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Designing mAgriculture Applications for Rural Smallholder Farmers

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Abstract: *ICT has been widely accepted and adopted as a key driver for various sectors of the economy for both the developing and developed nations. In developing countries, there have been multiple interventions to employ the available technology such as mobile, wireless, radio and TV technologies in key areas that concern human development such as health, agriculture, education and finance. The design and development practices, are mostly borrowed from established markets with different user profiles, and do not always consider the profile of the target users such as their level of education, language and culture. In this research, we explore the design and development of ICT4D innovations, specifically in mAgriculture among medium to low-literate communities in developing countries. The aim of this research was to evaluate the design principles used in ICT4D for mAgriculture applications, and how they attempt to accommodate smallholder farmers of different literacy and technology exposure backgrounds. The study made proposals of consideration to be made by researchers, developers and content providers, when designing ICT4D innovations targeting smallholder farmers and users of low to medium literacy levels.*

Keywords: *ICT4D, mAgriculture, Literacy levels*

1. INTRODUCTION

In every country, the major economic activities involve the vast majority of the population. For African countries, such an economic activity is agriculture, which is a high contributor to the continent's GDP. Agriculture is a high contributor to the GDP of most African countries, making it a key activity of interest and of potential for growth within economies that are key to boost their growth rate.

In the past decade, mobile technology among African countries has grown tremendously. For example, Kenya recorded a mobile subscriber base of 38 million at the end of September 2016, translating to 87.3% penetration among the country's population [1]. The availability of technology, a skilled and enthusiastic tech-savvy community has been a catalyst for the emergence of an innovations hotbed within Kenya. These innovations range from financial services such as mobile money transfer systems for example M-Pesa [2], innovations in health, education, transport and agriculture. The area of agriculture has experienced a large share of ICT-based innovations. For the developed countries, complex equipment and machinery have been integrated with ICT components to enable mechanized large-scale agriculture. On the other hand, in Africa, the primary computing device is a mobile phone and therefore ICT-based agriculture innovations rotate around mobile based applications.

1.1 mAgriculture

mAgriculture is the use of mobile-based technology such as mobile phones and other telecommunication handheld devices to provide agricultural-related services. mAgriculture mobile-based platforms have cut across different platforms such as Short Message Services(SMS), Unstructured Supplementary Service Data (USSD), Interactive Voice Response(IVR), Subscriber Identify Module (SIM) toolkit applications, installable applications such as Android and iOS, and mobile web [3]. The services offered under the mAgriculture spectrum range from advisory(extension) services, weather and alert messages, diagnosis, pest and disease control, agriculture related alerts and announcements, and market information. In addition, these services have also contributed to the improvement of agriculture supply chain integration and facilitating market links [4]. mAgriculture services are regarded as critical for farmers in developing countries, as they have limited access to relevant, timely and actionable agriculture-related information required for best practice in farming and improved productivity [5].

1.2 Design and Development of mAgriculture applications

Several development approaches have been suggested for mobile-based systems. In most cases, the choice of development approach depends on the development platform: SMS, voice, installable application, mobile

web, SIM toolkit applications and USSD. However, most of the mobile development approaches are generic in nature and are not specific to ICT4D fields such as mAgriculture. This leads to the 'importation' of approaches that work perfectly in other parts of the world for certain type of applications, into a different part of the world, with a different user base target, technology ecosystem and constraints. Being insensitive on the approach to use in the design and development of mobile-based systems has highly hampered their adoption.

This paper addresses the issue of designing mAgriculture applications for smallholder farmers in rural areas. These farmers are primarily characterized by medium to low literacy levels, limited exposure to technology, financial constraints, infrastructural constraints and poor farming methods.

The paper begins by contextualizing the study through an introduction, followed by a brief background on mAgriculture and the design and development of mAgriculture applications. Secondly, the paper provides the objectives of the study and the methodology followed while conducting the research. Thirdly, details on the findings and discussions are made, followed by a conclusion.

2. OBJECTIVES AND METHODOLOGY

The objective of this study was to:-

a) Explore existing mAgriculture applications for smallholder farmers in rural areas

b) Explore the design and development approaches used for mAgriculture innovations targeting smallholder farmers in rural areas

c) Discuss a design and development approach for mAgriculture innovations to enhance technology adoption success by smallholder farmers in rural areas

The study involved 78 smallholder farmers drawn from 2 different regions of Kenya namely Embu and Kirinyaga. The farmers practiced both livestock and crop farming in medium to small pieces of land. Data was collected from the farmers using questionnaires and through Focus Group Discussions (FGDs). The questionnaires were used to conduct a survey on the existing mAgriculture applications being used by the specific groups of farmers, their impact on usage and also the exposure to technology among the groups of farmers. In addition, constructive discussions were achieved through FGDs where farmers highlighted their challenges, the various ways they fill technology can be of benefit to them, citing possible opportunities to apply mAgriculture.

