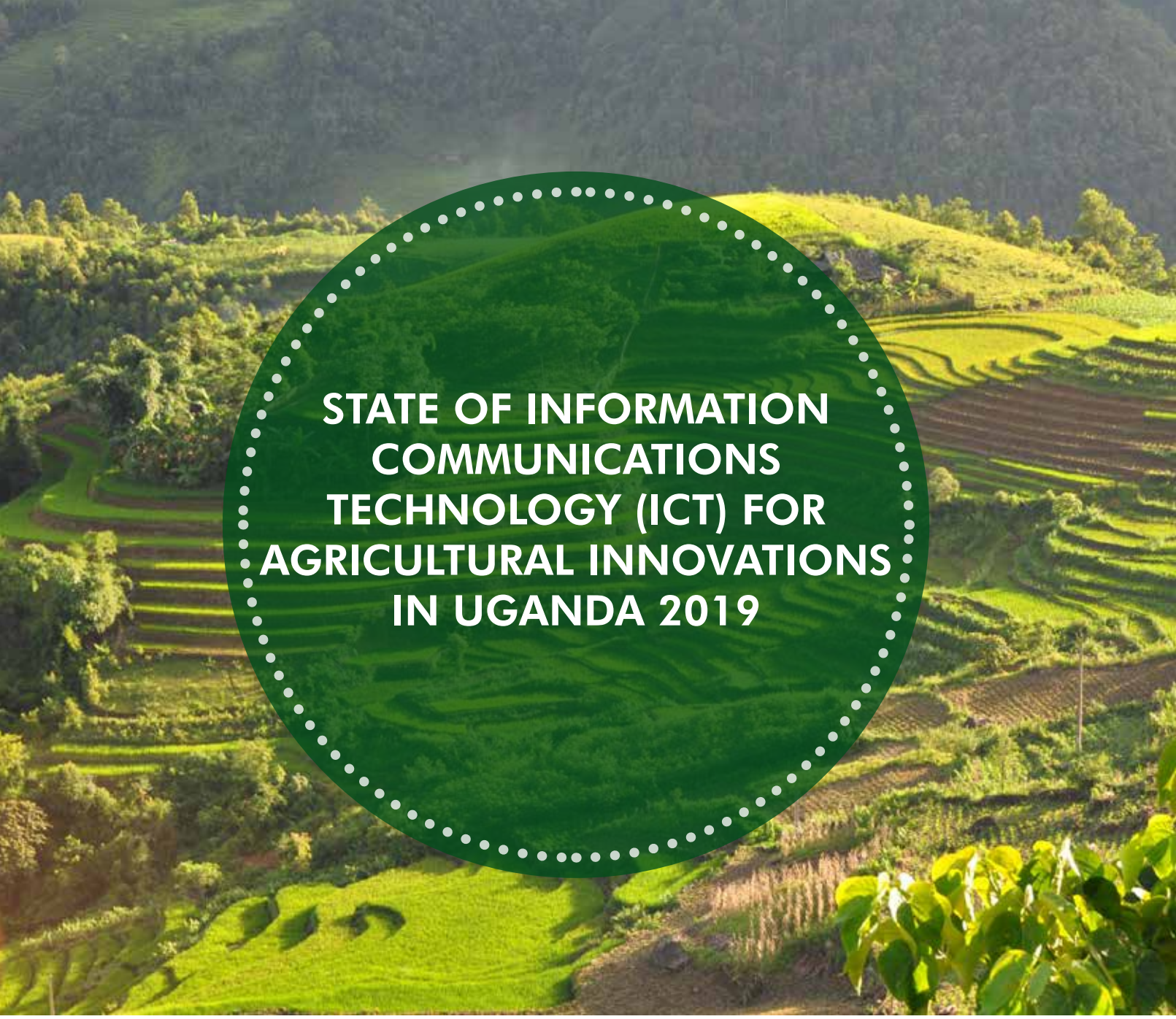
STATE OF INFORMATION COMMUNICATIONS TECHNOLOGY (ICT) FOR AGRICULTURAL INNOVATIONS IN UGANDA 2019



STATE OF INFORMATION COMMUNICATIONS TECHNOLOGY (ICT) FOR AGRICULTURAL INNOVATIONS IN UGANDA 2019

Submitted to:

The Director
Rural Communications Development Fund (RCDF)
Uganda Communications Commission (UCC)
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UGANDA COMMUNICATIONS COMMISSION

Submitted by:

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PURPOSE AND INTENDED AUDIENCE

This document describes how the study on the state of ICT4Agric in Uganda was conducted. The document presents the researchers' study findings and provides a multitude of recommendation in terms of ICT4Agric adoption within Uganda. The document is intended for UCC and other stakeholders including government, international cooperation, academicians and researchers to understand how ICT4Agric is adopted in the country and the region.

AUTHORS

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Prof. Jude Lubega is a Professor of Information Technology who has vast experience in ICT4D. He is currently the Deputy Vice Chancellor of Uganda Technology and Management University. He previously served in Makerere University from 2007 t0 2012 as the Deputy Dean and the Head of the Information Technology Department in the College of Computing and Information Sciences. He has been the Chief Executive Officer for 8Tech Consults one of the leading ICT consulting companies in Uganda. He was listed among the 100 Movers and Shakers in Corporate Online Learning for 2018 in Africa. He is an experienced ICT4D consultant and has undertaken numerous researches and projects both nationally and internationally. He is a member of several boards and has won several research funding to undertake ICT4D projects. He is formerly a researcher and Lecturer in the School of Systems Engineering at the University of Reading, UK. He has been involved in developing several information systems including election monitoring using mobile devices.

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APPROVAL

Name	Title	Signature	Date
Hon. Nyombi Thembo	Director, RCDF		25th May, 2019

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Last but not least we would like to thank a team of researchers and research assistants who participated in the whole process of producing this report.

Prof. Jude T. Lubega
LEAD RESEARCHER

EXECUTIVE SUMMARY

Context and Background

It is well documented that in Uganda, agriculture employs over 70% of the population, of which, the majority are youth and women. Also, a number of studies show that both locally and internationally, ICT has positively impacted agriculture by addressing a number of bottlenecks along the agriculture value chain. Nevertheless, while the ICT sector is rapidly growing in Uganda, there are limited studies which have documented the state of ICT4Agric, which creates weaknesses in advocating for policy and investment frameworks for the sector. The lack of a clear understanding of the innovations and trends in ICT4Agric has in turn constrained effectiveness of government interventions, often times resulting into government procuring solutions which would be scaled up from locally developed innovations. Moreover, in many cases, the different technological advancements are not synchronized and hence causing a lot of duplication in terms of ICT interventions being made within the sector.

This document presents results of a study that was conducted on the current state of art and practices in ICT4Agric in Uganda with an aim of addressing the existing knowledge gap about the sub-sector, but more importantly to provide evidence to guide policy development and intervention strategies designed by government and other stakeholders. To be able to achieve this overarching aim, the study has proposed an ICT Integration framework to effectively provide a guided policy direction towards implementation of sustainable interventions.

This study was conducted within a research collaboration framework between the academia (Uganda Technology and Management University – UTAMU) and Uganda Communications Commission (UCC) through its research and innovation arm –Rural Communications Development Fund (RCDF) programme.
The broader objective of the study was to establish the current state of ICT4Agric innovations in Uganda. The specific objectives of the study were to;

1. Profile key ICT4Agric innovations in Uganda;
2. Highlight the current state of ICT4Agric innovations development in Uganda;
3. Assess the ICT in Agriculture policy and its regulatory environment;
4. Highlight the state of Agriculture content development and delivery;
5. Highlight key lessons from countries in the region on their approach to ICT4Agric;
6. Document user testimonies on integration of ICT4Agric innovations in agricultural processes; and
7. Propose a framework of ICT integration in Uganda's Agriculture sector.

In order to achieve the above set study objectives, the following guiding research questions were developed and used in the study;

1. What is the current state of art and practice in the development and use of ICT in agriculture? What are the existing approaches and applications? Can these approaches be scaled up and how?
2. What is the current state of practices in content development and delivery for farmer training? What are the successes, failures and bottlenecks in content development and delivery?
3. What are the enabling and constraining elements in the development of ICT4Agric? Does Uganda have the right policy environment, education and technical platforms to spark ICT4Agric?
4. Does the country have an ICT integration strategy for Agriculture, if yes how appropriate is the strategy in relation to the country's development agenda and operating context?
5. What challenges are faced both in the development and adoption of ICT4Agric Innovations? What are the possible recommendations to counter check the challenges?
6. What institutional development needs to take place to ensure that ICT4Agriculture has a sustained

impact?

7. What is the Return on Investments (RIO) by adopting ICT within the agriculture sector?
8. How can success be measured? Which initiatives should best be left to private sector role players, development agencies and government respectively, and how can these initiatives be supported by research, policy and strategy?
9. What part of the information and knowledge chain should be subsidized, and what part should be handled by commercial players?
10. What lessons are there to learn from countries in the region who are integrating ICT in agriculture?

Methods

The study was conducted by a team of experts using a mixed research methods approach incorporating both quantitative and qualitative data collection and analysis techniques. The quantitative methods (the survey) were used mainly to gather data from the key stakeholders such as; ICT4Agric innovators, Consumers of ICT4Agric innovations (farmers), academia and private sector players. Qualitative data were generated from the sector opinion leaders, policy makers such as Ministry of Agriculture Animal Industry and Fisheries (MAAIF), Uganda Communications Commission (UCC) and Ministry of ICT and National Guidance (MoICT&NG), industry leaders, development and implementing partners, and innovation hubs using appreciative inquiry methodologies such as Key Informant Interviews (KII), and Focus Group Discussions (FDGs). An extensive review and analysis of secondary data sources was also conducted to gather facts about the ICT4Agric sub-sector ecosystem. The survey questionnaires were digitalized in Google's forms to improve quality and clarity. The data was then analyzed using spreadsheet software. Qualitative data was analyzed with the aid of qualitative data analysis software ATLAS.ti and principles of thematic analysis.

Findings

Several findings derived from different aspects of the study are highlighted below:

1. Both development and uptake of ICT4Agric innovations were found to be largely driven by donor projects as opposed to demand or policy implementation by government.
2. Most of the innovations were found to be targeting crops farming with very few focused-on animal husbandry yet animal husbandry is one of the critical activities in the commercial value chains for subsistence farmers. Also, very few innovations were targeting use of drone technologies.
3. Majority of the innovators are graduates who recently completed their bachelor degree, giving interpretation that most of the current innovations start as projects within the institutions of learning. Majority of these were self-employed and quite a few in either formal employment or not employed at all.
4. Majority of the innovators were between the ages of 19-29 years and the age range of 24-27 years was established as the most active age group to participate in the innovation activities. The study also revealed that a few older innovators between 35-42 years of age also participated in innovations.
5. The innovators are developing applications for a variety of service sectors and Agriculture ranked number three amongst the sectors with innovations that are locally commercialized. Education and health sectors were taking lead.
6. The agriculture sector has not realized enough innovations to be used on the market since majority of the innovations were at the Prototype stage. Most of the innovations at the commercialization stage have either been personally supported or have received donor support.
7. ICT4Agric innovations adoption has been slow within the sector since majority of the innovations have been in existence for less than 3 years, meaning that most of them are new on the market.
8. Currently there is little investment into development of ICT4Agric innovations since majority of the innovations had less than one thousand dollars' worth of capital investment.
9. Agriculture innovations were mostly funded from personal funds, nevertheless, government has started giving support to the innovators albeit on a small scale.
10. Many of the innovators lack appropriate spaces to innovate from and rely on free spaces such as homes and institutions since the hubs are restrictive and have to be paid for. Yet many of the innovators are fresh graduates with no reliable sources of income.
11. Most of the innovations are currently consumed locally since majority of the innovators indicated local

customers as their main clientele.

12 The technologies used by innovators range from open source platforms to professional industrial frameworks, with some innovators using both open source and proprietary database technologies. With regard to the ICT depth of adoption, many innovators were enhancing and transforming rather than disrupting.

13 There is less ICT4Agric innovations taking place at both the pre-production and post-production levels. Majority of the innovations were innovated at the level of production.

14 There are several challenges faced by different players in the agriculture eco-system. Most are linked to lack of availability of resources and affordability to access. Recommendations are focused on improved access to resources and knowledge development and sharing.

15 Majority of the ICT4Agric innovations in commercial use in Uganda fall under the production and post-production stages of the agriculture value chain. Few are in the pre-production stage of the agriculture value chain.

16 ICT4Agric innovations were majorly utilized at the production level of the value chain with majority of the consumers using them to access and share market information, access and share agronomical information, detect pests and diseases, process automation and record keeping respectively.

17 Majority of the consumers for ICT4Agric Innovations are small-scale holder farmers who depend on projects to support them in acquiring the innovations and therefore, they tend to incur zero-costs of initial acquisition and licenses. A larger percentage of the few who spend on licenses spent less than one hundred dollars ($100) annually.

18 ICT4Agric innovations are helping farmers in different ways such as gaining increased return on investments, improved decision making, improvement in customer satisfaction; access to markets and inputs and increase in business growth.

19 Content development and distribution is uncoordinated which impacts negatively on the quality of services extension workers deliver. Although the current content is mostly in English majority of farmers preferred the local language to English.

20 CBOs/ NGOs were established as the main sources of information the farmers followed by radio while production guides, newspapers and internet were established as the most commons sources of information for service providers. Researchers and students' interns were found to have more field presence than district production officers and extension workers due to lack of facilitation.

21 The study established that most of the current extension content does not take into account the increasing impact of climate change and environmental degradation.

22 Generally, there is an enabling policy environment to promote the development and uptake of ICTs in agriculture in Uganda with well-articulated guiding frameworks.

23 Uganda compares well with other countries in the region in terms of ICT4Agric development and uptake. However, in some countries e.g. Rwanda, innovations seem to come from a well-structured pipeline process as compared to Uganda where innovators are largely driven by students and fresh graduates.

Conclusions

A number of conclusions were deduced from the study. For purposes of effective communication, the conclusions are discussed and presented in the document along the key research questions of the study.

1 State of art and practice in the development and use of ICT in agriculture: During this study a total of 183 ICT4Agric innovations at various stages of development were identified across the country. It was observed that majority (109) of the innovations are at idealization stage largely focusing on smallholder farmer information management needs as a means of complimenting extension service delivery. The innovations are largely developed using mobile and web technologies especially android platform for mobile, java, PHP and MySQL for web applications. It was also observed that most of the innovations are not driven by scientific research but rather by intuition and passion, often resulting into duplicated efforts and slow transition into commercial viable products. In terms of profile of innovators, majority are students in higher institutions of learning followed by fresh graduates. It emerged from the study that majority of users (nearly 85%) of these innovations are smallholder farmers. We also

note a few agro processors and logistic dealers are adopting ICT4Agriculture for effective process management. Generally, there are a few high-end technology innovations using platforms like artificial intelligence and advance mobile technologies like drones and RFIDs. Yet these technologies provide excellence opportunities to address critical challenges on the services such as pest and disease detection and surveillance, climate smart animal and crop management, real-time information gathering and automate decision making among others.

2 State of practices in content development and delivery to farmers: We noted that currently agriculture content development is uncoordinated and unregulated. Various actors including MAAIF, research institutions and Civil Society Organizations (CSOs) develop and distribute content to farmers and other value chain actors without having the content validated and certified. Most of the content is developed in text format in form of information leaflets, posters and production guides. The content is mostly authored in English, yet majority of farmers prefer content in their local language given their limited comprehension of English language concepts. Generally, there is lack of a central point of reference for authentic content for various value chains. Where content exists it's often inaccessible to stakeholders who need it. The study revealed that CSOs/ NGOs were the main sources of information for most farmers as indicated by 61 out of 74 farmers who answered this question, followed by social events and radios.

3 Enabling and constraining elements in the development of ICT4Agric. The review of the ICT4Agric sub-sector ecosystem revealed that, the country in general does have an enabling policy environment to promote the development and uptake of ICTs in agriculture. For example, the recently approved national agriculture extension policy 2016 clearly articulates gaps in extension service delivery and proposes progressive strategies of how to address these gaps, especially promoting the use of ICTs to address the gaps. Furthermore, the efforts by the ministry of ICT and National Guidance under digitalizing Uganda and the associated programme of the National ICT Innovation Support Programme (NIISP) all have defined agriculture as the anchor sector for these interventions. Furthermore, a number of social transformation instruments at national level including; the national development plan two, the NRM manifesto and the Rural Communication Development Fund (RCDF) have all prioritized ICT4Agric development as a means of enhancing sector growth. In terms of technical skills availability to spark ICT4Agric, it was observed that the country has witnessed a rapid expansion of the higher education sector in recent years, with most the of new institutions focusing on science and technology and it's not surprising therefore that majority of the innovations profiled during this study have their origins from universities. Furthermore, the country is witnessing a rapid expansion of innovation and incubation centers, with potential to catalyze the ICT4Agric by accelerating innovations into products.

4 Does the country have an ICT integration strategy for Agriculture? From the study, it was clear that there are various efforts promoting the integration of ICT in agriculture and these efforts are largely driven by three forces, which are; policy direction, demand driven and technology driven. It was observed from this study that there is lack of a coordination mechanism (integration framework) in the sector to drive ICT integration. The lack of this framework is resulting into duplication of efforts and minimal sharing of experience, resulting into suboptimal impact on the sector. However, the new efforts by the MAAIF to develop an ICT strategy for the sector is a welcome intervention as it will streamline actions of various stakeholders resulting into aggregation of efforts as opposed to the current state of practice which is full of duplications of efforts. Through the World Bank funded ATAAS programme, an ICT specialist was hired to provide leadership in development of e-platforms at the MAAIF and the capacity of number of ICT officers at National Agriculture Research Organization (NARO) Secretariat and selected ZARDIs was enhanced. MAAIF through ATAAS programme piloted an e-Certification platform through which 4,276 traders were certified. This study revealed that MAAIF is developing other platforms such as e-M&E, e-Extension, and e-Markets which help to accelerate project management and service delivery significantly. It was observed that efforts at MAAIF are focusing on sector performance improvement in terms of; (a) flow of information between farmers and other actors, (b) enhancing sector e-M&E function and public accountability; (c) facilitation of market links through e-marketing and e-certification; (d) production support through e-vouchers; and (e) publicly accessible platform for agricultural information and statistics (e-agric statistics).

5 Some of the greatest challenges of the agriculture sector are; poor information access and management and poor quality of extension services. It is well noted that, although the sector employs nearly 70% of the citizens, its direct contribution to the tax base is about 1%. Furthermore, the few sector development incentives are accessed by large foreign investors leaving the majority of Ugandan sector players out. It was noted that most of the challenges are associated with information access and management. Therefore, government should expend significant efforts to profile sector players to ensure effective planning, and development of information and knowledge products for various actors. Further efforts are needed to develop advanced technologies in smart farming like use of drones and automated irrigation, artificial intelligence based pest and disease detection and surveillance among others. Government needs to promote information access and invest in research for development of advanced technologies which may not be easily financed by private sector led efforts.

6 What institutional development needs to take place to ensure that ICT4Agriculture has a sustained impact? It is very clear that current progress in ICT4Agric development and adoption are largely donor driven as opposed to being policy or demand driven. Furthermore, the study revealed that there is lack of a coordination mechanism in the sector to streamline the development and integration of ICT for Agriculture. Therefore, at institutional level, there is need to develop and implement an ICT strategy for the agricultural sector with the sole aim of streamlining intervention actions by various stakeholders. Furthermore, there is need to establish an extension service academy under relevant departments of MAAIF to streamline extension content development and access. This action will operationalize the provisions of the new National Extension Service policy and this will enhance the effectiveness and efficiency of extension services provisioning.

7 What is the Return on Investments (RIO) by adopting ICT within the agriculture sector? The adaption of ICTs in agricultural sector guarantees a number of benefits including; improved service delivery by state actors like extension workers, opening of new job opportunities and service lines, enhancement of processes efficiencies like the distribution of inputs among others. For example, the Ezyagric app which is built on SUFACE model of stakeholder engagement has created over 480 jobs for village agents. The use of green leaf system at Mpanga Tea Growers Factory has reduced losses associated with green leaf collection by 32% given the improvements in process information management. A number of applications like Jaguza, Kudu, Mcrops, ERIGNU and M-voucher have received thousands of dollars in funding hence resulting into a good return on investment for the innovators.

8 How can success be measured? Which initiatives should best be left to private sector role players, development agencies and government respectively, and how can their initiatives be supported by research, policy and strategy? In principle, success in ICT4Agric sub-sector can be measured in terms of number of innovations developed and adapted by the stakeholders, the impact of these innovations on the overall sector performance most importantly on; productivity, post-harvest handling among others. Furthermore, the success of an innovation can be measured by the amount of revenue being generated, the number of users who have adapted the innovations, and innovation users experience. Government should largely focus on regulation, guidance and market access promotion strategies. Furthermore, government needs to profile all farmers who receive government services to generate critical data set for real-time visualization of sector performance. Success can also be measured through overall sector contribution to GDP.

9 What part of the information and knowledge chain should be subsidized, and what part should be handled by commercial players? In terms of information value chain, government should focus on; regulation of content development and certification but let the private sector lead efforts on content delivery. On the high initial investments in development of more advanced technologies like drones and embedded systems, government needs to stimulate the development of such high end artificial intelligence innovations through seed funding to research institutions, but also reviewing the policy on access and importation of lower end drone technologies for research purposes.

11 What lessons are there to learn from countries in the region who are integrating ICT in agriculture? The study revealed that Uganda is not far from Rwanda and Kenya in terms of ICT4Agric development and uptake. However, Uganda's ICT4Agric sub-sector is poorly coordinated and there exists poor information management and weak promotion of local innovations by state actors. Furthermore, it was clear that both Kenya and Rwanda have dedicated efforts on ICT development and application in

agriculture and they have enacted an enabling environment for the development of these innovations. Key strategies identified are; the promotion of locally developed innovations by the state especially in Rwanda, acts as a means of attracting foreign direct investment in the country. While innovators in Uganda are largely driven by students and fresh graduates, which is the same case in Kenya, in Rwanda, innovations seem to come from a well-structured pipeline process.

Recommendations

It was observed from the study that the development and integration of ICT4Agric Innovations has a number of stakeholders along the value chain; farmers, ICT innovators, policy makers like MAAIF, UCC and MoICT& NG, researchers, Civil Society organizations, development partners among others. Accordingly, the following recommendations are suggested:

1. To address the challenges associated with poor extension service delivery by extension workers, the government of Uganda through relevant MDA like MAAIF, should establish an extension service providers' platform.
2. To address the issues of quality content in extension service delivery, the Government of Uganda through MAAIF should establish an e-extension academy and reference knowledge portal to facilitate stakeholder engagement and access to validated content.
3. To increase access of content to farmers, the government can through Uganda Communications Commission (UCC) deliver content using the free media slots on media platforms which are provided for under the current media house licensing regime. Furthermore, UCC can explore the use of digital advertising boards in strategic public spaces like government markets, hospitals among others.
4. To enhance agriculture sector performance in terms of effectiveness and efficiency MAAIF and associated agencies need to integrate ICT in various business processes.
5. To improve the usability of production guidelines and various content, the MAAIF and associated agencies like NARO, need to develop guidelines on transformation of most of the content into multimedia formats to stimulate content uptake by various stakeholders.
6. To stimulate the development of high end innovations especially innovations based on embedded systems, drones and artificial intelligence, government needs to review taxes on some of these components to make them easily accessible to the researchers and innovators.
7. It is clear that most of the applications are internet connective intensive and yet significant rural areas where farming takes place have weak network connectivity. Although the cost of internet has come down, it is still relatively high for ordinary smallholder farmers. Accordingly, the government needs to develop a policy environment that reduces some of the barriers which limit the development and uptake of ICT solutions in agriculture.
8. It was noted that most innovations are developed by fresh graduates and students who often lack the domain specific knowledge, hence the slow transition from prototypes to products. The Ministry of ICT and National Guidance through the National ICT Innovations Support Programme (NIISP) needs to identify these promising innovations and pair them with domain field research experts to help the innovators appreciate the context and build either research driven and on demand innovations.
9. Most of innovations in the sector are developed by innovators in and around Kampala. The two upcountry innovation hubs visited i.e. ComTECH at MUST and Department of computer science in Gulu University did not have any good innovations in agriculture. Therefore, government through relevant ministries needs to accelerate the establishment of innovation hubs in other regions to stimulate the development of innovations.
10. Innovators need to develop creative business models and stop depending on donor funds to stimulate innovation uptake. The current model of depending on donor projects is not sustainable.
11. Innovators need to explore more opportunities in animal sector as most of the innovations are in crop farming.
12. In order to promote organic uptake of ICT innovations in agriculture by various stakeholders, models that promote ownership of programmes like co-funding should be explored especially when dealing with smallholder farmers. Therefore, government and development partners should minimize creating a culture of free services by promoting co-funding of services received by farmers and other stakeholders.

ACRONYMS AND ABBREVIATIONS

Term	Definition and Description
ACIA	Annual Communications Innovations Award
ATAAS	Agricultural Technology and Agribusiness Advisory Services
BPO	Business Process Outsourcing
CSOs	Civil Society Organizations
EU	European Commission
GDP	Gross Domestic Product
GII	Global Innovation Index
GOU	Government of Uganda
ICT	Information Communication Technology
ICTAU	ICT Association of Uganda
IDI	ICT Development Index
DP	Development Partners
ICT4Agric	ICT for Agriculture
IPR	Intellectual Property Rights
IT	Information Technology
ITES	Information Technology Enabled Services
M&E	Monitoring and Evaluation
MDA	Ministries, Departments and Agencies
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
MoFPED	Ministry of Finance Planning and Economic Development
MoICT&NG	Ministry of ICT and National Guidance
NARO	National Agricultural Research Organisation
NDP	National Development Plan
NIISP	The National ICT Innovations Support Programme
NITA-U	National Information Technology Authority Uganda
NPA	National Planning Authority
NRM	National Resistance Movement
NTF	Netherlands Trust Fund
PS	Permanent Secretary
R & D	Research and Development
SDGs	Sustainable Development Goals
SIP	Strategy and Investment Plan
SMEs	Small Medium Enterprises
TORs	Terms of References
UBOS	Uganda Bureau of Statistics
UCA	Uganda Consumer Association
UCC	Uganda Communications Commission
USA	United States of America
RCDF	Rural Communication Development Fund

UTAMU	Uganda Technology and Management University
YIIP	Youth ICT Innovation Project
COCIS	College of Computing and Information Sciences, Makerere University
RAN	Resilient Africa Network
RFIDs	Radio Frequency Identifications
IDI	ICT Development Index
MUST	Mbarara University of Science and Technology
Mak	Makerere University
CoCIS	College of Computing and Information Sciences, Makerere University
AIR	Artificial Intelligence Research group Makerere University
ComTech	CamTechMbarara University of Science and Technology
MIC	Makerere Innovation Centre
ZARDIs	Zonal Agricultural Research and Development Institute

DEFINITION OF KEY CONCEPTS

Innovation- an idea or invention that is developed into a good or service that creates value and/or for which customers will pay

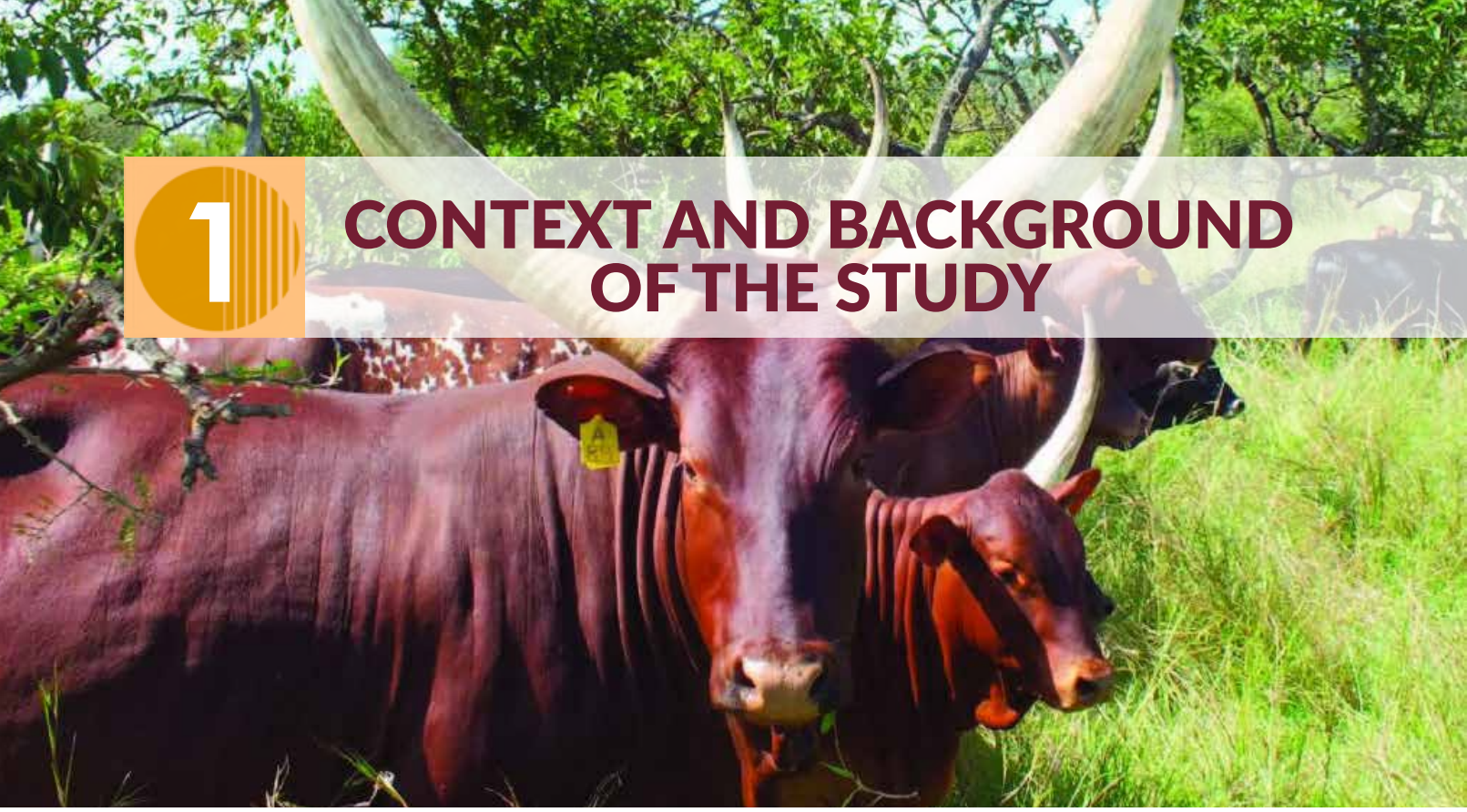
Innovation hub- Organizations that run innovation and incubation programmes.

Innovator- an individual who has developed ICT4Agric innovations that have attracted national and international attention and recognition.

Innovation Consumers- individuals and organizations that have taken up the ICT4Agric innovations especially small holder farmers.

Innovation influencers- government agencies aligned to the ICT and agricultural sector and sector opinion leaders.

Information Communication Technologies (ICT)- any device, tool, or application that permits the collection, visualization and exchange of data through interaction or transmission. ICT4Agric- the conceptualization, design, development, evaluation and application of innovative ways to use ICTs, with a primary focus on agriculture.



1 CONTEXT AND BACKGROUND OF THE STUDY

Globally, Information Communication Technologies (ICTs) have transformed the way people live and work. It is fair to note that, every sphere of human life, i.e.; education, agriculture, healthcare, trade and commerce, entertainment and leisure among others have all been transformed by a number of innovative ICTs. These technologies create systematic rapid transformation causing some societies to leapfrog development stages. One of the sectors which is seeing a more focused attention in terms of integration of ICTs is Agriculture. From basic agriculture enterprise selection, to more complicated diseases and pest detection, from basic farmer records management to more complicated logistics management, ICTs are opening new frontiers in the agricultural sector. The rapid development and adoption of ICTs in Agriculture is in part attributed to the relevancy of the sector to the economy since nearly 70% of the population in most developing countries depends on the sector. Besides this, the growing higher educational sector is providing highly skilled young people who are inspired to address contextually relevant issues in their communities. Therefore, this chapter of the report provides the context and background of the study in section 1.1 and discusses the study objectives and deliverables in section 1.2. Section 1.3 presents the guiding research questions and section 1.4 presents the overall report outline.

1.1. Evaluation Background and Context

The global sustainable development goals (SDGs), the African agenda 2063, Uganda vision 2040, and the National Resistance Movement (NRM) manifesto 2016-2021 and other development agenda frameworks all have earmarked Agriculture and Information Communication Technologies (ICTs) as pillars for social economic transformation. It is well documented that agriculture employs over 70% of Uganda's population of which majority are youth and women. Besides agriculture, ICT provides a unique opportunity to addressing youth unemployment as majority of the participants in the sector, particularly the innovators, are youth.

In many developing countries including Uganda, there is a demonstrable need for a new revolution that will bring lower prices for consumers through the use of smart agriculture –Agriculture that depends on ICT innovations to effectively and efficiently provide consumers with the necessary agriculture resources. There is no doubt that ICT has demonstrated incredible potential of improving agriculture productivity in developing countries specifically through innovations that use ICT. In this context Information Communication Technologies (ICT) are defined as; any device, tool, or application that permits the collection, visualization and exchange of data through interaction or transmission. Studies show that both locally and internationally, ICT has positively impacted agriculture by addressing a number of bottlenecks along a given value chain.

