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Information and communication technology (ICT) in greenhouse farming: Smallholder farmers training programme in Kenya

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Increasing agricultural production is critical in reducing poverty as it boosts farmers' income especially smallholder farmers who have limited resources to leverage in growing and marketing their produce. Greenhouse farming has been identified as a viable technology for smallholder farmers to venture in as it promises high returns from limited land resources and labour. With diminishing support from extension officers in Kenya and the advent of ICTs, smallholder farmers can be empowered to take charge of their livelihoods. This paper discusses the usefulness of ICT interventions identified and adopted by farmers during KARLO/FtF capacity building training program held in five cluster regions in Kenya in 2017. Farmers will be able to use ICTs available to them to share experiences and seek information, buy and sell through online platforms, mobilise savings and access financial services from their mobile phones, use in build computer programs for record keeping and financial management as well as adopt technologies by simply watching videos and demonstrations from online sources among other possibilities.

Key words: Greenhouse farming, ICT, smallholder farmers, feed the future.

INTRODUCTION

Increasing agricultural productivity among smallholder farmers is important for poverty alleviation and stimulation of economic growth and development (Nyoro, 2002). Sustainable poverty reduction can only be possible through economic growth and development strategies. Most people in sub-Saharan Africa live in rural areas (61.4%), and most Africans work in agriculture (57.3%) (OECD/FAO, 2016).

Over 75% of Kenyans are employed in agriculture and 46% live below the poverty line (USAID in Kenya, 2016). Thus, agriculture remains the primary source of livelihoods for the majority of households in Sub-Saharan Africa. Smallholder farmers constitute the bulk of agricultural producers and majority of them are poor (Muyanga, 2013). Most of these households operate their own farms and farm sizes are extremely small in most African production settings, with almost all land holdings under 5 hectares (Eastwood et al., 2008). Agriculture's central role in the economy, combined with its importance for food security and the persistence of low rural living

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standards make the agricultural sector a prominent focus for policy makers in developing countries. Many countries are concerned with moving the agricultural sector away from a subsistence orientation and towards higher productivity and market orientation.

Agriculture is the backbone of Kenya's economy and critical to the attainment of Kenya's vision 2030 (Government of Kenya (GoK), 2010). It employs 75% of workforce and accounts directly or indirectly to approximately51% of Kenya's Gross domestic Product (GDP). The population in Kenya grows at approximately one million per year (World Bank 2010). This combined with stagnant agricultural productivity and limited arable land pose critical challenges to food security.

Significantly, only 20% of land in Kenya is arable. In addition, maximum yields haven't been attained, leaving considerable potential for increases in productivity. Some of the reasons given are that farmers work without basic inputs, outdated technologies, lack financial or extension services (USAID, 2018; FAO/OECD, 2014). These challenges have persisted considering that access to extension services in Kenya has been on the decline with only a few county governments reviving it (KARLO, 2017).

In order to overcome both the challenges and counter the stretch on land by an ever increasing population, innovative technologies in food production are inevitable. One of the technologies promising high yields on limited land space is the greenhouse technology, which in addition to high yields promise to realise FtF goals of economic growth that increases incomes, reduces hunger, poverty and under nutrition. To note is that greenhouse farming targets high value crops that could easily translate to extra income and in effect transform rural population livelihoods.

Greenhouse farming

Greenhouses are framed or inflated structures covered with transparent or translucent material large enough to grow crops under partial or fully controlled environmental conditions to get optimum growth and productivity (Agrifarming, 2017). This method is used to protect the plants from adverse climatic condition to the plants such as cold, wind, precipitation, excessive radiation, extreme temperature, insects and disease.

In Greenhouse technology, the environmental conditions are modified using greenhouse / glass house so that one can grow any plant in any place at any time by providing suitable environmental conditions with less labour. Farming has always taken place in the open fields, thus leaving crops exposed to the weather fluctuations. Weather conditions directly influenced the length and success of crop growth seasons sometimes living to the expectations of the farmer while other times disappointing the farmer with adverse weather conditions, inadequate rainfall or depletion by pests and diseases. In addition traditionally practiced farming that is rain fed has continuously suffered low yields as a result of lack of critical information, market facilities as well as financial intermediation (World Bank, 2012).

The introduction of indoor crop growth in controlled climate conditions neutralizes the impact of weather hazards and with careful planning is capable of year round growth. This new technology has ushered in a new era of controlled farming and therefore intensive agriculture capable of achieving predictable results and profits. The competitiveness in markets and the ever-increasing quality standards for growers in greenhouse farming have increased the importance of each small agricultural production unit. Greenhouses control crop growth parameters resulting in higher quality crops hence higher profits, Improved land utilization, better-supervised production organic and bio produce, without the use of pesticides, substantial decrease in water and fertilizer use, as well as minimal exposure to infections and environmental hazards.

