EVALUATION OF INFORMATION AND COMMUNICATION TECHNOLOGY UTILIZATION BY SMALL HOLDER BANANA FARMERS IN GATANGA DISTRICT, KENYA

By

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Thesis Submitted in:

Partial fulfillment of the Requirement for the award of the degree of Master of Science in Agricultural Information and Communication Management in the Department of Agriculture Economics, University of Nairobi

July, 2011

DECLARATION

This thesis is my original work and to the best of my knowledge it has not been submitted to any other institution of higher learning for examination.

Signature…… Date 13/7/2011

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This thesis has been submitted for examination with our approval as University of Nairobi Supervisors.

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DEDICATION

This thesis is dedicated to my dear family members: Wife Rose, daughter Diana and the late dear son Delvis for their patience and encouragement.

ACKNOWLEDGEMENT

I would like to thank the Ministry of Agriculture in Gatanga District for all their help in my research. Special thanks go to Regina Thamaine, the Deputy Agricultural Officer for material support and for allowing her staff to assist me in data collection. I am grateful to Regina Wanjeri, the District Agribusiness Development officer iSn Gatanga for coordinating my research work.

To my Supervisors Dr Fred I. Mugivane and Prof. John Nderitu, I wish to appreciate their valuable professional guidance without which I could not have finished my studies in good time. I would also wish to thank Ms Kalekye G. Musyoki of Agricultural Economics Department in Kabete for her continuous assistance throughout my course. I acknowledge the technical assistance I received from Oliver Kirui (CMAAE, 2008 class) whose invaluable input shaped my work at the final stages. Special thanks go to my class mates; Ivan Adolwa, Iren Aburi and Dali Mwagore for their special assistance. Mr. Adolwa of CIAT/TSBF Nairobi for willingly and tirelessly providing me with all the reference materials I needed for my thesis at no cost, may almighty God reward him in abundant.

Lastly I wish to thank the District Agricultural Officer Ruiru, Mr. George Ngigi and the entire staff who are my colleagues for giving me humble time throughout my studies. Not forgetting Jane Gachui at the University of Nairobi for type setting and printing this work

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LIST OF ABBREVIATIONS

CBO	Community Based Organization
CIAT	Centre for International Tropical Agriculture
CMAAE	Collaborative Masters in Agricultural and Applied Economics
DAO	District Agricultural Officer
DLPO	District Livestock Production Officer
GoK	Government of Kenya
ICT	Information and Communication Technology
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KACE	Kenya Agricultural Commodity Exchange
KARI	Kenya Agricultural Research Institute
LPM	Linear Probability Model
NALEP	National Agricultural and Livestock Extension programme
NASEP	National Agriculture Sector Extension Policy
NBR	Negative Binomial Regression
NGO	Non-Governmental Organization
OLS	Ordinary Least Squares
PRM	Poisson Regression Model
TC	Tissue Culture
TSBF	Tropical Soil and Biological Forest institute
TV	Television

ABSTRACT

The general objective of this study was to analyze the factors which influence the farmers' access and Use of Information and Communication Technology (ICT), and how the ICT affects adoption of improved farming technologies in banana production in Gatanga District of Kenya. The ICT in this study was defined to include technologies and media that capture, store and disseminate data and information and tools such as video, television, digital camera, radio, mobile telephone, computer-mediated networks and print media among others.

A multi-stage purposive sampling and proportionate allocation technique was used in the study to select n=120 respondents. Three main banana growing locations were purposively selected across 3 Divisions. Three banana groups from each location were randomly selected from a list of 20 groups obtained from the District Agricultural Office. Systematic simple random sampling technique was then used to select half of the members from each group at interval of two. A fifty percent Sample size was drawn to minimize cost and time. Mugenda and Mugenda (1999) argue that a 50% sample is large enough and can be used to represent the target population if such population is large enough to justify sampling. A pre-tested questionnaire was use to obtain primary data from the respondents. Four questionnaires were discarded because they were incomplete, a total of 116 questionnaires were usable. Data entry was done by Statistical Package for Social Sciences (SPSS) data builder. Descriptive analysis was done by Excel and SPSS while quantitative analysis by STATA computer software.

Radio, mobile phone and television were the most accessible ICT among smallholder banana farmers. The least accessible were internet, computer and video cassette. Gender, education and income levels were found to influence use of ICT in obtaining information on banana production. Affordability, physical access and prerequisite skills to use internet and computer related services were a problem to majority of farmers. The study findings indicate that access to ICT influence adoption of Tissue Culture banana biotechnology. Use of ICT as a source of agricultural information improves banana productivity and market efficient resulting into increased farm income for smallholder farmers.

To enhance use of ICT in extension the study recommends capacity building of extension staff and researchers, reduction of taxes on radio-wave licensing to encourage more FM radio stations and improve accessibility to ICT services by investing in both complementary infrastructure and higher education. Further research should be contacted to find out technology-specific attributes and socio-economic factors that impede actors in agriculture sector to effectively use ICTs to full potential.

CHAPTER 1

1.0. INTRODUCTION

1.1. Background

Small-scale agriculture and harvesting of natural resources provide livelihoods to over 70% of the population in Africa. According to Munyua (2008), about 80% of the farmers in Africa are smallholders. In Kenya, the agriculture sub-sector of the economy provide livelihood for over 80% of the rural population, majority of whom are small-scale farmers, eking a living from less than 2 hectares (Davis, 2004). Small-scale farming accounts for 75% of the total agricultural output and about 70% of the marketed agricultural produce (GoK, 2008a).

Dissemination of agricultural information to these rural people, who are usually scattered and sometimes inaccessible, poses a big challenge to development agents. Information Communication Technology (ICT) provides an effective means of communicating knowledge and information to rural agricultural communities. ICT includes technologies and media that capture, store and disseminate data and information and tools such as video, teletext, voice information systems, radio, mobile telephone, fax and computer-mediated networks among others (Munyua, 2008).

The National Agricultural Sector Policy (NASEP) offers guidelines on participatory technology development, packaging and dissemination and embraces use of ICT in extension service delivery (GoK, 2008a). NASEP presumes that extension service providers and clients will increasingly apply ICT in their transaction for wider

coverage and enhanced sharing of information. This current initiative of ICT in agriculture calls for a study in the way smallholder farmers are utilizing this new mode of extension service delivery.

Production and marketing of fruits and vegetables require that farmers access reliable and timely information. These fresh produce is susceptible to diseases and highly perishable. Munyua (2008) notes that inadequate access to markets and unfair market conditions, limited access to advanced technology, weak infrastructure increases production and transport cost. She further advances the view that agricultural markets do not work efficiently for poor small-scale farmers because of the long transaction chain between farmers and consumers. ICT could offer an opportunity for small-scale farmers access export and other markets in urban areas.

Banana is a major fruit crop among subsistence and commercial farmers. It is ranked as the most important crop among fruit crops (Njuguna *et al,* 2007). Banana is predominantly grown by small-scale farmers in less than 0.3ha of land holding and covers up to 13% of the total arable land in the country (Qaim, 1999). The average yield is 14 tonnes per hectare, which is less than a third of the crops potential (Njuguna *et al,* 2007). It is grown in a diversified cropping pattern of semi-subsistence, domestic cash crops, as well as typical export commodities.

African Harvest, a non-profit organization is involved in promotion of Tissue Culture (TC) Banana is a lead agent in propagation and distribution of TC banana suckers in Kenya. Tissue Culture is a laboratory method of micro-propagation that enables rapid

multiplication of pathogen-free planting material (Wambugu and Kiome, 2001). The technology significantly reduces diseases and increases yields.

African Harvest uses strategic value chain approach with TC banana technology, which includes: awareness creation and information outreach, access to TC banana seedlings, agronomic best-practices, post harvest fruit handling, best practices and linkage to competitive markets (Kamanga, 2005). In its approach, African Harvest uses various ICT channels to disseminate information on TC bananas among farmer groups in Gatanga District; however adoption of this technology still remains low.

1.2 Statement of the problem

Economic Review of Agriculture (GoK, 2008b) indicates that fruit and vegetable production for local and export market has continued to decline. The decline is attributed to low adoption of current agricultural technologies, ineffective markets and exploitation of farmers by middlemen. Farmers are disadvantaged in these areas because they lack timely and adequate information (Kiplang'at and Ocholla, 2005; Munyua, 2008). Among fruit and vegetable crops, bananas are the most adversely affected in these areas because infected materials are planted as clean planting material is not available and farmers have no information as to where to obtain good varieties.

Banana farmers therefore face challenges which include planting low yielding and disease susceptible cultivars (Njuguna *et al,* 2007). The resultant yield losses make banana relatively expensive for consumers and reduce the cash earnings of producers, thus reducing the potential of the crop to contribute to the food security of the rural

household. Banana serves as an important staple food to rural households who are faced with perennial food insecurity. The continuous availability of harvestable bunch from a banana stool is important to farmers, who are mainly women, because it contributes to the year round food security and income. The Kenya Agriculture Research Institute(KARI) and stakeholders have used conventional extension approaches to promote the supply of pathogen–free bananas from Tissue Culture (TC) laboratory technique to farmers since 1996(Qaim,1999; Njuguna *et al*,2007), this has been done as a way of improving production.

However, Kenya extension agents do not have access to ICT yet they need these tools to disseminate research information to farmers (Kiplang'at and Ocholla, 2005). Information on how Banana farmers access and use ICT is lacking and/or not readily available. This study therefore seeks to determine factors influencing intensity of use of ICT tools and by extension how use of ICT influences adoption of TC bananas. Knowledge of these factors will assist in determining why banana farmers have limited access to ICT and new information on banana production and what strategies to put in place to address this limitation.

1.3 Objectives of the Study

The general objective of the study is to analyze the factors which influence the farmers' access and use of ICT, and how the ICT influences the adoption of Tissue Culture bananas in Gatanga District, Muranga County of Kenya.

1.3.1 Specific objectives

1. To identify ICTs used for information on banana production by small-scale farmers in Gatanga District.
2. To determine factors influencing intensity of use of ICT tools in small-scale banana production in Gatanga District.
3. To assess whether use of ICT has a significant influence on adoption of Tissue Culture bananas.

1.4 Hypotheses

The following hypotheses will be tested:

- Socio-economic factors do not influence the intensity of use of ICT tools in Banana production.
- Use of ICT has no influence on adoption of Tissue Culture bananas.

1.5 Justification of the Study

The decision to focus on small-scale banana growers was influenced by the role of bananas in food security and income for smallholder farmers under very low input regimes. To speed up technology adoption requires understanding and improvement of information flow through use of modern ICTs. Lio and Liu (2005) showed that rural telephone helped farmers to receive better prices for their crops and led to significant increase in earnings. The study also showed that mobile phones help raise farm output prices and lower farm input prices through mechanism of information diffusion. The study will inform both the public and private extension service providers the available ICTs in regard to banana production and factors that affect

their use. It will also guide the policy makers and software developers to develop tools and materials that are locally suitable in order to promote banana production.

1.6 Scope and Limitation of the Study

One of the challenges envisaged in the study is the limited scope. Other than information diffusion through ICT, there are many other factors contributing to banana productivity that shall not be covered due to time and resource constraint.

