AWARENESS AND USE OF KENYA AGRICULTURAL COMMODITY EXCHANGE SERVICES (KACE) INFORMATION SERVICES BY SMALLHOLDER FARMERS OF BUNGOMA COUNTY, KENYA

AMOS WANJALA WAWIRE

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DECLARATION

This thesis is my original work and has not been submitted for an award of a degree in any other university.

Signed……Date……

Amos Wanjala Wawire

Department of Agricultural Economics

University of Nairobi

APPROVAL

This Thesis has been submitted with my/our approval as University Supervisors:

Signed ……..Date…….…….

Dr. Sabina M. Wangia

Department of Agricultural Economics

University of Nairobi

Signed ……..Date…….…….

Dr. Julius J. Okello

Department of Agricultural Economics

University of Nairobi

DEDICATION

This thesis is dedicated to the two pillars of my life: the Almighty God, who has been able to do exceedingly abundantly above all that I have asked or thought, according to his power; and my family who assiduously supported me through my years of study and made this work possible.

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DEFINITIONS OF TERMINOLOGIES

This Section defines the main concepts constituting the Topic under study. The key terms elaborated under this section include: awareness and Information and Communication Technologies (ICT). In general, ICTs stand for Information and Communication Technologies and are defined, as a "diverse set of technological tools and resources used to communicate, and to create, disseminate, store, and manage information. These technologies include computers, the Internet, broadcasting technologies (radio and television), and telephony (Wikipedia). World Bank defines Information and Communication Technology as consisting of hardware, software, networks, and media for collection, storage, processing, transmission, and presentation of information (voice, data, text, images)." (World Bank, 2002, p.3) This study used Meager et al. (2002) definition of awareness, namely, ***"****Awareness occurs when an individual is sufficiently informed about a subject for him/her to be conscious of its existence and its broad subject matter.*

ABSTRACT

Agricultural information is a key component in improving small-scale agricultural production and linking increased production to remunerative markets. This leads to improved rural livelihoods, food security and national economies. However, farmers' access to market has consistently remained very poor at various phases of the agricultural supply chain, as a result of lack of market information. This has prevented farmers from negotiating for commodity or input price on the market. The use of ICT tools in transaction thus provides the opportunity for improving profitability of farming as a business. The overall aim of this study was to assess farmers' awareness and use of the technological tools employed by Kenya Agricultural Commodity Exchange (KACE) in linking the rural population to marketing as well as other agricultural information. Operations of KACE involve linking smallholder farmers in Western Kenya to markets. Data was obtained via personal interviews with 136 randomly sampled farmers drawn from 8 villages where KACE was conducting its activities. The collected data was analyzed using econometric models such as Logit and Poisson regressions. Logit regression model was separately used in examining factors influencing awareness and use of Information and Communication Tools. Poisson regression model was used in examining the factors conditioning the number of ICT tools and services used by the farmers in accessing marketing information from KACE. Descriptive analysis was used in assessing awareness and use of KACE tools and information services. Farmer specific, farm-level characteristics and capital endowment factors were found to affect the awareness, use and intensity of use of ICT tools. Specifically, farmer-specific variables conditioning awareness of KACE information activities are age and gender. Awareness is also influenced by literacy level, a capital endowment variable.

The use of KACE information tools is determined by farmer-specific characteristics: age and gender. Literacy level and group membership, are the capital endowment factors that influence use of KACE tools and services. Further, farmer-specific variables (gender and age), condition the intensity of tools used by farmers in accessing KACE services. In addition, farm-level characteristics such as distance to the nearest centre and main market; elucidate the intensity of use of ICT tools for agricultural transaction purposes. In terms of capital endowment, ownership of mobile phones, group membership and literacy level, also explains the extent of use of ICT tools by households in accessing agricultural information.

The implications of these findings is that access to ICT tools, in general and in particular, to KACE information services, can help reduce the problems of market asymmetry that characterize the smallholder farmers. Consequently, the findings recommend the need for policymakers and other stakeholders to beef up investments in programs geared towards making the ICT infrastructures accessible to smallholder farmers. Designing of tools that can easily be adopted by people with low literacy level as well as the older members of rural community will help in addressing the issue of digital gap. Women empowerment, in terms of knowledge, access to technology and financial resources will improve their adoption of these innovative tools.

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Acronyms and Abbreviations

ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
CCK	Communication Commission of Kenya
CTC	Community-Based Technology Centre
DAEO	Divisional Agricultural Extension Officer
DAO	District Agricultural Officer
DN	Daily Nation newspaper
FAO	Food and Agricultural Organization
FARA	Forum for Agricultural Research in Africa
FSD	Financial Sector Deepening
GoI	Government of India
GoK	Government of Kenya
GPCIC	Grameenphone Community Information Centre
GSMA	Global System for Mobile Communications Association
ICAR	Indian Council of Agricultural Research
ICT	Information and communication technology
IDRC	International Development Research Centre
ILRI	International Livestock Research Institute
ITU	International Telecommunication Union
KACE	Kenya agricultural commodity exchange
KNBS	Kenya National Bureau of Statistics
MICs	Market Information Centres
MILS	Marketing Information Linkage Systems
MOA	Ministry of Agriculture
NAIP	National Agriculture Innovation Project Initiative
NGO	Non Governmental Organization
RIA	Research ICT Africa
RIA	Research ICT Africa
SMS	Short Message Service
TAM	Technology Acceptance Model
TRA	Theory of Reasoned Action
VAT	Value Added Tax
WOUGNET	Women of Uganda Network

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Agricultural information is a critical ingredient to improving small-scale agricultural production and linking farmers to remunerative markets. This will consequently lead to improved rural livelihoods, food security and national economies. Improvement of agricultural productivity will be realized when farmers are linked to market information (Rogaly, et al, 1999). In many rural regions, however, the farmers and small entrepreneurs are consistently incapacitated by lack of price information on prevailing market prices before they travel or if they don't travel to the market. This is due to poor communication facilities and more often rely on middlemen who take advantage to exploit them. In particular, small-scale farmers have poorly organized market activities, inadequate marketing experience, and poor access to agricultural inputs (Munyua, 2007).

This scenario has necessitated the emergence of ICT-based marketing information systems especially in developing countries, which target smallholder farmers. These include, among others, Kenya Agricultural Commodity Exchange (KACE) and DrumNet in Kenya; TradeNet in Ghana; Malawi Agricultural commodity Exchange in Malawi; Songhai Centre in Benin, and women of Uganda Network (WOUGNET) in Uganda (Ferris et.al, 2006). Others include Govi Gnana Seva (DDEC) in Sri-Lanka; D-Net1's Community-based Technology Centre (CTC) and Grameenphone and Katalyst2's Grameenphone Community Information Centre (GPCIC in Baghladesh (Dey et al., 2008).

Despite the proliferation of ICT Information Systems, capable of addressing farmers' marketing information needs, numerous challenges still prevail, such as low prices for farm produce and poor access to farm inputs, due to poor bargaining power. The problem has been blamed to such factors as low literacy among the target users, complexity of some tools, and lack of electricity in the rural areas, and so, the awareness and level of utilization of the services offered by these initiatives among farming communities is reportedly low (Munyua, 2007).

KACE's Marketing Information Linkage Systems (MILS) employs modern ICTs to deliver inexpensive accurate and opportune market information to farmers aimed at enhancing their bargaining power for better prices for the agricultural produce in the market, and to link them to demand and profitable markets. KACE allows mobile subscribers to access market information using mobile phones on "411 Get It" Short Message Service (SMS). Market information is also accessed through voice response by dialing a KACE hotline number, using a mobile phone. This helps farmers get a competitive range of market prices for their produce.

The components of the KACE MILS are (rural based Market Information Points (MIPs) which are information kiosks located in rural markets and serve as sources of reliable and timely market information for farmers (e.g. current commodity prices in different markets), as well as provide market linkage through matching commodity offers and bids. District-level Market Information Centres (MICs) have internet connectivity and serve as liaison points between KACE and the remote MIPs. Other areas with MICs are: Eldoret in Uasin Gishu District, Kisumu in Kisumu District and Machakos in Machakos District. KACE launched an agricultural radio program dubbed "Soko Hewani" through a local FM radio stationed in Bungoma Town called 'West FM.' (Mukhebi et al., 2007).

According to Synovate analysis, the West FM radio has over 2.5 million listeners spread across western Kenya and Rift Valley. "Soko Hewani' was voted the most popular agriculture program among such other radio programs in the region (Kenya Media Programme 2011). This program has since been moved to Kenya National Broadcasting (KBC), the government funded radio station. In addition, KACE collects prices of agricultural commodities from different major towns across the country, and broadcasts them on a local FM station, Radio Jambo, on a program called 'Bei ya Vyakula,' Swahili phrase meaning 'Food Prices.' KACE has also set up Market information centres in various markets. Chwele market, because of its strategic location for business, has a busy information centre that collects price information from various markets and displays it on information board.

Chwele is Kenya's second biggest outlet for fresh produce after Karatina in Nyeri. Although Chwele market has three official market days: Monday, Wednesday and Friday, it is active throughout the week. The market is well known for its technology driven system of linking producers and buyers. KACE has been implementing its activities in Bungoma (Chwele) since 2003. The initiative helps farmers to know the price of commodities and links them to buyers. Farmers and traders visit the programme information centre at the market every day. The centre identifies prices for such commodities as vegetables, onions, cabbages, cereals as well as chickens, goats, sheep and cattle. The market resource centre uses technology and science to benefit small-scale farmers so that they can improve productivity and their incomes. The centre also provides timely information on recommended seeds and fertilizers and gives farmers technical advice on where to get help on growing crops. It is estimated that 30,000 farmers and traders have benefitted from the programme since its inception (ASARECA, 2010).

1.2 Statement of the Problem

Millions of livelihoods in most of the developing world depend heavily on agriculture and small to medium businesses (Dey et al., 2008). Kenya, and Bungoma County, in particular is primarily occupied by small-scale farmers. The farmers' main enterprise is maize-bean intercropping which serves as the main household food supply with the surplus being sold through complex, and often unfair, marketing chains for income generation (Woomer et al., 1998).

Farmers bargaining power, especially in the input market is still very weak as a result they pay exorbitantly for the inputs, a situation that leads to reduced net revenue. Poor bargaining power is also manifest in prices farmers receive when marketing their produce. With the reduced net revenue, farmers lack incentives to increase their productivity and expand investment in agriculture. It has been established that one of the major constraint in many rural regions is that smallholder farmers and entrepreneurs usually have no reliable way of accessing market prices before travelling to the market owing to lack or poor communication facilities. Consequently, they have to repeatedly depend on middlemen who often take advantage of this situation to exploit them. Specifically, rural farming communities have underdeveloped market infrastructure, insufficient marketing knowledge on agricultural inputs. Precise, commodity timely and up-to date market information, especially of perishable items, can considerably lower transaction and travel costs (Munyua, 2007).

The role of information for efficient functioning of markets has been a major concern of economic theory for a long time. After the influential work of Stigler on the "Economics of Information" (Aker, 2008; Stigler, 1961), a lot more literature has cropped up with attempts to explaining how asymmetric information and high cost of search can elucidate equilibrium price

dispersion for identical goods. Price dispersion across markets is a common trend, both in developed and developing countries, partly as a result of asymmetric information. The linkages between costly search and market efficiency are important for welfare in Sub-Saharan Africa.

One of the concerted efforts is the launch of the Kenya Agricultural Commodity Exchange (KACE) in 1997. The ICT-based is being implemented in Kenya and is particularly active in Bungoma County. However, the awareness and use of KACE by smallholder farmers has not been evaluated. Despite the concerted efforts of linking farmers to timely and accurate market and other related agricultural information aimed at helping farmers to get a competitive range of market prices for their produce, lack of dissemination of information across the agricultural supply chain, is still evident in Kenya and across many developing countries (Dey, 2008). Market access in most developing countries remains severely constrained by poor access to agricultural and market information. Poor access to market information results in information-related challenges such as adverse selection and moral hazards which result in increased transaction costs and hence discouraging farmers' participation in the market (Omamo, 1998; Fafchamps & Hill, 2005; Shiferaw et al., 2009; Okello et al., 2011)

1.3 Objectives

1.3.1 Overall Objective

To assess the awareness and usage of Kenya Agricultural Commodity Exchange (KACE) information services by farmers in accessing market information.

1.3.2 Specific Objectives

Specific objectives were:

1) To assess factors influencing awareness of Kenya Agricultural Commodity Exchange (KACE) information services among smallholder farmers.

2) To examine factors conditioning use of Kenya Agricultural Commodity Exchange (KACE) information services by smallholder farmers

3) To identify factors influencing intensity of use of Kenya Agricultural Commodity Exchange (KACE) ICT tools by farmers in accessing market information.

1.4 Research Questions

1 .Have the smallholder farmers heard of Kenya Agricultural Commodity Exchange (KACE)

2. Are the farmers aware of the KACE services?

3. Do smallholder farmers use KACE services to access agricultural information?

4. How do farmers access market information?

5. Which KACE ICT tools do smallholder farmers use in accessing market information?

The answers to these questions have important implications for development agencies, like KACE, mobile providers and policy-makers.

1.5 Justification

The capacity and potential of ICTs to improve the quality of life of the rural farming poor by linking them to information, is no longer in doubt. Through ICT tools and applications, farmers are able to acquire agricultural information on the prices of inputs and output, the weather, commodity demand, agronomic practices, agricultural insurance, among other important information. For this information to be helpful and to improve the life of the farmer, its content

must be relevant to the local situation. It also calls for an examination on ease or difficulty of access by the farmers, to the information provided by the ICT initiatives.

The overwhelming focus on modern ICT-based strategies of accessing information is informed by the realization of the crucial role they can play in: I) disseminating knowledge and information to rural farming communities, ii) relaying education and training components to rural farmers at a minimum cost, iii) increasing rural smallholder farmers' access to markets and agricultural credit, iv) empowering rural farmers to negotiate better prices, and v) developing and enhancing networking among smallholder farmers. Despite the growing enthusiasm by development agencies in promoting the application of ICT-based marketing information systems in delivering market information to farmers, little is known about farmers' awareness and use of these tools for agricultural transactions. Farmers bargaining power remains weak, especially in the input market, as a result, they continue to pay exorbitantly for agricultural inputs, a situation that leads to reduced net income. Low bargaining power has also seen farmers fetch poor prices for their produce. Reduced net revenues from farming activities will continue to result into reduction in investment in agriculture.

It has been argued that dissemination of timely and accurate market information to the farming communities is critical in the war against poverty and deprivation. Information plays a crucial role in availing opportunities to farmers and hence lessening their vulnerability (Kizilan, 2006). Kiplang'at (1999) posits that, equipped with relevant information, farmers are likely to adopt new technologies such as agricultural inputs, having bargaining power in the market decision as well as acceptance of improved scientific methods. Market access can result in surplus production for sale and in turn an income from agriculture. In the medium to long-run, the

surplus stemming from enhanced market access can lead to increased income, savings and thus investment in productivity enhancing innovations. The market access impact for smallholder farmers is significantly higher for high-value products, such as high value fruits, vegetables as well as organic products. There are multiple benefits for smallholder farmers, accruing from access to market for high value products, namely, direct income from sale of commodities and indirect effects at household as well community level, in terms of job creation.

