International Journal of Scientific Research & Engineering Trends
Volume 5, Issue 2, Mar-Apr-2019, ISSN (Online): 2395-566X

The role of mobile technology in improving Food productivity in sub-Saharan Africa

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Abstract **- With the increasing need to improve food productivity in meeting the growing population's food demandin sub-Saharan Africa. This essay takes a look at how rising acceptance of mobile technology in this region is been leveraged using SMS and USSD service features, in addressing critical issues facing small-holder farmers. These mobile service features are fully explained and the resulting technical solutions proffered by indigenous agri-tech start-ups to such farming challenges like inadequate access to information, financial transaction and supply chain issues are also discussed.**

Keywords- **Mobile phone, Agriculture, Food productivity, sub-Saharan Africa, SMS, USSD**

I. INTRODUCTION

1. Overview

Every year about 3.9 billion tonnes of food is produced globally, out of which the sub-Saharan region of Africa alone contributes a relative large proportion of about 16.74%[1]. This region consists of countries that lies below the Sahara desert and has more than 65% of about700 million people depending on subsistence agriculture as their source of livelihood[2]. A major challenge faced by these farmers in the 21st century, is to increase food production and enhance productivity in order to feed this teeming population, while also meeting up with the demand from the rising bio fuel market [3]

Although, agriculture is the mainstay of the economy of many of these countries within this region. However, owing to poverty, infra structural issues, corruption, unfavourable extension workers to farmers ratio and inadequate access to market information. This region has witnessed an increase in financial losses and decline in food production over the years[4]. In addressing these problems and achieving food security, it is imperative that huge investment of resources is required to be made in improving the livelihood of these smallholder farmers[1]. However, such investments stand to have the most profound impact if directed towards technology, especially mobile technology.

2. Mobile Technology in sub-Saharan Africa

Since the introduction of mobile technology to Africa in the 90's, sub-Saharan Africa has witnessed the fastest penetration of mobile phones in the world with over 430 million subscribers and a potential rise to a billion subscribers by 2020 [5]. Growth in the acceptance of mobile technology amongst small-holder farmers has opened up a new world of possibilities in the world of agriculture. Studies in [4] and [7]shows that despite the high level of illiteracy amongst these farmers, Global System for Mobile communication (GSM) 2G enabled phones are most popular amongst these farmers due to its easy-to-use features, cheap call rate and good network coverage in remote areas.

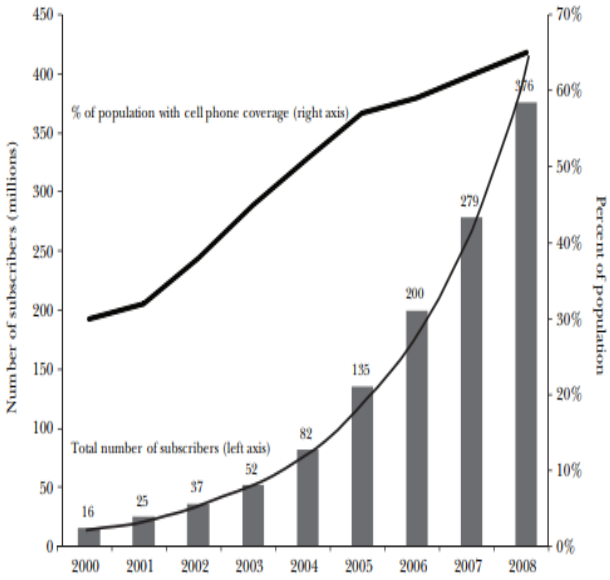

Fig. 1 Plot showing the growing population of mobile phone subscribers and mobile phone coverage in the sub-Saharan region of Africa from 2000-2008(Image source: [6].