1.7 Outline of the Thesis

The first chapter gives the background to the research theme, research problem and objectives of the study. The hypotheses and justification of the study are outlined in the chapter. Chapter 2 is a literature review on Banana Biotechnology in Kenya, role of ICT in production and marketing of Bananas, factors influencing ICT utilization and past studies. The 3rd chapter presents the research design, methods; procedures followed to collect data, and expected output. Chapter 4 presents the results, discussion and hypotheses. Chapter 5 contains summary, conclusion and recommendations of the study. Instruments used are included in the appendices.

CHAPTER 2

1.0 Literature Review

As ICT diffusion grows in heaps and bounds across many countries in the world, the application of ICT in agricultural development is attracting the attention of both researchers and policy analysts. ICT has an impact on agricultural development because market transactions and agricultural technology dissemination critically depends on information flow between distance markets, research centers to the rural areas. By providing a powerful tool of information transfer, ICT could substantially improve the efficiency of transactions between main markets, research centers and rural areas.

Various studies have suggested that ICT could play an important role in agricultural development. For instant in 1994 a microwave-radio telephone system was installed in the remote region of Tumaco, Columbia, along with community access points. Within three years, residents of the region reported that service provided by the system had resulted in better trade and market opportunities (Lio and Liu, 2006). Cyber extension mechanism has been implemented in Sri Lanka in the year 2004 as appropriate information exchange mechanism affordable to rural farmers to satisfy their information needs (Rohan *et al*, 2008). Cyber extension utilizes the power of networks, computer communications and interactive multimedia to facilitate information sharing mechanism. In the case of Sri Lanka, each Cyber Extension unit comprises of a high end multimedia computer, digital camera, laser printer and Uninterruptible power Supply (UPS) and manned by Agriculture Instructor (AI).

A study conducted in the central Punjab showed that more than 56% of farmers listened/watched agricultural programmes on Radio and Television (Irfan *et al*, 2006). Farooq (2007) stated that important sources of agricultural information for the respondents were fellow farmers and print media (100%), private sector (95%), Television (80.83%), extension field staff (67.5%), Radio (75%) while none mentioned NGOs. Frequent Modulated (FM) Radio stations, internet, e-mail, websites and web-based applications are becoming increasingly important in small-scale agriculture for purposes of sharing and disseminating agricultural information (Munyua, 2008; Munyua *et al*, 2008). Television was the major ICT used in extension delivery in Nigeria, while Radio was the most important ICT followed by Television and Video in Kenya (Ovwigho *et al*, 2009).

In Kenya studies show that Radio and television have been used widely by agriculture Researchers and Extension workers to disseminate agriculture information to the farming community (Kiplang'at and Ocholla, 2005). They noted that mobile phones were used to communicate urgent messages and facilitate consultation by farmers. Video was also used to repackage technological messages from extension to farmers. Lwande and Muchemi (2008) finds that majority of farmers prefer receiving agricultural information via regular visits by extension officers, however expresses concern about their availability. Farmers appreciate use of mobile phone to receive information but majority still prefer receiving weather information through Radio (Lwande and Muchemi, 2008).

A marketing and Technology diffusion research (Wambugu and Kiome 2000) indicate that use of ICT could improve flow of information to farmers. The research

recommends institutions like the Kenya Agriculture Commodity Exchange (KACE), a private sector firm, to keep farmers informed about distance market prices through rural telecentres.

An impact assessment study of the National Agriculture and Livestock Extension Programme (NALEP) in 2006 cited by Davis (2008) showed that 70% of farmers acknowledged that access to information enabled them access new farming opportunities and increased profits in their farms. Mukhebi (2004) asserts that ICT increases search activities and eventually raises the quality and quantity of available information, thereby reducing uncertainty, lowering transaction cost and enhancing market participation.

The use of ICTs in extension has several benefits that include; reduced communication cost, rapid speed of communication, reduced uncertainty and risks (Richardson, 2006; Jagun *et al,* 2007). In Uganda, Banana traders have used mobile phones to set up trading encounters with producers, rendering produce collection more efficient, obtaining higher prices in Urban markets and increasing produce sales by 50% to 68.8% from 2003 to 2005(Muto and Yamano, 2008). Jensen (2007) showed that use of mobile phones by fishermen to sell their fish, extended the number of outlets used, reduced wastage from 5-8% to zero and increased profits by 4%.

In its efforts to promote TC bananas, African harvest, a lead agent in developing and promotion of banana biotechnology in Kenya, has used ICT to disseminate information on advantages of TC bananas along the banana value chain, with varying success. They have used mobile phone to co-ordinate farmer group meetings and FM

radio stations that broadcast in vernacular to promote TC bananas in the study area. A critical review of use of ICT towards this end has not been taken or the information is not readily available, it for this purpose that this study wish to establish.

1.1 Banana Biotechnology in Kenya

In 1996, Kenya Agriculture Research institute (KARI) with the facilitation of stakeholders initiated a banana Biotechnology project to promote and distribute Pathogen-free banana planting material to small-scale farmers (Wambugu and Kiome, 2001). Studies indicate that the Tissue Culture (TC) Banana has high yields, fast growth rate and uniform maturity compared to the conventional suckers (Wambugu and Kiome, 2001; Njuguna *et al*, 2007). The application of this biotechnology has the potential to improve the living standard of resource poor rural farmers.

Banana yields in Kenya continue to decline due to lack of clean planting material, pests and diseases and lack of awareness among farmers of the existing technologies and management practices (Wambugu and Kiome, 2001). Wambugu and Kiome (2001) further notes that poorly established marketing system and inefficient channels of distribution to urban markets affect returns to farmers. Farmers have little access to information and about market prices, consequently open to exploitation by middlemen.

1.2 Factors influencing intensity of use of ICT tools

Socioeconomic characteristics of the farmer; education level, economic wellbeing, socio-demographic variables affect use of an innovation (Wejnert, 2006). Ovwigho *et al* (2009) found that major constraint to use of ICT is high cost of telephone service, limited access to computer and rural poverty. Use of a particular type of ICT will depend more on economic variables than on socio-demographic variables like gender, marital status and education level (Wejnert, 2006). While implementing a Cyber extension mechanism in Sri Lanka in the year 2004, it was revealed that lack of awareness was the major drawback to popularize the new digital extension mechanism (Rohan *et al*, 2008).

Studies indicate that there is a positive and significant relationship between ICTs adoption and agricultural productivity (Lio and Liu, 2005). They found out that certain socio-economic characteristics such as higher level of education and skills are prerequisites for effective development of agricultural productivity by new ICTs. Sustainability of ICT initiatives and public access points is a major problem (Munyua *et al*, 2008). Launching of an ICT project need to be accompanied by advocacy so that communities understand their role (Richardson, 2006). Sustainable strategies such as charging for services, creating strategic partnership and diversifying services need to be put in place (Munyua *et al*, 2008). Choice of communication technology and method to employ can be determined by participation of all relevant stakeholders.

CHAPTER 3

3.0 METHODOLOGY

3.1 Theoretical framework

3.1.1 Diffusion of innovation Theory

Diffusion of Innovation (DOI) theory sees innovations as being communicated through certain channels over time and within a particular social system (Rogers, 2005). The diffusion theory analyzes as well as helps to explain the adoption of new innovation. Diffusion is a social process of interpersonal communication networks that helps to explain the process of social change. Extension service providers depend on the diffusion model as the main theory guiding their efforts to transfer new agricultural technologies to farmers. ICT is new and its impact in extension delivery is still minimal (Ovwigho, 2009). Studies show that adoptions of technology innovation that are channeled through ICT tend to take the form of a news event. News events are diffused very quickly and rapidly via radio, telephone, newspaper and interpersonal channels, like the 1998 US embassy bombing in Kenya and Tanzania (Rogers, 2005). The rapidity of news-event diffusion occurs because the individual only needs to gain awareness-knowledge of the news event, while the adoption of a technological innovation in agriculture consists of the knowledge, persuasion, and the implementation stages in the innovation-decision process.

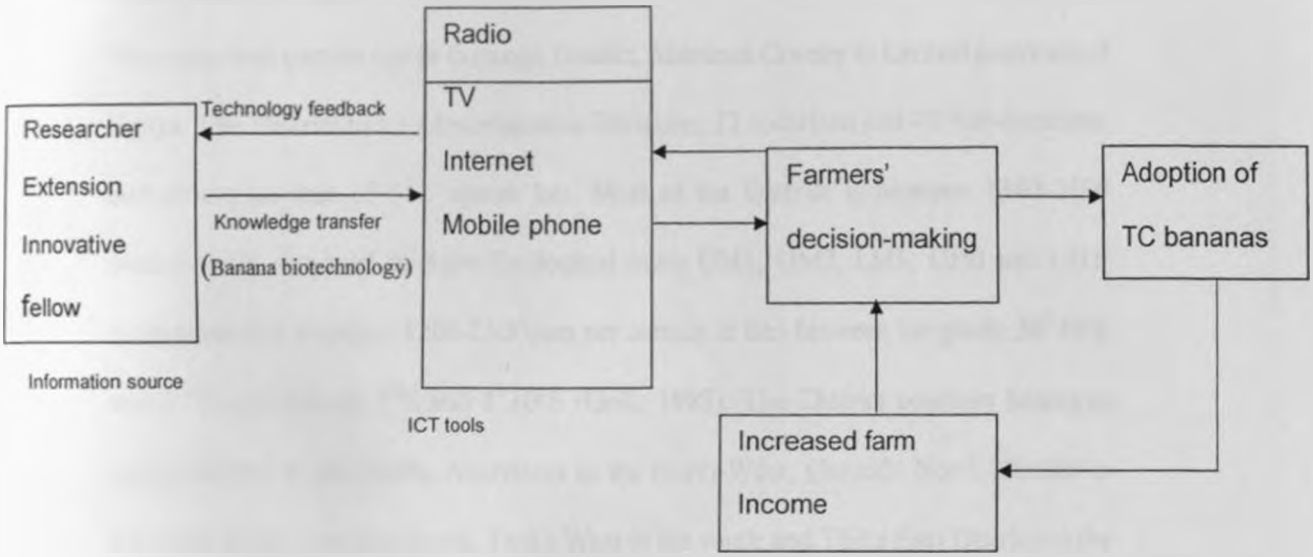
Mass media messages stimulate interpersonal communication, which in turn motivates attitude change and overt behavior change. The Bass forecasting model by Frank Bass in 1969, assumes that potential adopters of an innovation, like the banana biotechnology, are influenced by two types of communication channels; the mass

media and interpersonal word-of-mouth channel (Rogers, 2005). It is therefore important for extension agents involved in promotion of TC banana to use both ICT and interpersonal face-to face communication to achieve their objectives.

It is expected that banana technology, disseminated through ICT spreads quickly and rapidly to the farming community. However use of ICT poses challenges to both extension service providers and their clients. Rogers (2005) in his diffusion theory proposes five attributes of innovation that impact on adoption of innovation. The attributes are: relative advantage, compatibility, triability and observability and complexity. The first four factors are generally positively correlated with rate of adoption while the last factor, complexity, is negatively correlated to rate of adoption. The theory is very relevant to this study as use of ICT or any other technological innovations like the tissue culture banana technology is influenced by these factors.

