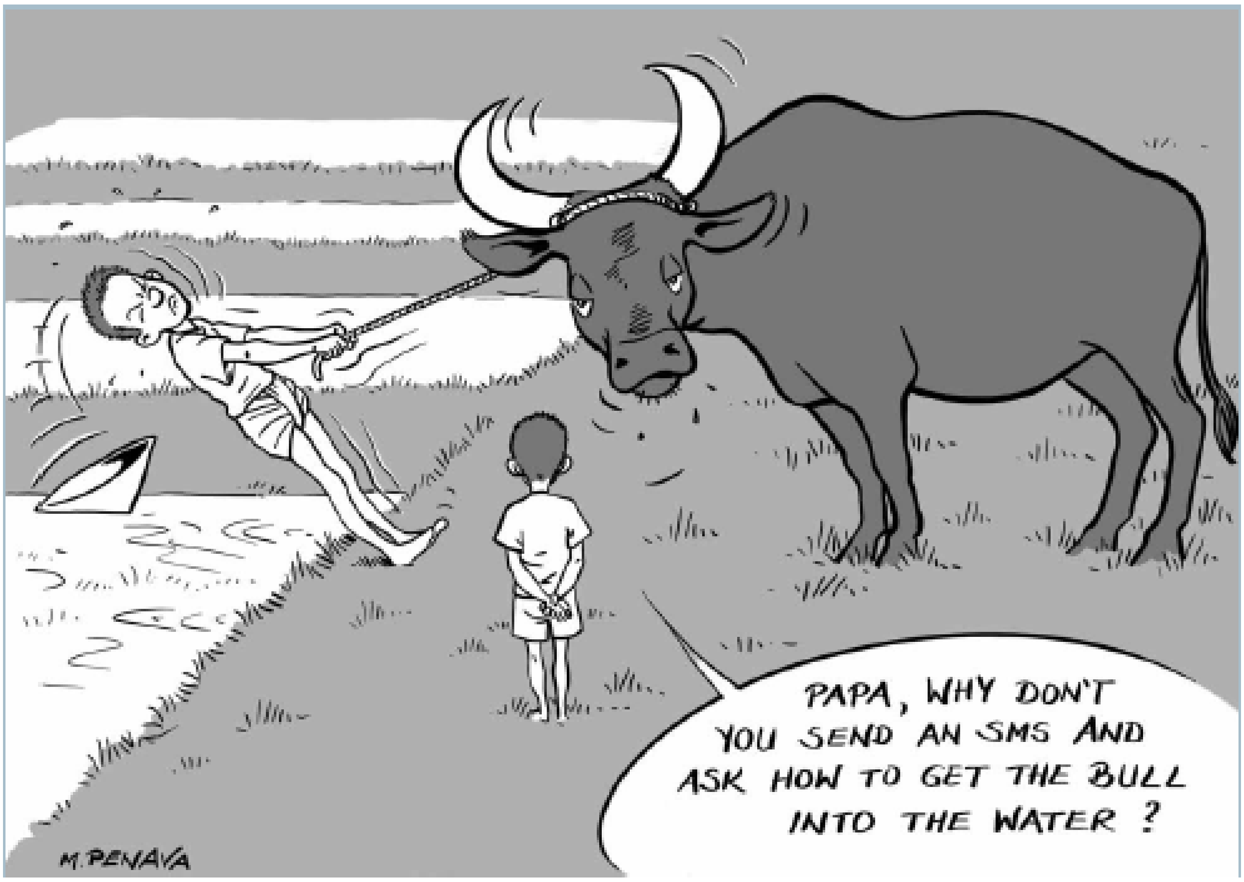
Mobile Applications in Agriculture



(Illustrations and graphs: GTZ 2008, The Participatory Web - New Potentials of ICT in Rural Areas)

Disclaimer: Given the pace of development, information on mobile technology can rapidly become outdated. In most cases, this publication reports on applications' status as of mid-2010. Mention of an application, or its absence, does not reflect any opinion of the Syngenta Foundation. The author is grateful for readers' additions to the information provided here.

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Abbreviations

ARPU	Average return per user
AWS	Automated Weather Station
CRM	Customer Relationship Management
FARA	Forum for Agricultural Research in Africa
ICT	Information and communication technology
ICT4D	Information and communication technology for development
IDI	ICT Development Index
IVR	Interactive Voice Response
M4D	Mobile for Development
PDA	Personal digital assistant
RFID	Radio frequency identification tag
RSS	Really Simple Syndication
SaaS	Software as a Service
WAP	Wireless Application Protocol

1. Framing the issue

Over the past 50 years, crop yields have grown at very different rates around the world (Fig. 1).

Most smallholder farming systems are much less productive and profitable than they could be. The reasons include lack of access to inputs and credit, and the inability to bear risks. . Another major contribution is the information and skills gap that constrains the adoption of available technologies and management practices, or reduces their technical efficiency when adopted (World Bank, 2007). Public extension programs are often underfunded, suffer from weak agricultural research and lack adequate contact to farmers. A further problem is the lack of coordination along the agricultural value chain from farm inputs to food processing, which increases the cost of production and lowers revenue for farmers.

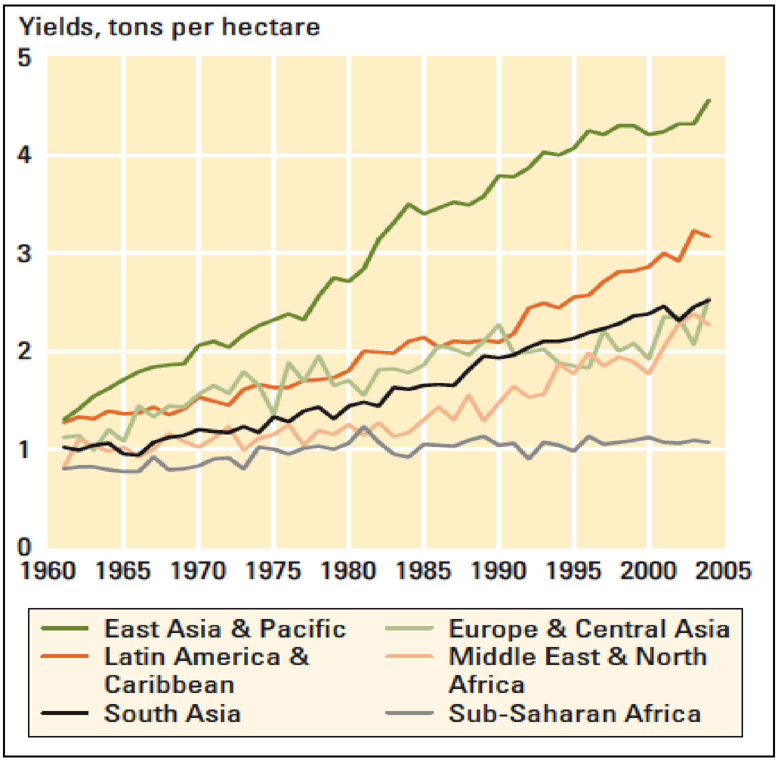

Figure 1: Productivity growth since 1960 varies widely between regions.

Farming is becoming a more time-critical and information-intense business. A push towards higher productivity will require an information-based decision-making agricultural system. Farmers must be get information at the right time and place. Research in Sri Lanka[i] recently found that the cost of information from planting decision to selling at the wholesale market can make up to 11% of total production costs. The study also found that information asymmetry is an important contributor to overall transaction costs (De Silva and Ratnadiwakara, 2008).

ICT, and in particular mobile technologies, are often seen as a 'game changer' in smallholder agriculture.

The list of potential benefits (McNamara, 2009) covers numerous aspects of extension and agriculture development:

– Increasing smallholder productivity and incomes

- Making agricultural markets more efficient and transparent
- Linking poor farmers to urban, regional and global markets
- Improving services and governance for the rural poor
- Promoting – and including smallholders in – agricultural innovation
- Helping farmers manage a range of risks
- Improving land and natural resource management and addressing environmental pressures
- Helping poor farmers participate in higher-value agriculture
- Supporting the emergence of a more diverse rural economy, and supporting rural families' decisions about their mix of productive activities

The discourse on mobile technologies in agriculture is part of a wider debate on ICT and mobile technology in development, which has received significant attention over the last ten years. Enthusiastic studies find "mobile phones do have a multi-dimensional positive impact on sustainable poverty reduction" and identify accessibility as the main challenge in harnessing the full potential (Silarszky et al., 2008). More critical political economists (Leye, 2009) contest the assumption that technologies are autonomous forces or independent variables causing change in every domain of human life. Pointing to the importance of socioeconomic, cultural, political, and institutional factors, they believe rather that ICT reinforces existing dependencies, and call for the examination of crucial matters of control, cost, selection, and utilization. A third group (Fourati, 2009) takes a pragmatic approach, noting that poverty is a multidimensional phenomenon, and lack of access to information and communication can exacerbate its causes. They see ICT not as an end in itself but as an important enabler. Instead of IT-driven approaches, they call for appropriate policies and for a careful coordination and integration in other development strategies for ICT to create a positive overall impact.

'Tele-density' is rapidly increasing, as shown by the ITU's ICT Development Index IDI (ITU 2010)- Mobile penetration in rural areas is also growing strongly (International Telecommunication Union ITU, 2010). Our survey presents an inventory of current mobile applications in agriculture and assesses the potential of mobile 'apps' to strengthen existing development efforts. It strives to identify models and applications that can make a difference on the ground. The results will inform SFSA's own engagement with mobile applications to fulfill its mandate even more effectively.

Other organizations are also running similar surveys. They include FARA (Gakuru et al., 2009) and the CTA observatory (Cranston, 2009, Parikh et al., 2008). Academic examinations of trends in ICT in agriculture include those of Parikh et al., 2008 and Ballantyne et al., 2010. The World Bank's InfoDev unit is preparing an ICT in Agriculture Sourcebook[ii] to be published in late 2011.

2. Analytical Framework

This chapter describes the conceptual, analytical and methodological framework deployed in this survey. The following five issues are addressed:

- *Delineation of the topic to be studied:* In the first place, agriculture involves everything from planting to harvesting. However, looking at it from a business perspective like the SFSA puts agriculture in a much broader context and opens up more opportunities for mobile applications

- *Typology of information flows along the agricultural value chain*: To discuss the mobile applications in a structured way, we propose a way of clustering them according to the type of information processed.
- *Definitions used in the survey*: ICT terminology is rapidly evolving and not always used in the same manner. We introduce the key terminological concepts relevant in this survey.
- *Levels of complexity of mobile applications in mAgriculture initiatives*: Mobile applications range from the very simple to highly complex ITsystems. This has consequences for the type of services and information provided, the number of stakeholders involved, the equipment and skills required, and the cost of operation and maintenance. We map some basic mobile app “ecosystems”.
- *Viability and sustainability of mAgriculture services:* We introduce the basic elements and variables of mobile application business models, to inform our thinking about value for money delivered by mobile applications and to consider their financial sustainability.

