and ability to adopt new technologies, the relative weight of the influencing factors and the associated needs for support may change over time. For instance, the willingness to adopt may change with age and experience (CIMMYT 1993). Older farmers may be less willing to invest in technologies that only pay off in the longer term (Feder & Umali 1993), but may also have more resources to invest in new technologies. Younger farmers on the other hand may be more educated or be more open to trying out new technologies. Moreover, farmers often modify their perceptions of the riskiness of new technologies over time as they acquire more information (O'Mara 1980 cited in Marra et al 2003).

Also, adoption is not necessarily a binary decision. Rather, the intensity of adoption may change over time, e.g. as a result of learning or through better access to farm resources. Some technologies may also be abandoned again (CIMMYT 1993). There is also some evidence of a 'technological ladder'. Kaliba et al. (2000) note that the majority of adoption studies had found that smallerholder farmers tended to adopt simple technologies first before moving on to more complex ones, while cheaper technologies may be adopted before the more expensive ones. Moreover, over the past two decades researchers have been increasingly recognising the need to look at agricultural technologies as a package where farmers may adopt components at different times and speeds (Feder & Umali 1993).

2.2 Factors influencing agricultural technology adoption

This paper examines the agricultural technology adoption process from the perspective of the farmer, looking beyond the initial decision to adopt (or not) to also incorporate the farmer's effective and profitable use of the technology. To this end, the process is divided into three stages:

1. Obtaining **access** to the technologies requires knowledge of the existence of the technology, the ability to assess its suitability for the farming system as well as potential risk, and the ability to obtain and finance the technologies.
2. To be able to **use** technologies, farmers need to have the necessary knowledge of how to us them, the ability to use them (e.g. sufficient labour or other resources) and the ability to manage any associated risk.
3. Finally, farmers can generate **income** if they are able to profitably sell surplus produce and save and reinvest the resulting returns.

The following section reviews some of the key enabling factors at the different stages of adoption, with a focus on those that may be most easily supported by mobile phone-enabled services (see also Figure 2 in Section 3.2 for a summary). Examples of existing m-services that could support technology adoption at the various stages are provided in Section 3. In general, factors that will influence a farmer's ability and willingness to adopt agricultural technologies involve both farm-specific aspects (i.e. the characteristics of the farmers and the resources at their disposal) and circumstances related to the biophysical and socio-economic context of the farming operation. Technologies may at times be rejected not because of their intrinsic qualities, but rather because they are not compatible with these factors (CIMMYT 1993).

2.2.1 Accessing agricultural technologies

Information regarding the existence of (new) agricultural technologies is of course a prerequisite for technology adoption. Such information can be obtained from various external sources, such as extension agents, fellow farmers or different media such as mobile phones, TV or radio.

Importantly, farmers will also require the necessary **information to assess the suitability of the technology for their farming system and to understand the potential risks** associated with the use of the technology.[1] For instance, farmers may be uncertain about the profitability of the new technology or differences in economic returns between new and old technologies. Such uncertainties may arise due to insufficient knowledge about yields of new technologies, the types and costs of needed inputs, or expected market prices and demand for the produce (Abadi Ghadim & Pannell 1999). Weather conditions and climatic shocks also increase uncertainty and risk, in particular among subsistence farmers who are dependent on rainfall (Kaliba et al. 2000).[2]

Searching for this information can be costly. A study in Sri Lanka found that the information search costs amounted to around 70% of transaction costs among smallholder farmers (de Silva & Ratnadiwakara 2008). Searching for information at the decision stage – i.e. when deciding which crops to grow, how much land to allocate and how to finance the production – was found to incur the second-highest share of information search costs (24%) after search costs incurred during the growth stage (53%).[3] These costs included visits to meet other farmers, arranging loans with finance institutions and renting land from other farmers.

Information from *external sources*, such as agricultural extension agents, m-services, radio, TV or newspapers, can play a central role in the assessment of suitability and risk of a technology. A study of maize adoption in Tanzania, for instance, showed that high intensity of extension services was one of the major factors positively influencing the adoption of improved seeds (Kaliba et al. 2000). Farmers may also gather information through *experimentation* ('learning by doing'). Evidence suggests that imperfect knowledge of the technology as a barrier to adoption decreases with experience (Abadi Ghadim & Pannell 1999; Foster & Rosenzweig 1995).

Alternatively, farmers may also *learn from others* who are already using the new technology. Foster and Rosenzweig (1995) found that farmers with experienced neighbours were more likely to devote more land to new technologies. Vicinity alone may not be sufficient, however. Rather, farmers

[1] See Marra et al. (2003) for a review of theoretical and empirical literature on the role of risk and uncertainty in technology adoption decisions.

[2] Another influencing factor in technology adoption is the farmer's attitude to risk. In this context, the farmers' attitude to risk – i.e. whether they are risk averse, risk neutral or risk preferring – is an important determinant for their willingness to adopt new technologies (Marra, Pannell, and Abadi Ghadim 2003).

[3] de Silva and Ratnadiwakara (2008) note, however, that information search costs during the growth stage are influenced by the particular context of Sri Lanka and are likely to be lower in other countries.

appear to learn through more limited social networks that are not based only on geographic proximity (Conley & Udry 2001). As explained blow, mobile phones have been found to help maintain and strengthen such social networks.

Access to **financial resources and services** is another important enabling factor for technology adoption, in particular where financial capital is required to obtain the technologies and associated inputs. Wealthier farmers or those with off-farm income may be more willing to bear the financial risk in case the technology does not perform well (CIMMYT 1993; Kebede 1992 cited in Marra et al. 2003). Financial resources may also be available through *loans*. In particular in the case of smallholder farmers, limited access to credit may provide an important constraint to technology adoption as lenders may be unwilling to bear the high transaction costs of small disbursements (Poulton et al. 2006). Also, the seasonality of agriculture and climatic variability can hinder regular repayments. At times, access to credit may also be linked to the use of particular inputs, thus limiting technology choices (CIMMYT 1993).

Banking facilities offered through bank branches or mobile banking can enable technology adoption by offering *transmission services* to pay for agricultural technologies or inputs, or to repay loans (Poulton et al. 2006). Famers may also be more willing to adopt new technologies if their financial risks were reduced through *insurance schemes* to protect against crop failure e.g. due to drought or floods. Insurance schemes for smallholders are subject to similar challenges as credit, however. In particular monitoring and paying out dispersed and small insurance claims can be costly for the insurer (Poulton et al. 2006). As elaborated below, a number of innovative m-services are starting to be developed which aim to overcome these challenges through the use of weather stations and m-payments.

2.2.2 Using agricultural technologies

Farmers require the necessary **knowledge and information to use technologies**. Some studies have found the adoption of new technologies to be positively correlated with the farmer's level of education (Feder & Umali 1993). This factor is likely to play a more important role the more complex the technology (CIMMYT 1993). In addition to schooling, farmers will also benefit from the skills to use the technology that may be acquire in the course of their life through learning (Marra et al. 2003). As mentioned above, sources of information and learning can encompass external sources (including m-services), experimentation and learning from others.

Moreover, use of the technologies will require **additional farm resources**, such as labour, machinery, seeds, fertiliser, pesticides, energy, storage facilities and irrigation. Accessing these resources will need well-functioning labour and input markets which can be a serious constraint in particular in remote areas. Also, where input demand is seasonal and small-scale, there may not be enough incentive to develop the necessary market infrastructure (Poulton et al. 2006). Collective purchasing of inputs, for instance through farmer organisations facilitated by mobile phones and related services, could help to address these shortcomings by creating economies of scale and reducing transaction costs (Poulton et al. 2006). Moreover, financial resources and services outlined in the previous section will facilitate the procurement of inputs.

The **biophysical and agro-climatic environment** can also be crucial for the success of new agricultural technologies, such as soil quality, water availability, topography, seasonal temperature changes or the presence of pests or diseases that could damage the crops. Experience has shown that these environmental factors and in particular the availability of and control over water resources are often the most important factors explaining differences in adoption patterns (as reviewed e.g. in Feder & Umali 1993, Barker et al. 1985). M-services are starting to be developed which aim to facilitate access to water, for instance irrigation pumps operated through mobiles or through m-payments for water.

