Prospects of Cloud and Mobile Computing Adoption for Dissemination of Agricultural Information in Developing Countries

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1 RESEARCH PROBLEM

Timely access to agricultural information by farmers is critical to agricultural productivity. ICT has the potential of improving agricultural information delivery and farmers productivity. Most developing countries however lack both the resources and the expertise to build and maintain many data centres distributed around the country. These countries have to look for other ways to access Information and Communications Technology infrastructure and services. This research investigates whether cloud computing combined with mobile computing provides an efficient, effective, sustainable way of bridging this digital divide between developed and developing countries, delivering appropriate expertise to remote areas.

2 OUTLINE OF OBJECTIVES

- To determine the status of mobile computing in Nigeria while reviewing the trends in mobile computing based extension delivery for farmers.
- To assess farmers perception of the present level of interaction between farmers and extension agencies in Nigeria in relation to the level of support given to the farmers via farm/extension information delivery.
- To determine the prospects of leveraging cloud and mobile computing to deliver support to farmers by deploying low tech web solutions via feature phones.
- To evaluate the impact of these low tech web solutions on farmers' productivity.

3 METHODOLOGY

Analysis of documentary sources about access to telecommunication and Internet services by Nigerians especially rural farmers will be conducted. All the 37 Agricultural Development Agencies (ADPs) and farmers in Nigeria will form the population of this study. The country will be divided into five Geo ecological zones. A convenience sample will be used to select one ADP each from the North West, North Central and from the South West Geo ecological Zones. The North East and the South East Geo ecological zones are presently experiencing security threats and will not be surveyed. It is hoped however that if the conditions permit a survey will be conducted in these zones at a later date. One hundred (100) farmers; fifty (50) from the rural areas and fifty (50) from urban areas will be selected from each of the surveyed ADP states using a simple random sample. A semi - structured Interview schedule will be used to elicit responses from the ADPs and a structured and semi structured questionnaire schedule will be administered to the farmers. A thematic analysis will be done on the qualitative data collated from the interviews to determine common trends and goals. The data from the questionnaire will be analyzed using descriptive statistics and other appropriate statistical tools. Low-tech web service solutions will be developed to leverage existing cloud computing, mobile computing infrastructure and feature phones. This low tech web service will be deployed in the areas surveyed. A further survey will be conducted to evaluate the impact of these low-tech web service solutions on the productivity of farmers.

4 STATE OF THE ART

4.1 Introduction

Within the past two decades there has been a burst of research activities in the area of agriculture in Nigerian universities and agricultural research centres. Far reaching innovations that are capable of boosting the small scale farmer's agricultural production and Nigeria's economic development have been discovered.

Unfortunately these have not had a correspond-

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ing effect of improved agricultural productivity due to the poor dissemination and adoption of these findings. According to (Madukwe et al., 2002) , effective integration of communication elements, enhances sustainability in communication of ideas and consequent transfer of agricultural technology to farmers.

Information is an essential ingredient in agricultural development programs but Nigerian farmers seldom feel the impact of agricultural

4.2 Agricultural Extension Delivery in Nigeria

The Agricultural extension system in Nigeria has been beset by a myriad of problems. According to (Agbamu, 2005) these problems include inadequate agricultural research extension linkages, poorly trained extension workers at the local level, poor logistic support for field staff, inadequate funding for extension services, inappropriate and ineffective agricultural technologies for farmers. Other problems include inability to access extension services especially in small towns, villages and farm settlements, ill equipped extension agents, difficult access especially in rural areas and general apathy towards extension services.

The government has tried to resolve these problems by introducing several agricultural extension agencies at state and Federal level. They include the Agricultural Development Project (ADP) which was established in 1975 (Olujenyo, 2006) to improve agricultural information dissemination to farmers especially small-holder and rural farmers. There are presently 37 ADPs; one in each of the 36 states and one in the Federal Capital Territory, Abuja. Many agricultural based universities and research agencies have some form of agricultural extension service. The Federal Government also established the Agricultural Extension and Research Liaison Services with the mandate to develop and disseminate agricultural innovations to farmers. They are also involved in research into new agricultural extension methodologies and policy. There is also a lot of collaboration between all these agricultural extension agencies.