3.2 Conceptual framework

Conceptual framework explains either graphically or in narrative form, the main dimensions to be studied and the presumed relationship among them (Mutai, 2000). It presents a preferred approach to an idea or thought. It can act as a map that gives coherence to empirical inquiry (Wikipedia, 2009). The conceptual framework of the study on ICT is shown below (fig 3.1)



(Adopted from Madhur, 1999)

Fig 3.1: Conceptual framework on ICT

3.2.1 Explanation of Conceptual framework diagram

Technology or information originates from a source, which could either be a researcher, Extension agent or an innovative fellow. The technology or information is transferred to the farmer, through some communication channel (ICT), who in turn makes a decision on to whether use the information or not. The outcome could be adoption of improved farming methods or increased income from the information obtained. The farmer may decide to continue using the information/technology or discontinues, and gives feedback to the source using appropriate ICT channel (fig 3.1). Extension agents are expected to use the existing ICT tools to diffuse new banana technology developed by researchers to the farming community for purpose of increasing banana production and income for smallholder farmers.

3.3 Description of the Area of Study

The study was carried out in Gatanga District, Muranga County in Central province of Kenya. The District has 3 administrative Divisions, 12 locations and 41 Sub-locations and covers an area of 312 square km. Most of the District is between 1340-2190 meters above sea level in Agro Ecological zone; UM1, UM2, LM1, UH0 and UH1. Annual rainfall averages 1200-2500mm per annum. It lies between longitude $36^0$30'E and 37^0E and latitude 1^0S and $1^0$30'S (GoK, 1983). The District boarders Maragua South District to the North, Abardares to the North-West, Gatundu North District to the south-West, Gatundu South, Thika West to the south and Thika East District to the East (fig 3.2).

Farmers in Gatanga practice mixed cropping. The main cash crops includes: Tea (*Camellia sinensis*), coffee (*coffea arabica*), summer flowers (*Arabica spp*), avocado (*perica americana*), macadamia (*macadamia tetraphylla*). The common food crops are : maize (*zea may*), common beans (*phaseolus vulgarii),*bananas (*musa,spp*), potatoes (*solanum,tuberosum*), kale(*Brassica,spp*), tomatoes(*Lycopericum esclentum*), cabbage (*Brassica oleracea capitata*) (Gok,2009a).

Livestock in the area include cattle, sheep, pigs, rabbits and chicken. Dairy farming is an important economic activity in Gatanga, especially with decline of the coffee and Tea industry due to poor market prices. Many farmers own dairy cows and keep them in intensive zero-grazing units. This necessitates the growing of fodder and buying of animal feeds for enhanced milk production (Gok, 2009b).

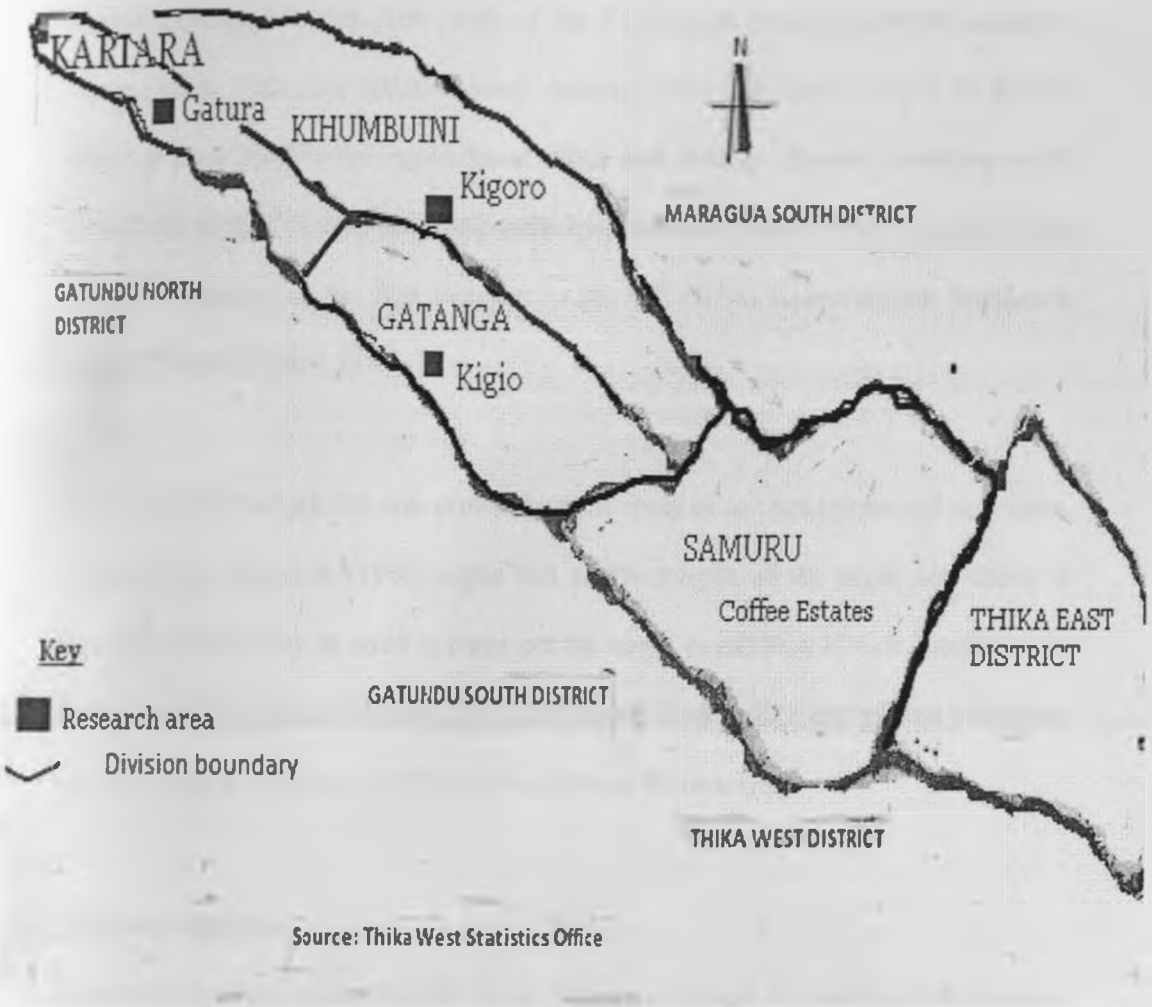


Figure 3.2: Gatanga District, Muranga County

3.4 Sampling procedure

The farmer groups involved in banana production with African Harvest were chosen for the study. The smallest group had 16 members while the largest group had 56 members with an average of 36 members per group. It was decided to focus on one type of crop rather than a number of crops to reduce the number of variables. The sample Frame is all groups involved in banana cultivation in Gatanga District. The unit of analysis was individual small-scale banana farmers. A multi-stage purposive

sampling and proportionate allocation technique was used in the study. One main banana growing Location from each of the 3 Divisions was purposefully selected. Three groups from each location were randomly selected from a list of 20 groups obtained from the District Agricultural office and African Harvest Extension staff. Systematic simple random sampling technique was then used to select, starting from every 2nd member on the lists in order to get half (50%) representation from each group selected (Table 3.1).

A fifty percent Sample size was drawn from the study to minimize cost and save time. Mugenda and Mugenda (1999) argue that a 50% sample of the target population is large enough and can be used to represent the target population if such population is large enough to justify sampling. Key informants from public and private extension agents involved in promotion of banana crop were interviewed.

3.5 Data collection

Descriptive survey was used in the study. This is a method of collecting information by interviewing and administering a questionnaire to a sample of individuals. Primary data was collected through field interviews using questionnaires. Secondary data was collected from published and unpublished materials and from key respondents. Both qualitative and quantitative data was collected. A total of 120 respondents of smallholder Banana farmers from three locations participated in the study. The completed questionnaires were reviewed to determine their usability. Four questionnaires (3 from kiganjo banana growers and 1 from Kiambere) were discarded because they were incomplete. A total of 116 questionnaires were usable. Data was

collected between May and July, 2010. Table 3.1 shows the distribution of respondents in the three locations.

Table 3.1: Distribution of Respondents in 3 Locations in Gatanga District

Division	**Location**	Name of group	Membership	Responded selected
Kariara	Gatura	Mugaka S.H.G	21	10
		Mwagu S.H.G	22	11
		Kiganjo Banana growers	56	25
Gatanga	Kigio	Ithang'arari Wendo	21	10
		Wakio S.H.G	16	8
		Kabui	26	13
Kihumbuini	Kigoro	G2 S.H.G	18	9
		Kiambere S.H.G	40	19
		Mununga Umoja	23	11
Total Number of Respondents				**116**

Source: Author's Field Survey, 2010

Objective 1: To identify ICTs used in production and marketing of bananas by small-scale farmers in Gatanga District.

A universe of ICT was collated. The respondents were asked which ICTs were accessible to them for the purpose of obtaining banana production and marketing information and responses tabulated.

Objective 2: To determine factors influencing intensity of use of ICT tools in small-scale banana production in Gatanga District.

Study participants were asked to respond to some selected social economic factors such as age, income levels, Gender, acreage under bananas, education level and

marital status among others. A list of possible socio-economic factors were listed and the respondents asked to indicate how each influence their use of ICT in receiving agricultural information; from very serious=3, serious=2 Not serious=1. A mean score of below 2 was taken as not serious constraint and a mean score equal to 2 and above was taken as serious constraint to effective use of the ICT (Sonnenwald *et al*, 2001, Agwu 2008, Ekanem *et al*, 2008,).

Objective 3: To assess whether use of ICT has a significant influence on adoption of Tissue Culture bananas.

To evaluate whether use of ICT use has any influence in adoption of Tissue Culture bananas, participants were asked whether the respondent planted suckers from Own-Farm/Fellow-farmer=0 or Tissue Culture = 1 from Kenya Agricultural Research Institution (KARI), Jomo Kenyatta University of Agriculture (JKUAT) and Aberdares Technologies. These organizations work in collaboration with African Harvest to produce and distribute certified Tissue Culture banana suckers to farmers.

To evaluate the farmers' opinion on ICTs, they were asked to state in their own opinion, the extent to which each of the listed ICT tools had helped them on issues pertaining to Banana production and marketing with end points such as; 'to great extent' and 'moderate extent' ' to small extent' and 'not at all' was applied. 4=Great extent, 3= moderate, 2=small extent, 1=Not at all. A mean score was taken and a score of more than 2.5 was considered having the greatest influence.

3.6 Data Analysis

A coding scheme for the questionnaire was developed. Data entry was done by SPSS. Descriptive analysis was done using SPSS and Excel computer programmes while quantitative analysis was done by STATA software.

3.7 Empirical Models

3.7.1 Intensity of use of ICT tools: Statistical modelling of count data

Intensity of use of ICT tools in this study refers to total numbers of ICT tools used by a farmer for receiving and/or seeking information for banana production and marketing. Farmers access various information sources to improve productivity and marketing efficiency for their bananas. The number of ICT tools used (intensity of use) assume integer values of discrete nature and is nonnegative count variable. Poisson and negative binomial regression models have become the standard models for the analysis of response variables with nonnegative integer (Green, 2008).