1.6 Thesis Organization

This thesis is organized into seven chapters: the first chapter introduces the Topic of the study: giving the background information, the statement of the problem, objectives and hypotheses. This is followed by literature review in chapter 2. This Chapter reviews related previous studies on application of ICTs in Agriculture. It highlights the existing efforts aimed at promoting ICT market information strategies and factors affecting these initiatives. Chapter 3 addresses the methodology that was used to realize the stated objectives. Chapter 4 presents the results followed by a detailed discussion of the findings. Summary, recommendations and conclusions are given in chapter 5.

There is a section with a list of the reference materials used in the study. The last section presents annexes which include the survey questionnaire used in collecting data and summary statistics tables and a table providing examples of innovative agriculture-based applications in Kenya.

CHAPTER TWO

LITERATURE REVIEW

2.1 Current State of Agriculture and the Need for ICT

The agricultural sector, in general and farmers in particular, are highly vulnerable to risks due to increased variations in climatic conditions and to market uncertainties. The farmer's exposure to risk and uncertainty is often exacerbated by lack of information about weather, inputs, farm management practices or market prices, and this lack of information has an adverse impact on crop production and income. Severity of these risks depends on individual farmer's knowledge and ability to cope. The evidence suggests that a farmer who receives quality, up to date information, and who has the ability to use that information, is able to reduce the magnitude of these risks (Mittal and Tripathi, 2009).

Poor performance of agriculture in sub-Saharan countries has also been attributed to the stagnation in public investment, and breakdown of extension services, leading to large gaps between the yield from experimental farms and the yield from farmers' fields (Goyal, 2010). Insufficient extension services and poor access to information have impeded the transfer of technology at the farm level. A survey conducted by the National Sample Survey Organization in June, 2005, reveal that only 40% of farming households have access to information about modern farming technologies. Similarly, the cost of delivering information face-to-face in the public sector is very high (Goyal, 2010).

This crumbling extension network can be strengthened by the use of ICT in disseminating agricultural information to farmers. Although the cost of delivering information through ICT to farmers would be a huge investment, this to a larger extent can be offset by the large number of

potential users and its sustainability over a long period (Kumar, 2005). These initiatives are usually operational in a public participatory partnership mode. The sustainability of these extension models depends on the benefits generated and the efficient functioning of support from all the stakeholders in the system. Consequently, extension services have to be fine-tuned to meet the changing requirements. They have to play a role in the transfer and diffusion of technology, create appropriate interventions and become involved in innovations that strengthen the extension system (Kumar, 2005). Recent efforts to address poor access to remunerative markets by smallholder farmers have in turn focused on promoting information transfer through ICT-based information systems (Tollens, 2006; Aker, 2008; Okello, et al., 2011). The commonly used innovations include mobile telephony, internet/web-based strategies, interactive video and CD-ROM programs. The conventional ICT-based technologies, namely radio and television are also being used (Munyua, 2007). The promotion of these mostly new ICT innovations especially the mobile phones emanates from its rapid diffusion in Africa and swelling ownership by rural households (Okello, et al. 2010).

It is expected that modern ICT can play a role in bridging the information gap, and in reducing the information asymmetry that exists between farmers and between regions (Okello, et al., 2011). There is a need for fundamental information about expected weather conditions, and about general know-how: which crops to plant, which seed varieties to use, what the best cultivation practices and farm management practices are for that area, and the best suitable technology available locally (Munyua, 2007). Improved returns from agricultural production through enhanced access to markets can be a crucial step in alleviating poverty and overall livelihood improvement (Okello et al., 2011). Lack of market information such as prices,

demand indicators and logistical information can lead to higher production costs, increased transportation costs, higher information search costs and can also affect wages (Munyua, 2007; Kumar, 2005).

2.2 Mobile Phone Usage

Sub-Saharan Africa has some of the poorly developed infrastructure investment in the World. Barely 29 percent of roads are paved and less than 25 percent of the population has access to electricity (ITU, 2009; World Bank, 2009; IDRC 2009). On the other hand, however, access to and use of mobile telephone in Sub-Saharan Africa has unprecedentedly increased over the past decade. Currently, mobile telephony is the predominant mode of communication in the developing world (IDRC, 2009). More than 60 percent of the population has mobile phone coverage. Mobile phone subscription increased by 49 percent annually between 2002 and 2007, as compared with 17 percent year in Europe (ITU, 2008; Aker, 2010). Mobile telephony has presented new possibilities to the continent. Across urban-rural and rich-poor divides, mobile phones connect individuals to the rest of the society, information, markets and services.

In Kenya, the Information and Technology sector has emerged as a steadily growing contributor to the national economy. Since 2000, the sector has leapfrogged all other components in the economy, growing on average by approximately 20% annually (World Bank Economic Update, 2010). This has been attributed to the development in infrastructure; a favourable government policy, as well as a vibrant and innovative private sector. Most of the people are now actively interacting with technology in terms of creation and development of the technology, as well as actual application and dissemination of technology products and services. Thus technology advancement is becoming integral components of daily lifestyle (Kenya's communications

regulator Quarterly Sector Statistics Report, June 2012). With a steady decrease in the cost of mobile phones, what was once considered a luxury good is now more commonly considered a necessity by majority of the population. The country has a mobile penetration of 75.4% (October, 2012). This figure is significantly higher than the African average of 65% (Praekelt, 2012).

Literature on Information Communication Technologies (ICTs) imply that with the availability of telecommunications, incomes increase and local economies become more efficient (Jensen, 2007; Aker, 2008). Survey data from Morocco suggests that mobile phones make a financial difference in the lives of micro-entrepreneurs and act to both intensify and extend local and nonlocal forms of communication (Ilahiane & Sherry, 2012).

Despite lagging behind developed countries in overall ICT usage and application, mobile telephony has been regarded as the more accessible and less expensive means to close the digital divide for the low-income countries (Wade, 2004). Mobile phones have been regarded as particularly important for various reasons: 1) they offer mobility and security benefits to the owner (Donner, 2006); 2) its considered a 'leapfrogger' as it works using the radio spectrum and does not rely on physical on physical infrastructure such as roads and telephone wires and base stations can be powered using their own generators in places where there is no electrical grid (Economist, 2008); 3) mobile phones only require basic literacy and are therefore accessible to a larger segment of the population; 4) mobile phones have technical advantage that make them applicable for development. In addition to voice communication, mobile phones allow for the transfer of data, which can be used in the context of application for purposes of health, education, commerce or governance. Increased competition among mobile service providers and

innovative payment methods (e.g. prepaid method), mobile phones are increasingly becoming affordable to the lower strata of the population and thus can be used as a mechanism to ensure greater participation of the groups in the development process (IDRC, 2009).

The penetration of mobile phones into rural areas demonstrates a major transformation among farming communities in many developing nations in the past decade. Agricultural producers, processors, and marketers have graduated from a culture in which there was practically no telephone service of any kind to one in which mobile phones are now widely utilized among farmers at local markets (GSM, 2008). The use of mobile phones has been found to encourage poor farmers of these developing countries towards greater market participation and diversification to high-value crops. These new initiatives in the use of ICT which include community radio, SMS and voice-based cellular telephony, information through tele-centers, internet kiosks, village knowledge centers, multipurpose community centers etc; are transforming the traditional agricultural extension system (Mittal and Tripathi, 2009). Information and communication technologies can play a vital role in rural development and poverty reduction within developing countries, as a result of increase in local people's ability to obtain information for sound decision-making (Hudson, 2006; Jagun, Heeks, & Whalley, 2007).

Despite the opportunities presented by mobile telephony, rural farmers are still faced with constraints of poor access to agricultural and market information and little is known about the awareness and usage of such by smallholder farmers in Africa (Okello et al., 2011). Meanwhile, the ICT interventions still lack appropriate network linkages with research institutes and other knowledge banks which are a possible source of appropriate content for the customized, timely information that is necessary for the smooth flow of information to farmers to help them to

mitigate risk (Aker, 2008). Some studies have suggested the complementary role mobile- and internet-based information delivery models have to conventional extension services (Mittal et al., 2010).

2.3 Mobile phones and ICT Applications in Kenya

The super fast growth of Telecommunication and ICT in Kenya has transformed the country in terms of economic capacity by enhancing free flow of information, communication and Money. This remarkable gains made towards mobile phone access have seen consistent development in the scope of innovations stemming from exploitation of these fairly new technologies. Some of applications and ICT-enabled tools for data collection have been launched to address problems of information asymmetry in Agriculture in Kenya include: KACE, KaiNet, DrumNet, M-Kilimo, M-Farm, Icow, Mkulima mobile, Freshmate, and Ukulima.net.

The need for convenient ways of accessing financial resources beyond the conventional norms has seen the recurrent expansion and modernization of banking patterns (Njenga, 2010). Mobile banking is an innovation that has progressively rendered itself in pervasive ways, cutting across numerous sectors of economy. An appropriate banking environment is considered a key pillar as well as an enabler of economic growth (Koivu 2002). With the continuously emerging wave of information driven economy, the banking industry in Kenya has inevitably found itself unable to resist technological indulgence.

Considered as the biggest in the ICT space in the world in money transfer, MPESA has transformed lives in Kenya, socio-economically, especially to the rural poor who can receive small amounts of money from their relatives working in urban areas to invest in their farms,.

This flow of financing makes a huge difference since the farmer can liaise with market operators, kilometers away making business flow much faster and smoother. Safaricom's MPESA have partnered with financial institutions to develop more innovations, namely, M-SHWARI, MKESHO. These are mobile banking /micro-financing solution that can help many unbanked people access basic financial services like loans, deposits, savings, all this without having a bank account. These innovations resonate well with recent data which indicate that only 19% of adult Kenyans were reported to have access to a formal, regulated financial institution (Financial Sector Deepening, FSD, 2007). Other examples of financial innovations include pesapal, TxtEagle, crowdpesa, Musoni, Uhasibu and kopokopo. All these initiatives have helped in getting the much-needed funds to the most remote but productive areas and have improved rural livelihoods very significantly.

2.4 Past Studies on the Application of ICT in Agriculture

The increased diffusion of ICT in most developing countries has received massive attention from researchers, policy makers as well as private sectors. This development presents unprecedented potential of delivering information to poor rural communities and linking them to profitable markets, and thus contributes to increased food security, poverty alleviation and social and economic transformation (Aker, 2008).

Several studies have been advanced to demonstrate application and impact of the ICT innovations in agricultural growth and rural development (Aker, 2010). Some studies suggest that "information technology, together with the ability to use it and adapt it, is a critical factor in generating and accessing wealth, power, and knowledge in our time" (Njuki *et al*., 2004). In

their separate studies, Dey (2008) and Todaro (2008) opine that value addition in agriculture must be preceded with institutional, technological and price incentive changes intended to increase agricultural production among smallholder farmers (Dey et al., 2008; Todaro, 2000).

Dey (2008), in his study with two mobile phone technology-based telecentres investigated how ICTs could be used to address agricultural information needs of Bangladeshi farmers. The research in which groups of farmers were enabled access to the services provided by the two telecentres using different ICT tools, namely, mobile telephones, computers and internet mobile allowed for interaction between farmers and these telecentres. The action research intervention also enabled small groups of farmers to retrieve information from the telecentres using mobile 'phones. This allowed for the assessment of the roles of telecenres and mobile telephony technology in resolving farmers' agricultural information needs (Dey B., et al., 2008)

An investigation by Lio and Liu (2006) established that a microwave-radio telephone system initiated in the interior part of Tumaca, Columbia, together with community access points led to improvement in trade and market opportunities. James (2004) reported that rural telephone and community radio services implemented in India and Sri Lanka were positively received by the farming community. Bayes (2001) observed that the Village Phone Program (VPP) of Grameen Bank of Bangladesh had the potential to turn telephones into production goods through reduction of transaction costs.

While a number of studies point out on the crucial role of ICT in development, others have expressed skepticism. For instance, Cullen (2003) posits that new and old technologies may exist concurrently resulting into a situation of digital divide. Some findings suggest that the

opportunity cost of the resources invested in reducing the digital gap may lead to abandonment of priority developmental projects (Dey et al., 2008).

These resources used in bridging the digital divide would have a much more positive impact if they were channeled in meeting the basic needs of the resource poor members of the society (Mutula, 2005). Nevertheless, like other scholars, Mutula (2005) remains positive about the outcome of the effective application of ICTs. Heeks (1999) argues that ICT has a potential to making a positive contribution to the economic growth if correctly utilized. Following the arguments advanced by other researchers like Nikam et al. (2004), Kirlidog and Aydemir (2005) and Leaning (2005) as regards the execution of western based ICTs in the developing worlds' environment, an all-inclusive stakeholders approach is highly recommended. This will ensure that locals' informational need is taken into account.

Some studies that explored how mobile phones impact livelihoods of farmers and fishermen have been advanced. Jensen's (2007) study on the fish prices in Kerala, India provides strong evidence of the micro-economic impact of mobile phones. He found that the arrival of mobiles brought significant and immediate reductions in the variability of price and the amount of waste in the fishing system. Mobiles allow fishermen, particularly the more prosperous ones, to get timely price information and decide on the best place to land and sell their daily catch. This suggests that unless these innovations are carefully implemented, they may only benefit the already progressive members of the society hence widening even further, the gap between the rich and the poor. Similarly, direct impact are less obvious in most other studies which show greater use of mobile phone for social purposes and emergencies, rather than dedicated economic

activity such as calling suppliers or customers (Okello et al., 2010; Souter et al., 2005; Donner, 2004).

Another study by Abraham (2007), which also looked at Kerala fishermen, revealed that the widespread use of mobile phones increased the efficiency of markets by decreasing risk and uncertainty. While using mobile phones at sea, fishermen were able to respond quickly to market demand and prevent wastage from the catch – as it was the case before the adoption of phones. A study by Aker (2008, 2010) on the impact of mobile phones on Agricultural markets shows that mobile phone coverage reduced consumer's price dispersion by 10-15% for millet in Niger. Mobile phones help co-ordinate supply and demand, enabling traders and transporters to take advantage of transparency in the flow of price information (Abraham 2007).

Aker (2010) observes that realizing potential efficiencies is dependent on easy access to capital. In his study, Okello et al. (2010) also argues that although 99% farmers had awareness of mobile phones, only 36% of the interviewed farmers owned mobile phones. This minimal ownership is largely attributed to the inability of smallholder farmers to afford the handset (Okello et al., 2010; Chigona et al., 2009).

