# Leveraging Mobile Platform Technology to Address the Information and Developmental Needs of Marginalized Communities in Uganda

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ABSTRACT

This paper describes the designing and deploying an information system that leverages mobile technology to address the information and developmental needs of dairy farmers in Western Uganda. Poverty is a multi-dimensional phenomenon that needs a number of theories and methodologies to solve. In this project, participatory theories and triple helix methodologies were used in managing the collaboration among multiple stakeholders. Agile methods of software systems development were used. The major outcome of the project is that iFARMs, an open source solution, was developed and deployed for use by rural dairy farmers in Western Uganda.

**Categories and Subject Descriptors**: H.3.5 [**Online Information Services]:** *Web-based services*; C.2.2 [**Network Protocols**]: *Applications (SMTP, FTP, etc.)*; [H.2.3 **[Database Management]**: Languages…MySQL

**General Terms**: Design, Languages, Security

**Additional Keywords**: Mobile platform, Development, Rural, Uganda, Information Needs, Poverty

**Keywords:** ICT, Banking, Cashless Transaction, Nigeria, Economy

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## 1. INTRODUCTION

### 1.1 Background

Despite numerous policy interventions since attaining independence from Britain in 1962, Uganda remains one of the least-developed countries in the world. According to the 2007 report, the population of Uganda was estimated to be 33 million people, and the majority of the citizens (approximately 85%) live in rural areas where they practice subsistence, non-commercial agriculture. Since the majority of the poor people live in rural areas, any interventions aimed at improving their livelihood should target them.

Uganda is one of the 189 member states that in 2000 at the Millennium Summit of United Nations, pledged to achieve all the eight Millennium Development Goals (MDGs) by 2015. The twin UN World Summit on the Information

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Society (WSIS) which took place in Geneva in 2003 and Tunis in 2005, developing countries were advised to mainstream ICT as tools for accelerated achievement of the MDGs. One of the most progressive ICTs that has led to the establishment of the knowledge economy is the Internet. Furthermore, for transforming society, the use of broadband Internet is strongly recommended.

Uganda liberalized its economy fully in the early 1990s. More specifically, the telecommunications sector was fully liberalized by 1997. Currently, there are five active telecommunications companies operating in the telecommunications sector: MTN, Orange, Airtel, UTL and Warid. More than 90% of the country is covered by the mobile GSM network. Up to 30% of the Ugandans are mobile phone users. The telecommunications companies now offer mainly mobile 3G voice and data/Internet services. MTN is spearheading the introduction of 4G Broadband Internet in Uganda. It is this widespread level of penetration of mobile phone usage in Uganda that may be leveraged for development purposes.

### 1.2 Problem Statement

In the dairy sector in Uganda, rural farmers lack information about the prices of milk in urban markets. For example, the farm gate price of milk in Western Uganda ranged between 0.058-0.115 USD (at an exchange rate of 1 USD = 2,600 Uganda shillings by July 2011) depending on the season. Yet a liter of processed milk sells for 0.692 USD in urban areas. It means that middlemen make up to ten times more money from the same liter of milk. This is an excessive exploitation of the rural farmers who have no capacity to know the price of milk in urban areas. It is even worse that rural dairy farmers do not know which milk processors are operating in the country so that they can bargain for higher prices.

Another problem is that dairy farmers in Western Uganda do not keep farm records. They are mainly illiterate and generally do subsistence farming. Without proper records, it is impossible to transform them into commercial farmers. Financial institutions and other relevant Government departments cannot support them in the absence of credible farm records.

An information system can be developed for use by rural dairy farmers to manage their farm records.

### 1.3 Objectives

#### *1.3.1 Main Objective*

The purpose of the project was to develop and apply SMS technology to address the information and developmental needs of the under-privileged dairy farmers in Western Uganda.