Within the agriculture value chain, stakeholders have always sought information from each other whether during growing of crops, raising livestock, farming fish, diagnosing diseases, buying and selling of produce among others. Questions that have always been raised include; what is the most effective planting strategy for a particular crop? Where can I buy the improved seed? How can I acquire a land that suits a specific crop with the right nutrients? Who is paying the highest price at the market? How can I participate in the government's credit program? Answers to all these questions are found within fellow agriculture stakeholders in form of information which they need to communicate amongst each other whenever it is needed.

For example, farmers may have planted the same crop for several years without facing a challenge; but over time, weather patterns and soil conditions change and epidemics of pests and diseases come and go. Receiving up to date information from other agriculture stakeholders allows farmers to deal with any challenges that they may face. However, acquisition of such information may be very challenging in the absence of technological interventions. Reason being that information needs to be captured within the local context, processed, tailored to specific challenges or conditions and finally disseminated in the best way possible for those who need to access it. With rapid changes in the environment, agriculture is facing new and severe challenges which have largely raised the cost of living due to rising food prices, low crop yields, droughts and so on thereby increasing the poverty levels both locally and globally. The World Bank (2011) noted that more effective interventions are essential within the agriculture sector in order to resolve the challenges that have contributed to over 40 million people being pushed into poverty.

Important to note is that mobile technology has supported reach out to the most remote smallholder farmers, who are the majority in Uganda, to improve context awareness and make better decisions along the value chain. Today, smallholder farmers can ably access, provide and contribute to agriculture data generation through the extension services or the available wireless technologies. Traditionally, pen and paper have been used to collect data in the field and for monitoring and evaluation of agriculture projects in the rural areas. However, this approach is time consuming and susceptible to human error that may affect productivity and accuracy. Information and communication technologies are now being used widely with remarkable positive results to perform these tasks in agricultural development projects. The adoption of ICTs in agriculture has led to the development of a field called ICT4Agric.

ICT4Agriculture involves the conceptualization, design, development, evaluation and application of innovative ways to use ICTs, with a primary focus on agriculture. In Uganda today, innovations in ICT4Agric include; ICT devices, applications, services and business models. Their growth is rapid and unpredictable, and it is becoming increasingly difficult to keep track due to the so many evolving solutions and models, the opportunities they create, and their implications to the agriculture sector. While the ICT sector is rapidly growing, there are limited studies which have documented the state of ICT4Agric and accordingly, this creates weaknesses in advocating for policy and investment frameworks for the sector. It is noted that, in many cases, the different technological advancements are not synchronized and hence causing a lot of duplication in terms of ICT interventions being made within the sector.

It is this lack of clear understanding of the innovations and trends in ICT4Agric which has constrained effectiveness of government interventions, often times resulting into government procuring solutions which would as well be scaled up from locally developed innovations or completely supporting duplicated efforts. Furthermore, there is lack of clear understanding of ICT needs for agriculture sector for Uganda. Besides devices, platforms and access infrastructure there is need to understand constraints in extension service delivery in terms of content development and access. It is important to note that without a framework of needs and wants,

it is complicated to effectively provide a policy direction to guide implementation of sustainable interventions. Therefore, Uganda Communication Commission (UCC) through its arm of Research and Innovation and Rural Communications Development Fund (RCDF) programme has supported academia in undertaking research and their participation in innovative ICT research. Through the special projects, UCC has supported the academia to accelerate research in areas of specific interest to UCC while leveraging on the knowledge, facilities and/or skills of the academia. The engagement between UCC and academia is well articulated in the UCC mandate described in the Uganda Communications Act 2013. The UCC Act 2013 states that UCC was established with the objective of developing a modern communications sector and is mandated by the Act to among others, promote research into the development and use of new communication equipment, techniques and technologies.

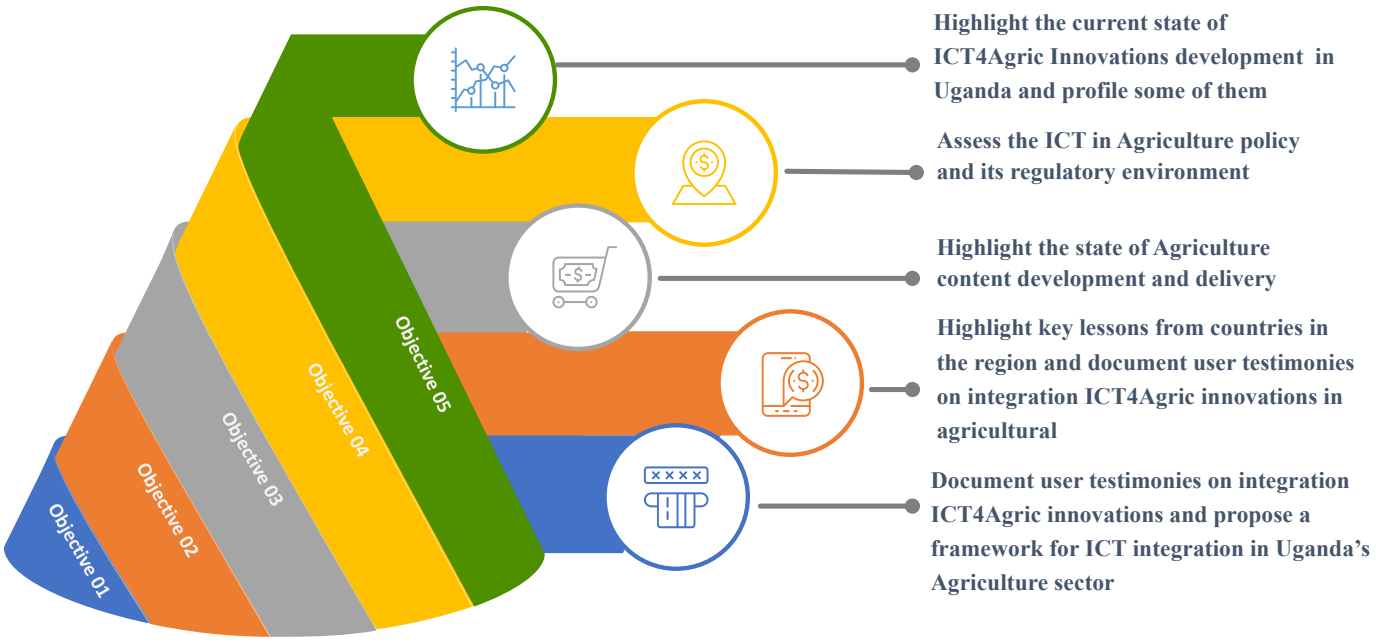
The execution of the research and knowledge generation mandate of UCC is largely implemented through its Rural Communications Development Fund. RCDF was established to administer a Universal Service Fund (USF), and supports research programmes for the development of new knowledge, and advance the deployment, development and use of communications services for sustainable development in Uganda.

The projects implemented by RCDF include; Internet points of presence (POP) - 76, Internet cafes – 106, ICT training centers – 78, Public payphones – 4,099, District web portals – 78, Multi-Purpose Community Tele-centers (MCT) – 13, Postal projects – 45, School ICT laboratories – 708, Health ICT facilities – 174, Voice network sites – 90, Content development projects – 106, Local governance projects 2, and Other unique projects – 31. The direct impact realized out of the projects implemented by RCDF so far includes; 100% voice coverage at the sub county level, 100% data coverage for every district town of Uganda, teaching of Computer Studies as a subject in at least 50% of government secondary schools and providing basic ICT equipment in all district government hospitals.

Thus, in line with the mandate of UCC and RCDF, this study seeks to provide a clear understanding of the current state of art and practices in ICT4Agric in Uganda with an aim of addressing the existing knowledge gap about the sub-sector, but more importantly providing evidence to guide policy development and intervention strategies designed by government and other stakeholders.

1.2. Objectives and Scope the Study

The broader objective of the study were to establish the current state of ICT4Agric innovations in the country. The specific objectives of the study were to;



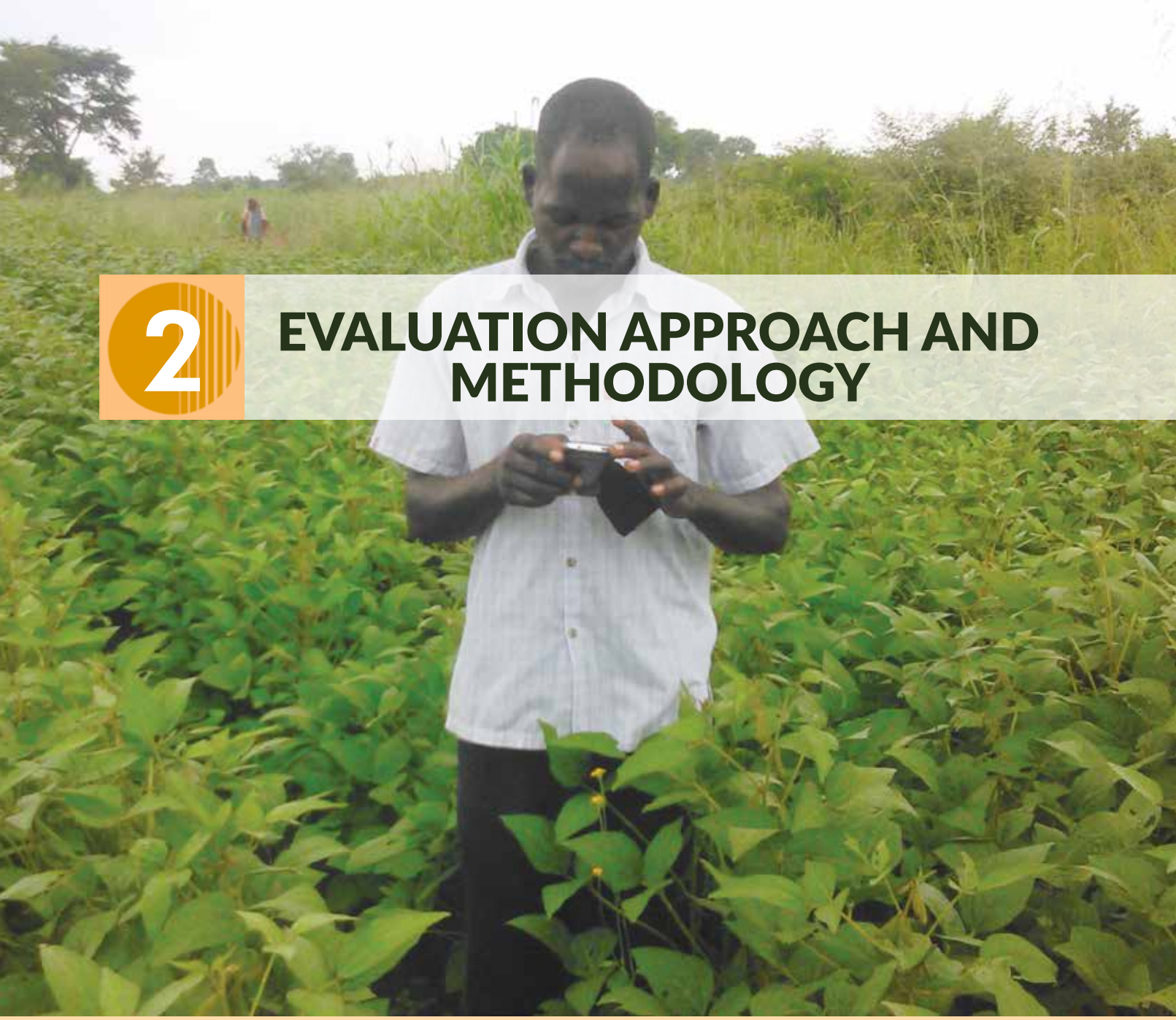
1.3. Evaluation Guiding Questions

In order to achieve the study objectives, guiding research questions were developed. The questions were meant to guide the processes of data collection, synthesis and results presentation. The following were the study guiding research questions;

1. What is the current state of art and practice in the development and use of ICT in agriculture? What are the existing approaches and applications? Can these approaches be scaled up and how?
2. What is the current state of practices in content development and delivery for farmer training? What are the successes, failures and bottlenecks in content development and delivery?
3. What are the enabling and constraining elements in the development of ICT4Agric? Does Uganda have the right policy environment, education and technical platforms to spark ICT4Agric?
4. Does the country have an ICT integration strategy for Agriculture, if yes how appropriate is the strategy in relation to the country's development agenda and operating context?
5. What challenges are faced both in the development and adoption of ICT4Agric Innovations? What are the possible recommendations to counter check the challenges?
6. What institutional development needs to take place to ensure that ICT4Agriculture has a sustained impact?
7. What is the Return on Investments (RIO) by adopting ICT within the agriculture sector?
8. How can success be measured? Which initiatives should best be left to private sector role players, development agencies and government respectively, and how can these initiatives be supported by research, policy and strategy?
9. What part of the information and knowledge chain should be subsidized, and what part should be handled by commercial players?
10. What lessons are there to learn from countries in the region who are integrating ICT in agriculture?

1.4. Structure of the Report

The rest of the report is structured as follows; chapter 2 presents the study methodology and approach, chapter 3 presents and discusses the findings of the study, chapter 4 presents the proposed ICT4Agric Integration framework for Uganda, chapter 5 presents the discussion on emerging conclusions and recommendations. Chapter 6 provides the bibliography and chapter7 presents relevant appendices.



2 EVALUATION APPROACH AND METHODOLOGY

For the results of any scientific inquiry to be accepted by the peer community, the processes that yielded the results must be articulated and justified for appropriateness for the purposes of the principle of "Fit for purpose". Therefore, this Chapter presents the evaluation approach used to conduct the study in section 2.1 and details the step by step methodology in section 2.2. Section 2.3 discusses the quality assurance practices and the associated ethical considerations. The chapter ends with a presentation of the study sample details and stakeholder mapping in section 2.4.

2.1. Assessment Frameworks and Approaches

The study was conducted by a team of experts with a variety of skills and experiences in conducting similar tasks. The team deployed mixed research methods approach incorporating both quantitative and qualitative data collection and analysis techniques. The quantitative methods (the survey) were used mainly to gather data from the key stakeholders such as; ICT4Agric innovators, Consumers of ICT4Agric innovations, academia and private sector players. Qualitative data were generated from the sector opinion leaders, policy makers (MAAIF), industry leaders, development and implementing partners and innovation hubs using appreciative inquiry methodologies such as Key Informant Interviews (KII) Focus Group Discussions (FDGs). An extensive review and analysis of secondary data sources was also conducted to gather facts about ICT4Agric sub-sector ecosystem. The overall approach is as illustrated below:

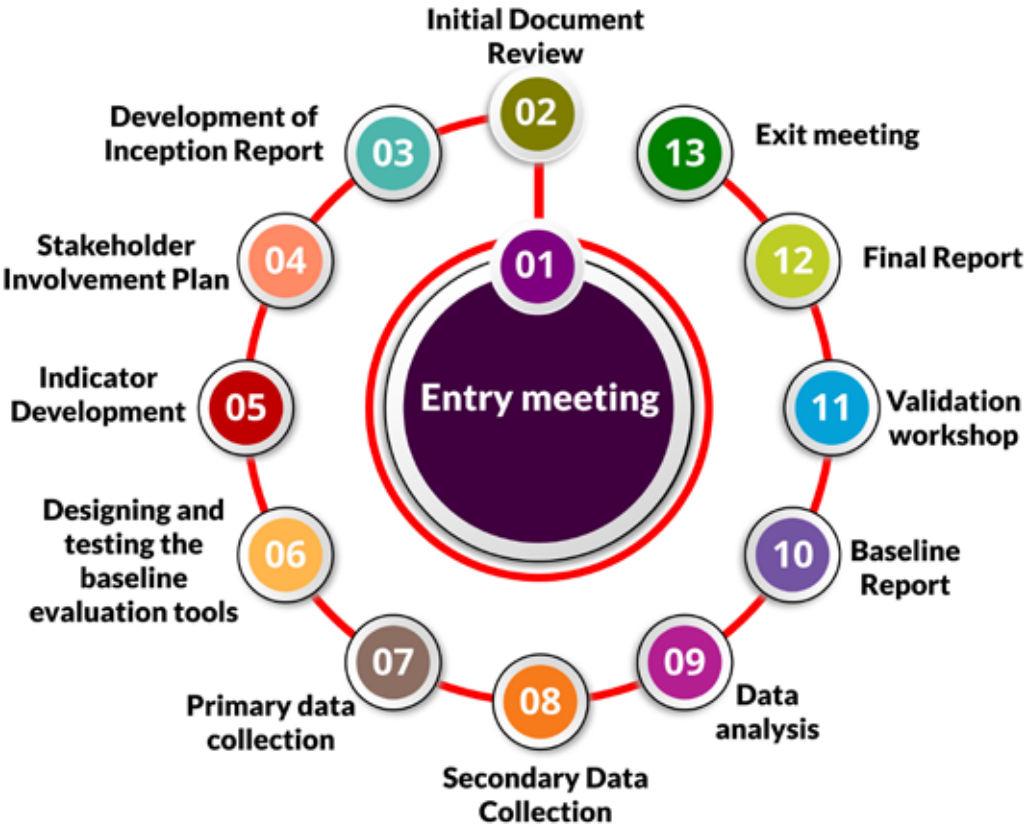


Figure 1: Evaluation Approach

The survey questionnaires were digitalized in Google's forms to improve quality and clarity. The data was then analyzed using spreadsheet software. Qualitative data was analyzed with the aid of qualitative data analysis software ATLAS.ti and principles of thematic analysis. The step by step process is presented in section 2.2 below.

2.2. Evaluation Methodology

The rest of the report is structured as follows; chapter 2 presents the study methodology and approach, chapter 3 presents and discusses the findings of the study, chapter 4 presents the proposed ICT4Agric Integration framework for Uganda, chapter 5 presents the discussion on emerging conclusions and recommendations. Chapter 6 provides the bibliography and chapter7 presents relevant appendices.

Activity/step	Description of what is involved in each stage
Entry meetings	Upon the receipt of the signed MoU from UCC, the researchers held a couple of preliminary entry meetings with the UCC project team. The meetings sought for clarification of the unclear issues pertaining to the assignment so as to bring both the researchers and the UCC at par thereby creating a similar understanding of the assignment and the deliverables expected thereof. This was a critical activity for the success of the assignment.
Preliminary review of documents	After the entry meetings, background documents were reviewed to provide an appropriate context for the assignment. The team reviewed a number of reports about ICT4Agric and ICT innovations in Uganda and the region.
Stakeholder Mapping	From the entry meetings and preliminary document reviews, key stakeholders were identified and the strategy of engaging them developed. The research team used a stakeholder matrix to map out the key stakeholders, their roles and nature of information needed from them as aligned to the objectives of the study.

Inception Report	From the preliminary works, a complete inception report was developed and shared with the UCC team. The report stipulated the team's understanding of the assignment from conceptual level to outcomes, the methodology and approach, work plan for the execution of the assignment, and a template for the final impact report. This inception report acted as a service level contract for the execution of the assignment.
Inception meeting	As standard procedure, the research team officially presented the inception report to UCC team in January 2019. Upon its acceptance, the execution of the assignment commenced
Secondary data collection	The consultants conducted a rigorous collection of information from secondary sources both within UCC and the ICT sector in general. The reports from different organisations, regulatory bodies, books, journal papers, case studies, feasibility reports were used as useful sources for the secondary data.
Designing of instruments for impact Assessment	During this stage, data collection tools were designed, tested and validated. Furthermore, the survey questionnaires were digitized to improve both data collection efficiency and data quality.
Training of Research teams	As part of the quality assurance system for this evaluation, all teams were taken through half day training. The training covered not only the data collection process requirements but generic best practices in collecting data. The training also took the research team through the data collection instruments so as to make them well conversant with the tools.
Data collection and analysis	The team deployed the different instruments developed to collect data from various sources. The primary data was largely collected using Key Informant Interviews (KII), Focus Group Discussions (FDGs) and Survey Questionnaires (SQ). Given the nature of information desired to answer the research questions, the respondents were selected using purposive sampling technique. The data was later cleaned and analysed using spreadsheet software, ATLAS.ti and principles of thematic analysis to derive meaning in line with the assessment objectives.
Draft Report	The draft report detailing emerging observations, conclusions and recommendations for various stakeholders was prepared and shared with UCC and other stakeholders at a validation workshop.
Validation workshop	In order to have stakeholder input in the draft report, the research team facilitated a stakeholder validation workshop. Whereas the consultant prepared and delivered the research outcomes, UCC took care of all the logistics pertaining to the workshop.
Final Report	Taking into account the comments from the validation workshop, the researchers incorporated the comments to make this final report.
Exit meeting	An exit meeting will be conducted as a formal procedure for closing the assignment. The consultant will share with UCC the key lessons and discuss the plan for implementation of the recommendations as per the work philosophy of professional consultancy advise.

2.3. Quality Assurance and Ethics

Quality assurance is a key element in any evaluation assignment. A quality evaluation should provide credible and useful evidence to strengthen accountability for results observed and conclusions drawn. The research applied guidelines of the Uganda evaluation association standards for conducting this study plus those provided by other relevant professional and ethical guidelines and codes of conduct. Assessment was conducted with the highest degree of integrity and honesty. The researchers observed human rights and differences in; culture, customs, religious beliefs and practices of all stakeholders during the processes. The research team

accommodated gender roles, ability, age, language and other differences when designing and carrying out the assignment. Quality control was carried out through an internal mechanism of peer review of tools and data sets, monitoring and evaluation of the research process among others. All participants and actors in the study were treated with respect and dignity and the respondents had to first consent before any survey or interview was conducted. To ensure that objective data was collected and analyzed, researchers were duty bound to declare any conflict of interest with any respondent so that alternative members were assigned a data collection source with which they do not have a conflict of interest.

2.4. Sampling and Stakeholder Mapping

The study respondents were purposively selected and their level of importance established. A total of 185 respondents were targeted out of which 279 responded as highlighted in the summary table below;

Category	Level Importance	Targeted	Responded	DCM
Innovators in ICT4Agric	High	40	105	KII & SQ
Innovation and Incubation hub operators	High	10	13	KII
Industry Analysts and influencers	High	15	8	KII
Policy Makers	Medium	10	6	KII
Development partners	Medium	10	4	KII
Consumers of ICT4Agric innovations	High	100	143	SQ
Total number of stakeholders targeted		**185**	**279**	

Table 1: Summary Profile of Respondents

Outstanding innovators- in this study were individuals who have developed ICT4Agric innovations that have attracted national and international attention and recognition. These included; ERIGNU project, Kudo, Fits Uganda, Ensubiko, Jaguza, M-Voucher, Greenleaf, Ticprome among others. The innovation and incubation hub operators included organizations that run innovation and incubation programmes. Some of the key organizations surveyed are; Mbarara University of Science and Technology (CAMTech), Uganda Technology and Management University (CIBI), Gulu University Department of Computer Science, Outbox, HiveColab, Design Hub, Makerere Innovation Centre, CURAD, AI Lab Makerere University, TechBuzz and Innovation Village. Industry Analysts, influencers and policy makers included; government agencies aligned to the ICT and agricultural sector and sector opinion leaders. Consumers of ICT4Agric innovations-included individuals and organizations that have taken up the ICT4Agric innovations especially small holder farmers. Development partners are organizations who are active in the promotion of ICT integration in agriculture sector, these included; the World Bank, The Dutch Embassy in Kampala among others.

The research team conducted a total of 49 interviews among stakeholders, held 1 focus group discussion (with a total of 15 participants) with innovators at one of the innovation hubs in Kampala. At total of 143 consumers of ICT innovations in agriculture were surveyed and these included; farmers (majority of whom were smallholder farmers), agro processors, input providers, produce dealers and logistics providers. The response rates were representative enough to enable the researchers draw sound conclusions.

A review of local initiatives in ICT4Agriculture focusing on improving agriculture productivity through a number of interventions aimed at; access, advice, surveillance, diagnosis, information dissemination, as well as a focus on market linkages and marketing, and mobile money was conducted.

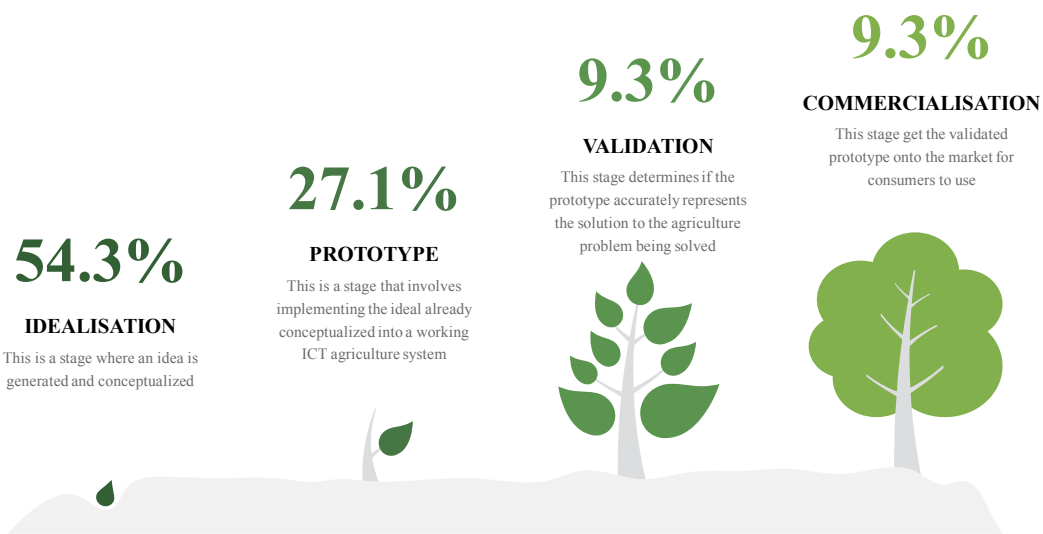
The study also conducted case studies on some widely mentioned innovations such as; ERIGNU, JAGUZA, AKORION, E-voucher system, SUFACE model, Kudo, VIAZI system, among others.

3 STUDY FINDINGS

In line with the set study objectives, this chapter presents and discusses findings of the first six objectives of the study. Section 3.1 presents a profile of key ICT4Agric Innovations in Uganda, Section 3.2 presents the current state of ICT4Agric innovations development in Uganda, section 3.3 presents state of ICT4Agric policy and regulatory environment, section 3.4 presents state of agriculture content development and delivery, section 3.5 presents regional trends in ICT for Agriculture and lastly section 3.6 presents user testimonies on integrating ICTS in their agricultural processes.

3.1. Profile of Key ICT4Agric Innovations in Uganda

In this study, a total of 173 ICT innovations for agriculture were identified. These innovations were at various stages of development. Of the 173 ICT4Agric innovations identified, majority (94 out of 173) representing 54.3% were at idealization stage and these were not considered for further analysis. Of the remaining 79 innovations, 47 were prototypes, 16 were at validation stage and a further 16 were at commercialization stage. In order to provide a good context of the innovations in the ecosystem, in this section we highlight a few profiles of key innovations identified during the study. The innovations are profiled based on the following framework; innovation name, innovator, services provided, stage of innovation, number of users, remarks.



1. **Jaguza**

Parameter	Value
Innovation brand name	Jaguza
Innovator name	Mr. Ronald Katama
Years of existence	7 years
Contact	katambaronald@gmail.com and https://jaguzafarm.com
Services provided	Animal health detection, animal movement tracking, farmer records management and livestock inventory management.
Stage of Innovation	Commercialization
Capital invested	>20,000USD
Number of users	1967
Number of employees	6
Remarks	This innovation has been tried and tested and has excellent potential for scaling out.

2. **Axiom Zorn Ltd**

Parameter	Value
Innovation name	Market-led, User-owned ICT4Ag-enabled Information Service (MUIIS)
Innovator name	Carol Kyazze Kakooza
Years of existence	4 years
Contact	ckakooza@axiomzorn.com
Services provided	Farmer profiling services
Stage of Innovation	Commercialization
Capital invested	>150,000USD
Number of users	250,000
Remarks	Focuses on farmer profiling as means of creating information service value. As of May 2019, a total of 250,000 farmer profiles have been created. This also has an excellent prospective for scaling up.

3. **Kudu**

Parameter	Value
Innovation name	Kudu
Innovator name	Dr. Richard Ssekibuule
Years of existence	9 years
Contact	rkayondo@gmail.com or https://kudu.ug/
Services provided	Market access information and brokerage services including auctions
Stage of Innovation	Commercialization
Capital invested	>150,000USD
Number of users	Over 15,600 users as of May 2019
Remarks	This is an excellent innovation, which addresses critical gaps in the value chain on the segment of market access. It improves farmer negotiation position for better prices but also enhances buyers decision making on logistics management.

4. **M-Voucher**

Parameter	Value
Innovation name	M-Voucher
Innovator name	Vouch Digital
Years of existence	4 years
Contact	http://vouchdigital.africa/, or info@vouchdigital.africa
Services provided	The M-Voucher system is a software-as-a-service that consists of a USSD (Unstructured Supplementary Service Data) system used by farmers and agro-dealers to redeem seed crops as well as post-harvest equipment; a management information system that tracks real-time data collected from beneficiaries as well as a payments system integration that allows agro-dealers and beneficiaries to receive instant payments for products redeemed
Stage of Innovation	Commercialization
Usage	By December 2017, M-voucher had made about 1,177,633,700 Billion transactions. The current levels of usage were not provided.

Remarks	This is a good application that supports farmers in getting real-time data and payments from a variety of beneficiaries.
Remarks	This is an excellent innovation, which addresses critical gaps in the value chain on the segment of market access. It improves farmer negotiation position for better prices but also enhances buyers decision making on logistics management.

5. **M-Omulimisa**

Parameter	Value
Innovation name	M-Omulimisa
Innovator name	Daniel Ninsiima
Years of existence	7 years
Contact	https://m-omulimisa.com/ or dninsiima@gmail.com
Services provided	Extension services, Soil testing, Agriculture insurance, Provision of inputs and output marketing, Farmer profiling, Agriculture finance
Stage of Innovation	Commercialization
Number of users	13,314 farmers registered, 109 extension officers and 51 districts served. On agriculture insurance service, 302 Agro- Insurance Agents have be recruited onto the platform, 2453 farmers subscribed for season 2 2018 and a total of 3670 acres of crop insured generating 23,536,000 UGX in insurance Premium.
Remarks	This is very good platform which is maturing and has capacity for scaling out. The village agent model is novel and similar to SUFACE model of key farmer trainers. The innovation addresses key gap areas along the value chain on access to finance and extension services.

6. **Decfa**

Parameter	Value
Innovation name	Decfa
Innovator name	Faith Ahabyoona Mugisha
Years of existence	2 years
Contact	faithmugisha80@gmail.com ; http://decfastudio.com/
Services provided	Credit facilitation decision information and credit management services
Stage of Innovation	Commercialization
Capital invested	>50,000 USD
Number of users	Over 520 users as of February 2019
Remarks	A practical innovation for addressing, credit capital sourcing, credit screening and approval and credit reporting challenges for small holder farmers in community based agricultural cooperatives. It empowers cooperatives managers and members to raise optimal capital for credit and ensure this credit is lent out optimally, ensuring transparent and timely reporting for all stakeholders which results into agricultural credit sustainability a key requirement for agriculture today.

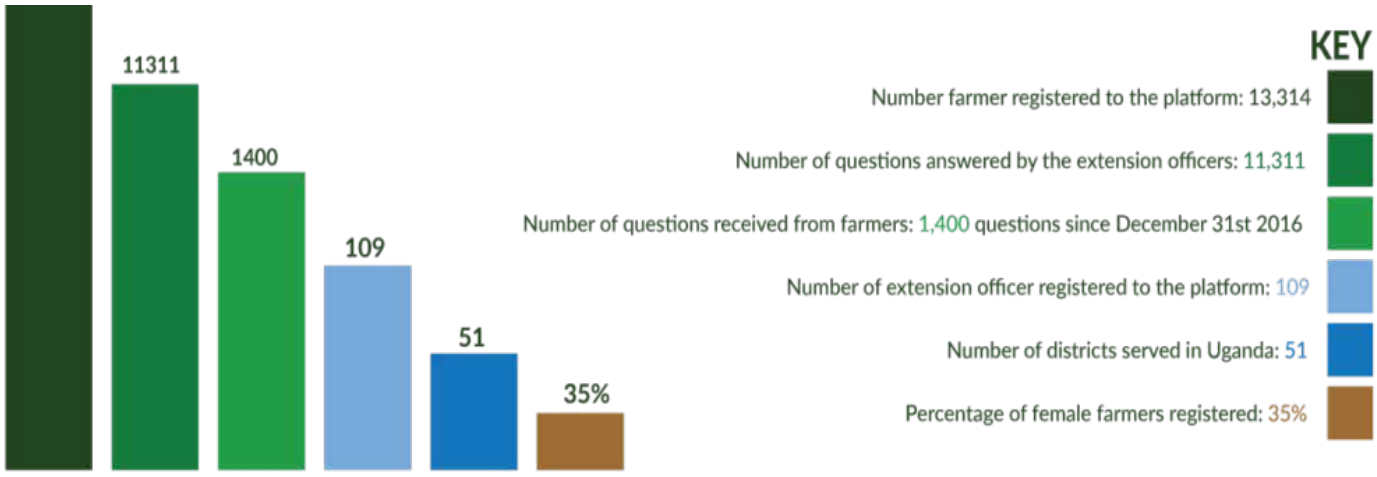


Figure 2: M-Omulimisa Usage Statistic as of April, 2019 (Source: M-Omulimisa)

7. **ERIGNU-SUFACE**

Parameter	Value
Innovation name	SUFACE Model (ERIGNU &Viaz)
Innovator name	Dr. Drake Patrick Mirembe
Years of existence	9 years
Contact	dpmirembe@gmail.com, www.suface.org , www.erignu.org , www.sweetpotatoeseastafrica.org, www.cassava-carp.org and www.drakemirembe.org
Services provided	Farmer profiling, input and output markets linkages, garden mapping, farmer query management, pest and diseases surveillance, farm record management, extension service provisioning largely using the Key Farmer Trainer (KFT) community based extension agents.
Stage of Innovation	Commercialization
Number of users	Over 6423 farmers have been served, over 232 gardens mapped across various instantiations of the innovation. The innovation has largely been use in northern and eastern Uganda with Anchor centers in APAC and Bukedea.
Remarks	This innovation was designed as a scientific model for enhancing extension service delivery. Accordingly various variants of the platforms have been developed, including adaption for the east African wide sweet potatoes systems www.sweetpotatoeseastafrica.org. The innovation is ideal for scaling up in terms of depth and breadth. The current usage has been largely donor driven as part of research efforts with various actors.