The areas of opportunities for mAgriculture application were identified. The tops needs were advisory information services (extension) and market information. As shown in the findings, farmers had preferable platforms of choice through which they wished the services to be delivered.

A prototype was designed and developed in close contact with the farmers to address the identified top needs. During this process, key lessons were drawn on how to successfully design and develop mAgriculture applications in close contact with stallholder farmers from rural communities. Through the developed system, the farmers were able to receive and ask agriculture-related questions through SMS and Voice, from their mobile phones. Continuous review, feedback and improvement on the prototype was done throughout the research.

The data collected in the various phases of the research was analyzed and the key observations that were made are discussed in Section 3 of this paper.

3. FINDINGS AND DISCUSSION

Among the interviewed smallholder farmers, 43.5% were actively using mobile phones to request for agriculture related services. However, most of these were making phone calls to service providers such as *agrovet* vendors, making online searches and receiving payments for market items sold via mobile money. Among the interviewed famers, only less than 1% had previous exposure to mAgriculture applications.

During the study, we were able to confirm the presence of a number of mAgriculture applications that are usable to smallholder rural farmers. However, most of them were not known to the farmers, neither were their means of marketing them accessible to the farmer. For instance, almost all the identified mAgriculture services had a lot of mention on online platforms such as blogs, and in mainstream newspapers. Majority of smallholder farmers in the rural areas do not have access to the Internet and newspapers, therefore they could not get the information related to these services, and consequently they could not subscribe to them. Some of the farmers cited other reasons of not using the existing mAgriculture applications due to certain reasons such

as high continuous cost, language barrier, lack of specific information which is tackling their specific needs. Moreover, other mAgriculture services existed as installable applications which could only work on smartphones, while the majority of the population among smallholder farmers have basic mobile phones that could only use SMS or voice capabilities.

The farmers gave their preference on the kind of technologies they would be comfortable with. Table 1 below shows the preference of mAgriculture platforms among farmers.

Table 1: *mAgriculture platform preference among smallholder farmers*

Region	Preferable mAgriculture Platform		
	SMS (%)	**Internet (%)**	**Voice (%)**
Embu	39.8	10.74	42.86
Kirinyaga	57.19	15.2	14.33
Average	**48.5**	**12.97**	**28.6**

There was a negligible preference to other technologies such as mobile applications. However, 10% of the farmers did not prefer any of the above options.

There exists design and development approaches which are followed by most developers in ICT4D. Developing mobile-based systems is regarded as similar to software engineering for other embedded systems [6]. However, for the identified mAgriculture services targeting rural farmers, most of them were designed and developed without their involvement. Lack of user involvement is a major challenge in ICT4D applications, as most developers and practitioners feel they understand the user without deliberate ethnographic efforts. This contributes to a high failure rate of mAgriculture and other ICT4D innovations, whereby only about 16% of ICT4D innovations reach sustainability stage. In this study, a user-centered approach was followed to come up with the prototype. The involvement of the target users from the beginning to the end lead to a high adoption rate and interest in the developed mAgriculture service. Users were comfortable with all aspects of the service including the features, ease of use, cost and were able to participate in continuous improvements. Customizations were done in the system for multi-lingual support on SMS and IVR to accommodate farmers with low literacy levels.

The design and development approach followed in this research entailed starting with paper prototypes while working with farmers. Graphical UI expressions have been proven to work well even with non-educated groups of people. The farmers proposed changes on the paper prototypes while the researchers modelled their interaction. During the prototype discussions, the group leaders explained the system in mother tongue for the group members for better understanding. The iterative discussions on the prototype in mother tongue and expressions that the famers understood best developed a sense of ownership very early in the process. Moreover, the continuous involvement of the farmers during design, development, implementation and usage phases of the innovation ensures high adoption and usage rates of the system.

In addition, farmers were able to get a highly localized platform for their needs. Besides ability to use their language of choice, including mother tongue, farmers were receiving information which is specific to their region, their category of farming, and their operating environment.

4. CONCLUSIONS

ICT4D innovations such as mAgriculture require design and development approaches that take into consideration the profile of the target users. Smallholder farmers cannot be generalized as typical system users, and conventional software engineering principles may not be merely applied to provide solutions to them. It was also evident that besides the expert knowledge provided by agriculture extension officers, community members have their own training and knowledge ecosystem which relies on indigenous knowledge. Designing mAgriculture innovations that focus on smallholder farmers in rural areas ensures that both the modern and indigenous knowledge are utilized to the maximum for the benefit of the farmers.

The type of the platform was also key towards the usage of the system. For example, farmers with basic mobile phones were very glad to use SMS messages to interact with experts. On the other hand, farmers who did not know how to read and write in English or *Swahili* were able to use the interactive voice response system in their mother tongue and get similar services with their educated counter parts.

In conclusion, conventional software engineering approaches may not just be duplicated into ICT4D innovations. Instead, there is need to discover a user-centric approach which is a best fit for the target users.

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