A model for harnessing the power of the Mobile Phone Technology to improve Smallholder Agriculture in Zimbabwe

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Abstract: Mobile technologies are capable of facilitating networks of farmers and agribusiness in a dynamic way such that these stakeholders can support each other. The initiative of using mobile technologies in agriculture is in its infancy stage in the world at large while in some developing countries it is already in use. The smallholder farmers largely depend on agricultural activities for food and income for all their requirements which include paying school fees for children, buying farming implements for next season and housekeeping requirements. The bulk of small scale farming systems in the developing world are very much limited in production and therefore inherently less profitable than they should be. The chief contributor to this is the information lopsidedness and the necessary farming skills gap that hinder the embracing of available technologies and management practices. This paper designs a model that could be used for harnessing the power of Mobile Phone Technology to improve Smallholder Agriculture in Zimbabwe. An analysis of the current array of models was done and their weaknesses evaluated. The proposed model is holistic in nature and build on the strength of current existing models but it stresses the need to integrate USSD technology, together with web-enabled and Android based platforms. It also stresses the need for a hybrid mechanism for data dissemination which facilitates for both push-based and pull-based data dissemination.

Keywords *Mobile phone technology, Smallholder farmers, Harnessing, Agriculture, USSD.*

1 Introduction

There have been exponential growths of mobile phone penetration in the developing world. In Zimbabwe the mobile penetration is 103% although this figure does not take into account such factors as dual and triple Subscriber Identity Module (SIM) card phones and multi handset ownership. The mobile technology ownership is so widespread in Zimbabwe that even in the most rural areas there is a very high level of mobile ownership. Mobile technology is unquestionably a boon to all the third world countries due to its capacity to make available information as well as transforming personal lives and businesses operations more efficiently through dual communication. Due to this capability this technology has since developed into one of

the fundamental building blocks of modern society, within a very short time. ICT covers any product that can accept, store, retrieve, manipulate, transmit or receive information electronically in a digital form (Aker & Mbiti, 2010).

Introducing mobile phone technology in agriculture can have a lasting impact on agricultural outcomes and the welfare of smallholder farmers in a variety of ways. According to (Silva, 2008) information asymmetry is a significant contributor to overall transaction costs. ICT is starting to influence the way agriculture is practiced in the world (Maumbe, 2013.) For instance the bulk of the Zimbabwean population (67%) (Agency, 2012) live in the rural areas and heavily depends on farming activities for a living. In actual fact there is empirical evidence of urban to rural migration in Zimbabwe as confirmed by the census of 2012 (ibid).

The smallholder farmers largely depend on agricultural activities for food and income for all their requirements which include paying school fees for children, buying farming implements for next season and housekeeping requirements. These smallholder farmers labour on their land but what is happening is that there are middlemen who are benefitting from these farmers' work as they prey on farmers poverty and bring second hand clothing and groceries to small holder farmers and take away the hard-earned farmers' produce as observed by this researcher in one area. There is need for boosting the performance of these smallholder farmers as this result in the uplifting of the overall level of standards of living of smallholder farmers and the development of the economy at large. This segment provides a source of living to 70+ percent of the Zimbabwean population and up to a third of the country's labour force is employed in the agricultural sector.

2 Background

Smallholder farming activities in Zimbabwe include the practice of cultivating crops and breeding and raising livestock. Livestock save a number of purposes. Most smallholder farmers lack machinery like tractors and other implements hence livestock provides the draught power for the farmers. Over the years livestock have been harnessed for such activities as pulling carts, transporting people, hauling water, trashing harvests, ploughing and weeding of crop fields. In times of difficulties like drought the livestock is sold for income augmentation. The vast majority of smallholder farmers practice dryland farming. Dryland farming is a form of farming that is practiced in areas that receive inadequate rainfall. Farming in these areas highly depends on tillage methods. This results in the soil being more receptive of moisture but selection of suitable crops is required for each region. Failure to observe this results in very low or no yields at all.