2.1. Agriculture from a business perspective

Understanding agriculture as a business, this report puts the farming cycle – and the use of mobile applications in agriculture – into a broader perspective and adopts a view of agricultural activities within their entire economic, social and institutional environment. It tries to understand existing initiatives and experiences as well as the potential of mobile technologies to foster the productivity and performance of individual farmers, of the agrifood value chain including its supporting services, and the agrisector as a whole (Figure 2).

This perspective on the structure and organization of the food system involves the coordination of many stakeholder groups and agents. These includes intermediaries (brokers, processors, exporters, retailers), supporting organizations (extension agencies, NGOs, foundations, researchers, government), financial service providers (banks, insurance), and consumers.

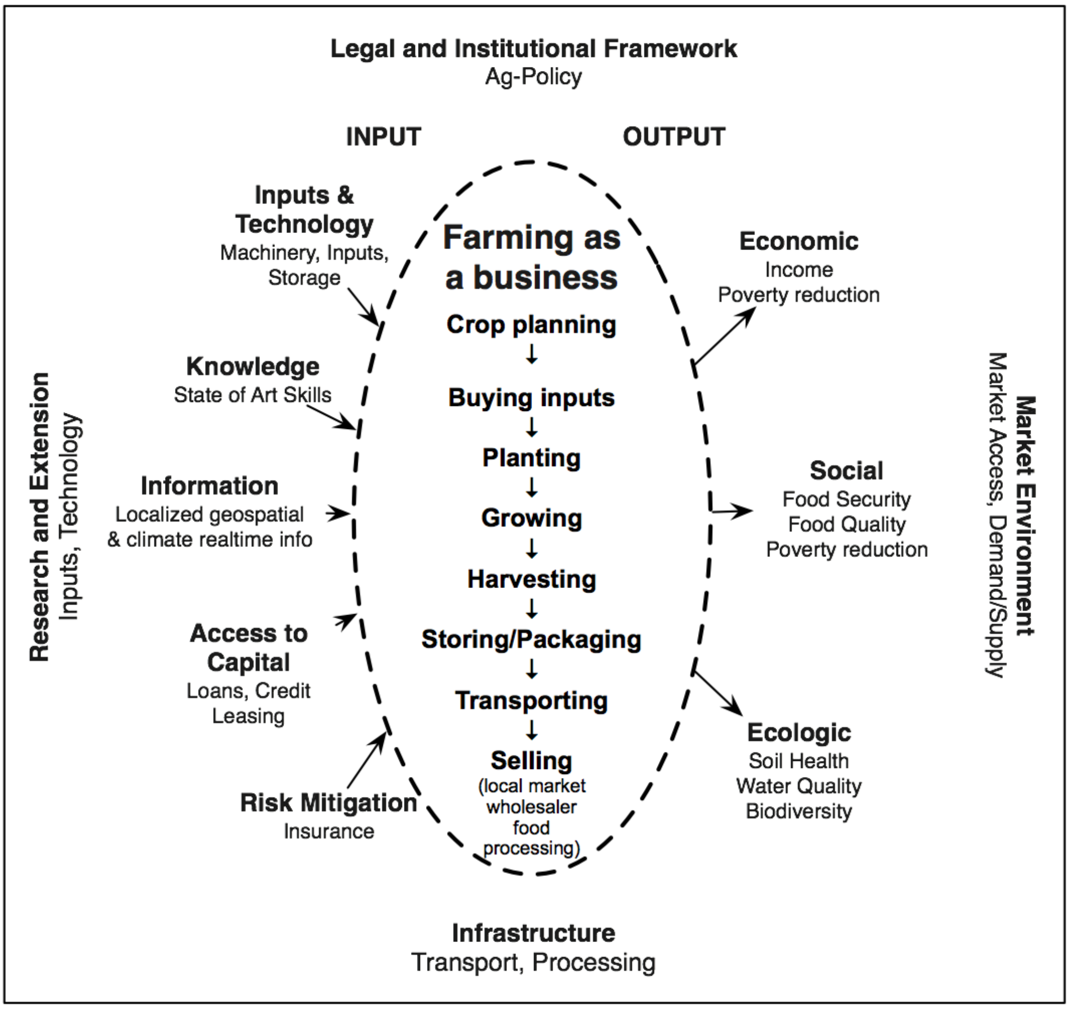

Figure 2: Farming activities in a business perspective

2.2. Typology of information flows along the agricultural value chain

ICT's power is in collection, processing and exchange / distribution of information. Each stakeholder involved in the agricultural value chain has different functions, interests and information flows that need to be managed

Some surveys have clustered mobile applications around the categorization of information flows in agricultural value chains according to the inter-stakeholder communication needs that are satisfied. Parikh et al., 2008 distinguish three categories: a) link-to-link (L2L): those information flows required to coordinate the distribution of produce along the value chain, b) peer-to-peer (P2P): communications required to share knowledge and experiences between members of the same stakeholder group, and with the expert community serving that group and c) end-to-end (E2E): communications between producers and consumers, to facilitate exchange of non-economic values as external inputs to market pricing (e.g. certification).

We use a clustering that focuses on the function of information in the farming process.

a) Extension services:

Applications discussed under this category cover communications required to transfer and exchange knowledge and experiences to and among farmers, to facilitate the dissemination of information from research and extension agencies to farmers. This information flow addresses the significant skills deficit among small producers, and offers the potential to reach many more farmers than relying on traditional extension channels only.

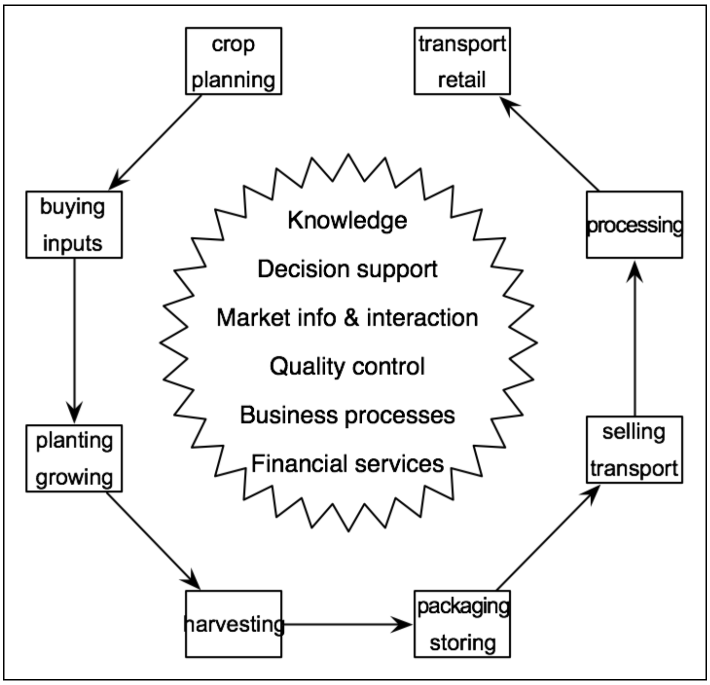

Figure 3: Information requirements and business processes offering opportunities for mobile applications along the value chain

Mobile projects in agriculture extension can be clustered in two broad categories:

a. **mLearning:** Transfer of general know-how on farming techniques and trends, information on plants and varieties and how to grow them, etc. This mainly takes the form of one-way push communication to subscribers to a service (e.g. general information related to particular crops, weather forecast) or enables users to send queries to a database. More interactive forms also offer possibilities for exchanging experiences among farmers.

b. **mFarming**: Individual decision-support systems and services based on localized contextual information, i.e. delivering location-specific (spatial) information based on microclimatic patterns, soil and water conditions throughout the cropping season, in order to inform decisions on agricultural measures to optimize plant growth. In essence, this is about making some key elements of 'precision farming' available to small producers. mFarming requires remote sensing instruments. and GIS. It can also involve advice systems such as remote diagnosis of diseases by experts.

b) Market information and interaction:

This category clusters information flows required to coordinate the procurement and distribution of produce along the value chain. The use of mobile technology is expected to improve market transparency and efficiency and strengthen the farmers' position as sellers of commodities.

a. **Market information:** This includes price information systems (e.g. market prices of different inputs and agricultural commodities in different trading locations).

b. **Trade facilitation / trading platforms:** trading systems and platforms to identify best sale/buy opportunities and commodity exchange platforms.

c) Support services and systems

a. **Operational process** management:

b. **Quality control:** communications between sellers and buyers, producers and consumers, to facilitate exchange of quality of product (e.g. grading) and non-economic values as external inputs to market pricing (e.g. certification of fair trade products, adherence to quality standards, ecological footprint, verification of origin of product).

c. **Logistics and business process management:** Applications that facilitate sound business processes in rural areas (e.g. transporting agricultural commodities, tracking goods, organizing seller/buyer accounts).

d. **Financial services**: Communications and processes to provide financial services such as payment or insurance to rural farmers and agents involved in the agriculture value chain. Applications in this area particularly address the issues of distribution, outreach and business processes that enable dealings with clients in rural areas.

d) Data collection:

The last category is not unique to agriculture, but does support agricultural development. Data collection is often used to inform extension services, research, policy-making and market intelligence. It includes surveys on farming practices and general collection of data related to the agriculture value chain.

2.3. Definitions

In the context of this survey, we adopt the following definitions for various types of ICT use in agriculture:

– **eAgriculture**

The term eAgriculture describes the delivery of agriculture-related services via information and communication technology (ICT). Using this kind of service requires access to PCs and internet. eAgriculture can also involve the use of techniques like GIS, remote sensing and various wireless devices.

– **mAgriculture**

mAgriculture is a subset of eAgriculture, referring to the delivery of agriculture-related services via mobile communications technology. Mobile communication technology includes all kinds of portable devices like basic mobile phones, smartphones, PDAs or tablet devices (e.g. iPad)

mAgriculture can also involve gathering relevant data through mobile technologies like automated weather stations (AWS) or systems and sensors for location-based collection.

– **teleAgriculture**

  teleAgriculture is another subset of eAgriculture, referring to agriculture-related services delivered with agronomist participation via electronic communications. teleAgriculture overlaps with mAgriculture when mobile communications technologies are employed in the delivery process. This can, for example, include remote diagnosis of plant disease based on a picture of the plant (see m-Krishi or e-sagu projects)

– **Mobile 2.0**

  Mobile 2.0 applications offer services beyond simple voice or text messages. These include payments, money transfers and mobile banking.[iii]

2.4. Levels of complexity of mAgriculture initiatives

mAgriculture projects vary in the complexity of technology used and agents involved, depending on the service offered:

– Low complexity: systems pushing one-way information that is generated automatically (e.g. price information, weather forecast) or offering information stored in a database.

– Medium complexity: systems that include location-based services for decision-support based on local climate and soil information (e.g. crop disease warnings). Content generation is more complex, but the systems still rely mainly on one-way communication.

– High complexity: two-way systems that provide individual feedback and advice (e.g. remote diagnosis), administer business processes and individual transactions (e.g. insurance policy registrations, individual information for farmers or traders on sales, quality, inputs, etc.) or enable user-generated content. These systems typically include the use of smartphones and intermediaries for the communication with farmers.