4.3 Agricultural Development Project (ADP)

ADPs started as a World Bank intervention in 1975/76 in three Northern Nigeria towns namely Funtua, Gusau and Gombe . It later spread to other states. It was established to boost the agricultural production of small holder farmers as well as improve their socio economic status and food security of the nation. It was established as a joint state and federal government collaboration to improve extension services and to provide a robust monitoring system of small holder farmers and their activities.

The ADP programme has recorded significant success in the area of revitalizing the extension services in Nigeria, It has also brought about the dissemination of much needed technological transfer to farmers. It has however been plagued by lots of problems ranging from political manipulation, corruption, high turnover of staff and rivalry between the states and the federal government, inefficient tools for information dissemination, restricted access to small holder farmers etc.

In recent years the ADPs have been actively involved in the success of the e-wallet approach of the Nigerian government. ADPs supplied 3-5 helpline staff per local government (Adebo, 2014) who connected to the farmers daily to help to resolve issues.

However, in a study conducted by (Obidike, 2011), some of the problems encountered by rural farmers in Nsukka L.G.A. of Enugu State, Nigeria served by an ADP include lack of access roads for regular visits by extension officers, poor public relation of some extension staff, poor radio and television signals, non-availability of electricity supply in most Nsukka villages, lack of funds to purchase newsletters, leaflets on agricultural information; illiteracy and inability of radio and television stations in Enugu State to broadcast agricultural information programmes in native Nsukka dialect. These problems are also experienced by most rural farmers served by ADPs throughout Nigeria.

The ADP's are the major agents for information dissemination to farmers in Nigeria. It has become therefore become imperative that their methods of disseminating information be improved. ICT?s can be exploited for this purpose.

4.4 Mobile Computing Access in Nigeria

Sub-Saharan Africa had 367 million unique subscribers and 680 million connections by the second quarter of 2015 (Association et al., 2015). Nigeria remains the largest mobile market in Africa and as at 2014 had 145 million subscribers, 2.4 sims per subscriber, 58 million unique subscribers, 80 percent penetration rate for all subscribers, 32 percent penetration rate for unique subscribers and an annual subscriber growth of 18 percent in 2014 (Intelligence, 2014).

Table 1: Key mobile indicators for Nigeria 2010 -2014 Source(Intelligence, 2014).

Nigerian mobile market

Metric	2010	2011	2012	2013	2014
Connections (million)	87	95	113	127	145
% active	98%	98%	98%	97%	97%
% prepaid	97%	97%	97%	97%	97%
SIMs per subscriber	2.3	2.4	2.4	2.4	2.4
Unique subscribers (million)	36.5	39.2	45.4	51.1	58.0
Penetration, connections	54%	57%	66%	72%	80%
Penetration, unique subscribers	23%	24%	27%	29%	32%
Connections growth (annual)	19%	9%	19%	12%	14%
Unique subscriber growth (annual)	14%	7%	16%	13%	14%
ARPU, by connection (US$)	$7	$7	$6	$6	-
ARPU, by subscriber (US$)	$17	$16	$15	$15	-
Recurring revenue (US$, million)	$7,084	$7,324	$7,627	$8,717	-
Recurring revenue growth (annual)	-6%	3%	4%	14%	-

According to (Intelligence, 2014) (Intelligence, 2014), while a 70 percent mobile connections penetration would paint a picture of a well-connected market, the actual penetration on a unique subscriber (e.g. human user) basis is more sobering, with many subscribers having several SIMs with different providers to give adequate coverage. The problem of mobile coverage is more glaring when viewing mobile access from the urban and rural perspective. According to (Intelligence, 2014), the Nigerian population distribution has a 50:50 ratio for rural and urban centres with a 24 percent subscriber penetration for rural areas and a 34 percent subscriber penetration for urban areas.