A study by Rashid and Elder (2009) reported improvement in market efficiency following the adoption of mobile phones among Senegalese fishermen. The increased use of mobile phones and the resulting increase in returns was evident in Goyal's study on information direct access to farmers and rural market performance. He found that internet kiosks increased farmers' prices for soybeans in Central India (Goyal, 2010). Investigation the impact of SMS-based agricultural Information on Indian farmers, found no effect of mobile phone based information service on the agricultural prices received by farmers (Fafchamps et al. 2010). Results from a study on the

effectiveness of short text message (SMS) in reaching smallholder farmers with market information, revealed that 81% of mobile phone users depend on the voice system to communicate. The preference for voice rather than SMS is linked to the low level of education among farmers (Okello et al., 2010).

Abraham (2007) found out that Senegalese fish farmers in the field were able to check prices before they set off to markets and thus they could secure, on average, about 15 per cent higher profits. The adoption of mobile telephony by farmers and agricultural traders in Ghana has helped them reduce both their transportation and transaction costs. The members associated with trade networks, now equipped with new technology, are able to organize their activities more efficiently and with considerable cost savings (Overa, 2006).

The expansion of mobile phone networks and increase in mobile-density in Uganda has enabled higher market participation by farmers producing perishable crops located in remote areas and helped them realize higher prices by reducing the information asymmetry that existed between farmers and traders (Muto and Yamano, 2008). This programme helped farmers to access useful information for efficient planning and production (Fong, 2009).

Gherkin farmers in Sri Lanka were able to improve their incomes through simple mobile phone applications that helped reduce waste through a feedback system. More than 40 percent of crop loss could be prevented with quick interventions facilitated by information received via SMS (de Silva & Ratnadiwakara, 2008). Farmers also expressed their willingness to pay for such services if it would save their time and money. In traditional Indian markets, commission agents and traders dominate the supply chain and are the major price setters. Most farmers are dependent on them for information (Mittal & Mukherjee, 2010). For the crop sector, information search costs

form a significant part (to the tune of 11 per cent) of the total cost incurred by farmers during the agricultural cycle, starting from the decision to sow to marketing (de Silva, 2008).

Mobile phone usage by farmers can reduce the information search costs, thereby dramatically lowering transaction costs and enabling greater farmer participation in commercial agriculture (de Silva & Ratnadiwakara, 2008). The rural ICT initiatives in agriculture such as computerization of agri-markets, e-Choupal and eSAGU, informational extension services, digitalization of land records by the Karnataka government and computerization of co-operative milk collection centres have lowered costs for farmers, added value to output and improved transparency in the system (Bhatnagar, 2008).

Grameen Telecom's village phone programme in rural Bangladesh, in which Grameen Phone leased cell phones to poor rural women who set up local village pay phone shops, reveals the far reaching impact of ICT on rural livelihoods (Richardson et al., 2000). The project was found to be of considerable benefit both to the provider and the users. Not least, the average operator was earning between 24 and 40 per cent of household income from providing phone services and the estimated consumer surplus from phone usage ranged as high as $2.70-$10 per call (Richardson et al., 2000). Against this backdrop, Donner (2008, p.146) argues, the broader story of the mobile phone's impact on small enterprises, farmers, and the self-employed is not clear-cut. At the same time, most of the models of information provision are Internet-based. Yet, as one study shows mobile phones offer a more reliable and cost-effective tool for serving farmers' need for information compared to the Internet (Campaigne et al., 2006).

2.5 Factors Affecting Awareness and Adoption of ICT

Literature on the drivers of productivity growth shows that the development of markets improves the input-output interface. This, together with the development of research, extension and literacy, leads to growth in crop productivity. Education and awareness leads to the adoption of new technology and use of modern inputs like machinery and fertilizers (Mittal and Kumar, 2000; Kumar and Mittal, 2006; Kumar and Rosegrant, 1994; Evenson et al., 1999; Fan et al., 1999). Today, information and communication technology (ICT) and mobile-enabled agricultural services act as instruments to deliver extension services through infrastructure for mobile telephony and help create awareness amongst farmers.

Exploring the development impact of mobile phone usage, Rashid and Elder (2009) conclude that mobile phones do offer a potential for application, and show evidence of having a positive effect on the lives of the poor, and do contribute to greater efficiency for farmers and fishermen. However, it also cautions that if we do not have a clear understanding of the need, skill requirements, applicability and the environment that needs to be created to use modern ICT, then there are chances that this might turn out to be a "white elephant".

Despite the increasing rural demand for relevant, timely agricultural information on the one hand and recent advances in quality and capacity of ICT services on the other, the benefits remain unevenly distributed among people. The main causes are the lack of a policy and regulatory environment and the poor availability of ICT and mobile infrastructure (Bhavnani et al., 2008). The cost of the use of available infrastructure is also an issue. Those having resources and skills benefit more than those who lack them. Separate studies by Jenson and Abraham confirm that well-endowed fishermen gained more than small ones. High transaction costs deter the entry of small farmers into the market. Interventions aimed at reducing transaction costs would, therefore,

encourage increased farmer participation in competitive markets and help meet broader poverty reduction objectives (Pingali et al., 2005).

According to Bertolini (2004), knowledge and information are important factors for accelerating agricultural development through increased production and improved marketing and distribution. ICT could make the greatest contribution by telescoping distances and reducing the cost of interaction between stakeholders. ICT has the potential to help farmers in the entire cycle of production, i.e., from production to sales. ICT impacts both observable and unobservable transaction costs (Bhatnagar, 2008). Most efforts to make ICT available to rural farmers have sought to improve the availability and quality of information either indirectly through producer associations, extension workers and the like, or directly through broadcast radio information, telecentres, and mobile short messaging services (SMS) (Bertolini 2004).

The application of ICT in agriculture is not a new concept. But the use of modern tools of ICT like the internet, web portals and mobile phones is in its initial stages and thus it is important to understand how ICT is used in agriculture, how we expect ICT to play a crucial role in meeting farmers' needs and in improving their adaptation to climatic changes, and what potential tools of ICT can be used to do so. The National Agriculture Innovation Project initiative (NAIP) of the Indian Council of Agricultural Research (ICAR), Government of India (GoI), has also pointed out the need for a comprehensive assessment of major ICT initiatives in the country in order to understand their successes, failures and gaps. This will help suggest the way forward in terms of the design and implementation of ICT initiatives to ensure that they meet farmers' expectations and needs so that they can better manage risk.

The Forum for Agricultural Research in Africa (FARA, 2009) report emphasizes that to monitor the impact of rural mobile telephony on agriculture, a better understanding of the farmer's context for the adoption and adaptation of an innovative information tool is required. The investments required to build up the kind of ICT infrastructure that will be able to deliver the information to farmers are huge. Capacity building and awareness campaigns are needed to win farmers' trust in the system and to motivate them to shift to new modes of accessing information (Mittal et al., 2010; Lokanathan and De Silva, 2010)

CHAPTER THREE

THEORY AND METHODS

3.1Theoretical Framework

3.1.1 Theory on Technology Adoption and Use

According to Pedersen and Ling (2002), literature on technology adoption can be classified at three levels, namely, diffusion, adoption and domestication. Pederson (2005) explains diffusion research as describing the adoption process as an S-shaped function of time that may be used to classify adopters of different kinds (Rogers, 2003; Kiljander, 2004); domestication research as looking at adoption and use of technology in everyday life with a focus on the social, cultural, political and economic consequences (Silverstone and Haddon, 1996); and adoption research as explaining adoption decision of individuals by applying cognitive and social theories of decision making (Davis, 1989; Fishbein and Ajzen, 1975).

Building primarily on adoption and domestication schools of thought, Van Biljon and Kotze (2008) contextualized mobile phone adoption in an extended technology acceptance model (TAM) framework where perceived usefulness in adoption is encompassed in a multi-dimensional setting in terms of socio-cultural, gender and income criteria. Formerly proposed by Davis (1989) the TAM is an adaptation of the theory of reasoned action (TRA) developed by Fishbein and Azjen (1975) using attitude and subjective norms as the two factors that affect behavioral intentions. Davis (1989) and Davis et al. (1989) conceptualize TAM as focusing on the attitudinal explanations of intention to use a specific technology or service consisting of six concepts; external variables, perceived usefulness, perceived ease of use, attitudes towards use, intention to use and actual use. While this model is able to explain adoption well from a technical

perspective, Malhotra and Galletta (1999) identify the lack of explicit accounting of social influences affecting adoption as a limitation in the TAM.

Van Biljon and Kotze's extension identifies a number of factors that influence mobile phone adoption and use. They are social influence, expressed as the pressure exerted on the individual by the opinions of others; facilitating conditions or the necessary infrastructure; perceived usefulness or the extent to which a user believes that he or she will benefit from using the mobile phone; and perceived ease of use. Besides the determining factors the model contains a set of mediating factors that influence the determining factors towards behavioral intention; say a person finds it beneficial to use a mobile phone (determining factor; perceived usefulness) but lack of income (mediating factor) can significantly undermine technology adoption. To this effect, mediating factors acknowledged by the model are personal factors, like preference and beliefs about mobile phones (including image), demographic factors like age, gender, education etc. and socio-economic factors such as occupation and income. The model postulates that actual adoption and use is the final outcome of the interplay of the mediating and determining factors.

3.1.2 Attitude and Behavior in Technology Adoption

In examining diffusion from a holistic approach, it is important not only to take into consideration the impact of demographic characteristics, and material and structural factors, but also individual attitude and behaviour. As far as research focused on ICT diffusion in rural areas is concerned, scholars have identified a particular set of structural factors that impact the rate and effectiveness of adoption. Unlike urban dwellers, rural residents may encounter particular challenges likely to impede their access to ICTs. The principal among them being physical

access to an ICT project, which can be too far from home or made distant due to wobbly road conditions, unreliable or unstable electrical power supply, equipment maintenance, theft, and limited financial resources (Baggio, 2008; Hernandez et al., 2007; Mori & Assumpção, 2007; Sorj, 2003).

It has also been demonstrated that individual attitude and behaviour have an impact on ICT adoption. Writing about digital inclusion in Brazil, Sorj (2003) highlighted the importance of individual motivation and self esteem as a driver for ICT use. Indeed, Wilson (2004) pinpointed motivation as the single common factor among individuals who are able to overcome structural and personal barriers to ICT adoption. Furthermore, an individual's ability to understand and appropriate the information accessed through ICTs can impact effective ICT adoption. The quality of one's experience using ICTs is inevitably linked to one's ability to navigate the logic and language of digital processes; these skills may not be available among individuals who are functionally illiterate or live in primarily oral societies (Proenza et al., 2001).

According to the Technology Acceptance Model (TAM) (Davis 1989), the Theory of Reasoned Action (Fishbein and Ajzen, 1975) and the Theory of Planned Behaviour (Ajzen, 1991), perceived usefulness and perceived usability determine the users' behavioural intention to use a technology. Most TAM studies use quantitative tools to find and validate factors determining behavioural intentions. However these take a snapshot of perceptions, and do not allow for changes over time, as people learn to use a technology (increasing perceived usability) and discover new benefits or costs (changing perceived usefulness). Snowden et al. (2006) have used action research approach to assess the technology acceptance for m-commerce. They argue that it is equally important to find how practitioners can intervene to positively affect the acceptance and therefore the adoption of new technologies. This is particularly necessary when the potential users are not much aware of the

technological applications. As farmers interact with the ICT projects, they gradually learn how to use these technologies in their farming, improving subsequent interactions, until they can integrate the new tools into their lives.

3.2 Conceptual Framework

Knowledge is becoming an increasingly significant factor in production and marketing for small-scale agriculture. Timely knowledge about what and when to plant; where and who is buying the farm products, how much is being offered, who the potential buyers are and what the expected costs including transport, is important for the decision making of rural farmers

In this study agricultural information (production and marketing) is expected to be accessed through ICT such as the internet, radio, telephone, television, newspapers, and magazines (Figure 1). It is expected that access to agricultural information through ICT and particularly mobile phones, will have an impact on farmers' adoption of new crops and new technologies, the quantity marketed, prices and incomes. Access to timely market information via ICT tools is expected lead to increased income among the rural farmers, overall improvement of livelihoods of rural households, improved national food security and a motivation increased technology adoption.

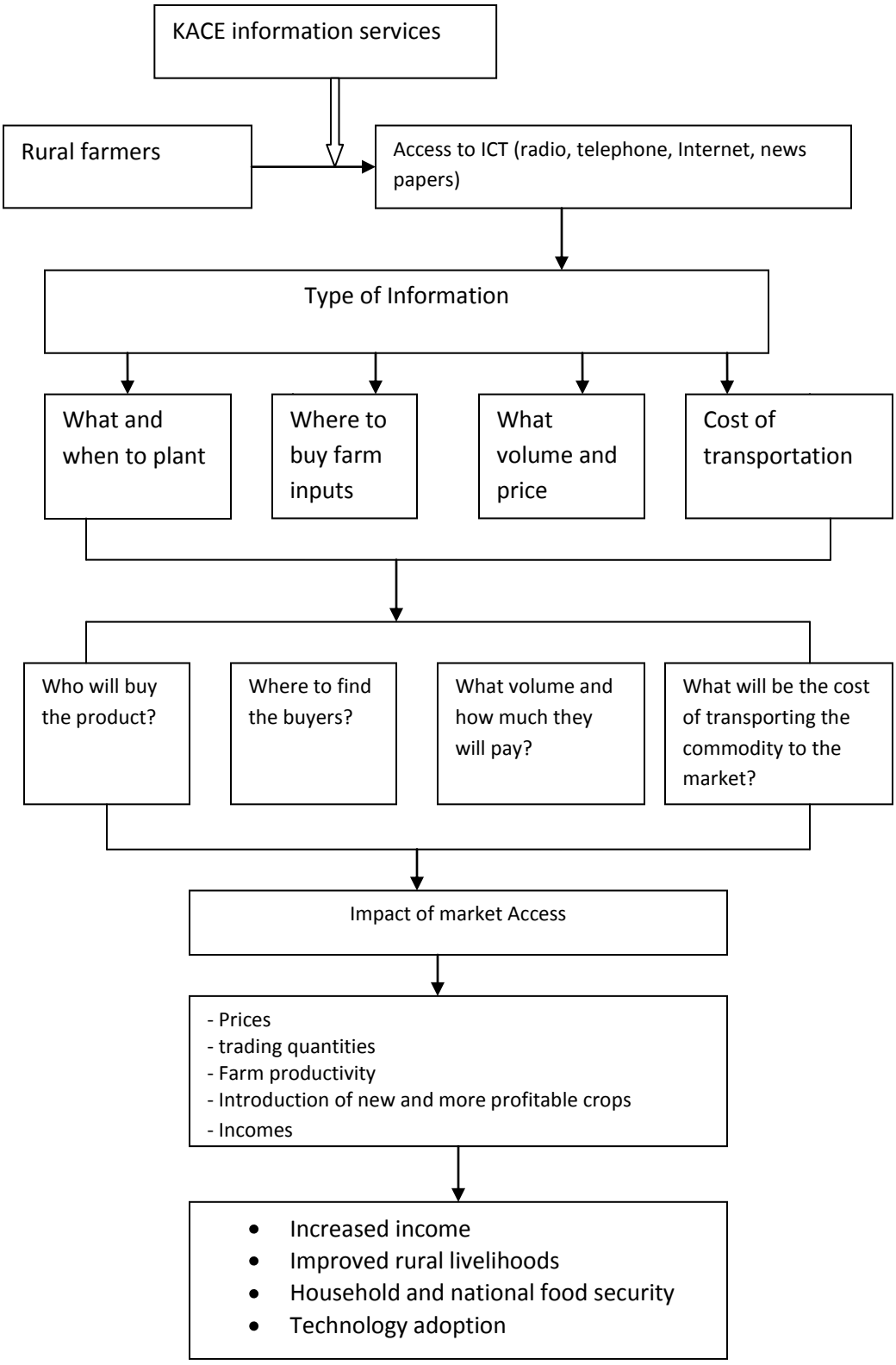


Figure 1: Conceptual framework for market Information access impact on rural Livelihoods

3.3 Empirical Models

3.3.1 Assessing Awareness and Use of KACE ICT Tools

To realize the stated study objectives, both qualitative and quantitative methods of data analysis were used in interpretation of the results. Descriptive analysis was used to assess the awareness and usage of KACE information services. Logit regression model was used to separately examine the factors that condition awareness and use of KACE information services. In a logistic regression model, the probability, *p*, that a household will use (be aware of) KACE Information Services is given by the reduced form of a logit model below:

$$P = e^{Z}/1+e^{Z} \quad (1)$$

Central to the use of logistic regression is the logit transformation of *p* given by *Z*

$$Z = ln(p/1-p) \quad (2)$$

Where;

$$Z = X\beta + \varepsilon \quad (3)$$

β is the vector of regression parameters, X is a vector of explanatory variables and ε is the stochastic term assumed to have a logistic distribution. The vector X comprises of farmers' demographic characteristics, physical, human, and social capital endowments. Z is a latent variable that takes the value of 1 if the farmer has knowledge or uses KACE ICT services and 0 if otherwise.