II. MOTIVATION IN WRITING THIS DISSERTATION

Although, a number of agricultural laws, policies and programs aimed at improving farming productivity have been enacted by governments in sub-Saharan African countries over the years. This has yielded little success

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due to the combination of inefficiencies in extension services, political instabilities, corruption and poor social infrastructure. Hence, this dissertation takes an outlook on how mobile technology is been leveraged using basic applications of Short Message Service (SMS) and Unstructured Supplementary Service Data (USSD)mobile phone services in disseminating information and networking agricultural stakeholders for the purpose of improving food productivity in sub-Saharan Africa.

III. STATE OF MOBILE NETWORK INFRASTRUCTURE

1. Pre-mobile telephony era

Before the emergence of mobile phones in sub-Saharan Africa, the most prominent medium of disseminating information to farmers was the use of radios. Although, this communication tool proves to be viable, as unlettered rural farmers can get to hear community-based radio broadcast messages in their dialect[8]. However, the disadvantage of not been able to call-in and ask questions during broadcast time is a problem mobile technology through the use of mobile phones have come to solve.

Beyond offering a two-way communication link, mobile phones have become more affordable and assessable in remote areas. It also requires basic literacy in its usage, hence, many of rural-based farmers own and can use a mobile phone contrary to popular opinions[8]. This is evident in the research study conducted in literature [8] to determine the actual ownership and usage of ICT gadgets within a group of subsistence farmers in Kenya.

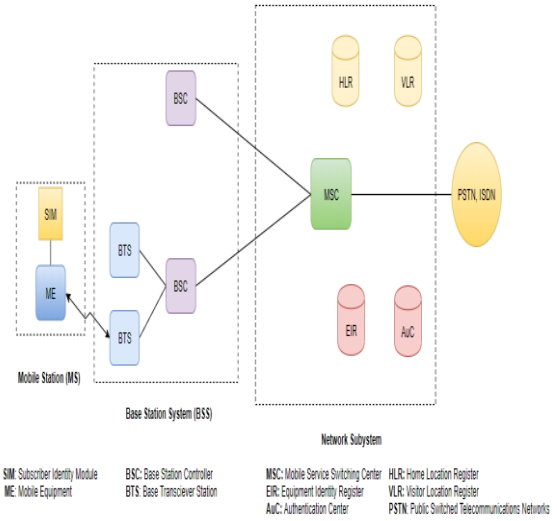

Fig.2 GSM Network Architecture block diagram.

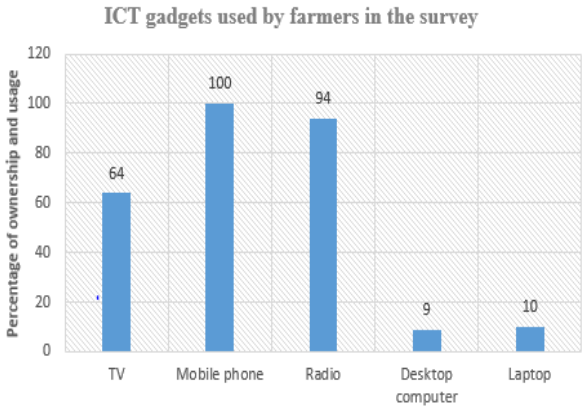

Fig. 2 ICT gadgets ownership and usage by a selected group of Kenyan farmers.

2. State of mobile communication network infrastructure

Mobile network operators in this region mainly provide 2G GSM or 3G Universal Mobile Telecommunication System (UMTS) network services. Although, 4G and Long Term Evolution (LTE) networks are relatively operational in sub-Saharan Africa. However, they are yet to be available in the remote and rural areas where majority of the small-holder famers abound[9].

GSM cellular network works by connecting mobile phones within an area cell using a900/1800 MHzGSM microwave frequency band or UMTS frequency band to a Base Station Subsystem (BSS). The Base Station Controller (BSC) in a BSS is used to coordinates the interconnection ofone or several Base Transceiver Stations (BTS) that are wirelessly linked to the mobile phones [9], [10].Within the mobile phone/mobile station device is a Subscriber Identity Module (SIM) which provides user identity to the GSM network[11].