Most smallholder farmers reside in remote areas where infrastructure is rudimentary and uncoordinated. Lack of capital causes a challenge in securing farming inputs. Lack

of good farming knowledge coupled with absence of information threatens viability of their activities. Some of the more mirrored problems include unavailability of credit facilities, unavailability of ready market for their produce, perishable products, unavailability of transport and high transport costs, erratic rainfall and frequent drought. It is these problems, coupled with absence of information that gave rise to the mushrooming of the middlemen. Smallholder farmers daily toil on their land putting in so much effort in their agricultural activities, but alas they remain considerably poor. This has always distressingly turned out that other players in the value chain of products produced by these farmers get richer and richer while the rural farmers wallow in poverty.

3 Literature

In September 2000 the world leaders came to an agreement in which they crafted 8 Millennium development goals (MDGs) which were targeted at being realised in 2015. The world development agenda was premised on the MDGs for the period in question. Since then contemporary discourses on development consistently identified ICT as a requirement for economic growth and the general improvement of Social conditions (Avgerou, 2003, 2008, 2010; Geldof, Grimshaw, Kleine, & Unwin, 2011; Perkins, 2010). According to (Stalker, 2008) the MDGs are credited for lifting approximately more than one billion people out of extreme poverty. A number of milestones were achieved as a result of MDGs, these include inroads against hunger, the enabling of more girls to attend school than ever experienced before especially in the developing world and environment issues protect our planet. MDGs initiated novel and innovative partnerships within and between countries; they influenced public opinion and reshaped decision-making in both the developed and developing countries to reduce poverty in all its extreme forms.

International development agencies make a strong association between ICTs and development. They argue that more successful economies have more technologies and are better prepared for using them to their competitive advantage (Avgerou, 2003). According to Norton (1992) the availability of ICT infrastructure lowers fixed costs of acquiring information and the variable costs of participating in the market. Professor Charles Schwab pointed out that ICTs are the best hope for developing countries to accelerate their development process. It is important to note that health and education have been given primacy by both researchers and policy makers the world over and therefore they have dominated ICT4D research over the years (Chepken, Mugwanya, Blake, & Marsden, 2012). Agriculture has been attracting very little attention until the recent years (ibid).

It is important to note that 60% of all ICT4D research was done in Asia especially India and by Indians (Chepken et al., 2012), hence this researcher believes that is why it is reported that there are a number of ICT4D success activities in India. In Africa

less research have been done compared to other regions of the world and most of it was not done by Africans and let alone Agriculture. Emulation of western practices in developing countries have rarely succeeded (Avgerou, 2003). Arguably, more successful commercial farmers have more technologies and they are better prepared and resourced for using them to their advantage. Therefore it is important for locals to be involved in the research and policy development agendas as they have a better appreciation of the local settings.

Smallholder farmers are the world's largest group of working age poor yet much of the world's supply will continue to depend on their effort (Bagazonzya, Bank, Safdar, & Sen, n.d.). ICTs increase efficiency, provide access to new markets or services, create new opportunities for income generation and give poor people a voice (AfricaPartnershipForum, 2008). The use of ICT in Agriculture is beginning to influence the way Agriculture is practiced (B. Maumbe & Owei, 2013). In a research conducted in Niger it was established that mobile phones helped to reduce information search costs and improved farmers bargaining power on the market (Aker & Ksoll, 2012). In Africa to include Zimbabwe the mobile phone is the predominant mode of communication. The mobile phone requires basic literacy to operate hence it is easier to use for the basic user. The mobile phones are increasingly being capacitated to offer facilities like data transfer. In Kenya there are using a facility called DrumNet to deliver targeted services to rural farmers. However this was found to be unsuccessful because of ignorance as most respondents could not send an SMS which is a basic requirement for one to use the system.

3.1 Models review

This researcher looked at different models that have been proposed and developed over the years in order to come up with an informed position for the model to be proposed in this paper. The issue of information dissemination models is not a new concept, it started in the early 1970s and it evolved over the years to its current scenario. In order to determine what is the most appropriate model to be adopted for a particular situation, there things to be considered and these are; the information infrastructure, operating costs, farmers' capabilities, farmers' information consumption behavior and, most importantly, the local context should be taken into consideration (Zhang, Wang, & Duan, 2016).

