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# Mobile Phones for Agricultural and Rural Development: *A Literature Review and Future Research Directions*

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# **Mobile Phones for Agricultural and Rural Development:** *A Literature Review and Future Research Directions*

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## Abstract

This paper provides a systematic review of the potential and the limitations of mobile phones in the delivery of rural services for agricultural and rural development (ARD) in developing countries. Evidence from published research is framed according to the design, uptake, usage and impact of mobile phone-based innovations through a critical review of the literature encompassing both academic and practitioner sources.

The review indicates a rapid expansion of research in recent years, and a growing number of primary research studies that have developed rigorous methodologies for data collection and analysis, with welcome contribution from developing country institutions and researchers. There is positive linking with mainstream research disciplines and specific attempts to develop new theoretical understandings.

Gaps in the literature suggest areas where future research priorities may lie, relating to assessment of information and service needs, consideration of indicators of sector performance and productivity, assessment of broader impacts at the community level, greater focus on methodologies that emphasise user involvement, and expansion of qualitative approaches which could form the basis for theorising and greater geographical diversity. There is also need to investigate new trends that are emerging due to the convergence and integration of new information and communication technologies.

# A. Background and Aims

Rural services are at the heart of successful agricultural and rural development (ARD) in developing countries. Effective delivery of services is defined by Poulton et al (2010:1413) as... "essential if small farms in high potential areas are to intensify production, contribute to economic growth and reduce poverty". Efficient and effective services are required to overcome high unit (non-labour) transaction costs and to access capital, markets and technical inputs, thus enabling small producers to compete successfully with larger counterparts. In recent years, rural services have diversified from agricultural extension and those delivered by government agencies to include a wider range of organisational forms – encompassing non-governmental organisations (NGOs), public-private partnerships, and increasingly, the private sector. A transformed institutional basis for service delivery has broadened the scope of intervention – away from solely providing inputs for improving yields with upgraded production technologies and techniques – to include support for marketing, market access and quality assurance of produce (Feder, Birner & Anderson, 2011). There is also greater emphasis on how small-holder farmers and other rural producers can be engaged more effectively in local, regional or global supply chains – an expanded agenda that has taken on environmental and social concerns, involving new forms of community mobilisation, organisation, learning and interaction (Davis, 2008).

Set against this backdrop of rural transformation, the advent of the mobile phone is stimulating a revolution in rural connectivity for small-holder farmers and other small-scale rural producers in developing countries. Infrastructure networks have expanded rapidly[i] and for many rural producers the mobile phone is enhancing communication, information exchange, and innovation in service delivery (Donner, 2009; Tickner, 2009; Parikh et al, 2007). Mobile phone-based services have proliferated in recent years, providing new ways to access price and market information, and coordinate input/output resources including transport and logistics, finance and production techniques (Qiang et al, 2011; Gakuru, Winters & Stepman, 2009). Successful innovations – that have been scaled – have tended to be market-driven such as Esoko (formerly Tradenet)[ii] in Ghana that provides electronic means to pull data (concerning market prices, buyers, sellers, inventory, transport, etc) and push it back via mobile phone interfaces to thousands of small-holder farmers that are participating in a wide range of produce markets. Personal use of the mobile phone has also enabled rural producers to interact directly with end-user markets, traders, suppliers, extension services and with each other.

The aim of this review is to analyse and understand the potential and the limitations of mobile phones in the delivery of rural services for agricultural and rural development (ARD) in developing countries. This will be achieved by assessing the available evidence concerning the design, uptake, usage and impact of mobile phone-based innovations

through a critical review of the literature encompassing both academic and practitioner sources. This review will...

- Provide analysis of literature and synthesis of research concerning mobile phones for ARD in developing countries – with reference to mobile services that impact upon small-holder farmers and other small-scale rural producers.
- Categorise and analyse conceptual approaches for understanding mobile phones for ARD in developing countries.
- Assess methodologies used to carry out research studies that have been conducted into mobile phones for ARD, and evaluate the evidence from those studies.
- Identify key research trends and gaps relating to concepts and methodologies, evidence presented, issues addressed and questions raised, and provide an agenda for future research.

A review of evidence in this area is opportune given growing global interest in the role of mobile phones for development (M4D) from donors, NGOs, governments and the commercial sector. Expanded rural connectivity, and in particular the growth of mobile services, appears to be stimulating a new wave of optimism concerning the potential of mobile applications (and ICT more generally) to deliver greater scalability, replication and sustainability than has been achieved in previous phases of ICT for development (ICT4D).[iii]

# B. Framing and Methodology

In framing the research area, there is need to move beyond the type of taxonomies that predominate in the predominantly practitioner-orientated literature. These are illustrated by Vodafone (2011) that suggests mobile-based 'solutions' that can provide dedicated systems for mobile payments, farmers help-lines, produce traceability and tracking systems, agricultural trading platforms, etc. IDRC (2008) simply list the technologies, ranging from Geographical Information Systems (GIS) using mobile mapping and Personal Digital Assistants (PDAs) to mobile cellular, Internet and Web-based applications. Whilst useful for providing compendiums of existing initiatives, these approaches to framing mobile phones in ARD have a key drawback. Although they pay attention to prescribing broad areas of application, they are technology-led – viewing the technologies as readily available and to be picked 'off the shelf' rather than part of more complex and dynamic processes of rural development and transformation in service delivery. This tends to give rise to insufficient understanding of the diverse agricultural and rural contexts within which mobile applications are being introduced.

To address this shortfall, this review will be framed within a 2-dimensional matrix that incorporates a temporal lifecycle for mobile phone innovation (based on Heeks, 2007) and a further distinction according to the methodological basis for the study. Additionally, a

categorisation is developed in Section 4 for emergent theoretical approaches based on a taxonomy used by Gregor (2006).

The temporal lifecycle identifies the positioning of the identified study according to four interconnected parameters.

- *Design:* assessment of the requirements for mobile phone innovation that includes the diversified information and service delivery needs of potential users.
- *Adoption:* an understanding the factors that either drive or constrain uptake, and patterns of usage of mobile phones for ARD.
- *Output*: the identification and measurement of the tangible costs and benefits of use of mobile phones such as in the provision of information or transactions.
- *Impact*: the evaluation of broader productivity or welfare gains or threats that result from the application of mobile phones for ARD.

The lifecycle model allows for a broad range of research to be considered in the review that draws upon divergent theoretical and methodological perspectives – ranging from practitioner-led action research that has evolved out of the design processes attached to specific applications to more academically-orientated impact studies that analyse larger and more representative samples. This broad spectrum of research incorporates both a provider and user perspective. Thus, on the one hand, research concerning *active innovation* in mobile-based service delivery is surveyed – studies focused on analysing specific initiatives that are designed to incorporate the use of mobile phones into existing rural service interventions. On the other hand, it is also important to consider how access to rural services results from *passive diffusion* of mobile phones – to understand the patterns of usage and the degree of uptake of services that is stimulated by pre-existing ownership of mobile phones and access to networks.