Measures to **manage associated constraints and risks** can include the use of agricultural inputs, such as fertiliser, pesticides or irrigation systems. Moreover, information related to the production environment can help farmers to adjust their farming practices accordingly. Weather forecasts, for instance, can influence planting times or water usage while information on soil nutrients or disease outbreaks allows farmers to apply appropriate amounts and types of fertilisers and pesticides. Mobile phones and related services can play an important role in this regard by facilitating access to information, e.g. on weather or disease outbreaks, as well as access to inputs. Also, as noted above, financial risks can be reduced through insurance schemes.

2.2.3 Generating income from the use of agricultural technologies

The ability to **profitably sell surplus produce** for income generation will depend on good access to markets. A prerequisite is the ability to physically access different markets which depends on proximity to and the transport infrastructure to reach the market. In addition, farmers may lack information on or access to alternative buyers or markets. Many farmers in poor areas are often forced to sell their produce to middlemen or may be required to sell to their creditors at pre-arranged prices. M-services may play a role in broadening their networks and facilitating contacts.

Farmers also often lack information on current market prices to be able to negotiate better deals. Disseminating price information, for instance through mobile phones, is seen as a way of reducing information asymmetries and increasing the bargaining power of farmers. Market participation may also be constrained because larger buyers tend to favour scale and may be unwilling to pay the transaction costs associated with sourcing from a large number of small dispersed farms (Pingali et al. 2005). Social networks supported through m-services could help to create the necessary economies of scale. In addition, the trust established between buyers and sellers plays an important role in business transactions (Molony 2006).

Moreover, **savings** from the sales would enable farmers to better deal with the seasonality of agricultural income and increase the choice of when and where to purchase inputs rather than being limited to the time when income is available or to the obtain inputs from their creditor. Banking facilities can help farmers manage and earn interest on these savings. However, similar to loans and insurance, banking with small-scale farmers incurs high transaction costs due to the small-scale deposits, dispersion of the population and poor infrastructure (Poulton et al. 2006). Such services may be more profitably delivered through m-services which can be offered through small agents rather than physical banking facilities used by conventional banks.

3 Mobile phones in the rural economy and agriculture

3.1 Mobiles phones in agriculture

Several studies have identified opportunities for using mobile phones in the agriculture sector and to promote rural development. A report by Vodafone and Accenture, for instance, notes that mobile phone-enabled solutions for food and agriculture could assist producers to access financial services, obtain agricultural information, improve data visibility for supply chain efficiency and enhance access to markets (Vodafone Group & Accenture 2011) (Table 1). The greatest potential for cost savings were seen in mobile financial payments and mobile information provision. Donner (2009) distinguishes between different livelihood functions of mobile phones, including mediated agricultural extension, market information systems, virtual markets, financial services and direct livelihood support.

Table 1: Mobile-enabled solutions for food and agriculture

Improving access to financial services	Mobile payment system	Increasing access and affordability of financial services tailored for agricultural purposes
	Micro-insurance system	
	Micro-lending platform	
Provision of agricultural information	Mobile information platform	Delivering information relevant to farmers, such as agricultural techniques, commodity prices and weather forecasts, where traditional methods of communication are limit
	Farmer helpline	
Improving data visibility for supply chain efficiency	Smart logistics	Optimising supply chain management across the sector, and delivering efficiency improvements for transportation logistics
	Traceability and tracking system	
	Mobile management of supplier networks	
	Mobile management of distribution networks	
Enhancing access to markets	Agricultural trading platform	Enhancing the link between commodity exchanges, traders, buyers and sellers of agricultural produce
	Agricultural tendering platform	
	Agricultural bartering platform	

Source: Vodafone Group and Accenture (2011)

A comprehensive sourcebook on ICTs in agriculture published by the World Bank outlines opportunities for ICTs to enhance farm-level productivity, access markets and value chains, and improve public services delivery (World Bank 2011). The study sees the greatest potential for the use of ICTs in agricultural innovation systems in the pervasiveness of telecommunications networks emerging facilities for data collection and sharing through cloud computing; opportunities for public involvement in research and development; and new forms of knowledge brokering. While the focus is on ICTs more generally, much of the emphasis is on mobile phones which the study notes "are on the vanguard of ICTs in agriculture" (p6) due to the rapidly expanding telecommunications infrastructure and the availability of low-cost handsets.

Another recent study by the World Bank identifies four areas where mobile applications can promote agricultural and rural development, including better access to markets, disease and climate information; better access to extension services; better market links and distribution networks (by linking buyers and sellers, and facilitating accounting and traceability); and better access to finance, including credit, insurance and payment methods (Qiang et al. 2011). After reviewing 92 mobile applications, the study found that the majority of available services focus on providing information. Most of the applications are still at the proof of concept or scalability stage (33% and 51% respectively), while only a few are already sustainable. One of the main challenges of scaling up m-applications in developing countries was thought to be the need to provide highly targeted and granular services. Private sector engagement is also still limited. Just over half of the applications are donor-funded and only around 15% are financed from commercial or private sources.

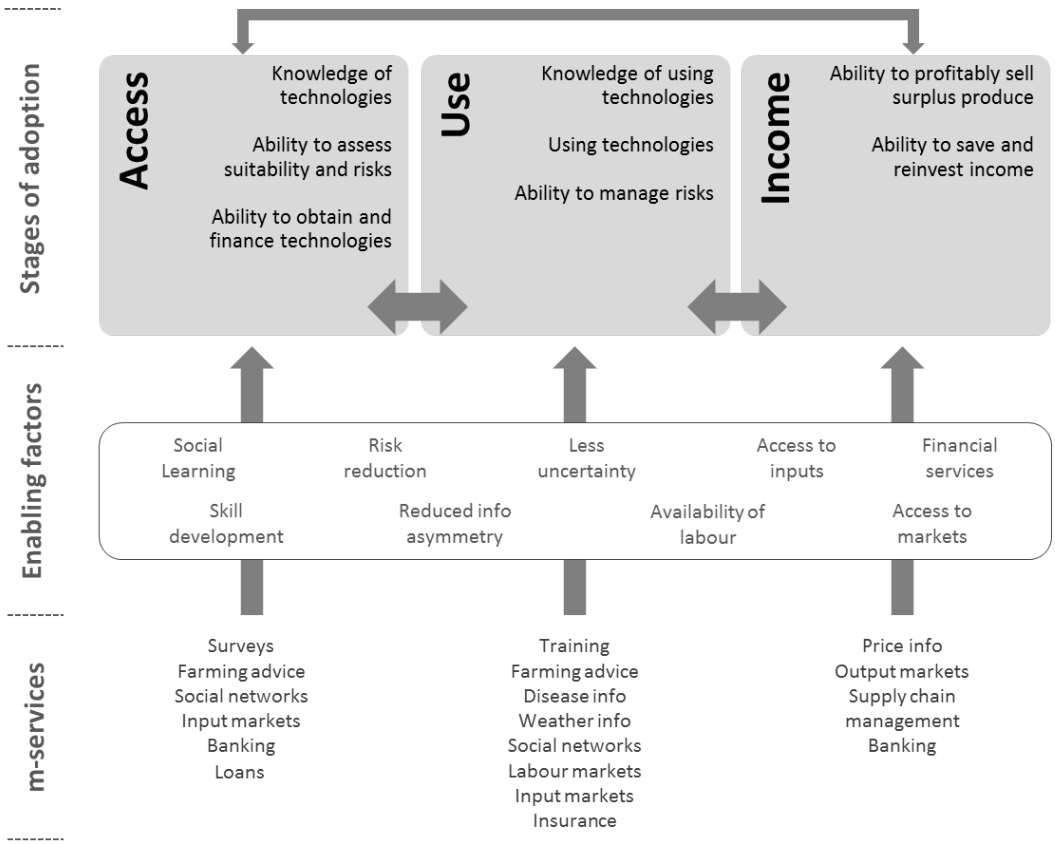
Finally, Aker (2011) examines the role of mobile phones in supporting access to information about agricultural technologies and extension services. She identifies several potential mechanisms in this context, including improving access to information from private sources or through agricultural extension services; improving the management of input and output supply chains; facilitating the delivery of other services; increasing the accountability of extension services; and increasing linkages with research systems. She also notes a number of challenges associated with the use of mobiles in agricultural extension, such as the need for literacy skills and technological knowledge, the limits of mobiles to display complex information, and technical difficulties in developing voice-based systems.