According to Green (2003), models for count data are much closer to regression models than other discrete choice models. This is because just like OLS(Ordinary Least Square) (Gauss Markov theorem) optimality conditions can be derived from the Poisson regression model and that violation of variance assumptions in both models does not necessarily result in inconsistent estimators but rather the coefficient estimates are inefficient and standards errors are potentially biased (Wooldridge, 2002).

Examples of models normally used to analyze count data include: the Poisson Regression Model (PRM), the Negative Binomial Regression Model (NBRM), the

Zero Inflated Poisson (ZIP) and the Zero Inflated Negative Binomial (ZINB). The last two (ZIP and ZINB) are used to account for the frequency of zero counts i.e. when there are more zeros than would be expected in either Poisson or Negative Binomial model, which is not the case in this study. Only PRM and NBRM are discussed since the response variables were nonnegative integers and with only a few zero counts.

3.5.1.1 Poisson regression

Poisson regression model is normally the first step for most count data analyses (Areal *et al.*, 2008). The model makes an 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

$\lambda(x) \equiv E(y|x)$ ..... (1)

$$f(y_i|x_i) = \frac{e^{-\lambda(x)}\lambda_i(x)^y}{\Gamma(1+y_i)} \quad \text{..... (2)}$$

Where $\lambda_i = \exp(\alpha + X'\beta)$ $y_i = 0,1,...,i$

Poisson regression model 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' (Green, 2003; 2008). The Poisson regression model is derived from the Poisson distribution by introducing parameters into the relationship between the mean parameter λ_i and predictor variables (covariates) x. Previous work on count data analysis has shown that the expected number of events (total number of tools used) over time is given as (Green, 2003; Green, 2008)

$E(y_i|x_i) = \text{var}[y_i|x_i] = \lambda_i = \exp(\alpha + X'\beta)$ For i = 1, 2... n. ..... (3)

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 (Green, 2008). The log-linear (also referred to as multiplicative) regression models accounts for the nonnegative restriction imposed by Poisson on the dependent variable (Winkelmann and Zimmermann, 1995).

The merits of Poisson regression are outlined by Winkelmann and Zimmermann (1995) as: (a) it takes into account the nonnegative and discrete nature of the data (b) the assumption of equality of the variance and conditional mean accounts for the inherent heteroscedasticity and skewed distribution of nonnegative data, (c) the log-linear model allows for treatment of zeros. Empirically it is easier to estimate the parameters of Poisson regression model using maximum likelihood techniques.

3.7.1.2 Application of Poisson regression

The Poisson regression model has found application in the various studies. Famoye *et al* (2004) used Poisson regression to model the relationship between the number of accidents and drivers' demographic factors, driving habits and medication use by drivers. Parodi and Bottarell (2006) applied it to veterinary epidemiological studies while another study by Zurbrigg *et al* (2005) used the model to analyze the relationships between tie-stall designs and selected cow-based injury, lameness, and cleanliness measurements. Okello *et al* (2007) used the Poisson regression model 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. The model has also been used by Gitonga (2009) to study factors influencing number of control strategies used by smallholder Snow peas farmers in Kenya.

3.7.1.3 Limitations of Poisson regression

Limitations of the suitability of Poisson regression model in empirical work have long been recognized in literature. Restrictions imposed by the model on the conditional moments on the dependent variable in most cases violate its application given that the observed data will most likely display overdispersion (Wooldridge, 2002; Green, 2008). Berk and MacDonald (2007) define overdispersion as the excess variation when the systematic structure of the model is correct. It therefore assumes absence of omitted variables or other errors in the systematic part of a model. Two assumptions of the Poisson regression model give rise to overdispersion. The first assumption that the Poisson process is a deterministic function of the predictor variables does not allow for the unobserved heterogeneity.

$$E(y_i|x_i) = \text{var}[y_i|x_i] = \lambda_i = \exp(\alpha + X'\beta) \quad \text{..... (4)}$$

The second assumption that events constituting each count are independent (Berk and MacDonald, 2007) and occur randomly over time ignores the fact that present occurrences can influence the probability of future occurrences. For example, if we assume that farmers are continuously appraising various ICT tools, the effectiveness of current channel might influence farmer's decision on its use in future. The consequences of overdispersion in the data are larger variance of the coefficient estimates than anticipated under the Poisson regression. This results in inefficient, potentially biased parameter estimates and spuriously small standard errors (Wooldridge, 2002; Xiang and Lee, 2005).

Violation of the above two assumptions can also lead to underdispersion where the variance is less than the conditional mean. Underdispersion results if the events constituting the counts are negatively related (Berk and MacDonald, 2007). This has

the same effect as overdispersion. To address the problem of overdispersion or underdispersion, the negative binomial variant of Poisson-based regression model is used (Famoye *et al.*, 2005; Berk and MacDonald, 2007; Green, 2008).

3.7.1.4 Negative binomial regression

Functional form for the negative binomial regression model relaxes the equi-dispersion restriction of the Poisson model (Green, 2003; 2008). It also takes care of any model misspecification (Berk and MacDonald, 2007). The introduction of gamma-distributed stochastic term in the conditional mean of the deterministic Poisson regression accounts for the inherent unobserved latent heterogeneity (Green, 2007; 2008). Negative regression allows variance to exceed the mean.

Following Green (2007), the negative binomial model can be presented as:

$$E(y_i|x_i,\varepsilon) = \exp(\alpha + X'\beta + \varepsilon) = h_i\hat{\lambda}_i \quad \text{.....5}$$

Where

$h_i = e^{\varepsilon}$ is assumed to have a one parameter gamma distribution, G(θ, θ) with mean 1 and variance 1 / θ = κ;

The model requires that, $Var(y_i|x_i) = [1 + \alpha \exp(X'\beta)]\exp(X'\beta)$ where X' is a vector of explanatory variables like the one used in section 2.4.1

In presence of under-dispersion or over-dispersion, the estimates of Poisson regression are inefficient and biased which leads to the invalidation of inference based on the estimated standard errors (Famoye *et al.*, 2005; Cameron and Trivedi, 1996). Consequently, negative binomial regression was fitted and used for comparison. The functional form for the negative binomial regression model relaxes the equidispersion

assumption of the Poisson model and takes care of any model misspecification (Green, 2008).

3.7.2 Factors Influencing Adoption of Tissue Culture Bananas

Applicable to a broad range of research situations, logistic regression analysis can be applied where the dependent variable is of dichotomous nature. The coefficient of the regression can be used to estimate the odds ratios for each of the independent variables included in the model (Ekanem *et al*, 2008).The binary-choice model to be estimated as

(1) Prob(event j occurs) = Prob(Y= j)=F(relevant effect: parameters).

In our model, the respondent either plants TC bananas(Y=1) or does not(Y=0). The general model can be re-written as

(2) Prob(Y=1)=F(β'x),

(3) Prob(Y=0) = 1-F(β'x)

The set of paremeters, β, reflect the impact of changes in the independent variable x on the probability. A linear expression of the form F(x, β) = β'x will be estimated. Since E[y/x] =F(x, β), we use a regression model of the form

(4) Y = E[y/x] = (y – E[y/x]) =β'x + ε, where ε is the disturbance term.

According to Ekanem *et al* (2008), the marginal effect in probability terms can be calculated as

(5) $\delta y/\delta x$ (Prob (Y =1/x) =$\beta^* [e^{-x\beta} /(1 + e^{-x\beta})^2]$

The most commonly used approaches to such dependent variable regression models are (1) the linear probability model (LPM), (2) Logit and (3)Probit. They have been used in a variety of studies (Gujarati, 2004). Logit and Probit are preferred because they guarantee that the estimated probability lie between the logical limit of 0 and

l(Wooldridge, 2002). Many researchers choose the logit model because of its comparative mathematical simplicity. Sirak and Rice(1994) argues that logistic regression is powerful, convenient and flexible and is often chosen if the predictor variables are a mix of continuous and categorical variables and/or if they are not normally distributed.

In this study we apply binary logit model to determine whether use of ICT influences adoption of TC bananas because the dependent variable was dichotomous in nature and some of the predictor variables are a mix of continuous and categorical.

3.8 Outputs

ICTs used in production and marketing of bananas by small-scale farmers in Gatanga District were indentified. Socio-economic factors like age, education level, gender and income levels that influence use of ICT by smallholder farmers were determined. Major constraints in effective use of these communication technologies in accessing market and production information on bananas were identified. Influence of ICT to adoption of TC bananas was determined.

3.9 Variables

3.9.1 Dependent Variables Used in the Study

The dependent variables used in the study were adoption of TC bananas i.e. respondent plants tc banana or does not, and the intensity of ICT used i.e. the total numbers of ICT tools used by the respondent. The ICT tools include radio, television, video, print media among others used by smallholder banana farmers in Gatanga District. This count variable considered the total number of ICT tools used for seeking or receiving information on bananas

3.9.2 Independent Variables Used in the Study.

The Independent variables used in the study were some selected socio-economic characteristics of the farmers that were hypothesized not to influence intensity of use of ICT tools. The socio-economic characteristics of the farmer included age, gender, education level, acreage of bananas planted and income levels of the respondents among others.

Table 3.2: Recorded dependent and Independent variables used in estimating PRM and Logistic Regression

Variables	**Variable Description**
Dependent variable • Intensity of ICT tools used • Adoption of TC bananas	Total number of ICT tools used for banana information [0, 1, 2, 3…] Plants TC suckers=1,Ownfarm/fellow farmer=0
Independent variables	
Age	Age of respondent in years
Gender	Gender of respondent [male=1,female=0]
Maritalst	Marital status of respondent [married=1, otherwise=0]
YearEduc	Years of education completed [Secondary/tertiary=1,upto primary=0]
Income	Income level of respondent[≥15,000=1,<15,000=0]
InIncome	Natural log of Income(KES)
Use of ICT	Use of at least one ICT tool for banana information(Yes=1, No=0)
Acreagebanana	Acres of bananas planted (Acres)
DistAgricOffic	Distance to nearest Agriculture office(in KM)

CHAPTER 4

4.0 RESULTS AND DISCUSSION

4.1 Introduction

The chapter examines socio-economic characteristics of the respondents and the existing ICT commonly used by smallholder banana farmers in Gatanga District to seek and/or receive information on banana production. Socio-economic factors that influence farmers' use of these ICT were analyzed and determined. Poisson Regression (RP) and Logistic Regressions models were then used to test hypotheses that socio-economic factors like gender, income levels and education do not influence the intensity of use of ICT tools in banana production and that use of ICT has no influence on adoption of TC bananas respectively.

4.2 Socio-economic characteristics of the Respondents

Descriptive analysis of the data collected showed that most of the respondents interviewed had less than 0.4 hectares of bananas (97.4%), indicating that they were small-scale banana farmers whose main occupation was farming (78.4%). The age range was between 32 and 76 years with average age of 52.4 years. Educational attainment of the respondent cut across all levels with the majority having completed primary (27.6%), secondary level (19.0%), tertiary/college (18.1%) and only 1.7% had University education (Table 4.1).