Methodological approach was selected as a secondary axis for coding of the articles primarily due to ease of identification, and was distinguished in a fourfold manner: a) quantitative studies which are more representative in terms of sampling, but possibly contribute less to theoretical understanding. These comprise 12 research articles all of which rely on field experiments and survey instruments (using structured/semi-structured questionnaires) or the analysis of secondary data; b) qualitative studies which largely focus on analysis of individual case studies, which make no claims to the general population, but tend to provide more in depth data concerning processes and contribute more to explanatory theory. These comprise 10 research articles – seven of which build case studies. Also added were: c) mixed methodology studies which totalled 18 research articles – 17 of which relied on survey instruments (using interviews or semi-structured questionnaires); finally, d) those containing a strong action-participative element. – comprising 3 research articles. The spectrum of methodological approaches is broad and in many cases there is crossover of data collection methods and data analysis techniques. For

example, some mixed methodology studies tend more towards quantitative analysis, whilst some purely quantitative studies make use of participatory methods to formulate and test suitable research instruments. The outcome of the coding of the articles is represented according to the distribution of articles in Fig 1 (overleaf), and analysed in more detail in Section 4 of the review.[iv]

The review identifies published research that is peer reviewed from academic journals, conference and working papers. However, because many key developments in the field are practitioner-led, some non-peer reviewed sources are also surveyed and analysed including consultant and official reports and other occasional and published papers.[v] In line with Table 1, the review is time limited – encompassing research published during the past 10 years with a cut-off point of 31st March 2012. Given the cross-disciplinary nature of the topic, research is drawn from a wide range of academic disciplines which include development studies, economics, technology and innovation, information systems (IS) and information & communication technology for development (ICT4D). The scope of the review includes those studies assessing the application of mobile technologies for ARD in developing countries and English language sources only. The review includes research articles that report the results of analysis of primary data, with emphasis on critical assessment of findings according to the theoretical and methodological approaches followed. Also included are studies that analyse data from secondary sources, either from official sources such as provided by international organisations (e.g., the International Telecommunications Union – ITU) or through analysing data extracted from pre-existing associated research (such as household panel data drawn from surveys conducted in rural areas).

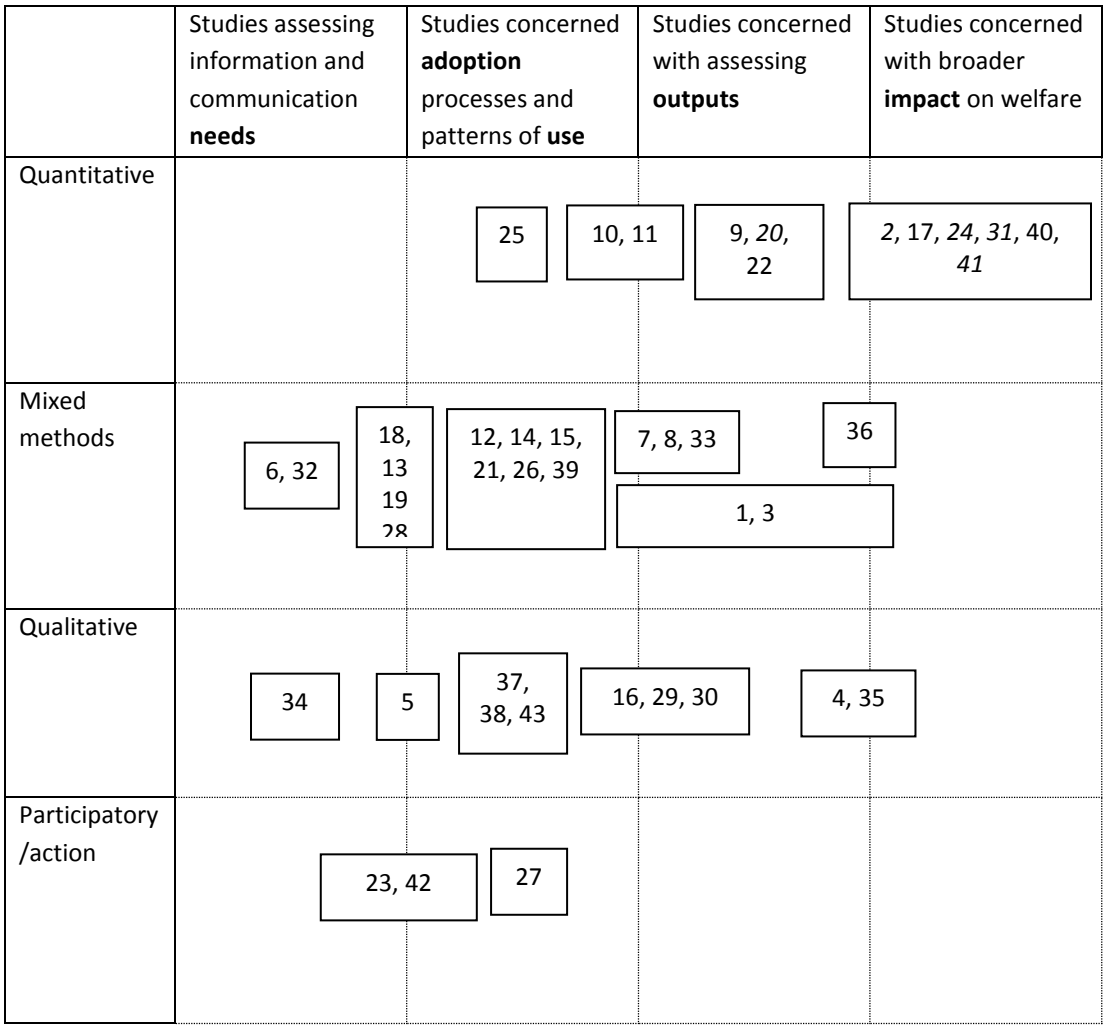
**Table 1. M4ARD Research Timeline and Country Focus**

| Final year of data collection | No of research articles | Country focus |
|---|---|---|
| 2000 | 1 | Botswana |
| 2001 | 1 | Bangladesh |
| 2002 | 1 | India |
| 2003 | - | |
| 2004 | 2 | India, Mozambique, Tanzania, RSA |
| 2005 | 3 | Uganda, Tanzania, Ghana |
| 2006 | 8 | India, Rwanda, Kenya, Nigeria, Tanzania, Niger, Philippines |
| 2007 | 2 | Uganda, Ghana |
| 2008 | 7 | India, Uganda. Tanzania, |
| 2009 | 8 | Ghana, Uganda, Malawi, Kenya, Sri Lanka, India |
| 2010 | 9 | Ghana, Uganda, Malawi, Kenya, Sri Lanka, India, Bangladesh |
| 2011 | 1 | Tanzania |
| Total | 43 | |

# C. Mapping Mobile Phones for ARD: Issues and Evidence

As a first step, the overall distribution of the articles was gauged according to the 2-dimensional modelling outlined (temporal lifecycle and the methodology employed). Additionally, it is indicated whether the evidence presented is based on analysis of primary or secondary data (Fig 1).

**Fig 1. Mapping Mobile Phones for ARD Research**




Normal: analysis of data collected from primary sources (38 articles)
*Italic*: analysis of data collected from secondary sources (5 articles)
Refer to list of references for article number

The following sections will discuss research findings for mobile phones for ARD in terms of the evidence presented and the issues and questions raised in the articles. The discussion is structured according to the temporal lifecycle model, also recognising where areas of overlap exist (as suggested in Fig 1).

## C1. Addressing Needs

The number of studies that analysed mobile phones for ARD exclusively in terms of the needs of farmers and the rural community were few. Prominent was De Silva & Ratnadiwakara (2010) who randomly sampled 300 farming households in Sri Lanka across four traded vegetable markets, and attempted to understand information search costs for core operations along the agricultural-farmer value chain. They found that 70 percent of all transaction costs related to information search costs (the transaction costs themselves were recorded as 15 percent of the total costs incurred). Costs were accounted for both in direct financial expenditure and the opportunity costs of time expended. Similarly, Furuholt & Matotay (2011) view the mobile phone as a means whereby the high transaction costs associated with information market failures and inefficiencies in the business environment can be reduced, thus overcoming costs incurred in the coordination of economic activities related to: a) accessing inputs (infrastructure; production technology, knowledge, finance, materials, learning/training, etc) and, b) reaching output markets (either directly or through market intermediaries) as well as monitoring financial transactions and consulting with experts. Typically, the studies surveyed view search costs and the asymmetric relationships that govern price setting as the most significant informational impediments producers face (e.g., Islam & Gronlund, 2011; Martin & Abbott, 2011). Such high costs normally add to the market price of products and affect competitiveness in the market.