3.2 M-services facilitating agricultural technology adoption

This section examines how m-services are already being used to facilitate agricultural technology adoption (though that may not necessarily be the stated aim of the service). Different types of services may serve different needs at the three stages of adoption outlined above (see Figure 2 for an overview). For instance, a service may provide information about the availability, performance and use of a new variety, thus facilitating access to and use of the technology. This section therefore categorises m-services by the type of service they provide rather than adoption stages, with a focus on the provision of information and learning, and improved access to agricultural inputs, financial services and output markets.

While some of the m-services discussed here provide only one service, many are recognising the need for more comprehensive applications with complementary functions. Different types of information are often combined in one service such as market prices, farming advice, weather or disease outbreaks. Moreover, information services are increasingly being offered in combination with other m-services such as virtual markets (e.g. *M-Farm*, *Esoko* or *iCow*), supply management systems (*Star Shea Network, African Cashew Initiative*) or micro-loans (*Star Shea Network*). Such integrated services are useful to enable farmers to apply the information they receive and thereby support technology adoption at different stages (Gakuru et al. 2008).

Figure 2: Facilitating agricultural technology adoption through m- services



3.2.1 Information and learning

In general, mobile phones can reduce information search costs, e.g. for jobs, input and output prices, or potential buyers and sellers (Aker & Mbiti 2010). In many parts of the developing world, the most common way of obtaining information remains personal travel which is costly both in terms of time and money. Other channels also have their limitations, such as newspapers (which tend to be

concentrated in urban areas and require literacy), internet (low access) or TV and radio (limited information range and one-way communication) (Aker 2011). Thus mobile phones have the potential to not only reduce costs, but also allow for more regular and timely access to information. Several m-services have already been developed that deliver information to farmers either on demand or by sending updates via SMS or audio recordings. M-services may also serve to facilitate farmer-to-farmer or farmer-to-buyer relations, such as sharing of experiences on farming practices and market information related to prices, supply and demand.

Advice on farming practices is one of the most widely available m-service in agriculture, often as a complement to existing extension services. Some services are delivered through SMS, such as *Reuters Market Light* developed by the business data provider Thomson Reuters which delivers personalised information to Indian farmers.[4] A more sophisticated example is *iCow* which combines general livestock management advice with advice for individual cows (among other functions). More often, however, such services are delivered using voice-based systems because of literacy or language barriers and the limits of SMS to convey large amounts of information. Technologies include interactive voice response systems (e.g. the government-run *National Farmers Information System* in Kenya or *IKSL – IFFCO Kisan Sanchar Limited* offered by the Indian Farmers Fertiliser Cooperative Limited and Airtel in India), helplines (e.g. *IKSL*) or radio programmes that respond to questions sent by mobile phones (e.g. *The Organic Farmer* in Kenya).

M-services are also used for **training and education**. In India, for instance, *Lifelong Learning for Farmers* offers learning modules as recorded audio content delivered to women livestock producers through mobile phones (World Bank 2011). The service is provided by the Commonwealth of Learning in collaboration with the Indian non-governmental organisation VIDIYAL. The messages are recorded by VIDIYAL and women farmers and sent to participating women every morning. Another example is *Nokia Life Tools* operating in India which offers English learning courses through mobile phones. [5]

M-services are also increasingly being used as a tool to support **social learning and networking**. Various mobile phone-based survey applications (e.g. *FrontlineForms*, *Episurveyor* and *ODK Collect*) have been developed, such as *FrontlineForms*, *Episurveyor* and *ODK Collect*. Such services could, for instance, be used to collect data on the performance of agricultural technologies which can then be shared with other farmers. *FrontlineForms*, for instance, is used by the Technoserve *Coffee Initiative* in Tanzania to evaluate the impact of training on farmers' behaviour and yield changes (Oyenuga 2011). Data collection is also offered through the *Community Knowledge Worker* (CKW) programme in Uganda which gathers data from farmers by sending them questions via SMS or by designing mobile surveys through *ODK Collect* which are then carried out by CKW staff.

There are also examples where mobile phone-based technologies are used to facilitate interaction and learning among farmers. *Sauti ya wakulima* (The Voice of the Farmers) in Tanzania, for instance, is a collaborative knowledge base created by a small group of farmers who share two smartphones with GPS to publish images and voice recordings about their farming practices on the internet. Another example is *CocoaLink* in Ghana which uses voice calls and SMS to connect farmers to each other and to experts at the Ghana Cocoa Board (finanzen.net 2011).

Several m-services also provide information that help farmers to better **assess and manage risk related to weather events and diseases**. Weather information is often combined with other types of information that is regularly disseminated to farmers (e.g. *Nokia Life Tools* in India or *Esoko* in Ghana) or can be requested via SMS (e.g. *Google SMS* in Uganda). There are also some dedicated weather

[4] Links to the m-services mentioned in this section are provided in the Bibliography.
[5] The service also provides agricultural information, but the two functions are not linked.

information services. For instance, the government-run *Radio and Internet for the Communication of Hydro-Meteorological Information* (RANET) project in Zambia collects weather data from farmers (sent by SMS) and satellites and disseminates information on extreme weather events and seasonal climatic information to farmers via SMS (Mumbi & Ghazi 2011).

Mobile phone-enabled technologies are also used to monitor and disseminate information about crop disease outbreak. The *Digital Early Warning Network* in Tanzania, for example, receives information about cassava disease outbreaks from farmers via SMS (Ndyetabula & Legg 2011). The resulting maps are then used to focus mitigation efforts in affected areas. In Uganda, Makerere University in collaboration with the National Crops Resources Research Institute and the University of British Columbia is trialing a system to *monitor cassava crop disease outbreaks* using camera phones with GPS. Maps showing disease outbreaks area then displayed on a website.[6]

3.2.2 Agricultural inputs

A limited number of m-services are facilitating **access to agricultural technologies and associated inputs**. Several of these services enable farmers to purchase agricultural technologies, either bilaterally or collectively. The *CKW* programme in Uganda, for instance, provides a directory of input suppliers, including location and contact information, which farmers can access by contacting a CKW or through an SMS-searchable database. There are also examples of service providing price information on inputs, such as the *National Farmers Information System* in Kenya.

A few services have been developed to support access to and use of **water and energy**. For example, mobile phones are being used to manage irrigation systems. In India, the *Nano Ganesh* device, which was developed by the Indian company Ossian Agro Automation and is being disseminated in collaboration with Tata Teleservices phones, allows farmers to switch water pumps on and off, thus saving them the journey to their fields (Ribeiro 2009). In Nigeria, a mobile phone-enabled irrigation system is also being developed for horticulture farmers (African Science 2012). In other cases, mobile phones are used to pay for water, such as *Grundfos LIFELINK* in Kenya which allows farmers to charge a smartcard via m-payments (M-Pesa) which is then inserted into the water tapping unit.

Mobile phones also facilitate access to electricity, although somewhat indirectly. Mobile network operators have been providing excess power from their base stations to local communities, for instance in Kenya where Safaricom has laid min-grids to supply power for local infrastructure, such as water pumps and lighting (Roach & Ward 2011). Moreover, similar to water services, m-payments have been used to pay for electricity, such as *Shared Solar*, a project of the Modi Research Group at Columbia University, which allows users to credit their electric account via SMS similar to charging prepaid phones (Ulbricht 2011).

Some virtual **labour markets** have also been developed, although their use in the agriculture sector is still limited. *Berendina Employment Resources Centre* in Sri Lanka, for instance, enables employers and job seekers to register with the service by phone. Their details are entered into a web-based database which can match labour demand and supply.

3.2.3 Financial services

Among mobile phone-enabled financial services, **mobile payment systems** are expanding most rapidly in developing countries.[7] These systems are often initiated by mobile network operators

[6] cropmonitoring.appspot.com

[7] For an overview of global mobile money deployments, see www.wirelessintelligence.com/mobile-money

which have the necessary communications and distribution network to run the service. More sophisticated services generally require collaboration with local banks (IFC 2011). As noted above, m-payments are also used to ease the delivery other services, such as water or energy provision or insurance pay-outs. One of the earlier and successful examples is *M-Pesa*, an m-payment system launched in 2007 by the Kenyan mobile network operator Safaricom in collaboration with Vodafone. By January 2012, M-Pesa had expanded to over 14 million customers with 28,000 agent outlets across the country, providing mobile banking facilities to more than 70% of the adult population (IMF 2011; Nation Reporter 2012).