Harnessing ICT to develop community and identity: a model for academic departments by Clara M. Chu and José Rodolfo Hernández-Carrión. In this article the authors talked about the need to get access to the right information at the right time. They further talked about the new world order where technology has become ubiquitous and the world has become politically, economically and technologically integrated. Because of this interwoven of these aspects of the global world there is need for a transformation of the social processes to reflect the new dispensation. The authors then proposed to develop the web based community portal

for the university. While the model was then and probably still a good thing this researcher would like to think that it is relevant in a university set up in a developed country where web enabled gadgets are a common feature.

Agricultural information dissemination using ICTs: A review and analysis of information dissemination models in China. This article looked at a number of models that have and are being used in China and other advanced countries to support agriculture. With the rapid development of information technology, the agriculture information dissemination models have and are still constantly evolving and improving. These agricultural information dissemination models are therefore listed below.

- Web Based Portal – a collection of relevant web sites to form one stop centres for users.
- Voice-Based Service – information dissemination through telephone.
- Text Message (SMS)-Based Service – information dissemination through text message of mobile phones.
- Self-Support Online Community – information services provided by a community to its members.
- Interactive Video Conferencing Service – using online multimedia technology to facilitate information service.
- Mobile Internet Based Service – information dissemination through smart phone service.

These models are evaluated in Table 1.

These models have served and are still serving the agricultural community in China and other regions very well. However, it is important to note that the conditions in China and other countries are different from those in Zimbabwe and other developing countries. Zimbabwe's high ICT Development Index (IDI) and the harsh economic climate make it difficult for most of the smallholder farmers to access and use these models. ICT Price Basket (IPB) is an exceptional metric that is used to track and weigh the cost and affordability of ICT services in more than 160 countries in the world. The IPB index measures communication costs such as call costs per unit as a percentage of Gross National Income (GNI) per capita, and reflect on the regional disparities in connectivity costs. According to the ITU report of September 2011, Zimbabwe is ranked number 3 in the whole world as the most expensive country to make a call. Smallholder farmers in Zimbabwe are poor by any standard, they cannot afford the smart phones hence cannot access the internet on their phones. Calling is very expensive hence smallholder farmers cannot afford to call for information services.

Table 1. Analysis of the available models (adapted from Zhang et al., 2016)

Model	Operational features	Advantages	Shortcomings
Web Portal	A collection of relevant web sites to form a one stop portal for users	Easy access, compressive and in-depth information provision	One for all information, No customization. May not be relevant to an individual user's specific information need.
Voice-Based Service, IVR	Information dissemination through phones or online voice calls.	Interactive communications, easy to understand and individual service	Require human involvement, time consuming and less efficient, more costly
Text (SMS)-Based Service	Disseminating information via Mobile phone texts	Push-based approach, very effective and efficient in sending short and timely messages	Cannot provide comprehensive and in depth information. One for all service. May not be relevant to individual user's specific information needs
Online Community	A membership system involving all stakeholders comma share experience and exchange information through interactive service platforms	Interactive communications, relevant information, user participation, cost effective service	Require active user participation, efforts and good management. Service is only available for members
Interactive Video Conferencing Service	Information dissemination using online conferencing service	Easy to understand, very effective communications, interactive service	Require human involvement can be time consuming and less efficient, costs is high due to the involvement of human experts
Mobile Internet Based Service	Information dissemination using Mobile Internet service via smart phones	Ubiquitous, cost effective, easy access, can incorporate GPS technology to provide location related service	Require adequate infrastructure and the use of smart device. Require higher IT skills to use new technologies

Some of the models indicated there use a push based mechanism of data delivery where the system simply broadcasts messages to farmers without getting any form of feedback from the farmers. Some models are heavily skewed towards android Applications which only run on Smart phones. Smallholder farmers typically represent the working poor of the developing countries. That is the main reason as to why these writers believe that use of an integrated system which supports all web based system, the android system as well as supporting both the push based mechanism and the pull based mechanism.