Ndiwalana et al (2010) identify information gaps outside of the economic sphere that are equally, if not more critical, for farming households. This expands the definition of needs into a more diversified set of livelihood concerns that are important for overcoming the broader social, political, location and environmental-climatic constraints that rural producers face. Kameswari et al (2011) surveyed 132 farmers across 8 villages in 4 districts of the Indian Himalayan region and found wide variations between districts (and villages) in terms of crops grown, scale of production, water supply, types of soil, etc. This gives rise to diverse vulnerability contexts and differing needs for information-related services often between districts and settlements in quite close proximity, and which are more or less active in information seeking. A similar perspective was taken by Masuki et al (2010) highlighting how differences in the cultural and social make up of different parishes within the same district of Uganda gave rise to different needs for information, as well capabilities to make use of information. These livelihoods perspectives support the view that fostering sustainable rural production involves addressing a wide range of interconnected constraints which may be longstanding and entrenched within the realities of rural life, and reach into broad and diverse development concerns of environmental protection and conservation, gender imbalances, political participation, health and education (Feder, Birner & Anderson, 2011).

Studies emphasise that information received (either as voice or data) needs to be made usable and actionable, and this requires further information chain resources (Duncombe &

Heeks, 2002) which are both intrinsic – pre-existing knowledge and the necessary capabilities to act – and overt – the necessary infrastructure, technical and specialist expertise that are required to make effective use of information received. In research from Uganda, Burrell & Matovu (2008:3) concur, suggesting that the... "main challenge to providing information services to rural Ugandans rests on providing dependable accurate information that is 'actionable'. Whether information is actionable depends especially upon what capital and what social connections are required to make use of it". Information may also be viewed differently by recipients than by providers. For example, recipients may not view information as a distinct resource, but as broader advice, the veracity and utility of which, is strongly associated with the source, and most commonly demonstrated through human interaction (Burrell & Matovu, 2008). In this regard, mobile phones are strongly linked in the literature – and in the eyes of users – to maintaining and improving social networks – particularly family and personal ties – due to the greater scope of communication they afford (Sife et al, 2010; Goodman, 2007; Donner, 2007; Souter et al, 2007).

Historically, the complex information needs of rural producers have been pursued through these personal and social networks, and mediated through face-to-face contact. Traditional networks of communication tend to be better aligned with the interests of rural dwellers and information sources may embody a certain level of trust (Molony, 2007). Indian research (Islam & Gronlund, 2011) and research from Kenya (Okello et al, 2010) and Uganda (Martin & Abbott, 2011; Kashem, 2010) found that input suppliers, fellow traders and clients were the main sources of market information, thus reinforcing the view that pre-existing informal networks of communication represent the bedrock of rural information systems (Duncombe & Heeks, 2002). An interesting perspective was provided by Fu & Akter (2011) who investigated how mobile phones impacted upon pre-existing extension networks in India where phones were carried and used by *munnas* – assistants to agricultural specialists travelling between villages. The study takes a randomised population (treatment and control group) and measures proxies for adoption, knowledge generation, attitude and awareness amongst a sample of 698 farmers (where there existed a 50% illiteracy rate) measuring before and after intervention differences. Evidence suggests that the amount and quality of services and the speed of delivery had been improved significantly as a result of the mobile phone based intervention with quality of services measured as 74 percent higher than what was available before the ICT (mobile) enhanced services were introduced. Also, disadvantaged farmers – who were starting from a lower base of awareness and knowledge – made greater use of the intervention that those that were better off.

## C2. Adoption and Use

The most prominent early mobile phone-based intervention was the Grameen village phone operator (VPO) programme in Bangladesh. The programme provided important empowerment opportunities for women, but the detailed study of Aminuzzaman et al

(2003) found that both phone operators (predominantly female) and users of the services offered (predominantly male) were more likely to be traders and entrepreneurs than farmers, and only 4 percent of users were illiterate (compared with an 80 illiteracy rate nationally at the time). More recent studies still identify early adopters and more intensive users as better off with a high correlation between mobile ownership, use of a bank account and greater asset endowment (e.g., Katengeza et al, 2011). Intangible characteristics of farmers (such as confidence and aspiration) are also highly correlated with more intensive use, and the constraints of ownership and use are exacerbated for the less well off and the poor. These disparities were evident in the findings from a number of studies from different countries and regions represented in the literature. However, some contrasting findings were also evident. Martin & Abbott (2011) suggest that mobile phones are having a democratising (levelling) effect with no significant difference in ownership between leaders and non-leaders identified in rural communities. Another study from a poor remote area with difficult terrain shows relatively high adoption rates by poor farmers such as an 80 percent ownership rate within the sample reported by Kameswari et al (2011) for the Indian Himalayan region. Similarly, two empirical studies based on a representative sample of phone users demonstrated that greater distance of farmers from markets (i.e., greater remoteness) implied greater intensity of phone use (Katengeza, Okello & Jambo, 2011; Lwasa et al, 2011).

A further set of issues arose in relation to predisposition towards individualised or group-based ownership and use. This is pertinent, given that in developing countries rural producers look to mitigate risk by acting collectively through various forms of community-based organisation. Typically this takes the form of producer groups organised around the cultivation and marketing of specific crops or produce. Extension support also tends to be group-directed such as training and visit (T&V), farmer field schools (FFS) and more contemporary market-based fee-for-service aimed at farmers groups, cooperatives or whole communities (Davis, 2008). Although the literature highlights a number of cases of innovation in mobile-based services built upon group-based participation (Masuki et al, 2010; Gandi et al, 2009; Kithuka et al, 2007; Veeraraghavan et al, 2009), there is also evidence that ownership and use of mobile phones is allied to an emerging individualised culture. Research conducted in Uganda by Masuki et al (2010) indicated relatively low levels of usage of communally provided phones (available to women's groups via village information centres) compared with their use by individual farmers (predominantly men) which was expanding rapidly amongst lower income groups. In associated research from Uganda, Lwasa et al (2011) found that owners of phones are less inclined to participate in, and less aware of, group-based initiatives for information sharing and delivery, whereas existing group members are more aware and more inclined to participate. However, studies showed variation in levels of awareness and usage of services that could potentially be accessed via mobile phones. Most commonly, this was due to poor technological skills and

experience (of the farmers that could potentially access the service) and in many cases that the information provided lacked relevance to their needs.

Another common finding was that use of voice predominates (e.g., Furuholt & Matotay, 2011) with significant constraints on using other formats such as SMS with only 5 percent of users recorded as regular text users by Islam & Gonlund (2011). Similarly, Okello et al (2010) found that 79 percent of rural market traders used mobile phones in their trading activities, with 77 percent preferring to use voice rather than 2 percent that used SMS. This was because traders preferred a system that allowed interaction with the broad range of participants in any given produce value chain including agents, brokers, assemblers, wholesalers and final purchasers – and voice best facilitates this. The preference for voice is also illustrated by Veeraraghavan et al (2009) showing how Indian farmers benefited from a move away from PC-Internet-data-based systems located in rural kiosks (which showed a high failure rate) to a mobile network voice-based system that was found to be less vulnerable, easier to maintain, more accessible to farmers in remote areas, and delivered more up-to-date provision of information and notification of prices.[vi]

## C3. Output and Impact

A distinction has been drawn in this review between *passive diffusion* of mobile phones into communities (largely market driven) and *active innovation* in mobile-based service delivery (largely intervention/donor driven). Theories of reasoned action suggest that passive diffusion is stimulated by the perceived benefits of ownership (Venkatesh et al, 2003) and much of the evidence from the studies surveyed supports this proposition. Of particular note is the study of Jensen (2007) that carried out a longitudinal analysis of 300 sardine fishing units (boats) operating off the coast of Kerala in India. The findings were almost wholly positive with the use of mobile phones strongly linked to reduced price dispersion across markets for landed fish and an almost complete elimination of fish wastage. Whilst wealthier fishermen (early adopters) were the greatest beneficiaries, small-scale fishermen (including those without mobile phones) also benefited due to the spill-over effects of more efficient markets. Abraham (2007) provides less empirical rigor, but qualitative results largely confirm the positive outcomes associated with Jensen. Interestingly, however, respondents viewed the use of mobile phones as less important for their livelihoods than the introduction of improved production (fishing) technology and improved roads and transport. Other studies of use of mobile phones by fishing communities largely confirm the results from Kerala including those of Salia et al (2011) where 22 percent of the sample used phones to obtain market price information from multiple landing sites which led to better market coordination and market prices.