The apparently low unique subscriber challenge has been mitigated by high household access. Many individuals have arranged sharing of mobile phones especially in rural areas among lower income populations, and mobile phone penetration has become near ubiquitous (only radio is more widespread), with broadcast TV still behind, and PCs lower still as a result of a paucity of fixed broadband infrastructure(Intelligence, 2014).

Some of the major causes of the low penetration of mobile telephony in rural Nigeria include bad roads, security problems especially in the North east region, tough geographic terrain especially in the Niger Delta, vast distances in the North, poor electricity supply, low investment in rural coverage (including new sites and backhaul). Despite these challenges the regulator set a goal of 60 percent rural penetration by 2015, with an increase to universal levels by 2017 (Intelligence, 2014).

As cellular networks become increasingly mature and reliable, Nigerian consumers are having faster and better access to the Internet using their mobile phones without the need for broadband or a computer at home. This positive development has been identified as a key driver for a range of applications that will support Cloud computing (Dogo et al., 2013). However, at the lower end of the market, and especially in rural areas, much of the use of mobile Internet is done from feature phones. This makes it imperative to state that any program to leverage mobile access for agriculture has to take the issue of the widespread use of feature phones into consideration.

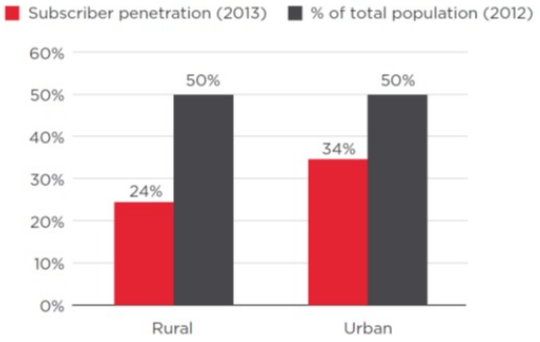

Figure 1: Gap in rural vs urban mobile telephony penetration Source:(Intelligence, 2014).

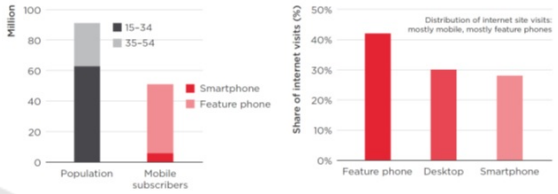

Figure 2: Phone type ownership in Nigeria and Frequency of Internet visits Per phone type Source: (Intelligence, 2014).

4.5 ICT and Agricultural Information Delivery in Developing Countries

Agricultural extension services in most developing countries have not been as effective as in developed countries. This has had serious implications on the productivity of the average farmer in a developing country. Information Communications Technology (ICT) has been deployed successfully in agricultural information delivery. The fast acceptance and widespread nature of mobile telephony has contributed immensely to this success.

4.5.1 Mobile Telephony: Improving Access to Agricultural Information

Most farmers live in rural areas which are largely under-served by ICT infrastructure like Internet services, broadband connection and telecommunications services. This has made the delivery of farm infor-

mation via mobile phones challenging; but there have been promising pilots in Nigeria in this area.

4.5.2 The Electronic Wallet (e-wallet) Approach for Small Holder Farmers in Nigeria

The Electronic Wallet (e-wallet) approach which was started in 2012 facilitates the distribution of seeds, fertilizer and other agricultural inputs directly to small scale farmers. In a study of three sample sets of farmers conducted by (Adebo, 2014) on the e-wallet approach in Kwara State, Nigeria, 53.5 percent, 51.0 percent and 87.2 percent of the respondents? respectively benefited from improved seeds of maize, rice and two bags of fertilizers each.

This program has helped to eliminate corruption and has improved access to timely farm inputs which is critical to improved productivity. In Nigeria as a whole the number of farmers with access to the e-wallet system grew from 1.7million in 2012 to 5 million in 2013 (Association et al., 2015).