#### *1.3.2 Specific Objectives*

- Identify and train a team of Makerere University engineering students in the development of the software solutions emanating from the project.
- Provide both the necessary ICT infrastructure and conducive systems development environment for the team of students working on the project.
- Work with identified stakeholders in the dairy value-chain to articulate requirements of a solution that meets their needs of the dairy farmers (Requirements Specification).
- Design and implement an open source information system to support supply chain management in the dairy value chain. The solution should support access via Web and SMS or GPRS and espouse concepts gleaned from working with various partners in the dairy value chain (working prototype of proposed solution).
- Pilot the resulting solution with dairy farmer groups for a minimum period of four months. During this period the team should document any lessons learned, which could feed into further phases of the project.
- Provide another opportunity for the University to consolidate linkages with the private sector by working with the national clusters initiative to create a thriving open source community that can support and use the resulting solution beyond the life of the project.

### 1.4 Research Area Location

The project was implemented in Western Uganda, Kiruhura District, Nyabushozi County, Keshonga sub-county.

## 2. METHODOLOGY

### 2.1 Introductory Remarks

Poverty is a multi-dimensional phenomenon that needs multi-methods and theories to address. In this particular project, participatory theories and two methodologies were used. Triple helix methods were used to establish the university-Government-industry alliance. Agile methods of systems development was also used. This project actual implementation started in March 2009.

In 2009 Faculty of Technology identified four second year telecommunications engineering students to be trained as software application developers of the required information systems solution. There were two male and two female students for purposes of mainstreaming gender in the project. However, one of the male students dropped out due to lack of motivation for it. Faculty of Technology, Makerere University, provided office No. 5 for the students in the Center for Technology Development and Transfer building. The students used that space as their ICT laboratory and working space. The office was later equipped, furnished and broadband Internet was connected.

The three student developers were trained in SMS and Web-based application software development by industry experts from Magezi Solutions Ltd during the Recess Semester, June 1st –August 7th, 2009. Magezi Solutions Ltd is one of the firms constituting the Kampala ICT Software Cluster company. The training was conducted in the project office. In Web Applications they were trained in the following areas: Introduction to web application (eg Basic HTML, server configuration, Operating Systems in managing servers), Relational Database Management Systems (with MySQL as a case study), Scripting Languages (PHP), Cascading Style Sheets (CSS), DHTML (JavaScript), and Website template development and graphics. In Mobile Applications, the following topics were covered: Introduction to Mobile Applications, WAP and WML, SMS Gateways, Integration of SMS Gateways with Web APIs, a look at enterprise SMS solutions (push and pull) and Documentation.

After the training, the engineering students started to design the software solution to address the problems of rural dairy farmers in Western Uganda. The software they developed was named as an 'Integrated Farm Records Management System, iFARMS'. It had two core modules the Web and mobile application modules. The development of the software was done in four phases.

### 2.2 Requirements Analysis Phase

Initially, leaders of Amategaitu Dairy Cooperative articulated the requirements of a solution that met the needs of the end-users of the cellular platform (Requirements Specification). In the project proposal document, Amategaitu was supposed to be the main project beneficiary. It was assumed that Amategaitu Cooperative Ltd had more than 800 dairy farmers in Western Uganda as members of the cooperative. The leaders of Amategaitu were based in Kampala, just like Makerere University. It was easy to meet these leaders at short notice.

### 2.3 Design Phase

After establishing the system requirements from Amategaitu leaders in Kampala, the applications were designed. The design phase was done in two steps: First the logical design was done. All functional features of the system as specified in the requirements analysis phase was described independent of any platform. This involved translating the requirements into systems design specification. The second step was the physical design. The logical specifications of the system from the logical design were transferred into technology-specific details from which all programming and system construction could be accomplished.

**2.4 Implementation Phase**

This phase included coding, assembling, testing and calibration of the *iFARMS* software, installation/deployment for use by the end-users, end-user training and documentation and/or production of manuals. The web-based SMS solution consisted of:

*i. Functionality of the system:* Through a username and password, permission was granted to administrators, extension workers and farmers.

The administrator had the following rights:

a. Management of all the users of the system- creating new user accounts and deleting them.
b. Management of SMS content and viewing the information the extension worker sent to the farmer and vice versa
c. Basing on the data in the system, the administrator could take substantial decisions to increase the milk productivity by the farmer.

The extension worker was to register the farmer in the system; he/she could also edit the farmer records, search and view reports depending on his or her preferences. The extension worker could execute all the tasks of the farmer. However, not all the tasks of the administrator could be performed by the extension worker.