3.3.2 Assessing Intensity of Use of KACE ICT Tools

Intensity of use of KACE ICT tools in this study refers to the number of tools a farmer used, to access information from Kenya Agricultural Commodity Exchange (KACE). The number of

tools a given farmer uses to access information assumes integer values of discrete nature and is therefore a non-negative count variable. According to Maddala (2000), count data are non-normal and hence are not well estimated by Ordinary Least Squares (OLS) regression.

The most commonly used models in analyzing count data include the Poisson Regression Model (PRM), the Negative Binomial Regression Model (NBRM), the Zero Inflated Negative Binomial (ZINB) and the Zero Inflated Poisson (ZIP). Poisson and negative binomial regression models are the most popular models for analyzing response variables with nonnegative integer (Winkelmann and Zimmermann, 1995; Greene, 2008). The remaining two models, ZIP and ZINB, are particularly used in accounting for the frequency of zero counts (in cases where more zeros are recorded, than expected, in either PRM or NBRM). However, that is not the scenario in this study. In our case, the response variables were nonnegative integers and with not many zero counts. Hence a discussion of PRM and NBRM was undertaken.

According to Greene (2003) both PRM and NBRM models (for analyzing count data) are closely related to Ordinary Least Squares (OLS) regression model more than any other discrete choice models. As in the case of OLS, the optimality conditions can be derived from the PRM models and that violation of variance assumptions in the models does not essentially lead to inconsistent estimators, instead the coefficient estimates are inefficient and standards errors are potentially biased (Wooldridge, 2002). However, OLS regression models rest on particular assumptions which oftentimes are not satisfied (Maxfield & Babbie, 2001). OLS assumes that the dependent variable is a continuous value, normally distributed (e.g. not skewed), and linearly related to the independent variables (McClendon, 1994)

Poisson and negative binomial regression models are designed to analyze count data. The occurrence nature of counts is controlled for in the formulas of both Poisson and negative binomial regression. However, Poisson and negative binomial regression models differ in regards to their assumptions of the conditional mean and variance of the dependent variable. Poisson models assume that the conditional mean and variance of the distribution are equal. According to Osgood, (2000), Patemoster and Brame, (1997), Negative binomial regression does not assume an equal mean and variance and particularly correct for over-dispersion in the data, which is when the variance is greater than the conditional mean.

3.3.2 Poisson Regression

Poisson regression is a modeling method that overcomes some of the problems of traditional normal regression in which the errors are assumed to be normally distributed (Cameron & Trivedi, 1998). For most count data analyses, Poisson regression model is normally the first step (Areal *et al.*, 2008). The model rests on assumption that the dependent variable ***y*** given vector of predictor variables ***x*** has a Poisson distribution. The probability density function of ***y*** given ***x*** is completely determined by the conditional mean as shown by the log linear expression, 4 and 5 below. PRM specifies that each observation y_i is drawn from a Poisson distribution with parameter λ_i which is related to a ray of predictor variables X` (Greene, 2003; 2008). The model is derived from the Poisson distribution by introducing parameters into the relationship between the mean parameter $\lambda_i$ and predictor variables X`.

$$\lambda(x) = E(y \mid x) \qquad (4)$$

$$f(y_i|x_i) = \frac{e^{-\lambda(x)}\lambda_i(x)^y}{\Gamma(1+y_i)} \qquad (5)$$

Where $\lambda_i = \exp(\alpha + X'\beta)$ and $y_i = 0,1,\ldots,i$ is the number/count of tools/services used (in our case); X = a vector of predictor variables.

Wooldridge (2002) and Greene (2003; 2008) have demonstrated that the expected number of events, y_i , (in this case, number of tools used for accessing information via KACE ICT tools) is given as below:

$$E(y_i|x_i) = var[y_i|x_i] = \lambda_i = \exp(\alpha + X'\beta) \quad \text{for i} = 1,2,\ldots,n \quad (6)$$

The log-linear conditional mean function $e(y_i|x_i) = \lambda_i$ and its equi-dispersion $var(y_i|x_i) = \lambda_i$ assumptions are the main features of Poisson regression model (Greene, 2008). As pointed out by Winkelmann and Zimmermann (1995), the log-linear regression models accounts for the non-negative constraint imposed on the dependent variable by Poisson. The Poisson distribution is often used to model information on *counts* of various kinds, particularly in situations where there is no natural "denominator", and thus no upper bound or limit on how large an observed count can be. This is in contrast to the Binomial distribution which focuses on observed proportions.

The Poisson model has the advantages of overcoming some of the problems of the normal model. First, the Poisson model has a minimum value of 0. It will not predict negative values. This makes it ideal for a distribution in which the mean or the most typical value is close to 0. Secondly, the Poisson is a primarily skewed model; meaning, it is data characterized with a long 'right tail'. Additionally, this model is appropriate for counts of rare events, such as crime incidents. Third, because the Poisson model is estimated by a maximum likelihood method, the estimates are adapted to the actual data. In practice, this means that the sum of the predicted

values is virtually identical to the sum of the input values, with the exception of a very slight rounding off error. Fourth, compared to the normal model, the Poisson model generally gives a better estimate of the counts for each record. The problem of over- or underestimating the number of incidents for most zones with the normal model is usually lessened with the Poisson. When the residual errors are calculated, generally the Poisson has a lower total error than the normal model.

Conclusively, the Poisson model has some desirable statistical properties that make it very useful for predicting incidents. The PRM has been applied in quite a number of disciplines. The model has been used in agriculture by Ramirez and Shultz (2000, cited in Kirui, 2010) to explain the adoption of agricultural and natural resource management technologies by small farmers in Central American countries. Another application of the model has been in the study of hidden health costs of pesticide use among Zimbabwe's smallholder cotton growers by Maumbe and Swinton (2003). In another study by Okello (2005), the model was used to examine the drivers of the number of pesticide that induced acute illnesses and the count of gear items used to prevent exposure to pesticides.

Despite its strengths over normal models, the Poisson model has its shortcomings that render it not perfect. The major weakness is that count data are usually *over-dispersed* (Wooldridge, 2002; Greene, 2008). Over-dispersion refers to excess variation when the systematic structure of the model is correct (Berk and MacDonald, 2007).

3.3.3 Over-dispersion in the Residual Errors

In the Poisson distribution, the mean equals the variance. In a Poisson regression model, the mathematical function, therefore, equates the conditional mean (the mean controlling for all the

predictor variables) with the conditional variance. However, most actual distributions have a high degree of skewness, much more than are assumed by the Poisson distribution (Cameron & Trivedi, 1998). In other words, the simple variance is many times greater than the mean. Most real-world count data are similar to this; the variance will usually be much greater than the mean (Lord et al., 2005). The Poisson model calculates a standard error as if the variance equals the mean. Thus, the standard error will be underestimated using a Poisson model and, therefore, the significance tests (the coefficient divided by the standard error) will be greater than they really should be.

The problem of Over-dispersion in PRM is as a consequence of two assumptions (Winkelmann and Zimmermann, 1995). 1) the supposition that the Poisson process is a deterministic function of the predictor variables hence does not allow for the unobserved heterogeneity and 2) the supposition that events constituting each count are independent and occur randomly over time thus ignoring the fact that present occurrences can influence the probability of future occurrences (Berk and MacDonald, 2007). In a Poisson multiple regression model, one might end up selecting variables that really should not be selected because of the tendency to think that they are statistically significant when, in fact, they are not (Wooldridge, 2002; Xiang & Lee, 2005).

Violation of the above two assumptions can also lead to under-dispersion. This is when the variance is less than the conditional mean which results if the events constituting the counts are negatively related (Berk and MacDonald, 2007). Under-dispersion has the same effect as over-dispersion. In presence of under- or over-dispersion, though still consistent, the estimates of the Poisson regression model are inefficient and biased and may lead to misleading inference (Famoye *et al.*, 2005; Greene, 2008).

In practical sense, the fundamental assumption of equality of the mean and variance imposed by PRM is rarely satisfied. Hence the necessity of a reliable and realistic test for over-dispersion to justify the need for models beyond the standard Poisson regression (Xiang and Lee, 2005). To deal with the dual problems, the negative binomial, a variant of Poisson-based regression model, is normally used (Wooldridge, 2002; Famoye *et al.*, 2005; Berk and MacDonald, 2007; Greene, 2008).

3.3.4 Negative binomial regression model (NBRM)

A second type of dispersion correction involves a mixed function model. Instead of simply adjusting the standard error by a dispersion correction, different assumptions are made for the mean and the variance (dispersion) of the dependent variable. In the *negative binomial* model, the number of observations (y_i) is assumed to follow a Poisson distribution with a mean (λ_i) but the dispersion is assumed to follow a Gamma distribution (Lord et. al., 2005; Cameron & Trivedi, 1998, 62-63).

Mathematically, the negative binomial distribution is one derivation of the binomial distribution in which the sign of the function is negative, hence the term *negative*. For purposes of this thesis, it is defined as a mixed distribution with a Poisson mean and a one parameter Gamma dispersion function having the form:

$$E\,(y|x_i,) = \exp\,[\alpha + X`\beta +) \qquad (6)$$

The model requires that:

$$Var(y_i\,|x_i) = [1 + 1 + \alpha\,\exp\,(X'\beta)]\,\exp\,(X`\beta) \qquad (7)$$

Where X′ is a vector of explanatory variables similar to those outlined in the earlier section, Hence the estimated NBRM is specified as:

KACE Tools used = KACE Tools used (*age, age squared, gender, distance to extension, affordability, household size, distance to market, income, natural log of education, farming experience, group member) + e*

3.4 Study Area

This study was conducted in Bungoma, one of the 47 Counties in Kenya. The County is located in the western region of the country and occupies an area of 3013 square kilometers with a population of about 1.65 million people. Like many parts of Kenya, farming is the main economic activity. The County is primarily occupied by small-scale farmers, many practicing subsistence agriculture. The area receives reliable, bimodal rainfall of between 1200 to 2000 mm per year. Temperature variations are very moderate ranging from 21-25^0 centigrade during the year.

The region is endowed with well-drained, rich and fertile arable soils but poor husbandry methods and a bulging population have resulted in declining yields, deforestation and soil erosion (Sombroek et al., 1982). The farmers main enterprise is maize-bean intercropping which serves as the main household food supply but, in good years and larger farms, is also sold through complex, and often unfair, marketing chains (Woomer et al., 1998) for income generation. Other crops grown include sunflower, sugarcane, coffee, tobacco and potatoes. The average farm size in the district is about 1.4 hectares (GoK 2002, Dose 2007, Okello et al., 2010)

Bungoma is among the regions in which some components of marketing information and linkage systems (MILS) developed by Kenya Agricultural Commodity Exchange (KACE) have been implemented. Despite these efforts and a developed understanding of them, farmers' production

constraints still persist. Smallholder farmers in Bungoma district face crop production and marketing constraints that bind them within a cycle of poverty. More than 80% of the population

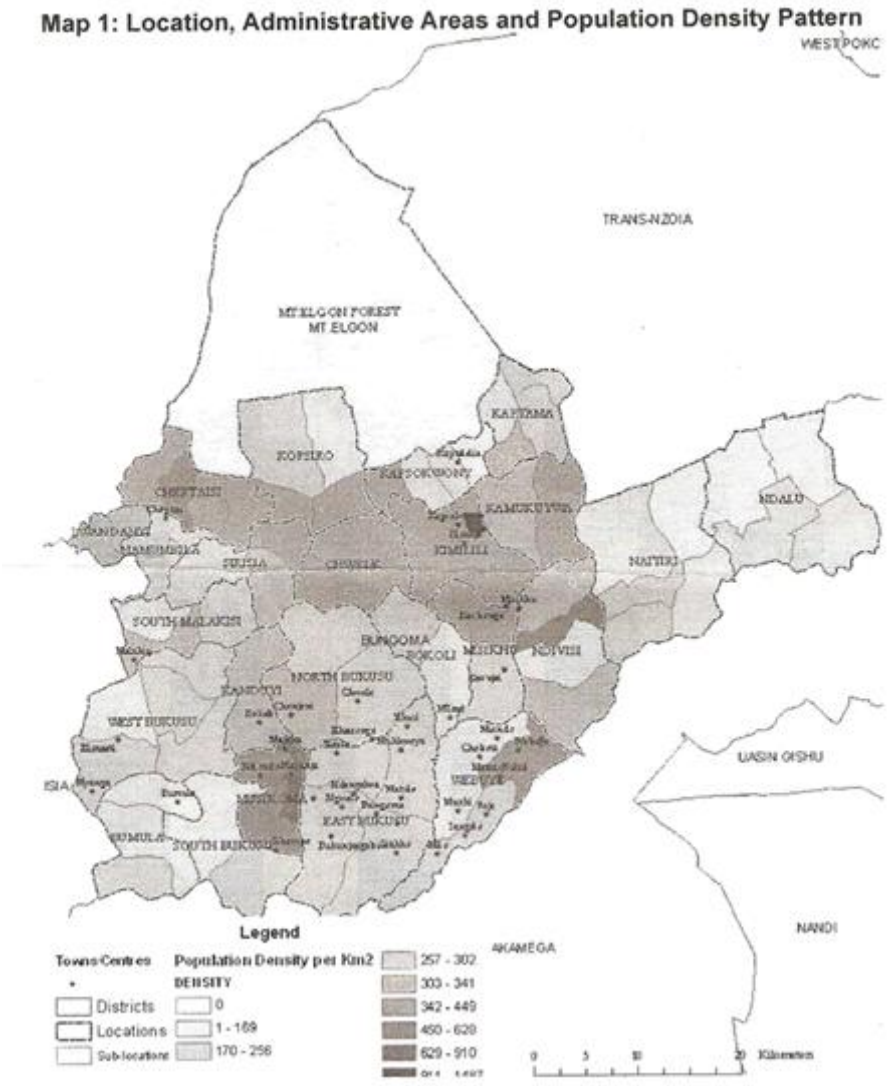


Figure 2: Map of Bungoma

lives in rural areas, and 62% of all households generate their income from agriculture. At the same time the district suffers from extreme demographic pressure with an annual population

growth rate of 2.12% and a proportion of 62% leaving below the poverty line (Omiti et al., 2006). These revelations highlight the farmers' problems that necessitate research attention.