In the agricultural sector, Egyir et al (2011) identified mobile phones as the pre-dominant communication technology amongst farmers in Ghana, measuring an increased speed of price transmission in maize markets – but no marked decrease in transaction costs in

markets where exchanges were dominated by traders that lack literacy and rely heavily on visual inspection. Whilst 80 percent of traders and 48 percent of farmers surveyed used mobile phones to access information, traditional means of collecting and exchanging information had not changed (such as travelling to the market) but use of phones speeded up pre-existing processes. For mobile users, this led to the trading of larger volumes, better prices and slightly larger margins – but only marginal increase in transaction costs (due to an increase in the net cost due to the costs of mobile ownership and use). Similarly, Muto & Yamano (2009) from analysis of data collected between 2003 and 2005 in Uganda found that mobile network expansion (from 41 to 87 percent coverage) had positive effects on market participation. The effects were found to be more beneficial for farmers in remote areas and particularly for those producing perishable crops such as bananas. Similarly, Aker (2008) investigated the impact of cell phones on grain markets in Niger identifying positive arbitrage (reduced grain price dispersion and variations across markets) resulting from a reduction in search costs and hence transaction costs, as well as lower grain prices (3.5% reduction from 2001 to 2006). In common with Muto & Yamano, phone use was found to have greater impact when travel costs were higher – for markets that were more remotely located and unconnected by paved roads (Burrel & Matovu, 2008; Kithuka et al, 2007). Phones also caused traders to change their behaviour – with a greater number of markets searched and more contacts and sales in more markets. These studies also identify a 'network effect' meaning that cell phones have higher impact (on price dispersion, for example) once more markets are covered by the network – with Acker (2008) suggesting diminishing returns over and above 75 percent network coverage.

Data and evidence concerning active innovation in services is less apparent in the review. Notable recent studies include that of Subervie (2011) evaluating the impact of SMS-based alerts for farmers via *Esoko* where econometric modelling of spatial arbitrage conditions found a significant effect on prices with a 10 percent increase amongst the treatment group of 500 farmers to whom mobile phones were distributed in the northern region of Ghana. In contrast, Fafchamps & Minten (2011) gauged the benefits that Indian farmers derive from market and weather information delivered to their mobile phones via a commercial service called Reuters Market Light (RML). A robust estimation technique was used to generate findings for treatment and non-treatment groups comprising 933 farmers across 100 villages (20 in each of 5 villages) in the Maharashtra region. There was some evidence that use of RML positively impacted upon spatial arbitrage and crop grading, although the effect was small. However, no significant effect was measured on the price received by farmers for the produce, nor on crop added value, crop losses resulting from bad weather or the likelihood of changing crop varieties and cultivation practices. In this case, better price information did not result in higher prices paid to farmers and this is explained due to the lack of alternative market destinations and the lack of opportunities for arbitraging by farmers. Overall, the study found a small number of clients for the service in aggregate across the study area and stagnation in take up of the service over the study period. Also in India,

Mittal et al (2010) surveyed the use of IFFCO-IKSL, Fisher's Friend (and RML), each of which provide subscription-based messaging services for packaged information concerning weather, crop advisory tips, market prices, input availability and government schemes. Increasing numbers of subscriptions had brought some benefits to some famers, but constraints on these 'stand-alone' services included lack of awareness of their existence and what they can offer, lack of customisation and updating of content, concerns over timeliness and reliability of information and lack of use of local languages.

More positively, Katengeza et al (2010) demonstrated benefits accruing to farmers from improvements in spatial rice market integration comparing a period before and after the introduction of the Malawi Agricultural Commodity Exchange (MACE) (involving use of mobile phones for the communication of market information) across nine selected markets. The post MACE period saw improvements in market integration (and arbitraging) enabling farmers to access bigger markets and get better prices. However, key intervening factors (that caused high variation in results) were the distance of markets from other markets and poor transport links, which impeded trade. In a separate study making use of a sample of participants and non-participants in MACE, Katengeza et al (2011) found that greater distance from markets was correlated with greater intensity of phone use, which supports findings set out previously. Largely positive results were also reported by Annamalai & Rao (2003:19) in an evaluation of e-Choupal – a pioneering Indian initiative that makes use of mobile phones to connect farmers into the agricultural supply chains of ITC – a large Indian agro-business. In this case... "farmers benefited from more accurate weighing, faster processing time, and prompt payment, and from access to a wide range of information, including accurate market price knowledge, and market trends, which help them decide when, where, and at what price to sell." The research suggested that farmers received an average of 2.5 percent higher income (though it is unclear if this is due to higher price or lower transaction costs) as well as lower prices for inputs and other goods, higher yields, and a greater sense of empowerment. The losers from the new value chain model were commission agents, labourers at the non-ICT-enabled government markets, and shops near those markets, as well as women who had no access to the system at that time.

The preceding studies demonstrate primary interest in impacts on farmers and the markets they trade into. Studies also highlight the impact of phone use on transactional relationships within value chains – and in particular the changing role of intermediaries or traders. Overå (2006) found that both producers and traders benefited considerably from the use of mobile phones after their introduction in 2001 in Ghana. Speed of communication allowed for more efficient information flows within the network of value chain actors, which in turn, saved time and reduced transportation costs. This led to better matching of supply and demand, and improved monitoring of compliance within the terms of trading contracts. One effect was that early adopters of mobile phones strengthened their existing trader relationships and networks, which were built on strong lineage-based

social structures. New market entrants managed (through using mobile phones) to quickly cement good trading reputations and facilitate the building of more efficient trading networks. By contrast, existing traders and new entrants without phones were not able to attain these advantages, although it is not clear whether they were financially worse off as a result.

In contrast, Jagun et al (2008) found little change to the structural characteristics of transactional relationships which remained localised and intermediated. In fact the use of mobiles had consolidated the power and influence of market intermediaries (middlemen) due to their role in accessing complementary market resources such as access to capital and materials. Similarly, a study carried out in India points towards the strong position of established commission agents and traders in local supply chains who are the major price setters (Mittal et al, 2010). Traders and input dealers also provide an important source of information – particularly related to agricultural technology and techniques. One of the key benefits identified for phone use was as a basic communication device enabling farmers to communicate more effectively within their pre-existing networks – ranging from 10-30 calls per day – thus reinforcing those networks. Finally, Molony (2007) concludes that trust in economic relationships does not exist independently of social ties and these tend to be embedded in personal interaction which necessitates face-to-face communication, whilst Masuki et al (2010) found that the complex nature of interactions between service providers and farmers largely mitigated against use of phones.

# D. Conceptual Approaches and Methodological Issues

## D1. Conceptual Approaches

A picture of the conceptual approaches used to research mobile phones for ARD in developing countries can be gained from Table 2 where the research articles are identified together with key references to their antecedents – previous research cited in the article upon which the conceptual approach was based.