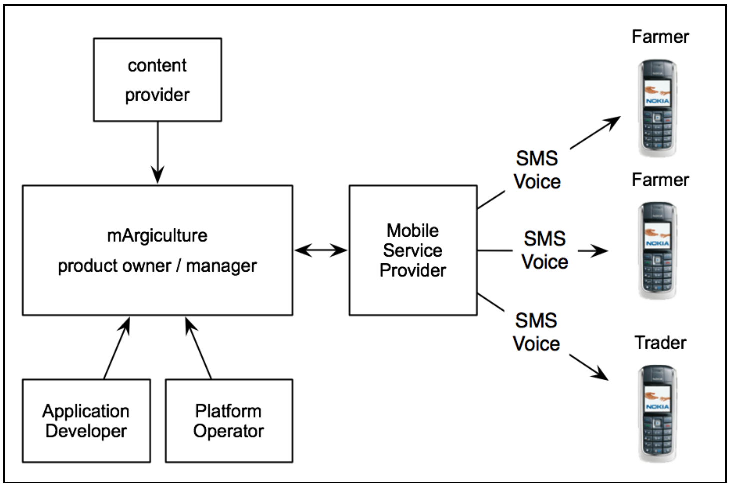

Figure 4: Basic mAgriculture services and agents involved

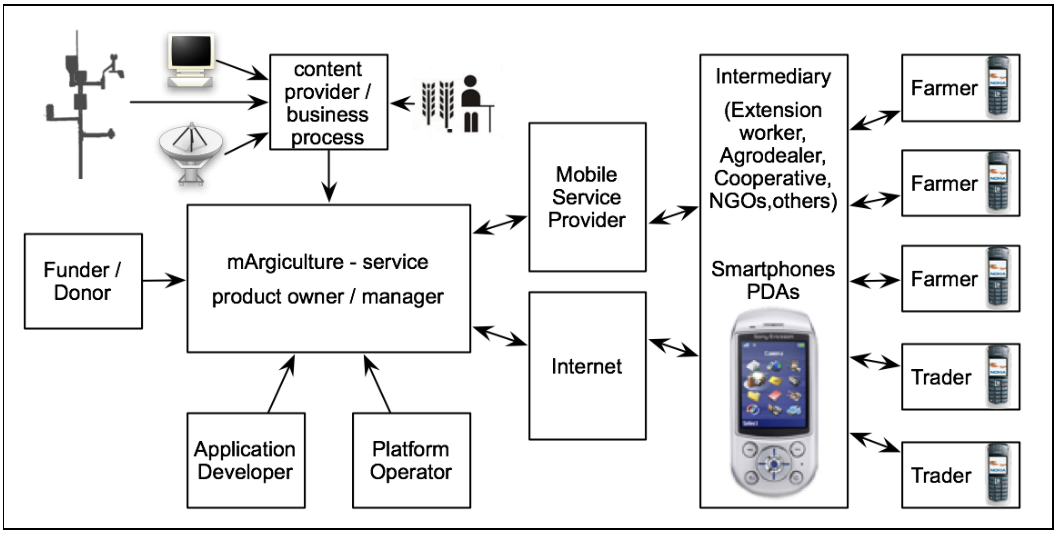

Figure 5: Complex mAgriculture initiatives

2.5. Viability and sustainability of mAgriculture services

Figures 4 and 5 illustrate the various parties involved in mAgriculture services. Together, they represent the value chain of a particular mAgriculture service, i.e. the collection of participants, their relations and steps involved in the design of the solution components, content production, promotion and delivery process, including support and training for the end user.

To turn a mAgriculture initiative into a viable and self-sustaining product, two critical sets of criteria must be addressed:

– The first set of criteria focuses on the end user of the service and is mainly about usefulness of the product (value for money);

– The second set of criteria addresses the needs and incentives of the other players in the value chain of the service

Both are discussed below.

a) Viability criteria for end user of the service

mAgriculture projects are built on the opportunities provided by increasing use of mobile phones by farmers in developing countries. The expectation is that they increase outreach and at the same time lower costs.

However, if they are to capitalize fully on the technical opportunities, mAgriculture projects have to benefit end users in terms of convenient and valid solutions to some of their every-day challenges. The following criteria help to evaluate this aspect:

– **Availability and Accessibility of service**: language barriers, literacy barriers (both general and technical), availability across a large diversity of handsets, skills and education level of prospective users, training and support requirements, time to learn and use, timeliness of service;

– **Value and 'richness' of content**, **value for money**: Richness and value of content provided or relevance of task performed, content generation and development over time, accurate local content that is really usable, responsiveness to user demands, affordability (in particular considering farmers' price sensitivity)

– **Impact**: impact achievements (e.g. improved performance or outreach); cost savings or increased operational effectiveness (e.g. where it is used to organize business processes);

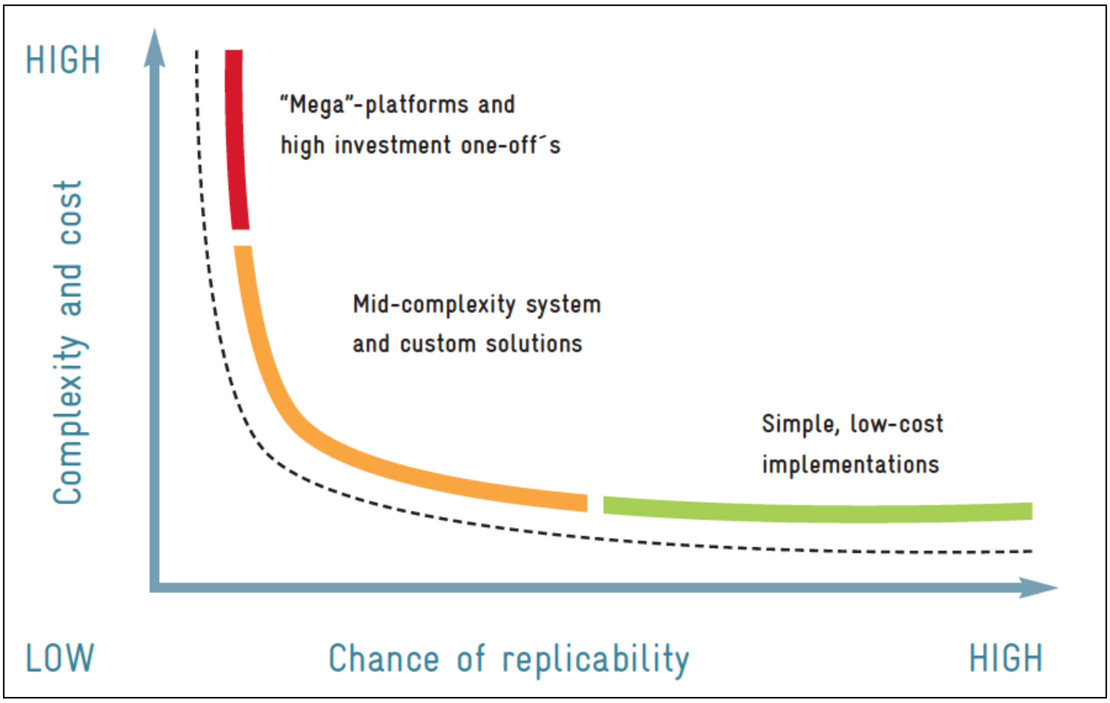

Figure 6: Complexity versus replicability of mAgriculture initiatives

b) Viability criteria for value chain players

The setup of mAgriculture services involves a broad range of players. The most important are:

– Handset manufacturers
– Content providers: public and private institutions that develop the content of the service
– Product manager: institution that runs the project
– Software companies: to develop and maintain the application
– Mobile carriers: technical and financial aspects of cellular network use
– Premiums Service Providers: intermediaries providing mobile services (e.g. mobile payments)
– Automated information sources providers: sensors (eg. weather stations, irrigation sensors)
– Funding agencies: Given the public interest in strengthening the agriculture sector, the development of ICT4D applications, systems and services usually benefits from donor and/or government money to meet the high initial costs.
– Others

The long-term sustainability needs to be secured without relying on external funding only. These aspects have to be considered in the initial design of the project.

The ability to demonstrate and deliver appropriate incentives to every stakeholder in the value chain is essential for a sustainable initiative: Each member of the mAgriculture value chain must have sufficient incentive to justify continued participation.

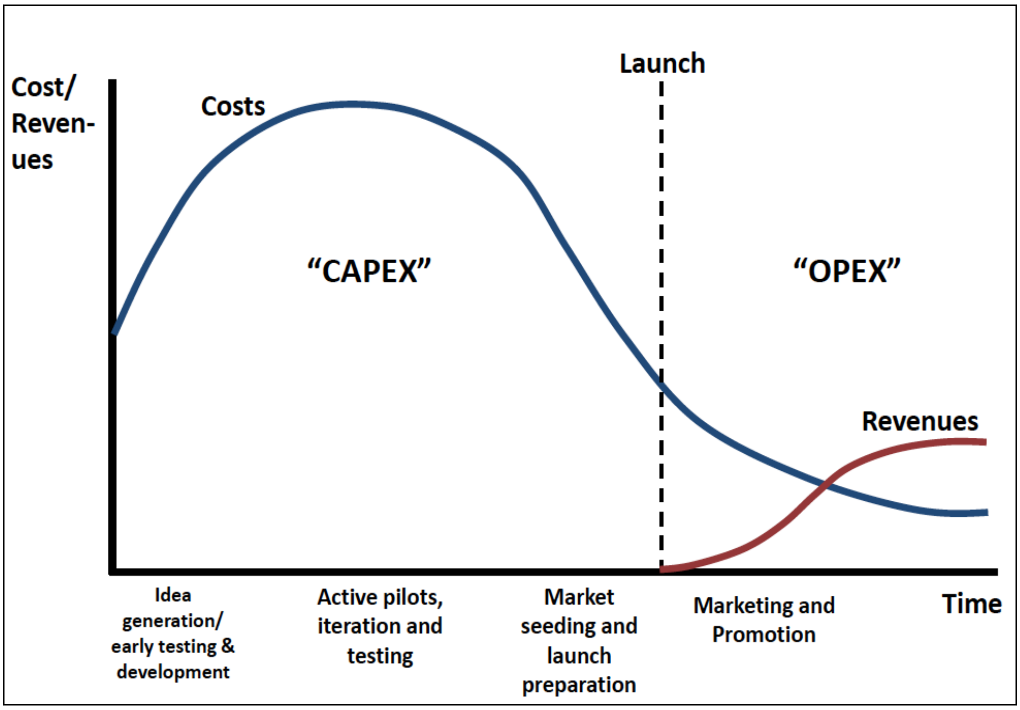

Figure 7: The role of donor funding of mobile applications for development (Cantor, 2009)

To assess long-term sustainably, the following topics are relevant in mobile applications:

– **Business model:** in mAgriculture, public and private institutions as well as NGOs often join forces. How are the partners in the project tied together? How are roles and responsibilities, risks and benefits allocated?

– **Cost of maintaining technical platform**: long-term operation, maintenance and replacement cost need to be addressed.

– **Costs for generating content**: Who is responsible for content development for the mobile application and how are these costs met? Research and extension agencies may anyway generate some of the content, but this almost certainly needs reshaping for project use. Generating more location-specific content may need extensive additional efforts.