3.5 Data Needs and Sources

The study relied on both primary and secondary data on information about farming activities and sources of communication channels available for farmers in accessing agricultural information. Secondary data was collected on the geography of the area; population statistics; farming activities, ICTs in agriculture. Such information was obtained from Food and Agricultural Organization (FAO) publications, Communications Commission of Kenya (CCK) reports, Research theses, Ministry of Agriculture (MOA), census reports. The primary data was collected using semi-structured questionnaires (Annex 1). Information was obtained on: socio-economic characteristics; output prices; ICTs used by farmers such as mobile phones, radios, TV, newspapers. The data was obtained through interviewing randomly selected farmers.

A pre-tested semi-structured questionnaire (Annex 1) was used to collect primary data with the help of one enumerator who was first trained prior to the exercise of the actual data collection. Both socioeconomic, biophysical and policy related data was collected. Information will be collected on: socio-economic characteristics; output prices; ICTs used by farmers such as mobile phones, radios, TV, newspapers. Village elders were engaged in locating both the homes as well as the individual farmers during the household survey work. The household survey and data collection was conducted in September and October 2011.

3.6 Sampling Procedure

This study used data collected from smallholder farmers located in Bungoma South and Bungoma Central sub-counties of Bungoma County. Personal interviews were conducted among 136 respondents. In determining, the sample size for this study, Cochran's (1963) formula was used. For large populations, Cochran developed the following equation:

$$n_0 = \frac{Z^2\ \mathrm{pq}}{e^2}$$

Where n_0 is the sample size, Z^2 is the abscissa of the normal curve that cuts off an area at the tails (1- equals the desired confidence level, e.g. 95%, e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population, and q is 1-p. the value Z is found in statistical tables which contains the area under the normal curve.

For this study, assuming, p = .5 (maximum variability), desired confidence level of 90% and ±10% precision:

$$n_0 = \frac{(1.96)^2\ (.5)(.5)}{(.01)^2} = 96\ farmers$$

To compensate for the farmers that may not be possible to reach a 10% was added. To further compensate for possible non-responses, the sample size was increased by 30% (Greene, 2003). A total of 136 farmers were hence interviewed during the study.

The target populations for this study were farmers in Bungoma Central, and Bungoma south Districts. The two districts are the hub of KACE services, famous for technology-driven systems of linking producers and buyers.

Two divisions were purposively selected from each of the 2 districts. All the locations in the selected divisions were listed, from which one was randomly selected. Sub-locations from the chosen locations were listed and one from each randomly picked. Random sampling was used to select two villages from the chosen sub-locations. Using the list of the villages at the selected sub-location, the first and second village was selected from each sub-location based on the distance to the nearest main market. Village one was closer to the market while village 2 was further away from the market. The major reason for this was the observed heterogeneity in socio-economic characteristics of the households across the villages. Households near the market tended to be settled on tiny pieces of land, mostly bought as compared to their counterparts in villages away from the market, who were doing farming on ancestral pieces of land. A total of 17 farmers from each of the 8 villages were randomly selected and interviewed. This translated to a sample of 136 respondents.

3.7 Data Analysis

3.7.1 Descriptive Statistics

In a research study we may have lots of measures and descriptive Statistics, which form the basis of virtually every quantitative analysis. In such cases, data must be captured and organized in a manageable form. Cross tabulations and frequency distribution bar charts were used to present the analyzed results.

A combination of tools was used in management of the collected data. Excel was used in recording and organizing data and presenting results in form of Tables, graphs and charts. Statistical Package for Social Sciences (SPSS) was used in formulating descriptive statistics and

generating cross tabulations and frequency tabulations. STATA was used for Logistic and Poisson regression.

3.7.2 Explanatory Variables

Based on the literature used in this study, the following independent variables have been found to influence awareness and adoption of agricultural-based ICT-oriented market information service project: ICT tools ownership; Gender, main economic activity; age, contact with extension; education status, years of experience, income; distance to supportive facilities; and membership of farmers' groups.

Ownership of ICT tools such as mobile phone, which is one of the tools used by KACE, will determine access to information and hence its ownership is likely to influence awareness and use in agriculture (Robeyns, 2000; Zheng and Walsham 2007). This variable was measured by asking if the respondent owns any or both of the tools and otherwise.

Gender, measured as dummies, 1 representing man and 0 for woman, according to numerous studies, has been shown to play a significant role in decision-making process and as regards embracing of new technologies (Adesina et al., 2001). It has been established that men in Africa, have a more advantageous access to capital and other productive resources (technological innovations included) as compared to women (Okello et al., 2009). Hypothesis therefore holds that awareness and usage of ICT-based market information services among male farmers would be higher to that of women.

The uptake of ICTs targeting agriculture will be influenced by the household's main economic activity. Since these ICT-based initiatives target farmers, it follows that those whose primary

occupation is farming would be more interested as compared to those who practice agriculture as a complementary economic activity. It is therefore hypothesized that where farming is the main activity, a positive reception of the technology is expected. Respondents were asked whether farming was their main economic activity or otherwise. The response was measured using dummies, 1 for yes and 0 if farming was not the main income earner.

Farmers' reaction towards new technology is highly influenced by years of experience in farming. According to De Silva and Ratnadiwakara (2009) farmers who have been in business for a long time are more unlikely to embrace new technologies; instead they would prefer to stick on their traditional ways of farming. Therefore, hypothesis alluded to this is that more experienced farmers would have a negative attitude towards uptake of ICT-based technologies. Years of experience was measured in terms of the number of years the respondent has been practicing farming.

Acceptance of change and willingness to take risk by trying out new technologies has been shown to have a direct correlation to the level of Education. It is hypothesized that Education would have a positive relationship as regards one's decision to obtain ICT services. According to Okello et al. (2009) farmers with more years of education would easily understand the need for new technologies. Level of education was presented as the number of years spent in school, with 0 indicating that the respondent never had formal education and 1 representing at least one year of schooling. .

In terms of income, studies reveal that the more the revenues a household has access to, the higher the chances of them buying ICT tools such as radios, mobile phones, radios, TVs and

even computers and hence ability of using them to access market information. Income in this case refers to the on-farm revenues, accrued from the sale of farm produce.

The scale of farming which is dictated by the size of land owned by the household has been shown to influence the behaviour of farmers. Farmers utilizing a large piece of land (owned or leased) would require more farm inputs and would have more output to sell and hence the motivation for more awareness and adoption of ICT-based agricultural technologies to take advantage of market access.

Group membership creates ties between member farmers and extension personnel and exposes the participating farmers to accurate information, training opportunities as well as knowledge on innovative initiatives. Hence, farming households whose members belong to farmer groups are more likely to be informed of a given technology and take advantage of the new ventures.

Distance to nearest facilities has been found to have a bearing on technology utilization. It is hypothesized that, the closer to important amenities such as nearest agricultural office; nearest tarmac road, nearest a market or shopping centre with electricity may influence awareness and use of intervention technologies. Accordingly, households further away from these centers are unlikely to have access to information on such initiatives.

Household's location is also likely to influence awareness and adoption of ICT-based agricultural initiatives. This is because different districts and regions vary in terms of infrastructure and resource-endowment. Hence the more a location is well developed in terms of infrastructure, the more the likely the penetration of technologies among the locals. To study how the awareness and use of ICT technologies, and extent of ICT tools use, are affected by

different independent variables, the three main dependent variables investigated during the study were: 1) awareness of KACE information services by smallholders; and 2) Usage of KACE information services by smallholders; 3) Intensity of use of ICT tools.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Household Characteristics

A summary statistics of the household characteristics (including age, education level, gender, household size, short and long season farm income, total farm income, total farm size owned as well as size of cultivated farm) is presented in Table 1.

Table 1: Characteristics of Households in Bungoma Central and South Districts

Characteristics	N	Min	Max	Mean	Std. Dev
Age of male farmers (years)	56	23	81	44.96	12.977
Age of female farmers (years)	80	22	73	43.18	11.555
Education of male farmers (numbers of years)	56	1	14	9.59	3.195
Education of female farmers (numbers of years)	80	0	14	9.16	3.038
Household size (count of family members)	136	2	18	7.4	3.4
Total farm size (acres)	136	0.25	11	2.0882	1.79725
Size of cultivated farm (acres)	136	0.1	8	1.6882	1.41753
Short season farm income (KES)*	136	0	504000	24244.07	45369.302
Long season farm income (KES)*	136	2700	2988000	89010.24	274994.58
Total farm income (KES)*	136	5600	2994750	112504.9	279024.66

*KES=Kenya shillings

Source: Survey data

Of the 136 farmers interviewed, 56 (41.2%) were male while 80 (58.8%) were female. The average ages of male and female farmers in the sample were 45 and 43 years respectively. The youngest farmer was 22 years with the oldest farmer being 81 years demonstrating a wide vary in the household farming experience. There was a slight variation in the average level of education of interviewed farmers across the two genders. The male farmers had an average of 9.6 years of education while the female farmers had 9.2 years. The results also show that farmers earn more from long rain season as compared to the short season. The mean income earned from short season was KES 24,244 while that earned from long season was KES 89,010.

The study also reveal that 89% of the households interviewed engage in farming as their main source of livelihood, of which 38.0% were men while 62% were women. Another 67.7% of the respondents practice farming as a secondary economic activity. The results suggest that more women than men are involved in farming. Other primary economic activities included formal employment (6.6%), small scale business (3.8). Secondary economic activities were also dominated by farming with 67.7% of the respondents being involved in small to medium sized businesses. Other respondents were engaged in casuals, community work, for complementary income to their main economic activities. Besides crop cultivation, households also practiced livestock husbandry, with 84.6% of the respondents having some form livestock on their farms while 15.5% had no livestock at all.

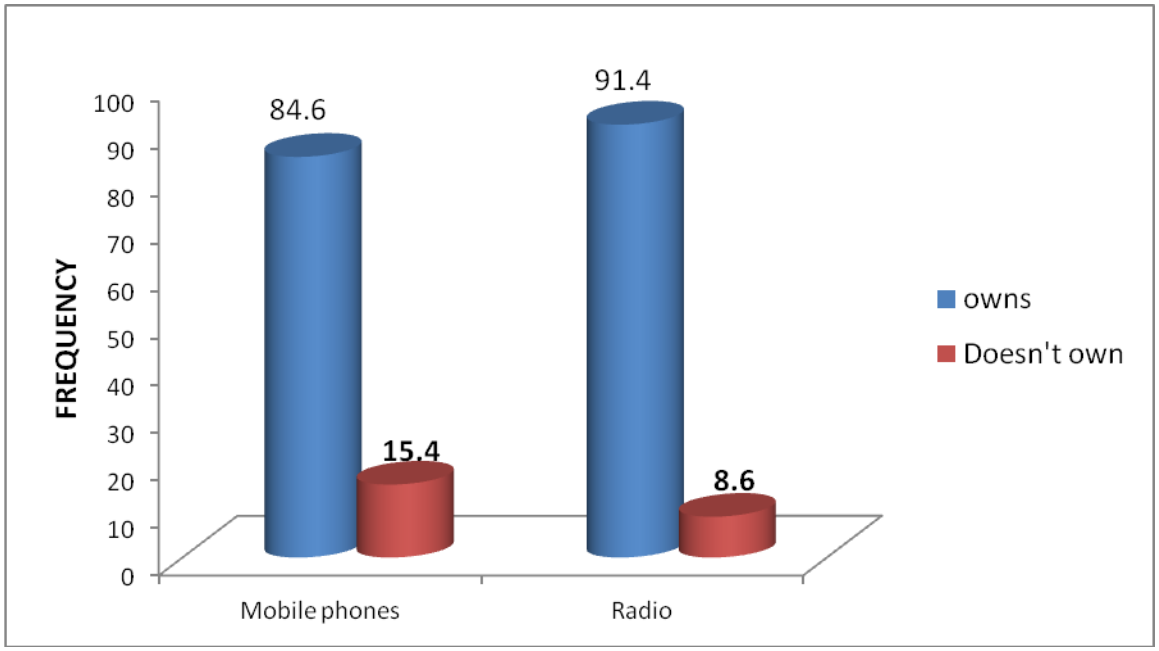
4.2 Media Channels Used In Accessing Agricultural Information

Timely access to market information via communication networks such as mobile phones voice calls, short messages, internet can help farmers make well informed decisions about what crops

to plant and where to sell their produce and buy inputs. The availability of information also enables farmers to compare on the prices they receive *vis-à-vis* the prevailing market prices.

Traditional media and new ICT tools play a major role in diffusing information to rural communities. Farmers need information on output prices, weather patterns, suppliers and buyers at the market, technical agricultural practices, prices of inputs, information on agricultural credits, insurance opportunities, among other information. Mobile phones and radio were the most common channels used by KACE to disseminate market and other relevant agricultural and market (Figure 2).

Results of Radio and mobile phone ownership



Source: Survey data

Figure 3: Ownership of Radio and Mobile By smallholder Farmers

Majority of the farmers (91.4%) owned at least one radio, and 84.6% had at least one mobile phone within the household. The study reveals that 72.2% of the households had a single mobile phone; 18.3% had 2 mobiles and 7.8% and 1.7% had 3 and 4 mobile phones, respectively. There has been a steady rise in mobile phones acquisition in Kenya, since 2000. The findings of this study closely relates to those by Research ICT Africa (RIA, 2012) which suggest that as of mid 2012, over 60% of the Kenyan population owned a mobile phone (RIA, 2012 and the Kenya 2009 population and housing census report which revealed that 63.2% of households own at least a mobile phone (Kenya National Bureau of Statistics, KNBS, 2010). The year 2009 recorded the highest percentage of mobile acquisition in Kenya. This could be attributed to the drastic fall of prices after the Kenyan Government exempted VAT on mobile handsets in June 2009 (GSMA 2011). Lack of mobile phone ownership in Kenya has been attributed to various reasons, namely, cannot afford, no electricity at home to charge the mobile phone, phones stolen, phones stolen, no network coverage and have no one to call (RIA, 2012).