**Table 2. Mapping Conceptual Approaches**

| Lifecycle | Conceptual approaches identified | Classification | Antecedents cited | Article |
|---|---|---|---|---|
| **Needs/ Design** | Information needs modelling | C | Heeks (2009)<br>Duncombe & Heeks (2002) | 32, 28, 8 |
| | Awareness/knowledge assimilation | C | - | 11 |
| | Value chain/supply analysis | C | Porter & Millar (1985) | 4, 6, 34, 12, 16, 36 |
| **Adoption/ Use** | Technology acceptance model (TAM) | B | Davis (1989) | 25 |
| | Capital endowments; incentives | C | - | 21 |
| | Diffusion theory | B | Rogers (2003) | 26 |
| | Modelling social capital formation<br>Social/economic network analysis | B | Granovetter (1973)<br>Andrade & Urquhart (2009)<br>Barr (2002)<br>Coleman (1988) | 7, 14, 15, 35 |
| **Output** | institutional economics; asymmetrical information; trust in economic relationships | B | Fafchamps (2004) | 3, 24, 29, 30 |
| | Micro-economic modelling – transaction costs; information search costs | A | Doward et al (2003)<br>Barrett (2008) | 1, 33 |
| **Impact** | Micro-economic modelling – changes in prices; spatial arbitrage/market integration | A | Fafchamps & Hill (2005)<br>Stigler (1961) | 2, 9, 10, 17, 20, 24, 31, 40; 41 |
| | Livelihoods analysis/technology appropriation at base of pyramid | C | Ellis (2000)<br>Orlikowski (1992) | 5, 37, 38, 39 |

Note: Eight studies are not included as they indicated no significant theoretical contribution

In line with the distinction drawn by Gregor (2006) the first category (A) identifies theories that are applied or tested to predict how mobile phones bring about changes in key

variables such as transaction costs and market conditions (e.g., prices paid and arbitrage across markets). These studies emphasise quantitative analysis. In this vein, Labonne & Chase (2009) and Katengeza et al (2010) measure the effects of mobile phone use on information asymmetry – proposing that better access to information (via phones) allows farmers to strike better price deals within their existing trading relationships, and to make better choices about where to sell their produce. Jensen (2007), Acker (2008) and Egyir et al (2011) move beyond measuring narrow price effects and look at differential prices (dispersion or arbitrage across markets for the same produce). Here, better information is hypothesised to lead to a better aggregated market performance and positive welfare outcomes for producers and consumers (as well as users and non-users of mobile phones). The hypothesis of Muto & Yamano (2009) is narrower, suggesting that expansion of mobile phone coverage induces greater market participation of farmers that produce perishable crops in remote areas. Fafchamps & Minten (2011), Subervie (2011) and Svensson & Yanagizawa, (2009) also focus more narrowly on the application of quantitative estimation techniques to evaluate the impact of specific interventions identifying key constructs concerning spatial arbitrage, farm gate prices and market efficiency indicators such as crop value added and crop losses, whilst Fu & Akter (2011) seek to quantify and measure proxies for intangible impacts (e.g., enhanced knowledge and awareness of farmers).

A second set of theoretical approaches (B) can be grouped as explanatory (rather than narrowly predictive) and they are located in diverse disciplines (anthropology; information/management studies; development studies). These include both deeper theory, and framework-based approaches derived from a body of theoretical work. Explanatory theories try to understand the often complex causal relationships between variables, and the resultant outcomes and impacts for ARD within a community. These approaches are most often framed within existing bodies of theory and can employ quantitative, qualitative or mixed methodologies. Most notably, Overa (2006) following the work of Granovetter (1985) argues that adoption and use of mobile phones enhances trust building in trading networks, thus facilitating a higher number of transactions in uncertain environments where trust is at a premium. Donner (2007) suggests a strengthening of pre-existing relationships within networks arising from phone use – phones are used to amplify and strengthen existing trading relationships which are often family and lineage based. The primacy of pre-existing channels for information exchange and the overriding importance of personal face-to-face communication is theorised by Jagun et al (2008) and Molony (2007). In line with Donner, both Islam & Gronlund (2011) and Goodman (2005) conceptualise mobile phones as users see them – as primarily social rather than economic tools. Lwasa et al (2011) takes a different approach, making use of innovation theories linked to the technology acceptance model (TAM) to gauge how socio-cultural factors (relating to farmer, household, farm, assets and location specific variables) condition adoption and use of mobile phones in agricultural transactions.

A third set of approaches (C) use frameworks, models (such as business models), single concepts or categories that are applied but which are not strongly grounded in theory. Most prominent are the producer value chain (Furuholt & Matotay, 2011; De Silva & Ratnadiwakara, 2010; Annamalai & Rao, 2003) where information search and other transaction costs are modelled according phases of pre and post harvest activity – differentiating the primary value chain according to land preparation, seed purchasing, growing, harvesting and selling. Other studies take a broader view modelling sector value chains (Salia et al, 2011; Okello et al, 2010) that include not only primary activities but also support activities and extended sector value chain (or supply chain) comprising actors located upstream (supplying farm inputs) and downstream (responsible for possible further processing, marketing and distribution of produce) as well as final consumers. Also prominent is the modelling of information needs (Mittal et al, 2010; Ndiwalana et al, 2010; Duncombe & Heeks, 2002) which are seen to vary according to market reach – into local, regional and global markets. Producers serving local markets are reliant on information delivered informally through local networks of communication, where trust and risk reduction are major factors that govern their dependence on those networks. Timeliness of information is a serious failure of the information delivery system currently used, and a significant aspect of their vulnerability to changes in the surrounding environment. A higher degree of integration of producers into market systems – extending to regional or global value chains – demands an increased volume and complexity of information as the value of information (and use of ICT) is better recognized. Producers that lack this capacity and opportunity are likely to become marginalized and excluded – particularly from global value chains. Another prominent group of studies look at how use of mobile phones in market settings can work better for the poor, addressing not only information (market) failures but also livelihood objectives – to build and acquire assets and reduce vulnerability. Thus in addition to providing a means to transact goods and services, mobile phones may also have potential to enhance the empowerment, opportunity and security of the poor – taking livelihoods perspective (Sey, 2011; Sife et al, 2010; Burrel & Matovu, 2008; Souter et al, 2007).

## D2. Methodological Issues

Research strategies followed in the studies encompass use of field experiments, field studies (especially case studies or ethnography), action/participatory research and compilation and analysis of data from secondary sources (such as existing surveys or panel data). The review evaluates the robustness of the research methods by assessing: 1) means of sampling and sample size; 2) the setting of baselines or provision for counterfactual explanations; 3) recourse to validity testing or discussion of validity concerns; 4) whether research is cross-sectional (snapshot) or longitudinal (giving time-span); 5) the extent of method guidance that would be sufficient to replicate the research. Finally, it is indicated whether the article is peer reviewed (which most are).

The largest group of studies falls between the two methodological poles employing mixed methodology approaches most commonly combining a questionnaire or interview survey with more in-depth key informant interviews or focus groups. With the exception of Aminuzzaman et al (2003) mixed methodology approaches are snap-shot surveys that employ varying degrees of cross-sectional design. In terms of contributing to stated programme and policy objectives they achieve their goal, but the rigour and transparency of their stated methods varies. Mixed method studies are less clear about whether or how they address the counterfactual, and tend not to employ sufficient triangulation of data sources to demonstrate validity. They tend to use anecdotal examples and measure perceptions of users of stated variables, rather than the variables themselves (e.g., Martin & Abbott, 2011). There is also limited method guidance. However, mixed method studies that are effectively designed and properly conducted provide useful exploratory findings.