This enables the receiver to see the identity of incoming caller and text message received. Communication is achieved when information (voice, text or data) is passed from a mobile phone user to another, through the BSS which is governed by a Mobile Switching Centre (MSC). The function of the MSC is to control the entire network operation for a particular region by performing call switching functions and channel signalling. It also provides a link to data networks, authenticates users and validates their accounts using a number of software databases and registers[9], [10].

This communication network allows for Interactive Voice Responses (IVR) between farmers and agricultural extension offices. Despite the concerns of low internet penetrations and unavailability of 4G network system in rural areas where vast majority of the farmers reside.

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Many agricultural technology start-ups in this region have been able to utilize USSD and SMS features in connecting and assisting extension workers and farmers in their activities.

IV.MOBILE PHONE FEATURE SERVICES

1. Short Message Service (SMS)

SMS has proved to be the fastest means of delivering and exchanging text-based information between agricultural offices/ extension workers and farmers[12].

In agricultural SMS application, text messages are sent to a farmer's mobile device using maximum characters of 160 for a 7-bit encoding. These messages are converted to binary data before it is processed in the SMS four-layer protocol (SMPP) stack in order to ensure the text messages are properly encoded, sent or received and receipt acknowledged [13], [14]. In addition, a store-and-forward system function in the SMPP is usually enabled, as this ensures the system keeps re-sending the message for a certain period of time until it is successfully received [14].

Furthermore, a SMS service centre (SMSC) is used to process and coordinate SMS interactions between farmers and extension workers and SMS broker. In achieving this, a Model-View-Controller (MVC) software framework is usually employed in order to create the required two–way communication platform[12]. Based on this topology, timely broadcast messages can be sent to farmers from a content server. Likewise, enquires, requests and replies made by rural farmers is forwarded to the nearest extension agent, whose response can be sent back to the farmer and stored in a database[12].

This platform allows for a convenient way of delivering agricultural information. As small-holder farmers can be located in remote areas far from the physical reach of other agricultural stakeholders and still get timely responses albeit for a small transaction fee.

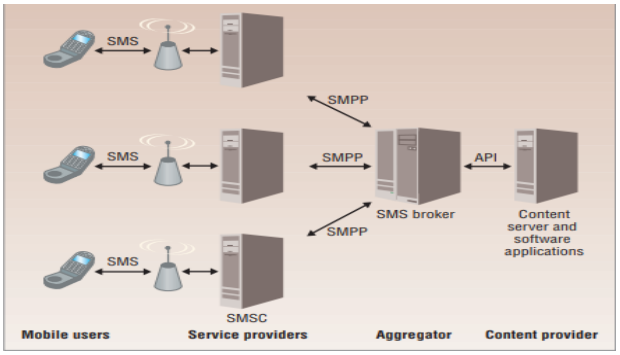

Fig. 3 Architecture of the SMS system (Image source: IEEE [14]).

2. Unstructured Supplementary Service Data(USSD)

Unstructured Supplementary Services Data (USSD) is a GSM session-oriented service that allows for a speedy offline interaction between a mobile user and the menu-based service application through a specific gateway[15]. Unlike the SMS, it allows for the use of more characters (182) and uses numeric characters to navigate and/or choose between items on a menu list[15].

However, this USSD is only structured to enable interaction between a user and a service application and not between a user and another. Despite this disadvantage, its query response to request process is seven times faster than a SMS application response [15].As a result of its high speed of interaction, the USSD application in the agricultural industry is mostly suited for financial transactions and networking. A farmer initiates an USSD session by dialling a specific code which consists of the combination of #, * and numeric keys. This opens up a menu with different instructions. Using numeric keys, the farmer chooses his option, then performs his intended operation after which he exits the USSD session using an assigned numeric key. The USSD session gateway may be manned by a third party service provider, in this case, an Agri-tech company.