Table 4.1: Respondents Characteristics (Responses to survey Questions)

Variable	Percentage
House Hold position	
Head	62.9
Spouse	30.2
Others (son/daughter/farm manager	6.9
Gender	
Male	57.8
Female	42.2
Marital status	
Married	84.5
Single	6.9
Widow	8.6
Ages of Respondents	
Minimum	32yrs
Maximum	76yrs
Mean	52yrs
Educational attainment	
None	5.2
Primary incomplete	15.5
Primary complete	27.6
Secondary incomplete	12.9
Secondary complete	19.0
Tertiary/college	18.1
University	1.7
Banana acreage (min. max. mean):Less than 1 acre	97.4
More than 1 acres	2.6
Off farm income	
Yes	51.7
No.	48.3
Occupation	
Farmer=1	78.4
Business/informal employment=2	14.7
Formal employment=3	6.9
Income levels : <5000	44.8
5000<10,000	28.5
>10,000	36.4
Distance to nearest agriculture office: <3km	74.1
4 < 10 km	15.4
10< 15 km	10.5
Distance to top up point for mobile phone: within 3km	99.1
4km	0.9
Distance to the nearest internet service: Within 4km	7.7
With modem/internet-enabled phone	2.6
Between 10-40km	87.7
Nearest electricity charging point	
With power at home	57.8
Within 3km	42.2
Price of banana price/bunch: Kshs150-200	58.6
KShs 200-350	41.4

Source: Author's Field Survey. Based on actual responses to questions, 2010

4.3 Existing ICT Available to Small-scale banana farmers in Gatanga District.

Table 4.2 shows various ICT tools available to smallholder banana farmers in Gatanga District, the degree of ownership, accessibility and use. The results shows that majority of the respondents interviewed own Radio, Television and mobile phone at 91.4%, 57.8% and 80.2% respectively. All the respondents accessed radio and a large number accessed Television (72.4%) and mobile phone (91.4%). The results indicate that 83.6%, 19.8% and 31% use Radio, Television and Mobile phones respectively as a source of information on production or/and marketing of their bananas. This study confirms Kiplang'at and Ocholla (2005), Farooq *et al* (2007) and Ovwigho *et al* (2009) findings that Radio and Television were used widely by agricultural researchers and extension workers to disseminate agricultural information to the farming community. The most common FM Radio stations broadcasting agricultural programmes in the local language includes *Inooro* (*Mugambo wa murimi* "voice of the farmer'), *Kameme* (*Kenyu na Kenyu* 'Piece by piece') and *Coro* (featuring programmes by Agro-chemical companies and Ministry of Agriculture). Radio, television and mobile phones are commonly used probably due their affordability, availability, portability and durability.

The least accessible ICTs were computer (9.5%), internet services (12.1%) and video cassette (13.8%), which was never used for getting information on banana production and marketing. Most farmers lacked requisite skills and physical access to internet and computer related services, inferring Kiplang'at and Ocholla (2005) observation that most extension workers relied entirely on printed source of information such as pamphlets, brochures and posters to obtain and disseminate agricultural information. None of the respondents owned digital camera, although 4.3% had access but never

used it for issues concerning bananas. Digital camera could be useful in capturing real crop pictures in farmer's fields for use by extension workers to advise farmers at office or desk information centers without necessarily visiting the farms to see the crops physically, this decreases extension cost and increase efficiency.

Table 4.2: Ownership, accessibility and use of Information Sources for Banana production and Marketing

	Type of Information source	Ownership	Access	Used for Banana info
1	Radio	106(91.4%)	116(100%)	97(83.6%)
2	Television	67(57.8%)	84(72.4%)	23(19.8%)
3	Mobile phone	93(80.2%)	106(91.4%)	36(31%)
4	Newspaper/magazine	28(24.1%)	55(47.4%)	23(19.8%)
5	Computer	2(1.7%)	11(9.5%)	0
6	Digital camera	0(0%)	5(4.3%)	0
7	Internet(www)services	3(2.6%)	14(12.1%)	0
8	Video cassette/DVD	9(7.8%)	16(13.8%	0

Source: Author's Field Survey 2010, Based on sample size n=116, 1=Yes, 2=No.

4.4 Socio-economic factors that influence Farmers' use of ICT in production and Marketing of Bananas.

In this section a summary of how farmers use ICT sources to obtain information on banana production and marketing is given using frequencies and percentages (Table 4.3). The means of factors that influence this pattern of use are identified and discussed. Cross tabulations and chi-square tests are applied to check for any statistical relationship between some selected socio-economic characteristics of the farmers and use of ICT tools.

Table 4.3: Summary of ICT Users and Non Users in Banana production and marketing

S/No	ICT	Users		Non Users	
		Frequency	%	Frequency	%
1	Radio	97	83.6	19	16.4
2	Television	23	19.8	93	80.2
3	M/phone	36	31	80	69
4	Print media	23	19.8	93	80.2
5	Digital camera	0	0	116	100
6	Internet services	0	0	116	100
7	Video cassette	0	0	116	100
8	Internet	2	1.7	114	98.3

Source: Author's Field work 2010, n=116

4.4.1 Socio-economic factors that influence Farmers' use of ICT

The focus of the analysis is to investigate factors influencing intensity of use of ICT tools by small holder banana farmers. Cross tabulation and Chi-square test were used to establish whether there were any relationships between selected socio-economic variables and use of a particular type of ICT tool.

4.4.1.1 Age and Use of ICT

Table 4.4 show that age was found to have a significant influence on use of ICT for information on bananas at 5% level of significance ($P<0.05$). Majority of users were found among the young group, and decreased with the elderly. Of those who used radio, 42.2% were less than 50 years old, 22.4% were between ages 51 and 60 years and 19% were above 60 years old. Television use, 9.5% were less than 50 years, 8.6% between 51 and 60 years and only 0.9% above 60 years old. Use of mobile phone also followed the same pattern, with 12.1% aged less than 50years, 10.3% between 51 to 60 years and 8.6% above 60 years. Print media users presented a slightly different pattern with 6.9% of those using were less than 50 years old and 8.6% above 60 years.

These could be farmers who have retired from formal employment and preferred using print media as a source of information.

Table 4.4: Ages and Use of ICT

ICT tool	% of Users			% of Non- Users			**X^2	P-Value
	Age(yrs)			Age(yrs)				
	<50	51-60	60+	<50	51-60	60+		
Radio	42.2	22.4	19	6.9	5.2	4.3	55.2	0.002*
Tv	9.5	8.6	0.9	38.8	19	21.6	54.1	0.003*
M/phone	12.1	10.3	8.6	37.1	17.2	14.7	55.9	0.002*
Print media	6.9	4.3	8.6	42.2	23.3	14.7	73.2	0*

Source: Author's Field work 2010 [* P≤ 0.05)] **X^2=Chi-square

4.4.1.2 Gender and Use of ICT

Table 4.5 shows that gender was found to influence use of Radio and Television. The calculated P-value of 0.001(Radio), 0.026(Television) and 0.004(Print media) at 5% level of significant indicate that there is a positive and significant relationship between Gender and use of these tools. Of those who used radio, 54.3% were males and 29.3% were females. 15.5% of males used television compared to only 4.3% of Females. Gender had no significance influence to use of mobile phone. The calculated P-value of 0.143(mobile phone) indicate that there was no significant relationship between gender of the respondents and use of mobile phone at 5% level of significant. This is in contrast with a study by Masuki *et al* (2010) in South West Uganda who found that more male farmers (59.3%) made use of mobile phone than female farmers

(40.7%). The difference could be due to the respondents in the two regions and type of information in question for the two studies.

Table 4.5: Gender and Use of ICT

ICT tool	% of Users		% of Non-User		**X^2	P-Value
	Gender		Gender			
	Male	Female	Male	Female		
Radio	54.3	29.3	3.4	12.9	11.03	0.001*
Tv	15.5	4.3	42.2	37.9	4.94	0.026*
M/phone	21.6	9.5	36.2	42.2	2.14	0.143
Print media	15,5	29.3	42.2	37.9	8.21	0.004*

[* $P \leq 0.05$] **X^2 = Chi-square

4.4.1.3 Educational Attainment and Use of ICT

Table 4.6 shows that education had influence on the use of radio, television and print media. For radio, those who had had no formal education were 5.1%, Primary 41.1%, Secondary 27.6% and Tertiary 12.9%. Television users with no formal education were (0%), primary (6.9%), Secondary (9.5%) and Tertiary (3.4%). Print media users with no formal education were (0%), primary (1.7%), Secondary (6.0%) and Tertiary (9.5%). The calculated P-value of 0.016(Radio), 0.003(Television) and 0(Newspaper) at 5 % significant level indicate that there is a significant and positive relationship between the ICT tools and education attainment. This agrees with Lio and Liu (2004) who found that education level and skills are a prerequisite for use of modern ICT to increase agricultural productivity. Use of mobile phone cut across all levels of education and had no influence as indicated by a P-Value of 0.383. Mobile phones

only require basic literacy and therefore are accessible to a large portion of the population (Masuki *et al*, 2010).

Table 4.6: Educational Attainment and Use of ICT

ICT tool	% of Users				**X^2	P-value
	Education Level					
	N/Formal	Primary	Secondary	Tertiary		
Radio	5.1	41.4	27.6	12.9	15.97	0.016*
Tv	0	6.9	9.5	3.4	19.75	0.003*
M/phone	2.6	12.1	10.3	6.0	6.37	0.383
Print media	0	1.7	6.0	9.5	27.32	0*

[* $P \leq 0.05$] **X^2=Chi-square

4.4.1.4 Income Level and Use of ICT

Table 4.7 shows that use of radio, television and print media was influenced by income levels. 37.1% of the respondents who used radio had income of <Kshs 5000, 31.1% had income between Kshs 5000-10,000 and 31.9% had income levels >Kshs10, 000. Television users were 10.3% (<Kshs 5000), 1.7% (Kshs 5000- 10,000) and 7.8% (>Kshs10, 000). The same trend was shown by print media users 2.6 %(< Kshs5000), 3.4% (Kshs5000-1000) and 12.1% (>Kshs 10,000). The p-values of 0(Radio), 0.041(Television) and 0(Print media) indicate that there is a positive and significant relationship between these ICT tools and income levels. The high number of radio users (37.1%) by low income group is because many people are able to access radio information from neighbors or other social places without necessarily

owning one. Income levels do not affect use of mobile phone, probably because of the availability of various mobile phones and airtime on the market at affordable prices.

Table 4.7: Income Level and Use of ICT

ICT tool	% of Users			**X^2	P-value
	Income level				
	< 5000	5000-10000	>10,000		
Radio	37.1	31.0	31.9	42.99	0*
Tv	10.3	1.7	7.8	27.08	0.041*
M/phone	9.5	11.2	10.3	24.97	0.070
Print media	2.6	3.4	12.1	49.66	0*

[* $P \leq 0.05$] **X^2= Chi-square

4.5 Test of hypotheses

4.5.1 Determinants of intensity of ICT tools used.

In order to determine the factors conditioning the number of ICT tools used by smallholder banana farmers, the study used Poisson Regression (PR) and Negative Binomial Regression (NBR) Techniques. These count variable models are suitable for dependent variables that are countable and finite like the number of ICT tools used by smallholder banana farmers for information.