## Table 3. Mapping Methodological Approaches

| No | Tax | Study focus | Data type/ collection | Data/sample | | Baseline/ counterfactual | Validity/ testing | Timing | Method guidance | Peer review |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **Primary data** | **Secondary data** | | | | | |
| 1 | A | -Economic impact of mobile phones on the fishing industry in India | Mixed methods<br>-focus groups<br>-survey | -12 locations<br>-172 respondents | None | None | Sample survey cross checked with focus groups | Snapshot | Little | PR |
| 2 | A | -Impact of cell phones on grain markets in Niger | Quantitative | -395 traders<br>-205 farmers<br>-35 markets | Monthly grain prices over 10 years (1996-2006) across 42 markets | Quasi-experimental – pooled and separate treatment groups | Alternative explanations tested by controlling for confounding variables, selection bias and heterogeneity | Multiple time periods | Detailed | PR (int) |
| 9 | A | -The effect of ICT-based market information services on the performance of agricultural markets in Ghana, | Quantitative<br>-structured questionnaire | -140 farmers<br>-11 markets<br>-486 traders<br>-KI interviews<br>-rural focus groups | None | Users and non-users surveyed | Testing for co-integration between source and destination markets | Snapshot April 2010 | Detailed<br>Non-Peer Reviewed | PR |
| 10 | A | -Impact of SMS-based agricultural information on India farmers | Quantitative<br>-interviews | -100 villages<br>-20 in each of 5 districts<br>-933 farmers interviewed and followed up | None | Randomised control trial<br>Treatment and control groups<br>Random sampling | Robust testing strategy | Snapshot | Detailed | PR (int) |
| 11 | A | -The impact of ICT on agricultural extension services delivery in India | Quantitative<br>Randomized survey data<br>-interviews | -698 farmers interviewed<br>-507 in control group | None | Careful identification of control and treatment group | Double difference strategy controls for farmer, household and village characteristics | Changes before and after the intervention | Detailed | PR (int) |
| 17 | A | -Information, technology, and market performance, and welfare in the South Indian fisheries sector | Quantitative | 300 fishing units | None | Baseline established prior to trial | Random sampling<br>Robust empirical strategy | Longitudinal 1996-2001 | Detailed | PR |
| 20 | A | -The role of ICT-based market information services in spatial food market integration in Malawi | Quantitative | None | Official data from 9 selected markets across Malawi | Baseline set according to study period | Causality tested through econometric means | Longitudinal 1994-2004-2007 | Detailed | PR |
| 24 | A | -Impact of mobile phones on farmers' welfare in the Philippines | Quantitative | None | Mobile phone coverage data for 2,400 HH combined with HH | Baseline established prior to study | Reliability tests conducted via estimation strategy | -Change measured between 2 data collection points | Detailed | PR (int) |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | data from 135 villages | | | 2003 – 2006 | | |
| 31 | A | -The impact of mobile phone coverage expansion on market participation in Uganda | Quantitative | None | 856HH<br>94 communities | Baseline established | Robust estimation strategy | 2 data points 2003 and 2005 | Detailed | PR |
| 33 | A | Use of information and communication tools and services by rural grain traders in Kenya | Mixed methods<br>-survey | 204 traders<br>141 in KACE project area<br>63 outside area | | Users and non-users surveyed<br>Random sample | None | Snapshot (May-July 2010) | Little | PR |
| 40 | A | -Evaluation of the impact of a Ghanaian mobile-based MIS | Quantitative<br>-interviews | 196 users<br>203 future users<br>200 non-users | None | Quasi-experimental<br>Users and non-users surveyed | Preliminary data – bias in sample | Before and after treatment groups | Little available as yet | NPR |
| 41 | A | -The impact of a market information service in Uganda | Quantitative<br>-interviews | Key informant interviews | Secondary data on farm gate prices from UNHS (2005) | Treatment and non-treatment groups surveyed | Robustness checks employed<br>Lack of reliability checking of source data | Before and after/selection controls | Some | PR |
| 3 | B | -A study of the village pay phone of the Grameen Bank in rural Bangladesh | Mixed methods<br>-survey | -350 VPOs<br>-20 locations<br>-158 users<br>-85 operators<br>-55 key informants | None | Included 50 non-users from control area | Triangulation between different data sources | Data collected 1999-2000 | Little | PR |
| 7 | B | -The use of mobile phones by rural micro-entrepreneurs in Rwanda. | Mixed methods<br>-interviews<br>-call logs | 277 interviews<br>2,700 discrete calls analysed | None | None | Non-random sampling<br>Variables tested through regression analysis | Snapshot<br>Dec 2003 | Detailed | PR |
| 14 | B | -Linking mobile phone ownership and use to social capital in rural South Africa and Tanzania | Mixed methods<br>-interviews | RSA-252<br>Tanz-223<br>Individual users | None | None | None | Snapshot 2004 | Little | NPR |
| 15 | B | -Farmers' information technology use practices in Bangladesh | Mixed methods<br>-questionnaire<br>-observation<br>Interviews | -420 farmers<br>-13 districts<br>-50 villages | None | None | Convenient and random sampling<br>Multiple methods | Snapshot<br>Nov 2007-Feb 2008 | Some | PR |
| 29 | B | -Trust and ICTs in Tanzanian micro- and small agricultural enterprises | Qualitative<br>-interviews<br>-observation | Multiple ethnographic case studies | None | None | Case specific cross checking of responses/observations | 15months duration | Detailed | PR |
| 30 | B | -The limitations of mobile telephony in a Tanzanian agricultural marketing systems | Qualitative<br>-interviews | Multiple case studies<br>Interviews | None | None | Triangulation of data collection methods | March-Sept 2003 | Some | PR |
| 35 | B | -Telecommunication development and changing trading practices in Ghana | Qualitative<br>-interviews | 80 traders | None | Baseline established in 2001<br>Non-random sample<br>Non-users interviewed | None | Longitudinal 2001-2003 | Some | PR |

Thus, the summary of methods analysis (Table 3) highlights research from categories A&B only (see Table 2). These tend to be of greater contemporary interest and relevant to researchers and policy makers given their claims to explanatory or predictive power.

The studies grouped under (A&B) demonstrate an encouraging level of rigor in their research design and methods. Quantitative studies conform most closely to the conventional model of positivist research employing longitudinal designs, incorporating baseline data, and addressing the counterfactual by surveying both treatment and control groups. On the whole, most of these studies provide detailed method guidance. This is important as such studies need to pay careful attention to sample selection through matching control groups of non users to phone user (treatment) groups. However, studies have varying degrees of awareness of other methodological pitfalls such as cross-over or contamination of control groups or a presumption of unidirectional relationships between cause and effect where the direction is from the phone (independent variable) to the assessed (dependent) variables. For example, it would be important to understand whether use of a phone stimulated higher farm gate prices, or whether those farmers gaining higher prices were more able to afford and make better use of mobile phones. Establishing the direction of causality across a broad range of indicators within a scientific approach requires large samples and careful use of methodological and computational techniques, or alternatively, complementary use of qualitative means to understand the directionality of influence within the complex process chains that link variables. One criticism of research to date would be the use of relatively small sample sizes, with the exception of those studies that draw data from existing secondary data sources (Katengeza et al, 2010; Labonne & chase, 2009; Lwasa et al, 2011; Muto & Yamano, 2009; Svensson & Yanagizawa, 2008). The specification of variables also presents concerns, where selection of narrow indicators such as price (e.g., Katengeza et al, 2010) does not take into account trade flows (quantities transacted) and transfer (transportation) costs. The studies surveyed demonstrate varying degree of transparency in the way they deal with these methodological challenges, but in most cases these challenges have been acknowledged in the written up research.

Qualitative studies (predominantly group B) make no claims to the general population where the use of small indicative samples means that findings can only be inferred within the particular context of the study, and validity of those findings will depend upon the detail and quality of the evidence provided, as well as the degree of triangulation used to cross-check data or demonstrate areas of contestation. The strength of qualitative research, however, is precisely that it is able to highlight the extent to which findings can be context-specific – but detailed

qualitative ethnography is thin on the ground. The emerging studies (particularly Donner, 2007; Molony, 2007; 2008 and Overa, 2006) provide valuable insights, but are representative of exploratory work in progress, and overall, there is a noticeable lack of in- depth qualitative case studies that could provide a basis for further theorising. Participative or action research can be a particularly appropriate method for investigating new phenomena[vii] and participative approaches are evident in studies associated with the design of specific initiatives (Masuki et al, 2010; Gandi et al, 2009; Kithuka, Mutemi & Mohamed, 2007; Veeraraghavan, Yasodhar & Toyama, 2009). These studies were designed to empower the beneficiaries of research and together with a focus on participatory learning are primarily focused on improving impact – with the exception of Fu & Akter (2011) – who provide a quantitative analysis of what was originally a participatory intervention.

# E. Research Gaps and Future Research Directions

This final section identifies key research trends and gaps concerning issues, evidence, theoretical and methodological approaches and outlines pointers to future research.