The e-wallet approach provides direct linkage between the farmers and the government which enables government to distribute valuable information to farmers and provide support for the program.(Adebo, 2014) identified some challenges to the system to include telephony network failure, low level of awareness among farmers, cumbersome procedure of getting approval from the mobile provider, low density coverage of agro-dealers, and supply of fertilizer and maize seeds.

Despite its challenges the e-wallet approach has proven to be an effective example of the application of mobile telephony in improving access to agricultural information and inputs which have a direct effect on agricultural productivity.

4.6 Use of Web Services in Agriculture

A pilot study conducted in Ago-Are village in Oyo State, Nigeria provided access to farming information through an integrated resource centre in which information and communication technologies including the internet provided communication links for farmers (Adekunle et al., 2006).

The results after 18 months showed that yield per hectare for maize increased from 1.05 to 2.46 tons. The average income per annum of the farmers increased from 437USD to 3,285USD. There was an increase in fertilizer usage from an average of 22 percent of recommended rate to an average of 62 percent of the recommended rate. The increased income from the improved productivity of farmers also had an impact on their farm holding rate which increased from 2.22 ha to 3.76 ha.

The results of the study have shown that proper application of ICT, Internet and Web services can have a great impact in delivery of agricultural information to farmers with the ripple effect of increasing farm productivity and income.

4.7 Wider Application of Web Services to Support Farmers in Developing Countries

Most farmers live in rural areas which are largely underserved by ICT infrastructure like Internet services, broadband connection and telecommunications services. The recent upsurge in mobile telephone activities in developing countries and the vast coverage of mobile telephony services in developing countries provides an opportunity to improve access to agricultural extension services by rural farmers in developing countries. Many developing countries in collaboration with developmental agencies have begun to leverage this new found tool to improve access and ultimately improve productivity of rural farmers. Two good examples of the use of are:

4.7.1 Esoko

Esoko is an agricultural information advisory service that provides farmers advice i.e weather forecasts, market prices etc . It is a communication tool that links farmers with government agencies, NGOs and other farming support agencies. Esoko is an offshoot of TradeNet which was formed in 2005 as a response to the need to give farmers access to market information that was being collected by the Ugandan government. It was formed out of the need to adapt technology to resolve communication gaps being experienced by farmers.

Esoko comprises 16 apps which are grouped into the following categories: Market apps, Monitoring apps, Advisory apps and Field services.

- Market apps ?These apps are used to send SMS messages that link farmers and sellers to each other and that provide for improved access by farmers to market information and prospective customers.
- Monitoring apps? These apps provide survey information to both farmers and agricultural agencies throughout the entire agricultural value chain. This survey information can then be used to provide a clearer picture of what is happening throughout the agricultural value chain.
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- Field Services ? Provides tools to support on-site training for farmers, extension agencies and also provides helplines and technical support via call-center services.

4.7.2 Ezaraat

Ezaraat is a Management Information System application that has both a web and a mobile interface. It also supports help-line facilities. The Ezaraat project was developed by the Centre for Agriculture Bioscience International (CABI) with funding from the UK Department for International Development (DFID) to improve the reach of extension services in Punjab district of Pakistan.

The system comprises a mobile interface for farmers and extension agencies and a web based interface for institutional users. The hub of the system is a communication centre which links the farmers and extension agencies via a mobile interface and the agricultural agencies and other institutions via a web based interface. A farmer sends queries for weather information, fertilizer availability and other extension based information. These queries are routed to the extension agents on the field via the information communication centre. The communication centre is supported by a database for farmer and agricultural related information. The extension agents provide answers to farmers queries based on information they have retrieved from the field and supporting information from the communication centre database. Queries that cannot be answered by the extension agencies are sent to expert panels on the particular area of expertise via conference call facilitated by the call entered connected to the communication centre.