The farmer had the rights to view most of the records for example his or her accounts statement and sales reports. However, the farmer could not execute the tasks of any of the other users.

*ii. Design of forms:* Forms designed for the applications were built using HTML and the validation from the client side was carried out by using JavaScript. Validation from the server side was done using PHP. The script that carries out this validation was also incorporated in the CSS template.

On successfully logging in, the user was directed to the home page where he/she could get to know about the iFARMS application and the services it offered. The services were: registering farmers together with their animals, workers, accounts, sales, milk transporters, loans status and the associations they belonged to. The home page also contained links that the users could click on in order to search for specific information and edit it if he/she had permission to do so.

Since a number of users were to access the home page, permissions were specified and this was done by ensuring that as a user registered, he/she specified his/her role such that from the role, permissions could be set. The roles to choose from were Administrator, Extension Worker, Farmer and Others.

Users were able to fill in forms and submit to the system. The information that was received from the forms was then posted and stored in a MySQL database called *iFARMS* using PHPMyAdmin.

*Implementation – Mobile (SMS) application*

The iFARMS mobile application was accessed by all mobile phones that could access Internet. By entering the URL, http://ifarms.co.ug into the browser address box of the phone, the login page was availed. On successfully logging in, the home page was availed to the user where a number of things could be done, for example, records of farmers, animals, loans taken, accounts, etc. When the user clicked the record of worker link, then the form was availed that required him/her to complete and submit it. After submitting, a message 'Registration successful' was sent back to the user.

Kennel was the SMS gateway talking with different kinds of SMS centres, relaying the messages onward to the content provider. The content provider then answered to this HTTP query and the answer was sent back to the mobile terminal. Keywords were used to query the system, for example, a keyword 'news' was sent to the server and the message that corresponded to the keyword in the database was sent back to the farmer.

The administrator could view the phone number, the date and the content of whoever accessed the system.

**2.5 Testing of the Prototypes during Fieldwork**

Debugging was done in Kampala before taking the prototype for testing in rural areas in Western Uganda. This was the process of detecting and fixing errors found in a program. The step by step movement of message from origin to termination is depicted in fig.1

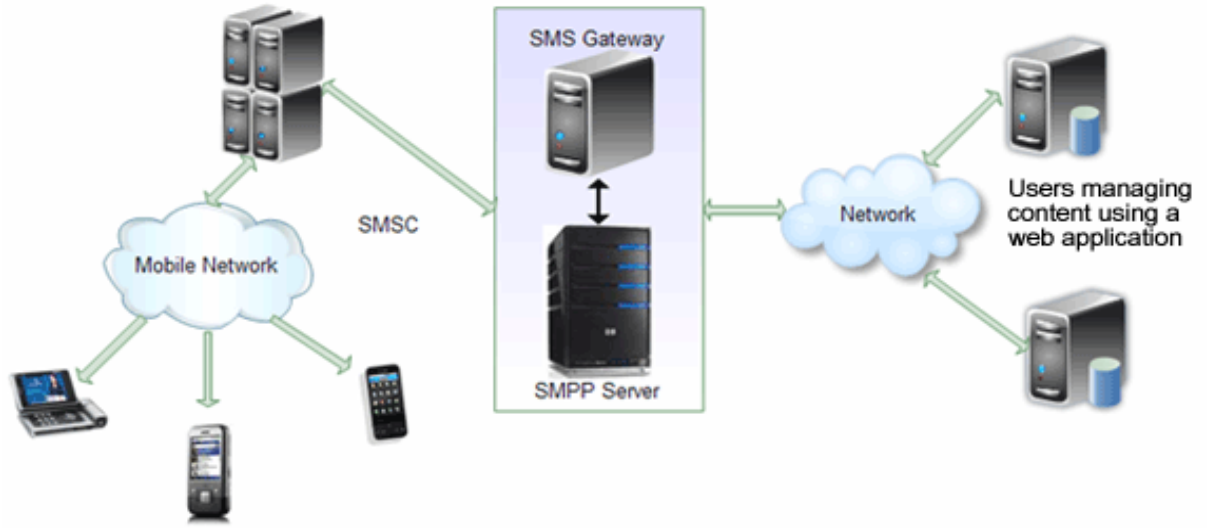


**Fig. 1 The step by step movement of message from origin to termination**

There was need to pilot the applications with the final end users, the Amategaitu Cooperative members in Western Uganda, Kiruhura District.