## E1. Gaps in Issues and Evidence

The distribution of studies along the temporal lifecycle tends towards researching both outputs and impacts, and these tend to include the studies that have greater rigor, and this is to be welcomed given the dearth of reliable impact studies in the discipline of ICT4D.[viii] From the limited amount of research currently available, a broad picture of overall benefits of mobile phones for ARD is emerging. Greater connectivity and communication has led to significant improvements in coordination of supply and demand, coordination within value chains, communication and transparency of market prices, speeding up and facilitating of transactions, mobility of traders and personalised communication (i.e., less reliance on institutional mediation). However, the benefits derived seem to be based to a greater extent on passive diffusion of mobile phones. That is, where phones have been adopted by individual farmers and traders, and have diffused organically into market segments. The form, extent and distribution of benefits (such as between producers and traders, men and women) is contested and evidence highlights constraints on access and use such as the absence of trust where communication lacks face-to-face contact, inexperienced users and inefficient or incorrect use of the phone functionalities.

Thus far, there is less evidence of significant benefits arising from active innovation in service provision. There are a number of reasons for this. First, most service innovations have not yet achieved scale, and are localised or at the pilot or proof of concept stage (Donner, 2009) and have not received sufficient attention from

researchers. Second, research outputs concerning innovations in service delivery have tended to be practitioner and not academic-orientated and insufficiently developed for publication or to inform policy. Third, according to Qiang et al (2011) 71 percent of mobile application projects aimed at rural development are funded by donors or governments – with the results of internal evaluation of project implementation and impact assessment not often released into the public domain. In many cases, donors are partnering with service providers and this creates further constraints of commercial confidentiality, with the expectation that new applications will form an increasingly important part of private sector marketing and revenue strategies in the years to come.[ix]

Another gap concerns how mobile compares with other technologies as a means to deliver information-based services. Evidence from project based evaluations in the field suggests that mobile can be used effectively as part of a mix of technologies, but there is lack of detailed research into areas of convergence. Studies looking at alternatives also tend to investigate discrete technologies such as Gandi et al (2009) who focused on (the largely failed) Internet-telecentre-based model for rural outreach, or Svensson & Yanagizawa (2009) who carried out econometric analysis to assess the effects of intervention of market information services provided by FM radio through agricultural service organisations.[x] The single technology focus combined with the narrow-empirical approach of research has caused lack of emphasis on service integration. This is also because most early initiatives are small-scale and focused on meeting specific/localised needs for market information. Increasingly, however, initiatives are being scaled to more comprehensive and flexible platforms (e.g., Esoko) that are customisable and integrate different technologies and services (information provision, prices, training/knowledge transfer and transactions) with the potential to transform significantly the *modus operandi* of agricultural values chains.

A further gap concerns lack of understanding of context. With the exception of Acker (2010) and some others, research tends not to differentiate or to seek to understand the vulnerability contexts of rural producers. Research employing livelihoods analysis tends not to be well developed – employing a livelihoods framework for analysis of data rather than engaging in livelihoods research – the emphasis of which should be to engage participants in the research process. However, the small number of participatory studies identified in the review is valuable. In this respect, there is need to gain the participation of producers and traders – to understand how information is generated, validated, evaluated and understood – and to further appreciate areas of contestation concerning the value of information. Active learning also arises through participation and this is important for understanding how use of mobile phones becomes adapted to specific

requirements for communication and information exchange. Producers should be recognised as well organised learning communities rather than just consumers of information – and in this respect there is a need to place greater emphasis on understanding the particular requirements of those organisational forms (e.g., farmers associations, coops, women's groups, etc).

## E2. Gaps in Conceptual and Methodological Approach

The emphasis of research rated as higher quality (i.e., that with greater theorisation and methodological rigor) into mobile phones for ARD has been aimed at the quantification of outputs. This research assesses economic measures such as farm gate prices, transaction and information search costs, the conditions for spatial arbitrage and overall market efficiency. There is a welcome focus on predictive theories that provide testable constructs (normally through the application of statistical models). This fulfils the requirement of Weber (2009: 14) to provide... "a normative foundation for policy makers – one that allows them to identify specifically the factors that they need to take into account in conjunction with ICT initiatives to achieve positive development outcomes". However, these approaches tend to be narrowly defined – identifying key focal constructs and then using empirical means to demonstrate the robustness of the chosen construct(s) for a sample of the population. Reliability of such research can be improved through use of larger and more carefully constructed samples, and repeat (panel) studies, but also through use of extensive and clearer statements of methodology which will aid the replication and transferability of lessons learned.

Explanatory theories provide a framework for thinking more broadly about how the problems of rural development might be solved through use of mobile phones – these are less well covered in the literature. As Acker (2008) points out, forms of rural intervention have been in decay for some years, beset by high costs, problems of scale, low motivation and accountability of field staff. Mobile phones may be correcting some of those market failures which are information related, but conceptualisation needs to take account of a broader set of infrastructure, geographical and societal factors. An important research gap is to understand the role of institutions and institutional linkages – such as the poor knowledge transfer that exists between research centres and extension systems and the weak policy and regulatory governance, which, within a resource poor environment, limits the value of information delivered via mobile phones. Explanatory theories can also assist understanding of why the existing institutions and networks that govern rural trade can be quite resistant to such a disruptive innovation as the mobile phone. For example, Kameswari et al (2011) point towards the strong ties that can force farmers to accept prices from established middlemen, rigidities that are compounded by other practical constraints of perishable products, lack of storage and inaccessibility

to alternative markets. To address these issues, there is need for more detailed qualitative case studies, and experimental research designs, which may add a greater degree of conceptualisation to the study of the phenomena.

Predictive and explanatory approaches to researching mobile phones for ARD have tended to create a divergence between quantitative and qualitative research. Different methodological approaches to research have different objectives and should not be judged by the same criteria. Thus, the robustness and validity of survey methods (broadly quantitative or mixed-method) will be dependent upon how the population and sample are selected, the development of appropriate survey instruments (e.g., questionnaires or interview schedules) and the effective execution of surveys. On the other hand, the robustness of case study or ethnographic methods (broadly qualitative – and which make no claims to the general population) will depend more upon case selection, triangulation of methods and evidence, time spent in the field, iteration between data and constructs, etc. Ideally, theoretical approaches should combine both explanatory and predictive power, and these constitute what Merton (1968) terms mid-range theories and according to Weber (2009) they should be preferred as they tend to be neither too broad nor too specific, and are more able to articulate relationships that hold across a range of contexts.

One key methodological gap in the studies, concerns only limited application of participatory methods or action research. This was surprising given the exploratory nature of much mobile phone for ARD activity and the high degree of involvement of practitioners within early initiatives. Unfortunately, the lessons learned have not yet been translated into definable and publishable approaches to research involving participatory methods. In this respect, mobile phone for ARD can be considered to be lagging behind other development sectors where participatory methods have been developed as a critique of positivist (both quantitative and mixed method) approaches (Mayoux & Chambers, 2005). It is also noticeable that the quantitative and mixed method studies surveyed provide little evidence (with some exceptions) of having made use of participatory methods in the process of developing indicators and survey instruments – or if they have, they have not been made explicit, and reported in the study.

## E3. Conclusions and Future Research Agenda

This review indicates a rapid expansion of research concerning mobile phones for ARD in developing countries. This is the first systematic attempt to review how this research has progressed both conceptually and methodologically. It is hoped that the studies reported here are representative of the field of research, and the interpretation of those studies by the author accurately reflects the research

conducted.[xi] Though not exhaustive, the review has yielded several important insights.

Overall, the reviewed studies indicate positive developments

- A growing number of primary research studies that have developed rigorous methodologies for data collection and analysis, with welcome contribution from developing country institutions and researchers.
- A positive linking with mainstream research disciplines – specifically information economics – where conceptual and methodological approaches have been advanced.
- Specific attempts to develop theoretical models, and create a deeper understanding of applications, most noticeable in the area of social network analysis and through the integration of approaches to understanding the formation and role of social capital.