M-services that link money transmission services with **bank accounts** are still less common, though also expanding. Such services would enable farmers to save money and earn interest on their savings. In Kenya, for instance, Orange (Telkom Kenya) is collaborating with Equity Bank to offer *Iko Pesa* which allows users to deposit and withdraw money from their accounts (Kimani & Mark 2010). A similar service is also provided through *M-Kesho*, a collaboration between Safaricom (M-Pesa) and Equity Bank. M-Kesho offers interest rates on micro-savings ranging from 0.5% to 3% depending on the amount deposited. Other examples include Orange Sonatel in Senegal and Tigo (Millicom) and Vodacom in Tanzania, working in collaboration with local banks.[8]

M-banking service may also be combined with **loan services**, including Iko Pesa which allows users to apply for, process and receive loans from their mobile phones, and M-Kesho which offers microcredits of Ksh100 to Ksh 5000. Credit facilities may also be integrated with other m-services, such as the MicoLoan Management system of the *Star Shea Network* in Ghana, developed by SAP and PlaNet Finance in collaboration with the local microfinance institutions Maata-N-Tudu and Grameen Ghana, which complements the supply chain management system that traces deliveries of shea harvests from small-scale producers (see below).

Finally, a few organisations are starting to develop mobile phone-enabled **insurance** schemes. In Kenya, for instance, *Kilimo Salama* was set up by the Syngenta Foundation in collaboration with Safaricom and UAP Insurance to insure crops against extreme weather events. To this end, weather stations linked to a central system monitor rainfall. In case of extreme drought or excess rain, pay-outs are automatically transferred to insured farmers via M-Pesa. The farmers pay an insurance premium of 5% of the retail price of insured inputs which is supplemented by 5% paid by the input suppliers. Another example in Northern Kenya is the *Index-based Livestock Insurance* developed by the International Livestock Research Institute in collaboration with local partners. The scheme – which compensates insured pastoralists in the event of livestock losses due to severe forage scarcity (determined through satellite data) – uses scanner-based mobile phones to register insurance contracts with livestock producers and upload their information in a central database.

3.2.4 Output markets

Numerous m-services provide information on **markets prices** for crops and (to a lesser extent) livestock, often as part of a broader information package. Such information might be sent on demand, such as in the case of *M-Farm* where farmers can send an SMS to a searchable database to obtain prices for specific crops. In other cases, farmers receive automatic updates for crop prices via SMS, for instance through *Esoko* in Ghana or *Nokia Life Tools* in India.

Virtual **markets for agriculture products** facilitated through mobile phones are also expanding. The Kenyan company *M-Farm*, for instance, enables farmers to sell their produce collectively with other small farmers through a mobile phone-enabled service, thereby facilitating access to large-scale markets such as exporters, wholesalers and retailers. Also in Kenya, the mobile application *iCow*

[8] www.wirelessintelligence.com/mobile-money

Soko, developed by the Kenyan company Green Dreams, allows producers to buy and sell livestock and livestock produce across its mobile platform. In many cases, such services are integrated into broader trading platforms where users can buy and sell a variety of products, such as *Cellbazaar* operated by Grameenphone in Bangladesh, or the SMS- and internet-based *Google Trader* in Uganda, a collaborative initiative of the Grameen Foundation AppLab, Google and the mobile network operator MTN.

Another expanding m-service includes **supply chain management systems** which use mobile phones and other devices using the wireless network as part of a management system to track and manage produce sales from a large number of small farmers. One example is the *Rural Sourcing Management* software developed by SAP and deployed in Ghana to facilitate sourcing of shea through the *Star Shea Network* and cashew through the *African Cashew Initiative* funded by the GIZ and the Bill and Melinda Gates Foundation. To this end, sacks of shea and cashew brought in by farmers are weighed and tagged with information about the seller. The barcode on the tag is then scanned using a mobile phone and the information is uploaded into a central management system.

3.3 Impact assessments of mobiles and m-services in agriculture

The first empirical study on the role of mobile phones in poverty reduction and rural development was carried out by Bayes, von Braun and Akhter (1999) who assessed the poverty impact of the *Village Pay Phones* in Bangladesh, an initiative of the Grameen Bank which leases cellular mobile phones to selected members. Since then, a growing body of literature has emerged assessing the impacts of mobile phones in developing countries. Most of these studies examine the impacts of the phones in general, including on macroeconomic performance, poverty reduction, individual users, agricultural and fisheries production and small business operations. Only a few studies have assessed services provided through mobiles phones.

Most studies used quantitative surveys, often combined with focus group discussions and individual interviews. Some studies also employed econometric or other statistical analyses while even fewer used panel data which allows for an assessment of impact over time. Moreover, only a small number of studies (e.g. Goodman 2005, Islam & Grönlund 2010, and a series of studies published in Grimshaw & Kala 2011) compare people with and without access to mobile phones or m-services to assess the extent to which impacts can in fact be attributed to the mobile technology.

The Annex provides an overview of impact assessments reviewed for this paper. All studies either addressed mobile phones specifically or disaggregated data for mobile phones and other telecommunication media. With the exception of Bayes et al. (1999), only studies were reviewed that were published (or used data) after 2000 when mobile penetration rates started to expand significantly in developing countries. The review covers articles published in both peer-reviewed journals and grey literature. The key findings are presented in this section, with a focus on those studies that assessed impacts of mobile phones on individuals, businesses or communities (rather than those assessing macro-economic impacts).

Many studies carried out across all regions of the developing world found that mobile phones are primarily used to **maintain social relationships** with family and friends and in cases of **emergencies** (de Silva & Zainudeen 2007; Galperin & Mariscal 2007; Goodman 2005; Mascarenhas 2010; Mittal et al. 2010; Samuel et al. 2005; Sife et al. 2010; Souter et al. 2005). Where mobiles are used in business transactions, they mainly serve to maintain and strengthen existing relationships rather than form new ones (Frempong et al. 2007; Galperin & Mariscal 2007; Goodman 2005; Jagun et al. 2007; Molony 2006; Overå 2006). The need to first establish contact and trust through face-to-face interaction was repeatedly emphasised.

In terms of **economic benefits**, several studies found that mobile phones reduced transportation costs where trips for social and business purposes were substituted with phone calls (Balasubramanian et al. 2010; Boadi et al. 2007; Frempong et al. 2007; Overå 2006; Samuel et al. 2005; Sife et al. 2010). Mobile phones were also thought to have reduced operational costs, increased the profitability of rural businesses and contributed to revenue generation and labour productivity of both formal and informal small and medium size enterprises (Boadi et al. 2007; Esselaar et al. 2010; Frempong et al. 2007). A study of mobile phone users in South Asia also highlighted perceptions among users that the phones had increased the efficiency of daily activities due to greater contactability and ability to obtain information, although the link between efficiency gains and cost saving were not necessarily perceived by the users (de Silva & Zainudeen 2007).

Looking at the use of **mobile phones in agriculture** more specifically, Furuholt and Matotay (2011) assessed how farmers took advantage of mobiles throughout the farming cycle. Based on semi-structured interviews with farmers and other informants, they found that mobile phones affected all stages of the cycle, including preparations, farming, harvesting and post-harvesting (Table 2). Overall, farmers felt that mobile phones had helped to raise incomes by improving their ability to deal with risks and take advantage of income opportunities.