The first field visit to the area was from 16- 18th June, 2010. The project team included the three student developers, their industry instructor from the Kampala ICT Software cluster firm (Magezi Solutions Ltd) and leaders of Amategaitu Cooperative. The team was introduced to Kiruhura District political leadership headed by the Local Council 5 Chairman. The District nominated their District Veterinary Officer to be part of the project implementation team in the District.

The first shock to the project happened when the District Chairman said Amategaitu was a non-existent company in the District. The District was learning about Amategaitu for the first time. Amategaitu had no dairy farmers who had shares in the cooperative. It had no trading license to do business in the District.

During the next field visit to Kiruhura District from 16-18th August 2010, Amategaitu leaders were challenged to take the project team to at least 40 members of their co-operative. They failed to produce a single dairy farmer who was a member of the co-operative.

The project team concluded that Amategaitu was a brief-case cooperative without members in the project area location. It was a legally registered company in Uganda with no members of the cooperative. Relationship with Amategaitu was terminated thereafter. The District leadership was approached and they helped the project team to identify farmers who could use the iFARMS solutions for purposes of implementation of the project. However, the process of identification of the beneficiary farmers was not easy.

Most farmers were found to be illiterate- could not read and write. The team was talking to the farmers through an interpreter who was one of the student developers.

Furthermore, the culture in the project area was found to be against the counting of cows. They believe in the quantity of cows; cows are always few and must not be counted. In their culture, they believe that if cows are counted, they

will die. No farmer could tell you how many cows he/she had. The District officials also did not know how many cows were in the District. The team was told a story that one time the District ordered for the mass vaccination of all the cows in the area. The intention was to let veterinary officers determine how many cows were in the District to help planning of the Government support to the dairy sector. The farmers did not take all the cows for vaccination. Their thinking was that if the vaccines were bad and all their cows died, they would have no source of livelihood left. So farmers took fewer cows for vaccination. The 'clever' attempt to determine the number of cows in the District consequently failed.

The number of cows determines how great a farmer is in the project area. In village meetings, farmers with fewer cows are not given opportunity to contribute to debates on topical issues. Farmers with fewer cows cannot be appointed to positions of leadership. Women are not allowed to get married into families which have few cows. If a cow dies, the homestead must migrate from that location where the unfortunate incident happened. That is why the communities there are nomadic. Their life depends exclusively on cows.

The farmers were geographically dispersed within the District. Accessing the farms was difficult since the roads were extremely poor, particularly during rainy season. The project needed to have a GIS component for purposes of mapping the locations of the farms.

There were other infrastructure challenges to the project. The farmers did not have access to grid electricity, despite the fact that the town had some limited though unreliable electricity supply mainly for the convenience of a few rich people in the trading centers. Furthermore, while Uganda has almost 90% of the country having GSM telecommunications networks, in the project area the signals were weak and unreliable. There was need to keep switching from MTN (which has the biggest number of mobile subscribers in the country) to Orange (Uganda) Ltd.

Since the culture was against counting and illiteracy of farmers was high, by implication, records were not being kept. It was common to get a farmer with 200 cows but no records were kept on the farm. This was what the project intended to address- the information needs of the poor farmers.

Despite the complex context of implementation of the project, the District Veterinary Officer helped the project team to identify five farmers in Keshonga Sub-County. The farmers selected were literate, geographically co-located and were willing to break off with the tradition of not keeping records and counting. This was done during the third field visit from 18$^{th}$- 20$^{th}$ October, 2010. Forms for accurate data collection were distributed to the farmers and also set up the wireless router for mobile internet connectivity. There was no electricity in the town for the three days during this field visit. Consequently, very little was done during that fieldwork and the team returned to Kampala very disappointed.

From 27$^{th}$-29$^{th}$ October, 2010 two experts from Blekinge Institute of Technology, BTH, Sweden, came to Makerere University to review progress of the SMS application that the students developed under the guidance of an IT person from the industry.The student developers demonstrated the use of the application to the visitors. They were impressed with the solution but requested that the security aspects of the software application should be improved. This was immediately done.