Documented advantages of greenhouse farming include extending of the growing season, expanding the variety among ones produce, minimizing external threats to crops, increased yields of up to 10 to 12% depending upon the type of greenhouse, type of crop, environmental control facilities, ease of operation, Serves as a storage of farm tools (Nyalala and Mutua, 2015). On the other hand, greenhouse farming also comes with its challenges, these challenges include: High upfront and operating expenses, susceptibility to pests and lack of pollination, high maintenance cost as well as imperative knowledge and skills for gainful farming.

Kenyan scenario

Greenhouse farming has been identified as a potential technology to address challenges of food security in Kenya in the advent of diminishing farming area per person and massive failures in rain dependent farming. Consequently, the strategic application of ICT to greenhouse farming offers the best opportunity for economic growth and poverty alleviation. While farmers in Kenya have been supplied with greenhouses by various organizations and respective county governments, the rates of success was wanting with most of the farmers reporting that they lacked the technical know-how in greenhouse farming and had given up on greenhouse farming after incurring huge losses and massive crop failure (Ooko, 2014). These failures are attributed to high cost of running the greenhouses, poor knowledge of good farming techniques and inability to implement new technologies appropriately, inadequate access to markets and unfair market conditions, weak infrastructure, high production costs and transport costs (World Bank, 2012). In cognizance of the role ICTs can play in greenhouse farming, there was need to create

awareness and capacity among greenhouse farmers on the key areas in the cycle of greenhouse farming demonstrating how these ICTs can be used to overcome the challenges in pre-cultivation, during and post-harvest periods.

Kenya agricultural research and livestock organization (KARLO)/ United States agency for international development (USAID) training program

The FtF through the Integrated Agricultural Research for Development (IARD) project in Kenya aims at expanding innovative market driven solutions that improve food security and nutrition. The interventions sought include agricultural research, extension services, communications technology, farm input distribution and other interventions that promise to realise the FtF goals in the country.

The KARLO in Kenya works with FtF to increase quality and availability of draught tolerant crop varieties that build resilience to effects of climate change among other solutions that aim at realising the FtF objectives of promoting value chain growth and diversification, to increase GDP, smallholder farmers' incomes, nutritional status and economic opportunities for women, youth and other vulnerable populations (FtF, 2013).

While striving to fulfil its mandate and in partnership with FtF, KALRO organized a capacity building workshop across four cluster regions in Kenya, namely, Western, Taita, Rift Valley, Eastern and Nyanza. The training of trainers (ToTs) and Farmers on greenhouse crop production aimed at improving the capacity of the ToTs and farmers on greenhouse crop production, so that they can invest in greenhouse farming as a viable commercial enterprise, a technology singled out as viable in addressing food security, economic empowerment of vulnerable populations and undernutrition in Kenya.

The Training facilitators were drawn from KALRO and the private sector that had expertise in greenhouse crop production and use of ICT in agriculture. The farmers were identified through a baseline study conducted in March 2017 by KARLO and were drawn from 27 counties in Kenya and grouped into clusters. The training covered modules on: Business Plan, Record Keeping and Marketing; Greenhouse, Structures, Installation and Maintenance; Agronomic Practices in Greenhouse Production; Greenhouse Seedling Production and Management; Crop Nutrition and Water Quality; Greenhouse Pest Management; Greenhouse Disease Management; Greenhouse Weeds; Greenhouse Pollination Management; Crop Harvesting; Postharvest Handling of Greenhouse Crops; Safety in Greenhouse Crops; On-farm Value Addition of Greenhouse Crops; ICT in Greenhouse Farming; and Hydroponics. This paper based on the training at the Kisii Agricultural Training Centre where the author was a one of the facilitators (KARLO, 2017).

Problem statement

Greenhouse farming is a technology that seeks to address the critical food security challenges in Kenya that include limited land against a growing population, youth employment, women empowerment and undernutrition among other challenges. While most of these barriers may pose an unsurmountable challenge to the breakthrough in food security in Kenya, there is hope in the use of ICTs in greenhouse farming and strategic partnerships with greenhouse farmers can as well lead to over 70% success. While studies have been done on the role of ICTs in agriculture indicating how ICTs can add value in agriculture, none of these studies have actually demonstrated any hands on intervention to increase uptake and actual use among farmers. Consequently there exists scanty literature on greenhouse farming in regard to outcomes of capacity building among farmers. A well thought out ICT strategy mapped to the greenhouse cycle from pre cultivation, during and post-harvest phases of farming can have a positive impact on the life of a farmer and in effect food security and economic empowerment. Three main areas that cut across the greenhouse cycle include knowledge and implementation of good farming techniques, access to markets to generate sufficient income and affordable and reliable financial services. The aim of the training was to create awareness, identify, demonstrate use and implement actual use of available ICTs in greenhouse farming in Kenya.