Among those who owned a radio in their households, 83.7% had a single radio that served all the family members, while 15.5% of the respondents had two sets of radio in the family. Less than 1% (0.8%) had more than 3 radios.

The study also sought to establish the different sources of information used by households in accessing information (Table 2). Results showed that 62.5% of the farmers were using the radio for information on the price of agricultural produce. This can be attributed to high level of radio ownership as shown earlier in this study. Slightly half of the farmers interviewed (47.1%) used their mobile phones to compare the price of agricultural produce on the market. Among the modern ICT tools, mobile phones are said to be the most widely-accepted mode of delivering

information (Mittal, 2012). A good number of farmers (42.6%) relied on their neighbours, families and friends for information on the price outputs.

Table 2: Information sources Used by respondents for Market information

Information Channel	Type of Information						
	Output price	**Whether**	**Commodities Supply**	**Agricultural practices**	**Input price**	**Agricultural credit**	**Insurance**
SMS	25.00	15.00	20.60	4.40	16.90	0.00	0.70
Mobile Voice calls	47.10	0.00	48.50	9.60	45.60	2.90	0.70
Internet	0.00	0.70	0.00	0.70	0.00	0.70	0.00
Newspaper	8.10	2.90	2.90	2.90	3.70	4.40	3.70
Neighbors	42.60	15.40	34.60	29.40	22.80	4.40	1.50
Television	8.80	18.40	0.70	1.50	1.50	1.50	0.70
Extension	4.40	3.70	2.90	39.70	8.80	15.40	3.70
Middlemen	29.40	2.90	27.20	3.70	8.80	1.50	0.70
Radio	62.50	83.10	16.90	32.40	33.80	25.00	15.40
Trader	32.40	0.70	41.20	2.90	41.20	1.50	0.70

Total N=136

Source: Survey data

There was no use of internet services for checking the price of commodities at the market. Most mobile phone owned and used by many of the farmers are not internet enabled. Internet access among developing countries and for rural communities, in particular, remains a challenge. Statistics of Kenya 2009 population and housing census reveal that only 3.6% households owned

at least one computer (KNBS, 2011). According to a national study by RIA, 16.2% of Kenyan population browses the internet on their mobile handsets (RIA, 2012). By end of June 2012, 35.5% of the Kenyan population had internet access, and 98.9% of Kenyan internet users access the internet on their mobile phone through GPRS/EDGE or 3G (CCK, 2012).

The results reveal that a large number of respondents (45.6%) used their mobile phones to check the prices of the inputs. Traders, radio and neighbours were also popular sources, with 41.2%, 33.8% and 22/8% respectively. On the information on the supplies at the market, use of mobile phone calls was the most preferred channel, with 48.5%, some farmers (41.2%) relied on traders for such information, and a few farmers (20.6%) used the short messaging services (SMS).

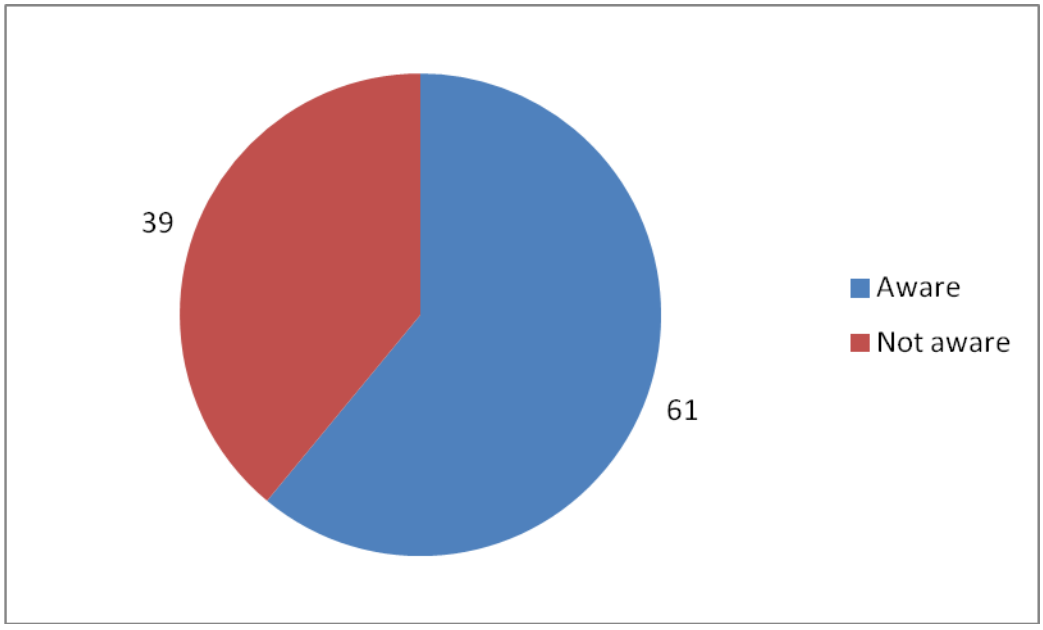
The results show a remarkable adoption of ICT tools such as mobile phone voice calls, in accessing agricultural information. However, the more conventional channels of agricultural information such as radio, extension agents, middlemen, have been shown to be most preferred sources of information among farmers.

4.3 Awareness and Usage of KACE Information Services

The study examined the knowledge of respondents about the existence of KACE, and the results were as shown in Figure 3. These answers the research questions: 'have the farmers heard of KACE?' and 'are farmers aware of KACE services?'

All the farmers surveyed were not aware of KACE activities. The results showed that 61% of the farmers interviewed had knowledge about the existence of KACE, while 39% had not heard about the market information provider. Despite the great excitement by development agencies in

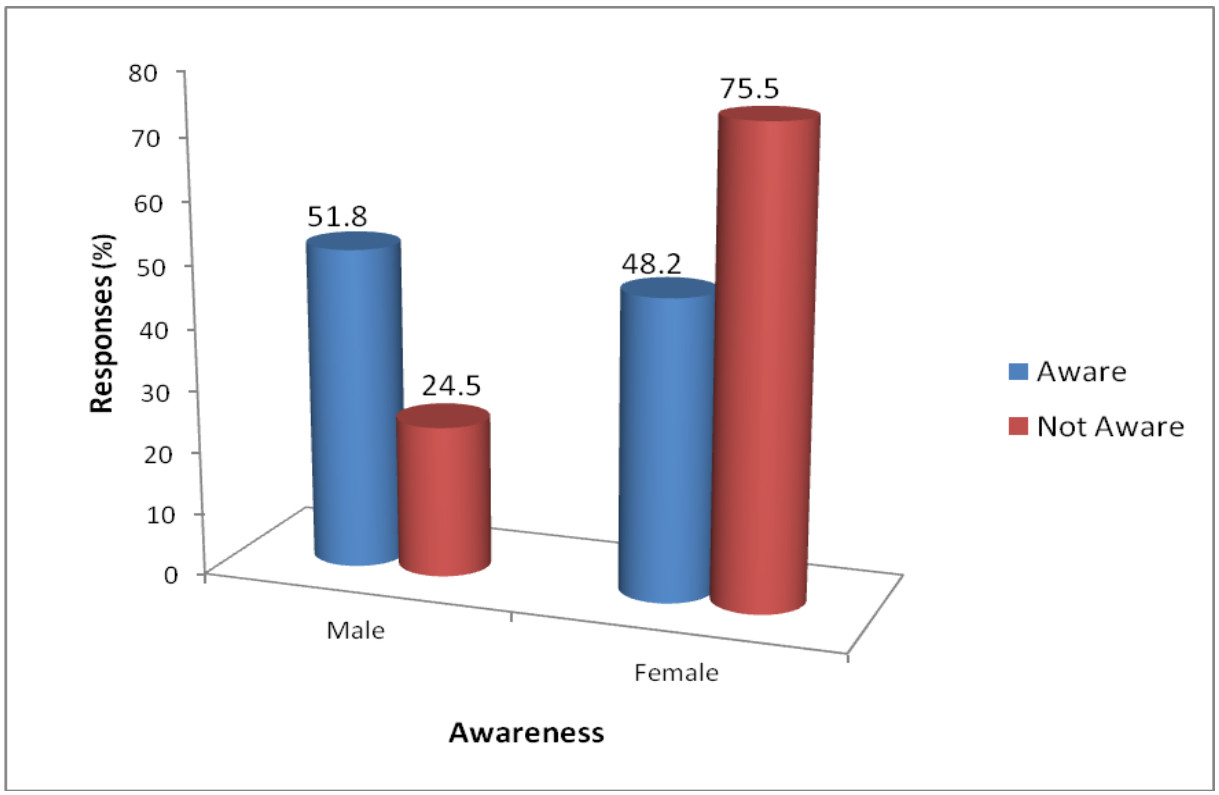
promoting ICT-based marketing systems among the farming communities, there is reportedly low awareness and usage (Okello et al., 2011).



Source: Survey data

Figure 4: Respondents Awareness of KACE (percentage)

Awareness based on gender; show that among those aware of KACE, 51.8% were men with 48.2% being women, as shown in Figure 4. Most of the women interviewed, had no knowledge on the existence of KACE as a market information provider, where they comprise 75.5% of the unaware group, while men make up 24.5% of the category. Low awareness among women could be attributed to their many casual responsibilities in the home including cultivation of land and taking care of the family. On the other hand, the commercial activities are in most cases designated for men (FAO, 2009). Lack of assets ownership by women also contributes to their lagging behind on information and influence (FAO, 2009; Koehler, 1999).



Source: Survey data

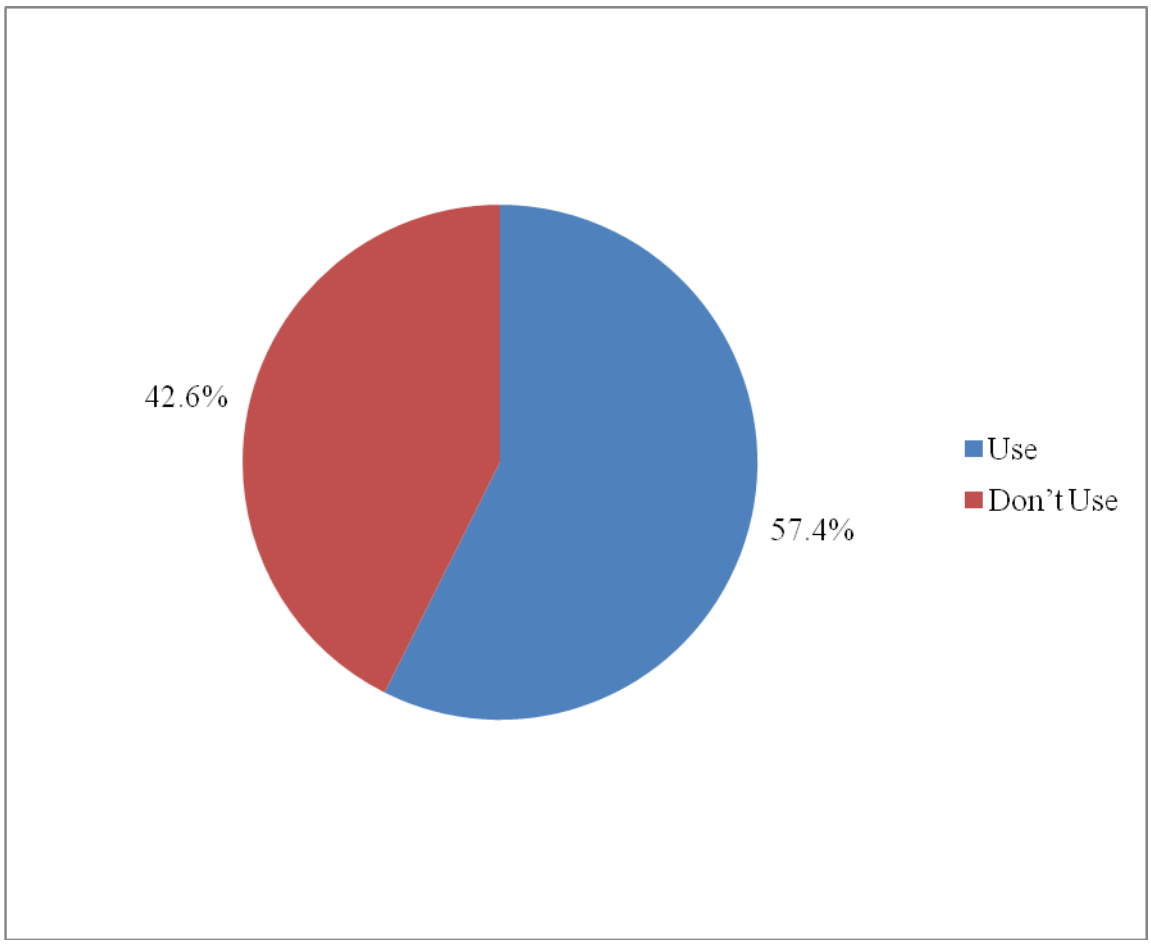
Figure 5: KACE Awareness across Gender

The findings could also be attributed to the low literacy levels among the women as revealed in this study. Human resource development is necessary for technology adoption and promotion of sustainable development. In agriculture, education creates conditions that enable farmers to acquire and use knowledge for decision making (Mittal & Kumar, 2000; Kumar & Rosegrant, 1994).

Kenya Agricultural Commodity Exchange Information Use

Results show that there were slightly higher percentages of usage of KACE services with 57.4% of farmers indicating to have utilized the services of the information provider, while 42.6% were yet to make any practical use of the project. These findings could be attributed to the fairly

increasing ICT tools ownership, in particular, mobile phones, among the smallholders, as a response to the drastic fall in the device prices (GSMA, 2011). However, non-use of KACE services could be due to lack of awareness or lack of the necessary ICT tools. According to 2009 data collected by Research ICT Africa, the cost of mobile services can be up to 27% of monthly income in Kenya (Hystra, 2011).



Source: Survey data 1

Figure 6: KACE Information Use (as a percentage) by smallholder farmers in Bungoma County

There was higher usage of Kenya agricultural Commodity exchange information services among men (52.2%) as compared to women (47.8%) as shown in Figure 6. Most of the farmers and traders from Bungoma central indicated to have either seen KACE billboard or their franchise at

Chwele market. As expected, usage among men is higher compared to women. This could be explained by the fact that culturally, men tend to have control of economic resources in families (FAO, 2009).

4.4 Logit Regression

4.4.1 Factors Affecting Awareness of KACE Information Services

Farmers' knowledge of ICT tools in this study was measured using a dichotomous (binary) choice variable of "Yes" or "No" type indicating the farmers' *awareness* or *lack of awareness* of KACE services, respectively. The most commonly used approaches for estimating such discrete dependent variable regression models are the Logit and Probit regression techniques (Liao, 1994; Maddala, 2001; Gujarati, 2004).