On the other hand the reviewed studies also indicate gaps in research which suggest areas where future research priorities may lie

- The assessment of information needs and aspects of service access and use behaviours and preferences of poor users in advance of specifying mobile phone for ARD solutions.
- To move beyond narrow measures of output (market prices, market penetration, etc) to consider indicators of sector performance/productivity and broader impact on household/community welfare.
- Greater focus on methodologies that emphasise user involvement such as participatory methods and action research, or where these approaches have been used to ensure they are fully documented.
- An expansion of qualitative approaches and experimental designs which could form the basis for theorising.
- Greater geographical diversity – the state of current knowledge is based upon a relatively narrow evidence base (a limited number of countries in sub-Saharan Africa and South Asia).

Overall, the review suggests that as market information systems become more sophisticated their impact upon market efficiency is growing. The evidence from this review already suggests that new information technologies involving mobile communications and networks are realising significant benefits of speed, mobility and efficiency in information exchange creating new opportunities for arbitrage and making it easier for small producers and new entrants to participate and compete in markets. Future research needs to address the existing gaps in conceptual approach, data and methodology, but it also needs to assess the trends that are emerging due to the convergence and integration of new technologies.

In this regard, more detailed and rigorous research is required into areas of active innovation, where research into emerging services is still at an early stage. Currently there is a big push to create innovation in service provision in the form of mobile-platforms that integrate mobile for ARD applications with handsets, payment mechanisms and common standards (Qiang et al, 2011) thus potentially integrating a range of actors in producer value chains. According to Poulton et al (2010:1420) these emerging commodity exchanges have the potential... "to enhance the efficiency of impersonal long distance trade by providing market information and offering fast and low cost resolution mechanisms for contractual disputes. The existence of such exchanges is also a prior step to the development of more sophisticated trading contracts, such as futures and options that could protect traders (and indirectly producers) against price volatility". There are opportunities to extend current research concerning value chain analysis (which this review suggests is currently at a basic level) to broader issues relating to competition, regulation, market structure, returns and equity, that will arise as use of integrated platforms become more widespread and potentially dominant in the way in which some agricultural markets operate.

Finally, there needs to be a new awareness amongst researchers of the rapidly changing technological landscape where competing technologies are converging and where limited functionality (e.g., voice, text to voice, interactive voice response, and SMS, etc) is being supplanted by a wider range of more sophisticated technological options. As higher capacity networks become available in rural areas this will create opportunities for greater functionality via GPRS, full Internet coverage via smart phones and tablets, providing scope for multi-media applications, location-based services, and social network features. As well as giving greater mobility and portability, such devices and applications will offer greater processing power through cloud connections, open source development, and possibly greater affordability, speed to market, new opportunities for micro-revenue generation and financial sustainability. Scaling and replicating these emerging applications will require large-scale investments in technical and human resources, and it is important that future decisions concerning mobile applications are not based upon false optimism, but rather upon a critical understanding of the conceptual and practical basis for application and a reasoned and balanced view of the evidence of their efficacy.

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[i] Growth in mobile-cellular subscriptions (now almost 6 billion worldwide) has been driven by developing countries in recent years, which accounted for more than 80% of the 660 million new mobile-cellular subscriptions added in 2011. In 2011, 142 million mobile-cellular subscriptions were added in India, twice as many as in the whole of Africa, and more than in the Arab States, CIS and Europe together. By end of 2011, there were 105 countries with more mobile-cellular subscriptions than inhabitants, including African countries such as Botswana, Gabon, Namibia, Seychelles and South Africa. Countries where mobile-cellular penetration increased the most in 2011 include Brazil, Costa Rica, Kazakhstan, Lao P.D.R. and Mali (ITU, 2012).

[ii] Using mobile phones, Esoko gives agribusiness and projects the opportunity to share information quickly and affordably, creating a free flow of information in and out of rural areas. Esoko provides a range of applications that both push updates out to the field and pull data in from the field, and any organization can use it to bring thousands of small-holder farmers into markets, communicate with clients and members, track stock and inventory, find buyers and sellers and pull interactive data from the field. (see: http://www.esoko.com/about/)

[iii] The first phase of ICT for development (ICT4D 1.0) stretched from the mid/late-1990s to the mid/late-2000s, and was characterised by Internet/tele-centre projects. Many of these failed to deliver and/or survive, had limited reach and there was lack of objective evaluation of impacts. The outcome of the first phase of ICT4D led to a rolling re-appraisal of priorities, processes, and purposes. The second phase (ICT4D 2.0) has been characterised by a new wave of services and innovation which have centred around the use of mobile technologies and networks, and a desire not to repeat the mistakes associated with ICT4D1.0 (Heeks, 2009).

[iv] Because the review was carried out by a single author the procedure for coding of the articles was carried out in two stages in order to provide means for cross checking and verification of coding. The first stage involved: a) a detailed reading of each article to identify key issues addressed and evidence/findings presented. On this basis the articles were categorised according to the temporal lifecycle – also highlighting areas of overlap; and b) a preliminary categorisation according to the methodology followed which provided the clearest separation between distinct groupings of studies (quantitative, mixed method and qualitative). In the second stage the articles were separated into the aforementioned three grouping and re-read in order to look more closely at both the methodologies followed and the conceptual basis for the research. This resulted in the more detailed coding set out in Tables 2 and 3.

[v] On-line searches were conducted accessing a broad range of databases from within the social sciences – incorporating a broad range of disciplines – economics, development studies, business and management, as well as more specialised disciplines that reach across into the technical domains – Informatics, Information Systems and Information and Communication Technologies for Development (ICT4D). Databases searched were: *ABI-Inform (ProQuest), EBSCO Business Source Premier*, *Emerald Fulltext* and *Science Direct* as well as more general searches using both *Google* and *GoogleScholar*. Additionally, a number of websites specialising in the dissemination of research concerning mobile phones and development were searched (*kiwanja.net/ dgroups.org/ mobileactive.org*). Search criteria cross referenced key words linked to: a) mobile technologies (e.g., mobile networks, cell phones, mobile, mobile phones) with b) those linked to rural and agricultural development (e.g., agriculture, rural development, agricultural extension, livelihoods, fishing, etc) and c) those linked with the developing country contexts (e.g., developing countries, poor, rural services, livelihoods).

[vi] The "unwired" system benefited farmers in terms of a significant reduction in the number of journeys needed to reach trading centres thus reducing transaction costs, more efficient management of relationships with their customers, greater transparency and availability of data on sugarcane output for individual farmers, including fertiliser usage, harvesting permits and pay schedules; and provided a competitive advantage for the cooperative, over those farmers that did not have the system (see: Veeraraghavan et al, 2009).

[vii] Action research is a reflective process of problem solving led by individuals or teams or as part of a 'community of practice' to address issues and solve problems. Action research can also be undertaken by organizations, assisted or guided by professional researchers, with the aim of improving their

strategies, practices, and knowledge of the environments within which they practice. See (for example) Greenwood & Levin (1998)

[viii] See Duncombe &Boateng (2009) that review research into the application of mobile phones in the delivery of financial services in developing countries.

[ix] A recent industry report entitled 'connected agriculture' (Vodafone, 2011) identifies a wide range of market-orientated mobile-based products ranging from mobile payments and insurance systems to farmer help-lines and agricultural trading platforms all directed at... 'driving efficiency in food and agricultural value chains'.

[x] This was based on a survey based on analysis of weekly data on district farm gate and market prices for different commodities in Uganda during 2004/2005. They observed a high degree of fluctuation of prices at different markets, but also higher prices gained for those making use of the FM radio broadcasts, and an improvement in the relative bargaining position with local traders.

[xi] The methodology of the review has sought to search out a comprehensive range of literature concerning mobile phones for ARD in developing countries and apply an objective and balanced analysis, but some limitations to the review are also noted: First, there are gaps in the literature coverage due to coverage being limited to peer-reviewed journals and other non-peer-reviewed sources printed in the English language. Coverage is also biased towards those countries where mobile phones for ARD initiatives are underway, with a particular focus on African English speaking countries and the Indian sub-continent. Second, the review included available published sources only, which may have excluded 'grey literature' and other reports or studies compiled in developing countries that have not been disseminated via established networks.