Purpose of the paper

This paper documents the ICT training module for ToTs and farmers in Kenya whose aim was to empower them with relevant ICT skills necessary for active use of ICT based services in greenhouse farming and demystifying the complexity associated with technology use. The key objectives of the ICT training program were to:

(1) Identify phone based channels and train farmers on how to access and share information using their ICT gadgets
(2) Train farmers on how to identify electronic markets, buy and sell produce, procure equipment and other farm inputs online
(3) Introduce a convenient phone based farmer managed financial service for convenient management of financial needs
(4) Develop a convenient and sustainable platform for farmers to share information and access advisory services on various farming technologies
(5) Train farmers on how to use in build programs on their

ICT devices for record keeping and financial management

LITERATURE REVIEW

Agricultural growth is important for alleviation of poverty and stimulation of economic growth and development. Sustainable poverty reduction can only be possible through economic growth and development strategies. Increasing agricultural production is critical in reducing poverty as it boosts farmers income especially smallholder farmers who have limited resources to leverage in growing and marketing produce. Small holder farmers constitute the bulk of agriculture producers in sab Saharan Africa and majority of them are poor; yet inevitably small holder landholding and access shrink as population density increases (Muyanga, 2013).

Despite this unfortunate circumstance, analysts point out that Africa still has the potential to revitalize small holder agricultural productivity for reduced poverty and hunger if appropriate policies focused on reduction of income inequity are pursued an example being the Asian green revolution which contributed to rural poverty reduction. Currently Kenya is characterized by an extremely skewed income distribution partly because of barriers to access of productive assets such as land and credit. To achieve economic growth with equity and therefore reduce poverty, there is need to place priorities on the policies that enhance incomes of rural households; this informs the greenhouse training of subsistence farmers by KARLO.

Recent studies have shown that in many developing countries, the largest growth in poverty reduction has occurred as a result of agricultural sector growth (Thirtle et al., 2001). The implication is that agricultural growth is generally pro poor and that improving farm production helps spur non-farm activities in the rural areas. Such nonfarm activities are now seen as crucial to insulating rural families from poverty.

The role of ICT in agriculture

Information and communication technology (ICT) is an umbrella term that covers all advanced technologies in manipulating and communicating Information. Information technology means the processing and distribution of data using computer hardware and software, telecommunications and digital electronics.

ICT is concerned with the storage, retrieval, manipulation, transmission or receipt of digital data. Importantly, it is also concerned with the way these different uses can work with each other. The strategic application of ICT to the agricultural industry, the largest economic sector in most African countries, offers the best opportunity for economic growth and poverty alleviation on the continent. This is because community survival is reliant on food security yet agriculture has suffered neglect particularly in Africa with poor farmers remaining poor and subsisting on less than a dollar a day (World Bank, 2012). Like other sectors, African agriculture is disadvantaged owing to factors that include: under-investment in rural areas, inadequate access to markets and unfair market conditions, inadequate access to advanced technologies, weak infrastructure, high production and transport costs, gender asymmetry in access to assets and services, among other factors.

A study conducted by a team from Delloite dabbed E transform Africa (World Bank, 2012) identified ways in which ICT can help agriculture through a three-stage process farming life cycle. The first stage is Pre-cultivation; crop cultivation and harvesting. An integrated ICT model mapping the distinct stages in the value chain model with appropriate interventions is critical in ensuring that farmers access the necessary information, credit facilities as well as markets for their final products. Existence of an efficient value chain characterised by efficient and systematic flow of relevant information which depends on a reliable ICT infrastructure and associated services to connect a diverse range of stakeholders along the value chain is necessary (Halewood and Surya, 2012).

Kenya boasts of the best internet penetration in Africa with over 3/4s of adult population using the internet according to data monitored by the Internet World Statistics. Consequently, according to the Communications authority (CA) quarterly sector statistics report (2016) at the end of 2015/2016 quarter, mobile penetration stood at 88% with 8 million subscribers up from one million in the previous quarter. With this impressive uptake of mobile technology and associated services backed by the fact that empirical analysis has shown that use of appropriate ICTs can considerably contribute to enhancing agricultural productivity (Chavula, 2014). ICT could provide a unique opportunity to facilitate agricultural related technological adoption and access, provision of information on markets, agricultural techniques and access to financial services. ICTs are crucial to research in extension services which facilitate the adoption of improved agricultural practices as well as dissemination of this knowledge to farmers and facilitating information flow amongst stakeholders. ICTs increase efficiency of market interactions and access to real-time information (World Bank, 2011).