Table 4.8 shows the output of both PR and NBR models that were fitted on the data. The results did not show any significant difference, an indication of equi-dispersion, meaning that Poisson binomial regression model can be assumed to be appropriate in modeling the data. The p-value showed that the data fitted well in the model. The

results of robust regression showed similar trend (Appendix IV). Robust regression provides stable and reliable results in the presence of outliers by limiting their influence (Finger and Hediger, 2008). Therefore the following discussion is based on Poisson and robust regression model.

The result shows that p-value for gender (0.003), income (0.027) and banana acreage (0.095) were significant at 5% and 10% significant level respectively. The result for robust regression showed similar results, i.e. gender (0), income (0.012) and banana acreage (0.021). The results show that males were more likely to use more ICT tools as a source of information on bananas than female. Those with income of KShs 15,000 and above per month were more likely to use ICT as a source of information on bananas than those with income of less than KShs 15,000. Intensity of use of ICT tools increased with increase in the acreage of banana planted. The null hypothesis should therefore be rejected and the alternative accepted that socio-economic factors mainly have influence on the intensity of use of ICT tools as a source of agricultural information by smallholder banana farmers.

The significant relationship between gender and use of ICT as a source of information for banana production is due to the fact that men have more free time to listen/watch radio and television agricultural programmes. Women on the other hand are engaged in domestic chores and other productive activities leaving them with very little time to tune in. This is supported by the earlier findings that men who use radio and television were 54.3% and 15.5% compared to women users of 29.3% and 4.3% respectively.

Income directly determines ability to purchase and own ICT tools. The higher the income, the higher the purchasing power of ICT tools and hence the higher the number and frequency in use of these tools for agricultural information. The more acreage of bananas planted means that the farmer is motivated by the income received from sell of bananas. He/she is encouraged to seek information on production and marketing from various sources. This study partially agrees with Wejnert (2006) that use of a particular type of ICT tool depends more on economic variables than on socio-demographic variables like gender, marital status and education level.

Table 4.8 Results of Poisson Regression Model

Definition of Variables	**Poisson regression model**		**Negative binomial model**	
Dependent variable- Intensity of ICT use	Coefficient	p-value	Coefficient	p-value
Independent Variables				
Age	-0.0064296	0.389	-0.007948	0.285
Gender	0.5096335	0.003*	0.5468067	0.002*
Marital Status	0.1342787	0.803	012368	0.798
Education	0.229894	0.661	0.134568	0.783
Income(ln)	0.4185542	0.027*	0.0314436	0.022*
Distant to Agric. Office	-0.01677796	0.519	0.0000157	0.021
Distance to Internet	0.0103656	0.214	-0.0150441	0.525
Acreage of Bananas	0.2393224	0.095**	0.0531012	0.091**
Source of Suckers	0.3693907	0.111	0.307958	0.170
Constant	-0.2569166	0.621	-0.0860652	0.864
	No. of Obs.=116 LR chi2(10)=23.9 Prob. > chi2=0.012 Pseudo R2 =0.069 Log likelihood = -161.665		No. of Obs.=116 LR chi2=22.4 Prob. >chi2 =0.013 Pseudo R2 =0.064 Log likelihood =-161.30523	

Source: Author's Field work, 2010 * **significant at 5% and 10% confidence level

4.5.2 Influence of ICT on adoption of Tissue Culture bananas

In order to examine factors influencing adoption of TC bananas, a binary dependent variable of 1 if the respondent plants TC bananas, 0 otherwise was used to fit a logistic regression model. Robust regression was done to compare the outcome. The results of the fitted regression model and robust regression are presented below (Table 4.9).

Table 4.9

	Logit Regression		**Robust Regression**	
Dependent Variable-Plants TC bananas	Coefficient	p-value	Coefficient	p-value
Independent variables				
Age	0.0774289	0.039	.0774289	0.070
Gender	-1.487708	0.093	-1.487708	0.131
Marital status	-0.7128584	0.461	-.7128584	0.495
Education	-0.8783833	0.001*	-.8783833	0.006*
Income	2.256187	0.002*	2.256187	0.009*
Banana acreage	-1.749246	0.008*	-1.749246	0.009*
Use of ICT	0.8423881	0.026*	.8423881	0.025*
Constant	-22.78967	0.002	-22.77595	0.004
	No of obs. =116 LR chi2 =29.84 Prob > CHI2 =0.001 Pseudo R = 0.3340 Log likelihood = -29.748186		No of obs =116 Wald chi2(7) =20.76 Prob.> chi2 =0.0041 Pseudo R2 = 0.3340 Log likelihood= -29.748186	

Source: Author's Field work, 2010 *P≤ 0.05

The second hypothesis stated that Use of ICT has no influence on adoption of Tissue Culture bananas. Logistic regression results (Table 4.9) yield a p-value of 0.026(0.025 for robust). We therefore reject the hypothesis that Use of ICT has no influence on adoption of TC bananas at 5% and 10% significant levels. A unit increase in frequency of use of ICT increases adoption rate of TC bananas by 84%. The result shows that farmers who use ICT for information on bananas are aware of the availability and advantages of growing TC bananas and therefore willing to purchase the suckers and plant. Promoters of TC banana biotechnology have used various ICT tools including mass media to promote the technology.

The p-values for income (0.002) banana acreage (0.008) and education (0.001) influenced adoption of TC bananas at 5% significant level. Respondents with high income have the ability to travel and purchase TC suckers from research institutions that promote TC biotechnology. The positive coefficient indicates that a unit increase in income increases adoption of TC bananas significantly. The negative coefficient for acreage of bananas planted indicate that a unit increase in acreage planted reduces adoption rate of TC bananas by 17%. This could be that respondents with larger acreage have adequate planting material on their farms and therefore less willing to purchase TC planting material.

4.6 Constraints to Use of ICT by Banana Farmers

The study participants were asked to indicate constraints that influence their use of ICTs in receiving agricultural information, from very serious=3, serious=2 Not serious=1, 0='Not applicable to the respondent/refused to answer'. The constraints indicated were Lack of money to buy the ICT tool, cost of batteries, lack of

electricity, irrelevant content, and wrong time of the programme and low level of education. The ICT tools in question were: Radio, Television, mobile phone, print media, Computer, digital camera, internet and Video cassette/DVD. Mean constraint values were calculated after 0='Not applicable to the respondent/refused to answer' were eliminated. A mean score of below 2 was taken as not serious constraint and a mean score equal to 2 and above was taken as serious constraint to effective use of the ICT tool.

The result in Table 4.10 show that Internet services (2.7069), digital camera (2.6638) and computer (2.6379) had the highest score for constraint to use of ICT tool. Distance to internet service could have been another constraint since 87.7% of the respondents were 10-40km away from the nearest internet service (Table 4.1). This study partially agrees with Ovwigho *et al* (2009) findings that major constraint to use of ICT is limited access to computer and rural poverty. Interestingly lack of money to buy Radio and mobile phone was not a constraint with least score of 1.0862 and 1.5172 respectively. The low score for radio and mobile phone could be attributed to the existence of a wide range of these two tools on the market at affordable prices. Electricity posed the least challenge to use of mobile phone (1.0086), radio (1.1466) and all other ICT tools, which agrees with the study finding that 57.8% of the respondents had electricity in their homes while the rest had it within 3km of their homesteads (Table 3). A detailed constraint ranking is provided in Table 4.10

Table 4.10: Mean Responses for Constraint to use of ICT for information on Bananas

	Constraint	Type of ICT equipment	Likert scale	
			Mean response	Std deviation
1.	Lack of money to buy ICT tool	Radio	1.0862	.33800
		Television	1.5172	.82865
		Mobile phone	1.1552	.44922
		Print media	2.0431	.77339
		Computer	2.6379	.69026
		Digital Camera	2.6638	.65864
		Internet(www) services	2.7069	.72252
		Video cassette and DVD	2.6724	.64303
2.	Cost of batteries	Radio	1.0948	.34837
		Television	1.3534	.71328
3.	Lack of electricity	Radio	1.1466	.46165
		Television	1.6195	.79416
		Mobile phone	1.0086	.09285
		Digital Camera	1.1638	.50980
		Computer	1.7759	1.00508
		Internet(www) services	1.7241	1.01798
		Video cassette and DVD	1.8017	.94381
4.	Lack of money to buy air time	Mobile phone	1.1034	.40388
		Internet(www) services	2.4224	.89589
5.	Irrelevant content	Radio	1.3966	.72086
		Television	1.5603	.74936
		Newspaper/magazine	1.8276	.70125
		Computer/Internet(www) services	2.0259	.89890
6.	Wrong time of the programme	Radio	1.3879	.73154
		Television	1.7241	.80850
7.	Low level of education	Print media	1.6034	.70870
		Internet/computer	2.5690	.66233

Source: Author's Field work, 2010.Based on sample size n=116, Mean response ≥2 indicate serious constraint while < 2 indicate not serious constraint to use of ICT.

4.7 Influence of ICT Use to Banana yields

The study revealed that respondents who use ICT as a source of information on bananas had high yields compared to non users. Radio, television and mobile phone users harvested 15, 17 and 16 bunches compared to 4, 13 and 12 bunches of bananas per month respectively in 0.1ha (fig.4.1). The finding concurs with Lio and Liu (2005) and Davis (2008) who indicated that there is a significant relationship between ICTs adoption and agricultural productivity.

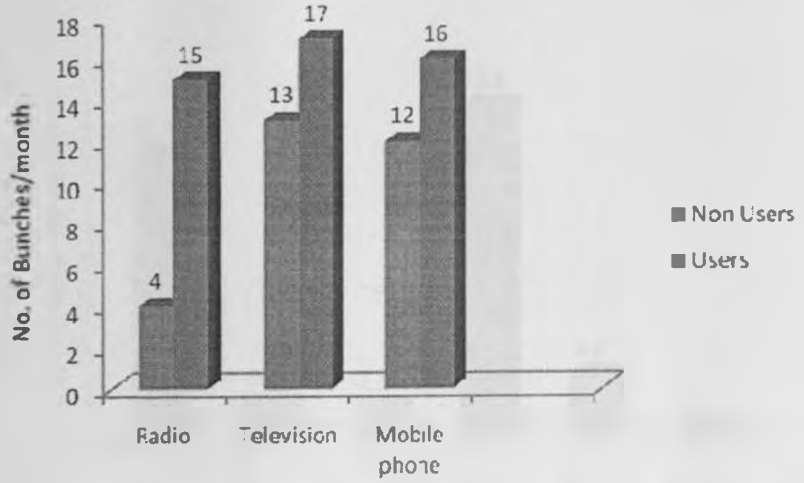


Fig 4.1: Comparison of ICT Users for banana information and Mean yield of bananas

4.8 Main sources of Production Information for banana farmers

Respondents were asked to respond to a numbers of information sources on banana agronomic practices and varieties. Those who said they received from Neighbors/fellow farmers were 40.5% and those who said they received from extension staff were 28.4%. Neighbors/fellow farmers (43.1%) and extension staff (37.1%) played a major role in dissemination of information on banana varieties while the least important was middlemen (1.7%), radio (4.3%) and visits to research stations

8.6%) (See fig 4.2). This result is in line with Farooq (2007) findings which stated that important sources of agricultural information to farmers in Pakistan were fellow farmer (100%), extension field staff (67.5%) and radio (40.8%). The big disparity in use of radio as a source of information could be because the current study was specific to bananas and/or because of different extension strategies in the two countries. The results indicate that majority of farmers still prefer receiving agricultural information through face-to face and regular visits by extension workers, agreeing with Lwande and Muchemi (2008).