4.8 Potentials of Cloud Computing for Agricultural Information Delivery

Cloud Computing (CC) is defined by (Mell and Grance, 2011) as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and realized with minimal management effort or service provider interaction?. It is useful in developing countries, grappling with the problem of inadequate on-site ICT Infrastructure caused by limited resources to build robust Data Centres and manage them appropriately. CC has the potential to provide a quicker, cheaper way of bridging the digital divide that has developed between developed and developing countries, and could provide developing countries with the necessary tools to exploit the potentials of the information revolution.

There are many existing factors that will support the adoption of CC in Nigeria but the major ones are, namely; recent revolution in mobile technology, availability of skilled manpower, high volume of research in this novel area and the sudden influx of multinational data players in Nigeria seeking to invest due to the huge opportunities on ground (Dogo et al., 2013). The recent drop in oil prices which provides most of Nigeria?s revenue has made it more imperative to look to other sectors of the economy to drive development and job creation. ICT based agriculture has the potential to improve the economy and create jobs.

According to (Ballantyne et al., 2010), the use of ICT to connect farmers and producers to new agricultural knowledge and technology has been tested and found very useful, to the extent that ICT is now considered to be transforming agricultural extension. Cloud Computing provides a leap forward in agricultural development if properly applied, enabling sustainable and optimised utilization of these computing resources for agricultural extension information delivery. It also provides for networking between farmers and extension agencies even across large geographical areas. These cloud based resources could be scaled to meet the particular computing need of farmers and extension agencies on demand and at minimal cost. It will enable the extension agencies to focus on their core mandate of agricultural extension delivery rather than managing computer resources. The combination of cloud and mobile technologies would reduce the expenditure on information delivery and monitoring by extension agencies, while increasing the overall coverage of farmers by these agencies.

More farmers can be reached on time at less cost and risk to human life with mobile phones. Presently most extension agencies in Nigeria have to deploy extension agents to remote areas at great cost and high risk. This is much more challenging in flash points like the North east. Data ranging from location information and other farmer specific information can also be easily collected from the field promptly and regularly. This information alongside with location specific information like weather information etc can be very critical to the productivity of farmers. This information can also be analysed on the Cloud at minimal cost to the extension agencies. The Cloud could also provide data storage which can be scaled on-demand. This data store could serve as pooled information to aid improved information delivery based on analysed results. Farmers? activities and progress can also be

monitored by extension agents much more regularly.

(Dogo et al., 2013) while acknowledging the economic and operational benefits of CC cautioned that security, privacy, trust and data integrity remain the major concerns slowing down its adoption by governments, financial institutions, ICT firms, Industry and researchers in Nigeria.(Dogo et al., 2013) also implicated other challenges to the adoption of CC in Nigeria to range from ownership and security of data and information on the cloud, Internet availability, unstable power supply, policy implications arising from implementing cloud services, litigations and legislation on data ownership in the cloud and infringement rights, interoperability and international legislation.

5 EXPECTED OUTCOME

The present trends and status of mobile computing access especially for rural farmers would be determined. The present level of support given to farmers by extension agencies would also be assessed. The feasibility of introducing low-tech web service solutions that would significantly improve the productivity of farmers in Nigeria would be explored. Appropriate low-tech web service solutions to enable access to cloud based services via feature phones by the farmers will then be developed. These web services will be deployed and made available to farmers. The results of this deployment will be monitored to determine its impact on the productivity of farmers. This project will provide a framework for the utilization of cloud based resources by farmers in developing countries.

6 STAGE OF THE RESEARCH

I am presently doing a literature review of the concepts and present developments that underpin this project. They include an understudy of the status of mobile computing in Nigeria while reviewing the trends in mobile computing based extension delivery for farmers. The present cost of access to mobile networks and the penetration especially in rural areas will be investigated. A one month survey of agricultural agencies and farmers they serve will be conducted shortly in Nigeria. This study will assess farmers perception of the present level of interaction between them and the extension agencies in relation to the level of support given to the farmers via farm/extension information delivery. The information gained will be used to determine the kind of solution to be designed and the deployment model that will be highly beneficial to the majority of farmers in those areas and by extension the whole country.

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