8. **Green Leaf**

Parameter	Value
Innovation name	Green leaf system
Innovator name	Eight Tech Consults Ltd
Years of existence	7 year
Contact	www.8technologies.net or robert@8technologies.net

Services provided	Enterprise information management for tea processing factories. This include; employee record management, out growers record management, invoicing and payments, sales and marketing records among others.
Stage of Innovation	Commercialization
Number of users	One enterprise user (Mpanga tea growers factory)
Remarks	This innovation is a commercial innovation and can be adapted by other factories operating business related to agro-processing. The development and deployment is both demand driven anddonor driven.

9. **Adsurv**

Parameter	Value
Innovation name	Adsurv / Mcrops
Innovator name	AIR research lab, Makerere University
Years of existence	5 years
Contact	http://air.ug/mcrops/, emwebaze@gmail.com
Services provided	Cassava disease diagnosis, geo spatial mapping, white fly detection and on field data collection.
Stage of Innovation	Validation
Number of users	It was not easy to determine the number of users.
Remarks	This is a good innovation and the foundation principles can be applied to other crop value chains.

10. **EzyAgric**

Parameter	Value
Innovation name	EzyAgric
Innovator name	Akorion Company LTD
Years of existence	4 years since September 2014
Contact	www.akorion.com
Services provided	Farmer profiling, garden mapping, extension information, Agri-shop, market linkage, farm record keeping.
Stage of Innovation	Commercialization
Number of users	60,000 farmers and digitally profiled 42,000 farmers through a network of 480 village agents majority of which are youth and 100 farmer associations.
Remarks	It is a good innovation serving a critical segmentation of the section. However, like many other innovations in the sector the current deployment model is largely donor driven as opposed to be being demand driven.

11. **AkelloBank**

Parameter	Value
Innovation name	Akello Bank
Innovator name	Jean Anthony Onyait
Years of existence	About 3 years
Contact	http://www.akellobanker.com

Services provided	Financial services including; credit worthiness index, service brokerage and linkage to financial service providers. Other services include financial record keeping.
Stage of Innovation	Commercialization
Number of user	According to Akello bank website as of 30th April, 2019 more than 300 Merchants are using the platform to manage their inventory and sell their products and services on credit to farmers.
Remarks	Akello Bankoffers easy access to tractor hire, improved seed, medical services and farm labor on credit, by leveraging data & mobile Tech to offer structured re-payments compatible to the user's needs. The platform integrates mobile money and use of USSD to facilitate instant access, disbursements and repayments. The technology uses the historical data collected to generate unique Credit Identities, which track the user credit behavior to assign appropriate credit scores.

12. **Ensibuuko**

Parameter	Value
Innovation name	Ensibuuko
Innovator name	Opio David
Years of existence	6 years
Contact	https://ensibuuko.com
Services provided	Microfinance software platform helps cooperative microfinance entities automate their data, process and payments so as to become efficient in delivering financial services in their communities.
Stage of Innovation	Commercialization stage
Number of users	About 5,000 users
Remarks	Ensibuuko is a leading Uganda-based fintech whose work seeks to address financial inclusion in Africa. Ensibuuko's proprietory microfinance software platform helps cooperative microfinance entities automate their data, process and payments so as to become efficient in delivering financial services in their communities.

Efficient management of savings and loans.

Mobis is a cloud-based microfinance management platform designed uniquely to help savings and loans cooperatives go paperless and become more efficient by digitizing how they manage customer data and transactions.

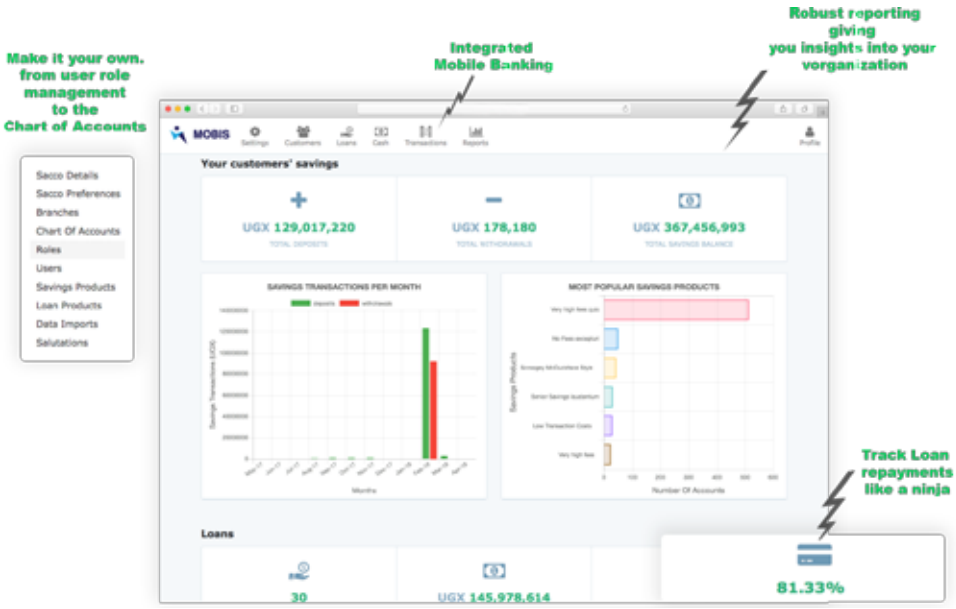


Figure 3: Ensibuuko Interface

13. **Automated Irrigation System**

Parameter	Value
Innovation Name	Intelligator (Intelligent Irrigation System)
Innovator Name	Nuwagaba Collins
Years of existence	1
Contact	0753 099 733, nuwacole@gmail.com
Stage of innovation	Prototype
Number of Users	Thousands once deployed
Remarks	Intelligator; an acronym for Intelligent Irrigator is a modern innovation for farmers today. This innovation is intended to autonomously monitor and control distribution of water in gardens by use of a micro-controller and a number of sensors and devices. The devices and sensors are used to check water reservoir levels, temperature, soil moisture, control opening and closing of valves as well as self-diagnosis. Also, data from the individual gardens is sent to a central online database. It is from here, that data mining is done; particularly for insights about agriculture in the region. The beauty of this system is that it can easily be configured onto already existing plumbing systems (preferably drip irrigation).

14. **WIMEA Project**

Parameter	Value
Innovation name	WIMEA
Innovator name	WIMEA project
Years of existence	5 years
Contact	https://wimea-ict.net
Services provided	Wealth information services
Stage of Innovation	Validation
Number of users	
Remarks	This is a very good innovation as it addresses critical information needs of reliable and timely wealth information for enhanced decision making.

15. **Larvae Incubation Can**

Parameter	Value
Innovation name	Larvae Incubation Can
Innovator name	Kamya Simon Peter, Agaba Deuse, Kagame Thomas
Years of existence	2 Years
Contact	0773 030 132
Services provided	Production of Larvae for poultry farmers using technology under a domestic home environment.
Stage of Innovation	Prototype
Number of users	Multiple Users
Remarks	As an alternative for insects, larvae are now fed to poultry. With the rising need for a mass production, the use of technology to enhance the incubation cycle of house fly larvae is inevitable. The Larvae Incubation Can is a portable bucket that enables continuous in door production of larvae by incubating eggs of house flies in an ICT regulated temperatures based on programmed heat sensors and generators. This eliminates dependence on natural conditions that affect the production rate of larvae for poultry by farmers. This technology can be used in production of other foods that can be used for human consumption such as incubation of grasshoppers among others.

The analysis of the most promising innovations targeting smallholder agriculture or what one can call success stories indicate that deployments and uptake of these innovations has largely been driven by donor projects as opposed to demand driven or policy implementation by government. This observation raises challenges of sustainability of innovation uptake among smallholder farmers if the technology adoption and adaption processes are driven by donor projects. Furthermore, most of the innovations are targeting crops farming and very few have focused on animal husbandry yet animal husbandry is one of the critical activities in the commercial value chains for subsistence farmers as most farming communities' practice mixed farming. It was quite revealing that very few innovations are targeting use of drone technologies. This might be explained by the fact that most of the farmer targets are smallholder farmers with less than 1 acre of land and might find drone technologies quite expensive, hence the slow development and adoption of these technology platforms.

3.2. State of ICT4Agric Innovations Development in Uganda

This section highlights what is currently in place in terms of what ICT4Agric innovations have been developed within the agriculture value chain.

3.2.1. State of Development of ICT4Agric

a) Innovators' Profiles

Education level-Past research that has been undertaken in Uganda has clearly showed that the innovation eco-system within the country comprises of different types of innovators. These innovators range from certificate to PhD holders. The innovators are developing applications for a variety of service areas including the agriculture sector. Past research on the education levels of innovators indicates that 58.5% innovators are bachelor holders, 18.9% certificate holders, 13.2% diploma holders and 9.4% master level holders as described in figure 4. These results describe that the majority innovators are those that have just completed their bachelor degree hence making an interpretation that most of the current innovations start as projects within the institutions of learning.

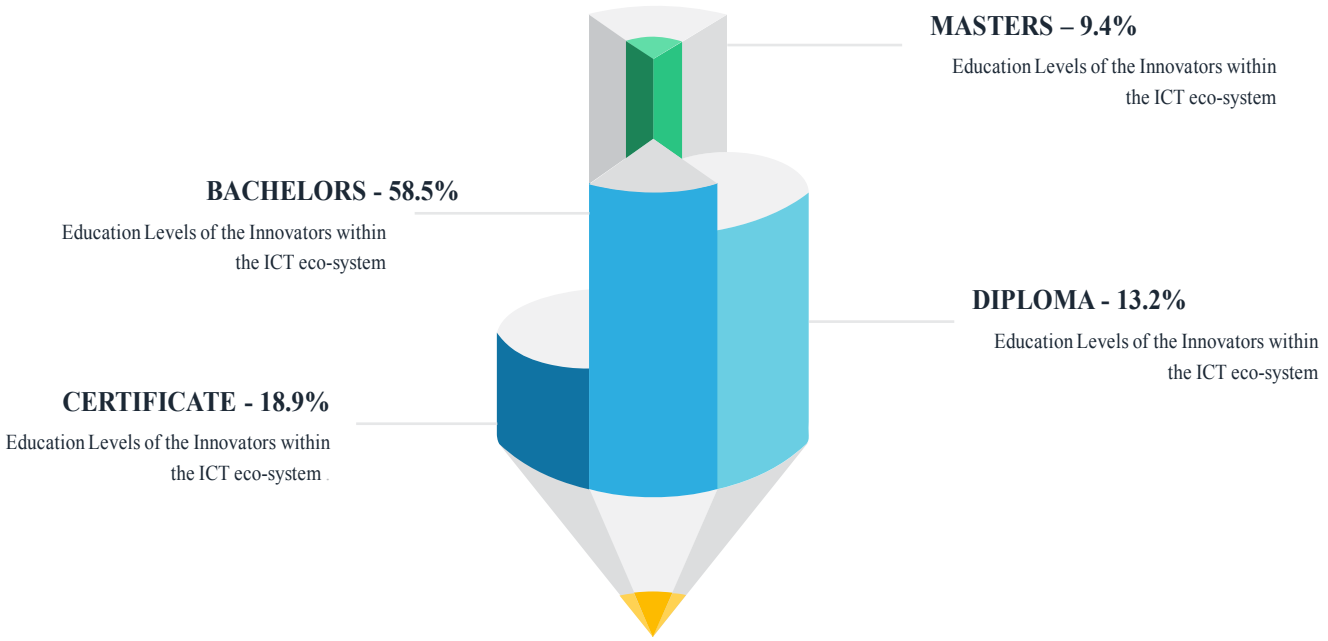


Figure 4: Education Levels of the Innovators within the ICT eco-system (Source: ICT Innovation Initiatives Impact Assessment Report 2018)

However, these innovators have some motivations that drive them to participate within the ICT4Agric innovations.

Motivations-The study sought to find out from the innovators what motivated them to participate in the development of the ICT4Agric applications with background information that agriculture in the country is for smallholder farmers who may have no resources to pay. The study therefore, examined the goals and mandate that the innovators had when developing the innovations. Table 2 below provides a summary of the findings.

Table 2: Visions and Motivations of the Innovators

- Use of modern technologies like irrigation etc
- Elimination of middle men and link farmers and potential buyers
- Product and service substitution
- Monitoring of farming activity
- Reach the remote farmers
- Improve quality of agricultural products
- Provide educative agricultural relate content
- Risk management of farming
- Digitalize the agricultural sector
- Fight pests and diseases
- Registration of livestock and plantations
- Improved buying and payment systems
- Improved record keeping
- Improved productivity
- Information to farmers (seasonal, markets, soil condition, weather updates etc)
- Marketing farmers' output
- Reduce farming costs

It is clear that majority of them were motivated by the fact that they wanted to improve on production within the agriculture sector. With such facts, it is clear that there is less sensitization amongst the innovators on what levels of the agriculture value chain to innovate for.

One of the innovators who had a product already commercialized indicated to the research team

"I noted that my uncle in the village received less from his hard work because his produce was being bought off at a giveaway price. This means that farmers are not getting worth their efforts and time because the middlemen buy their products very cheaply. This is very discouraging to many of them and it is the reason we developed this application to support the farmers in getting worth their efforts. My uncle can now publish what he wants to sell and the produce can be bought off right from the garden and this has increased his income."

The findings in table 2 above together with the statement above indicate that majority of the motivations were demand driven because the innovators wanted to solve various problems that the agriculture sector faced. Subsequently, many of the innovations are a result of trying to meet a demand from the (smallholder) farmers and not an opportunity to make money from them.

Age-The research on ICT innovation in Uganda of 2018 that evaluated 1,385 innovators indicated that in the innovation eco-system, innovators as young as 19 years participate actively in the development of different ICT applications. It is these same innovators that are actively developing innovations for the agriculture service sector. The research clearly indicated that majority of the innovators were between the ages of 19-29 as described in figure 5 below.

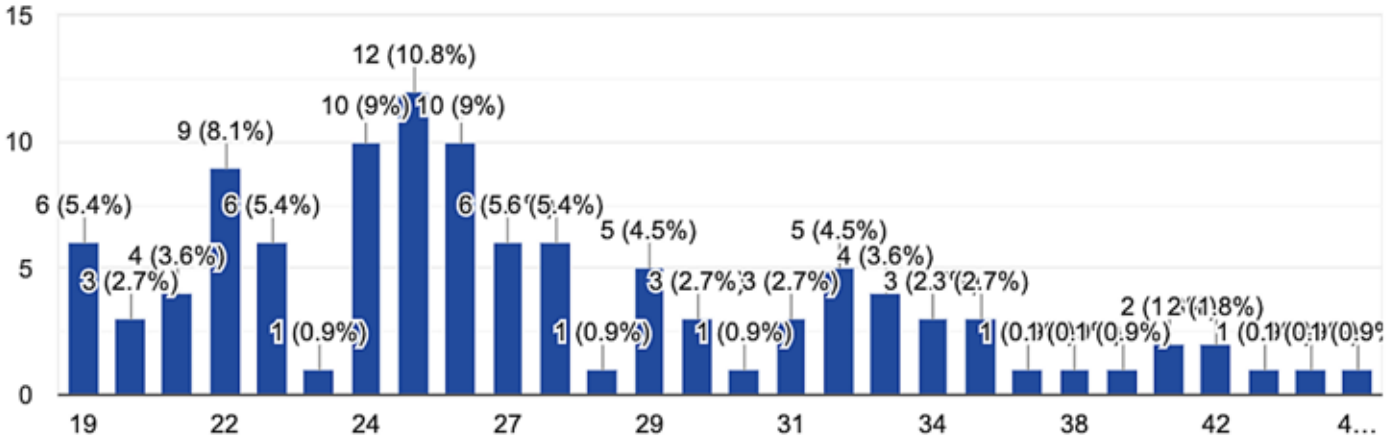
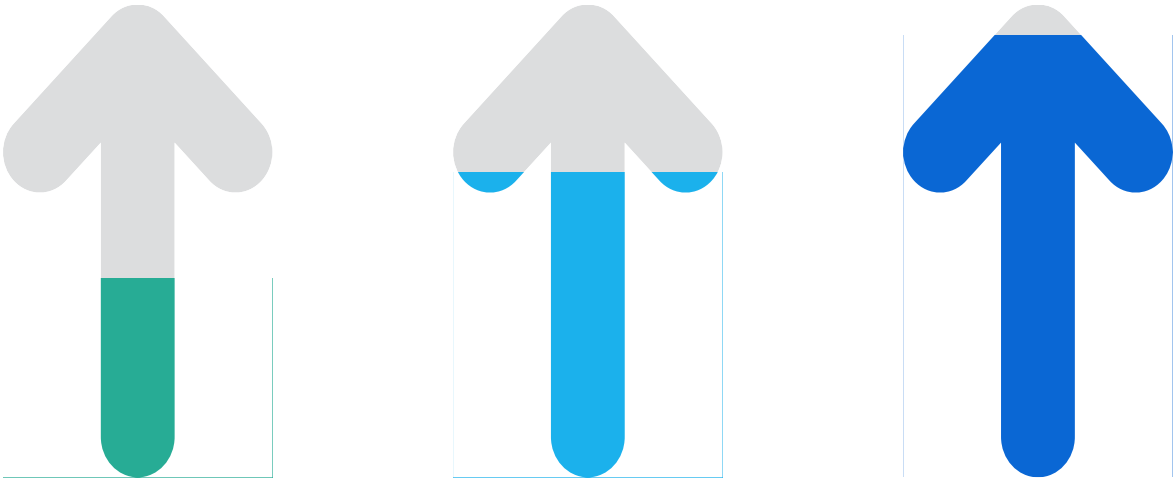


Figure 5: Sample Age bracket for the innovators (Source: ICT Innovation Initiatives Impact Assessment Report 2018)

The results of survey among innovators also revealed that there is an older category of innovators between 35-42 years of age who participated in innovations. It was also noted that as the innovators grow in age, participation in innovation initiatives dwindled too. The most interesting observation is that the age range 24-27 is the most active age group to participate in the innovation activities. This is the youthful age after completion of the higher institution of learning and graduates are looking for what to do next. It is therefore important to note that the agriculture sector needs to actively tap into this age group if more ICT applications within the sector are to be developed.

Employment status- Majority of these innovators are fresh graduates who are not employed but have the skills to innovate. Sometimes, the graduates have worked on their final degree projects which they feel they can transform into a startup company to support the agriculture sector among others. It should also be noted that since many of them are just fresh graduates, they are may be employed, not employed or self-employed within their startups. Figure 6 below describes the employment status of the innovators who are actively innovating for the industry which includes agriculture.



UNEMPLOYED – 22.6%

Employment status for the Sampled innovators

FORMERLY EMPLOYED – 36.8%

Employment status for the Sampled innovators

SELF EMPLOYED – 40.6%

Employment status for the Sampled innovators

Figure 6: Employment status for the Sampled innovators (Source: ICT Innovation Initiatives Impact Assessment Report 2018)

Majority of the sampled innovators were self-employed (40.6%) followed by the formal employment (36.8%) and then the unemployed with (22.6%). In general, results indicate that majority (63.2%) of the graduates who participated in the study were not in the formal employment. These results clearly confirm that most innovators are the unemployed graduates who do not have enough resources to get their innovations to commercialization.

b) Innovators interest among the service sectors

It was also observed that not all service sectors receive equal attention from the innovators but agriculture was found to be one of those already having locally commercialized innovations. Figure 7 below describes the service sectors that have already commercialized their local innovations in Uganda.

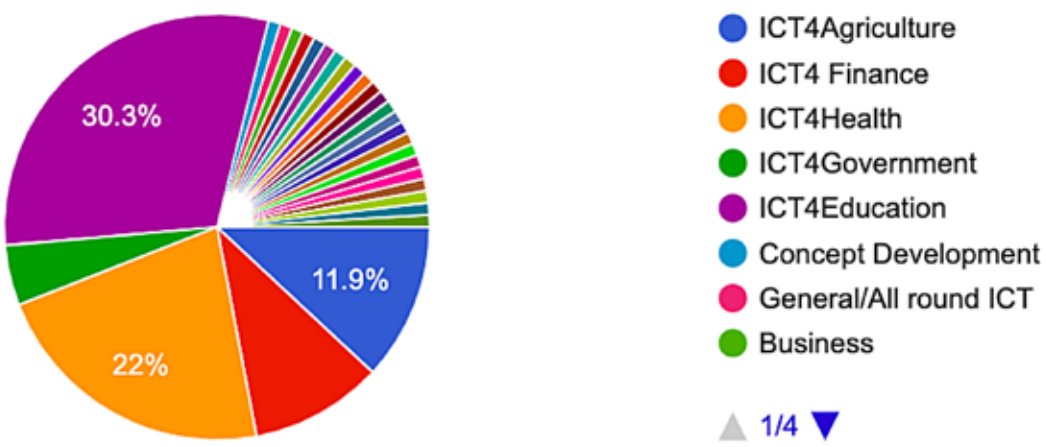


Figure 7: Service sectors of the innovators (Source: ICT Innovation Initiatives Impact Assessment Report 2018)

It should be noted that agriculture was ranking number three amongst the service sectors that were having their local innovations commercialized. The results further show that ICT4Agric innovations are some of the popular ones within the ICT innovation eco-system. Since agriculture is the sector that brings in the highest income to the country, the expectation would be to have the highest number of innovation participants. This is an indication that this sector is not yet receiving its desired return on investment since it generates the most income for the country but there is less innovation around it.

c) Years in Existence for the Innovations

The research team further wanted to understand the age of the ICT4Agric innovations that were being used in the country. Figure 8 describes the years of existence for the selected 79 ICT4Agric innovations.

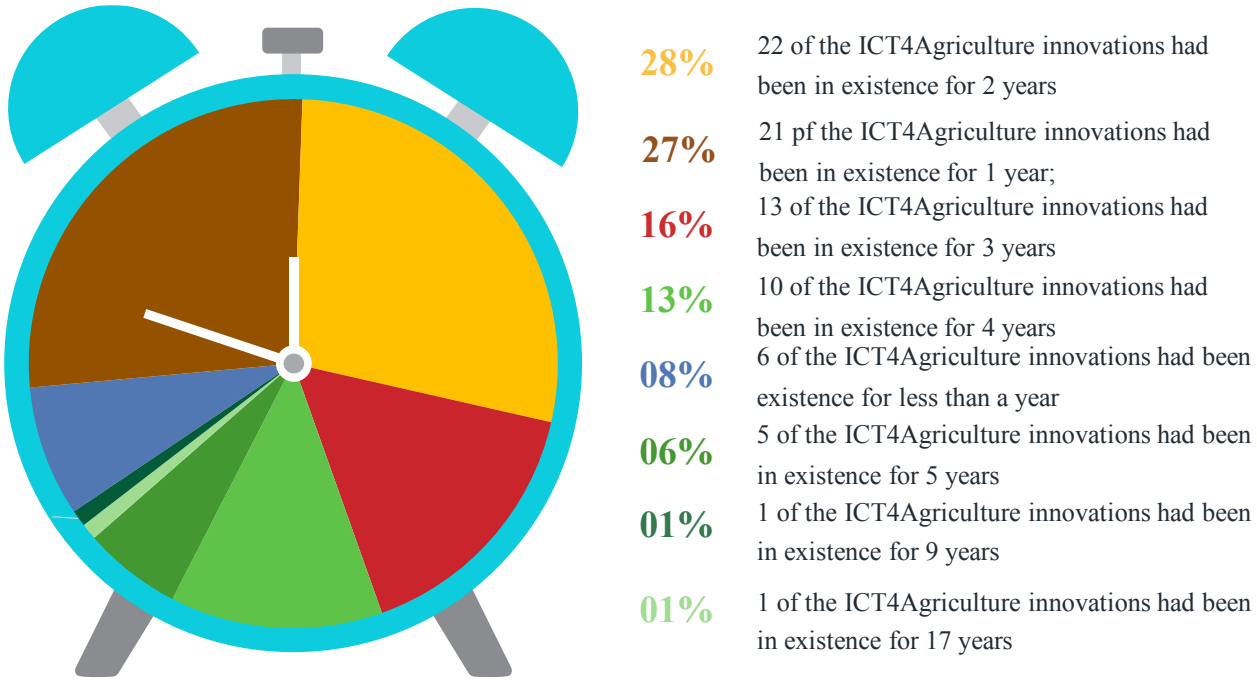


Figure 8: Years in existence for the ICT4Agriculture Innovations

Figure 8 shows that majority 22 (28%) of the ICT4Agriculture innovations had been in existence for 2 years; followed by 21 (27%) which had been in existence for 1 year; 13 (16%) had been in existence for 3 years, 10 (13%) had been in existence for 4 years, 6 (8%) for less than a year, 5 (6%) for 5 years and 1 (1%) for 9 and 1 (1%) for 17 years. From the results, it can be noted that majority of the innovations for ICT4Agric 48 (61%) had been in existence for less than 3 years hence indicating that most of them are new on the market. This result also indicates that there have been innovations being developed within the other service sectors and that the ICT4Agric innovations have lagged behind and just a few of them have been at the center stage.

d) Innovations' Years/period in Use

Further still, it was important to understand the number of years the ICT4Agric innovation had been in use, since existence may not necessarily mean that they are already commercialized. Therefore, the study examined from the consumers the number of years in use of the ICT4Agric innovation they had adopted. Figure 9 below describes the results.

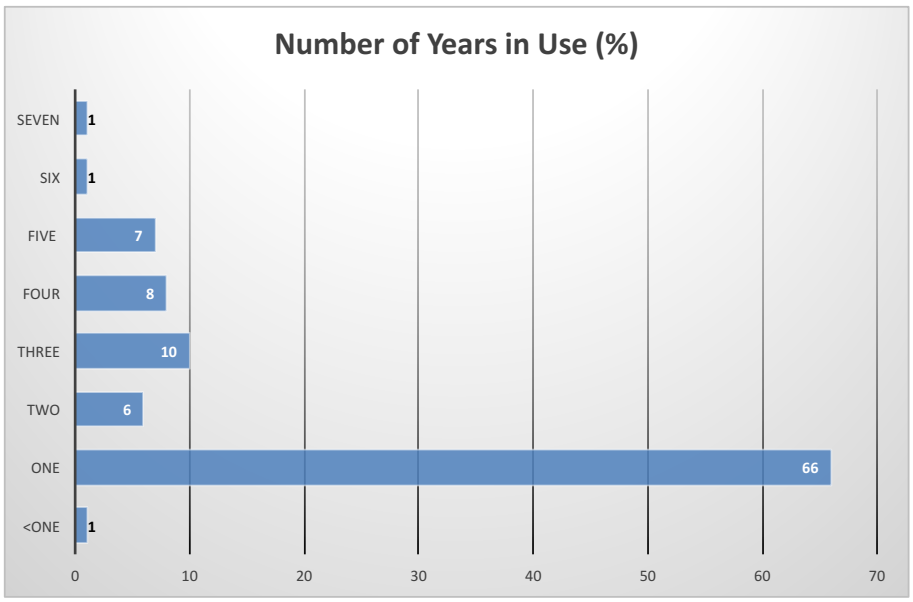


Figure 9: The Period for which the Innovations were in use

The results in figure 9 shows that majority 94 (66%) of the consumers who participated in the study indicated that the ICT4agriculture innovations they were using had been in use for one (1) year; 14 (10%) indicated three (3) years in use; 11 (8%) indicated four (4) years in use; 10 (7%)indicated five (5) years, 9 (6%) indicated two (2) years in use. 4 (1%) indicated Seven, Six and Less than One year of use of the ICT4Agric innovations. These results closely related to the finding above on years of existence of the ICT4Agric innovations which indicated that 61% had been inexistence for less than 3 years. These two results indicate that the ICT4Agriculture innovations adoption has been slow within the sector. This may be attributed to the fact that majority of the consumers of the ICT4Agric innovations within the country are small-scale rural farmers who may have low levels of education deterring them to adopt or have no resources to invest in the adoption. One academician involved in the ICT innovation eco-system noted that;

> **"Each innovator would want to reap from their efforts and so venturing into something that may not reward you so easily is no go zone area for many of the youthful innovators. Many of the ICT4Agric innovations on market are a result of projects started by donors through higher institutions of learning. Government needs to find alternative ways of motivating innovators to innovate more for the agriculture sector."**

e) Level of Investment in Innovations

The study was also interested in finding out from the ICT4Agric innovators how much had been invested within the innovation. Since it had been noted that the innovators developed applications based on the existing demand, it was important to understand what investments had been made in order to have the innovations accomplished and commercialized. The study examined the amount of money used in financing the acquisition of equipment, software and hardware plus other items needed to develop the ICT4Agric applications. Below is figure 10 describing the findings.

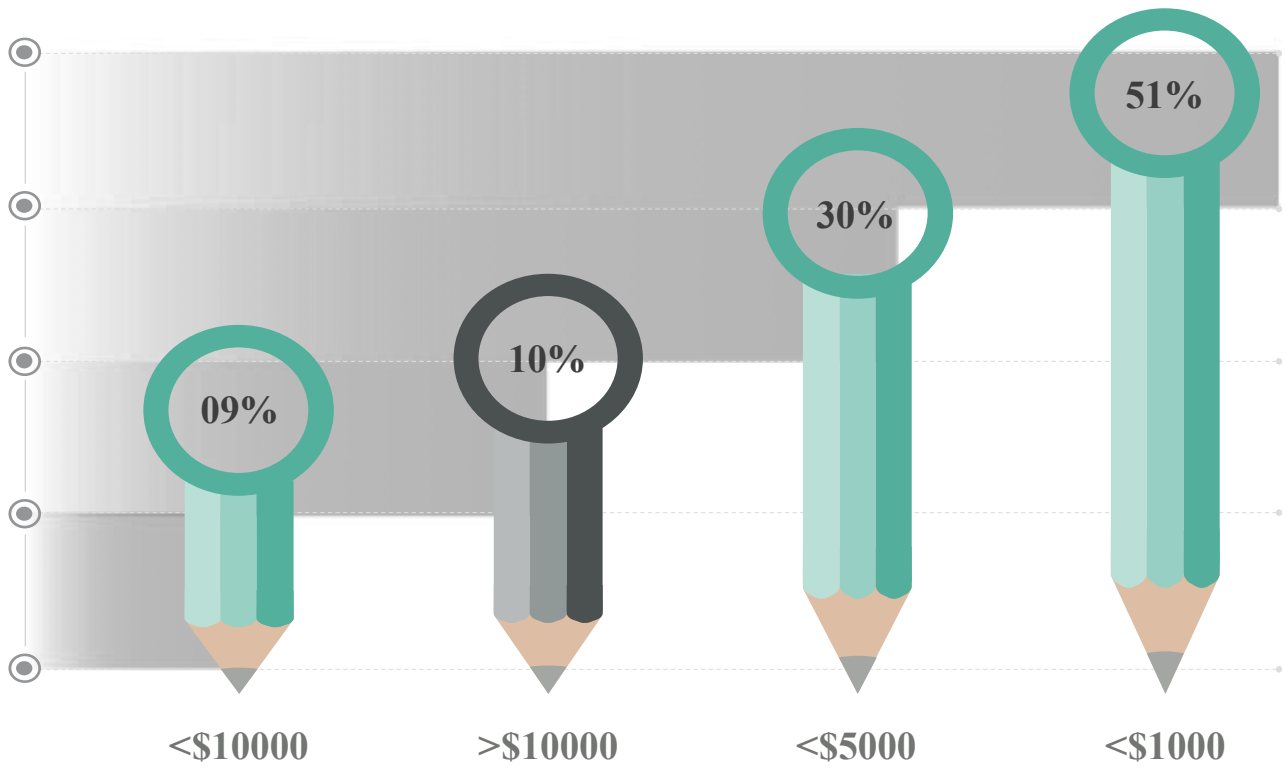


Figure 10: Investments made into the Innovation

Results in figure 10 above show that 40 (51%) of the Innovator category of participants in the study had invested less than one thousand dollars (<$1,000), 24 (30%) had invested less than five thousand dollars (<$5,000); 8 (10%) had invested more than ten thousand dollars (>$10,000) and 7 (9%) had invested less than ten thousand dollars (<$10,000) as capital in the innovation process. It is clear from the results that more than 80% of the innovators had invested less than five thousand (<$5000) in the innovations development. These results relate closely with the results reported on the stages of innovation where only a few innovations had been commercialized due to the little resources invested by the innovators. Since majority of the innovations are personally funded by the innovators who are fresh graduates, such results are not surprising because for a product to get onto the market it needs quite some good amount of investment.