– **Revenue generation, scale and volume required**: The cost / revenue model is a key part of all mobile applications and will vary depending on the service provided. Two main situations may apply:

  a. systems that run like other "premium services" offered by mobile providers on a subscription basis (e.g. RML), or perform routine tasks, need high volumes to generate enough revenues for the operator;

   b. services that are more content-focused and provide a higher degree of individualization need greater content generation efforts, and probably have to consider additional funding sources beyond user fees.

- **Impact**: the total cost calculation as well as the evaluation of impact needs careful attention, in particular when permanent third party funding is required to maintain a mAgriculture service.
- **Exit strategies for donors and commercialization of product** (if donors are involved): many mAgriculture projects require high up-front investments to build the necessary infrastructure and environment. . An exit strategy is needed for when the service becomes fully operational.

3. Mapping mAgriculture services & projects

This section presents the surveyed projects, clustered by the type of service provided. The boundaries are blurred to some extent, since many applications provide a combination of services (e.g. extension combined with market prices).

3.1. Mobile-driven extension services

This chapter presents the application of mobile technologies to foster demand-led extension and to reduce knowledge and skills gaps.

a) mLearning

The focus of mLearning applications is transfer of basic skills state-of-the-art technologies, and production skills for crops, livestock and fisheries.

- **Internet platforms**: many governments and research institutions offer or work towards comprehensive internet platforms that provide access to all relevant information. These are eAgriculture projects, but not mAgriculture services as defined above.

  a. **Philippines**: **e-extension**[iv]: government-operated platform that provides comprehensive information. The innovative features are online training courses on a broad range of different topics.

  b. **India**: **Agropedia**[v]: This is a Wiki-type of website developed as a collaborative project by seven consortium partners (ICRISAT, IIT Kanpur, IIT Bombay, GBPUAT Pantnagar, UAS Dharwad, IIITM Kerala and NAARM Hyderabad). Agropedia also offers a crop-specific library, blog and chat.

  c. **India: aAqua**[vi] (Almost All Questions Answered) aAQUA is basically an internet-based discussion portal, initiated by the Developmental Informatics Lab at IIT. Use of mobiles extends the service. As aAQUA works as an open discussion forum, users have created more than 90% of the content. aAQUA service started in kiosks and cyber-cafés in Pune district in December 2003. aAQUA portal has different discussion groups such as Crop Cultivation, Animal Husbandry and Dairy, Market Prices and other related activities. It provides easy and fast retrieval of contextual information, documents and images using various keyword search strategies with the help of query expansion and indexing techniques. Using this, a farmer can ask a question on aAqua from a kiosk (cyber-café); other farmers or experts answerwith solutions to the problem. It is available in English, Hindi and Marathi.

     Kiosk operators at the field level assist users in creating the content. Farmers / other users can upload text, photographs and videos on the website.

     Based on free access software with very low initial investment, development of the system is easy to replicate. However, the challenge is to get the user base. Between 2003 and June 2010 there were only 14’230 registered users. Poor internet connectivity in villages, illiteracy of farmers and lack of revenue all hamper long-term sustainability.

Access to the platform via SMS is an additional service, as is the offline modus for use on e.g. TVs via an aAqua-box.

Pakistan: Pakissan[vii] Pakissan.com is the first and largest agricultural web portal in Pakistan, providing a platform where the entire agri-community can connect with each other, sharing ideas, experiences and information. Viewable in both English and Urdu, the portal offers features like the latest news and issues from around the world as well as inside Pakistan. There are also advisory, report and business center sections, including a regular special report on important aspects of agriculture. To promote the site, Pakissan.com inaugurated its digital mobile van in 2002. The internet-ready van travels around the country to familiarize rural farmers with the use of information technology in the agricultural sector, and how it can enhance their profitability.

– **Call center approach:** On their mobiles, farmers can call a tele-center where agents – usually agronomists – answer their questions and provide vital information on cultivation techniques such as planting, irrigation, disease treatment and other input-related issues. The agents also answer queries relating to poultry, livestock and fisheries. Most often, a knowledge database is developed with content providers like the government, research institutes and universities; the database is continuously updated with relevant content to support the agents. Examples include:

a. **Bangladesh: Jigyasha 7676**[viii]: launched by the second biggest mobile operator Banglalink in December 2008 as the first mobile-based agro-info service in Bangladesh. The Banglalink call center service has generated enormous response among the target farmers. 700,000 calls came in within six months of launching the service, 40% of which were repeat calls. More than 1’000’000 calls were received in 2009. The trend mid-2010 was around 100,000 calls/ month. A study is being designed to measure the impact on farmers' lives. Katalyst (a project implemented by Swisscontact on behalf of several international donors) has provided technical support to Banglalink for the development of this service.

b. **India: Kisan Call Center (KCC)**[ix]**:** The Department of Agriculture & Cooperation (DAC) at the Ministry of Agriculture launched Kisan Call Centers in January 2004 across the country to deliver extension services to the farming community.

The purpose of these call centers is to respond to agricultural and related issues raised by farmers, instantly, in their local language. There are call centers for every state, which are expected to handle traffic from any part of the country.

c. **Kenya: Kenya Farmers’ Helpline – m-Kilimo:** This service was initiated by the call center operator KenCall. KFHL started in September 2009 and provides agricultural and horticultural information, advice and support.. The service primarily targets individual farmers and will also be accessible to agriculture extension facilities. In-house agricultural experts answer registered farmers’ queries in English or Swahili. In the event that an agricultural expert is unable to respond at once, the helpline agent contacts the second-line consultants and reverts to the farmer within 24hours.

KFHL has required significant financial and non-monetary investment. When KenCall started this idea, it did so using its own financial capital and time and energy. When the GSMA Foundation came on board, it reimbursed KenCall for its investment in technology, infrastructure and time. The overall project has a budget of $1.8 million investment over 18 months which began in October 2009. After 12 months, KenCall is expected to begin to commercialize the project, investigating which revenue generation activities are viable. KenCall plans to try to commercialize the service and anticipates that it will be financially self-supporting by the time donor funding ends. By end of March 2011, it was not yet clear how much progress has been made on this.[x]

The service is free. Callers only pay the standard mobile usage rates to place the call. As of March 2011, m-Kilimo had 45,000 registered farmers and 38,000 questions have been asked and answered, although KenCall has not yet released any specific impact data.

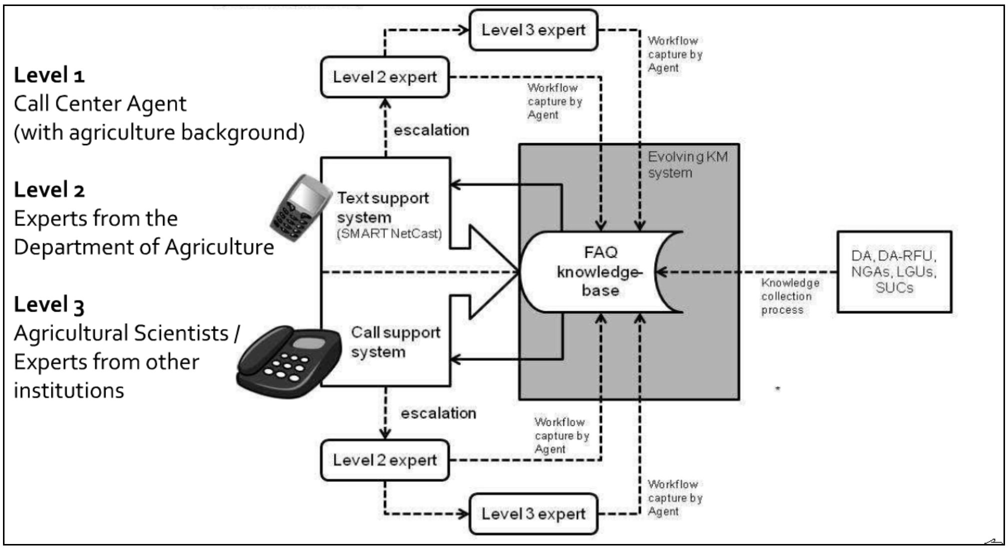

Figure 8: Typical work-flow for call-center service

– **SMS and voice message delivery (push and pull)**

a. **India: IFFCO Kisan Sanchar Limited (IKSL)**:[xi] Mobile operator Bharti Airtel partnered with IFFCO (Indian Farmer Fertilizer Cooperative Ltd) to form the joint venture IKSL in 2007. This company provides information on market prices, farming techniques (including dairy and animal husbandry), weather forecasts, rural health initiatives and fertilizer availability, etc. IKSL sends 5 free daily voice updates (except Sunday) in local language so that also illiterate farmers can benefit. The project also runs a 24-hour helpline to answer farmers' questions. Content is developed with inputs from agricultural universities, experts and government departments.

   IKSL is mainly targeting the 55 million farmers who are members of IFFCO. The service is marketed as part of specialized mobile tariff package only on Airtel's network with an IFFCO Kisan branded SIM card: The farmer pays a one-time activation fee for the SIM card. After that, voice mail service is free, helpline queries are charged at 1Rp/min.

As of mid-2010, a total of around 2.5 million SIMs had been sold, with 0.7 million farmers as active customers. (Users who do not listen to messages for a specific period are removed from the list).

In 2009, a market research Interviewed around 8'000 users to assess their satisfaction level. Overall, the service received good ratings on parameters such as clarity and relevance of messages, and comparison with other sources of information.

To develop the service, IKSL has received a 450'000 USD one-time grant from GSMA Foundation.

After the IKSL success, two similar initiatives were launched in India. Government-owned telecom company BSNL and National Fertilizers Ltd (NFL) piloted a project offering crop information services, weather forecasts, soil testing and health information in local languages. RCOM formed a joint venture with Krishak Bharti to retail customized telecom products and farmer-specific value-added services in rural India.

b. **Thailand: *1677 Farmer Information Highway**[xii] is a Corporate Social Responsibility (CSR) project by telecom operator Telenor. Subscribers receive free information on market trends, commercial crops (rice, vegetable and fruit), livestock and fisheries, important news updates and warnings on weather conditions. The Thai Department of Agriculture and Agricultural Economics provided content.

   4-6 messages per day are forwarded to subscribers. The content format has been upgraded in phase II of the project and includes MMS and Video Clip, no longer SMS only. The project is also linked to Happy Radio of the Telenor group and a farmers' help center, where subscribers can network with successful farmers and experts.

   The service is free to Telenor subscribers and has around 200'000 registered users and more than 5,000 subscribers have agreed to subscribe to receive content per MMS and Video Clip The government of Thailand contributes to the cost of the service.

c. **Nokia Life Tools**[xiii]: Launched in India in 2008, Indonesia and China in 2009. Information related to commodity prices, commodity news, agri-inputs (seed, fertilizer and pesticides) prices, weather forecasts and agricultural tips & techniques. In Indonesia, instead of market price, which is the main focus in India, Nokia Life tools concentrates on information related to animal husbandry, fisheries, etc.

   For agriculture-related information, Nokia initially tied up with Reuters Market Light (RML), but this cooperation has now finished. For market prices, Nokia partners with State Marketing Boards; Skymet provides weather information. On agricultural technology, NLT has tied up with Syngenta and various other sources of expertise.