In order to examine factors affecting awareness from a holistic perspective, it is important to take into consideration the possible influence of several variables, among them: material and structural factors, individual attitude, behavior, and demographic characteristics (Table 3).

Independent variables demonstrated to influence awareness of ICT project, and shown in reviewed literature, are also considered (Table 3). The goodness-of-fit measures of the model estimates along with the estimated coefficients were also captured (Table 3). Based on the assumption that in a normal distribution, approximately 95% of the sample values are within two standard deviations of the true population value, a confidence level of 95% (Table 3) was assumed. The null hypothesis that all slope coefficients are zero in each of the outwardly disparate logit regression is rejected at 5% significance level.

Table 3: Estimation results for the Logit Regression model on awareness of KACE ICT project

	Logit Regression			Marginal effects	
Unit	**Coef.**	**Std. Err**	**P-value**	**Coeff**	**p-value**
Gender	2.57	0.70	0.000	0.50	0.001
Age	-0.10	0.04	0.003	-0.02	0.002
Education	0.31	0.11	0.005	0.06	0.004
Main occupation	1.97	0.78	0.012	0.00	0.012
Farm size	0.14	0.18	0.444	0.08	0.443
Farm ownership	0.64	0.56	0.251	0.06	0.250
Mobile ownership	-1.27	0.89	0.151	0.00	0.150
Radio farm listenership	2.15	0.99	0.003	0.00	0.002
Farm income	0.02	0.02	0.629	0.00	0.627
Group membership	1.32	0.65	0.042	0.07	0.041
Agricultural Field days	-0.99	0.64	0.124	0.00	0.124
General Radio listenership	-10.04	27.19	0.712	-0.96	0.711
Radio ownership	-0.01	0.03	0.726	0.00	0.656
_cons	13.19	27.34	0.629		
Pseudo R^2= 0.362 LR chi2(14)= 94.14 Prob>chi2=0.000 Number of observations=136					

Source: Survey data

The model demonstrates that a number of factors are significant in influencing awareness of KACE ICT tools. Among the farmer-specific characteristics that influence awareness are age and gender. A unit increase in age decreases the likelihood of a farmer being aware of KACE ICT tools by 0.02, holding other factors constant. Age has an inverse relationship to likelihood of awareness. The younger people are more likely than older people to be enthusiastic about new technology and hence more likely to purchase advanced technology. Literacy, a capital

endowment variable, also influences awareness. Increase in education by one year increases the expected awareness by 6 percent. Younger and hence more educated farmers are more likely to use ICT tools for seeking market information,

The expected awareness of KACE ICT tools is 0.5 times higher among men than female farmers. According to the Food and Agriculture Organization of the United Nations (FAO), rural women constitute the majority of the world's poorest due to low levels of education, illiteracy, and lack of assets such as credit, agriculture extension training, and agricultural inputs (FAO, 2009). The differences between men and women could be due to socio-economic factors, dictated by culture. Diffusion theory states that individuals who are higher in socio-economic status are able to adopt innovations much more quickly than those with lower levels of education and fewer assets (Rogers, 2003, p. 288)

Belonging to a social group increases expected respondent's awareness of KACE ICT tools by 0.7 times. As information is disseminated better in farmer groups, members of those groups acquire more knowledge about existing services than non-members. This finding corroborates, Chabossou et al. (2009) study that demonstrated a relationship between mobile adoption and membership of "social networks" (church groups and sports clubs). In their model, they found that belonging to such networks contributed positively to the probability of mobile adoption in seven of the seventeen study countries, but not the others.

On the other hand however, farm ownership and size of the farm ownership; did not confirm increase of awareness. While radio and mobile ownership alone did not show increased awareness, listenership of farm agricultural related programmes, which was measured by farmer's response on whether they listen to radio programmes with a subject matter on farming

and/or marketing of agricultural commodities, was shown to increase farmer's awareness of the ICT-based market information service project.

As expected, farmers who listen to farm radio programs are 0.02 times expected to be aware of KACE ICT tools than those who don't. When farmers listened to farm-based radio programmes in general, and Soko Hewani (KACE program), in particular, they got better informed on the KACE information services.

Contrary to our expectations and to the reviewed literature, the logit estimate showed no impact of income on awareness. Previous studies had, however, indicated that farmers with high incomes had more than one ICT (normally radio and mobile phone) and therefore were in a better position to access market information through these items than those with less income who had only one type of ICT. This, thus suggest the necessity of low-cost access to ICT such as information centers as a prerequisite for the successful use of ICT by the poor (Cecchini & Scott, 2003). The significant lack of impact of farm income, observed in the study, could be explained by the high variation between the minimum and maximum income of the interviewed farmers.

4.4.2 Determinants of use of KACE Information Services

In addition to examining farmers' knowledge, the study also sought to measure rural households' use of KACE ICT tools. Farmers' use of ICT tools, was measured using a dichotomous (binary) choice variable of "Yes" or "No" type signifying farmers' use (Yes) or none use (No) of KACE ICT tools.

In addition to the variables used in the awareness model in Table 3, other included variables were: respondents' contact with extension; farmers' perception on service relevance and

affordability. Respondents were asked on whether they thought information services offered by KACE were affordable in terms of premiums charged, or otherwise.

Table 4: Estimation results for the Logit Regression model on Use of KACE ICT project

Independent variable definition	**Logit regression**			**Marginal effect**	
Variable	Coefficient	**Std. Err.**	**P-value**	**Coeff**	P-value
Gender	2.2	0.65	0.000	1.23	0.000
Age	-1.53	0.03	0.001	-0.34	0.001
Education	1.17	0.1	0.000	0.26	0.000
Main occupation	0.6	0.93	0.876	0.74	0.875
Family size	-1.14	0.1	0.599	-0.82	0.599
Farm size	-0.01	0.22	0.149	-0.21	0.148
Farm ownership	0.54	0.52	0.298	0.06	0.298
Farm income	0.2	0.23	0.663	0.03	0.663
Contact with Extension	0.05	0.94	0.104	0.005	0.940
KACE Importance	1.48	0.56	0.376	0.463	0.376
Affordability	1.32	0.65	2.03	1.08	0.650
Mobile ownership	0.32	0.81	0.146	0.065	0.146
Group membership	1.48	0.56	0.009	0.236	0.008
Radio listenership	0.4	19.4	0.566	0.023	0.566
Radio farm program listenership	1.97	0.78	0.012	0.875	0.012
_cons	-2.43	1.559	0.438		
Log likelihood= -47.65					
Pseudo R2= 0.46	LR chi2(14)= 84.14		Prob>chi2=0.000		
Number of observations=136					

The results (presented in Table 4), from the model were significant for farmers' perception on the importance of KACE services, and affordability. From the results, an increase in education level by one year is expected to increase adoption by 0.26. Men are 1.23 times more expected to use KACE ICT tools than women.

The results of the model suggest that increased perception of usefulness and affordability of the services increases the propensity of farmers to use ICT services, as in the theoretical adoption literature. Perceived usefulness has been considered an important influence in technology adoption.

However, the respondent's contact with extension workers was not statistically significant, showing lack of impact of extension on farmer's decision to adopt the technology. This could be explained by the rather diminutive contact between extension workers and the farmers. In fact, studies have demonstrated that stagnation in public investment and the breakdown of extension services has widened gaps between the yield from experimental farms and the yield from farmers' fields. Insufficient extension services and poor access to information have impeded the transfer of technology at the farm level (Mittal 2010).

4.4.3 Determinants of Intensity of Use of KACE Information Tools

To assess the factors determining the extent to which smallholder farmers use KACE information tools, the study used Poisson regression techniques. This count variable model was chosen because of its suitability for dependent variables that are countable finite such as the number of tools a farmer uses a service (Gitonga, 2009). Results for the Poisson regression model are presented in Table 5 below.

The independent variable used in the estimation is the number of KACE tools used by the respondent to obtain market information.

As was the case with previous models, the results for age, gender, education and group membership were statistically significant, suggesting their link on the farmers' use of the KACE

information. The expected number of ICT tools used is 0.75 times higher among men than female farmers, other factors held constant. This could be explained by most cultural practices which assign most of the domestic chores to women, leaving them with almost no extra time to allow them to seek such services.

Table 5: Poisson model of the intensity of the use of KACE ICT tools by Farmers

Independent Variables	**Poisson regression**	
Unit	**Coef.**	**P-value**
Gender	0.75	0.001***
Age	-1.53	0.012**
Education	1.21	0.005***
Main occupation	0.64	0.181
Family size	-0.14	0.432
Farm size	-0.01	0.149
Farm ownership	0.45	0.145
Farm income	0.09	0.129
Contact with Extension	0.05	0.163
KACE Importance	1.68	0.003***
Affordability	1.32	0.005***
Mobile ownership	1.32	0.004***
Group membership	1.48	0.008***
Radio listenership	0.4	0.14
Radio farm program listenership	1.79	0.078*
Distance to the nearest center that has electricity (km)	-0.006	0.009***
Distance the produce and livestock market (km)	0.37	0.067*
_cons	-2.43	19.6
Log likelihood= -57.25		
Psedo R^2= 0.26		
LR chi2(14)= 89.14 Prob>chi^2=0.000		
Number of observations=136		

Significance at 1%, 5%, and 10% levels is denoted respectively by ***, **, *.

The findings corroborates past studies which argue that culture among the rural communities places the responsibility of purchasing inputs and arrangements to sale farm output on men, may have a bearing on use of ICT tools (Okello, et al., 2011).

Increase in age of the respondent by one year reduces the expected number of KACE ICT tools used by 27 percent. The inverse relationship between use of KACE ICT to access market information, than the old folks, which upholds the findings by past studies, suggest that this group of farmers are more literate and well equipped to use ICT tools (Okello, et al., 2011). Being a member of a farmers group is also expected to have a positive effect on use of KACE information services.

Results of the Poisson regression model estimates that among the farmer-specific variables, gender and age, affects the intensity of use of KACE ICT tools. The expected number of tools used is 0.75 times higher among the males than female farmers, ceteris paribus. This finding corroborates earlier research which argued that culture among rural farmers which entrusts the responsibilities of purchasing inputs and planning for output sale on men, affects the use of ICT tools such as mobile phones.

The findings of the study also indicate that the expected number of ICT tools used is inversely related to age. Increase in age of the respondent by one year reduces the expected number of KACE ICT tools used by 27 percent. This findings point out that the younger the farmer, the more the likelihood of them using more ICT tools. The results agree with past studies which have explained that this generation of farmers is more literate and therefore capable of using ICT (Okello, et al., 2010).

The results further demonstrate that among farm-specific variables, distance to the nearest market with electricity, affect the extent of use of ICT tools for agricultural transactions. An increase in distance to the electricity source by one kilometer is likely to reduce the expected number of ICT tools used by 0.8 times. This is expected as mobile phones used, require to be charged. Farmers will find it difficult to travel to the market centre often, because of high transport costs. Distance to the main produce market has also been found to influence the number of ICT tools by farmers in accessing market information. Increase in distance of the respondent homestead to the market by one kilometre decreases the expected number of KACE ICT tools used by 8 percent. This finding contradicts past research that suggests an inverse relationship between distance to the market and number of mobile phone calls by farmers for agricultural transaction purposes (Okello, et al., 2011). This could be due to the fact that this study was based on different ICT tools, some of which were to be accessed at KACE's merchandize shops.

The study also suggests that increase in the size of a household decreases the intensity of use of ICT tools by the family for agricultural activities by 15 percent. Putting in mind of the large average family size of about 7 members, in the study area, this finding is expected, as large households have many mouths to feed, and therefore have little surplus to take to the market, as a result will be less interested in market related information.

Among capital endowment variables, education, literacy and mobile ownership, condition the extent of using ICT tools. Farmers who are literate will use more tools to access market information than their illiterate counterparts. Increase in age of the respondent by one year reduces the expected number of KACE ICT tools used by 27 percent.

A unit increase in education increases the expected number of KACE ICT tools used by 0.32. Literacy plays a big role in technology adoption, as the use of some of these tools require some basic knowledge.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

The study examined the level of awareness and usage of KACE information tools and services among the smallholder farmers in Bungoma County of Kenya. It finds that there is high level of awareness of KACE market information services. More than 61 percent of the respondents are aware of KACE information services. This figure constitute of 51.8 percent men and 48.2 percent women. However, this relatively above average awareness does not match the level of usage of the ICT information services provided by KACE. A fair proportion of the respondents (57.4 percent) were utilizing KACE information facilities. Like on the level of awareness, more men (52.2 percent) than women are using KACE information services.

The study finds the factors conditioning awareness of KACE information services to include age, gender, literacy level and membership of farmer organization (collective action). Age was found to have an inverse relationship on awareness of KACE ICT tools. The study also found more than women were aware of KACE ICT tools. Those with many years of education were found to be exposed and therefore aware of KACE market information services.

5.2 Conclusions

The role of information for efficient functioning of markets has been a major concern for many researchers. Application of ICT-based technologies have been touted as having the potential to empower farmers with market and other agricultural information to help them make informed decisions on where to sell their produce at profitable prices. Although, there has been a massive

rollout of such initiatives aimed at addressing the problem of information asymmetry to ensure market efficiency, research shows that farmers in sub-Saharan Africa still face challenges in accessing profitable markets.

This study finds that there is a fairly low awareness and usage of this project among the farmers. The study further finds that age, literacy level and gender (cultural backgrounds of rural communities), as well as a lack of motivation stemming from the farmers' perception of the scant usefulness of ICTs and their limited digital skills, affects awareness of KACE information services among smallholder farmers. Young farmers, considered more educated, are more outgoing and willing to know what is going on in their environment as compared to their older counterparts, otherwise viewed as conservative. More men than women have an opportunity to interact with the outside world and therefore more placed to be aware of the technology in the market.

Using the logit regression model to examine the use KACE ICT tools, the study found that the decision to use KACE tools was determined by age, gender and education explain the usage of KACE information services. Young farmers were more likely to use KACE ICT tools as compared to the older counterparts. This could be attributed to their high literacy level and ability to use modern technologies. More men than women were found to use KACE tools. This is because of the culture, which allocates women to non-financial responsibilities, while leaving financial obligations (which may require seeking of information) to men. Farmer's perception of affordability and importance of the services provided by KACE was also found to influence the usage decision.

Poisson regression model was used to examine factors that determine the intensity of use of KACE ICT tools by farmers in accessing marketing information. Age and gender were the farmer-specific factors found to influence the number of tools used by farmers. Capital endowment factors such as literacy and ownership of mobile phones also affected the use of KACE ICT tools. Further, number of ICT tools used were influenced by group membership (social capital), with number of KACE ICT tools expected to increase for farmers belonging to groups.