These results concerning investment in ICT4Agric innovations can be further confirmed by previous research that considered investment undertaken by innovators in Uganda. These are described in figure 11 which also shows that majority of the innovators invested less than $1000. Both results lead to a conclusion that currently there is little investments being put into the innovations development and hence there is need to improve on the support provided within the ICT innovation eco-system.

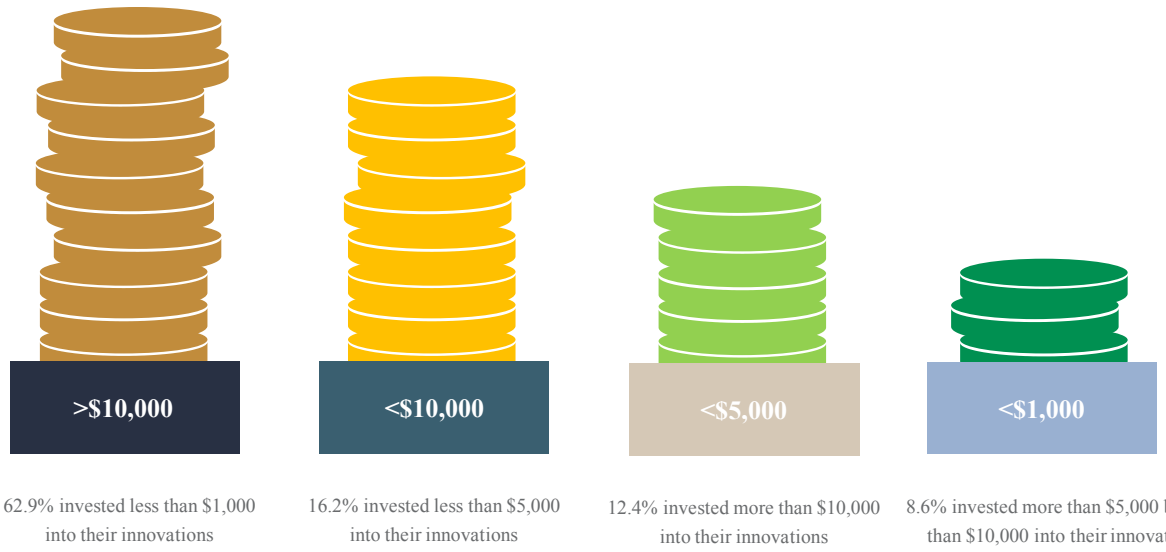


Figure 11: Level of Investment in Innovations by ACIA Beneficiaries (Source: ICT Innovation Initiatives Impact Assessment Report 2018)

f) Sources of Innovation Funds

Having noted that there is little investment that had been made into the ICT4Agric innovations, the study sought to find out the origin of the funds and any other monetary instruments which were used to finance the ICT innovations. Figure 12 below describes the results from the study.

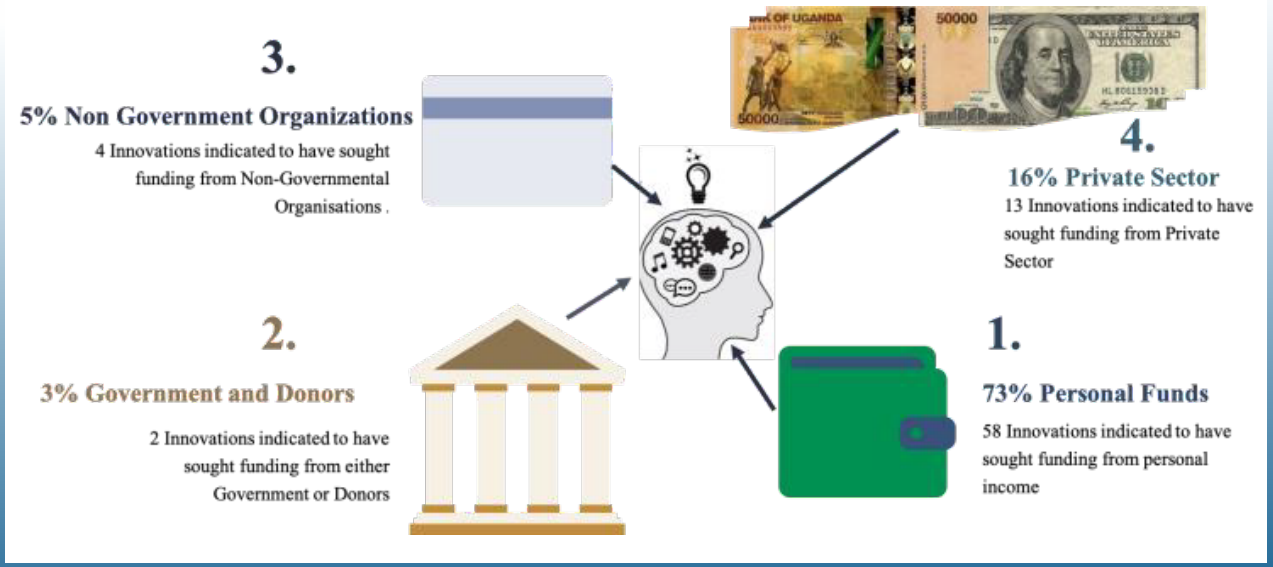


Figure 12: Source of the Innovation Funds

Figure 12 illustrates that 58 (73%) of the innovators that participated in the study indicated that the source of funding for investing in their innovations was personal; 13 (16%) indicated that the private sector provided the resources; 4 (5%) indicated Non-Governmental Organizations; and 2 (3%) indicated Government and Donors as their sources respectively. These results confirm that agriculture innovations were mostly funded from personal funds as further elaborated by one of the innovators;

> **"I started the innovation with my savings at University and support from my lecturer who was supervising me for my final project. The innovation is at a stage where I require more funds but do not have where to get them so that I can scale up its use. The best I can do is to keep applying here and there for support in order to roll it out"**

The above statement clearly indicates that there is a gap within the innovations eco-system for innovators to tap into funding resources. It is probable that innovations with investments more $5000 are funded under projects because there are not many innovators who are willing to invest money in innovations that are not likely to give them the return on investment and most especially to a customer such as a smallholder farmer. The ones that are already commercialized have largely been motivated around funding from projects. Therefore, there is need to establish opportunities for innovators who have mature innovations to seek for funding and be supported in order to commercialize their products.

When the researchers interviewed the policy makers, it was clear from them that in the past government had not done much to support the innovation eco-system. However, of recent government had come up with a programme to support the ICT eco-system as noted from a policy maker;

> **"The government initiated the National Innovation and Incubation Programme to support the ICT innovators to get their products nurtured up to the level of commercialization. The government provides space for the innovators and financial resources through the ministry of ICT and National Guidance. However, these resources are still less to accommodate all the existing innovators within the eco-system."**

With such information from a policy maker, there is an indication that government has started giving support to the innovators although still on a small scale. Tapping into the already existing innovation hubs that support innovators may be an easier way of reaching out to the innovators than the current form used to reach out to individual innovators that need support. The support required by the innovators ranges from financial to mentorship but in a more structured form.

g) Innovation Spaces

The study also examined the innovation spaces where the innovators were working from in order to have their ICT applications accomplished. The reason for doing this was to find out if the ICT4Agric innovations and others were being innovated within a conducive environment. Figure 11 below describes the results from the study.

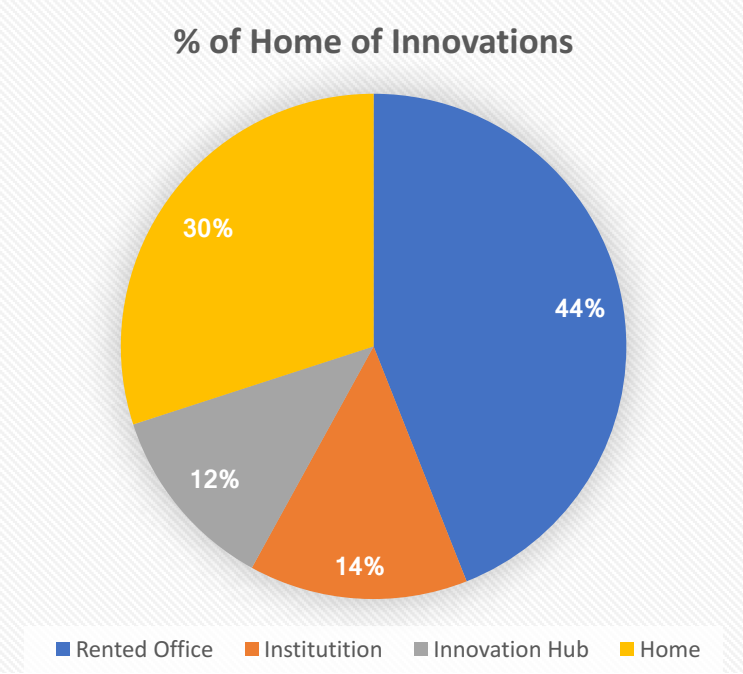


Figure 13: Types of Innovation Spaces used

Figure 13 above shows that 35 (44%) of the innovators indicated they used the rented office as the innovation space; 24 (30%) of the innovators indicated their homes of residence; 14% indicated Institutions and 12% indicated Innovation hubs as their innovation spaces. These results confirm that many of the innovators lack appropriate spaces where they can go and innovate but rely on free spaces such as homes and institutions. The rented offices come at a cost but not many innovators can afford them. The hubs are restrictive and innovators have to pay to be part of them. Since many of the innovators as already witnessed are fresh graduates, there is need to support to them to realize their dreams of commercializing their innovations. This calls for government to derive strategies of supporting such innovators and steer them to commercialization. One of the innovators who rents an innovation space had this to say;

> **"Renting space for the innovation is very important because you need a place where it is quiet, secure and where you have power and internet connection. Sometimes in our rented space we do not have power for several days. The internet gets so expensive in the long run since our innovations require constant access to it."**

h) Number of Employees within the Innovation

Because of the form of innovations spaces that housed the innovators, the study was interested to find out how many staff were employed within those spaces to work on the development of these innovations. Since many of the innovations were still at prototype stage, the study examined the number of persons working within the innovation process. It should be noted that not all people working within the innovation are salaried staff. Figure 14 describes the number of staff employed in the innovation process.

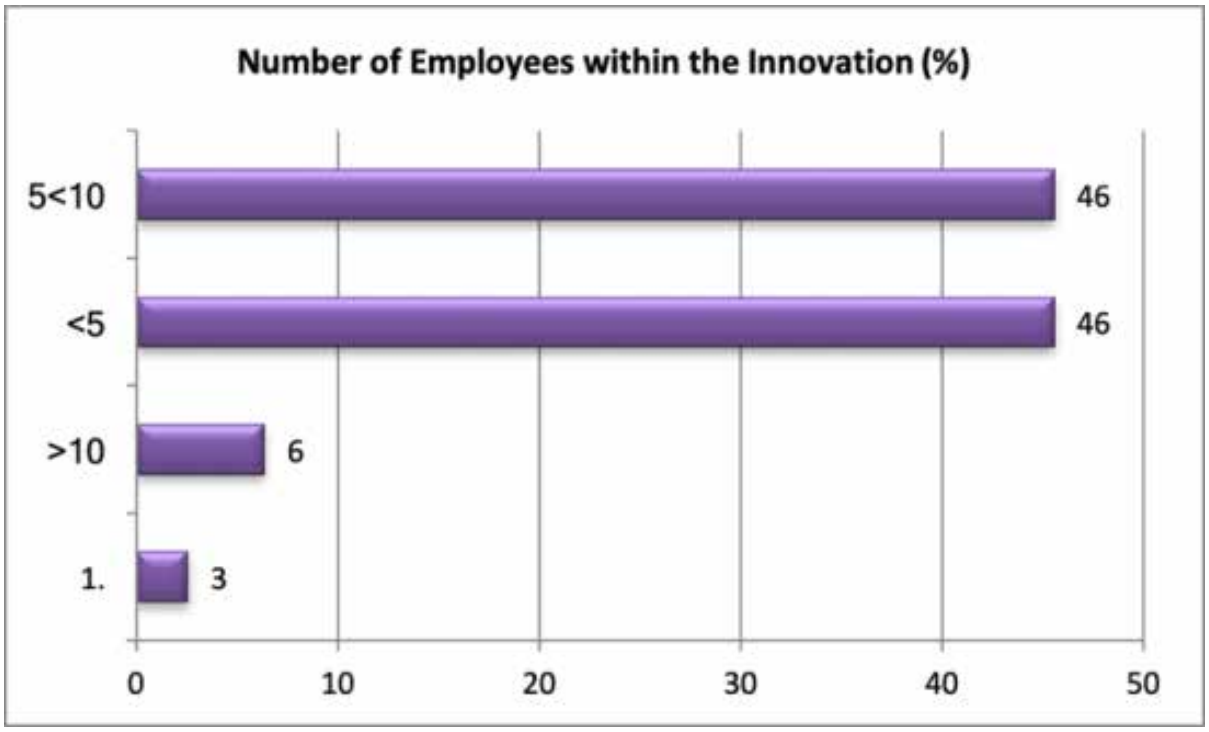


Figure 14: Number of Staff employed within the Innovation

Figure14 above shows that 36 (46%) of the innovators indicated that they had between 5 and 10 staffs employed within their innovations; another 36 (46%) of the innovators indicated less than 5staffs; 5 (6%) of innovators indicated more than 10 staffs and lastly 2 (3%) indicated that they had 1 staff employed within their innovations. What is clear from the results is that majority of the innovations are still small since 92% of them have between 1-10 staff working within the innovation spaces. This could be attributed to the low financial resources and the innovation spaces where these innovations are housed. It was observed from one of the innovations hub owner that

> **"Our innovation hub provides just a desk for the innovators to work from, internet connection and power. We discourage more than 4 people on one desk but if there are more than 4 people we always recommend the innovation to acquire another desk at a cost. Since many of the innovators are fresh graduates and do not have enough financial resources, they resort to working from home and only come to the hub for special activities such (as) presentations, meetings and expertise mentorship."**

i) Category of Innovation Employees

The study further examined the categories of staff that were employed within the innovations. Figure15 below describes the different categories that were mentioned by the innovation startups.

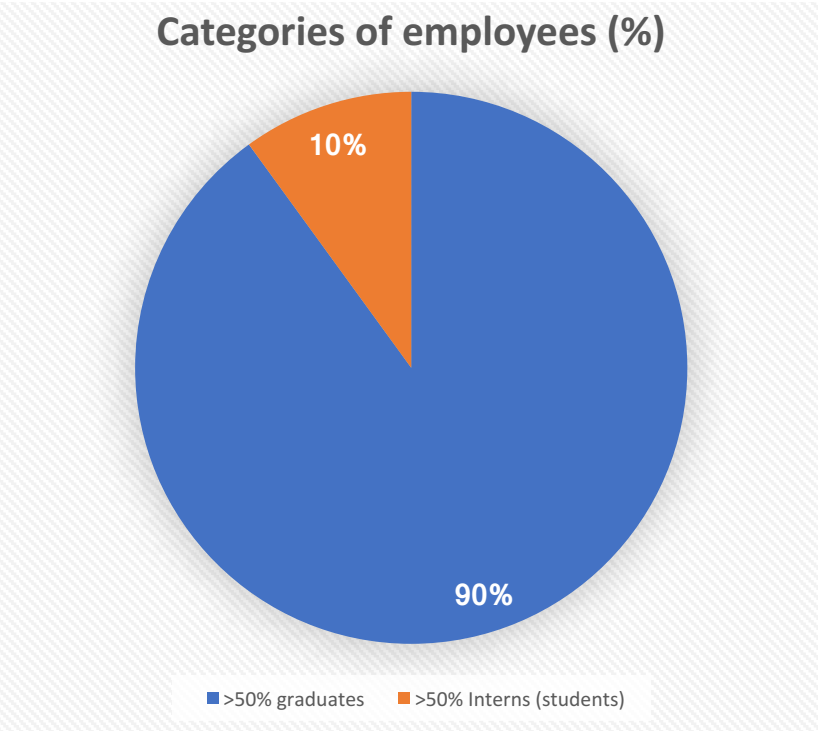


Figure 15: Category of staffs within the Innovation Startups

Figure15 above shows that majority 71 (90%) of the innovation startups that participated in the study had more than 50% graduates among their staffs and 8 (10%) had more than 50% interns among their staffs. These results clearly indicate that quite many graduates already participate in innovation startups and just need to be supported in securing those jobs. Government needs to support these start-up innovators by establishing an environment where innovation can flourish.

j) Type of Clientele for the Innovation

Since the innovators were still facing challenges such as conducive innovation spaces, financial resources among others, the study sought to understand some of the market trends for the innovations. Therefore, the study investigated the type of clientele for the ICT4Agric innovations i.e. the consumers/up takers of the innovations. Figure 16 below describes the findings from the study.

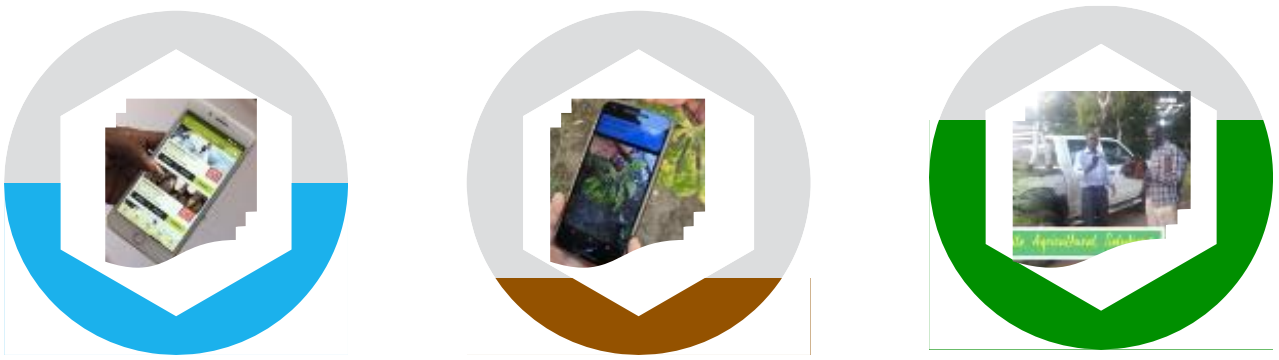


Figure 16: Type of clientele for the Innovations

Majority 44 (56%) of the innovators indicated that the main clientele for their innovations were local customers; 32 (41%) indicated both local and foreign clientele and 2 (3%)indicated foreign clientele. These results typically indicate that most of the innovations are currently consumed locally. It's probable that there is stiff competition in capturing the foreign market or the innovations are not appealing to the foreign markets. As such, government needs to support the innovators so that they are able to develop their innovations to international standards and hence be able to sell abroad. One of the innovators noted that;

> **"Our innovation is good for the local market but the farmers almost want it for free and we cannot support them without any payments from them. We wish government would support us so that we allow all farmers who can access it to use it for free."**

It was also noted that from an innovation hub owner that;

> **"Some of the local innovations such as ERIGNU have been adopted outside of Uganda to support farmers. However, this requires great efforts from the innovators to brand and perform public relations for their application. Not many of the innovators have done enough branding for their innovations beyond Uganda."**

These results indicate that branding for the local innovations is not being done in the most appropriate form and hence needs to be improved so that more products can be adopted internationally.

k) Technologies deployed within the Innovation

The research team felt it important to understand what technologies were being used by the innovators to develop the ICT4Agric innovations with a view of understanding if many of them are inter-operable. As such, innovators were requested to state the different technologies deployed within their respective innovations. Below is a summary table of the technologies used in the ICT innovations.

Table 3: Technologies deployed within the innovations

• Simple web application	• Java
• Laravel,	• Satellite imagery
• Linux for server mgt,	• Mobile payments
• jsc	• Live weather data
• Oracle	• Live farmer database
• Adrenal embedded systems	• Inventory tracking
• C++	• Season counter
• Website platform	• Adwino ide
• Gis remote setting	• Enzyme inhibition science
• Iot platform	• Light spectrometry
• Raspberry pi	• Mobile application science
• Block chain technology	• Robotic system
• Php	• Solar tracking system
• Html	• Remote control panel
• Ajax	• Wireless router
• Sql	• Moodle
• Android	• Totra
• Cloud services	• Code igniter
• Ussdapllication	• Tensa flow for machine gunning
• Geo-cledian	• Dreamweaver
• Wamp	• Quick account

Table 3 above indicates that the technologies used range from open source platforms to professional industrial frameworks. Some innovators used both open source and proprietary database technologies. It was reported that the innovations that have been there for some time preferred some proprietary technologies for various reasons including security. However, there is a growing adoption of the open source technologies for use during development due to several reasons. One of the hub owners indicated to the research team that;

> **"In this innovation hub, we use a lot of open source software to support the development of the ICT applications. Our mentoring programmes also focus on the same because these have been found to have adequate support across the world and very cheap to maintain."**

Level of Technology Adoption- The research team further investigated the depth of technology adoption for the innovation that were being developed. The innovators indicated to the research team that they adopted ICT at 3 main levels. These levels include;

Enhancement: Under this level, the innovators use ICT to redefine the specific service provision within the agriculture value chain by adopting technology to directly change the offering of the service and to see if there could be some functional improvement or not. In this level, technology comes in to provide an alternative form of undertaking to the activities within the agriculture value chain. It was noted that several innovators who were interviewed had been enhancing as they adopted ICT to support service provision within the agriculture sector. One of the innovators had this to say;

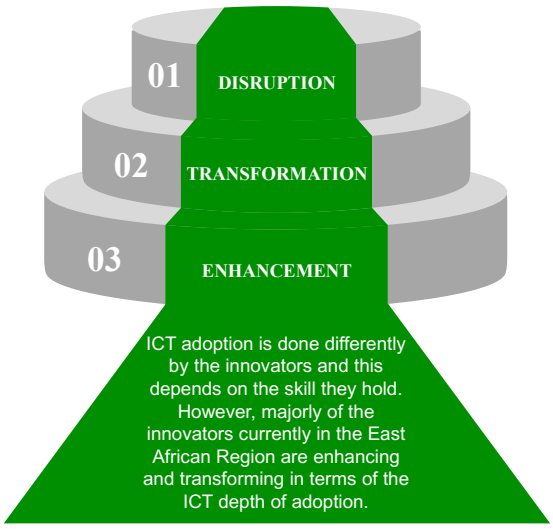
> **"Our ICT application was developed to regularly send information to farmers about something of importance via SMS instead of going to the farmers face to face and giving them the information. This has helped farmers to receive information in real-time and hence solve their farming problems by use of their phones"**

Transformation: At this level, innovators used ICT to modify the specific agriculture services by using technology to significantly redefine the activities being undertaken. By doing so new tasks emerge within the service due to the introduction of technology and these could have never been conceived before in delivering the same service. One of the innovators had this to say;

> **"The application that we developed a farmer to use their mobile phone to perform a disease diagnosis by taking an image of the plant. The embedded algorithms within the application is used to analyze the images and hence provide knowledge about the plant disease. Instead of using personal eye sight to perform a disease diagnosis by either the farmer or expert the mobile phone application supports the service provision."**

Disruption: Under this level of adoption, ICT is used to provide an alternative way of delivering a service as compared to the traditional way of delivering it. The integration of technology completely brings into existence of a new way of delivering a service in a more effective and efficient form. One of the innovators who had his innovation still at prototype stage had this to say;

"I have developed an application that uses Internet of Things (IoT) and Sensors to manage farm irrigation. Sensors are placed strategically around the farm along with other technologies which can allow irrigation to be triggered on a need basis by the ICT application and also allows a farmer to monitor what takes place ubiquitously."



From the above analysis, the research team noted that ICT adoption was being done differently by the innovators and this depended on the skill they held. However, the research team noted that majorly the innovators were enhancing and transforming in terms of the ICT depth of adoption. There were very few innovators who were disrupting in terms of ICT depth of adoption. In comparison to other ICT4Agric innovations taking place across the world, where more interest is being offered to disruption, Uganda needs to do more in mentoring innovators to innovate for international standards.

l) Agriculture Value Chain

During the study, it was important for the research team to understand where innovations were really majorly taking place across the agriculture value chain. Therefore, the study investigated the levels at which innovations were taking place and results are described in the figure 17.

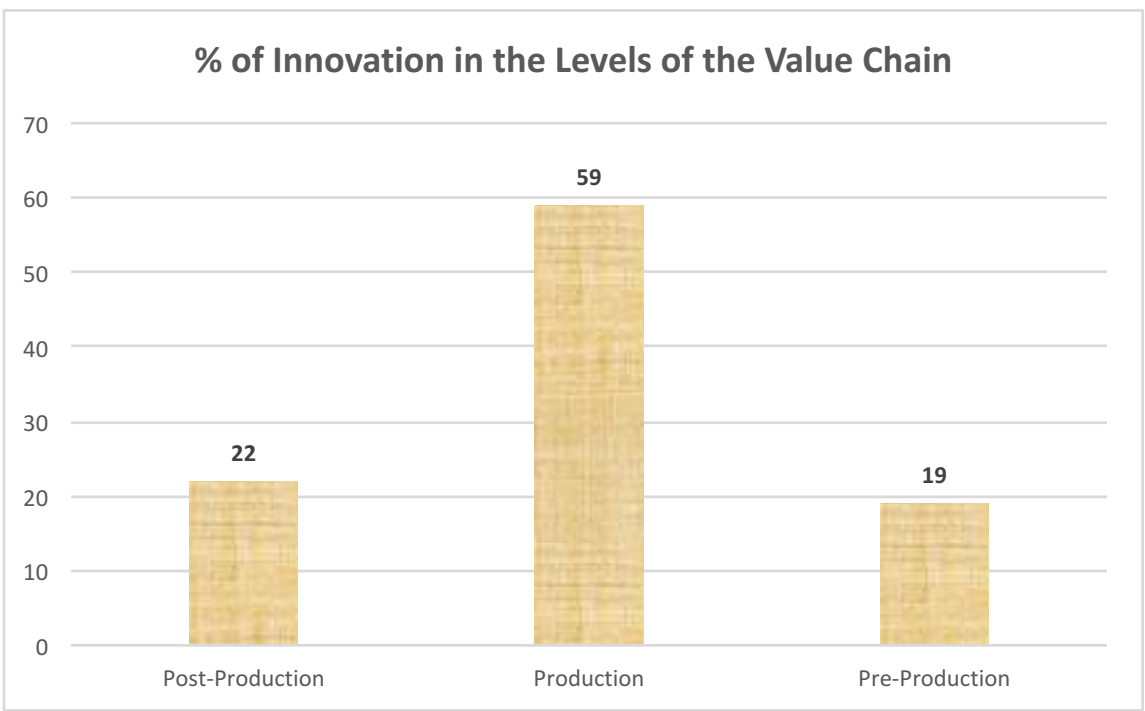


Figure 17: Innovations within the Agriculture Value Chain

Figure 17 indicates that 47 (59%) of the innovations were innovated at the level of production, 17 (22%) at the level of post-production and 15 (19%) at the level of pre-production. The results indicate that there is less ICT4Agric innovations taking place at both the pre-production and post-production levels. There is need to encourage innovators to consider innovating for these other levels since they are vital too for the agriculture value chain.

An academia participant who is involved within innovations across a variety of sectors was consulted on the current stages of innovations within the agriculture sector. This is what he had to say;

> **"The current state of ICT4Agric innovations development has been slow since innovators see less demand for the applications from the small-scale holder farmers. Many of the ICT innovations that have been developed have resulted as research from academia that largely wanted to support the production stage in the agriculture value chain. There is almost nothing in terms of locally developed ICT applications in pre-production and post-production stages of the agriculture value chain. Since this agriculture sector is largely in the hands of the rural farmers who are presumed to have no resources. Therefore, government needs to finds ways of supporting farmers in acquiring such ICT application at the different stages of the value chain"**

m) Stages of Innovation

Having noted from the above research that innovators were innovating around the agriculture value chain and that they were adopting technologies at different depth, it was important for the study to investigate what stages the innovations were on. The study noted that the ICT4Agric innovations were falling under 3 main stages (commercialization, prototype and validation). Figure 18 describes the 3 stages investigated and how many innovations were at each stage.

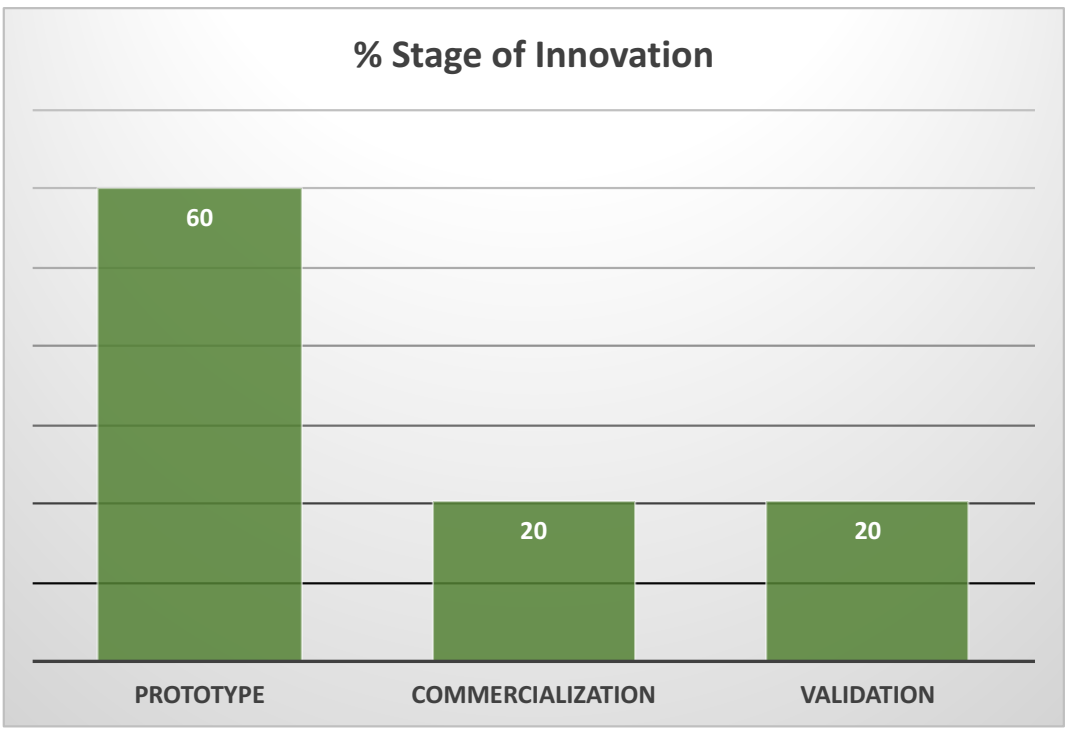


Figure18: Stage of the Innovation

The results show that majority 47 (60%) of the innovations were at the Prototype stage, 16 (20%) of the innovations were at validation and commercialization stages respectively. These results clearly show that the agriculture sector has not realized enough innovations that are ready to be used on the market since only 20% of the innovations were in commercialization by the time of study. It was also noted that it is very likely that the consumption levels of the ICT innovations within the agriculture value chain in Uganda are saturated with the old innovations. One innovator noted;

> **"This application has been developed and commercialized with the support of a grant from USA. But many of the innovations are being supported by own funds from the innovators because farmers do not have the resources to support the technology. Many of the customers for our application are just smallholder farmers in the rural areas and can't afford funding the development of the technologies. This is the reason why many of the agriculture ICT innovations are not yet on market since they do not have resources to commercialize."**

The above statement shows that some of the ICT4Agriculture innovations that have been developed are personally supported up to the level of commercialization. However, it was also reported that in some cases some of the innovations have received donors support to have them commercialized on market. Nevertheless, it is clear that majority of the smallholder farmers do not have the resources to push for the development of the innovations and greatly rely on projects or individuals who sacrifice their personal funds to invest in the innovations.

n) Challenges faced by the Innovators

With the prior information on the stages of innovation, the study sought to deduce some of the challenges faced by the ICT4Agric innovators and table 4 summarises what was mentioned. However, it should be noted that some of these challenges are similar amongst the innovators and not only linked to ICT4Agric only.

Table 4: Challenges facing ICT4Agric Innovations

- Farmers failure to adapt and use the new technology and limited funds
- Language barrier
- Limited finances for the projects
- Limited research due to lack of access to wider data
- Long distances to the farms to acquire information
- Farmers have challenges embracing technology
- High costs of outsourcing components
- Poor network coverage
- Extension workers' equipment (internet bundles)
- Lack of team membership
- Limited working space
- Lack of equipment which are not readily available but have to be shipped
- Complex to make research and development
- Expensive tools to be used in the process
- Building trust with the farmers to use their resources by investors
- Agricultural challenges of pests diseases and weather that affect farming

o) Recommendations to minimize challenges

Also, the study requested the ICT4Agric innovators to provide some recommendations to the challenges put forward in the Agricultural innovation and below is a summary of the recommendations:

Table 5: Recommendations to the ICT4Agric Innovations Challenges

- Need for partnerships (telecoms, energy companies, government, NGOs, private sector etc)
- Need of a USSD code
- Provision of larger Space for the training
- Need for more repeater units
- Wi-Fi extenders to cover larger areas
- Teaching farmers how to use and embrace technology
- The government should also bring ICTs closer to the people
- Need for open source platforms
- Need for capacity building
- Need for a toll-free number so that farmers can easily access innovators
- Need for system integration to have a stand-alone system
- Subsidizing internet costs for innovators(startups)
- Limit new untested innovations from going into the market
- Make funds available (donors, government, private sector) for agricultural innovations and ways to allocate those funds

The innovators' recommendations are majorly focusing on the provision of resources to support them within the innovation eco-system. By creating a conducive environment within the innovation eco-system, several ICT4Agric innovations can be realized.