**2.6 Operation and Evolution Phase**

The five farmers who were identified earlier were trained in the use of the open source software solutions (iFARMS) from 4-8$^{th}$ August, 2011. More ICT equipment for the rural farmers were purchased. The training covered the following topics:

-Introduction to the project and its objectives,

-Introduction to ICTs (Web, E-mail and Mobile Telecommunications technologies)

-Importance and benefits of proper records management in Agriculture and Business

-Records management using data collection forms and the web platform,

-Uses of data collected,

-SMS functionality of the system.

The feed back from the trainees led to the emergence of some additional requirements that the system needed to address. The farmers were given the forms they would use in the project for purposes of collecting records. All the forms from farmers were collected at the end of every month and given to the District Veterinary Officer. A small computer laboratory was set up in the District Veterinary Officer's office and wireless Internet was connected to the PCs. Contents of the forms are uploaded on the project server. The project website was uploaded, http:// ifarms.co.ug. Those with the necessary permission could access the databases online.

At the end of 2011, the Uganda Communications Commission, UCC, a regulator of communications in Uganda, allocated Short Code No. 6778 for use by the project. The project got operational license for this code for one year. The short code was activated in October 2011.

A technical team from BTH, Sweden, visited Makerere University again in December 2011. A final assessment of the solution was done and found no problems with it. They only regretted that they were not given opportunity to visit the project location and record the experiences of end-users of the application.

## 3. RESULTS

It is very common that during transdisciplinary projects, more results are achieved than originally planned. It was the same case in this project.

*iFARMS*, an open-source web-based SMS application, was developed and is being used by the rural farmers to manage their product value chain and link them to buyers. *iFARMS* is a database system which stores all the information about a farm. The system can be accessed over the Web and Mobile phone. The SMS component of the system was developed to allow information to be broadcast to farmers simultaneously. The farmers can also query the system and get information about the best farming methods available.

The iFARMS Innovative solutions won an award in 2011 by Orange Uganda Ltd. Orange (Uganda) Ltd is collaborating with the project in running the short code on its network as part of the sustainability plans. MTN was also approached to run the short code. The revenue sharing was proposed to be 50:50 (the project gets 50% of the revenue from any SMS sent by a farmer and MTN retains the remaining 50%). There was need to commercialise the innovation.

Project-based learning was successfully used in training the three student software developers. This is a new form of pedagogy in Makerere University which is one of the traditional universities that use the teacher-centered pedagogies. The capacity of the students to develop software was greatly increased. The three students were employed by reputable international companies immediately after the completion of their studies. The students were employed by Warid, Huawei and Alcatel.

The three students wrote their final year dissertations on the project. Consequently, the university approved the three research project reports.

Training of the students was done by an instructor from Magezi Solutions Ltd, a cluster firm from the Kampala ICT Software cluster. This is one clear evidence that industry can collaborate with the academia in problem-solving projects.

A conference paper was written by the students about the project. The paper was presented at the 2011 Annual Communication Conference in Kampala. The paper will be published in the conference proceedings.

The student developers compiled an end-user training manual. Farmers were trained using the manual during the pilot phase of the project.

Piloting the project in the context of the problem helped to clarify on additional systems requirements. It also exposed Amategaitu as an insincere partner in the project.

The project co-evolved into the establishment of a triple helix alliance between academia, industry/business and Government. Such alliances lead to innovation and sustainability.

Rural farmers were trained in ICT skills, use of Internet and iFARMS.

4. DISCUSSIONS

**4.1 Research Approach**

Qualitative, action research approach was used. Action research is a reflective process of progressive problem solving led by individuals working with others in teams or as part of a "community of practice" to improve the way they address issues and solve problems.

The origin of 'action research' can be traced back to the works of Lewin [1946]. Lewin, then a professor in MIT, argues that research that produces nothing but publication of books and journal papers will not suffice. Action must be taken by disadvantaged people with a view to changing their situation.