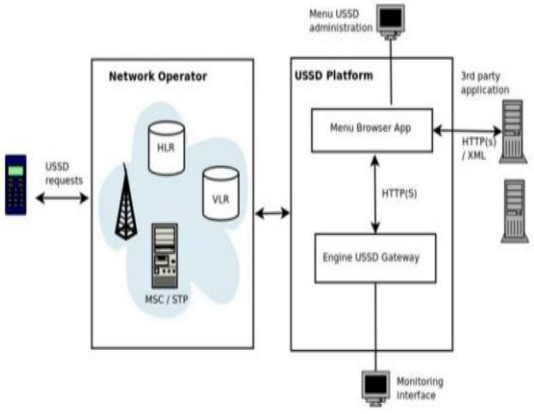

Fig. 4 USSD architecture (Image source: IEEE [15]**.**

V. MOBILE TECHNOLOGY APPLICATIONS DISRUPTING THE AGRICULTURE INDUSTRY

A number of sub-Saharan Africa's start-ups have been able to harness these basic mobile phone feature services in addressing key challenges facing agricultural stakeholders in the industry. In spite of the region's slow growth in infrastructural development, these agricultural innovative solutions that has been successfully implemented, has become the reference model for technological development in the developed countries. A review of these solutions and its applications in financial transactions, information dissemination and supply chain network services are discussed below.

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1. Financial transaction services

M-Pesa ("M" means mobile, "Pesa" means money in Swahili language) is the first world mobile money transfer service and was originally targeted at agricultural stakeholders especially the farmers[16]. This Safaricom owned application refers to the use of mobile phones to initiate, authorize and confirm financial transaction in exchange for farm goods and/or services[16].

In partnership with M-farm (an agri-tech start-up company), this collaboration has been able to connect farmers to credit and loan facilities using 2G SMS and USSD mobile features. It is imperative to note that most of the rural farmers do not have bank accounts[16]. Hence, a small-holder can register at any M-Pesa retail shop within his/her local community and upon verification and documentation, can exchange cash deposit for a mobile money top-up. With that, the farmer can make easy USSD financial transaction with any agricultural agent, middlemen or consumer using their phone numbers. In order to withdraw money, the said farmer can electronically send the withdrawal amount to any of the ubiquitous M-Pesa retail shops and receive cash in return upon proper verification[16][17].

This simple financial transaction technology has helped a lot of agricultural farmers residing in rural areas where banks, Western Union or post-offices are not available. Needless to say, this application pioneered the emergence of Google Wallet, Apple Pay and other prominentmobile financial transactions services available in elite societies[18]. Presently, according to [14] and [16], more than 70 million farmers in sub-Saharan Africa are registered users of M-Pesa having started about 10 years ago.

2. Information dissemination services

Access to timely and quality information by stakeholders in farming industry is key to the growth and development of the sub-Saharan region's economy[19].The primary means of communication employed by these services is via SMS and USSD.

2.1. Market prices

SokoniMS64 is a prominent USSD application in Kenya that is used to provide farmers with accurate market wholesale and retail prices of crops and livestock from popular markets around the country. This vital information allows the farmers to determine where to sell farm produce before they travel long distances to the market [4].

2.3 Weather information

Mobile services like Tigo Kilimo in Tanzania provide subsistence farmers with instant weather information and data along with useful tips on agricultural best practices. This enables the farmer plan their planting seasons ahead [20].

2.4 General information

Cocoa Link is a mobile service created solely for cocoa farmers in order to provide information on farming practices, crop disease prevention, crop marketing using IVR and SMS text messages either in English or the local dialect [7]. M-farm (Kenya), Esoko (Ghana) and Agro Hub (Cameroon) mobile services also provide farmers with access to relevant market information, prices of farm inputs (fertilizers and feeds) and farm produce, weather information and credit facilities.