3.2.2. Current Practice and Use of ICT4Agric

a) Consumer's Profile

Level of Education- Since the adoption of the ICT4Agric was mainly amongst the farmers and are known to be in the rural areas, the study sought to find out the level of education of those who consumed the innovations. The study evaluated the education levels for the consumers and these are described in figure 19.

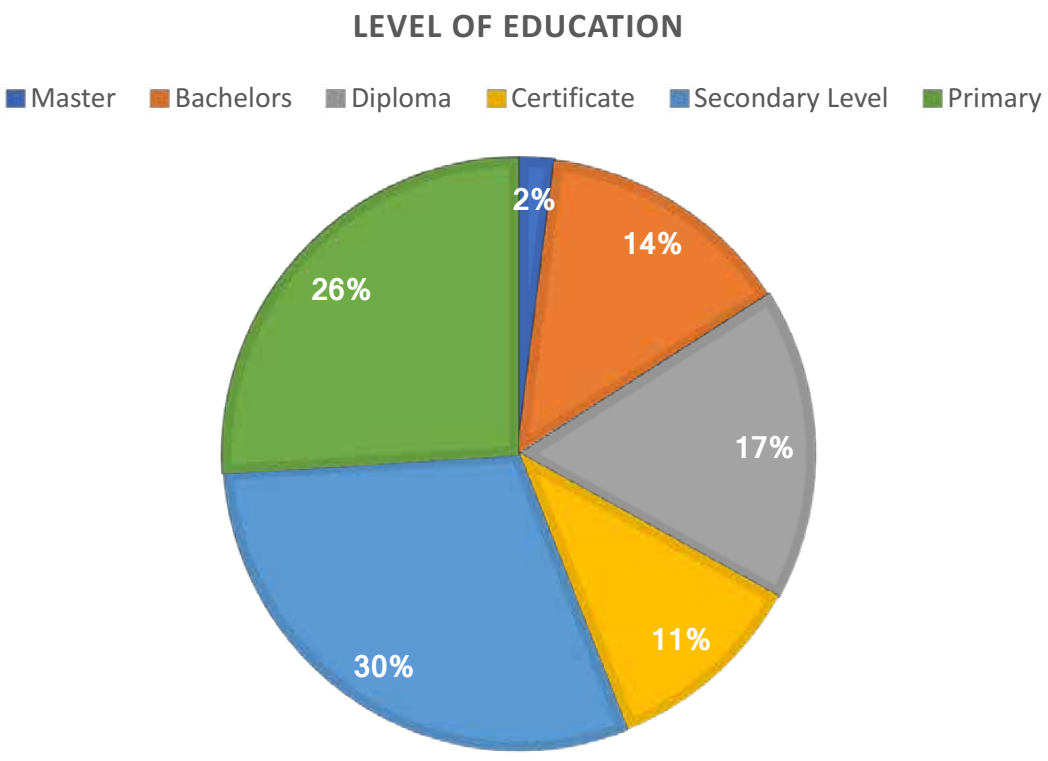


Figure 19: Level of Education of innovation Consumers in the ICT4Agriculture Ecosystem

The results from the study revealed that out of the 142 participants in the study majority 95 (67% - Certificate 11%; Primary 26%; Secondary level 30%) of the consumers had an educational level below diploma and degree. 24 (17%) of the participants had Diploma level of education; 20 (14%) of the participants had Bachelors and only 3 (2%) of the participants had Master level of education. The results indicate that innovations within the ICT4Agriculture were popular amongst the very low educated consumers and this could be attributed to the fact that agriculture in Uganda is mainly undertaken by the low educated people within the rural areas. Such results may also indicate that the ICT4Agric innovations are not demand driven and since it is the low educated people mainly within the sector, there is less demand from them to innovate around their sector and hence the less adoption.

Having noted the level of education amongst the adopters within the agriculture sector, the study sought to find reasons for the trend and hence consulted with the experts within the academia. A question was raised to the academia why there were mostly non-degree holders in the agriculture sector as consumers of innovations and one of them noted the following.

> **"In Uganda majority of the graduates seek for white collar jobs and presume that farming is for those people in the villages. The farms that use ICT in performing their day to day business have either been funded by projects or the farm owner is a degree holder and has financial resources to invest in technologies."**

The information provided by the academia is proof that the demand for the ICTs amongst the farmers is still low since the people largely involved in the agriculture are those regarded to be the poor, rural and not highly educated. These rural farmers simply receive what has been developed and given to them but rarely participate in the demand for a specific ICT solution to improve their services.

The study also investigated the number of consumers who were using the ICT4Agriculture innovations for the participating staff from farm enterprises. Figure 20 describes the results obtained from the consumers.

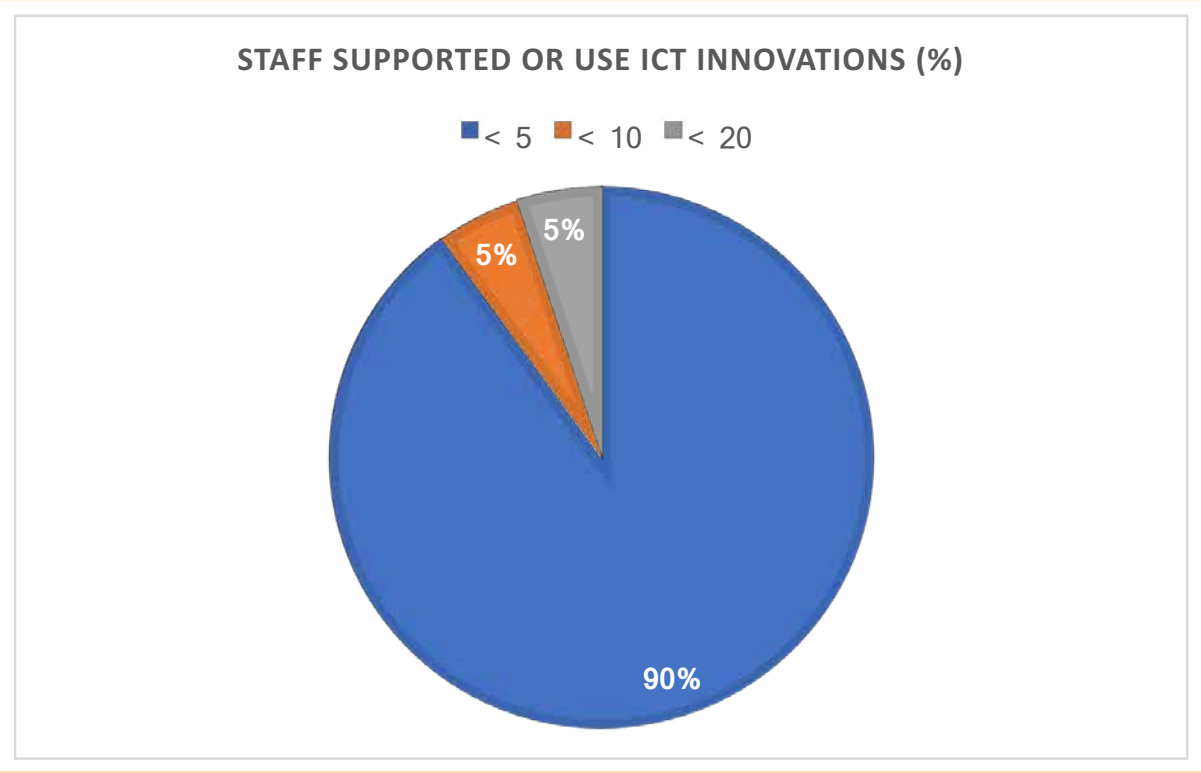


Figure 20: Number of Consumers using the Innovation per farm enterprise

Figure 20 indicates that 128 (90%) of the consumers indicated that their farm enterprise had less than 5 staff supported or using the ICT4Agric innovation. It was also noted that 4 (5%) of the consumers indicated that their organizations had more than 5 but less than 10 supported to use the ICT4Agric innovation. Another group of consumers 4 (5%) indicated that their farm enterprise had between 10-20 staff using the ICT4Agric innovation. These results imply that there is less use of the innovations are not yet widely used hence not popular amongst farm enterprises. There is need for further sensitization about the community of the existence of such innovations.

b) Type of Technologies used

Having noted that there are some ICT4Agric innovations in use, the study sought to find out the common applications on market today. The results are described in figure 21.

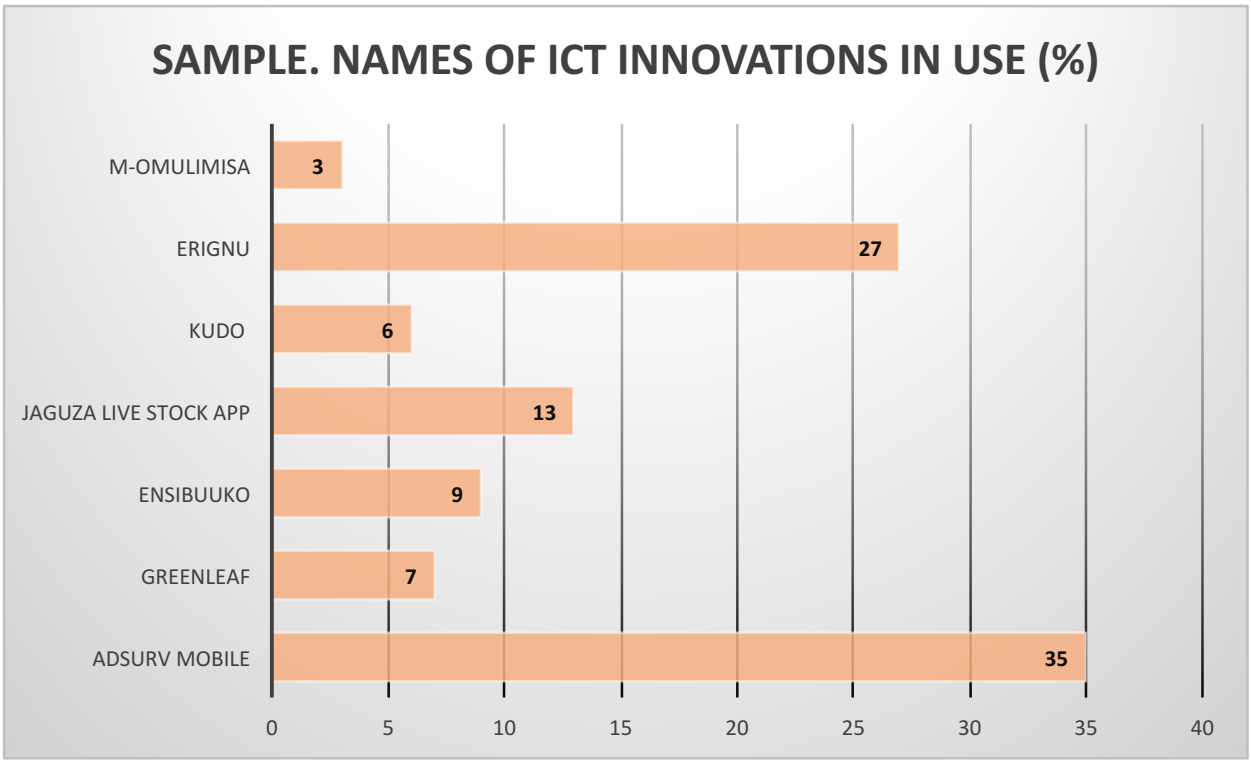


Figure 21: Typical ICT4Agriculture Innovations currently in use

The results show that amongst the consumers who participated in the study majority 50 (35%) of were using Adsurv mobile, 38 (27%) were using ERIGNU, 18 (13%) were using Jaguza livestock App, 13 (9%) were using Ensibuuko, 10 (7%) were using Greenleaf, 9 (6%) were using KUDO and 4 (3%) were using M-Omulimisa. The ICT4Agric innovations that appeared in the study were all locally developed and some of them had already an international presence. The results further confirmed that majority of the ICT4Agric innovations in commercial use in Uganda fall under the production and post-production stages of the agriculture value chain. One of the consumers mentioned that;

"I plant my crops all the time in the same farm and do not know if they will grow because am not sure of the soil fertility. I wish there was an ICT application like this one for diagnosing diseases that could be used to test for the soil fertility."

From the statement mentioned by the consumer (farmer) it is clear that they needed ICT4Agric innovations that could support them in the pre-production stage of the agriculture value chain. It is therefore important for the ICT innovation eco-system to provide regularly an update on the existing ICT innovations and their stages of adoption within the agriculture value chain.

c) Place and role of Innovation on Agriculture Value Chain

In order to substantiate the claim that ICT application development was mainly at the production stage of the agriculture value chain, the study sought to find out from the consumers where they were using the ICT innovations. The study examined the roles played by the consumers of the current ICT applications in the value chain as illustrated in figure 22 below.

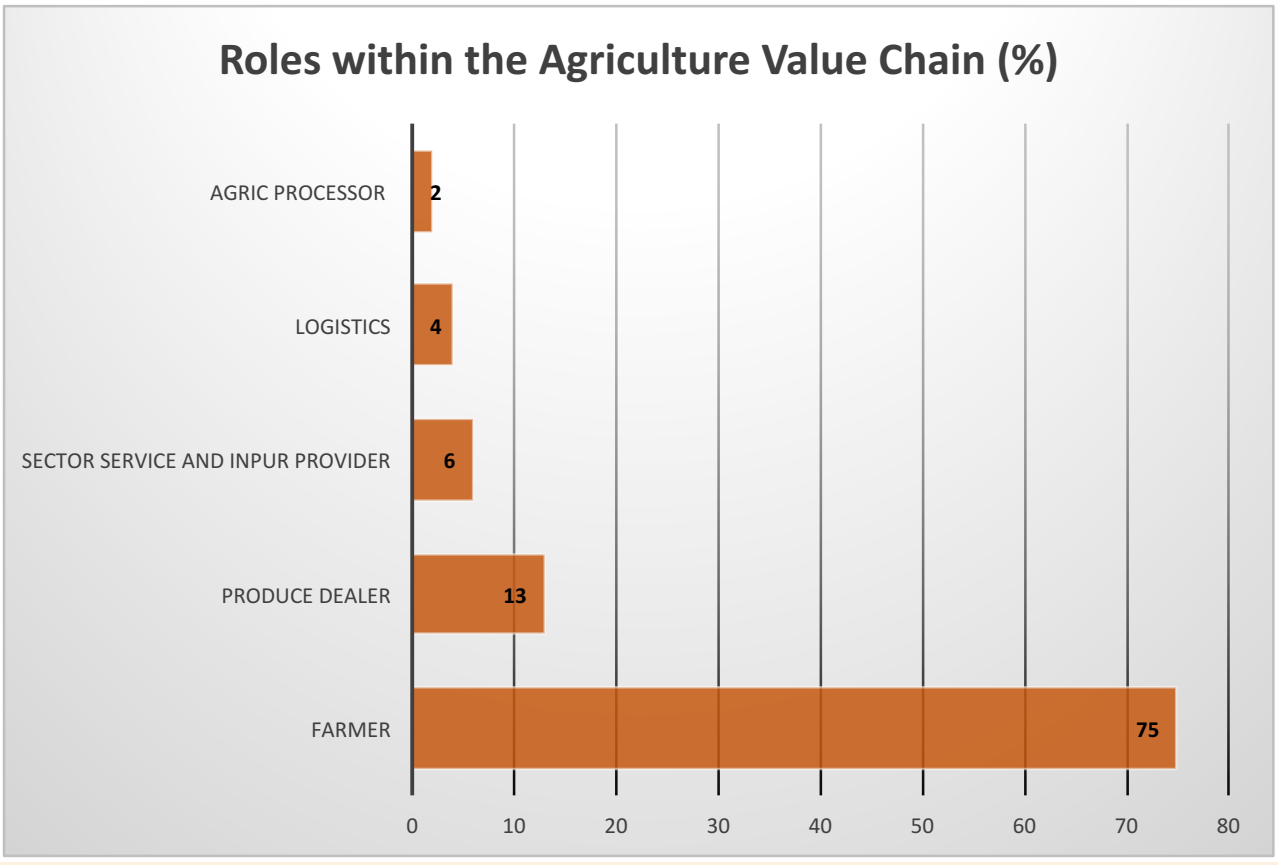


Figure 22: ICT Innovation Roles within the Agriculture Value Chain

Among the consumers who participated in the study, majority of them 107 (75%) played the role of farmer, 18 (13%) were produce dealers, 9 (6%) were service sector and input providers, 6 (4%) were consumers in the logistics and 3(2%)were agriculture processors. The results clearly show that use of the ICT4Agric innovations was majorly being done under the production stage of the agriculture value chain and these are the smallholder farmers within the rural areas of Uganda. These results also show that there was no consumer of the ICT4Agric innovation who indicated that they were using the application at the pre-production stage.

The research team was interested to understand the value addition of ICT4Agric innovations within the agriculture value chain. The consumers were asked to indicate what exactly the ICT4Agric innovation were serving them and Figure 23 describes the actual roles the ICT4Agric innovations played or were used for.

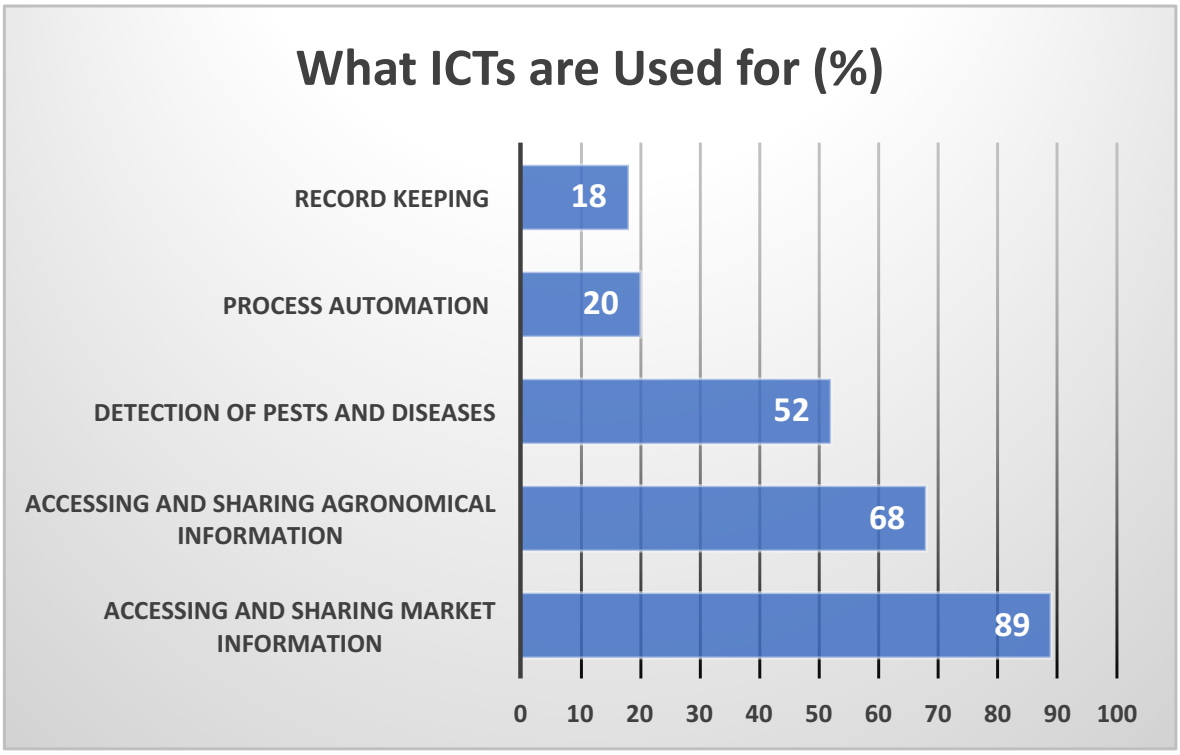


Figure 23: Use of the ICT4Agriculture Innovations

The ICT4 Agriculture innovations were found to play a variety of roles ranging from record keeping to disease diagnosis. It should be noted that these applications played more than one role for the consumers. Majority of the consumers 128 (89%) indicated that they used the ICT4Agric innovations to access and share market information, 97 (68%) indicated to have been using the innovation to access and share agronomical information, 74 (52%) indicated that they used innovations to detect pests and diseases, 28 (20%) indicated that they used them for process automation and 26 (18%) indicated that they used ICTs for record keeping. It should be noted that use of the innovations was majorly at the production level of the value chain. One of the consumers noted as follows;

> **"Sometimes we cannot find information concerning a disease breakout even if you use this application for farmers. It has no answers on how to treat our plants and animals. Why can't government help us because we lose all our savings because of this maize worm?"**

The statement made by the consumer (small-scale holder farmer) clearly indicates that there is a gap in the knowledge creation within the agriculture sector to support the farmers. ICT applications without content localized to the farmers' needs are deemed useless within the agriculture value chain. There are no current methods for agriculture content creation and dissemination to the farmers which is a very big hindrance to agriculture development within the rural areas. Government needs to think about strategies on how to support the farmers with content development so that they can have access to it in multiple ways at no cost.

d) Return on Investment

It was also important for the study to investigate the cost the consumers of the ICT4Agric had incurred when acquiring the innovations. The study therefore sought from the consumers to indicate the minimum costs they had spent on the innovations acquired. The findings are described in figure 24 below.

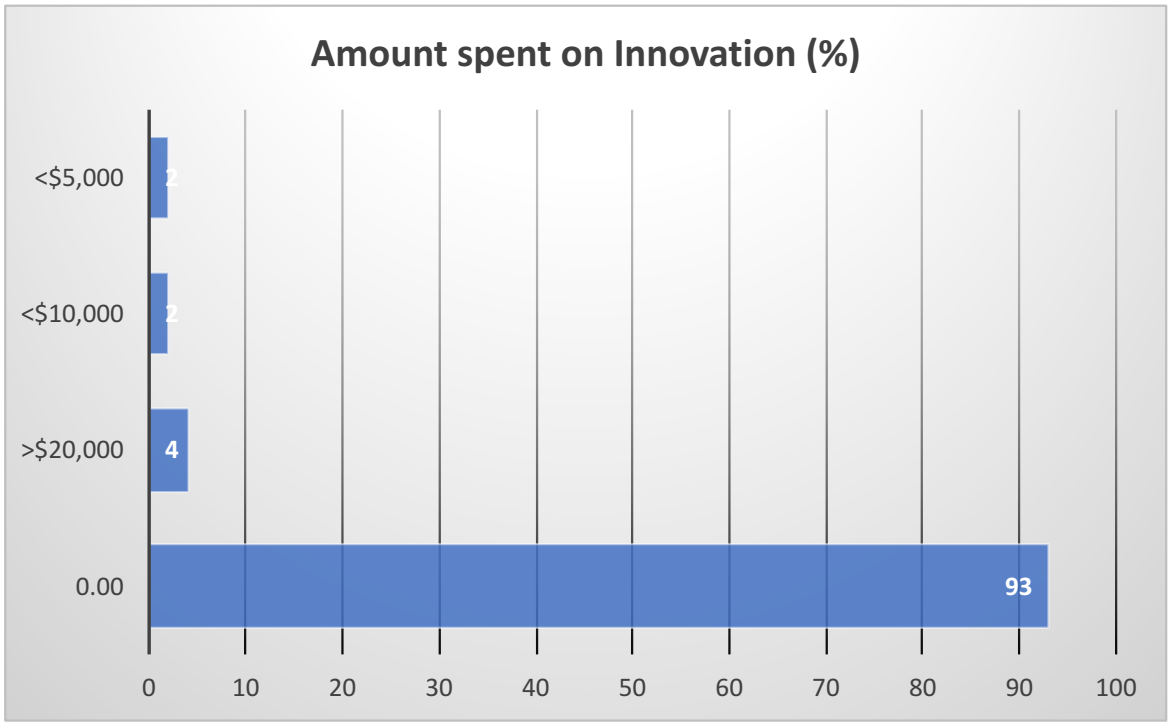


Figure 24: Expenditure made in acquiring the Innovation

The results from the study show that among the consumers of ICT4Agric majority of them 132 (93%) had spent nothing on acquiring the innovations. 3 (4%) of the participants indicated that they had spent more than $20,000 on the acquisition of the ICT4Agric innovation, 2 (2%) spent less than 10,000 and 5,000 respectively on acquiring their innovations. These results confirm the established fact that majority of the consumers are small-scale holder farmers who depend on projects to support them in acquiring the innovations and hence the zero-cost incurred. This result further indicates that there is an issue of sustainability of such funded ICT integration projects. Once the project ends, the use of ICT4Agric innovation tends to close down since the smallholder farmers did not plan for such incidents. One of the farmers who was using the M-omulimisa noted that:

> **"Through our farmer cooperative we were given these phones which have the system to use. Am happy I have a new phone and also use it to know more about my plants, seasons, markets and diseases. We did not spend anything for the phone and system but just pay a little Mbs to have internet."**

The study further investigated whether the consumers spent funds on licenses for using the innovations. The results are clearly described in figure 25.

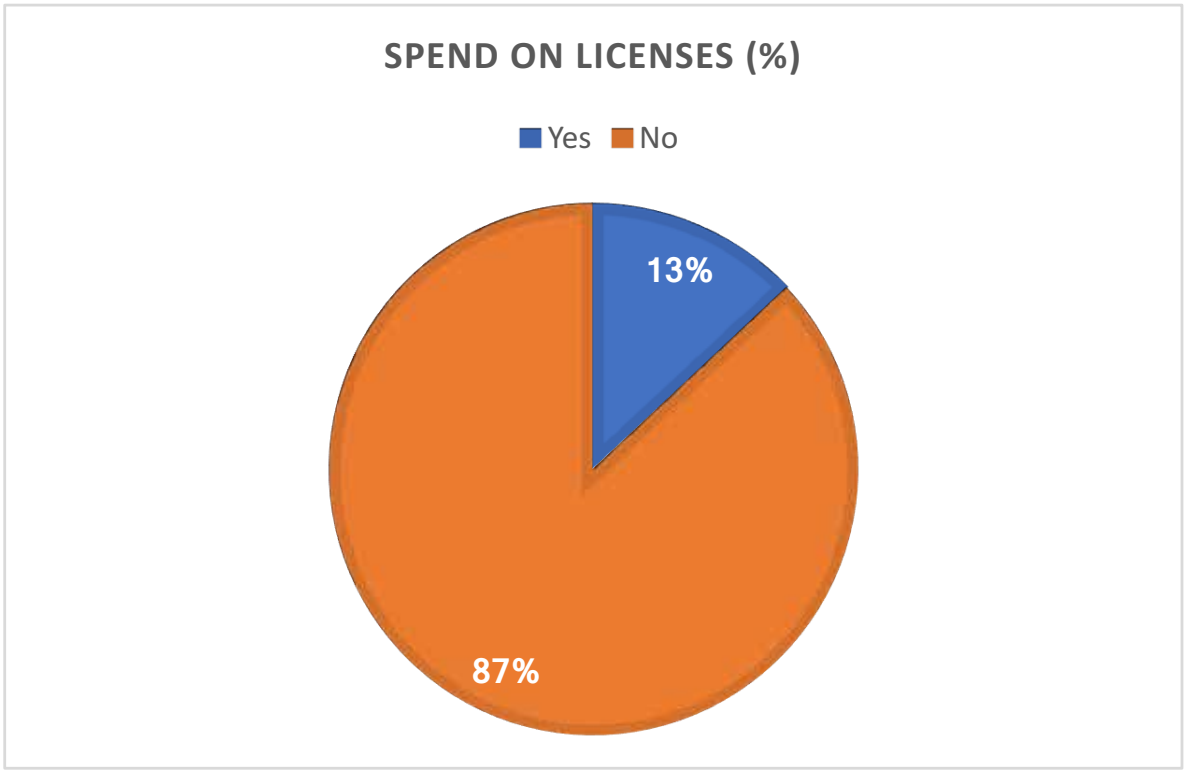


Figure 25: Expenditure incurred on Licenses

The Figure 25 shows that majority 124 (87%) of the consumers of the ICT4Agriculture innovations did not spend any funds on licenses. Only 10 (13%) indicated that they spent some funds on paying for licenses. These results confirm that generally current integration of ICT4Agric within the smallholder farmers is through projects that support the acquisition and payment of licenses for the innovations.

Amongst the consumers who indicated that they did pay for licenses, the study investigated how much they spent annually on licenses for the innovations. Figure 26 describes how much was spent on the licenses by the consumers.

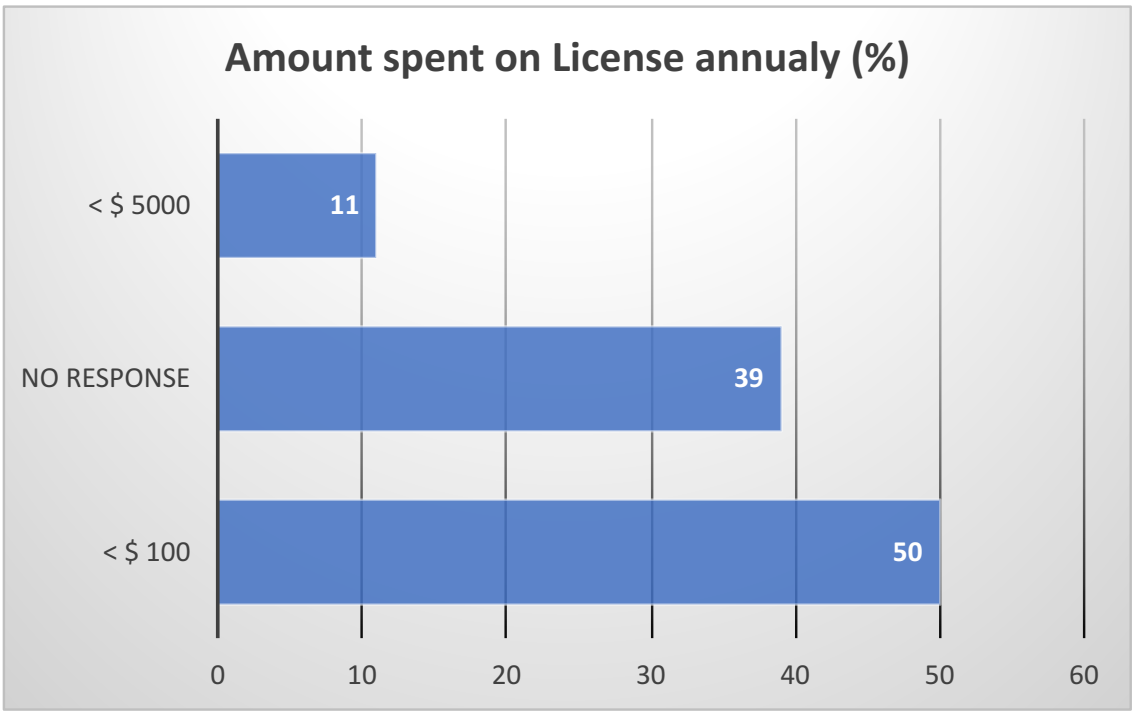


Figure 26: Funds spent on Licenses by the Consumers who were paying for innovations

The results indicate that majority 71 (50%) of the consumers who spent on licenses, spent less than one hundred dollars ($100) annually, 31 (39%) did not know how much they spent and 9 (11%)indicated that they spent less than five thousand dollars ($5,000) annually. These results show that the license consumers spend mainly below $100. However, it is also a fact that majority of the consumers are small-scale holder farmers who are low earners and may not afford paying the $100 a year.

e) Impact of ICT innovations

The study also examined the impact of ICT4Agric innovations onto the business/enterprises of the consumers who participated in the study. The study therefore sought to understand the customers' views, regarding the impact of use of ICT Innovations as per the following 5 dimensions; return on investments, decision making, employee satisfaction, access to market and business growth. Table 6 below describes the use as per each dimension.

Table 6: Impact of innovation onto the customers

Impact aspect of the innovation on business/ enterprise	4.1		SD (%)	D (%)	N (%)	A (%)	SA (%)
Increase of Return on Investment		0	1	16	68	15	
Improved decision making		0	1	12	59	28	
Improved customer satisfaction		1	3	24	62	10	
Access to markets and inputs		1	1	2	38	58	
Business growth		0	1	1	48	50	
SD - strongly disagree; D - disagree; N-neutral; A - Agree; SA - strongly Agree							

From Table 6 above, 83% (SA 15%; A 68%) of the participants were in the affirmative that the use of ICT innovations had an increase on the return on investment; 87% (SA 28%; A 59%) of the participants were in the affirmative that the use of ICT innovations had improved decision making; 72% (SA10%; A 62%) of the participants were in the affirmative that the use of ICT innovations had an improvement in customer satisfaction; 96% (SA 58%; A 38%) of the participants were in the affirmative that the use of ICT innovations had an improvement in access to markets and inputs and lastly 98% (SA 50%; A 48%) of the participants were in the affirmative that the use of ICT innovations had an increase in business growth. A farmer who was using the ERIGNU mobile application noted that:

> **"Through this phone system I can communicate my problem and someone answers me. I get good ideas on how to deal with diseases for my crops. It is helping me a lot but my other farmers cannot read English and I interpret for them."**

The information shared by the farmer who uses the ERIGNU mobile application confirms that the ICT4Agric innovations are helping farmers in different ways as already described in table 6 i.e. increased return on investments, improved decision making among others. The interactions the farmers were making with the unknown person via the ICT4Agric innovation supported them in making sure they treat their diseases and take decisions where possible. However, it is also noted from the farmer that there was a language barrier when accessing the content which was in the English language. The content in English deterred some farmers from accessing some information hence being affected during the farming seasons. It is therefore a good practice to also have the same content translated in local languages understood by the rural farmers.

f) Challenges faced by Consumers of ICT4Agriculture Innovations

The research also sought to understand challenges faced by the consumers of ICT4Agriculture Innovations. A number of challenges were mentioned by the consumers as described in table 7.