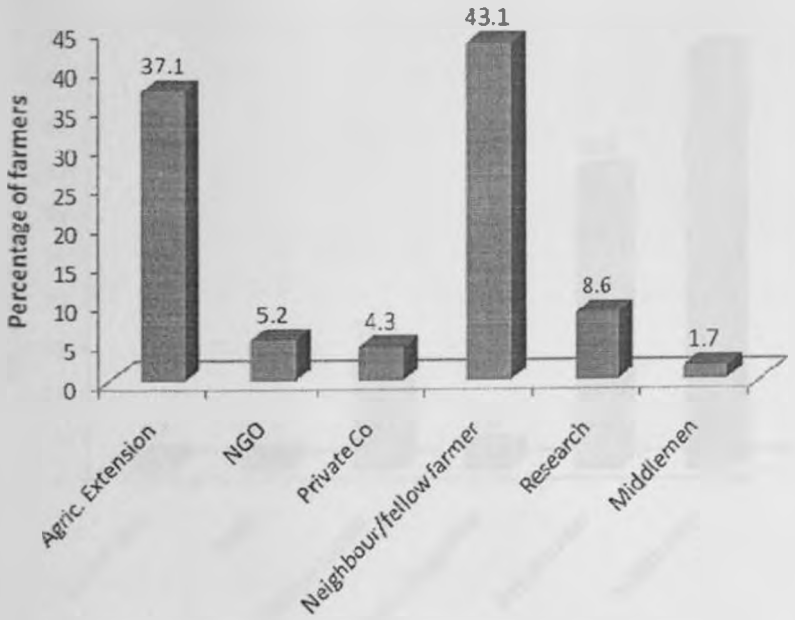


Fig 4.2: Farmers' source of information on banana varieties

4.9 ICT and Banana market Information

Figure 4.3 show that middlemen and traders accounted for 81% of market price information to small scale banana farmers, while a neighbor/fellow farmer provides 12.9% of market price information. The study indicates that small holder farmers lack

timely and adequate information about market and therefore subject to exploitation by middlemen: this was noted in Economic review of Agriculture (Gok, 2008b) and Munyua (2008). Print media (2.6%) and Non-Governmental organizations (1.7%) provided the least information. Visits to market 86(74.1%) and Neighbors/Fellow farmer 30(25.9%) were the most important means of accessing market information. These findings indicate that farmers have not taken advantage of the modern ICT to reduce cost of transaction, increase produce sales and obtain higher prices in urban markets for their produce (Muto and Yamano, 2008).

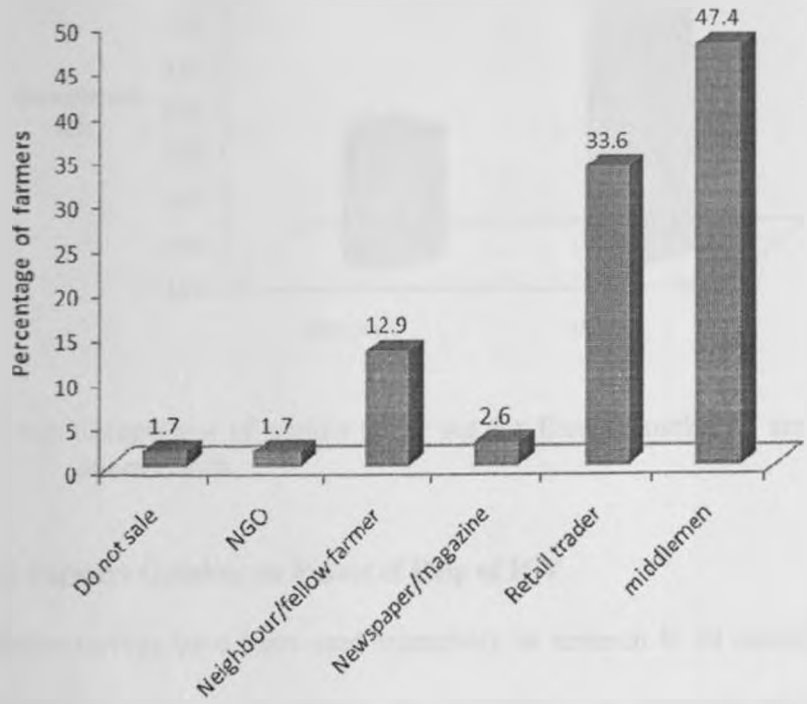


Fig 4.3: Farmers' source of banana market price information

4.10 Comparison of Banana market prices for ICT Users and non Users

In figure 4.4 the price per bunch of bananas was compared between users and non-users of ICT. It was found that users of mobile phones obtained higher prices for their bananas with a mean average of KShs 221 and KShs199 respectively. The findings agrees with Muto and Yamano (2008) who stated that use of mobile phones by banana traders in Uganda set up trading encounters, rendering produce collection more efficient and obtaining higher prices in urban markets.

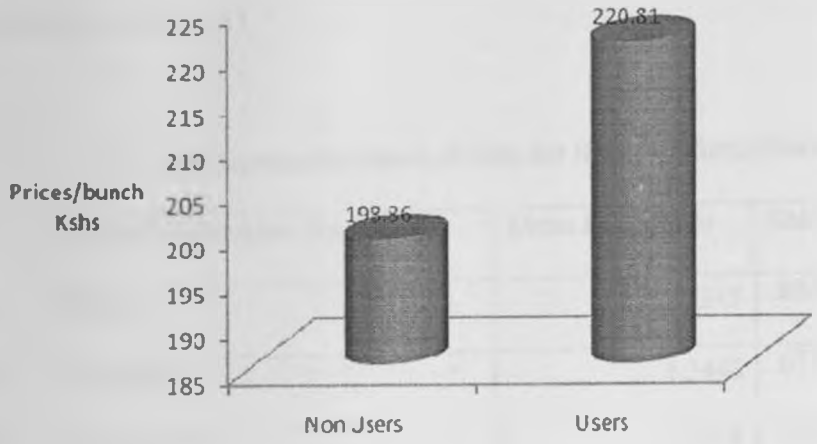


Fig 4.4: Comparison of mobile phone use for Banana marketing and mean banana prices/Bunch

4.11 Farmers Opinion on Extent of Help of ICT

Opinion surveys have been used extensively in research in all disciplines including agriculture, when used correctly; the technique can generate useful information (Ekanem *et al*, 2008). The participants were asked to rate, in their own opinion, the level of help received from different type of information sources using a 4-point Likert scale ranging as follows: 4= very great extent, 3=great extent, 2=little extent and 1=Not at all. The six sources of information were radio, television, Newspaper/magazine, internet/email, mobile phone, Video cassette/DVD.

Mean help values were calculated. Values closer to 4 would indicate great extent of help while those closer to 1 would indicate no help. Radio (2.53) provided the greatest help followed by mobile phone (1.9), while television (1.34), print media (1.28), Internet/email (1.28) and Video cassette/DVD (1.03) provided the least help as a source of information on banana production. Video cassette/DVD for repackaging extension messages to farmer and extension workers is not widely used; this is in contrast to Kiplang'at and Ocholla (2005). A detailed Extent of Help ranking is provided in Table 4.11

Table 4.11: Mean Response to Extent of Help for Banana information sources

No	Type of Information Source	Mean help values	Std Dev
1	Radio	2.5345	.88888
2	Television	1.3448	.63388
3	Print media	1.2759	.44889
4	Internet/email	1.2759	1.59666
5	Mobile phone	1.8793	.88618
6	Video cassette/DVD	1.0345	.26147

Source: Author's Field Survey, 2010, Based on sample size n=116, Mean help values close to 4 indicate great extent of help while those close to 1 indicate no help at all.

CHAPTER 5

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY

It is obvious that Extension service providers and Clients, both public and private, will increasingly apply ICT in their transactions. The exploitation of the potential of ICT in agriculture sector can play a significant role in improving agricultural productivity. The findings suggest that FM Radio stations and cellular phones have become important tools in improving small scale agriculture in rural areas.

The study reveals that smallholder farmers can access a number of ICT tools within their community. Majority of the respondents own Radio (91.4%) and mobile phone (80.2%). All the respondents accessed radio while a large number accessed mobile phone (91.4%) and television (72.4%). Of those who owned/accessed radio, television and mobile phone only 83.6%, 19.8% and 31% used them for banana information respectively. The least accessible ICT are computer, internet and video cassette. This is because of affordability and physical distance to public computer related service.

Age was found to influence use of radio, television and mobile phone as a source of information on bananas. Majority of users of these information sources were found among the younger group and decreased with the elderly. Gender was found to influence use of radio and television. Male radio users were (54.3%) compared to only 29.3% females who used radio as a source of information. 15.5% of males used television for banana information compared to only 4.3% of females. There was no

significant relationship between gender of the respondents and use of mobile phone and print media as a source of information on bananas.

Education level of respondent influenced use of radio, television and print media. Majority of radio users was found among those who had attained primary education (41.4%), fewer among those without any formal education (5.1%) and tended to decrease with attainment of higher levels of education. Those with higher education level are likely to be employed or engaged in other off farm activities and rarely get time to listen to radio.

The higher the income the less use of radio and television, however those with higher income tended to use print media as a source for information, probably because they are retired individuals from formal employment who preferred print media. The income levels had no effect on use of mobile phone as a source of information for banana production and marketing. This could be because of existence of a variety of mobile phones on the market at affordable prices.

Other constraints influencing use of ICT was lack of money to buy internet services/airtime, digital camera and computer. Money was not a constraint to use of radio and mobile phone as a source of information to smallholder banana farmers. Requisite skills and physical access to internet and computer related services were found to affect use of these ICT tools as a source of information.

The study found that use of certified planting material increased yields by 62%. Respondents who used various ICT tools as a source of information on banana

production and marketing got high yields and sold at higher prices compared to non users (see fig. 4.1 and 4.4). Individuals with large banana acreages tended to use more ITC tools than those with small acreages, probably because of motivation from high income obtained from sale of bananas and ability to purchase and own ICT tools.

5.2 CONCLUSION AND RECOMMENDATIONS

5.2.1 CONCLUSION

The study concludes that following the liberalization of the airwaves, FM Radio broadcasting in local languages, have been very effective in dissemination of agricultural information. Growth of mobile phone has been explosive, its use in provision of market links to farmers, reduction of transaction cost and use as electronic money transfer channel is increasingly becoming important. Use of ICT as a source of agricultural information improves banana productivity and market efficient resulting into increased farm income for smallholder farmers.