While the role of ICT in agriculture is not debatable, it has been observed that given the available technology used by farmers overtime, agricultural extension does not play a significant role in agricultural productivity unless new strategies are developed (Chavula, 2014). Human capacity development especially through education is the key element of a knowledge based innovation driven economy as it affects both the supply and demand for technical innovation and utilization. Human capital and

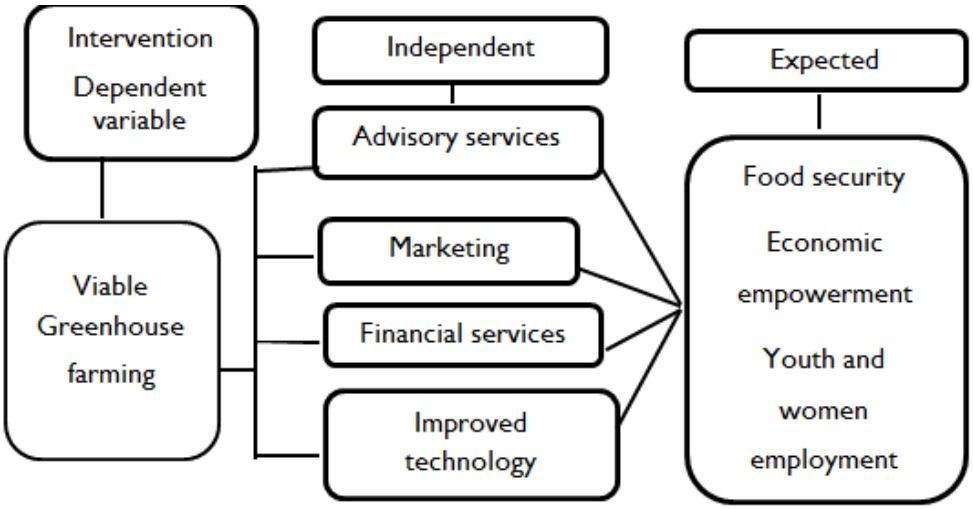

Figure 1. Conceptual framework of ICT interventions in greenhouse farming.
Source: Author.

skilled labour complement technological advances and new technologies cannot be adopted without sufficiently educated and trained workforce (Chavula, 2014).

Consequently, the study further established that despite the level education, mobile penetration does not seem to have a significant impact on agricultural production, signalling underutilization of mobile technologies in enhancing agricultural production hence the need for investment in education to innovate new technologies and techniques to increase production.

The foregoing discussion inevitably places the training program conducted by KARLO and USAID under the Feed the Future initiative at the centre of the debate. The program primarily hands on and an endeavour to empower the grass root participant in farming with knowledge, skills and know how to act on behalf of self is definitely a step in the right direction. Particularly the ICT module not only sought to identify but primarily demonstrate, and have the farmer participate and adopt ICTs within reach and available to them to enhance their productivity in greenhouse farming (Figure 1).

Conceptual framework

Despite the documented advantages of greenhouse farming, massive failures characterizing the Kenyan market dismiss this notion of greenhouse farming as the magic bullet solution. For the greenhouse to deliver the expected outcomes as indicated in Figure 1, various interventions here indicated as intervening variables are necessary. These include extension services to empower the farmer with knowledge, skills and knowhow of greenhouse farming techniques and technologies and their implementation throughout the pre, during and post-harvest period, adequate financial resources to ensure supply of required inputs and maintenance of crops throughout the planting period, access to necessary technologies for improved efficiency and production and finally viable markets for the finished product.

ICTs in green house farming

A variety of ICTs are available to farmers in Kenya to enhance their greenhouse farming. Farmers use ICTs to communicate through emails, mobile calls, USSD dials, short message texting services, videos, video chats, YouTube and social media channels. They also use ICTs to access information from online sources, financial services and financial management, record keeping as well as in the automation of various farm processes.

METHODOLOGY

The training was conducted in five cluster regions, namely, Meru, Kisii, Kitui, Busia and Taita that were mapped by KARLO. A total of 423 farmers and 95 trainers of trainers participated. Training was delivered through participatory approaches including presentations using PowerPoint slides, flip charts, videos, photographs, group work, plenary presentations/discussions, brainstorming and experience sharing sessions, interactive question and answer sessions, case studies, and practical “hands-on” sessions by participants and a post training evaluation. The module on ICT covered how ICTs are used in knowledge sharing, advisory, savings and credit, record keeping, financial management and general communication.

Farmers were prevailed upon to seek information from online sources, share experiences among themselves and reach out for advisory services from experts throughout the farming cycle. Various marketing channels and platforms were discussed in length with demonstrations on how to download the specific applications,

Table 1. Number of farmers during the farmers' training at Kisii Agricultural Training College.

County	Number of participants		
	Males	Females	Total
Kisii	16	2	18
Nyamira	18	8	26
Homa Bay	13	5	18
Migori	35	5	40
Total	82	20	102

Source: KARLO (2017).