Table 7: Challenges faced by Consumers of the ICT4Agric Innovations

- Shortage of data
- Lack of power source
- Network problem
- Power shortages
- Increased taxes
- Few ICT staff to sensitize the masses
- Need more knowledge and skills to better use the services
- Capital interns of airtime to accesses
- Lack of ICT services centers
- Language barrier as most ICT tools are designed in English
- High costs of buying internet data
- Lack of smart phones

From the list of the challenges mentioned by the consumers of the ICT4Agric innovations it is clear that they are closely linked to availability of resources and affordability to access. One of the most critical challenges that requires immediate attention is the language barrier for the rural farmers who do not benefit from the English content since they can't understand it.

g) Recommendations for the identified challenges

The study sought the opinions of the consumers of ICT4Agric on addressing the challenges identified in table 7 above and below is a summary of their views on what should be done to deal with the challenges.

- Installing strong network masts to support in easy connection to the internet
- Reducing taxes on mobile data and solar system
- Extend ICT4 services in villages
- Provide more ICT4Agriculture outlets
- Government should make sure rural areas have better internet connection
- Provide trainings on the use of ICT for farming purposes
- Deploy more ICT officers within the rural areas to support farmers
- Sensitize the farmers on how to use the ICT4Agric Innovations through radios, TVs
- Use local languages during content development
- Reduce taxes on the ICT4Agric innovations and use
- Use other sources to access the ICT 4Agriculture services like radios etc.

The study also sought the opinion of the consumers on what could be done by the ICT innovators to address the identified challenges. Below is a summary of the findings.

- Develop applications that are easy to use by a lay person
- Create content in the local language that can be understood by the rural farmers
- Involve the farmers when developing the ICT4Agric innovations
- Go to the grass roots and sensitize people
- Employ as many ICT officers as possible
- Develop soft wares that help farmers in various activities and other crops
- Make sure that network issues are no longer a problem
- Give out more devices to the consumers or provide them for hire
- To allow more farmers to access automated services and pay for the devices slowly by slowly

Lastly, the study examined the suggestions and any relevant insights the consumers had and their experience in operating a locally developed ICT4Agric innovation. Below is a summary of the findings.

- It saves time and money of moving looking for experts in agriculture
- It has really improved the agriculture sector.
- It helps farmers know more about Agriculture activities
- It is cheap to use
- Information provided is clear and understandable.
- In the event that they involve small-holder farmers, they should facilitate the farmers on projects.
- Market are easy to get since they are right on your phone (market has expanded due to ICT services)
- It requires little payment to have access to a variety of agriculture services and easy to use.
- Services are received from anywhere at any time and my wish without traveling
- ICT4Agric innovation is real and works in solving farming problems such finding markets for products.
- The ICT investors should extend their services to village levels in order to benefit the local farmers

3.3. State of ICT4Agric Policy and Regulatory Environment

In this study, it was important to understand the policy and regulatory environment within Uganda so that it is clear how ICT4Agric has been implemented and adoption for service provision. It is possible that failure to understand the scope of ICT is one of the reasons for some of the challenges in policy, strategy and implementation of ICT in various sectors of the economy in Uganda. For this study in particular, policies and strategic documents that regulate and guide ICT use and application in agriculture and education have been analyzed among which are the following:

RELEVANT DOCUMENTS -REGULATIONS/ POLICIES	ISSUES ADDRESSED	REMARKS
THE UGANDA CONSITITUTION (1995)	**IV. National sovereignty, independence and territorial integrity.** (ii) The State and citizens of Uganda shall endeavor to build national strength in political, economic and social spheres to avoid undue dependence on other countries and institutions. (iii) The State shall endeavor to mobilize, organize and empower the Ugandan people to build independent and sustainable foundations for the development of Uganda. **XI. Role of the State in development.** (i) The State shall give the highest priority to the enactment of legislation establishing measures that protect and enhance the right of the people to equal opportunities in development. (ii) The State shall stimulate agricultural, industrial, technological and scientific development by adopting appropriate policies and the enactment of enabling legislation.	It can be argued that ICT is critical in ensuring that the State and citizens of Uganda fulfil these constitutional objectives and in particular to "stimulate agricultural, industrial, technological and scientific development". The state shall adopt appropriate policies and enact enabling legislation as indicated in sections below.

UGANDA VISION 2040	**4.1.7 Knowledge and ICT sector** 142. ICT and ICT Enabled Services (ITES) industry has enormous opportunities that Uganda can exploit to transform the economy and peoples' lives through job creation, accelerated economic growth and significantly increased productivity. 146. Uganda shall develop, improve and retool its ICT talent building mechanism by adopting globally-benchmarked, industry-rated skills assessment, and training and certification standards. The curricula and learning content will also be progressively reviewed and developed in order to align what students are taught and what industry globally requires. These efforts will be coupled with international industry collaboration in testing and certification standards. ICT shall be mainstreamed in education to take advantage of ICT-enabled learning and to prepare future generations of ICT-savvy workers, and ensure their effective utilization. 158. Government will review all legal and regulatory framework in the ICT sector to allow for efficient operationalization, enforcement and improvement of cyber laws, and enhance information security.	The Vision clearly appreciates the value of ICT in the economic and social transformation of Uganda. It emphasizes the need to have appropriate curricular, legal and regulatory environment in order to ensure proper education and utilization of ICT by government, NGO and private institutions.
NATIONAL ELECTRONIC GOVERNMENT (E-GOVERNMENT) POLICY FRAMEWORK (2011)	**2.1.2 e-Government Applications and Investments:** m. Education Management Information System (EMIS) n. Rural Information System to provide market information to farmers and other agriculture value chain stakeholders (Ministry of Trade, Tourism and Industry)	The framework highlighted several e-government applications that were being implemented at the time and among them were those in education and agriculture.
MINISTRY OF EDUCATION AND SPORTS POLICY STATEMENT 2012-2013	Priority Areas for the Education and Sports Sector during FY 2012/13 and in the Medium-Term Plan: Continue supporting ICT initiatives including digital science and other innovations in the teaching of science and mathematics; vii) Continued to implement the digital science project with a newly furnished computer lab at Kololo S.S, setting up of an ICT laboratory at St. Henry's college, Kitovu-Masaka, Kitende SS, Kiira College Butiki and Bishop Comboni College Kambuga and monitored progress of establishment of ICT labs in 420 schools supported by UCC and continued to support 9 others schools under the development of Secondary	According to this policy statement, Application of ICT in Education was still under a pilot state.

	Education Project. In addition, facilitated NCDC to develop and review ICT and Sub Mathematics curricula for A Level under the UPOLET programme. 160 Instructors in Business, Technical, Vocational Education and Training (BTVET) Institutions in ICT skills	
NATIONAL AGRICULTURE POLICY (2013)	**Objective 1: Ensure household and national food and nutrition security for all Ugandans:** Generate, demonstrate and disseminate appropriate, safe, and cost-effective agricultural technologies and research services to enhance production and increase quality of products through access to high quality agricultural technology, agribusiness and advisory services for all categories of farmers;	The Policy is not explicit regarding the role of ICT in the implementation of the policy. It generally refers to market information sharing, coordination, Monitoring and Evaluation, and management information systems.
THE NATIONAL DEVELOPMENT PLAN (NDP) II	Theme: "Strengthening Uganda's Competitiveness for Sustainable wealth creation, Employment and inclusive growth" Despite the remarkable achievements demonstrated by exponential growth of the sector in the last years, a number of challenges have emerged that have hindered further growth of the sector leading to the poor ranking of Uganda on the global ICT development index. These include: the high cost of internet bandwidth; vandalism and damage to infrastructure; poor quality of service; inadequate skilled human resource; limited local content (digital content); low uptake of e-services; and lack of commercial orientation for exploitation of the various ICT innovations. In addition, the increase in the benefits of ICT have not been matched with equal access to ICT platforms that are customized to the information needs of female artisans and smallholders, to link them with local and international buyers. 96. In order to improve access to ICT infrastructure and its usage as well as skills development in the sector, the country needs to address the limited ICT infrastructure network; invest in research, innovation and human capital development; implement policy reforms to ensure increased local participation, including ownership of ICT infrastructure and businesses, in order to reduce the externalization of sector gains. In order to enhance marketing and distribution of agricultural products, focus will be on: developing capacities of existing farmers' organizations, co-operatives and producer associations so as to reap from economies of scale; expanding market access through regional and international protocols and Uganda missions abroad; and deepening ICT access to facilitate market information sharing.	We need to explore the reasons for the "low uptake of e-services; and lack of commercial orientation for exploitation of the various ICT innovations" as indicated in the plan. "…the benefits of ICT have not been matched with equal access to ICT platforms that are customized to the information needs of female artisans and smallholders, to link them with local and international buyers." This phrase somehow addresses the gap in the application of ICT in agriculture.

	The ICT sector is envisaged to facilitate sustainable, effective and efficient development through harnessing and utilizing ICT in all spheres of life. It is composed of telecommunications, postal, information technology (IT), and broadcasting subsectors. No formal course designated for ICT in teacher education curricula;	
THE NATIONAL AGRICULTURAL EXTENSION POLICY (2016)	**Policy Area 3.3: Agricultural Knowledge Management and Information System:** Policy statement: Government will establish a knowledge based management and information system that will facilitate agricultural extension service delivery. Strategies: a. MAAIF will establish a decentralized one-stop-center for agriculture extension knowledge and information that is comprehensive and meets the needs of the users. The center will be serviced by an integrated national backend ICT enabled knowledge and information systems for agriculture. b. DAES will establish an integrated and dynamic system for the sub-sector statistics in collaboration with other actors to improve access and use of information generated. c. MAAIF will promote the sharing of agricultural knowledge and information through value added information products in print, electronic and web mode for all categories of users including beneficiaries and service providers. The system will also have an in-built mechanism for soliciting feedback from users. d. Build the capacity of MAAIF and other actors in agricultural knowledge management and communication.	The emphasis of this policy is basically limited to knowledge and information exchange. Technological innovations seem not to come out clearly.
AGRICULTURE SECTOR STRATEGIC PLAN 2015/16-2019/20	**Support innovation in agro-communication across the agro value chain:** The main objective of this intervention is to exercise innovation in agricultural message packaging and delivery so as to widen the range of information products and delivery mechanisms used in the sector. This is mainly to ensure that the entire spectrum of end users and consumers of agricultural information are provided with the right information and knowledge using the appropriate technologies. This will include use of music, dance, drama and ICTs platforms (including social networks) to communicate sector policies, strategies, and agricultural extension information.	The plan identifies some of the most recent ICT applications and relates them to how they can be applied at the various stages of the agricultural value chain but with more emphasis on information sharing, extension services and marketing.

	The intervention will particularly target the youth with innovative approaches, to attract and interest them in agricultural value-chains (production, processing, value-addition and marketing) via social media platforms like Facebook; Twitter, blogs on the internet; short message services (SMS) on mobile phones and any other technology related channels. The intervention also targets developing institutional support for AICU staff in MAAIF and its agencies through training in ICT-based agro-communication systems/platforms and in modern digital-based film unit operations, television and radio documentary/feature productions and dissemination.	
NATIONAL STRATEGY FOR YOUTH EMPLOYMENT IN AGRICULTURE (2017)	**4.4.5 Thematic Area 1 Strategy 5: Increase access and use of ICT for youth in agriculture:** This is an information age and access to ICT is critical in knowledge sharing on developments in the agriculture sector as well as demonstration of modern practices at all stages of the agriculture value chain. With increased ICT penetration (especially the use of mobile smart phones and social media). While this is possible with youth in urban and peri-urban centers, access to information remains a challenge for youth in rural areas. To reach youth with information and enable them access ICT facilities to boost their engagement in agriculture, Government will set up community information centers, sensitize youth, and provide training in use of ICT tools for agriculture and use these centers as reference points for knowledge based agricultural service provision for the youth across the country. Sensitization drives will be carried out using radio FMs, television programs and print media. The following will be the key strategic interventions: Strategic Interventions: a) Establishment of internet enabled community information centers (including ICT software and equipment) to provide and promote market information sharing to and among the youth in agriculture; b) Sensitizing and training youth in using ICT in agriculture; and c) Undertaking research and support dissemination of offline tools that are usable with no or limited internet connectivity.	The strategy makes an attempt to detail how ICT is to be applied in Agriculture but emphasis is put on the access and utilization of existing ICT technologies, little is provided for developing new ICT technologies and applications.

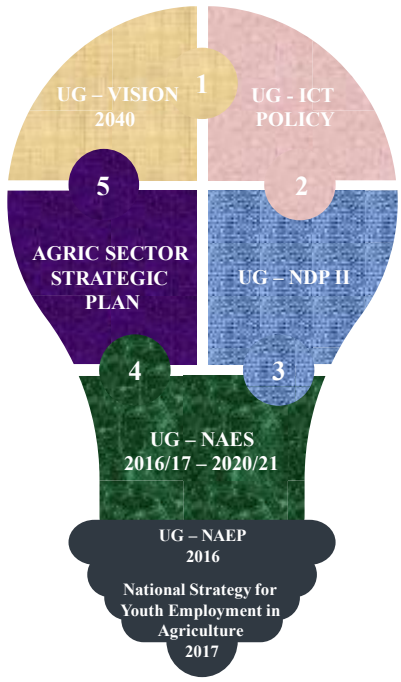
NATIONAL AGRICULTURAL EXTENSION STRATEGY 2016/2017 – 2020/2021	Objective 3: To develop a sustainable mechanism for packaging and disseminating appropriate technologies to all categories of farmers and other beneficiaries in the agricultural sector: Specific objective 3.2: Page 28 Agricultural Knowledge Management and Information System: Strategy 3.2.1. DEAS will establish a decentralized one-stop-center for agriculture extension knowledge and information that is comprehensive and meets the needs of the users. The center will be serviced by an integrated national backend ICT enabled knowledge and information systems for agriculture.	According to this strategy 'innovative technologies' or some of the 'appropriate technologies are: climate adaptation and mitigation technologies, irrigation technologies, labor saving technologies and value addition technologies. These can be linked in some way to ICT. However, there is no direct mention of ICT innovations and technologies.
NATIONAL INFORMATION AND COMMUNICATIONS TECHNOLOGY POLICY FOR UGANDA (2014	**5.2.7 ICT in Agriculture:** Ensure the systematic sharing and dissemination of information on agriculture, animal husbandry, fisheries, forestry and food security using ICTs, in order to provide ready access to comprehensive, up-to-date and detailed knowledge and information, particularly in rural areas; and Promote Public-Private Partnerships with a view to maximizing the use of ICTs as an instrument to improve the whole agricultural value chain, both in quantity and quality.	The policy clearly stipulates the role of ICT in Agricultural Development.
THE NATIONAL INFORMATION TECHNOLOGY AUTHORITY UGANDA (E-GOVERNMENT) REGULATIONS, 2015	3. Purpose. The objectives of these Regulations are— (a) to promote e-government services and electronic communications and transactions with public and private bodies, institutions and citizens; (b) to promote the use of the internet to provide increased opportunities for citizen participation in Government; (c) to promote interagency collaboration in providing public services by consolidating, rationalizing and integrating related functions and using internal e-Government processes to improve the service to citizens, efficiency and effectiveness of the processes; (d) to promote the use of the internet and other appropriate technologies within and across Government agencies in providing Government information and services; (e) to reduce the cost and burden for Government and businesses entities in the provision of public services; (f) to improve access and sharing of Government information and services.	The policy does not direct link to agriculture or education but these can be implied under 'e-government services and electronic communications and transactions with public and private bodies, institutions and citizens'.
THE NATIONAL BROADBAND POLICY (2018)	Each sector of the government needs to have digital milestones to achieve. For example, the Ministry of Education must adopt e-learning (e-education) and come up with innovative ways of packing and delivering, learning and instruction materials/ content to the pupils/students and teachers across all barriers of physical space (rural/urban divide) …agriculture must adopt…e-agriculture.	This policy is intended to provide the infrastructure for faster and cheaper internet and associated technologies.

MINISTRY OF SCIENCE, TECHNOLOGY MINISTRY OF SCIENCE, TECHNOLOGY & INNOVATION MINISTRIAL POLICY STATEMENT FINANCIAL YEAR 2017/2018	**Enhance R&D in Uganda:** Formulate and adequately finance a National Research Agenda through the National Research and Innovation Fund emerging technologies/scientific fields such as biotechnology, bio-medicine and life sciences (bio medical engineering, bioinformatics , biomaterials and synthetic biology); … and non-conventional sciences; nuclear energy, ICT (High performance computing, R&D in artificial intelligence, robotics, drones and assorted electronics), Nanotechnology/ material science, Geographical Information Systems (GIS) and other geo-spatial technologies and their multi-sector applications (natural resource exploration, disaster early warning systems, monitoring the effects of climate change and other meteorological functions).	This is the first policy document that identifies high level application of ICT in development. However, there is no clear budget allocated for this kind of research in particular.

The constitution of Uganda (1995) clearly indicates that 'undue dependence on other countries and institutions' should be avoided. Information and communication Technology (ICT) has emerged to be a critical resource and as such, the State should mobilize, organize and empower both citizens and local institutions to have control over such a resource. It is also evident that ICT is an enabler of inclusive development and that it affects most of the human activities. The state therefore should create an enabling regulatory and institutional environment in order to benefit optimally from ICT innovations and applications in various sectors of the economy such as education, industrial and agricultural development. This should be done in such a way to ensure equitable development.

The National Agriculture Policy (2013) stipulates the need to 'generate, demonstrate and disseminate appropriate, safe, and cost-effective agricultural technologies and research services…to all categories of farmers' in order to ensure food and nutrition security for Ugandan citizens. It is implied in the above statement that ICT is expected to play a great role in the implementation of the policy objective. It however seems to have a narrow perspective of the application of ICT since it mostly focuses on information generation and sharing.

The Uganda Vision 2040 and the second National Development Plan (NDPII) also appreciate the role of ICT as a driver for development. This is further emphasized by various policy and strategic documents such as the National Agricultural Extension Policy (2016), the Agriculture Sector Strategic Plan (2015/16-2019/20) and the National Agricultural Extension Strategy (2016/2017 – 2020/2021). The National Strategy for Youth Employment in Agriculture (2017) and the National Information and Communications Technology Policy for Uganda (2014) are more explicit on the application of ICT in Agriculture yet they also suffer from the same problem like most policies and strategies of limiting the scope of ICT to only generating and disseminating information on agricultural technologies and market access.



Uganda Vision 2040
The Vision clearly appreciates the value of ICT in the economic and Social transformation of Uagnda

National Information and Communications Technology Policy for Uganda (2014)
Ensure the systematic sharing and dissemination of information on agriculture, animal husbandry, fisheries, forestry and food security using ICTs

National Development Plan (NDP) II
Strengthening Uganda's Competitiveness for Sustainable wealth creation, Employment and inclusive growth

Agriculture Sector Strategic Plan 2015/16 - 2019/20
Exercises innovation in agricultural message packaging and delivery so as to widen the range of information products and delivery mechanisms used in the sector

National Strategy for Youth Employment in Agriculture (2017)
Attempts to detail how ICT is to be applied in Agriculture but emphasis is put on the access and utilization of existing ICT technologies

Figure 27: Summary of Policies to support ICT4Agriculture

3.4. Regional Trends in ICT for Agriculture

3.4.1. Regional policy environment for ICT4 Agriculture

RWANDA

Rwanda's government considers the use of ICT as the key to transforming the economy and hence the urge for its use in all services.

Rwanda Vision 2020 plan is very crucial to the country's strategic direction and has put ICT at the fore front in all what is done. It has the following objectives which clearly illustrate how ICT is taken as being very vital;

1. Put in place the legal, institutional and structural framework, favorable to the unfolding and the integration of ICT in the economy and within society
2. Encourage the private initiatives in the communication sector
3. Improve Rwandan skills in using and managing ICT
4. Adapt technological co-operation to the transfer of ICT to Rwanda
5. Improve communication facilities.

It is this Vision that has seen sectors such as agriculture to integrate ICT in many of the services provided.

Rwanda ICT-2020 Policy Framework provides for a commitment to pursuing both ICT exploitation and production policy to support the delivery of government services and the activities of various sectors of the economy, as well as the production, development and delivery of ICT products and services. It is this policy that promotes the adoption of ICT in the agriculture sector.

Rwanda Integrated ICT led Socio-economic Development Policy and Plan 2016 - 2020 (NICI 2020) which is an extension of the first NICI phases of 2001 – 2015. It aims to consolidate the process towards achieving a middle-income status and an information-rich, knowledge-based society and economy through addressing a plan for ICT development within the country's development agenda. The policy aims at developing a knowledge based economy around ICTs as well as consider sustainable development in the global market for information based services and products in all sectors, agriculture inclusive.

Rwanda Economic Development and Poverty Reduction Strategy (EDPRS) 2013 -2018 advances the concept of innovation as important principle for programme delivery and noting that its role is to emphasize new ways of thinking, working and delivering. It also proposes that agricultural research, technology, knowledge and skills are key to improving productivity in the sector.

Rwanda ICT for Rwanda Agriculture (ICT4RAg) Strategy for 2016-2020 aims at increasing agricultural productivity through the use of ICTs and to be realised by developing a database on farmer and farm information, increasing the number of skilled and knowledgeable farmers, spurring job creation in agriculture and peripheral services, improving access to agricultural information, knowledge and markets, and improving access to finance for agriculture.

KENYA

The Agricultural policy in Kenya 2006 revolves around the main goals of increasing productivity and income growth, especially for smallholders; enhanced food security and equity, emphasis on irrigation to introduce stability in agricultural output, commercialization and intensification of production especially among small scale farmers; appropriate and participatory policy formulation and environmental sustainability. The primary objective of the strategy is to provide a policy and institutional environment that is conducive to increasing agricultural productivity, promoting investment, and encouraging private sector involvement in agricultural enterprises and agribusiness.

The ICT policy for Kenya feeds into their vision 2030 whose main pillars include economic, social and political stability of which agriculture is included. It encourages innovations, attracts investments and promotes the ease of doing business for a positive social and economic impact through ICTs.

Kenya's **Information and Communications Technology (ICT) Policy** focuses on these main objectives;

1. ICT is a developmental tool that should be widely accessible and utilized by the general population;
2. There will be a technology neutral approach in the adoption and regulation of ICT systems and services in the promotion of competition;
3. Innovation will be promoted for the benefit of consumers, producers and service providers while at the same time protecting the interest of innovators;
4. Investing in human resource development and capacity building will also be prioritized.

It is these objectives that have supported the development of other service related policies to steer the effective integration of ICT in the service areas such as extension services, financial services, advisory services among others.

The **National Agricultural Sector Extension Policy (NASEP)** aims to guide and harmonize management and delivery of extension services in Kenya. The policy advocates demand-driven extension services and preparation of other players in the delivery of extension services. It emphasizes the ability to recognize a need to diversify, decentralize and strengthen the provision of agriculture services with a view of increasing sustainability and relevance to farms. Through this policy several extension services have come into place in Kenya and have supported the farmers.

The **National Agricultural Sector Extension Programme (NALEP)** is agricultural training programme in Kenya provided through tertiary training colleges and farmers training centers. Provides farmers with training at farmers' training centers where agricultural knowledge, information and technology are provided at the Agricultural Information centers.

All the above policies in Kenya have an emphasis on increasing productivity and supporting small holder farmers within the country.

Tanzania

Country Programming Framework (CPF) 2017 – 2020 sets out FAO 4 priority areas of support to Tanzania of which Agriculture is one of them.

Tanzania Development Vision 2025 (TDV) which envisages that by 2025 the economy will have been transformed from a low productivity agricultural economy to a semi-industrialized one, led by modernized and highly productive agricultural activities which are effectively integrated and buttressed by supportive industrial and service activities in the rural and urban areas.

The Tanzania Five-Year **Development Plan phase two (FYDP II)** is a framework that guides development planning in the Country to attain Development Vision 2025 and attaining SDGs. The FYDP II highlights key interventions, including for the agriculture sector which includes increased use of modern technologies including ICT and extension services, lengthening and deepening value chains, skills promotion along the value chains, commercialization, quality and standards, research and innovation, promotion of producer groups, and promoting marketing and improved access to financial services.

The Tanzanian government in collaboration with development partners has taken on initiatives that support ICT4 Agriculture, including the **Agricultural Sector Development Programme, (ASDP II), the Southern Agricultural Growth Corridor of Tanzania (SAGCOT), Kilimo Kwanza initiative, and Big Results Now (BRN),** all of them intended to enhance technology uptake, market development, and strengthening partnerships, towards 2 improving productivity, increasing production and incomes, increasing resilience, and ensuring food and nutrition security.

3.4.2. ICT Agriculture Services

There are a variety of services within the agriculture sector that have integrated Information Communication Technology (ICT) to support service provision. These have ranged from information services, diagnosis services, advisory services among others. ICT once adopted in these services it enables the services to be offered in a more effective and efficient form. The Food and Agriculture Organization of the United Nations (FAO) (2000) once asserted that information and knowledge play a key role in ensuring food security and sustainable development. Hence Information and Communication Technologies (ICTs) is considered as a cross-cutting driver of change for rural and agricultural development because it supports agricultural productivity.

The East African region has seen several of these services integrate ICT and these include Farmers Information Services (FIS), Agriculture Extension and Advisory Services (AEAS), Agriculture Financial Services (AFS), Agriculture Marketing Services (AMS) among others. Within the East Africa member countries these services have been adopted based on the existing policy environment and the available ICT infrastructure. Below is a summary of what the different countries are doing in terms of adopting ICT for the different service provision.

Figure 28: Common Agricultural Services for ICT Intergration

a) Farmers Information Services (FIS)

These are services that involve the dissemination of information to the farmers using a variety of ways. ICT has been used to provide FIS and numerous applications have been developed within the region to support such services.

Kenya Agricultural Commodity Exchange (KACE) which is an ICT based commodity exchange services application. KACE gathers, updates, analyses and provides timely and reliable market information as well as intelligence on a wide range of crops commodities. The exchange platform targets actors in commodity value chains, mainly focusing on small scale agribusinesses and smallholder farmers.

"DrumNet" which uses ICT to bring together multiple stakeholders in the Kenyan agriculture sector so that they can share information amongst each other in a more effective and efficient form.

"e-Nutrifood": Provides information on the production, conservation and consumption of nutritious foods. Quality information on nutrition is vital in fighting malnourishment, stunting and food insecurity in Rwanda.

"Weather and Crop Calendar": Combines information about weather forecasts and crop calendars which it disseminates to the Rwandan farmer. These early warning services provide users with potential solutions to risks in and help increase farmer's resilience.

"Farm Management and Information System (FMIS)" is an application in Rwanda that is responsible for managing agriculture information.

"Hallar Farms" is a web based application giving farming information in English and Swahili to farmers and supports agriculture and extension workers in Kenya.

"Farmforce" is a Software-as-a-Service solution that simplifies the management of small-holder farmers, increases traceability and enables access to formal markets. It is used to efficiently manage out grower schemes and contract farming programs in Tanzania.

b) Agriculture Extension and Advisory Services (AEAS)

"Cure and Feed your Livestock": This app provides real time on animal disease and feeding strategies. Users will also be able to create farmer groups to exchange information and learn from others' experiences and good practices.

"mNutrition" initiative in Tanzania is developing content for a mobile phone-based messaging service aimed at increasing knowledge of nutrition and health within communities. The information about nutrition is supposed to improve the community's reaction to deficiencies they suffer from.

"Airtel Kilimo" is a mobile agricultural value-added service (Agri VAS) developed by mobile network operator, Airtel Kenya. Airtel Kilimo offers an advisory service for smallholder farmers in Kenya related to crops, weather and market price information via mobile phones. Customers access the service via the USSD1 channel which is available on any mobile phone. The service also enables peer-to-peer communications between farmers via a chat function.

"Connected Farmer (CFA)" is an application for dairy cooperative in Kenya which supports detection of theft of milk by farm hands and collection agents as milk is delivered to the collection center. The CFA supply chain solution facilitates daily delivery receipts via SMS, allowing them to quickly identify potential fraud.

"Climate Change Adaptation and ICT (CHAI)" this is an application that strengthens the adaptive capacity and resilience of agro-pastoral communities in Uganda. It provides adaptation information which includes seasonal weather forecasts and agricultural information localized to sub-county level; weekly livestock and crop market information to help farmers decide what, when, where and how much to sell; guidance on low cost rainwater harvesting techniques; information on drought and flood coping mechanisms; and termite control measures. As well as using mobile channels, CHAI also has an FM radio presence.

"CHARIS Custom Based Drone Solution" is a solution developed by Charis a drone company in Rwanda

which supports garden mapping, crop mapping, crop spraying ubiquitously hence saving the farmer the efforts to physically do it. They use the drones to optimize farm inputs, react faster to threats, estimates yield among others.

Uhuru Labs in Tanzania, Third Eye Project in Kenya and TechnoServe Innovation in Uganda have also used drone technology for specific activities which include farm monitoring, yields estimation, crop health management, disease and paste identification and early warning. These disruptive forms of ICT4Agriculture adoption are shaping the future of agriculture extension services within the region.

c) Agriculture Financial Services (AFS)

"M-PESA" enables Kenyans farmers to access to credit and also facilitates the well-functioning and efficiency of the credit market, especially by reducing information and monitoring costs.

"Kilimo Salama" is an index-based agriculture insurance on agricultural inputs in Kenya and supports farmers in accessing insurance products for their farming. They can easily insure farm inputs against droughts or excessive rain through prepaid mobile phone fees via their mobile accounts.

"ACRE" is an agricultural insurance product for smallholder farmers in Kenya. Known as the 'replanting guarantee', farmers can find, within each bag of Duma 43 Maize Seed, unique code. Farmers, via their mobile phone text this code to register their purchased seeds.

"Virtual City AgriManagr system" allows management of the weighing, grading and receipting of produce collected from each farmer at the collection point in Kenya. The system also allows you to pay suppliers using cashless transactions and track & reward loyal customers and suppliers

d) Agriculture Marketing Services (AMS)

"eSoko" is a market information system put in place to provide farmers with price decision making tools to enlighten the path to socio-economic development through agriculture in Rwanda.
"AgriMarketplace" is a system that connects producers and traders to facilitate price access and ease of trades. The farmers have the opportunity to discover the best providers of raw materials as well as the best marketplaces to sell their products and the market prices in Rwanda.

"Tigo Kilimo" is an Agriculture value added service application that sends information on crops agronomy, market prices and weather forecasts to smallholder farmers in Tanzania.

"Infortrade" is an application that uses SMS Info codes provided to disseminate information of interest to the farmer based on the automated replies for the SMS requests.

3.4.3. Regional Technology Focus within the Agriculture Value Chain

As witnessed from the numerous agriculture services offered within the East African region, ICT4Agriculture adoption has been undertaken improve the efficiency of the agriculture value chain (pre-production, production and post-production) through the provision of services to the farmers. The agriculture value chain has benefited from the numerous ICT applications that have been developed to support service provision. A summary of as the sample ICT4Agric application is presented in the figure below;

PRE - PRODUCTION

- eSoko
- AgriMarketplace"
- Tigo Kilimo"
- Infortrade
- M-PESA
- Kilimo Salama
- Virtual City AgriManagr system
- mNutrition
- Farmforce

PRODUCTION

- ACRE
- Cure and Feed your Livestock
- Airtel Kilimo
- Connected Farmer (CFA)
- CHARIS Custom Based Drone Solution
- Kenya Agricultural Commodity Exchange (KACE)
- DrumNet
- e-Nutrifood
- Farm Management and Information System (FMIS)
- Hallar Farms

POST - PRODUCTION

- Climate Change Adaptation and ICT (CHAI)
- Weather and Crop Calendar

Figure 29: Sample ICT Innovations accross the Agricultural Value Chain

3.5. State of Agriculture Content Development and Delivery

It is no secret that to achieve the agricultural sector outcomes as defined in various international and national social development frameworks (SDGs, the African Agenda 2063, NDP II, etc) which largely focus on addressing hunger and nutrition security, the farming community and other actors in the agricultural sector require appropriate; information, knowledge and skills to optimize the use of available resources.

Thus, to address the information, knowledge and skills gaps of stakeholders in the sector, a systematic extension service delivery framework which is knowledge intensive is critical. In Uganda, the extension services are public good and the government continues to develop and implement various approaches to find the optimal mechanism for extension service delivery.