4 Proposed model

4.1 Motivation

The motivation for this model is twofold

Firstly, this researcher being a son of a smallholder farmer parents, grew up in rural Zimbabwe where the better part of their formative years were spent doing these activities and have watched over this vicious cycle repeatedly over and over again. Yet Zimbabwe ranks as one the best countries in the world in terms of literacy levels with 91% literacy rate according to a recent survey (Musungwini, Zhou, & Zhou, 2014).

Secondly, Mobile technologies are preferred because of their ubiquitous nature and their ability to facilitate convenient, synchronized communication for the rural people. This apparently has become the source of information for these rural people who previously had very little to zero access at all to affordable communication channels. Interconnectedness between sellers and buyers are transcending the spatial confines of logistics. It is because of this ubiquitous nature of mobile technologies that this researcher strongly believes exploiting this technology will unravel novel ways of conducting business that could be boon to the small scale farmers in rural Zimbabwe. ICT for development (ICT4D) has a large role in supporting the future of rural development with the integration of available technologies and the existing knowledge landscape (Brugger, 2011; B. M. Maumbe & Okello, 2010; Okwu, and T.I, 2011). The Egyptian Technology Development Centre, made the following statement in 1997:

> *The whole world is undergoing an overwhelming technological revolution in information, electronics, computers, and communication. This revolution will widen the gap between the developed and underdeveloped countries. Those who master science and technology and manage information will survive and those who do not will perish, at least economically.*

4.2 Overview of the proposed model

A model is a graphical representation of a concept. In the model presented here, the writer focuses on the creation of a novel system of information dissemination to and

from all concerned stakeholders 24/7. This includes: Agriculture Technical and Extension Services (Agritex) Officers, Zimbabwe Farmers Union Officers, Meteorological Services officer, Agricultural Marketing Authority Officers, Veterinary Services Officers, Agricultural Research Council Officers, Independent Market Information watchdogs, Seed Company Officers, Smallholder Farmers in different parts of the country are connected. All smallholder farmers are supposed to be registered in the database and this will ensure that they receive real time and comprehensive farming information. This information includes weather forecast, market information (prices and marketplaces), disease outbreaks, loans availability and terms, input information and relevant newly published research. This model will also work as a knowledge hub for Agriculture information as it will facilitate production of history, projection and trend analysis. (Foran & Escobar, 1996; Nchise, Boateng, Shu, & Mbarika, 2012.)

4.3 Architecture of the proposed model

The proposed model should be composed of the Application layer and the Backend layer. These two layers are the fundamental building blocks of the proposed model.

4.3.1 The Back end layer

The backend part of the application layer is where a processing zone resides. The backend layer is responsible for receiving requests and processing them. In this Architecture it is made up of three (3) key components and these are the GSM modem, SMS gateway and a Database server.

4.3.1.1 The Global System for Mobile (GSM)

The function of the modem is for receiving SMSs from application layer and sending back SMSs to the application layer. GSM Modem can also be used to provide internet connectivity.

4.3.1.2 The Database Server (DS)

The DS will be used for storage of the database as the web application. All computations and processing will be done in the DS.

4.3.1.3 The Short Message Service (SMS)

The SMS Gateway will be used as a bridge between the GSM Modem and Database server. The SMS gateway simplifies the process of sending and receiving SMS text messages to and from a web browser, web server or email.

4.3.2 Application layer

The Application layer shall consist of ten (10) elements and these are Agriculture Technical and Extension Services (Agritex) Officers, Zimbabwe Farmers Union

Officers, Meteorological Services officer, Agricultural Marketing Authority Officers, Veterinary Services Officers, Agricultural Research Council Officers, Independent Market Information watchdogs, Seed Company Officers, Smallholder Farmers.

4.3.2.1 District Agriculture Information Systems Assistant (DAISA)

The District Agriculture Information Systems Assistant (DAISA) is a person responsible for all information in the District pertaining to Agriculture. The DAISA collects Agriculture information in the District, collates Statistics and produces monthly, quarterly and annual reports for their district. This data is then collected to produce Provincial Data repository and further collated to produce information and statistics for the whole country. In the proposed model the DAISA's responsibilities would include registering all the ten (10) stakeholders named in 4.3.2 above, who are supposed to use the proposed system and system support and housekeeping. Ensuring that the system is up and running, updating, system backup and restore.