Table 2. Number of participants for ToT training at Kisii Agricultural Training College.

Participant category	Number of participants			
	Day 1 (11th Oct 2017)	Day 2 (12th Oct 2017)	Day 3 (13th Oct 2017)	Day 4 (14th Oct 2017)
Male	11	10	10	10
Female	5	5	4	4
Total	16	15	14	14

Source: KARLO (2017).

how to take photos of products and how to post or attach. Farmers were also prevailed upon to use their-contacts in marketing. The KARLO greenhouse WhatsApp group for farmers and trainers as well as Facebook page to aid in marketing of farmer products were created. ICTs in financial management with focus on how to conveniently save, borrow, guarantee and manage accounts were discussed. Farmers were also trained onuses of money transfer services and mobile banking in farming. This culminated in the creation of members M-SACCO to address their financial needs as well as other welfare needs.

The farmers were also shown how to use various inbuilt programs like excel templates for their record keeping and other financial management needs. The last was on the automation of the greenhouse processes like introducing censors and controllers for watering, temperature control and humidity. Barriers to ICT use were identified and mitigating strategies discussed. Post-training evaluation was done through a semi-structured questionnaire administered at the end of the training (Table 3). The post-training evaluation data were analysed in SPSS Statistics Version 20 (IBM Corporation, SPSS Statistics Release 20.0.0; USA) using descriptive statistics (frequencies, means, and totals). The results were presented in graphs, figures and tables (KARLO, 2017). Discussions in this paper will only focus on ICT in greenhouse farming for the Kisii Cluster (Tables 1 and 2).

FINDINGS AND DISCUSSIONS

During the sessions, participants were encouraged to ask questions on aspects which were not clear. Before commencing the workshop, pre-training evaluation was done qualitatively through informal discussions with the trainees to appraise the extent of their awareness of greenhouse crop production and a post training evaluation was done using a guided questionnaire. Farmers enumerated their expectations from the workshop which included lack of knowledge on greenhouse farming technology, greenhouse diseases, pests and weeds, nutrient depleted soils, temperatures and humidity in the greenhouses, marketing skills, land challenge and unreliable water sources. All the participants had engaged in greenhouse farming and majority of the greenhouses had been provided by their respective county governments to organized groups for free.

While farmers may have been familiar with farm practices on open air, they lacked the specific skills and knowledge required for successful greenhouse farming and as a result they experienced challenges in greenhouse temperature control, disease and pest control, soil management, water management, and marketing among other challenges. It was reported that prior to the distribution of the greenhouses to the farmers, there was no training conducted on the greenhouse farming to beneficiaries, a blunder singled out as the main reason for the massive failures recorded. Step by step throughout the training period, the farmers were able to point out where they had gone wrong and were delighted at the new knowledge provided by the trainers. The FtF/ KARLO project was handy in building capacity among the ToTs and farmers. Through the various modules and demonstrations, farmers were able to identify specific challenges they faced and get practical

solutions as well as gain skills and knowledge on how to manage these challenges in their greenhouses.

The aim of incorporating ToTs was to empower some of the farmers with training skills so that the existing and new greenhouse farmers could easily access training when need arose and to avoid massive plant failure as had happened before.

ICT deliverables of the workshop

M-Advisory

This is a virtual call Centre where farmers can get real time advice from experts in different parts of the country. Deviating from the traditional call Centre where farmers call and receive automated responses or advise from an expert stationed at the call Centre, the M-Advisory platform operates through an E1 line which facilitates connection of the farmer and the expert from any part of the country. The automated help-desk connects the farmer to pre-subscribed extension or subject matter specialists who respond to their individual queries and issues. When a farmers seeking specific information from KARLO initiates a call through the M-Advisory platform, the call is routed to the experts in that area by locating them on a normal mobile phone call. If the first expert is not available, the system automatically reroutes the call to the next expert. This is done up to the time the farmer is connected to an expert. The farmers will be able to call the Farmer Helpline anytime between 7 am and 11 pm, seven days a week. The model is sustainable as the caller bears the cost of the call. Members subscribed to the M-advisory platform via the short code 21211. The aim of these subscriptions was to build a database that will be used to channel expert advisory as well as access pre-recorded information so that a farmer identifies their specific requirement and step by step navigates the menu to the appropriate response. Integrated with a bulk sms application, the platform will also be used to disburse short messages to a large number of recipients on their database. KARLO will be able to alert farmers on disease outbreaks, advice on best disease control methods, send information on farmer trainings, seminars and trade shows besides specific farmer requests.

M-ASCA (mobile accumulating savings and credit association) model

M-ASCA is an end to end savings and credit platform that enables users to register as members save, apply for loans, request guarantors and get guaranteed on phone, get disbursements to M-ASCA phone based accounts, check balances and exit from the system among other functionalities.