Some of the approaches currently being used to deliver extension services in Uganda include: face-to-face training, student interns from universities, information and communication technologies, demonstration farms, agricultural shows and fairs, field days, exposure visits, mass media, adaptive research trials, randomized

control trials, and publications such as leaflets, production guides, posters, etc. The use of ICTs in extension service delivery is better summarized by the SUFACE Model which was developed at Makerere University as illustrated in figure 25 below;

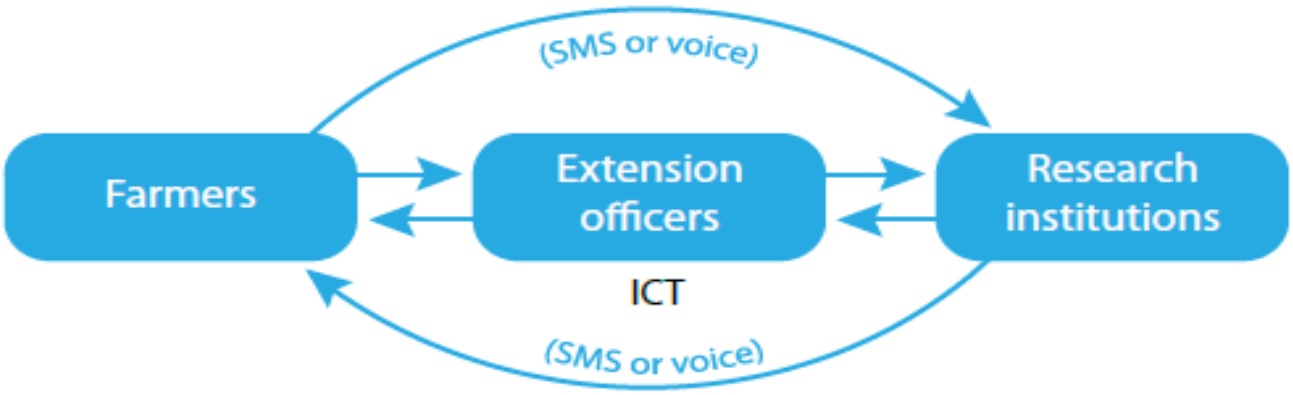


Figure 30: SUFACE Model of Extension Service Engagement between Key stakeholders

a) Quality of Extension Services

Various studies on Uganda's agricultural sector have identified knowledge management and sharing as one of the key challenges in the sector. Key among the identified gaps is inappropriate content development for various stakeholders, inappropriate content formats, and inappropriate content delivery channels among others. Mirembe, et al (2016), note that, weak knowledge management which involves; knowledge generation, information packaging and delivery are greatly affecting the delivery of extension services in the sector. The weak knowledge management systems directly impacts on the skills development of extension workers, hence impacting on the quality of services extension workers deliver. One professor of agriculture at Makerere University observed that;

> **"Most extension workers are graduates of the Bachelors of Agriculture, which is fairly a broad programme. Therefore, the graduates are exposed to a wider field of knowledge largely theoretical as a means of grounding their careers. However, for such graduates to be effective in extensive service, they would need regular, timely industrial oriented trainings to enhance their knowledge and skills."**

This observation was further echoed by one extension worker in Lira who noted that;

> **"The key challenge of an extension worker is the lack of timely reliable reference system of knowledge. When one is in the field, the only timely point of reference knowledge is Google which sometimes does not provide contextual information one needs. So one has to document the issues and consult researchers within the National Agriculture Research Systems (NAS) often times the extension worker relies on his/her social capital."**

Another extension worker in Kyenjojo added;

> **While a lot of research is being conducted and published in various scientific journals, the researchers often don't provide their findings in formats that are usable by extension workers. It's extremely important for researchers to develop knowledge products from their studies for various stakeholders to stimulate uptake of their findings**

The challenges of agriculture content are also well described by farmers, who are final consumers of most of this content, as observed by the famers in Lira;

> **It is hard to access a production guideline for some value chains like rice and green gram, and if the production guide exists it is often expensive to buy, written in English with complicated terms and largely text, which make it is difficult to interpret and sometimes visualize the message**

Another famer in Butaleja noted;

> **Some production guides use misleading expressions for example, where they state that plant spacing should be at least 2 feet, my question is whose feet? A child, woman or grownup man? Because each of these have different sizes and yet in our community all these categories of individuals participate in farming activities**

The engagement with plant breeders and heads of value chains at NARO revealed that they too have challenges when training farmers with the currently context format. One plant breeder observed that when training farmers using text based content he finds it very difficult to illustrate some concepts. In order to address these challenges, he is piloting the use of farming videos from access agriculture and other sources. These are often generalized content and lack contextual case studies which farmers can identify with.

> **To improve my training with farmers I often rely on open source video content. My experience from these trials indicate that famers tend to understand visual illustration more than virtual explanations**

An extension worker in Oyam observed that;

> **I lack a timely and reliable point of reference like YouTube due to internet connectivity and costs. How I wish Ministry of Agriculture and NARO can create a YouTube channel where they publish locally authored content for extension workers to use, but also provide free internet access to enable us to access these videos.**

A female farmer in Buikwe district narrated her experience on content as follows;

> **"I tried to venture into passion fruits farming, but I could not find content anywhere to guide me. We hardly see an extension worker in our area. Therefore, I have had to rely on mouth to mouth knowledge to understand how to grow passion fruits, this has not been easy and I have made losses due to limited availability and accessibility of passion fruit farming information"**

An interview with one community based organization promoting improved household incomes through agriculture in eastern and northern Uganda revealed that, development and accessibility of product guides is one of the fundamental challenges affecting farmers. The officer in charge of information and knowledge management representing the organization observed;

> **"Most of the needed information by farmers is not available within the community, even district production offices don't seem to have this information. In cases, where this information exists it is not timely or reliable. So we normally produce leaflets by reviewing information from various sources in order to guide our farmers"**

The issue of reliability of content was further articulated by farmers in a focus group discussion in Apac district, who noted that;

> **"Most of the content we receive is in English and yet majority of us did not go to school due to the war. Besides, sometime they provide us misleading information. For example recently we were advised to plant that rains have started only for our crops to be hit by drought. We lost entire fields, this was very discouraging"**

b) Language of Content

The survey among farmers and services provider who responded to the study on the language of content being used and their preferred choice revealed as illustrated in figure 26 below that majority of the farmers 65 out of the 74 who responded indicate the current content is mostly in English, this was a similar trend with service providers of which 5 out of 6 who responded indicated the content to be in English.

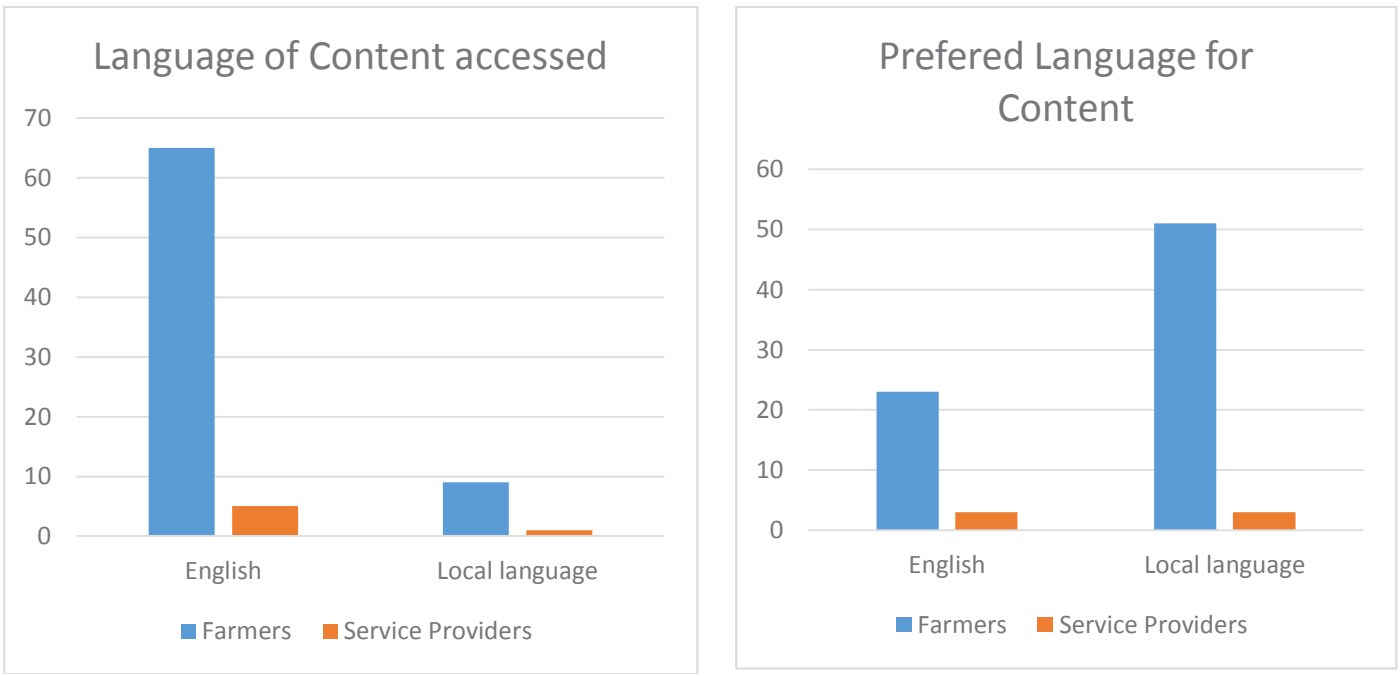


Figure 31: Language of the Content Accessed and Preferred

When asked about the language they would prefer the content to be in, majority of farmers who responded to the question (51 out of 74) preferred the local language to English while for the service providers they were evenly split between the local language and English (see figure 26 above). The desire to have content in local language could be attributed to the fact that majority (67%) of the farmers who responded had below university level education (Certificate 11%; Primary 26%; Secondary level 30%) and therefore, they have limited comprehension of English language. Even those who had secondary level education they mostly studied in rural schools which had poor standards, hence their weak comprehension of English language concepts.

c) Sources of Information

The study further sought to establish sources of information for both farmers and extension service providers and the figure below highlights the key findings.

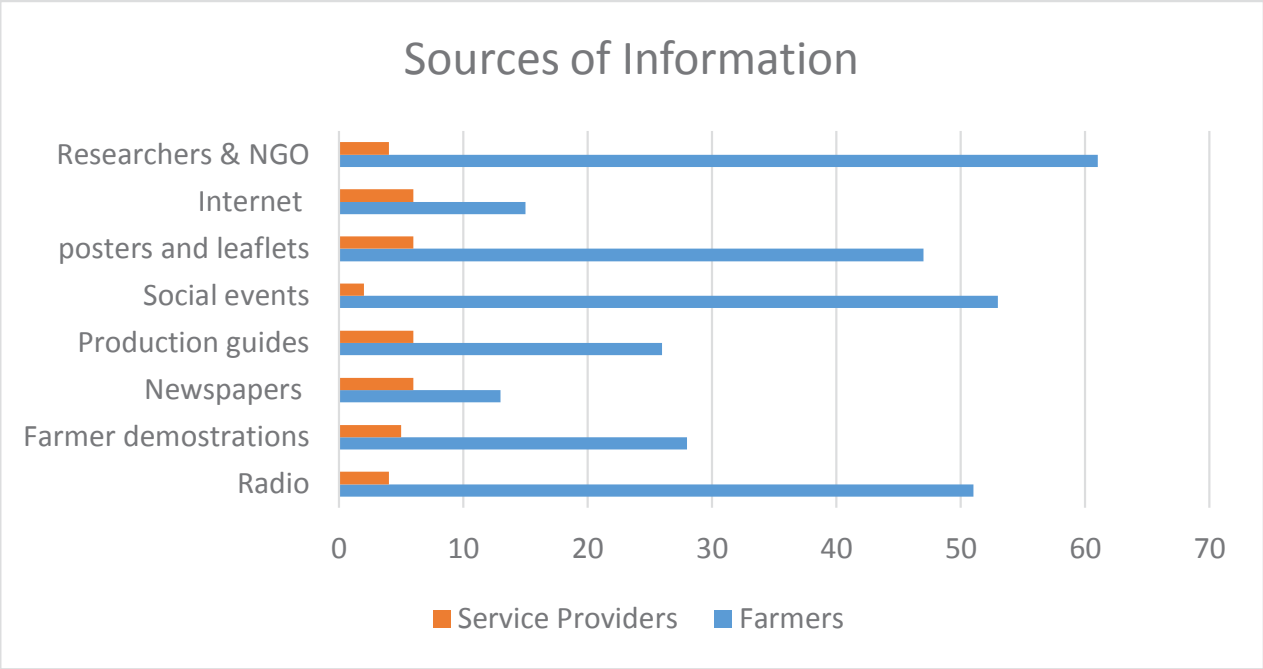


Figure 32: Sources of information for Farmers and Service Providers

From the survey among farmers who participated in the study, it was clear that researchers and NGOs were the main sources of information for most of these farmers as 61 out of 74 farmers indicated so. This is not surprising as civil society organizations are community based, enabling farmers to easily engage and interact. Furthermore, researchers and students' interns were found to have more field presence than district production officers and extension workers. The limited presence of extension workers is largely attributed to the lack of facilitation of extension workers and district production officers. This was well summarized by one extension worker who observed that.

> **"Often times we don't have fuel or field allowance to go to the field. So, we report to office and attend to office duties. The budget allocated for field operation is very low and unrealistic besides we experience delayed release of funds"**

The survey also revealed that radio is the second most popular source of information for farmers as illustrated in figure 27 above, while production guides, newspapers and internet were identified as the most commons sources of information for service providers.

Generally, this study has revealed that, content for extension service is still a main challenge as the content development and distribution remains uncoordinated. From both primary and secondary sources of this study, it came out clearly that there is significant variation in content in terms of what various extension service providers deliver on the same value chain in the same agro-ecological zone. Furthermore, we observe that, there are some cases of generalized content across the country that does not take into account variations in agro-ecological zones as well as the language needs of the intended beneficiaries. From various stakeholders and studies, it was revealed that the scope of most content is limited to production practices and omits other stages of the value chain which are important for optimizing returns to investment for the farmers and other value chain actors. Critical content lacking include; enterprise selection, business management, record keeping, leadership and human resource management, marketing and sales, price modeling, financial management among others. Yet these knowledge areas are critical in running a succession farming enterprise. Nevertheless, there are some emerging best practices in developing extension content as is the case with the coffee sector which has developed harmonized extension materials.

It was established that most of the current extension content does not to take into account the increasing impact of climate change and environmental degradation. Key to this is irregular update of the content to reflect dynamic changes in the environment. Some stakeholders observed that most of the content is not updated in a timely manner which affects the reliability and quality of content to the stakeholders.

Therefore, the current state of agriculture content development and delivery can best be characterized as having;

1. Poor curriculum development practices, which result into inappropriate curriculum
2. In appropriate content formats for various stakeholders
3. Inaccessibility of production content in communities who need it
4. High costs of agriculture content access
5. Unreliability of content and lack of timely access
6. Uncoordinated content development and delivery mechanisms
7. Lack of quality controls at various levels

These challenges affect all stakeholders from breeders to farmers, processors to logistics and consumers of agriculture produces.

3.6. Selected User Testimonies of Integrating ICTs in Agricultural Processes

Having documented the profile of innovators and highlighted some of the outstanding innovations in the sector. It was important to document some of the inspiring user testimonies of these innovations. Accordingly, in this section some user testimonies are highlighted.

a) Ensibuuko User Testimonies

One of the users of Ensibuuko who was contacted during this study who serves as the General Manager of Rukiga SACCO Limited in Kabale, observed that Mobis application has greatly improved their business processes, reducing significantly time it takes to process transactions but also produce reports, key for making various decisions. He noted that;

> **When Rukiga started, we used to keep all our financial records in ledgers and excel sheet. This became a big problem when it came to generating reports because we would have to do all the calculations manually and this became hectic especially for a SACCO with many branches. Mobis came to our rescue with automated reports that are generated without any extra effort and time**

b) KUDU User Testimonies

The importance of Kudu was summarized by one Agro-Producer dealer who noted that;

> **Often times we don't have fuel or field allowance to go to the field. So, we report to office and attend to office duties. The budget allocated for field operation is very low and unrealistic besides we experience delayed release of funds**

c) M-Omulimisa User Testimonies

M-omulimisa like many similar applications targeting smallholder farmers uses the village agent model users. One of the users of M-omulimisa is a farmer associated with WOUGNET in Pallisa district who noted;

> **The application helps us to get extension services which are scarce in our community**

Another village agent in Apac noted that;

> **The application has created a job opportunity for me as a village agent**

Extension officers have reported that it is more convenient, efficient and effective for them to reach out to farmers using the system instead of reaching them physically. An extension officer who has used the application observed that;

> **The system makes it easy and cheap for me to reach many farmers at once. This is difficult under our traditional extension service, as we have to travel long distances looking for farmers. The service saves me time and fuel**

d) SUFACE- ERIGNU User Testimonies

Most applications targeting smallholder farmers assume that farmers have zero knowledge to share and most of these efforts are focusing on pushing information and knowledge to farmers, without learning from farmers. However, for SUFACE-Model innovation allows farmers to view other farmer queries and share their own experiences, by commenting on the service which enables the development of "PROSUMER" communities of information i.e. producers and consumers of information. One farmer in Lira observed thus;

> **ERIGNU application has helped us to learn from each other, through the query comments section**

Another farmer on Kole observed that;

> **"Previously we used to go to Kubere Information Centre (KIC) in Apac to get advice on farming especially consultation on inputs, pest and disease management. But using ERIGNU application we now send a query on the mobile application."**

e) Jaguza User Testimonies

During the study, two users of Jaguza were interviewed about their experience of using the platform. The following are some of the testimonies they shared:

One farmer Okot Kenneth observed;

> **"I had challenges monitoring the health of my animals and farm records, the use of Jaguza platform has simplified my farm records management needs"**

Another early adaptor of the platform who never wanted to reveal his identity observed that;

> **"Jaguza application provides information on; market opportunities, access to online veterinary doctors, tracks sales and financials making it easy for me to manage my farm better"**

f) Mcrops User Testimonies

One of the pilot users of Mcrops apps on cassava disease diagnosis observed that;;

> **"In my professional practice calculating accurately and consistently the disease intensity in the plant is one of the most challenging issue as it largely depends on human judgment. However, the use of Artificial Intelligence tool from Makerere University, although still in pilot stage promises to provide accurate and reliable diagnosis of plant disease incidents"**

g) Green Leaf User Testimonies

In most corporative based farming models, managing members' transaction records is one of the most challenging tasks. This is a similar challenge Mpanga Tea Grower Factory Limited found itself with. Besides, managing members transactions (out growers), the factory had to deal with managing casual workers on her tea estates, whose payment depended on the daily tasks performed and yet various tasks had different remuneration rates. As observed by the Factory IT manager;

> **"Green leaf system has been a very good innovation and has streamlined our out growers' operation and significantly reduced any mis-computations which were a characteristic of the old manual system. Another core advantage of green leaf is that it was not costly and has timely local support whenever issues arise which by the way is very rare. It was well built"**

The testimonies derived from the above innovations show that the innovations have greatly improved the business lives of the smallholder famers in their daily operations. This could be one way through people who have previously shunned agriculture may be attracted thereby improving the livelihoods of many Ugandans, especially in the era where youth unemployment is a daring crisis in Uganda.

4 ICT4AGRIC INTEGRATION FRAMEWORK FOR UGANDA

This chapter provides the proposed ICT4Agric Integration Framework for Uganda as a based input in the development of an ICT4Agric Strategy for the country. Section 4.1 presents the way of thinking which guided the development of the framework, section 4.2 provides a description of the framework and section 4.3 present a brief on critical success factors.

4.1. Theory of Change and Way of Thinking

This study has revealed that successful integration of ICT in various sectors and business processes not only depend on availability of technologies and demand, but also on existence of a systematic coordination mechanisms to guide actions of various stakeholders. It is evident therefore, from regional case studies that accelerated use of ICTs in agriculture is largely guided by the existence of an ICT for agriculture strategy at national level.

The development of an appropriate ICT strategy for Agriculture should be informed by the existing; technology and utility infrastructure, human capital, state of regulatory environment, accessibility to finance resources, and stakeholder information and business needs. In terms of technology and infrastructure capacity we note that, Uganda has a rapidly growing telecommunication sector with about 24.6 million telephone subscribers, with associated increase in number of internet users estimated at over 7 million as of march 2018 as per the figure below.

Users and subscribers	2011	2012	2013	2014	2015	Annual Percentage Increase
Fixed Internet Subscribers	88,786	96,000	100,900	113,400	130,200	14.8
Mobile wireless internet subscriptions	977,500	2,692,705	3,625,559	5,694,930	7,349,540	29.1
Estimated internet users ('000)	4,800	6,200	7,314	10,813	13,842	28
Internet penetration (Rate)	3.2	8.2	20.7	29.5	39.7	34.6

It is worth noting that the cost of internet access in Uganda has been gradually declining resulting into increased uptake of online services. As noted by the National IT Survey report 2018, one the hindrance to ICT adoption especially the use of phones is the limited access to charging stations, therefore access to electricity and other sources of energy are critical in the development and use of ICTs in agriculture sector.

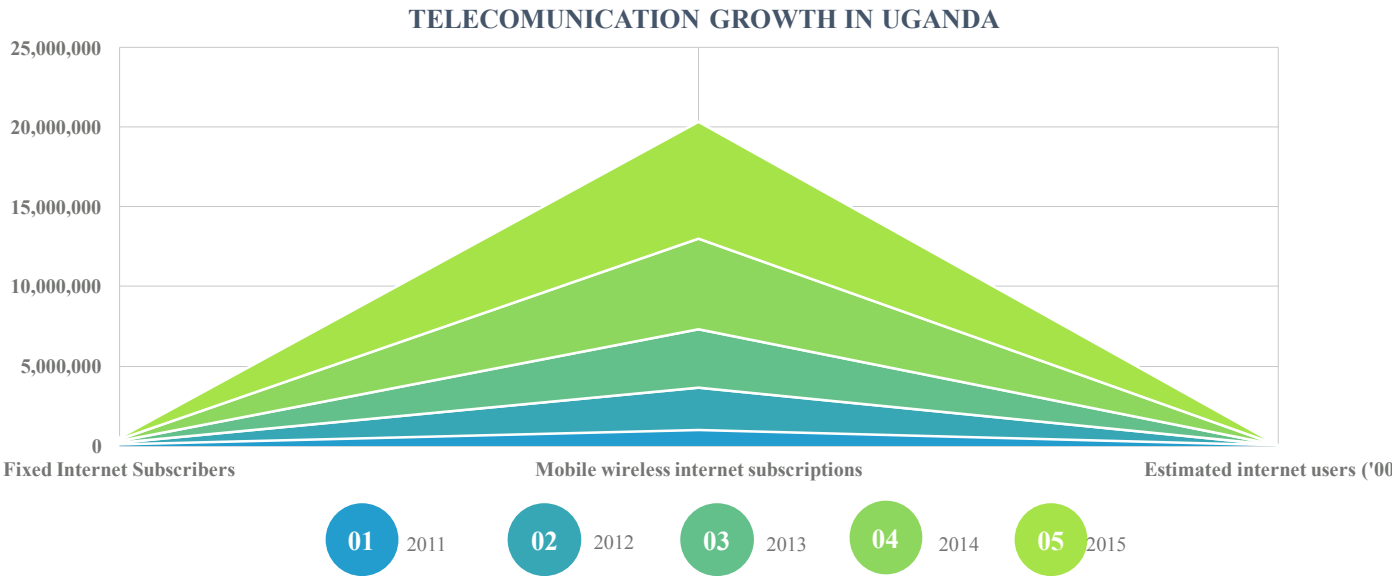


Figure 33: Internet Subscription as of 18-03-2018 (Source: Uganda Communication Commission-UBOS)

Stakeholder	Interests
Farmers	• Improve access to time and reliable information • Access to better input markets • Access to better output markets • Increased productivity and income • Informed agricultural enterprise selection and better farming practices (e.g., pests, disease, weather) • Improve access to extension services and expert information, services, and best practices • Enhanced record keeping • Increased access to financial services
Researcher Institutions	• Ability to access to otherwise unreachable farmers • Ability to test and validate academic research and innovation in real-world applications • Opportunity to solve practical problems and share best practices with aggregated groups of farmers • Better training curriculum and enhanced student learning experience through living labs models of teaching and learning • Timely and reliable feedback on research experiments
Input providers	• Access to farmer profile and production potential in order optimally develop market linkages • Open new market niches to serve new customers who previously would be out of reach for the input dealers • Access to reliably and timely sector information to enhance decision making in development of new products and services • Ability to track and get feedback on performance of their inputs
Produce dealers	• Access to farmer profile and production potential in order to predict yield potential and plan collection logistics • Open new market niches to serve new customers who previously would be out of reach for the produce dealers • Access to reliably and timely section information to enhance decision making in development of new products and services • Better forecasting for greater efficiency and fewer losses • Stronger relationships with farmers
Agro-Processors	• Access to farmer profile and production potential in order to predict yield potential and plan collection logistics • Open new input and output markets • Access to reliably and timely section information to enhance decision making in development of new products and services
Finance service providers	• Access to farmer profile and production potential in order optimally evaluate farmer creditworthiness • Open new market niches to serve new customers who previously had no formal access to affordable finance • Access agricultural information in the sector to better understanding of unmet financial needs and develop innovative financial products

Insurance service providers	• Access agricultural information in the sector to better understanding of insurance opportunities and develop innovative products like crop and animal insurance • Access to farmer profile and production potential in order evaluate farmer level of risk and define appropriate risk management plans
Development partners	• Access agricultural information in the sector to better understanding of insurance opportunities and develop innovative products like crop and animal insurance • Access to farmer profile and production potential in order evaluate farmer level of risk and define appropriate risk management plans
ICT innovators and entrepreneurs	• Access to timely and reliable sector information to stimulate innovating thinking • Development of new business opportunities based on evidence which increases technology adoption and acceptance e.g. soil testing, financing, logistics, farm machinery, e-extension etc. • Production and Service innovations with the ability to reach new customer base early, for longer-term benefits • New job opportunities with growth potential
Government through MAAIF and her agencies	• Enhanced sector productivity • Improved household incomes, and improve economic growth • Job creation especially among the youth • Improved food and nutrition security at household and national level • Improved effectiveness and efficiency of government services in agricultural sector • Enhanced sector information management and improved transparency • Better coordination among various actors in the sector and minimize duplication of efforts
Logistics Providers	• Access to timely and reliable information for enhancing planning • Improved logistics services in terms of effectiveness and e fficiency

Therefore, it's our considered opinion that the development of an ICT4Agric Strategy for Uganda should be driven by a multi-stakeholder and multi-sector views as the ecosystem depends on various stakeholders with various stakes as illustrated above. Furthermore, the process of integrating ICT in Agriculture sector should be envisioned as a long-term objective which requires continuous and rigorous planning given the dynamic nature ICT's and its ecosystem.

As alluded to in this document, a number of ICT applications over 183 have been identified during this study. It is worth noting this is not an exhaustive list, but an indicator of the potential in the sector. The number of these applications and services keep growing every day and in order to further encourage this development and ensure sustainability and better co-ordination of emerging and evolving technologies, guidelines needs to be developed in order to respond to the real needs in agricultural sector. Thus, ICT needs in the sector must be seen from the perspective of an integrated information management system which minimizes the duplication of data and ensures consistency, improves integrity of the data and can address a wide variety of information needs. It's these schools of thought that inform the proposed framework for ICT4Agric as described in section below

4.2. ICT4Agric Framework Description

The ICT4Agric Framework has been developed to guide and support different stakeholders, including; farmers, innovators and entrepreneurs, input and output providers, researchers, financial service providers among others in the agriculture value chain (pre-production, production, post-production) to infuse ICT in their business processes. This framework allows innovators to determine at what level of the agriculture value chain they can integrate and the depth of ICT adoption of the ICTs. Also, it guides the consumers such as farmers, researchers who are within the agriculture value chain to decide on the depth of ICT adoption they need to make in order to effectively perform their service provision.

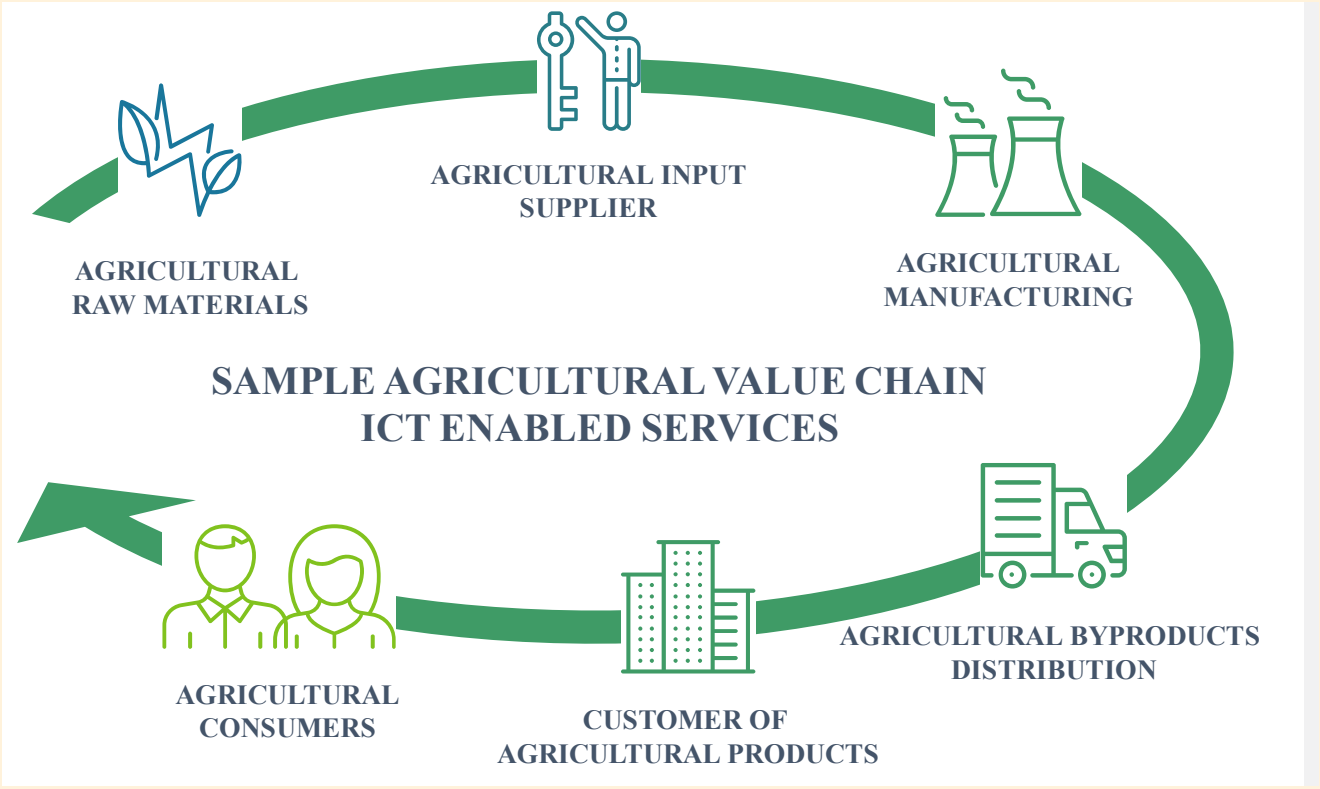


Figure 34: ICT Enabled Value Chain Process

The ICT4Agric framework has three (3) main layers that interrelate in order to realize the goal of effective integration of ICT within the agriculture sector. These layers include; inputs, innovation development and usage and outputs. The ICT4Agric framework works in such a way that one has to start with the input layer, innovation development and usage layer and lastly the outputs layer. The output layer highlight the immediate and long term outcomes as the result of using ICTs in agriculture, such as effective and efficient service provision. The model is illustrated in the figure below;

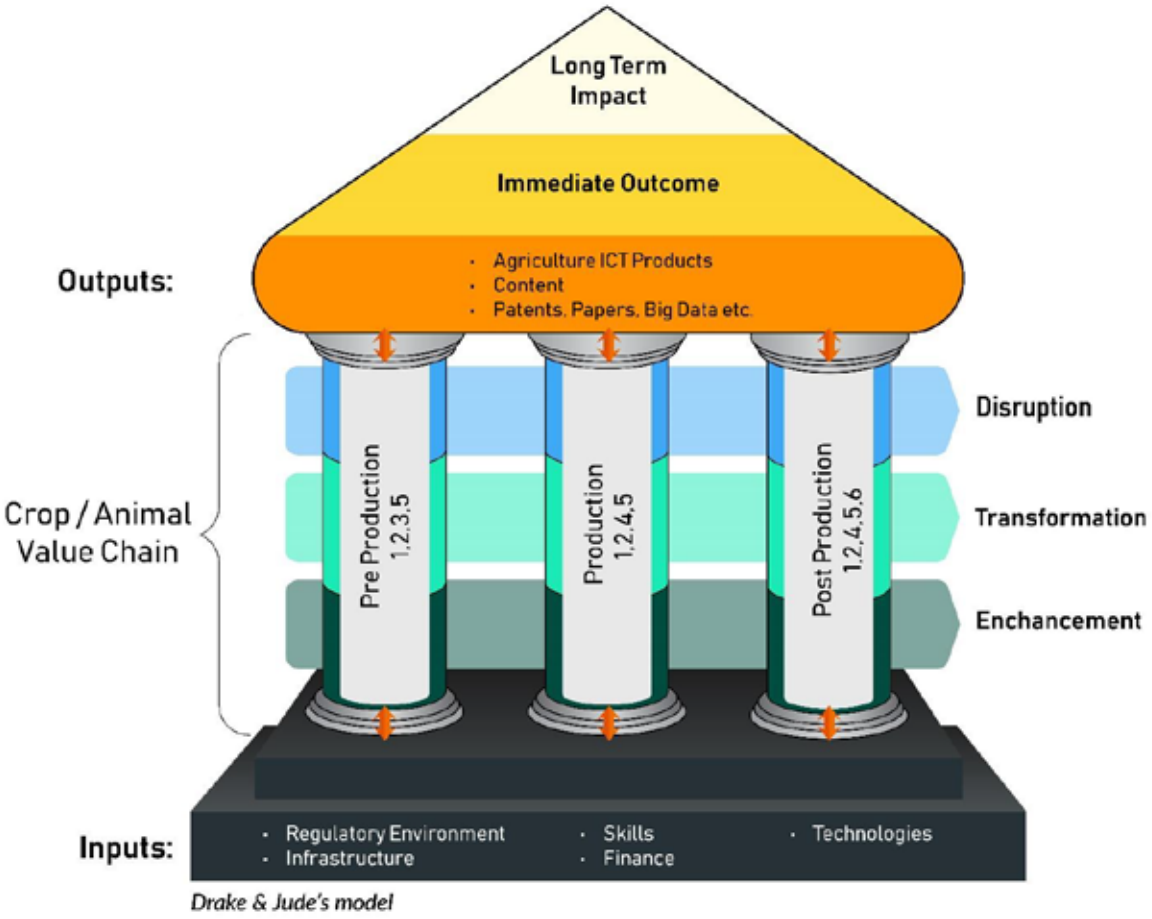


Figure 35: ICT4Agric Intergration Framework

Input Layer

This is a layer where the ingredients to support integration and adoption are put together in order for innovation to happen or consumption to take place. The input layer contains the capacity for innovation to flourish and be consumed by the different stakeholders. This layer will contain the regulatory environment, infrastructure, skills, technologies, and finances among others that can be tapped into by the stakeholders during the service provision. The different stakeholders use this layer differently and will depend on the need (innovate or consume). The innovators may need the infrastructure, skills, technologies and finances to support them in developing something innovative for the agriculture value chain. It is these inputs that are used at a certain depth of ICT adoption within the agriculture value chain to develop innovation for use in service provision.