   The information is pushed daily via text messages. There are two categories of services. Basic offers weather and agriculture news and tips for Rs. 30/-per month. Premium, which in addition provides selected market prices, costs Rs. 60/- per month.

   Nokia has started the project on a commercial basis without donor involvement. NLT is a strategy to maintain its position in the very competitive handset market. Service is being sold as an inbuilt tool with Nokia handsets (only selected models in the lower price range). Nokia is aggressively promoting this application by partnering with local organizations / agencies such as e-Choupal, KSK Microfinance, NGOs and other micro-

The service is currently available in India (since early 2009), Indonesia (since Nov 2009), China (since May 2010) and Nigeria (since Nov 2010). As of April 2011, over 15 million people have experienced NLT services in these four countries.

d. **Kenya: Corn variety SMS service**[xiv]: Kenyan Farmers can get an SMS for the recommended corn varieties in their division by sending a text message with the keyword MAIZE and the name of their administrative division to a short code. The response is a list with details of seed varieties. The SMS charge is Ksh 10.00 (twice the price of a standard SMS).

e. **Uganda: Farmer's Friend**,[xv] piloted in Uganda by Grameen Foundation's AppLab and powered by Google SMS. Farmers can search for agricultural tips through an SMS-based database, covering crop and livestock, pest and disease control information, planting, storage and harvesting tips, as well as regional weather forecasts. Keywords in the query are matched against the database and the farmer receives a reply with a tip related to his or her query terms.

   The local NGO Busoga Rural Open Source Development Initiative (BROSDI, supported by Syngenta according to its website)[xvi] provides the technical farming information. BROSDI works with a network of farmers to collect and share local farming techniques. The Government of Uganda's Department of Meteorology (DOM) provides daily and monthly weather reports. Answers to common questions are provided in English. The project is in pilot stage involving 3'000 farmers.

f. **Chile: Mobile Information Project (MIP) / DatAgro**[xvii]**.** DataDyne, a US-based NGO developed the MIP platform with grants from the Knight Foundation and the UN Foundation. The MIP platform organizes searchable content (user-generated or from the internet via RSS news feeds) and passes it to farmers via SMS.

   The MIP platform was piloted in the DatAgro project with a cooperative of 346 corn farmers in Chile who now receive details on weather, news, sports and more via SMS. The information comes from UNESCO, the government agency 'Fund for Agrarian Innovation', and from newspapers (El Mostrador and El Mercurio). Users can customize their message feeds and rate the messages they find the most helpful.

– **Connecting communities and enabling learning**

   a. **Digital green**[xviii] Digital Green (Gandhi et al., 2009) seeks to disseminate targeted agricultural information to small and marginal farmers in India through digital video. The system includes a database of digital videos produced by farmers and experts. Sequencing of the various content types enables farmers to progressively become better farmers.

      The Digital Green system provides structure to traditional, informal peer-to-peer training. The system improves the efficiency of extension programs by delivering targeted content to a wider audience and enabling farmers to better manage their farming operations with reduced field support.

      COCO, Connect Online | Connect Offline is the data input system that forms the base of Digital Green's video repository. The application also works offline in low and limited bandwidth locations, with uninterrupted usage in the browser. COCO is designed to support up to 100,000 concurrent users located anywhere in the world. It only requires internet connectivity when a user is ready to synchronize data with the global repository. Built as a robust stand-alone application in the internet browser, COCO has Java web architecture, and requires no additional software installation or maintenance. The system is designed in an open-source, customizable framework that can be deployed without the need for IT/engineering staff.

b. **Avaaj Otalo**[xix] Avaaj Otalo (literally, "voice stop") is a system for farmers to access relevant and timely agricultural information over the phone (Patel et al., 2010). The system was designed in 2008 through collaboration between IBM India Research Laboratory and Development Support Center (DSC), an NGO in Gujarat.
By dialing a phone number and navigating through simple audio prompts, farmers can record questions, review and respond to others, or access content published by agricultural experts and institutions. In addition to the Q&A forum, Avaaj Otalo includes an announcements board of headline-like snippets updated regularly by DSC staff, and a radio archive to listen to past episodes of DSC's popular weekly radio program.

   Avaaj Otalo was deployed as a pilot with 63 farmers throughout Gujarat in 2009. There were 3,500 hits to the system in the first month. Following this enthusiastic response, the application was fully launched across the state in 2010 with a publicly accessible number.

b) Geospatial applications

These applications enabling data and information related to geography and space to be managed, processed, and visualized. They contribute to land and water use planning, natural resources utilization, agricultural input supply and commodity marketing, poverty and hunger mapping, etc.

a. **SIBWA**[xx] This project intended to demonstrate the value of very high-resolution imagery (VHRI). In June 2009, the Seeing is Believing-West Africa (SIBWA) project, started working with six communities of farmers in the region – three in Mali, and one each in Ghana, Burkina Faso and Niger. Led by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the SIBWA team provided the farmers with very high-resolution imagery (VHRI) of their land. The images are made by sensors on satellites and show a high level of detail. The intention is to give farmers in West Africa information on soil fertility and accurate land size to plan and manage their crops for the coming growing season.

b. **Africa Soils Information Service (Afsis)**[xxi] This four-year project (2010-2013) is intended to fill the current gap in soil information by developing an accurate soil map for the whole of Africa in order to help farmers maximize the use of their land, and to assist agronomists and extension agents to plan and develop methods for improving soil fertility.

   Part of AfSIS involves taking samples of soil from selected sites. Handheld PDA devices fitted with GPS receivers document the exact sampling location. Remote sensing technology and the analysis of high-resolution satellite imagery provide further details on soil moisture, nutrients and organic content. This information also gives a broader overview of soil properties in places that have not been sampled.

The resulting soil map can show the properties of soil throughout the continent in blocks representing areas of land measuring 90 x 90 meters. This gives the map a resolution 100 times greater than any previous soil map.

The soil map will be available for free on the internet, and continually updated. The high resolution of the map means that farmers can zoom in to see the condition of the soil on their land. The project will also look at other ways to make the data available, via mobile phones.

The project is led by the International Center for Tropical Agriculture (CIAT) in Nairobi (Kenya) and funded by the Alliance for a Green Revolution in Africa (AGRA).

c) mFarming:

The key feature of mFarming applications is that local information is used to provide farm- and situation-specific advice.

a. **Philippines: Farmers' Text Center (FTC)**[xxii] FTC was started by the Open Academy for Philippine Agriculture (OPAPA) of the Philippine Rice Research Institute. This is a SMS service for providing technical knowledge to rice farmers as well as agricultural extension workers. Farmers receive message for one peso each. Through the FTC facility, farmers and extension workers can ask questions and get answers directly from rice experts. Started in 2004, the service answered around 2'000 SMS queries per month in 2010. In its first six years, FTC responded to about 53000 messages. In addition to rice, farmers also asked about livestock, vegetables, and other high-value crops. Aside from responding to queries, the FTC also sends technology tips to its 12'000 registered clients.

   Since the beginning of 2010, farmers and extension workers can send in photos of their diseased or pest-infested rice plant via MMS.

c. **Uganda: Community Knowledge Worker (CKW)**[xxiii] Grameen Foundation (GF) began piloting the project in two regions of Uganda in 2009, identifying, recruiting, and training rural community members to build a network of Community Knowledge Workers (CKWs). These individuals act as trusted intermediaries in their communities and use mobile phones to provide information services to farmers and also to collect data from villages. Each of the 38 CKWs was equipped with a relatively simple Java-enabled mobile phone, fitted with a suite of applications to provide on-demand information on farming practices, market conditions, pest and disease control, weather forecasts, and a range of other issues important to farmers.

   Using the information services, CKWs are able to locate agricultural input suppliers, send location-specific queries for recommendations about fertilizers, and solicit planting advice for farmers. In partnership with local organizations, the information provided is tailored to address local needs and immediately usable.

   By collecting data from rural communities, CKWs can also help experts identify disease and pest outbreaks before they become a widespread problem.[xxiv] For example, the CKW project developed and tested a Community Level Crop Disease Surveillance system (CLCDS). The system made use of both mobile phones and GIS (geographic information system) technology to link the local CKW network to scientists to enable them to identify, map, monitor and control banana diseases within farming communities.

The CLCDS phone application is designed so that the survey itself became a diagnostic tool. Based on the farmers' responses, a pop-up window opened on the phone's browser that showed information on disease identification, including photographs illustrating symptoms (this was achieved by launching a hyperlink to internal text and image files). These files, stored internally on the CKWs' mobile phones, contained the specific control measures necessary to prevent the spread of the diagnosed banana disease.

After completing a successful test of concept, Grameen Foundation received a 4.7 million USD follow-on grant from the Bill & Melinda Gates Foundation (BMGF) to expand the CKW initiative. Grameen Foundation will use new and existing partnerships to build a vast network of 4'000 CKWs, providing information and data collection services to a wide range of clients. The project aims to reach up to 280,000 smallholder farmers, reduce the cost of adoption of new and improved practices by 25 to 50 percent, and ultimately provide a model that can be scaled to reach millions of smallholders throughout Sub-Saharan Africa and South Asia.[xxv]

d. **India: m-Krishi**[xxvi] Initiative by Tata Consultancy Services (TCS) started in 2007 to deliver customized advisory services to farmers on crop production, market information, weather forecasts, etc. m-Krishi is a high-end technical service, which involves installation of different kinds of sensors in farmers' field to collect information on soil humidity and weather conditions.

In the current m-Krishi setup, an automated weather station is deployed at the center of the village that procures soil/weather characteristics and parameters for the entire village. The information related to crop, soil and micro-environment, gathered by sensors, is sent to a central server using the cellular network. M-Krishi relies on an automated Frequently Asked Questions database. This is able to handle the majority of farmer questions, since most are generic. More specific or sophisticated questions that cannot be answered automatically are forwarded to ten experts with internet access. These experts interact with a system that resembles e-mail; they are able to see attached photos and soil sensor information with each message and their response is sent back to the farmer by SMS. Farmers receive responses to their queries through the same channel within 24 hrs.

m-Krishi is also adaptable to illiterate farmers who can make a query from a cell phone using voice-specific functions. This platform is capable of providing personalized advice on pesticides, insecticides, soil, weather, water management, mandi (market price), government policies, financial aspects, transportation, and other topics, very specifically for each farmer. M-Krishi also uses farmer feedback to validate information from disease models (Pande et al., 2009).