The platform targets every adult Kenyan who may not hold any collateral and are interested in saving in order to access capital for investment, business start-ups or any other viable need. The segment targeted is excluded from formal financial services and henceforth exposed to the informal financial sector characterized by exorbitant interest rates for credit and poor management of group activities. The targeted segments engage in small businesses, with equally small margins of profit as a result of saturation of similar activities and limited capacity for alternatives therefore hurt by high interest rates charged by most microfinance institutions and informal lenders.

The model is deliberately designed to eliminate wasting crucial time for members in meetings at the expense of working choosing to empower them to take charge of the management of their financial affairs. The model also avoids tying members to a circle of friends and anyone anywhere can be an M-ASCA member and a guarantor can be anyone in any part of the country because it is mobile phone based. It encourages people to know each other and socialize from wherever they are.

As indicated in the literature review, improving small farmers' ability to save and invest requires the development of an entire rural financial infrastructure in which farmers can access a full range of financial services, including credit and deposit banking at competitive interest rates (World Bank 2008). This requires innovations that permit more flexible forms of lending while guaranteeing that borrowers repay loans (World Bank, 2008). This platform will be used to assist members in mobilization of their own funds conveniently from their virtual wallets guarantee one another via the platform get loans disbursed and repay via the platform (Figure 2).

KARLO greenhouse farmers WhatsApp groups

It was resolved that farmers in each cluster form a WhatsApp group and Facebook page where they can share information, experiences and post images of their products, pests or disease infected plants or any other need for advice. The platforms will also be used to alert other farmers of availability of products and assisting one another in getting markets. Farmers will also share posts to other Facebook groups near them with the aim of advertising their products to buyers. Demonstrations were done on how to download information attached to WhatsApp, how to take photos and attach and how to share information within the group and to other external media.

Record keeping

The computer comes with various in build programs to ease the management of accounts. These include

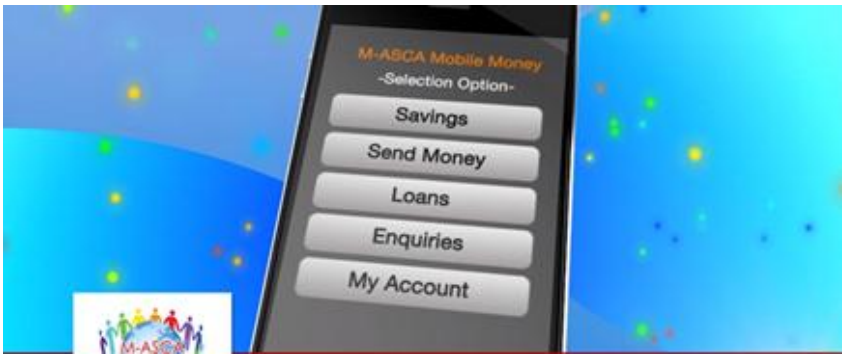

Figure 2. M-ASCA menu
Source: KARLO (2017) Module 16 ICT in greenhouse farming.

spreadsheets like excel which has automated templates for useful processes like profit and loss accounts, balance sheets, cash flow accounts, salaries among many others. Farmers were taken through some of the inbuilt computer programs that would assist them in keeping their records and automating all their processes which would make their decision making process convenient. Farmers were also able to see and practically use various electronic storage devices. These included flash disks, memory cards, CDs as well as the computer hard disk. All the participants were requested to bring at least one of the storage devices discussed for storage of the training content as there were not hard copy notes.

Financial management solutions

With the robust mobile money technology in Kenya, farmers are spoilt for choice and can easily manage all their financial transactions via their phone and other digital platforms. The breakthroughs in ICT that were discussed included:

(1) Mobile banking- farmers were shown how they can access their accounts via mobile phone applications that most banks have developed. This is as a result of the automation of all core banking processes. Demonstrations were done on how they can withdraw money from their banks to virtual wallets like m-pesa, send money to other parties, pay salaries to their employees at the comfort of their farms.
(2) Money transfer services- these have made it possible for farmers to load wallets from agent outlets near them, make savings to banks, SACCOs, Chamas and other groups they belong to, they also send money to buy inputs and other requirements, are paid for deliveries they do among others.

Online shops

This refers to making orders and making payments for goods and services procured via online and other electronic channels. Today farmers are finding it easy to order for farm requirements via online shops that provide a catalogue of products complete with photos, specifications, prices and other details for ease of decision making. Farmers were taken through the actual purchase process. Some of the items they could purchase online included, fertilizers, seeds and other inputs, farm machinery, pesticides as well as the greenhouse structure and its associated component's among many other items. Demonstrations were done through the Jumia online platforms and farm pride. Farmers were also informed of the need to create websites from which they can provide information about their activities and product lines besides ensuring authentic their online presence.