Action Research has evolved through the 1990s and into the 21st century as it has been applied within the international development. In this project, Freire's [1970] Participatory Action Research (PAR) is adopted.This technique builds on the critical pedagogy put forward by Paulo Freire as a response to the traditional formal models of education where the 'teacher' stands at the front and 'imparts' information to the 'students' that are passive recipients. This technique was further developed in 'adult education' models throughout Latin America.

The participatory method aims at involvement of the researched people in the research process. This leads to filling of some of the power gaps between the researchers and the researched people. In this project, the researched people were active participants rather than passive objects of the research.The research process was cyclical and included identifying the research questions, planning and designing the research, collecting system requirements, analyzing and interpreting the requirements and sharing the results. When the research participants can share their inputs based on their own experiences, the research can create relevant knowledge for them.

**4.2 Co-evolution in Triple Helix Processes**

This project co-evolved into an alliance between the academia-industry-Government; it is what Etzkowitz and Leydesdorff [1997] called the 'triple helix'. Triple helix relationships are important for two reasons: they stimulate innovations and sustainability- the two triple helix twins [Etzkowitz and Zhou, 2006]. Chesbrough [2003] identifies two types of innovation: the 'open' and 'closed' innovation. The author recommends 'open innovation' which is usually a result of collaborative research in the triple helix alliance in the context of the problem. 'Closed' innovations are products of in-house research. Most ivory tower universities are engaged in strictly disciplinary research which produces closed innovations. Closed innovations are usually difficult to commercialise or transfer to the industry/business.

The following triple helix partners were involved in the project as co-actors in knowledge production:

*a. Central and Local Governments*

The Uganda Communications Commission, UCC, a regulator of the communications sector, was established in 1997 by an Act of Parliament. UCC, allocated a short code No. 6778 for the project.

The Kiruhura Local Government assigned the Keshonga Sub-County Veterinary Officer to the project. He helped to identify the five farmers who participated in the implementation of the project. The veterinary office was used as a monthly data collection center for the forms filled by farmers. Contents from the forms were entered on the online database of the farmers. The project procured computers, installed them in the office of the veterinary offices. The computers were networked and connected to wireless internet. Kiruhura District helped to establish that Amategaitu Cooperative was a non-existent but legal entity that did not have any physical presence in the District.

While the project was designed to have extension workers, it was found that they were acting as middle-men. They were exploiting farmers. The Veterinary Officer assumed the role of helping the dairy farmers.

*b. Makerere University, Faculty of Technology*, was the management institution for the project. It provided student developers, space and researchers for the project. Blekinge Institute of Technology (BTH, Sweden) was involved in knowledge transfer, monitoring and evaluation of the project.

*c. From Industry/Business,* the Kampala ICT Software Cluster provided industry trainer and hosted the project website. The industry trainer was from one of the ICT Software cluster firms, Magezi Solutions Ltd. The two leading telecommunications companies in Uganda, MTN and Orange, agreed to run the short code over their networks. The participating farmers, the end-users, were very instrumental in all the stages of the project; from clarifying system requirements to piloting of the iFARMS solution.

### 4.3 Agile Methodology of System Development

Agile software development methodology was used in this project. The methodology focuses on production of working software, customer collaboration, responding to change and interaction among individuals. It was found necessary to use this methodology since there was no access to end users and their specific requirements were not known at the start of the project.

## 5. CONCLUSIONS

### 5.1 Conclusions

This project was successful. Two innovations came out of the triple helix academia-industry university alliances. First, the *iFARMS* open source software was developed by a community of practice or transdisciplinary team. Secondly, there was a pedagogical innovation. The project-based approach to learning produced very highly qualified graduates who were immediately employed by multinational companies even before they graduated. While this type of training is recommended, caution should be exercised; it is expensive. Another caution is that maintaining triple helix relationships are inevitably prone to conflicts that must be managed constantly. Contradictions are frequent and must be solved all the time for the project to progress. Getting solutions to contradictions is what makes triple helix relationships sustainable

### 5.2 Recommendations

Government should improve infrastructure in rural areas (roads, electricity, and internet backbone). The project can be extended to cater for the farmers' local language. More farmers should be able to use the application if it is in the local language. The software solution can be extended to cover other agricultural sectors like agro-processing industries.

### 5.3 Further Work

Further work will need to be done to study the impact of iFARMS on the improved livelihood of the participating farmers.

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