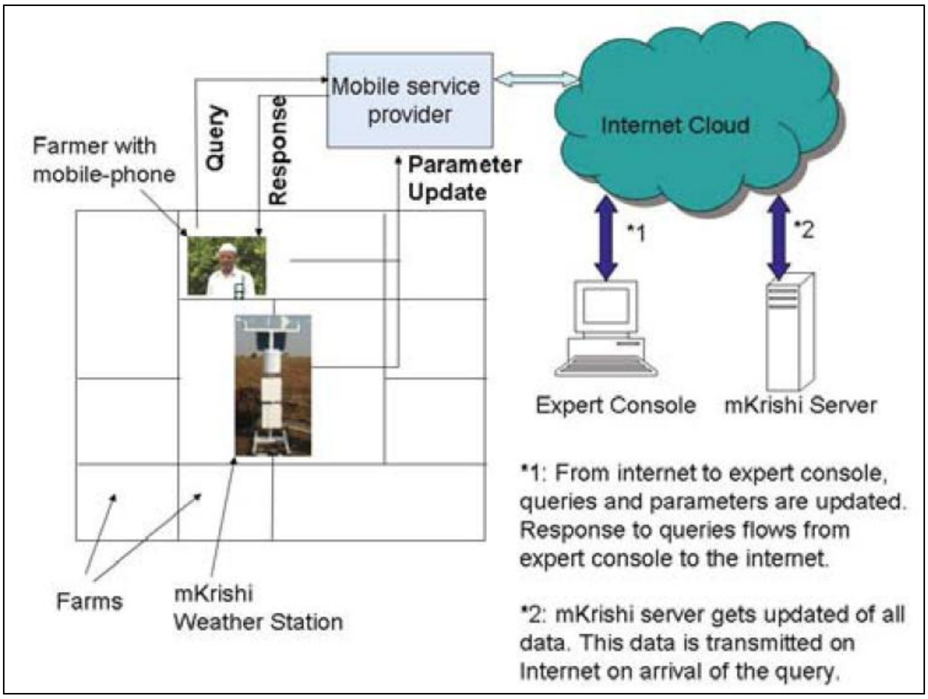

Figure 9: m-Krishi action chart

Registered users install the m-Krishi application suite on their handsets. This allows transfer of information in a rich content format to the farmer's low-end mobile handsets. The Pesticide Advisory application, for example, allows the farmer to capture an image of the crops and request advice from a central pool of experts. M-Krishi's Weather application is a micro-climate prediction system that provides a seven-day prediction of temperature, precipitation and cloud cover for the farmer's geographical location. This information is conveyed to farmers in their local language and with graphs.

Project is in pilot stage with 3-5'000 farmers. Farmers were initially reluctant to pay for this service – hence TCS reduced the subscription fees.

TCS is planning to commercialize the service through partnering with local entrepreneurs whoare expected to invest in local infrastructure (USD 220 for high-end mobile to USD 8'500 for mini weather station and sensors). Project plans also foresee collecting revenue through subscription (basic package of USD 2.20 per month, with an alternative premium advisory subscription) and mobile advertisements. The biggest challenge is large-scale installation of equipment in farmers' fields.

e. **India: e-sagu**[xxvii] e-sagu is a teleAgriculture project started in 2004 by the International Institute of Information Technology IIT, Hyderabad, and Media Lab Asia. e-sagu delivers farm-specific, query-less advice ,typically once a week from sowing to harvesting. This service reduces the cost of cultivation and increases farm productivity as well as the quality of agri-commodities.

   e-sagu consists of three components. The main Center (1) is housed at the IIIT in Hyderabad. It consists of a team of about 20 agricultural experts and an Agricultural Information System comprising crop photos, farm database, weather data, etc. An e-sagu local center (2) consists of a few computers and an operator, and covers about ten villages. A weather station is placed on this level as well. Educated and experienced farmers work as coordinators and intermediaries with other farmers (3). Depending on the crop, each coordinator is assigned a fixed number of farmers. He collects farm registration details including soil data, water resources, previous crops, pest issues, current crop, seed variety, capital availability, etc. and sends these to the main e-sagu system. Every week, the coordinator collects the data on farm operations over the last seven days. He then makes his own observation of the crop status and problems, and takes four to five digital photographs of the problem areas. A CD is prepared with the photographs and other information and transported to the main system by a regular courier service. The agricultural experts with diverse backgrounds (entomology, pathology, agronomy, etc.) at the e-sagu main lab analyze the crop situation with respect to soil, weather and other agronomic practices and prepare farm-specific advice. At the local e-sagu center, the advice is downloaded electronically through a dial-up internet connection. The coordinator prints out and delivers the advice to the farmer. In this way each farm gets the proactive advice at regular intervals starting from pre-sowing operations to post-harvest precautions. The advice contains the steps the farmer should take to improve crop productivity.

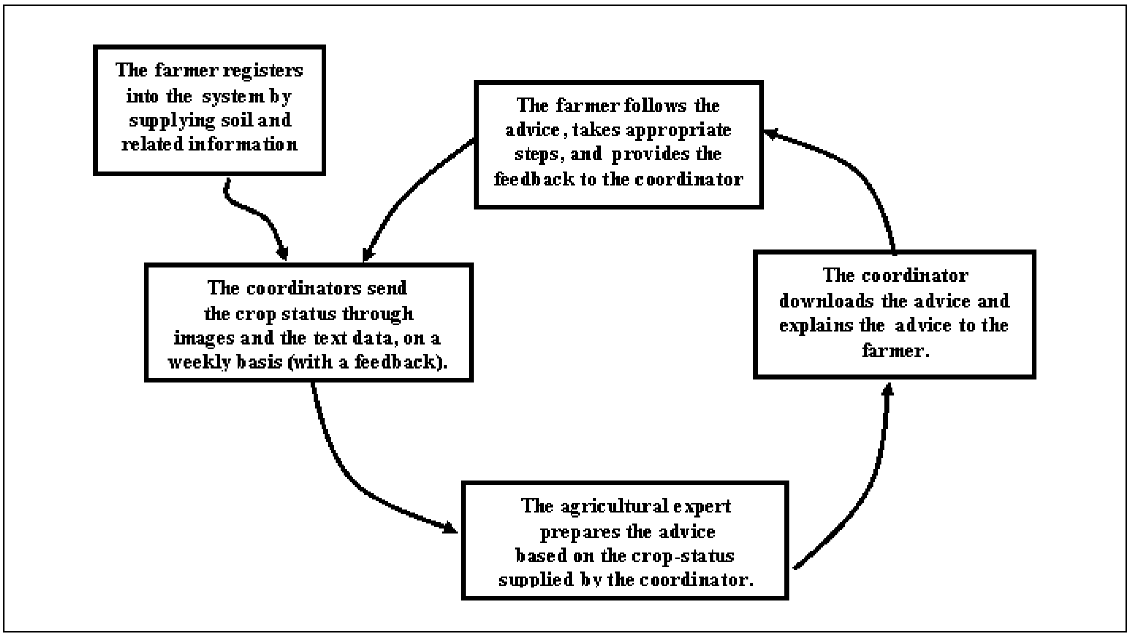

Figure 10: e-sagu action chart

An evaluation by the Centre for Environmental Studies Warangal (India) revealed an adoption rate of 50 percent (without details of the time-frame). The major factors hindering adoption were a low level of initial confidence, ‘pessimism about defeating pests, casual attitude of the farmers and lack of trust in low-cost pesticides.

An analysis of 51 cotton farmers (Ratnam et al., 2006) indicated a compliance rate with recommendations of about 50% and a high correlation between compliance and yield. The 2006 evaluation indicated that the average yields of farmers who had registered for the service rose 10 to 15% above those of non-participants. Furthermore, participating farmers saved up to 20% (Rs. 3874/acre) on the application of fertilizers and pesticides. For aquaculture, the recorded gain to farmers was Rs. 14,815/acre. The 2007 evaluation reports that a registered farmer had an average saving of Rs 194 / acre on fertilizer usage and Rs 630 / acre on pesticide usage. Farmers registered with the e-sagu program derived an average increase in yield of 1.35 quintals / acre. In value terms, the average increase in yield is Rs 1,757 / acre, with differences depending on the crop grown. For aquaculture, the recorded gain to farmers increased to Rs 25,999 /acre.

In the crop period, the system provided about 20,000 pieces of advice, and accumulated 111’000 digital crop photographs. Despite being a prototype, the cost of delivery works out at Rs.150/- per piece of advice, and Rs. 75/- per acre. As 70 to 80 percent of the advice rendered is repetitive and he system is a scalable cluster-based approach with certain modifications, the cost of delivery is expected to come down substantially. For the advice, the farmer pays a one-time registration fee and a variable fee based on the number of acres that he cultivates and the types of crop grown.

f. **CommonSenseNet and Agrocom**: There are at least two other projects in India which offer farm-specific advice based on sensors installed at village or farm level. Both have completed pilots but next steps are uncertain. One is the research project CommonSenseNet (Panchard et al., 2007) by ETH Lausanne and the Indian Institute of Science with funding from SDC. It focuses on the design and implementation of a sensor network for agricultural management in developing countries. The second project was a commercial pilot of Agrocom[xxviii] with grape farmers in 2007, for which no further rollout is planned (as of August 2010).

3.2. Mobile based market interaction

There are two different clusters of mobile applications that support market interaction: one is the provision of price information, the other goes one step further and also provides trading opportunities.

Several case studies have examined the impact of mobile phone use by fishermen in India and Senegal. They found that the introduction of mobile phones decreased price dispersion and wastage by facilitating the spread of information. This made markets more efficient and brought benefits both to consumers and suppliers. Mobiles allow fishermen, particularly the more prosperous ones, to get timely price information and decide on the best place to land and sell their daily catch (Mittal et al., 2010). A study in Niger found that the availability of mobile phones reduces price dispersion and fluctuation in grain markets. Cell phones have a greater impact on price dispersion for participants who are further away from their markets, and for those with worse roads (Aker, 2008). Similar effects were reported for dairy farmers in rural Uganda.[xxix]

a) Market intelligence

There are a vast number of price information systems available; the examples below provide just a small selection Interestingly, “proof” that market information can empower farmers remains largely anecdotal; there has been virtually no systematic impact evaluation so far.

a. In Senegal, the **Xam Marsé** service launched by Manobi[xxx] provides information on the prices and availability of fruit, vegetables, meat and poultry at all the country's markets. Although already present for some years, Manobi has so far not generated sufficient income from its Senegalese users to cover the costs of the information services without external support.

b. **InfoPrix** in Benin[xxxi] offers market prices of the 25 most important staple foods via SMS.

c. In Benin, Burkina Faso, Côte d'Ivoire, Guinea, Niger, Nigeria, Mali, Senegal and Togo, the **RESIMAO/WAMIS-NET** network supplies the latest information on 400 rural and urban agricultural commodity markets via the internet, radio, print, e-mail and SMS.

d. **ReutersMarketLight RML**[xxxii] RML is one of the strongest efforts to provide up-to-date market information, helping farmers to make appropriate selling decisions on their commodities.

   RML provides information on market prices and, weather as well as expert advice and commodity news. Farmers can subscribe to get the commodity prices from markets of their choice, and select the crops on which they require advice. . Text messages on various aspects of agriculture go to subscribers in the local language three times a day.

   RML has, at present, three channels for sales: through agri-retailers to farmers (RML Direct), bulk sales to agri input companies/NGOs/large groups, and bulk sales to mobile operators (IDEA Cellular). In the latter two cases, intermediaries – those with well-developed distribution networks – are used to sell individual subscriptions. Channel partners get commissions on their sales. Major partners are agri-input traders, credit societies, rural banks, government agencies and other organizations interacting with the farmers.

   Current prices are Rs. 175/- for three months, Rs. 350/- for six months and Rs. 650/- for a 1-year subscription for information on a limited number of crops. .