Table 2: Farmers' activities and use of mobile phones

Period	Activity
Preparations for farming	• Coordinating labour pool (voluntary-based, family members and neighbours) • Collecting weather information • Investigating seeds prices • Preparation kraal manure for planting (mainly used by the farmers in the area during planting)
Farming period	▪ Pooling of labour for cultivation and weeding ▪ Organizing manure for use during planting ▪ Collecting and exchanging rain information ▪ Hiring/borrowing farming implements (e.g. hand hoes, ox plough, harrows) ▪ Investigating prices of tractors for cultivation ▪ Ordering and hiring of oxen for cultivation ▪ Collecting information about new types of seeds ▪ Ordering seeds ▪ Investigating labour cost for cultivation and weeding in neighbouring villages ▪ Organizing fertilizer ▪ Collecting information about availability of extension officers and subsidized farm implements from the local authorities ▪ Coordinating information and deliveries of pesticides
Harvesting period	▪ Organizing and pooling of labour for harvesting ▪ Arranging for storage equipment and warehouses/stores ▪ Arranging for and ordering of chemicals against mice and "scania"
Post-harvesting (Marketing and transport)	▪ Organizing transport from the farms to warehouses (tractors or ox trailers) ▪ Calling market centres, traders, dealers and check prices and stocks of crops before settings deals with middlemen/agents or deciding to travel to obtain better opportunities ▪ Calling for and ordering transportation to markets ▪ Selling crops via mobile phone ▪ Contacting distant families/relatives (for decisions and money transfers) ▪ Money transfers and payments

Source: Furuholt and Matotay (2011)

Various studies have examined the role of mobile phones in facilitating **access to information**. Several assessments concluded that mobile phones had reduced search times and costs (Bayes et al. 1999; Jagun et al. 2007; Overå 2006) as well as information asymmetries (Overå 2006). In the case of

Village Pay Phones in Bangladesh, for instance, such cost reductions had benefited in particular the poor, resulting e.g. in better access to and prices for outputs and inputs, more stable supply of fertilisers and fuel, easier job searches and reduced livestock mortality rates due to better access to extension officers (Bayes et al. 1999). A study in Nigeria also found, however, that mobile phones had not necessarily improved the quality of information, but rather its completeness (Jagun et al. 2007).

Different studies have reached different conclusions regarding the extent to which farmers use mobiles to actively search for agricultural information. Surveys of mobile phone users in rural areas of India, Kenya, Mozambique, Sri Lanka and Tanzania found that phones were hardly used for knowledge gathering and agricultural information was mainly obtained through face-to-face contacts (Campaigne et al. 2006; de Silva & Ratnadiwakara 2008; Souter et al. 2005). In contrast, other studies of fishers in India and farmers in Tanzania found that mobiles were used to access market information for their produce (Jensen 2007; Sife et al. 2010). A study in India concluded that differences in the use of phones for information search may be explained by the profitability of agriculture in the region. Thus, farmers more actively sought information in areas where agriculture was profitable, while farmers in less profitable areas were reluctant to seek and try out new know-how (Kameswari et al. 2011).

Some of the most widely cited studies in this research area deal with the impact of mobile phones on **prices dispersion**. Jensen (2007) examined the use of mobiles to obtain markets prices among fishers from the Indian state of Kerala. He concluded that access to such information, which enabled fishers to choose the most profitable market, had led to a significant reduction in price dispersion (with the mean coefficient declining from 60-70% to 15%). Other benefits included the elimination of waste, increased profits and lower consumer prices. Similar though less pronounced reductions in price dispersion of 10-16% were also observed across grain markets in Niger (Aker 2010; Aker 2008). The effect was particularly strong for market pairs with higher transportation costs and in cases where a critical mass of market pairs had mobile coverage (the so-called 'network effect').

While some evidence suggests that the use of mobile phones to obtain price information has induced producers to move to other markets (e.g. Jensen 2007), several studies also point to examples where mobiles did not significantly change **producer-buyer relationships**. Rather, farmers were forced to accept prices of middlemen due to the perishable nature of the produce, limited storage facilities and lack of alternative markets (Kameswari et al. 2011). Moreover, farmers were often dependent on buyers as a source of loans and information (Kameswari et al. 2011; Lokanathan et al. 2011; Molony 2008). While one study in Ghana found that mobiles had enabled farmers to bypass middlemen (Boadi et al. 2007), another study in Nigeria concluded that mobiles had in fact entrenched the role of intermediaries with little change in the geography of supply chains (Jagun et al. 2007).

There is some evidence from East Africa, Bangladesh and Latin America that access to mobile phones in general had facilitated **job searches** (Bayes et al. 1999; Mascarenhas 2010) and the coordination of informal job market (Galperin & Mariscal 2007). An impact assessment of the mobile phone- and internet-based job bank *Berendina Employment Resources Centre* in Sri Lanka, however, found that although just over half of the rural casual wage labourers in the intervention group received information about jobs through the Centre, only 5% actually worked on jobs found through the service (Balasuriya & de Silva 2011). The users were generally reluctant to trust job offers that they had received over the phone, preferring information received from trusted sources. Nevertheless, the study also found that the job bank had helped to enlarge the users' network of potential employers and familiarised workers with the use of phones for job searches.

Most of the studies discussed so far assessed the role of mobile phones in general rather than specific services. The few empirical **assessments of m-services** (which compare outcomes for control and intervention groups) have highlighted several benefits. For instance, a service providing

information on the correct use of nutrients in the Nagapattinam district of India had led to 15% higher incomes among intervention farmers compared to the control group, mainly through cost reductions due to the application of appropriate (i.e. lower) amounts of seeds and nutrients (Raj et al. 2011). An evaluation of *LifeLines*, a telephone-based advisory service for Indian farmers, found that the majority of farmers thought that the service had improved their productivity (72% of respondents), increased savings and earnings (67%) and decreased the need for loans (31%) (Haider Rizvi 2011). Most queries received by the helpline concerned seeds, crop and animal diseases, new agricultural technologies and prices.

Two assessments of price information services in Bangladesh and Sri Lanka also showed financial gains for farmers. The study in Bangladesh compared groups of farmers that either received market information automatically (the 'push' group) or on demand (the 'pull' group) (Islam & Grönlund 2010). Around a third of the farmers estimated their profits to have increased by around 10-20%. The information was considerably more effective for farmers in the push than in the pull group. In Sri Lanka, users of the price information service provided *by TradeNet* estimated that they earned $0.045-0.09/kg more for their produce (Lokanathan et al. 2011). They were also able to make more informed decisions about the best harvest and selling times due to a better understanding of real-time price trends, though largely continued to sell to the same traders.

To date, little research has been carried out on the use of **m-banking** specifically in agricultural production. A study of m-payments in Kenya found that around half of the farmers used mobile phones to make and receive transfers, primarily through m-Pesa (Kirui et al. 2010). The use of such services was more widespread in areas with higher agricultural commercialisation. The majority of outgoing payments (23%) where made to pay for non-food household needs. In terms of agriculture-related needs, 7% of total payments went towards the purchase of agricultural inputs and 6% to pay farm workers. Further distance to banks, higher education levels and higher capital endowments all increased the likelihood of farmers using m-payments.

4 Inclusion – reaching the marginalised and poorest?

Due to their accessibility, mobile phones could help to reduce physical and social marginalisation of poor regions and people by facilitating communication that is not restricted by distance, volume, medium and time, thereby overcoming barriers of space and social standing (von Braun & Torero 2006). At the same time, there is a risk that the proliferation of mobile phones (and ICTs more generally) could deepen the 'digital divide', given that access to ICTs depends on various factors, such as education and income. Thus, the poor and marginalised with limited access to modern telecommunication technologies may fall even further behind. In this context, it is important to stress that connectivity alone (e.g. signal coverage) is not sufficient to ensure that the poor and marginalised can benefit from mobile phones. Equally important are the ability to pay for the mobile phones and m-services, the skills to use the technologies effectively and the accessibility and usefulness of the content and functions that mobile phones provide (ibid).

4.1 Access to mobile phones

Several studies have found that the wealthier and more educated are more likely to own mobile phones (e.g. Mascarenhas 2010; Muto & Yamano 2009; Souter et al. 2005).[9] In addition, there are also differences in mobile phone ownership between urban and rural areas, although the evidence is somewhat scattered in the absence of a comprehensive data set for rural and urban subscription

[9] It is interesting to note, however, that mobile phone ownership in Tanzania and South Africa was found to be less biased towards wealthier segments of the population than other consumer durables (Samuel et al. 2005).

rates. A Gallup survey carried out in 17 Sub-Saharan African countries in 2010 found that 69% of respondents living in urban areas owned a mobile phone compared to 53% in rural areas (Gallup 2011). Some country examples show large differences between urban and rural rates, e.g. in India (160 per 100 people versus 36 in November 2011) (TRAI 2012) or (though less pronounced) in Kenya (73 versus 41 in 2009) (FinAccess 2009).[10] In other countries, differences were less significant, such as Ghana (58% versus 60%) or South Africa (77% versus 66%) (in 2010; Gallup 2011).