Thus enabling them make informed decisions on when to produce, when best to sell farm goods, what crops and farms animals to produce and rear, and how to bargain with the middlemen.[21]. This right information obtained by farmers can help reduce unnecessary middlemen exploitations, and also reduce transactional & transportation waste [22], [23]. As a result, this is remarkably set to improve agricultural productivity as latest improved farm inputs and advice on best farming practices can be sourced which is important in increasing the quantity and quality of yields.

3. Supply chain network services

Due to the perish ability of farm produce, getting ready-buyers on time has always been a challenge for farmers.

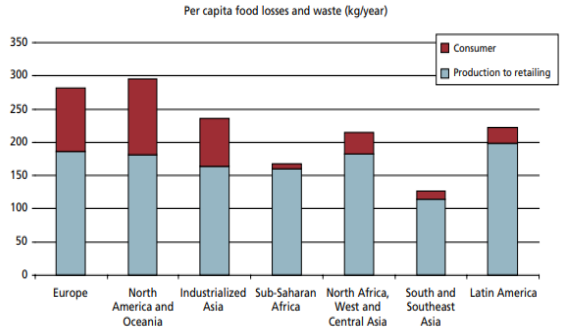

Fig. 5 Plot shows the high per capita food loss/ waste for sub-Saharan Africa at the production-to-retail stage (Image source: FAO [1]**).**

However, start-ups like M-farm, Esoko, mAgri (Botswana) and Agro Hub have recently started providing mobile solutions that has made it feasible for farmers to easily connect with middlemen and consumers via e-market [23].

Despise the subsistence farming operation commonly practiced, farmers can come together under a co-operative society umbrella in selling farm produce in bulk. Hence, making it easy for wholesale transactions in meeting consumers need. This e-market service uses USSD and SMS services communication between seller and buyer while M-Pesa application is used in facilitating financial transactions[16].

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In the case of M-farm's supply chain solution, farmers are required to dial *118# USSD code and use the service menu to state their intent. An SMS message is sent confirm receipt and to reply when a contacted consumer indicates trading interest. The farmer then takes his or her farm produce to the collection office and confirms delivery. The buyer is informed about this and comes along to verify food produce.

Once confirmation is done, M-farm forwards the agreed payment to the farmer's M-Pesa account[22]. On the other hand, Farm rowdy – a Nigerian Agri-tech start-up connects these small-scale farmers with middle-class sponsors who are ready to invest in agriculture for a percentage of monetary profit at harvest time. This solution has created a platform for the over 36 million rural farmers in Nigeria to be empowered financially in order to expand their farming operations and boost their farm production. This has also created a win-win situation for working-class members of the society who don't have time to engage in farming, but want to invest in farming[22][5].

Fig.6,8 Extension workers explaining to rural smallholder farmers how to use USSD and SMS on 2G mobile phones (Image source: IEEE Jaguza App [24]).

VI. CONCLUSION

This essay has provided an outlook into the utilization of 2G mobile phone technology in addressing challenges facing smallholder farmers in the sub-Saharan Africa.
A breakdown on the workings of USSD and SMS mobile phone services was explained and how start-ups and system applications have been able to leverage on these features in providing innovative solutions to farmers, middlemen, extension workers and consumers. These solutions include information dissemination, financial transaction and supply chain services. The advantages of these solution have helped to reduce food waste, improve access to information for farmers, increase food production and decongest the food supply value chain. As penetration of mobile phones continues to increase and mobile phone agricultural solutions continues to proliferate, it can be inferred that the food productivity would rise and meet the demand of the growing sub-Saharan population with a potential to feed the world. Nevertheless, a lot has to be done in the areas of 4G, LTE networks and rural education while basic social infrastructures should be upgraded. This would enable sub-Saharan Africa to meet the UN's Sustainable Development Goal (SDGs) of achieving food security and improving food productivity by 2020.

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