   For collection of updated information, RML has its own teams in the major commodity markets across the country. RML employs more than 300 full-time content professionals, offering news and data on more than 150 crops, 1’000 markets and 2’000 weather locations across 12 states. RML has also joined hands with experts from State Agricultural Universities (SAUs) to develop crop-related technical content.

   With an estimated investment of USD 16m, RML is a pure private sector project by Thomson Reuters without any donor funding. Launched commercially in 12 states, it has a subscription base of more than 1 million farmers.

   A survey by the Indian Council for International Economic Research (ICRIER), indicates that RML customers have increased their annual income by 5-25% through using the service.

   Farmers’ lack of literacy is the biggest barrier to greater use and benefits. One major challenge for Reuters is scaling-up its business and maintaining the relevance with updated information. Another is the entry of competitors like mKRISHI with voice-based information delivery systems and IKSL with strong networks of farmers (IFFCO) and distributors (AIRTEL).

b) Trading facilities

The second group of mobile applications focuses on enabling trading opportunities, rather than just on price information.

a. **e-Choupal India**[xxxiii]. Although e-choupal is not a mobile application in the strict sense, it is mentioned here since it is the most successful attempt to create a virtual market and address the weak infrastructure and the involvement of numerous intermediaries. e-Choupal was launched in 2000 by the Agri-division of ITC Ltd.

   The model is centered on a network of “e-Choupals”, information centers equipped with a computer connected to the internet, located in farming villages. E-Choupals serve both as a social forum for exchange of information (“choupal” means traditional village gathering place in Hindi) and an e-commerce hub.

   A local farmer acting as a sanchalak (coordinator) runs the village e-Choupal, and the computer is usually in his home. ITC also incorporate a local commission agent, known as the samyojak (collaborator), into the system as the provider of logistical support.

   The e-Choupal model has required ITC to make significant investments to create and maintain its own IT network in rural India and to identify and train a local farmer to manage each e-Choupal. The computer is linked to the Internet via phone lines or, increasingly, by a VSAT connection. Each one serves an average of 600 farmers in 10 surrounding villages within about a five kilometer radius. Each e-Choupal costs between US$3,000 and US$6,000 to set up and about US$100 per year to maintain.

   Using the system costs farmers nothing, but the coordinator (sanchalak), incurs some operating costs and is obliged by a public oath to serve the entire community; the sanchalak benefits from increased prestige and a commission on all e-Choupal transactions.

   The farmers can use the computer to access daily closing prices on local mandis (traditional dealers), as well as to track global price trends or find information about new farming techniques — either directly or, because many farmers are illiterate, via the sanchalak. They also use the e-Choupal to order seed, fertilizer and other products such as consumer goods from ITC or its partners, at prices lower than those available from village traders. The sanchalak typically aggregates the village demand for these products and transmits the order to an ITC representative.

   At harvest time, ITC offers to buy the crop directly from any farmer at the previous day’s closing price. The farmer transports his crop to an ITC processing center for electronic weighing and quality assessment. The farmer is then paid for the crop and a transport fee. “Bonus points” exchangeable for products that ITC sells are given for crops of above average quality. In this way, the e-Choupal system bypasses the government-mandated trading mandis. Farmers benefit from more accurate weighing, faster processing, and prompt payment. They can also access a wide range of information, including accurate market price knowledge, and market trends. This helps them decide when, where, and at what price to sell. Farmers selling directly to ITC through an e-Choupal typically receive about 2.5% more for their crops than through the mandi system. The total benefit to farmers includes lower prices for inputs and other goods, higher yields, and a sense of empowerment.

   The e-Choupal system has had a measurable impact on what farmers choose to do: in areas covered by e-Choupals, the percentage of farmers planting soy has increased dramatically, from 50 to 90% in some regions, while the volume of soy marketed through mandis has dropped by as much as half. At the same time, ITC benefits from net procurement costs that are about 2.5% lower (it saves the commission fee and part of the transport costs it would otherwise pay to traders who serve as its buying agents at the mandi), and it has more direct control over the quality of what it buys. The system also gives ITC direct access to the farmer and to information about conditions on the ground, improving planning and building relationships that increase its security of supply. The company reports that it recovers its equipment costs from an e-Choupal in the first year of operation and that the venture as a whole is profitable.

e-choupals also provide extension information and weather forecasts. Between 2005 and 2007, e-Choupal began offering third-party access to rural India. Currently, there are more than 160 partners from domains as diverse as seeds, consumer products, finance, insurance and employment who sell their products to rural consumers through e-Choupal's channel. ITC leverages the "e-Choupal" brand to promote these partners. Charging for access to the platform helps ITC recover substantial costs of infrastructure and operations.

'e-Choupal' services today reach out to over 4 million farmers producing a range of crops (soybean, coffee, wheat, rice, pulses) and shrimp - in over 40,000 villages through 6500 kiosks across ten states. Expansion to 100’000 villages in 15 states is planned.

b. **Esoko/TradeNet**[xxxiv] Esoko (formerly: TradeNet) was started in 2004 as an application from the Ghanaian software provider BusyLab, founded by Mark Davies.

Esoko has been described as 'a simple sort of eBay for agricultural products'.[xxxv] With Esoko, market information can be delivered automatically to mobile phones, specified by days, markets and commodities for which to receive prices, or commodities and locations from which one would like to receive offers. Agents and users can upload critical market data from their phones directly from the field and into their public or private networks. They do so by using a set of codes or a Java application available as a free download on Esoko. Registered users can also create and send SMS via the system.

A planned feature for one of the next releases is automatic SMS polling. This will allow users to track field activities and data. They can set questions and select participants, and Esoko will automatically send out the questions and map the SMS responses online. This will allow clients e.g. to track crop planting, inventory, product delivery, health services, etc.

Esoko is a public/private partnership, with part of the investment coming from social entrepreneurs from the United States and the UK, and the remainder from public projects focused on development in African agriculture markets. Current partners include IFDC, FAO, IFAD, Technoserve, USAID, Chemonics, Mercy Corps, MTN, Zain, UNDP and Ghana Met Office.

Esoko is currently available in Benin, Burkina Faso, Cameroon, Ghana, Ivory Coast, Madagascar, Mali, Togo and Afghanistan.

Already almost 800,000 price records have been entered from 10 countries, making this the largest SMS-based MIS system on the African continent. Over 12,000 registered users are profiled in the system, and almost 500 markets are covered.

Esoko can be used for various subscription fees adapted for individuals, businesses and large enterprises.

Esoko will expand across Africa and Asia through franchise agreements or subsidiaries. Total project cost is estimated at $3.5 million (expansion capital). The IFC decided in June 2010 to invest up to $1.6 million in equity.[xxxvi]

c. **Uganda: Google Trader**[xxxvii], a trading system under development by Grameen Foundation's AppLab in Uganda. It is SMS-based, with messages charged at twice the price of standard SMS. Although often mentioned as a promising project, the Google Trader website has beeninaccessible for extended periods.

d. **India: ExcelMe** is an SMS-based auction platform under development by Ericsson in 2010. It is currently in pilot testing until end of October 2010. The idea is to offer the auction platform to mobile operators as a commercial tool. Revenues are generated through a) cost of SMS and b) fee on successful transactions. In a second phase, an auction platform for transport capacity will be added.

e. **Bangladesh: CellBazaar**: The Grameenphone CellBazaar project uses mobile phones to create an electronic marketplace. Users register using a simple procedure and can then post items for sale via the mobile phone or a computer. For buyers interested in purchasing items or services, the process is just as easy. A simple search through an SMS, or browsing with WAP and WEB (www.cellbazaar.com), or even through IVR (call 3838) gives access to the listed available items with their respective price and the address of purchase.

   Unlikethe other projects described, every imaginable product is listed on CellBazaar, far more than just agricultural commodities.

   Since it started in 2006, over a million subscribers have accessed CellBazaar. On average, there are 600 new postings and 90,000 hits per day.

3.3. Embedded ICT in farm equipment and processes: Support services and systems

This chapter presents applications that enable greater efficiencies in farm equipment and agricultural processes, and traceability in agricultural products' transport and marketing through mobile technologies such as RFID, wireless Internet, and cellular telephony for labeling, traceability and identity preservation (Sugahara, 2009).

a) Operations monitoring, quality control, and product tracking

a. **Mexico: DigitalICS / CAMRANDI**[xxxviii] DigitalICS provides open-source mobile data collection for farm inspections of agricultural cooperatives (Schwartzman et al., 2007 Schwartzman and Parikh, 2007). It was developed together with a Mexican coffee cooperative to monitor compliance with fair trade requirements.

   The application prompts inspectors through every step of the survey process, with both text and audio. The latter option compensates for the small screen on the phone, and helps farmers with literacy problems to follow the process. The surveys can be customized to suit new conditions. The survey questions are 'multiple-choice', 'select-one', text and numeric fields, but inspectors can also use the phone to record an audio comment to any question. Inspectors can also capture images to visually document particular issues. This reduces the opportunity for producers to

claim that they were treated unfairly. The inspectors are also required to make an audio recording of the recommendations they made to the farmer.
All data, audio and photographs are stored on the phone's external memory card and transferred from there to the DigitalICS program on the office computer if wireless coverage for mobile phones is limited.

The software processes the results and posts them to a password-protected website using Wordpress, a blog-publishing application. Each post is automatically tagged with a unique producer code. Evaluators log in to review the inspection data (including pictures and audio) and enter their recommendations. The software automatically generates the evaluation reports, including all data and recommendations from the completed inspection forms, which the evaluators can print out. Each farmer receives a document that includes all inspection data, follow-up advice and evaluation results.

b. **Kenya: Identifying genuine seed sellers**[xxxix]
Counterfeit agri inputs – seeds, fertilizer, chemicals – can cause damage to crops and farmers' livelihoods, as well as losses to honest input companies. Combating counterfeit inputs is high on the latter's agenda, but tracing inputs from factory to farm often proves difficult.

KEPHIS, the Kenya Plant Health Inspectorate, has established a simple SMS service that allows farmers to check whether the seed seller is duly licensed.. The farmer texts the dealer's license number to the KEHPIS short code and gets an SMS from KEPHIS confirming the seed seller's status.

While this provides some guarantee that seeds sold are genuine, mobile technology could provide much more comprehensive and stringent counterfeit protection through a barcode system on the product level. One example is the service offered by Sproxil[xl], which allows verification of genuine pharmaceutical products via mobile phone. The service is focused on developed countries but is now expanding to emerging economies. Syngenta has also piloted a similar system for crop protection products.

c. **TIST**[xli]: The International Small Group and Tree Planting Program (initiated by the Tanzanian Diocese of Mpwapwa and US-based company Clean Air Action Corporation) monitors small-scale tree planting activities. It links scattered farmers to the global carbon market from where they are compensated for carbon sequestration by their trees. Monitoring of trees as "additional", with number, circumference and sequestered CO_2 compared to a yardstick biomass is a key to establishing carbon credits. This monitoring has to run for 50+ years, so the system must be robust and sustainable.

Mobile technology drives the accountability system using Smartphones (palm handhelds) for data collection (tree species, number, size, GPS location capture and tracking by grove, incl. hectare calculation, data on legal arrangements, training attendance and related activities [improved stoves, conservation agriculture, water sources, etc]), photo collection (trees, farmers, farmer groups), electronic payments (voucher) and electronic proof of payment. The mobile publishes all monitoring results to a website instantly. This ensures high transparency for the investors of carbon credits.