However, while ownership tends to be higher among wealthier users, income does not necessarily seem to be as significant a barrier to *accessing* mobile telecommunications. Surveys in Africa and Asia point to a high prevalence of phone sharing in particular with family members as well as friends (e.g. Gillwald 2005; Goodman 2005; Samuel et al. 2005). A survey in Sri Lanka, Pakistan and India, for instance, found that over 90% of respondents had used a phone in the last three months, even though 59-81% of those from lower income groups had to borrow someone else's phone. Similarly, a survey of Kenyan farmers found that only around a third owned, but 84% had used a mobile phone (Okello et al. 2010).

4.2 Benefits from mobile phone use

Several studies have highlighted the benefits of mobile phone ownership among better-off users. A study of micro-enterprises in Nigeria, for instance, concluded that there were few signs "of mobile telephony levelling the playing field; and more signs that it had been a technology of inequality" (Jagun et al. 2007, p.62). The most-resourced microenterprises who owned a mobile had gained through more and larger orders, faster turnaround and better quality of the final product, while the least-resourced without access to mobiles were losing orders. Similarly, Souter et al. (2005) concluded that the mobile phone had benefitted higher status groups in India, Mozambique and Tanzania most while "the most marginalised could well be left behind" (p.10).

On the other hand, a business survey in South Africa and Egypt concluded that mobile phones had benefited in particular the disadvantaged groups, including black-owned businesses in South Africa and informal sector businesses in Egypt (Samuel et al. 2005). For these businesses, mobiles were often the only source of telecommunications while others would also make use of fixed telephone lines and facsimile machines (along with mobiles). In both countries, over 85% of these businesses relied entirely on mobile phones. Mobiles also played an important role in small business start-ups in both countries.

There is little comparative data on the impacts of mobile phone ownership versus phone sharing, and the dynamics of shared phones outside of formal phone shops remain poorly understood (Donner 2008). In his survey of mobile phone usage in South Africa and Tanzania, Goodman (2005) compared data from mobile phone owners, non-owning users and non-users. In both countries, phone usage was considerably higher among owners than non-owning users. In Tanzania, owners used phones for a greater variety of purposes while non-users mainly used phones to contact family members or for business reasons.

A study of banana producers in Uganda showed that households that did not own a mobile phone could still benefit from the availably of mobile phones in the community (Muto & Yamano 2009). Based on an analysis of household panel data, the authors concluded that community-level possession of mobile phones had increased banana sales participation while household possession of mobile phones did not have significant impact. Thus, even those not owning a phone benefited from the network, for instance when one person in the village arranged collection of produce with a trader. The study also found that smallholder farmer had gained most from the extension of mobile

[10] The statistics could include multiple SIM ownership by individual mobile phone users.

phone networks, possibly because larger farmers had already had other means of contacting traders and obtaining information previously.

Relative costs and benefits may also be influenced by the share of income spent on mobiles phones. However, there is a lack of systematic data comparing monthly spending by income groups. Souter et al. (2005) noted that poorer mobile phones users in India, Mozambique and Tanzania spent a higher share of their income on the phones than high income groups, but did not quantify the difference. A survey of farmers in Tanzania found that respondents spent about 10% of total monthly expenditure on mobile phones (Furuholt & Matotay 2011). Users earning less than $100/month in Sri Lanka and India were estimated to spend 4-8% of their income on mobile access (Herath 2008).

In addition to these more tangible impacts, Gomez & Pather (2011) highlight the need to also evaluate issues such as "empowerment, self-esteem, and sense of self-worth, at the individual level, and social cohesion and strengthening of social fabric, at the collective level" (p.10) that may arise from the use of ICTs. A survey in Pakistan, India, the Philippines and Thailand, for instance, found that two-thirds of telephone owners surveyed felt that "ownership of a telephone has enhanced their social status and recognition in their community" (de Silva & Zainudeen 2007, p.11). Mobile phones in particular were regarded as more accessible for people from all socio-economic backgrounds, thereby "reducing the 'gap' between the rich and the poor leading to a feeling of 'upliftment' among the poor" (ibid).

Studies have also shown that mobiles have the potential to both reinforce and redress gender imbalance. The assessment of *Village Pay Phones* in Bangladesh, for example, pointed to the empowerment and increased social status of phone-leasing women and their households (Bayes et al. 1999). A case study of mobile phone use in Uganda, on the other hand, showed that gender inequality reinforced asset control by the husbands who sought to keep control over the phone while the women often felt that they were not benefiting from the new technologies (Diga 2008).

4.3 M-services

There is very limited evidence comparing the use of and benefits derived from m-services among different income groups in general and in the agriculture sector in particular. Given the above-mentioned ownership patterns and benefit distribution, it seems likely that the wealthier and more educated are also more likely to benefit from m-services. M-Pesa, for instance, continues to be used primarily by better-off Kenyans. While the reach into rural areas as well as middle and lower income groups has been expanding since 2009 (World Bank 2010), the main users of m-payments appear to be farmers in commercial agriculture areas with higher levels of income and education (Kirui et al. 2010).

At the same time, small and disadvantaged farmers may have the most to gain from m-services. For instance, smaller farmers have to spend a larger share of their income on information searches, given that search costs along the value chain tend to be relatively fixed (de Silva & Ratnadiwakara 2008). At the same time, the limited evidence available indicates that the poor and marginalised farmers may have less incentive to search for agricultural information and be less able to use the information received. Farmers in agriculturally marginalised areas in India were less likely to seek information, instead looking for alternative, more secure income opportunities (Kameswari et al. 2011). Thus, the interest in seeking information "depends on the returns derived from the activity itself (in this case agriculture) and the value that information can add to that enterprise" (Kameswari et al. 2011, p.10).

Moreover, additional constraints are likely to prevent in particular small and less-resourced farmers from making effective use of m-services, highlighting the need for complementary support activities.

For instance, farmers may not be able to take advantage of price information and seasonal price trends due to lack of access to alternative markets or storage facilities. Also, limited access to finance and input supply (such as fertiliser or pesticides) can prevent them from implementing farming advice. Remote agricultural areas that are located far from commercial centres are particularly disadvantaged in terms of access to and diffusion of agriculture technologies due to underdeveloped infrastructure, dealer networks and product support (Sunding & Zilberman 2001).

5 Conclusions

The paper highlights significant potential for m-services to facilitate adoption of agricultural technologies in developing countries. Service providers and m-service developers are increasingly recognising this potential, including the business opportunities of marketing m-services to a large number of smallholder farmers. While initially m-services focused mainly on the provision of farming and market information, services are becoming more comprehensive, offering more diverse and multiple functions that support farmers at different stages of agricultural production – a trend that will need to continue to increase the effectiveness of m-services in agriculture. At the same time, it will be crucial to embed these services in complementary support programmes and infrastructure developments to address other production and market limitations that cannot be resolved through mobile phones.

Mobile phone-enabled services also offer opportunities to extend the reach of agricultural services to the poorest and marginalised due to the widespread access to mobiles among geographically dispersed users from diverse socioeconomic backgrounds. However, judging from the limited evidence gathered to date, the poorest and marginalised are less likely to benefit from m-services as a result of lower income and education levels as well as social imbalances, such as gender inequalities. Also, the challenges they encounter when adopting new agricultural technologies are particularly severe and often complex, thus making it even more urgent to integrate m-services into broader support efforts.

Significant research gaps remain in this area which will need to be filled in order to increase the effectiveness and expand the reach of m-services in agriculture. To date, most of the research has focused on mobile phones as such and empirical evidence on the impacts and success factors of m-services in general and on agricultural technology adoption in particular are still limited. Moreover, as phone sharing remains a reality in particular in rural areas, the associated dynamics need to be better understood, including within households, communities and organised groups such as cooperatives. More research is also needed to differentiate between users from different income and social groups when assessing the effectiveness of m-services in order to better understand and address the particular opportunities and challenges of the poor. In marginal areas, the actors that aim to enhance technology innovation in agriculture may need to explore direct engagement in m-services, rather than wait for specialized m-service providers to come along and expand their reach in such areas.