5.2.2 RECOMMENDATIONS

Based on the results from the study, the following recommendations should be considered in formulating policies to promote use of ICT in agriculture sector.

1. Build the capacity of extension staff and researchers by training them on repackaging of agricultural information using media such as radio, television, computer/internet and digital camera. It is expected that the skills gained will enable them use a variety of ICTs in disseminating agricultural information to farmers.

2. Reduce taxes on radio-wave licensing to encourage more FM radio stations, reduce cost of mobile phones and air time and provide subsidies to agriculture related adverts.
3. Improve accessibility to ICT services by investing in both complementary infrastructure and higher education. Complementary investment includes cheaper electricity and rural electrification, better transportation, human capital, information-oriented business processes and establishment of community ICT centers to reach the rural poor.

Further research should be contacted to find out technology-specific attributes and socio-economic factors that impede actors in agriculture sector to effectively promote and use ICTs in their day-to-day endeavor in meeting farmers' needs.

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APPENDICES

Appendix I

Information Communication Technology (ICT) Utilization by Small Holder Banana Farmers in Gatanga District, Kenya.

INTERVIEW SCHEDULE FOR FARMERS

Questionnaire.

Questionnaire No.....
Interviewers Name.....
Farmers Name.....
Name of group.....Membership.....
Date of interview.....Time .....
Location.....Village.....

Instruction to the interviewer

- Introduce yourself to the respondent
- Tell them the purpose of your visit.
- Seek their consent to be interviewed.
- If they agree, then proceed. If they say no, ask them the most appropriate day and time for the interview.
- Assure them of the confidentiality of the information they will give.

Household characteristics

1. What is your position in the family?
   Head [ ] Spouse [ ] Others [ ]

2. What is your age? .....year.

3. Sex of the respondent? Male [ ] Female [ ]

4. What is your marital status? Married [ ] Single [ ] Widower [ ]

5. What is your level of education? None [ ] Primary complete [ ] Primary [ ] incomplete Secondary complete [ ] Secondary complete [ ]
   Tertiary/ college [ ] University [ ]

6. What is the total size of your land?____.acres.
7. Do you have any off farm income? Yes [ ] No [ ]
8. What is your occupation?_____
9. What is your average income per month? KShs .....
10. Distance to agricultural field office (km)
.....
11. What is the Distance to nearest public phone service (km).....
12. How far do you repairs/charging/top-up your phone (km).....
13. What is the distance to the nearest internet service (km) .....
14. How far are you from the nearest electricity Charging point (km).....

Objective 1: To identify existing ICT available to small-scale Banana farmers in Gatanga District.

15. .Among the ICT listed below which ones do you own or are able to access. Which ones do you use to receive or seek information on banana production? **(Circle appropriately in the corresponding box).**

S/No	Type of ICT	Own		able to access		Used for receiving information on bananas	
1.	Radio	Yes	No	Yes	no	yes	no
2.	Television	Yes	No	Yes	no	yes	no
3.	Mobile phone	Yes	No	Yes	no	yes	no
4.	Newspaper/magazine	Yes	No	Yes	no	yes	no
5.	Computer	Yes	No	Yes	no	yes	No
6.	Digital Camera	Yes	No	Yes	no	yes	No
7.	Internet(www) services	Yes	No	Yes	no	yes	No
8.	Video cassette and DVD	Yes	No	Yes	no	yes	No
9.	(others, specify)	Yes	No	Yes	no	yes	No

Objective 2: To determine socio-economic factors that influence farmers' use of ICT in production and marketing of Bananas.

16. On a scale of 1 –3, how do the following constraint influence your use of ICT in obtaining production and marketing information on bananas?
(Very serious=3, serious=2 Not serious=1) Put 3, 2 or 1 in respective cells

	Constraint	Type of ICT equipment	Likert-scale		
			Not Serious =1	Serious =2	Very serious=3
8.	Lack of money to buy ICT tool	Radio			
		Television			
		Mobile phone			
		Newspaper			
		Computer			
		Digital Camera			
		Internet(www) services			
		Video cassette and DVD			
		(others, specify)			
9.	Cost of batteries	Radio			
		Television			
		Mobile phone			
		Digital Camera			
10.	Lack of electricity	Radio			
		Television			
		Mobile phone			
		Digital Camera			
		Computer			
		Digital Camera			
		Internet(www) services			
		Video cassette and DVD			
11.	Lack of money to buy air time	Mobile phone			
		Internet(www) services			
12.	Irrelevant content	Radio			
		Television			
		Newspaper			
		Computer/Internet(www) services			
		Video cassette and DVD			
13.	Wrong time of the programme	Radio			
		Television			
14.		Newspaper			
15.	Language used				
16.	Low level of education	Newspaper			
		Internet			

Objective 3: To evaluate the effects of farmers' use of ICT on adoption of improved Banana production and marketing.

17. What are your major sources of information on bananas on each of the following?

Type of information	Information Source. (Code)	Means of accessing information. (Code)
	A	B
New varieties of banana		
Market/Markets needs(quality, volume, type)		
Prevailing market prices		

Code A

1 Agricultural extension officer
2 CBO
3 NGO staff
4 Private company
5 Neighbor/Fellow Farmer
6 Agrochemical dealer
7 Research institution
8 Newspaper/magazine
9 Trader
10 middlemen/broker
11 Self
12 Others (specify)

Code B

1. Visit agricultural office
2. Visit by extension officer
3. Visit by African harvest staff
4 Newspaper/magazine
5. internet/e-mail
6. Radio
7. Television
8. Mobile phone (voice)
9. Mobile phone (sms)
10. Neighbour/fellow farmer
11. Visit by CBO staff (yard)
12. Video/DVD/CD
13. Visit to Markets
14. Visit to research station
15 Self.
16. Others (specify)

18. What is the size of your banana orchard?.....Acres
19. What is the average yield? _____ (bunches/month)
20. Do you sell some of your bananas? Yes [ ] No [ ]

If yes what is?

A	B	C	D
No. of bunches sold	Price/bunch Kshs.	Who Buys your bananas? (Codes)	What is the Mode of transport? (Codes)

21. Where do you get your suckers?

Aberdare Technologies/KARI/JUAT [ ]

Own Farm/Fellow farmer [ ]

22. What methods to you use to improve yields of your Banana?

(a)Fertility Improvement: Chemical fertilizer? Yes [ ] No [ ]

(b)Pest Control: Pesticides? Yes [ ] No [ ]

23. How do you make your business contacts?

Traveling to market [ ] Sending notes/letter [ ] sending mobile SMS [ ] e-mail [ ]

Agricultural Officer [ ] African Harvest Staff [ ]

Via mobile phone [ ] Visit by trader/Middlemen [ ] Fellow farmer [ ] Visit to market [ ]

24. From your own opinion to what extent has each helped you in issues pertaining to banana production and marketing? **(On scale of 1-4: 4=very great extent, 3=great extent 2=little extent, 1= Not at all).**

Radio [ ] Television [ ] Newspaper/magazine [ ] Internet/email [ ]
via mobile phone [ ] Agricultural officer [ ] African Harvest staff [ ]
DVD/Video/CD [ ] Research station [ ] Fellow Farmers [ ]
Others (Specify).....

THANK YOU

Appendix ii

Letter to Participating Groups

28TH, April 2010

To..... (Name of group)

Chairperson.....

Location.....

PARTICIPATION IN A BANANA SURVEY

My name is Simon O. Mwombe. I am a Masters student at the University of Nairobi. I am carrying out a Study on Utilization of Information Communication Technology (ICT) by Smallholder banana farmers in the District.

I am glad to inform you that your group has been selected to take part in the Study. A half of the members of your group members will be selected to take part in a scheduled interview on various dates between 3rd May to 28th July 2010. The purpose of this letter is to let you know and inform the members of your group to cooperate during the exercise. I assure you that the information obtained will entirely be used for study purpose and not for any other gain. The results of the Study may be availed to you on request.

Looking forward to your cooperation.

Simon Mwombe.

Appendix iii

Letter to the district agricultural officer

28th April, 2010

District Agricultural Officer

Gatanga District

Utilization of information communication technology by smallholder farmers in Gatanga District

I am a second year Masters student at the University of Nairobi taking a degree in Agricultural Information Management. I wish to carry out a study on the above mentioned area for my thesis work between May and July, 2010.

The purpose of this letter is to request for your assistance to enable me collects secondary and primary data from your office and Smallholder banana farmer groups in your District. The farmer groups are those working with your Ministry and African Harvest in promotion of banana production in the District. I may also request to use your field extension officers as enumerators for this exercise.

Looking forward for your cooperation.

Sincerely

Simon Mwombe

Appendix iv

Comparison of Poisson and Robust Regression

Definition of Variables	**Poisson regression model**		**Robust regression**	
Dependent variable- Intensity of ICT use	Coefficient	p-value	Coefficient	p-value
Independent Variables				
Age	-0.0064296	0.389	-0.0094906	0.133
Gender	0.5096335	0.003**	0.6328177	0.000
Marital Status	0.1342787	0.803	0.1220715	0.349
Education	0.229894	0.661	0.0323525	0.398
Income(In)	0.4185542	0.027**	0.2053626	0.012
Distant to Agric. Office	-0.01677796	0.519	-0.019597	0.137
Distance to Internet	0.0103656	0.214	-0.0150441	0.525
Acreage of Bananas	0.2393224	0.095*	0.2145377	0.021
Source of Suckers	0.3693907	0.111	0.2403321	0.122
Constant	-0.2569166	0.621	-1.651223	0.029
	No. of Obs.=116		No. of Obs.=116	
	Wald chi2(11)=23.9		Wald chi2(9)=52.07	
	Prob. > chi2=0.012		Prob. >chi2 =0.000	
	Pseudo R2 =0.069		Pseudo R2 =0.06669	
	Log likelihood = -161.665		Log likelihood =-160.9741	

** * Significant at 5% and 10% respectively.

Appendix v

Correlation matrix: Test for multi-collinearity

	Use of ICT	Income	Plant TC	Age	Gender	Marital sta	Educ	Dist to Agr	Dist to Elect.	Acres
Use of ICT	1.0000									
Income(ln)	0.2890	1.0000								
Plants TC	0.2065	0.3107	1.0000							
Age	0.0031	0.0575	0.0798	1.0000						
Gender	0.3309	-0.0511	0.0175	0.0484	1.0000					
Marital status	-0.1936	-0.2939	-0.1129	0.2403	-0.3856	1.0000				
Education	0.1170	0.2224	-0.1575	0.0755	0.1832	-0.1730	1.0000			
Dist to Agric	-0.0668	0.1019	-0.0496	-0.0994	0.0029	0.0891	-0.1142	1.0000		
Dist to Elec.	-0.0333	-0.1662	-0.2105	-0.0961	-0.0301	0.1859	0.0141	0.0479	1.0000	
Acres of ban	0.1092	0.3189	0.0768	0.3290	-0.1758	-0.1759	-0.2417	-0.0182	-0.1358	1.0000