4.3.2.2 Agriculture Technical and Extension Services (Agritex) Officers

Agriculture Technical and Extension Services (Agritex) Officers are very critical in this model. In Zimbabwe Agritex officers are placed at various resource centres scattered all over rural Zimbabwe. These officers have their areas of coverage and there are demarcations where there are supposed to end and another starts. From time to time they hold meetings with smallholder farmers sharing information with farmers. Most rural populations are geographically dispersed and isolated from knowledge centres. This makes it difficult to provide information to everyone. Sometimes these Agritex Officers may travel to other areas within their area and at the same time some other farmer in the same area but from a different side may require emergence assistance and the Officer cannot be found.

After registration the Officer will then entirely depend on their cell phone to communicate anything with the system. Assuming that it happens that there is an emergency where a farmer requires immediate assistance the system should be able to select the Agritex Officer closest to him be able to relay information.

4.3.2.3 Zimbabwe Farmers Union (ZFU) Officers

In Zimbabwe smallholder farmers are encouraged to subscribe to the Zimbabwe Farmers Union (ZFU) and the benefits being that a ZFU member whenever they purchase any farming implements from seeds, fertiliser, chemicals etc, they are entitled to a 5% discount. ZFU officers are fewer than Agritex Officers and they are usually stationed at District offices. Their purpose is to register smallholder farmers to become ZFU members.

The ZFU Officer will depend on their cell-phone to communicate anything with the system. However, they require Smart-phones with internet connectivity capability because they need to interact with the backend. These Smart-phones should be

installed with an application which connects to the backend layer and uploads information to the server. In the case of an emergency where a farmer requires immediate assistance for registering with ZFU the system should be able to provide crucial information pertaining to the closest officer to them. These officers can also carry out field visits and register farmers there using their phones.

4.3.2.4 Meteorological Services Officers (MSOs)

In Zimbabwe Meteorological Services offices are found in provincial centres. The MSOs are responsible for gathering data about weather patterns, forecasting etc. This critical data is then disseminated through various media to include radio, TV, Newspapers, Internet etc. However there are a number of challenges impeding this information from reaching the critical recipients, smallholder farmers. The MSOs will then entirely depend on their cell phone to communicate anything with the system. However these require Smart-phones with internet connectivity capability because they need to interact with the backend. These Smart-phones should be installed with an application which connects to the backend layer and thereby enabling them to upload weather information to the server.

4.3.2.5 Agricultural Marketing Authority (AMA) Officers

The Agricultural Marketing Authority is a statutory board responsible for regulating the marketing of agricultural products in Zimbabwe. It sets up the producer price each and every agriculture year. In the proposed model, the AMA Officers will then make use of Smart-phones with internet connectivity capability to communicate anything with the system because they need to interact with the backend.

The AMA officers should be able to screen independent private buyers willing to participate in the buying of agriculture products. The selected private buyers should then be registered with the system providing their details like prices they offer and buying conditions. Smallholder farmers whenever they want to sell their produce should then check with the system and the system should be able to provide information about the best deals available at the time.

4.3.2.6 Veterinary Services Officers (VSOs)

Veterinary Services Officers (VSOs) are very critical in this model. In Zimbabwe VSOs are placed at various resource centres scattered all over rural Zimbabwe usually together with Agritex Officers. VSOs have their areas of coverage and there are demarcations where there are supposed to operate. From time to time they hold meetings with smallholder farmers sharing information with farmers about livestock. Most rural populations are geographically dispersed and isolated from knowledge centres. This makes it difficult to provide information to everyone. Sometimes these VSOs may make field visits to other areas within their area and at the same time some other farmer in the same area but from a different side may require emergence assistance and the Officer cannot be found. Assuming that it happens that there is an

emergency where a farmer requires immediate assistance the system should be able to select the VSOs closest to them to relay information.

4.3.2.7 Agricultural Research Council Officer

The Agricultural Research Council of Zimbabwe (ARCZ) is a statutory body born out of the Agricultural Research Act. This body is mandated to keep under review agricultural research in Zimbabwe. This encompasses Crop research, Plant and Animal diseases research and new chemicals for addressing such diseases. The ARCOs will then entirely depend on their cell phone to communicate anything with the system. These Smart-phones should be installed with an application which connects to the backend layer and uploads research information to the server. Whenever a smallholder farmer wants research information the system should be able to identify specific research for that particular farmer.