Further analysis will also need to focus on how m-services could best be used to address multiple constraints, either by providing several complementary functions or by integrating m-services with other support activities. Moreover, just as successful technology adoption is related to the farming context, suitability and effectiveness of m-services will be shaped by the context in which they are offered. These dynamics remain seriously under-researched. Further studies are essential so as to be able to adjust the services to the particular needs of the farming communities and develop business models that lead to the establishment of m-services for resource-poor farmers. Such research will need to be based on an interdisciplinary approach that takes into account the economic, social and biophysical dimensions of the users, technologies and farming contexts.

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M-services

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Annex: Studies examining impacts of mobile phones and m-services in developing countries

Focus	ICT	Method	Impacts	Location	Reference
Macroeconomic impacts					
Impact of mobile phones on economic growth in developing countries	Mobile phones	Econometric analysis using national-level indicators	• Mobiles have a significant impact on economic growth that may be twice as large as in developed countries • Increase in annual GDP growth rate by 0.59% for every additional 10% of mobile penetration (1996 -2003) • Mobile demand increases much more than in proportion to increases in income or reductions in price	92 developing countries	Waverman et al. 2005
Possible links between the penetration of mobile networks and FDI flows into developing countries	Mobile phones, fixed phones	Econometric analysis using national-level indicators	• Mobile telecommunications networks are positively correlated with FDI flows	Developing countries	Williams 2005
Economic impact of mobile services	Mobile phones	Data analysis	• Mobile industry contributes 1% to GDP (R313 bn annually), 3.6m jobs, R145 bn in gov revenues (2004)	India	Lewin & Sweet 2005a
Economic impact of mobile services	Mobile phones	Data analysis, econometric analysis	• Increase in annual GDP growth rate by 0.3% for every additional 10% of mobile penetration in middle-income countries (1996 -2003) • Mobile industry generated €16.9 bn in value added and €8.6 bn in gov. revenue annually, 2.3 m jobs and around $30 bn consumer surplus (2004)	Brazil, Chile, Colombia. Mexico, Peru, Venezuela	Lewin & Sweet 2005b
Economic and social impact of mobile services	Mobile phones	Data analysis	• Increase in annual GDP growth rate by ca. 0.6% for every additional 10% of mobile penetration • Increase in FDI as a proportion of GDP by 0.5% by increasing penetration by 1% • Mobile industry created 237,900 jobs in 2005	Bangladesh	Lane et al. 2006
Economic impact of mobile communications	Mobile phones	Static data analysis	• Mobile industry contributed 3.7-6.2% to GDP in 2007 (incl. supply side impacts, productivity increases and intangible benefits) • 0.8-2.1% increase in GDP due to raised productivity • Mobile sector generated 36,000- 244,000 jobs (direct, indirect, multiplier)	Serbia, Ukraine, Malaysia, Thailand, Bangladesh, Pakistan	Deloitte 2008

Economic impact of mobile phones	Mobile phones	Static data analysis	• Mobile telecommunications industry contributed 4% to GDP and up to 1% intangible benefit (2006-2008) • 43,000 (direct and indirect) jobs created • Business use of mobiles increased productivity of individual workers by 10% (in 2008)	Sudan	Deloitte 2009
Impact of mobile penetration rates on economic growth	Mobile phones	Econometric analysis using national-level indicators	• Increase in annual GDP growth rate by 1.2% for every additional 10% of mobile penetration (2000-2008) • Critical mass of 25% penetration rate for network effect • Significant variation in mobile access between states, urban-rural and rich-poor HHs	India (19 states)	Kathuria et al. 2009
Direct and indirect economic impacts of wireless broadband	Wireless broadband	Macroeconomic model	• Predict 1.22% GDP increase($5 b) due to wireless broadband, plus 0.27% GDP ($1.1 b) with policy support • Increase in industry productivity in 2015 of $ 800 m (or 0.2% GDP), esp. in the services sector	Nigeria	Analysys Mason 2011
Impacts on mobile phone users					
Characteristics of mobile phone users and impacts of mobiles on communities & businesses	Mobile phone	Quantitative survey of mobile phone users (individuals & businesses)	• SA, Tanzania: mainly to maintain social relations, cost savings from reduced travel • Tanzania: faster communication, access to business info • SA, Egypt: cost savings through reduced travelling time and costs, increased customer numbers and higher turnover – esp. important for disadvantaged groups	South Africa, Tanzania, Egypt (only businesses)	Samuel et al. 2005
Role of mobile phones in increasing social capital (incl. comparison of mobile owners and non-owning users)	Different communication tools	Quantitative survey of mobile phone users	• High degree of mobile phone sharing • Mobiles used extensively to mediate strong links with family and close friends • Mobiles also used to maintain weak links esp. in Tanzania but face-to-face contact remains most common communication medium	South Africa, Tanzania	Goodman 2005
Economic impact of telephone ownership to generate income or save costs	Telecom (own and shared mobile and fixed lines)	Quantitative and qualitative survey of mobile phone users	• Main benefits: emergencies, social relations • Somewhat improved efficiency of daily activities through greater contactability and ability to obtain info • India, Philippines: perceived improved ability to earn and save (less so in the other countries) • Links between efficiency gains and cost savings not necessarily perceived	Pakistan, India, Sri Lanka, Philippines, Thailand	de Silva & Zainudeen 2007

Impacts on poverty					
Role of telecommunications in rural development and poverty reduction	Village Pay Phone (shared mobile phone)	Quantitative survey, focus groups, econometric analysis	• Poor account for 1/4 of phone calls through VPPs • Reduced cost of communicating info, esp. for the poor, resulting e.g. in better prices for outputs and inputs, easier job search, reduced livestock mortality rates etc. • Empowerment and increased social status of phone-leasing women and their households	Bangladesh	Bayes et al. 1999
Impact of telecommunications on rural livelihoods and poverty reduction	telephones (phone kiosk, landline, mobile, SMS, fax, email), other media	Quantitative surveys of phone users in villages	• Main value: reduce vulnerability (emergencies) • High impact on social networking, esp. within the family • Useful for saving money but only beneficial for income generation among better-off and more educated • Phones not used for knowledge-gathering • Ag-related info mainly through face-to-face contacts	India, Mozambique, Tanzania	Souter et al. 2005
Understand the strategies employed by the poor in Latin America and the Caribbean to access and use mobile telephony services	Mobile phones	Quantitative Survey of mobile phone users	• Main benefit: strengthening existing social ties • Also useful for emergencies • Economic impact mainly through improved social capital variables, e.g. strengthening trust networks and coordination of informal job markets	Argentina, Brazil, Colombia, Jamaica, Mexico, Peru	Galperin & Mariscal 2007
Contribution of mobiles to rural livelihoods and poverty reduction	Mobile phone	Quantitative HH survey, focus groups, interviews	• Main benefit: expanding/strengthening social networks • Other benefits: increased efficiency of daily activities, emergencies, reduced or simplified travelling, changed business practices (price info, arrange payments), access market info for ag produce • Little direct income generation e.g. selling credit	Tanzania (Morogoro region)	Sife et al. 2010
Impact of changes in ICT use on HH poverty	Radio, TV, DVD, landline, computer, internet, email, mobile	Quantitative HH survey, follow-up qualitative survey	• Radio and mobiles were the most important ICTs. • Mobiles mainly used for social communication, but also money transfers, emergencies, job search and business • Urban-rural divide in terms of access and costs, unequal ownership and usage by gender	Tanzania, Kenya, Rwanda, Uganda	Mascarenhas 2010