Development started in 1999 and has continually added new features. Investment in systems and software amounts to $6m over the last 10 years. Incremental cost per quantifier in the field is now as low as 300 USD (one-time cost for equipment and instruction). Supporters include Dow Chemicals Foundation ($1.2m in 2001) and USAID.

Deployed with 45'000 farmers in Uganda, Tanzania, Kenya and India.

b) Logistics and business processes

The supply chain is a notoriously weak element in the agricultural market. It affects cooperatives' and farmer organizations' processes – collection, grading, weighting of produce; proper records of farmers' accounts –, transport and communication with processors. The projects surveyed below rely on a robust IT backbone; mobile phones are simply input and output devices replacing or complementing traditional screen interfaces.

a. **India: Nano Ganesh:**[xlii] Irrigation control through mobile phones. Indian mobile operator Tata Teleservices together with agro-automation company Ossian is helping farmers monitor and switch on irrigation pumps remotely, using a low-end Nokia phone and mobile modem called 'Nano Ganesh' which is connected to the electric starter of the pump. Since the system gives audio feedback, illiterate farmers can also use it.

   The need for the technology stems from India's erratic power supply; farmers routinely walk several kilometers to water their crops, only to find that there's no electricity available to power their irrigation pumps. Through Nano Ganesh, farmers can dial a code from any phone to a mobile modem attached to the pump's starter. This informs them whether electricity is available, and allows them to remotely switch the pump on or off. The system helps to save time, water, and electricity/fuel.

b. **CoopWorks**[xliii] is a financial and member management information system (MIS) for farmers' associations, agriculture or Saving & Credit cooperatives in Africa. There are many systems available to help farmer organizations computerize their administration. CoopWorks is noteworthy because it is the first open source software (which makes it accessible for smaller cooperatives), and the possible integration with mobile phones as access interface enables both communication and mobile payments.

   CoopWorks was initially developed for dairy cooperatives by the Kenyan software company Flametree (development began in 2006). It was adapted for coffee cooperatives in late 2009.

   Coffee module: If a farmer buys inputs from the cooperative store on credit, the system books the transactions under the farmer's name. At the end of the season, farmers' harvests are credited to their accounts, goods bought on credit are deducted, and the final pay calculated. Each member receives a statement detailing all the deliveries made against any goods taken in credit. If the member has loans, the system also tracks these and deducts the amount. The Kenya Coffee Producers Association (KCPA) has developed its website to deliver information to members on their cell phones via SMS, including coffee and input prices. The association is looking to link the software to mobile banking schemes, so that members can check their accounts and receive payments via their phones.

   Dairy module: The milk delivery module can track daily, weekly and monthly deliveries of milk by any farmer. It compiles reports based on collection routes, farm location and region. By calling up a particular farmer's production record the cooperative can offer credit to that farmer against future deliveries. The system also shows any outstanding loans and can display the farmer's previous repayment record. The development team is working on an addition to the system where members can query their balance via a text message. The program can also help the cooperative with disease control planning. If a delivery of milk is rejected for any reason, the problem is noted in the system along with details of the milk's source. CoopWorks can show if more supplies have been rejected from a particular farm or region and warn farm managers of a possible disease outbreak. The system can also immediately display the store's inventory and show if the cooperative has enough medicine to deal with a possible outbreak.

Reported challenges are: investment cost for computers, maintenance cost, computer literacy, and reliable source of electricity.

c. **AgriManagr**[xliv] mobile solution for the Kenyan tea industry (60 factories processing small-scale farmers' tea leaf production); used to accurately record growers' green leaf weights from the buying center through to the factory (site data capture, on-site transaction processing, electronic weighing, data reconciliation).

d. **Warana Unwired:** Warana Unwired (Veeraraghavan et al., 2009) sought to replace a eight-year-old Warana Wired Village Project (WWVP) using a PC network to manage information in a sugarcane cooperative with 50'000 farmers in 75 villages in Maharashtra. Warana Unwired uses SMS and mobile phones to replicate all the functionality in PC-equipped kiosks. Information supplied by both systems includes individual farmers' sugarcane output, fertilizer usage, status of harvesting permits, and the pay schedule for a given harvest. The mobile-based versionis less expensive, more convenient, and more popular with farmers than the PC-based system.

e. **Frogtek / Tiendatek**[xlv]. This point-of-sales software application allows micro-retailers to record all store expenses and revenues directly on a mobile phone; the camera serves as a bar code reader, which allows them to record sales and inventory at the product level. In exchange, micro-retailers gain access to financial reporting, personalized recommendations and additional value-added services. The application runs on Android-based smart phones that have touch-screens and synchronize wirelessly with Frogtek's web servers, from where shopkeepers get real-time reporting, analysis and personalized recommendations.

   Under development for small shopkeepers in Mexico and Colombia, the application would also fit the needs of agrodealers.

Figure 11: Frogtek's mobile shop management

f. **DrumNet**[xlvi] The NGO PrideAfrica and Nairobi-based Software Technology Limited (STL) established the joint venture TeamGaia Limited to develop a platform to improve cooperation and information-sharing between farmers/producers, agrodealers, buyers and banks. The IT platform is compatible with mobile phones and other wireless devices. TeamGaia started operations in mid-2010.

c) Financial Services

a. **Mobile voucher** systems: WFP Food Vouchers in Syria and Burkina Faso[xlvii]

In the Burkina pilot with Vodaphone, aid recipients get a hologram-imprinted voucher from the World Food Program (WFP). At the store they hand over the voucher and a beneficiary card which identifies them. The storekeeper keys in the details, which are formatted by a phone application. An SMS then goes to a database at WFP headquarters. The aim is both to eliminate fraud and to reimburse storekeepers within 24 hours, either by bank transfer or check.

Iraqi refugees living in Damascus will receive a text message on their mobiles providing a code enabling them to cash in all or part of the "virtual voucher" at selected government shops. Each family will receive one voucher per person, worth US$22 every two months. After each transaction, families will receive an updated balance, also sent by SMS to their mobile numbers.

b. Mobile payment systems have become very popular. Kenya Safaricom's M-Pesa, for example had 10 million accounts in 2010, or about one for every four people in the country. South Africa and the Philippines also have significant mPayment programs, which are increasingly linked with bank accounts. Mobile network operators run the systems.

In contrast, Mobile Transactions Zambia Limited (MT)[xlviii], a 2009 venture jointly owned by Dunavant Cotton Company (65%) and DEG (35%, €200'000 investment), has developed a cashless payment system which works independently of mobile operators. Although it is based on mobile phone technology (SMS and PIN-based), farmers can also receive money without a phone. The system also works without full cellular coverage (database on the phone, reconciliation on return to anarea with coverage).

MT has developed an electronic payment system for Dunavant Zambia Limited to make payments to cotton outgrowers (2009: 30’000; 2010: 100,000)[xlix].

The electronic payment system allows DZL to track input pre-financing loans to contracted farmers more accurately, and to monitor farmers’ yield performance. It will also increase farmers’ loyalty to sell their cotton to DZL rather than to competitors engaged in “pirate-buying”. This model also lays the foundation for cross-selling opportunities with micro-credits and micro-insurance.

The agent network is built around shopkeepers (e.g. agro-dealers). MTZL provides them with a stock management tool and supplier payment facilities.

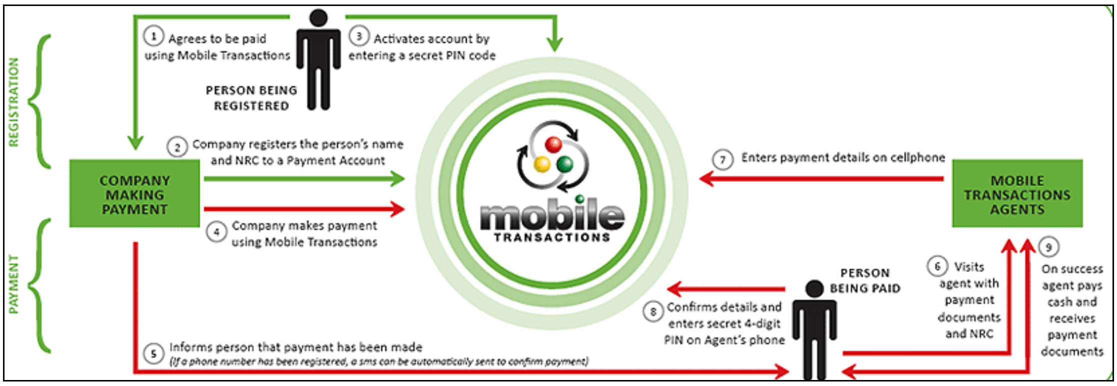

Figure 12: Function diagram of Mobile Transactions system

c. **KilimoSalama**: mobile platform to register and administer micro-insurance policies. Local agro-dealer registers insurance policies via mobile phone. Data are transferred to a server, which then sends the policy number and details to the insured farmer by SMS. M-Pesa is used for premium transfer as well as for payouts.

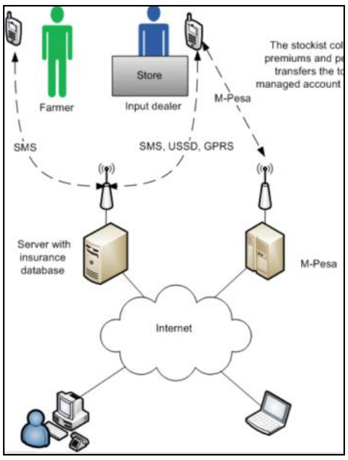

Figure 13: Function diagram of Kilimo Salama

3.4. Data collection

The last cluster of applications focuses on data collection. Agricultural and environmental data from biological and environmental sources are important for research, baseline surveys, monitoring, impact evaluation, to inform policy making and for many other purposes. Good collection enables proper analysis and use. Several projects provide survey and data collection functionality for different mobile phone operating systems with varying levels of sophistication in input fields, survey logic and data processing.

a. **openxdata**[l] Open-source data collection software that runs on Java (J2ME)-enabled phones, with the "light" version even available on low-end models.

b. **DataDyne / Episurveyor**[li] Data collection tool available since 2005, withover 57'000 survey records uploaded. Server enables instant analysis (including graphs); survey locations are shown on a map. Episurveyor works on Symbian-based phones, Android and Blackberry.

c. **Open Data Kit** (ODK)[lii] ODK is a suite of tools to help organizations collect, aggregate and visualize their data. Besides standard questions, ODK supports voice, image and video recordings. ODK runs on Android phones. Development started in 2009; many parts of the suite are available in Beta versions.

d. **Nokia Data Gathering NDG** is an open source survey tool released in August 2010. It runs on Symbian Series 60 3rd edition and phones with a QUERTY keypad. For analysis, data are exported into Excel.

e. **EpiCollect**[liii] provides a web application for the generation of forms and freely hosted project websites (using Google's AppEngine). Data can be collected using multiple Android or iPhone devices, synchronized and viewed centrally (using Google Maps) on the project website or directly on the phones. Beta level.

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