5.3 Recommendations

The implication of the findings of this study is that there is need to sensitize smallholder farmers on the KACE information services and other ICT-based market information initiatives. Application of ICT in agriculture present a potential opportunity of resolving the asymmetry in market information, that normally leads to market failures, resulting in farmers receiving minimal returns for their farm produce, a situation that ties them in a poverty cycle. Further, there is need to support the emerging ICT applications, while ensuring an enabling environment and infrastructures, such as electricity (this is a major constraint in most rural homes, where one has to trek quite a long distance to charge their mobile phones). The findings of this study identify priorities for policymakers and other stakeholders, including the private sector to invest in projects that aim at linking farmers to market and other agricultural information. Focus should also be directed to empowering the farmers with knowledge on how to use the facilities; since most of the farmers are either illiterate or semi-illiterate.the study indicates the importance of improving the general literacy standards of the rural community. Support should also be directed

to farmer organization groups (collective action), which have been found to play a significant role in technology adoption.

The fast development of technology facilitates huge possibilities for all of human kind, but as it is often the case, this progress is not automatic and unproblematic. As technologies evolution and usage take root, there emerges the digital divide which is seen as separating users from non-users, and distinguishing different types of adopters. There are a multiple of factors contributing to the divide, such as age, gender and education.

The development of technology is so vital to mankind that there are no alternatives for this. We have to ask ourselves if we truly comprehend the process of human technology interaction design as thoroughly as we should. If we do not, and in case there are any grey areas in the map of the design process, we should ask what could be done to improve this process.

It has been observed that age is likely to be a hindrance in technology adoption, with young people being more likely than older people to embrace new ways of doing things. There is need to design technologies that takes care of the interest of the older people. Older adults constitute an increasing number of the users of commercial services. Understanding the needs of older adults is more important than ever, and meeting these needs will represent a major market opportunity for new ICT products and services. At the same time, ICT literacy is critical for the older generation to enable them take advantage of emerging technologies.

Results also indicate that gender variable has a significant impact on adoption; being a woman decreases the probability of ICT tools ownership. Women empowerment is therefore necessary

in effort to improve production and enhance the living conditions of the rural population (Okello et al., 2010, FAO 1994).

Addressing of Social access issues must extend beyond gender. A full understanding of the local, national, and regional agricultural economy is important for ensuring that ICT interventions do not restrict poor producers' participation to the low end of agricultural value chains like other technologies have. ICT in itself does not guarantee full participation by all social groups. Efforts to be inclusive must focus on the full range of capacities and resources that small-scale producers will need to benefit from an intervention.

Results demonstrate a significant relationship between education and awareness as well as adoption. Increased investment in education to improve its quality is therefore key to boosting adoption of new technologies. Education should also be further extended to organized farmers groups to increase their uptake of the new technologies. The groups should also be supported to ensure their sustainable operations.

To take advantage of ICTs to reverse the unequal development of agriculture, national as well as regional policies must be implemented to overcome the barriers to adoption in the most underdeveloped segments. Perhaps one possible mechanism would be the exchange of successful stories between areas, or countries in the region, which share fairly similar realities in terms of the importance of agriculture in the economy and the origin of sectoral asymmetries.

The most extensive experience in the region in terms of facilitating farmers' access to ICTs has been with telecentres and computer-supply and connectivity programmes for rural schools. Policy on its own, however, cannot guarantee access to and use of ICTs in these areas.

Motivational and educational strategies aimed at overcoming resistance, demonstrating the usefulness of the technologies and developing digital skills and content are necessary.

Questions of social access should be raised consistently when using ICT to improve rural livelihoods. Do socio-cultural norms or divisions prevent certain groups from using the technology? Will better-off groups benefit more than poor groups? Broad-based rural development must be accompanied with monitoring and evaluation of outcomes while making necessary adjustments along the way.

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ANNEXES

Annex 1: Survey Questionnaire

AWARENESS AND USE OF KENYA AGRICULTURAL COMMODITY EXCHANGE (KACE) AGRICULTURAL INFORMATION SERVICES: THE CASE OF SMALLHOLDER FARMERS IN WESTERN KENYA.

Farmer number_____ Date_____

Farmer's Name_____

District_____ | | | | |

Division_____ | | |

Location_____ Sublocation_____ | | | |

Enumerator's name

Instructions

1. The information sought by this questionnaire is strictly for academic purposes. It is aimed at assisting the student in writing a thesis for his Masters Agricultural Information & communication Management.

2. All the information provided herein will be treated as confidential and shall not be disclosed to any third party.

3. The questionnaire should be administered to the household head or the decision maker on the farm

4. Circle or fill the appropriate response

1.0. Identification

1.1. Name of enumerator_____

1.2. Name of Respondent_____

1.3.Disrict:_____ Division_____Location_____

1.4. Date_____Start Time_____ End time_____

2.0 Background Information

2.1 Farm ID……

2.2 Age (years)……..

2.3 Gender……..Female [0] Male [1]

2.4. Formal education level (Years)…….

2.5 What is the size of your family?**.....**

2.6 What is the size of your farm……acres

2.7 How was the farm acquired?.....(0= Bought [ ] 1=Inheritance [ ] 2=Rented)

2.8 Are there members of you family who work off-farm?..... (0=No [ ] 1= Yes [ ])

2.9 House type? 1=Traditional [ ] 2= Semi-permanent [ ] 3=Permanent [ ]

3.0 Farm Enterprises

3.1 Name the four major crops that you had on your farm between January-December 2010?

Short rains

Crop	**Acreage**	**Output (units)**	**Price/unit**	**Total**
1.				
2				
3				
4				

Unit used= 90kg bag

3.2 Farm income in short rains……..

3.3 Long Rains

Crop	**Acreage**	**Output (units)**	**Price/unit**	**Total**

1.				
2				
3				
4				

Unit used=90kg bag

3.4 Farm income long rains…….

3.5Total crop farm income……

3.6 Do you rear animals on your farm in 2010?..... (0=No [ ] 1= Yes [ ])

3.7 If yes fill complete the table below.

Type	**Number**	**Value**	**Total**
1. Indigenous cow			
2. Exotic cow			
3. Goats			
4. Sheep			
5. Oxen			
6. indigenous poultry			
7 Exotic poultry			
8. other			

6.0 Extension

6.1. Has extension staff ever visited your farm? (0= No [ ] 1=Yes [ ])

6.2 If yes, what was the source of extension?.....

1= Government [ ] 2=NGO [ ] 3=Local traders [ ] 4=input dealers[ ] 5=Farmer group [ ]

6=cooperative society 7= Research [ ]8=Other (specify)_____

6.3 What was the type of service?.....

1=product handling [ ] 2=record keeping [ ] 3=crop husbandry[ ] 4=livestock husbandry [[

5=marketing [ ] 6=Financial management[ ] 7=other (specify)

6.4 On average, how many times do they visit you in a year?....

1=once [ ] 2= twice [ ] 3= thrice [ ] 4= not at all 5= any other (specify)

6.5 Are you a member of any farmer group? (0=No [ ] 1=Yes [ ]

6.6 if yes give the name

6.7 have you ever received extension through this group? (0=No [ ] 1=Yes [ ]

6.8 Have you ever attended any agricultural field day (0=No [ ] 1=Yes [ ]

4.0 Do you own any of the following Household Assets

Assets	**Current Quantity**	**Asset**	**Current Quantity**	**Asset**
1=Houses		7=Bicycle		23=Grinder
2=Radio		12=Wheelbarrow		24=Beehives
3=TV		10=Car		25=Spray pump
4=Mobile phone		11=tractor		26=generator
5=Fixed telephone		22=Weighing machine		pump15=zero grazing unit
29=Stores		13=Solar panels		28=Cart
21=Fishing hook		14=furniture(tot Value)		6=Motor cycle
8= Sheller		36=Harrow/tiller		30=Donkey
9=Battery car		16=chaff cutter		31=Borehole
37=Planter		17=water trough		32=Water tanks
38=Ploughs		18=poultry		34= piggery

for tractor		house		house
39= Trailer		19= Well		33=Truck
40=Irrigation equipment		20=Animal traction plough		35=Milking equipment/shed

N/B: it is almost impossible to have a household without furniture and therefore this asset must be valued in all cases.

5.0 Credit

5.1. Did you need credit last year's (2010) planting season? (1=Yes[ ] 0=[ ])

5.2 Did you get credit in the last 4 years (0=No [ ] 1= Yes [ ])

5.2 if yes in what form was the credit? (1=cash [ ] 2= in kind [ ] 3= both [ ] 4=N/A [ ]

5.3 if yes how much did you receive in 2010?

Source	Amount	Type	Value
AFC			
Government fund			
Co-operative			
Project/NGO			
Group			
Commercial Bank			
Friends			
Other			
Total			

Total amount…….

5.4. on what operations was the credit used?.....

1=Purchase of inputs [ ] 2=planting [ ] 3=weeding [ ] 4= harvesting[ ] 5= threshing [ ]

6= purchase of farm machinery [ ] 7= construction of farm structures

[ ] 8= improve crop production [ ] 9=veterinary services such as AI[ ]

10= Purchase feed[ ] 11= other(specify) [ ]

5.5 are there occasions you fail to receive credit when you need it?..(0=No [ ] 1= Yes [ ])

5.6. If no, why?

1=lack of credit supplier[ ] 2=credit too little to benefit[ ] 3=credit too costly[ ] 4=lack of collateral

5= Previous default [ ] 6= other(specify)

7.0 ACCESS TO MARKET AND INFRASTRUCTURE

7.1How many farm produce market places are there in this area?_____

7.2 What is the distance to the main/ common farm produce market from the farm? (kms)_____

7.3 How many livestock markets are there in this area?_____

7.4 What is the distance to the main/common livestock market from the farm?(kms)____

7.5 How often does the most commonly used farm produce market place open?_____

[codes: 1=Everyday,2=once a week,3=twice a week,4=once a month,

5=twice a month,6=other (specify)_____]

7.6 How often does the most commonly livestock market place open?_____

[codes: 1=Everyday,2=once a week,3=twice a week,4=once a month,5=twice a month,

6=other (specify)_____]

7.7 What is the type of road from the main/common farm produce market to the next

bigger market centre_____

7.8 What is the type of road from the main/common livestock market to the next

bigger market centre_____

7.9 What is the distance from the household's farm to a tarmac road?_____

7.10 Is there electricity(that can be tapped in this area?_____[1= Yes 2=No]

7.11 If your answer to above is yes, do you have electricity yourself?___[1=Yes, 2=No]

7.12 If your answer to j is No, what is the distance from the household's farm

to electricity supply?_____(kms)

7.13 What are the 2 major sources of drinking water in this area?[__] ands [__]

(codes: 1=river,2=well,3=borehole,4=piped,5=protected spring,6=unprotected spring,

7=roof catchment 8=other(specify)

7.14 If there is piped water, do you have it yourself?.. [1=Yes, 2=No]

7.15 If there is water in the household, how often do you have water in the pipes?

Frequency [ ] (1= throught [ ], 2=Once [ ], 3= twice [ ], 4= Thrice [ ], 5=Other (specify)...

Period [ ] 1=day [ ], 2= week [ ], 3=fortnight [ ], 4= month [ ], 5= year [ ], 6= other (specify)

8. SOURCE OF INFORMATION

Please answer the following questions on the commonly used source of information

(tick, where appropriate)

SOURCE	TYPE OF INFORMATION						
	Output price	weather	Suppliers & buyers at local markets	Technical advice on Agricultural practices	Input price	Agricultural credit	Insurance Services
Mobile phone SMS							
Mobile phone Voice calls							

Internet							
Daily newspapers							
Neighbors							
TV							
Govt Extn Agents							
Middlemen							
Radio							

9.0 KACE Information services

9.1 have you ever heard of KACE?...(1=Yes [ ] 0= No [ ])

9.2 If yes when (year)……

9.3 From what source did you first hear of KACE?.....

1= Radio[ ] 2=seminars/barazas[ ] 3= Agricultural field days[ ] 4= other (specify)…

9.4 Do you know if KACE provides agricultural information? .. ...(1=Yes [ ] 0= No [ ])

9.5 Have you ever used KACE's information services?... ...(1=Yes [ ] 0= No [ ])

9.6 If yes, indicate the number of times you accessed agricultural information in the last one year

Type of Information	**Frequency**	
	Short rains	**Long rains**
Agricultural credit		
Output prices		
Input prices		

Weather condition		

9.7 Which type of KACE ICT tool do you use?

Type of ICT	**Frequency**	
	Long Rains	**Short Rains**
Internet		
Mobile phone voice calls		
Mobile phone SMS		
Radio (Soko Hewani)		
Boards		

9.8 What would you say about affordability of KACE information services?

{1=affordable 0=not affordable}

9.9 would you say KACE information services are important? { 1=Yes, 0=No}

Annex 2: Summary statistics of variables used in empirical estimations

Variable name	Definition	Measurement
Gender	whether the respondent was male or female	1 if male, 0 for female
Age	age of respondent in years	natural log of age was used
Education	years spent in formal schooling	natural log of years was used
Main occupation	the respondent's main economic activity	1 if farming is main activity, 0 if otherwise
Family size	total count of family members	natural log of family size was used in regression
Farm size	total size of land owned by household in acres	natural log of total acreage
Farm ownership	mode of land ownership	1 if owned by household, 0 if otherwise
Farm income	total revenues from agricultural activities	natural log of income computed
Contact with Extension	respondent's access to extension staff and services	1 for access to extension in last 12 months, 0 if otherwise
KACE Importance	respondents perception on KACE information services	1 if important, 0 if otherwise
Affordability	respondent's perception on affordability of KACE services	1 if affordable, 0 if otherwise
Mobile ownership	respondent's ownership of a mobile phone	1 if yes, 0 if otherwise
Group membership	if a respondent belongs to any farmer's group	1 if yes, 0 if otherwise
Radio listenership	if respondent listens to radio	1 if yes, 0, if no
Radio farm program listenership	if the respondent listens to agricultural programs	1 if yes, 0, if otherwise

Annex 3: Examples of Agriculture-based ICT Applications in Kenya

iCow	This is another SMS app focused on giving the dairy farmer unbiased information concerning the cows' gestation period, vet info, record keeping and the world's first cow calendar. *http://www.icow.co.ke*
KUZA Doctor	Using the most basic mobile phones, farmers receive critical knowledge to increase their rates of production and subsequent incomes while learning the value of local biodiversity and conservation farming From BackPack Farms. *www.backpackfarm.com/site/1075kris/KuzaDoctorFAQ_FINAL.pdf*
Ukulima.net	Pamoja Media's mobile web platform that allows farmers to connect and interact on topics of similar agriculture interests. *http://ukulima.net*
mFarm	A Kenyan agribusiness software solution that seeks to provide delivers necessary information for Kenyan farmers, thereby helping farmers and agropreneurs improve their productivity and increasing their bottom line. Their main application is an SMS solution.
m-Kilimo	A mobile phone innovation targeting the small scale farmer with information, advice and support.
DrumNet	The project implemented by Pride Africa to utilize mobile phones in linking farmers t output markets
KaiNet	Kenya Agricultural Information Network is an information network set up to promote information exchange among stakeholders in the Agricultural sector.