4.3.2.8 Independent buyers (IB)

Over the years the smallholder farmers in Zimbabwe have always been swarmed by the people from all walks of life wanting to do business with them. There are those that buy for cash, those that buy on credit and the bulk who want barter trade. Some bring groceries but most bring second hand clothes. These people have been depending heavily on inadequacy or total absence of information. While a lot of sinister activities have happened because of these people including using fake money to buy farm produce from smallholder farmers these people remain relevant in the proposed model. The IBs will then entirely depend on their phone to communicate anything with the system. These IBs should send their profile information, products they buy and the prices they pay and their terms of service by SMS. Whenever a smallholder farmer wants to sell anything, the system should be able to identify independent buyers offering the best prices and their contact details and then compare the prices being offered by the AMA.

4.3.2.9 Agribusiness processing companies' Officers (APCOs)

Agribusiness processing companies play a crucial role in agriculture. These include Seed companies like Seedco and Pannar, Fertiliser companies like Windmill and Zimphos and other Agrochemical companies. All these companies play a crucial role in farming, they provide among other things seed varieties for different farming regions in Zimbabwe, variety fertilisers, pest and weed control chemicals. As time lapses they continue to produce new varieties to suit changing weather conditions and new diseases. These products are distributed through a number of outlets including retail shops. In the proposed system the APCOs will entirely depend on their Smart-phones to communicate anything with the system. These Smart-phones should be installed with an application which connects to the backend layer and uploads Product varieties, their prices and distribution centres information and their terms of service. Whenever a smallholder farmer wants to buy inputs the system should be able to identify best product varieties that are suitably priced for a particular region that the

farmer is querying from and be able to forward such information to that particular farmer.

4.3.2.10 Smallholder Farmers

In the proposed model the Mobile Network Operators are required to broadcast the message requesting smallholder farmers to register themselves into the system via Short Message Service (SMS). After registering with the system a farmer can send an SMS to the server seeking for any form of assistance described above in 4.3.2.1 up to 4.3.2.9. In each case the system then identifies the most suitable information appropriate for the farmer and the relevant persons in each case are notified. The system should also be able to schedule Farmer profiling, whereby each farmer's information history like region, variety of seeds used, assigned Agritex Officers, VSOs, ZFU subscription status, Produce history etc. Any change to this information is then used to update the farmer's profile.

5 Unstructured Supplementary Services Data (USSD) Technology

USSD technology can also be exploited in this model because of its robust nature. This is a messaging service that is almost seven times faster than SMS and is highly cost effective, its operations are simple and handset independent because the service can be accessed from almost any mobile device from old cell phones to the latest Smart-phones (Aricent USSD White paper, 2011). USSD is a messaging service used in Global System for Mobile Communications (GSM) networks similar to SMS. However USSD is capable of real time and instant messaging. This makes it faster and cheaper than SMS. Communication using USSD codes takes the format *3digit# or *3digit*3digit# in whatever case the asterisk marks the beginning of the format string and the hash symbol marks the end. Worldwide USSD software solutions have been developed for many applications. In Zimbabwe it is being used mainly in Mobile money transactions therefore it can be extended to agriculture.

The proposed architecture of the model is illustrated in Fig 1.

6 Conclusion

Sustainable Development Goals (SDGs) post 2015 – 2030 development agenda are premised on ICTs. The United Nations placed ICTs at the centre of all the identified 17 SDG goals to drive world development. Most of this development is mainly targeted on the developing world, including Zimbabwe. In developing countries however it has been established that there is virtual absence of other ICTs infrastructure except mobile technologies and therefore this places mobile technologies at the focal point to drive development forward in the developing world.