Automation of greenhouses

Modern greenhouses require constant monitoring of the key production factors in order to optimize their productivity. These factors include: temperature, tank water levels, humidity, soil moisture, light and wind speed where fans are provided. Monitoring sensors are provided to help in giving right indicators at the right time. All the installed sensors are programmed with optimized threshold values that either close or open specific valves that let in or close the specific supply. Automation mainly consists of motorized windows and water valves. The water valves serve two purposes:

(1) One is to turn on the plant watering system. The censors monitor the dryness of the plants and only allow watering to the group that needs watering. All fertilizers and disease control inputs are mixed with water and programmed so that the system automatically supplies the plants at specific times.
(2) The second is to provide the humidity control, delivering water to anatomising spray mounted centrally in the apex of the greenhouse.

Figure 3. Cameras installed inside a greenhouse.
Source: KARLO (2017) Module 16 ICT in greenhouse farming.

This provides a very fine mist of water vapour, quite effective in maintaining a good level of humidity. Though the greenhouses at the training centre were not automated, farmers were taken through the functionalities of controllers and censors in a green house. Through photographs and videos the farmers were able to see how the windows should open automatically whenever the temperature gets to a certain level and close again when it falls to a lower level. Throughout the training period and discussions, it was evident that farmers had challenges in monitoring the watering of their plants and as a result too many of their plants were ruined or their growth reduced due to under or over watering. They also suffered from the hard water that caused blockages due to scale build-up.

The only solution is to monitor the dryness of the soil and automatically deliver water when it gets to an appropriate dryness. Farmers agreed that plants were adversely affected by high or low humidity and there. was need to control the humidity inside the greenhouse. While farmers were conversant with the opening and closing of nets on the sides of the greenhouse, they were also shown how the automated greenhouse manages humidity in a greenhouse by automatically spraying a mist of water into the air whenever the humidity fell below a certain measured level.

The greenhouse can also be installed with cameras with specific programmes that identify symptoms of diseases, pests or other characteristics that are relayed to a smart device wirelessly, this device is used to send the information gathered to the control room and data centre for analysis and decision making (Figure 3).

Evaluation

While the workshop served to ensure particular skills were developed and would be used for the beneficial participation in greenhouse farming, the outcome was appreciated as an avenue for creating awareness and debunking the complexity notion associated with technology ICT included and that the ICT gadgets within reach and which they owned could actually transform their story about greenhouse farming. From the final report of the training program 3.4.5 below, it's evident from the evaluation that farmers found the ICT module beneficial to them and an eye opener. At the onset of the training, farmers were categorical that although greenhouses were given to them for free by the county governments, they were not prepared with adequate knowhow to make any significant gain in their farming. Most of them indicated that they had abandoned their greenhouse farming altogether. However with ICT, they were relieved to learn that one could access all the necessary information from online sources. One of the videos they watched was of a pioneer Hydroponics farmer in Kenya who actually learned all the skills through online sources (KARLO, 2017). An excerpt from the actual report on the training in Kisii ATC (Table 3) confirmed that ICT would play a critical role in ensuring that farmers remained informed on practically every aspect of greenhouse farming.

Training component found most useful by the farmers

Pests and disease control was the most useful item of the training at 20.5%, followed by business plan and record keeping at 14.1%. Post harvest and value addition came third at 11.5% while ICT in greenhouse farming was fourth at 11.5%. 14 of the farmers were not present for the evaluation. While farmers were keen on acquiring knowledge in respect to the immediate threats to their greenhouse farming, it is evident that particularly pests and diseases require constant update of information. Inevitably the information acquired here was useful for the moment but constant update of information is necessary. ICT then will play a significant role in ensuring that these farmers get the latest information on ways to control diseases and pests and any other emergent technology or information relevant to their greenhouse farming (Table 3).

Table 3. Training components found most useful.

Training component found most useful	Frequency	Percentage (%)	Reasons for usefulness
Pests and diseases control	16	20.5	They affect production yields Scouting helps to detect pests and diseases in time and act on time This is the area which is so sensitive and one of the most crucial How to choose on the right pesticide How to store pesticides Issues on nematodes, Tutaabsoluta and better conditions in the greenhouse were clear and understood Without some knowledge you cannot handle this part Methods of prevention were tackled Simple methods of control (Pesticides both synthetic and neem were taught) It is the component which determine the production
Business plan, record keeping and marketing	11	14.1	It makes me know when and where to sell my products Development of a business plan can help one achieve his dream It makes you know whether you have a profit or loss It makes you know when to start planting (plan for crop production) Helps me to manage and maximise production and market my produce well It opened my eyes on how poor record keeping or lack of can lead to losses or lack of financing
Postharvest handling and value addition	9	11.5	Maturity indices are sign factors To harvest quality clean raw materials The practical aspect of banana processing Value addition of tomatoes into tomato sauce, banana into wine It can help me get more profit on the farm It can help me preserve the produce to avoid wastage
ICT in greenhouse farming	9	11.5	It will help me market my products faster and sell them wholesale hence getting good profit M-SACCO helps to access loans easy and safe money Will help me find information Will connect me with other farmers, and the outside world and sharing knowledge Will help me find market for my products I can use it to get into outside world I can use it to easily get help in my farm management
Hydroponics	7	9.0	It is easier to manage Less inputs (use little water, less diseases; also saves on manpower) Requires little space and no soil Faster especially when growing fodder (barley) It is a new and impressive technology
Greenhouse structures and construction			This enhances to structure your greenhouse to avoid wind direction Materials used to construct your greenhouse (strong materials) Free area and away from shade with adequate sunlight Our area is a hot and raised greenhouse can definitely give good results