Impacts on farmers and fishers					
Economic impact of the DrumNet project, a network of farmer business support centres	Different communication tools	Quasi-experiment (with control group), panel data	• Farmers obtained most of the ag info through face-to-face contact with very little use of mobiles in farming • Transaction Agents use mobile to gather info on prices, collection days and grading standards • Most successful groups where those with TAs that had access to mobile phones	Kenya	Campaigne et al. 2006
Impact of mobile phones on market performance and welfare in the fisheries sector	Mobile phones	Econometric analysis using microlevel survey data	• Significant reduction in price dispersion (mean coefficient declined from 60-70% to 15%) • Elimination of waste (from 5-8% of catch previously) • Near-perfect adherence to the Law of One Price (compared to 50-60% of market pairs before) • Increase in consumer and producer welfare through higher profits (8%) and lower consumer price (4%)	India (Kerala)	Jensen 2007
Role of ICTs in correcting information asymmetries and inefficiencies in the fishing sector	Mobile phones	Quantitative survey across the fishing industry, focus groups	• More efficient markets as risk and uncertainty reduced • Greater market integration, gains in productivity and in the Marshallian surplus (sum of consumer and producer surplus), and reduced price dispersion and price fluctuations	India (Kerala)	Abraham 2007
Use of ICTs to reduce transaction costs in agriculture through better communication	ICTs (mobiles)	Questionnaire-based survey among smallholders vegetable farmers	• Information search costs associated with all stages of the ag value chain, in particular at decision (what do grow) and selling stages • Farmers hardly used their mobiles to search for information	Sri Lanka	de Silva & Ratnadiwakara 2008
Impact of mobile phones on price dispersion across grain markets	Mobile phones	Econometric analysis using survey and secondary data	• 10-16% reduction in price dispersion across markets due to reduction in search costs (esp. for market pairs with higher transport costs) • Stronger effect once a critical mass of market pairs has mobile coverage ('network effect') • Effect smaller than in the case of Jensen (not perishable)	Niger	Aker 2010; Aker 2008
Impact of mobile phone coverage expansion on market participation	Mobile phones	Econometric analysis with HH panel data	• Greater market participation of farmers in remote areas and producing perishable crops (bananas) • Price gains higher for less remote banana farmers • No significant impact on maize marketing and prices • HHs without a mobile phone still benefit from mobile phones in the community	Uganda	Muto & Yamano 2009

Impact of access to info on farmers' consumption	Mobile phone	Econometric analysis using GMS coverage and HH panel data	• 11-17% increase in HH-level growth rate of per capita consumption • Enable farmer to strike better price deals and to choose where best to sell	Philippines	Labonne & Chase 2009
Role of mobile phones in reducing information asymmetry in the agricultural sector and improving farm productivity and profitability	Different communication tools	Quantitative survey of farmers and fishers, focus groups, interviews	• Mobiles used mainly for social purposes • Increased convenience and cost savings among farmers • Fishermen benefitted esp. from weather info, but did not engage in market arbitrage to maximise prices • Greater benefits where phones used as information rather than purely communication tool	India (Uttar Pradesh, Rajasthan, Maharashtra, New Delhi, Pondicherry)	Mittal et al. 2010; Gandhi et al. 2009
Efficiency and effectiveness of a government-run agricultural market information service	SMS with price info (push and pull), voice-based system (push)	"experimental" case study with quantitative survey and observations	• Difficulties in reading the Roman script which led users to seek help from others • Indications that some farmers moved to other markets, some perceived increased profits by ca. 10-20% • Info much more effective for the push-group, only few request from the pull-group	Bangladesh	Islam & Grönlund 2010
Role of mobile phones as a learning tool for women in rural areas	Audio messages sent to the mobile	Quantitative survey, qualitative analysis	• Audio messages preferred to face-to-face learning • Vertical and horizontal learning and info sharing • Mobiles also used as business tolls, e.g. for marketing or to reduce transportation and other costs	Southern India	Balasubramania n et al. 2010
Awareness and use of m-banking among smallholder farmers	Mobile phone-based banking services	Quantitative survey, econometric analsysis	• 52% of farmers used m-payments, more widespread in areas with higher agricultural commercialisation • 7% of m-payments to purchase ag inputs, 6% to pay farm workers, 23% for non-food HH needs • Distance to banks, education and capital endowments influence likelihood of using m-banking	Kenya	Kirui et al. 2010
Development contribution of mobile phones across the agricultural value chain	Mobile	Semi-structured interviews with farmers and other informants	• Mobile phone affects entire farming cycle, incl. preparations, farming, harvesting and post-harvesting • Raised incomes by improving farmers' ability to deal with risks and take advantage of opportunities	Tanzania (Babati district)	Furuholt & Matotay 2011

Use of ICTs for information seeking in farming communities	Radio, TV, newspaper, internet, fixed phone, mobile	In-depth interviews with farmers	• Farmers actively sought info in areas where ag is profitable, e.g. on new varieties, pest control measures, market prices, extension activities • Info mainly sought from input dealers/middlemen • No impact on farmer-buyer relationship because farmers are forced to accept prices of middlemen	India (Himalayan region)	Kameswari et al. 2011
Impact of price information (provided through TradeNet) to reduce info asymmetries between farmers and buyers	Mobile (SMS, WAP, USSD), internet, call centres	Action research with HH surveys, focus groups, interviews	• Users obtained $0.045-0.09/kg more for produce • Choose harvest and selling time due to better understanding of real-time price trends • Interaction with more traders, but usually continued to sell to the same as before (source of loans)	Sri Lanka	Lokanathan et al. 2011
Impact of crop nutrient management info provided through ICTs on yield and cost of cultivation	Mobile (SMS, IVR system), internet	Action research with surveys, focus groups, interviews	• Income of intervention farmers 15.2% higher than control group • Gains due to using appropriate (i.e. lower) amounts of seeds and nutrients, and better market prices	India (Nagapattinam district)	Raj et al. 2011
Role of improved access to info through LifeLines in enhancing livelihoods of the poor	Mobile (IVR, answers as audio message)	Action research with surveys, focus groups	• Perceived improvements in productivity (72% of respondents) and savings and earnings (67%), decrease in loans (31%) • Most queries about seeds, crop & animal diseases, new ag technologies and prices	India	Haider Rizvi 2011
Use of ICTs to facilitate casual wage work in rural areas	Mobile, web-based database	Action research with surveys, interviews, case studies	• In intervention group: 54% received info about jobs, but only 5% worked on jobs found through job bank • Users reluctant to trust job offers through mobiles, prefer info through trusted sources • Nevertheless, project helped to enlarge network of potential employers and familiarised workers with the use of phones for job search	Sri Lanka	Balasuriya & de Silva 2011
Impacts on small businesses and traders					
Uses of mobile phones by micro and small business owners	Mobile phones	Q methodology (survey of 31 urban MSEs)	• Highlights diversity of needs of MSEs • Four perspectives on use of mobile, i.e. pursuit of business goals, satisfy emotional needs, productivity enhancement, mobiles as indispensable	Rwanda	Donner 2004

Use of ICTs in business transactions (perishable foodstuffs, informal construction, carvings)	Mobile phone	Case studies (qualitative)	• Mobiles do not significantly alter trust relationships, but used to facilitate existing, trust-based relationships • Farmers (potato & tomato) have to accept prices because buyers are also creditors	Tanzania	Molony 2006; Molony 2008
Impact of mobiles on informal traders' business practices	Mobile phone	Case studies (informal interviews)	• Reduced travel costs resulting in higher earnings and improved competitive position • Reduced search costs and info asymmetries through better info about supply, demand, quality and prices • Strengthen trust relationships through increased efficiency of existing trust-building mechanisms	Ghana	Overå 2006
Impact of mobile phones on rural businesses	Mobile phone (m-commerce)	In-depth interviews of mobile providers and users	• Reduced operational costs, e.g. travel, stock management, better decision making. • Bypass 'middlemen' ("disintermediation"), thereby avoiding costs, enhancing visibility, deepening business relationships and establishing closer ties with buyers	Ghana	Boadi et al. 2007
Impact of mobile telephony on developing country micro-enterprise	Mobile phones	Semi-structured interviews with participants in the cloth-weaving sector	• Mobile phones seem to entrench role of intermediaries • Little change in the geography of supply chains • Reduced time and financial cost of info-gathering • Impact on completeness of info, but not quality • Most-resourced have gained more from mobiles while least-resourced are losing orders	Nigeria	Jagun et al. 2007
Level of usage and contributions of mobile phones to the growth of small business in rural areas	Mobile phones	Quantitative survey of micro and small operators, focus groups	• Perceived as useful to keep contact with existing clients and to a lesser extent to communicate with new clients • Reduction in transportation costs • Perceived to have increased profitability of businesses • Obstacles: cost of subscription and calls, service quality	Ghana	Frempong et al. 2007; Frempong 2009
ICT usage and impacts on profitability of SMEs	Landline, mobile, fax, post box, computer, internet	Quantitative surveys of SMEs, regressions	• ICTs contribute to revenue generation and labour productivity of both formal and informal SMEs • Mobiles now used more frequently to run SMEs than computers, given their prevalence and accessibility • Often overlap of personal and business use of mobiles	13 African countries	Esselaar et al. 2007