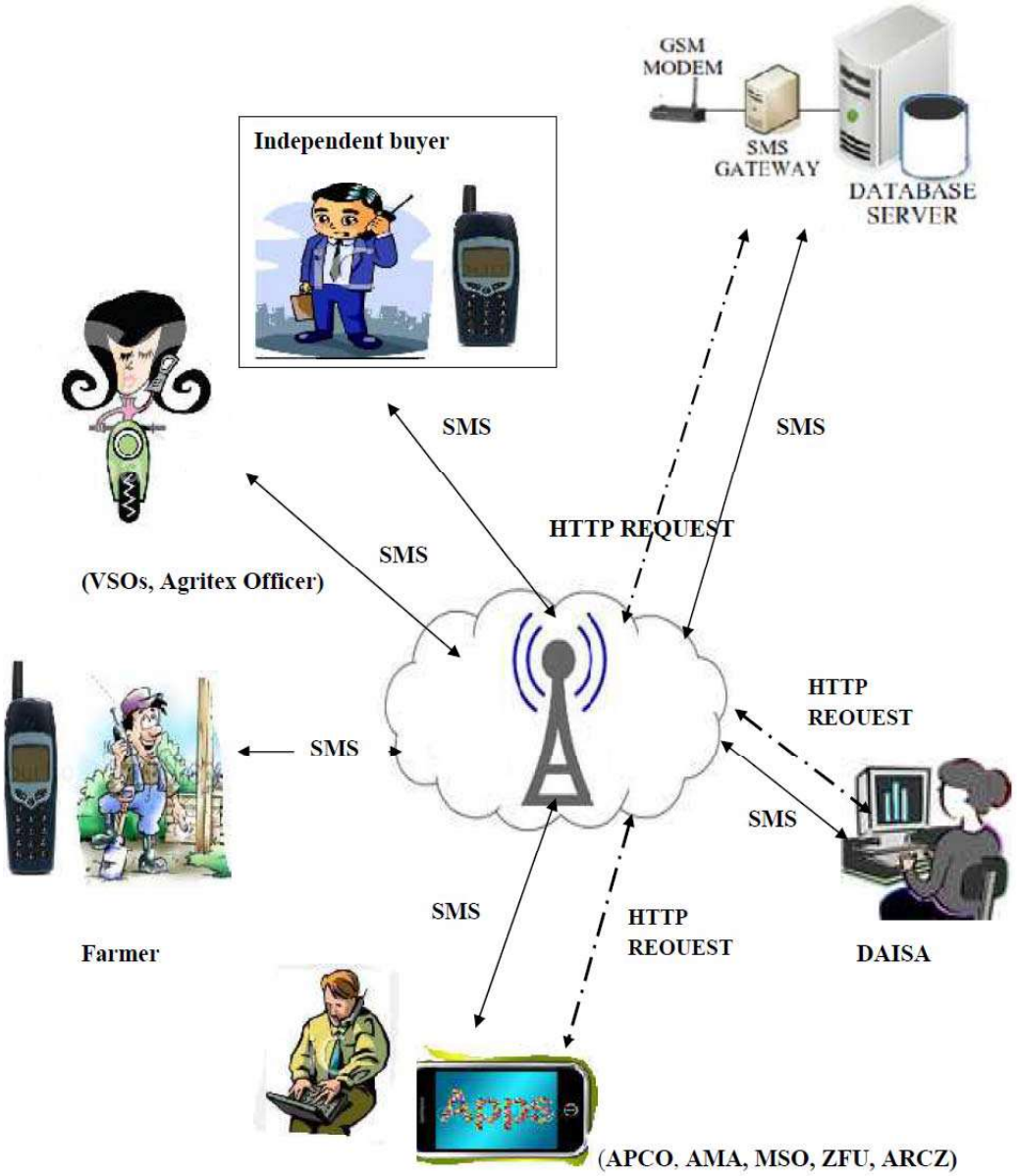

Fig 1: Architecture of the proposed model: Illustration developed by the author.

The vast majority of Zimbabweans reside in the rural areas of Zimbabwe. Most Zimbabweans solely depend on agriculture for their living. Most of these people are wallowing in poverty; hence there is need to redress the present situation. The country is struggling to find its foot on the economic front. The proposed model will see to it that the life of the smallholder farmer is highly improved and in the process helping the country to eradicate extreme poverty and hunger. Smallholder farmers will get