Table 3. Contd.

			I have been struggling to produce but faced several challenges and now the knowledge I have will enable me improve my production
	7	9.0	Every farmer must know how to maintain greenhouse
Soil fertility testing before planting	6	7.7	Any good production depends on how you prepared the planting system Find out sampling of the soil and the nutrients it has Find out how to add fertiliser and manure in the soil to produce good yields
Management of greenhouse	4	5.1	In case of soil treatment, there is much harvest and less bacterial wilt discovered
Marketing	3	3.8	To identify soil diseases
Irrigation systems	2	2.6	Drip irrigation – the use of water quantity not high Water management is the beginning of disease control
Field practical's	2	2.6	Determines the farmers profits It is because I can identify different diseases and pests Facilitators were very courageous
Modern technology in fodder production	2	2.6	See what is on the ground Require less space
Total	78	100.0	-

Source: KARLO (2017).

Conclusion

Greenhouse farming in Kenya is a technology that can go a long way in overcoming food security challenges and in effect realization of vison 2030 goals in respectto expectations mapped to agriculture. Though the debut experience from farmers depict a grim picture, the capacity building intervention by KARLO in partnership with FtF will go a long way in changing the mind-sets of farmers already discouraged in greenhouse farming

Key is the realization that despite the diminishing support coming from institutions through extension services, the farmers in this information era/ knowledge are fortunate as it's possible to access information through ICT gadgets available to them. In addition the nature of these ICTs is that they provoke action and users including the farmers are already geared to 'do it myself' tendency and may not wait for help but seek it themselves. The information society in which we live today unleashes the individual potential and has conditioned societies to convenience as opposed to dependency (Castells, 2010).

The ICT module will go a long way to assist the farmers solve their own problems their own way. Through online sources, interest groups and sharing forums, farmers will be in a position to seek information they require in addressing emerging issues in their farming. Unlike before where farmers incurred losses due to accumulation of produce at the same time and in effect low prices, ICT opens up their reach and access to markets across the globe. ICT also empowers them with knowledge on best times to plant, prices in different markets as well as demand periods for their products. With ICTs farmers who may not necessarily access credit from traditional banks because they lack collateral will be in a position to use their trusted networks of friends and relatives from wherever in the country to ride on for credit through the M-ASCA model.

Challenges of guarantors as a result of localised requirements will be a thing of the past as the M-ASCA model blurs geographical space making it easy to access social collateral from anywhere. Farmers will be able to make purchases online with clarity provided by the richness of hypertext technology where demonstrations through video and voice are enabled. Though ICT cannot work in isolation and other modules are equally important, increased capacity building of farmers will play a significant role in facilitating uptake and use of ICTs available to them leading to their ability to find solutions to their farming needs and in effect development.

RECOMMENDATIONS

ICT provides a useful trajectory for empowerment of the

farmer in their farming activities. Unlike before where a farmer was enslaved by the services of an extension officer, today a farmer has liberty to access all the information previously provided by extension officers at the convenience of their digital gadgets. ICTs now afford the farmer the ability to conduct their own research, education and awareness, access extension services virtually, consult as well as share information they possess.

However, unlike the face to face clarification afforded to the farmer by extension officers, there is a danger of farmers adopting practices that are unsuitable due to the flooding of online information. There is need for farmers to seek clarification on these information sources before actual use from their experts or others who have prior experience.

ICTs as discussed require knowhow meaning that farmers have to create an interest in the various platforms and practice actual use. They too must follow technology trends to avoid missing out on required skills as technology changes occur all the time. There is need also for farmers to be weary of dangers of ICTs which include wasting time on time consuming applications at the expense of attending to one's farming activities. Some online sites are not trustworthy and before the open internet sources are fortified through block chain and other secure technologies, farmers must ensure that all transactions are verified to avoid sending money or goods to fraudsters. They must also be alert not to pay for substandard goods and go for payment on delivery options.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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