It is important to understand that without these inputs innovation can hardly take place and also no consumables can result. Taking an example of regulatory environment, innovators need to work within agreed upon standard that do not conflict with the international guidelines set. Innovators have to develop innovations that support data protection rules and so on. Also, there are so many technologies that can be used during innovation. These could be open source or proprietary technologies which the innovators and consumers can decide to take on depending on their environment. Consumer need the finances to acquire the technologies

and also work within a regulated environment as they utilize the innovations for service provision. The inputs are provided by two categories public and private sectors. The public provides inputs such as infrastructure, regulatory environment among others. The private sector provides inputs such as financial support, skills (expertise), and technologies among others. However, in some cases both public and private sectors can collaborate to provide a specific input in order to support the innovation eco-system.

Innovation development and Adoption Layer

This layer is coined around the agriculture value chain which contains different stages (pre-production, production and post-production). There are different activities that are undertaken within these stages of the value chain. Therefore, the activities can embed ICT in different forms and this will depend on the depth of adoption. The agriculture value chain stages contain different activities as described in the table below.

Pre-Production	Production	Post-production
● Enterprise section ● Land selection ● Production modeling and planning ● Access to financial services ● Value chain determination ● stakeholder profiling ● Market access information ● Weather information	● Production systems establishment ● Land preparation ● Sowing or animal acquisition ● Input management ● Water management ● Fertilization and genetic material management ● Pest and disease management	● Food processing ● Packaging ● Marketing ● Transportation ● Food storage ● Etc.

Depth of adoption of ICT at the different activities will depend on the need and availability of the appropriate inputs. The depth of adoption of ICT is at three levels, enhancement, transformation and disruption. The input ingredients will determine what level of innovation will result and what will be consumed by the stakeholders.

Enhancement level

This is a level that redefines the specific service provision within the agriculture value chain by adopting technology to directly change the offering of the service and there could be some functional improvement or not. In this level technology comes in to provide an alternative form of undertaking to the activities within the agriculture value chain. What was being done manually by a human being, the ICT adopted can aid the same human being to do it more effectively and efficiently. See table xx for an example on how enhancement is realized.

Transformation Level

This is a level that allows modification of the specific service by using technology to significantly redefine the activities being undertaken. By doing so new tasks emerge within the service due to the introduction of technology and these could have never been conceived before in delivering the same service. Under transformation level, technology integrated within the agriculture value chain creates news tasks which are aimed at effectively and efficiently improving the delivery of service to the stakeholders. See table xx for an example on how transformation is realized.

Disruption Level

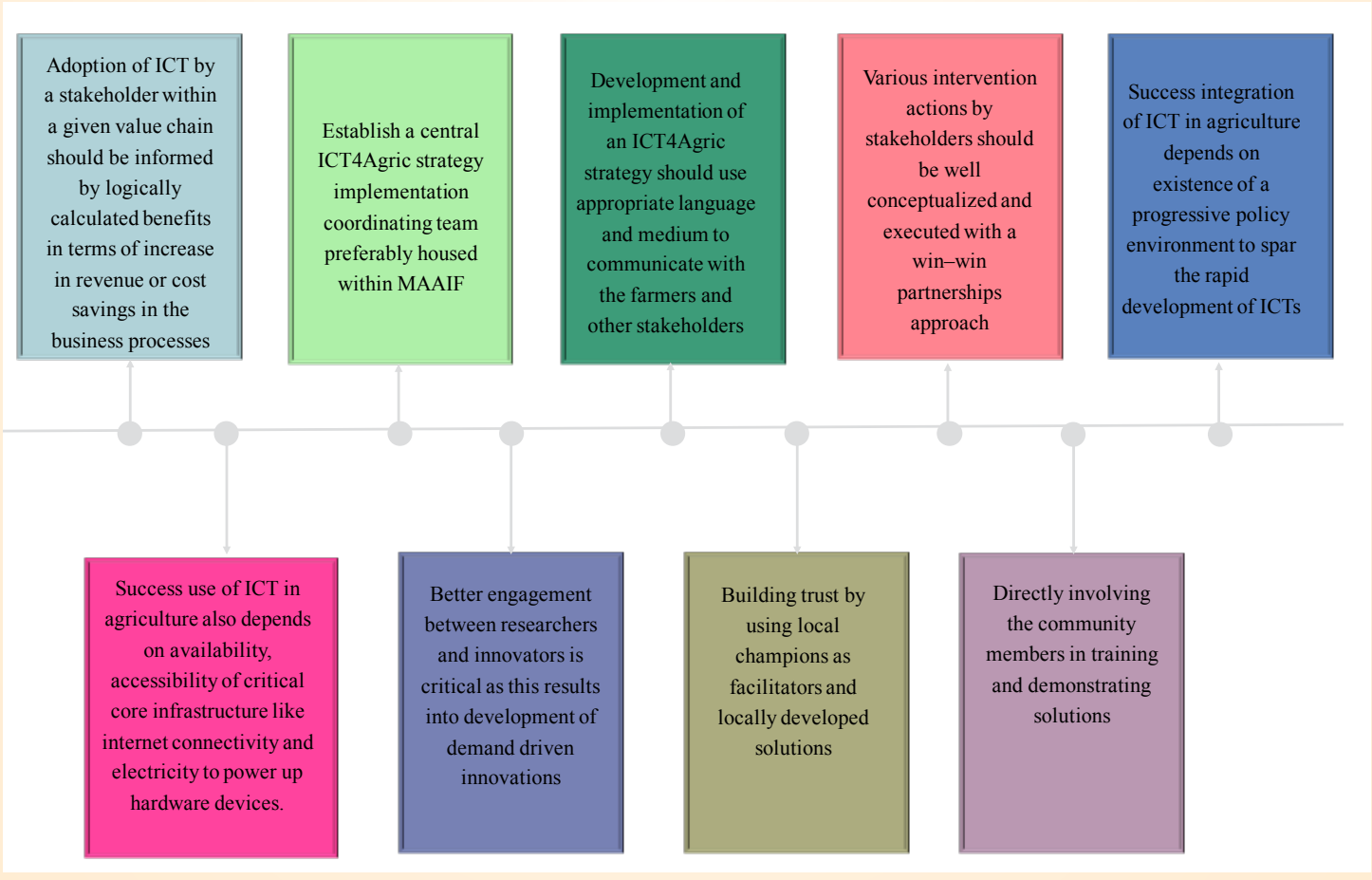
This is a level that allows technology to provide an alternative way of delivering a service as compared to the traditional way of delivering it. The integration of technology completely brings into existence of a new way of delivering a service in a more effective and efficient form. Many of these technologies being deployed under the disruptive level are ones that use artificial intelligence (AI), machine learning and advance wireless communication technologies to support service delivery. In the table same examples are highlighted on how transformation is realized. From disruptive innovations.

Level of Innovation	Example
Disruption	**Example 1 – Pre-production:** A farmer uses a drone to perform mapping of their farmland and information automatically is plotted onto the google maps. There is no need of the farmer to move but uses the drone technology to move across the farmland undertaking the plotting and mapping activities. **Example 2 - Production:** The farmer uses Internet of Things (IoT) and Sensors to manage their farms. Sensors placed strategically around farms along with image recognition technologies which can allow farmers to view their crops from anywhere in the world. These sensors can send farmers up to date information in real-time, so changes can be made accordingly to their crops. For example, they can trigger irrigation to take place within a particular part of the farmland where it is presumed that there is need of water and then send a report to the farmer in real-time. **Example 3 – Post-production:** A farmer uses a production ICT enabled unit to perform food processing where by the different activities are entirely performed by the machine with the help of AI and machine learning. Mixing of the different ingredients and within the required quantities is all managed by technology plus monitoring the food processing value chain.
Transformation	**Example 1 – Pre-production:** A farmer may decide to use a search engine such Wikipedia or Google to research about the soil samples and the crops that grow well in them instead of trying and erroring within the garden. **Example 2** - Production: A farmer may use an application onto the mobile phone to perform a disease diagnosis by taking an image of the plant, use the application to analyze the image and hence provide knowledge about the plant disease. Instead of using personal eye sight to perform a disease diagnosis by either the farmer or expert. **Example 3 – Post-production:** A farmer uses an agricultural ICT tool to sell their products through a bidding process by allowing bidders to bid and the highest bidder is offered the product. The ICT agricultural tool is able to determine which bidder offers the best price for the product amongst the many bidders with several other factors put into consideration such as location of goods, quantity, etc. Instead of the farmer taking their products to the market to find the best buyer, the ICT agricultural tool supports in getting the products bought off virtually and then sent to the highest bidder.
Enhancement	**Example 1 – Pre-production:** A farmer using google maps to measure their land size instead of using the physical land surveyors. **Example 2 - Production:** An ICT application is developed that regularly sends information to farmers about something of importance via SMS instead of going to the farmers face to face and giving them the information. **Example 3 – Post-production:** A farmer uses a known agriculture e-commerce website to know the current market prices for the agriculture products instead of going to the physical market to find out the actual costs which have already been inflated by the middle person.

4.3. Critical Success Factors for ICT4Agric Framework

The synthesis of data from both primary and secondary sources during this study revealed that, successful integration of ICT in agriculture sector will depend on a number of factors, key among them include;

1. Real economic value added either because of savings resulting from the use of ICT or an increase in revenue or profitability. The adoption of ICT by a stakeholder within a given value chain should be informed by logically calculated benefits in terms of increase in revenue or cost savings in the business processes.
2. This is need to have a central ICT4Agric strategy implementation coordinating teams preferably housed within MAAIF as the sector leader to empower and promote the implementation of the strategy
3. In any multi-stakeholder engagements, appropriate communication strategy plays a critical role. Thus, the development and implementation of an ICT4Agric strategy should use appropriate language and medium to communicate with the farmers and other stakeholders providing a good response to the programs
4. The various intervention action by stakeholder should be well conceptualized and executed with a win–win partnerships approach.
5. Success integration of ICT in agriculture dependents of existence of progressive policy environment to spar the rapid development of ICTs
6. Success use of ICT in agriculture also depends on availability, accessibility of critical core infrastructural like internet connectivity and electricity to power up hardware devices.
7. Better engagement between researchers and innovators is critical as this results into development of demand driven innovation, which increase the chances of innovation adoption and adaptation.
8. Building trust by using local champions as facilitators and locally developed solutions
9. Directly involve the community members in training and can demonstrating solutions



5 CONCLUSIONS AND RECOMMENDATIONS

This chapter provides a discussion of the emerging conclusions from the study and make some recommendations

5.1. Conclusions

From the study, a number of observations have been made and accordingly a number of conclusions have been deduced. For purposes of effective communications, the conclusions are discussed along the key research questions of the study.

1. State of art and practice in the development and use of ICT in agriculture: during this study a total of 183 ICT4Agric innovations at various stages of development were identified across the country. It was observed that majority (109) of the innovations are at idealization stage largely focusing on smallholder farmer information management needs as a means of complimenting extension service delivery. The innovations are largely developed using mobile and web technologies especially android platform for mobile, java, PHP and MySQL for web applications. It was also observed that most of the innovations are not driven by scientific research but rather by intuition and passion, often resulting into duplicated efforts and slow transition into commercial viable products. In terms of profile of innovators majority are students in higher institutions of learning followed by fresh graduates. It emerged from the study that majority of users (nearly 85%) of these innovations are smallholder farmers. We also note a few agro processors and logistic dealers are adopting ICT4Agriculture for effective process management. Generally, there are a few high-end technology innovations using platforms like artificial intelligence and advance mobile technologies like drones and RFIDs. Yet these technologies provide excellence opportunities to address critical challenges on the services such as pest and disease detection and surveillance, climate smart animal and crop management, real-time information gathering and automate decision making among others.
2. State of practices in content development and delivery to farmers: We noted that currently agriculture content development is uncoordinated and unregulated. Various actors including MAAIF, research institutions and civil society organizations (CSO) develop and distribute content to farmers and other value chain actors without having the content validate and certified. Most of the content is developed in text format in form of information leaflets, posters and production guides. The content is mostly authored in English, yet majority of farmer prefer content in their local language given their limited comprehension of English language concepts. Generally, there is lack of a central point of reference for authentic content for various value chains. Where content exists it's often inaccessible to stakeholders who need it. The study revealed that CSOs/ NGOs were the main sources of information for most farmers as indicated by 61 out of 74 farmers who answered this question, followed by social events and radios.
3. Enabling and constraining elements in the development of ICT4Agric. The review of the ICT4Agric sub-sector ecosystem revealed that, the country in general does have an enabling policy environment to promote the development and uptake of ICTs in agriculture. For example the recently approved national agriculture extension policy 2016 clearly articulate gaps in extension service delivery and proposes progressive strategies of how to address these gaps, especially promote the use of ICTs to address the gaps. Furthermore, the efforts by the ministry of ICT and National Guidance under digitalizing Uganda and the associated programme of the National ICT Innovation Support Programme (NIISP) all have defined agriculture as the anchor sector for these interventions. Furthermore, a number of social transformation instruments at national level including; the national development plan two, the NRM manifesto and the Rural Communication Development Fund (RCDF) have all prioritized ICT4Agric development as a means of enhancing sector growth. In terms of technical skills availability to spark ICT4Agric, it was observed that the country has witnessed a rapid expansion of the higher education

sector in recent years, with most the of new institutions focusing on science and technology and it's not surprising therefore that majority of the innovations profiled during this study have their origins from universities. Furthermore, the country is witnessing a rapid expansion of innovation and incubation centers, with potential to catalyze the ICT4Agric by accelerating innovations into products.

4 Does the country have an ICT integration strategy for Agriculture? From the study it was clear that they are various efforts promoting the integration of ICT in agriculture, the efforts are largely driven by three forces, which are; policy direction, demand driven and technology driven. It was observed from this study that there is lack of a coordination mechanism (integration framework) in the sector to drive ICT integration. The lack of this framework is resulting into duplication of efforts and minimal sharing of experience, resulting into suboptimal impact on the sector. However, the new efforts by the MAAIF to develop an ICT strategy for the sector is a welcome intervention as it will streamline actions of various stakeholders resulting into aggregation of efforts as opposed to the current state of practice which is full of duplications of efforts. Through the World Bank funded ATAAS programme, an ICT specialist was hired to provide leadership in development of e-platforms at the MAAIF and the capacity of number of ICT officers at NARO Secretariat and selected ZARDIs was enhanced. MAAIF through ATAAS programme piloted an e-Certification platform in which 4,276 traders were certified through the platform. This study revealed that MAAIF is developing other platforms such as e-M&E, e-Extension, and e-Markets which help to accelerate project management and service delivery significantly. It was observed that efforts at MAAIF are focusing on sector performance improvement in terms of; (a) flow of information between farmers and other actors, (b) enhancing sector e-M&E function and public accountability; (c) facilitation of market links through e-marketing and e-certification; (d) production support through e-vouchers; and (e) publicly accessible platform for agricultural information and statistics (e-agric statistics)

5 Some of the greatest challenges of the agriculture sector are poor information management and poor quality of extension services. It is well noted that, although the sector employs nearly 70% of the citizen, its direct contribute to tax base is about 1%. Furthermore, the few sector development incentives are accessed by large foreign investors leaving the majority of Ugandan sector players out. It was noted that most of the challenges are associated with information access and management. Therefore, government should expend significant efforts to profile sector players to ensure effective planning, and development of information and knowledge products for various actors. Further efforts are needed to develop advanced technologies in smart farming like use of drones and automated irrigation, artificial intelligence based pest and disease detection and surveillance among others. Government needs to promote information access and invest in research for development of advanced technologies which may not be easily financed by private sector led efforts.

6 What institutional development needs to take place to ensure that ICT4Agriculture has a sustained impact? It is very clear that current progress in ICT4Agric development and adoption are largely donor driven as opposed to being policy or demand driven. Furthermore, the study revealed that there is lack of a coordination mechanism in the sector to streamline the development and integration of ICT for Agriculture. Therefore, at institutional level, there is need to develop and implement an ICT strategy for agricultural sector with the sole aim of streamlining intervention actions by various stakeholders. Furthermore, there is need to establish an extension service academy under relevant departments of MAAIF to streamline extension content development and access. This action will operationalize the provisions of the new National Extension Service policy and this will enhance the effectiveness and efficiency of extension services provisioning.

7 What is the Return on Investments (RIO) by adopting ICT within the agriculture sector? The adaption of ICTs in agricultural sector guarantees a number of benefits including; improved service delivery by state actors like extension workers, opening of new job opportunities and service lines, enhancement of processes efficiencies like the distribution of inputs among others. For example the Ezyagric app which is built on SUFACE model of stakeholder engagement has created over 480 jobs for village agents. The use of green leaf system at Mpanga Tea Growers Factory has reduced losses associated with green leaf collection by 32% given the improvements in process information management. A number of applications like Jaguza, Kudu, Mcrops, ERIGNU and M-voucher have received thousands of dollars in funding hence resulting into a good return on investment for the innovators.

8 How can success be measured? Which initiatives should best be left to private sector role players, development agencies and government respectively, and how can their initiatives be supported by research, policy and strategy? In principle, success in ICT4Agric sub-sector can be measured in terms of number of innovations developed and adapted by the stakeholders, the impact of these innovations on the overall sector performance most importantly on; productivity, post-harvest handling among others. Furthermore, the success of an innovation can be measured by amount of revenue being generated, number of users who have adapted the innovations, and innovation users experience. Government should largely focus on regulation, guidance and market access promotion strategies. Furthermore, government needs to profile all farmers who receive government services to generate critical data set for real-time visualization of sector performance. Success can also be measured through overall sector contribution to GDP.

9 What part of the information and knowledge chain should be subsidized, and what part should be handled by commercial players? In terms of information value chain, government should focus on; regulation of content development and certification but let the private sector lead efforts on content delivery. On the high initial investments in development of more advanced technologies like drones and embedded systems, government needs to stimulate the development of such high end artificial intelligence innovations through seed funding to research institutions, but also reviewing the policy on access and importation of lower end drone technologies for research purposes.

10 What lessons are there to learn from countries in the region who are integrating ICT in agriculture? The study revealed that Ugandan is not far from Rwanda and Kenya in terms of ICT4Agric development and uptake. However, Uganda's ICT4Agric sub-sector is poorly coordinated and there exists poor information management and weak promotion of local innovations by state actors. Furthermore, it was clear that both Kenya and Rwanda have dedicated efforts on ICT development and application in agriculture and they have enacted an enabling environment for the development of these innovations. Key strategies identified are; the promotion of locally developed innovations by the state especially in Rwanda, acts as a means of attracting foreign direct investment in the country. While innovators in Uganda are largely driven by students and fresh graduates, which is the same case in Kenya, in Rwanda, innovations seem to come from a well-structured pipeline process.

5.2. Recommendations

It was observed from the study that the development and integration of ICT4Agric has a number of stakeholders including the following; farmers, ICT innovators, policy makers like MAAIF, UCC and MoICT& NG, researchers, Civil Society organizations, development partners among others.

1 To address the challenges associated with poor extension service delivery by extension workers, the government of Uganda through relevant MDA like MAAIF, should establish an extension service providers' ICT platform.

2 To address the issues of quality content in extension service delivery, the Government of Uganda through MAAIF should establish an e-extension academy and reference knowledge portal to facilitate stakeholder engagement and access to validated content.

3 To increase accessible of content to farmers, the government can through Uganda Communication Commission (UCC) deliver content using the free media slots on media platforms which are provided for under the current media house licensing regime. Furthermore, UCC can explore the use of digital advertising boards in strategic public spaces like government markets, hospitals among others.

4 To enhance agriculture sector performance in terms of effectiveness and efficiency MAAIF and associated agencies need to integrate ICT in various business processes.

5 To improve the usability of production guidelines and various content, the MAAIF and associated agencies like NARO, MAAIF need to develop guidelines on transformation of most of the content into multimedia formats to stimulate content uptake by various stakeholders.

6 To stimulate the development of high end innovations especially innovations based on embedded systems, drones and artificial intelligence, government needs to review taxes on some of these

components to make them easily accessible to the researchers and innovators.

7 It is clear that most of the applications are internet connective intensive and significant rural areas where farming takes place have weak network connectivity. Although the cost of internet has come down, it is still relatively high for ordinary smallholder farmers. Accordingly, the government needs to develop a policy environment that reduces some of the barriers which limit the development and uptake of ICT solutions in agriculture.

8 It was noted that most innovations are developed by students or fresh graduates who often lack the domain specific knowledge, hence the slow transition from prototypes to products. The MoICT and NG through NIISP needs to identify these promising innovations and pair them with domain field research experts to help the innovations appreciate the context and build either research driven and on demand innovations.

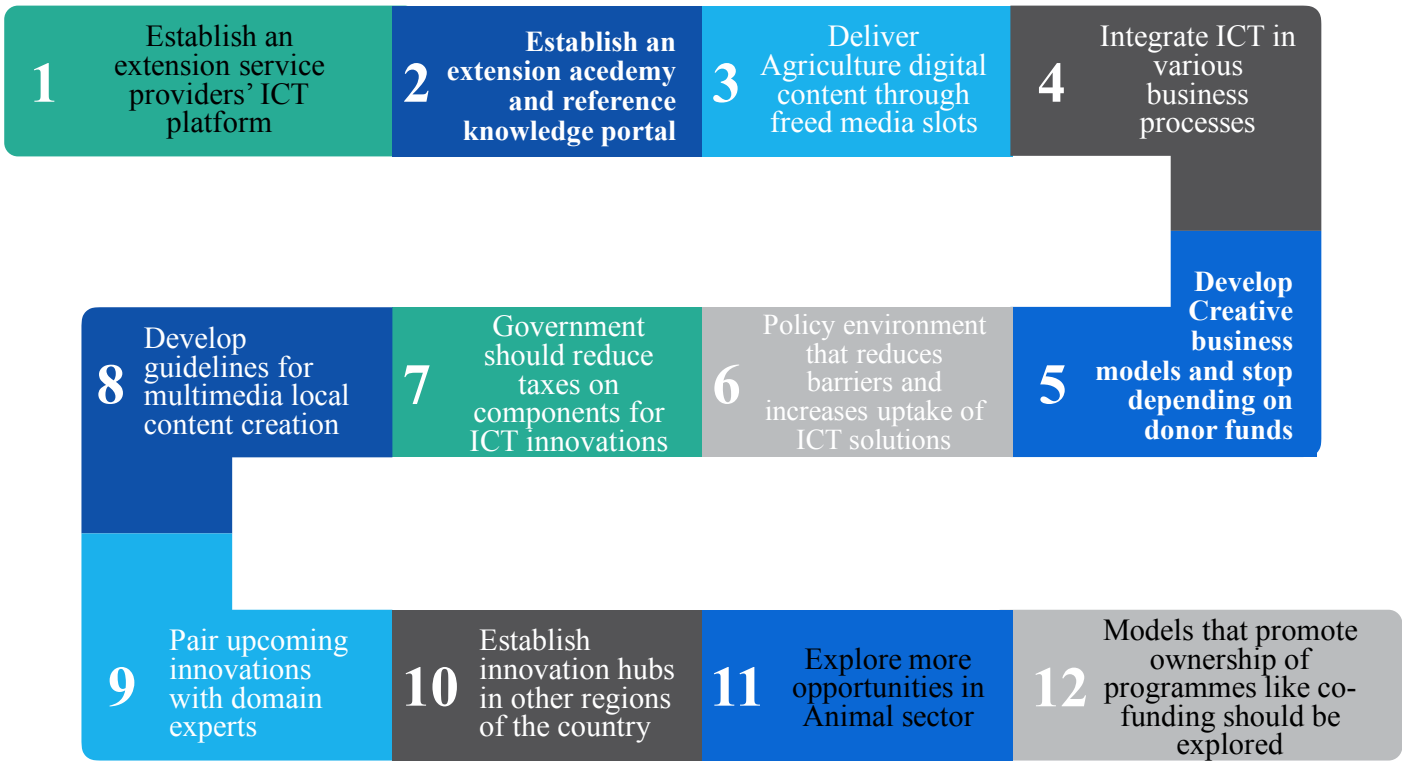
9 Most of innovations in the sector are developed by innovators in and around Kampala. The two upcountry innovation hubs visited during the study i.e. ComTECH at MUST and Department of computer science in Gulu University did not have any good innovations in agriculture. Therefore, government through relevant ministries needs to accelerate the establishment of innovation hubs in other regions to stimulate the development of these innovations.

10 Innovators need to develop creative business models and stop depending on donor funds to stimulate innovation uptake. The current model of depending on donor projects is not sustainable.

11 Innovators need to explore more opportunities in animal sector as most of the innovations are in crop farming.

12 In order to promote organic uptake of ICT innovation in agriculture by various stakeholders, models that promote ownership of programmes like co-funding should be explored especially when dealing with smallholder farmers. Therefore, government and development partners should minimize creating a culture of free services by promoting co-funding for services received by farmers and other stakeholders.

Summary of the Recommendations



6 REFERENCES

1. Uganda Vision 2040
2. The Second National Development Plan (2015/16 – 2019/20)
3. The National ICT Policy (2014)
4. The ICT Sector Strategy and Investment Plan (2015 – 2020)
5. The National Broadband Strategy for Uganda (2016 – 2020)
6. The Uganda Communications Act (2013)
7. National e-Government framework
8. The national Information Technology Survey 2017/2018 report
9. ITU 2015. Measuring the Information Society Report 2015. ITU. Source: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2015/MISR2015-ES-E.pdf

7 APPENDIXES

7.1. Appendix 1: List of ICT4Agric Innovations considered in the Research

	Innovation Name	Innovator Contact
1	INTELLIGENT AUTOMATIC IRRIGATION SYSTE	eng.mck@gmail.com
2	M-Voucher	enamara@uginnovate.com
3	PakaSokoni	spirejfss@yahoo.com
4	m-omulimisa	pinnoivan2000@gmail.com
5	LIMA KASOLI MOBILE APP	aduaisaacnewton@gmail.com
6	Online AGRO Markets and Advisory Portal	wkigenyi@gmail.com
7	Ziimart limited	ziimartonline@gmail.com
8	AGRO TRACKER	henrykaliisa@agrodynamics.biz
9	Love a friend	williamcherere@gmail.com
10	Xente	francisn@xente.co
11	SUASELL	nsabiyunvarobert@gmail.com
12	AUTOMATED IRRIGATION SYSTEM	robertnixsonokello@gmail.com
14	PESTICIDE RESIDUE TESTER	ambrosekamyak@gmail.com
15	Farmershub.net	farmershubuganda@gmail.com
16	LIMA APP	lukwatajohn@gmail.com
17	Matooke growing on a large scale	dnaikiriza@gmail.com
18	AUTOMATIC IRRIGATING ROBOT	nabasahiriji.kalim@gmail.com
19	FAM-Sol	nijconsult@gmail.com
20	AGRO-BASED MANAGEMENT SYSTEM	tayebwaian0@gmail.com
21	A mobile application that determines soil fertility	jimylukwago@gmail.com
22	Online Data Catalog for Ugandan Local Products	magicmugi03@gmail.com
23	DIGITAL NEIGHBOURHOOD	alfred.ariko@yahoo.com
24	CLIMATE SMART FARMERS' PLATFORM	ckatushabe@as.bsu.ac.ug
25	Farm Trader	douglas@hopeinitiativeug.org
26	OWC Monitor(Operation Wealth Creation Monitor)	vmatsiko@gmail.com
27	EMBEDDED IRRIGATION SYSTEM	sseguyajohn12@gmail.com
28	Agriculture e-Marketplace	brnamanya@gmail.com
29	Web based Leaner management System (LMS)	info@acadri.org
30	Driplex Cloud based irrigation controller	kawesa20@live.com
31	GreenerPages E-Directory	abu@avap.biz
32	Best Beef farming Practises	ednah.karamagi@ugandameat.ug
33	An Agricultural and Agronomical web portal	sprivah@gmail.com
34	Agri-Gap	jangajacob2@gmail.com
35	weather idicator	nyekosamuel@yahoo.com
36	we cast	romariom.afr@gmail.com
37	Weacast software	ernest575@outlook.com
38	Weacast software	ernest575@outlook.com
39	AgricRenaissanceProject	jasonmukama18@gmail.com
40	livestockfy	ghkatende@gmail.com
41	WEATHER AND CLIMATE INFORMATION DISSEMINATION SYSTEM	displayweatherscreen@gmail.com
42	EOWC Monitoring System	kennethotto6@gmail.com
43	Smart Livestock tracking and management system using IoT	viviangal20@yahoo.com
44	FARMERS ASSISTANT APPLICATION	okyalimunsi12345@gmail.com
45	WeatherBot	padrian.baba@gmail.com
46	AgroDuuka	mwotteax@gmail.com
47	Agriculture Connect	nakabandabeatrice@gmail.com
48	Farmer Lottery Receipt	baguma.andrew@yahoo.com
50	Farming Solution	thomas.ahurra@gmail.com
51	Operation Wealth Creation Management System	otteranz@gmail.com
52	A cloud based weather management system for the cattle corridor	rmkalibwani@as.bsu.ac.ug
53	Enhancing monitoring of OWC activities using ICT village agent model	sdacc.pricon@gmail.com

54	iLivestock Management	demartineo@gmail.com
55	My innovation is on the design and construction of an 'Urban Storm-water Management and Monitoring S	tjayshab@gmail.com
56	EzyAgric	williamluyinda@akorion.com
57	AgroTracker	pworld.designer@gmail.com
58	Live Stock Management	amonkats94@gmail.com
59	BrathaFama	daniel@bratha.co.ug
60	OPERATION WEALTH CREATION MONITORING INFORMATION SYSTEM	owenayebare@gmail.com
61	Farm Solutions 365	allanodongo92@gmail.com
62	MyFarm	sserubiri47@gmail.com
63	@MAHIO LTD	mtatlashorticultural@gmail.com
64	Lunda	kisekamarvin@gmail.com
65	Agrosure	dninsiima@gmail.com
66	Trophy Developers	response@trophydevelopers.com
67	Trophy Developers	response@trophydevelopers.com
68	eBits	godwin@aruabits.ug
69	YoSmartFarm	kisekamarvo@gmail.com
70	AGRICOMBO CALL SYSTEM BY BIFRIENS INVESTMENTS LTD	julius.birungiman@gmail.com
71	Poultry Keeping Support Application	opiodavid3@gmail.com
72	OASIS COLLECTS	oasisagroagent@gmail.com
73	Increasing commercial agriculture footprint	moseskalyango@gmail.com
74	george.ssettala68@gmail.com	marvinbanda78@yahoo.com
75	knowmyservices	otengobenjamin@gmail.com
76	Farm Animal Management system	billkiyimba@gmail.com
77	Constituency farmers App	niwagabarobert91@gmail.com
78	remote computerized management information system to help government track inputs distributed to far	afrisapltd@gmail.com
79	ANTI-CORRUPTION APP	nijconsult@gmail.com
80	I am Agaba mark holding a bachelors degree in bussiness administration and am expressing my interest	agabamark84@gmail.com
81	I will be greatfull if my application is positively considered.	schoramutetsi@gmail.com
82	Use of ICT to manage livestock records	mutalazaizo@gmail.com
83	NteLife	mkisiriko@rocketmail.com
84	Famers Diary	pisikopeter@gmail.com
85	ICT services usage in Agriculture value chain	venu@sourcetrace.com
86	Weather is key in agriculture and calls for serious interventions like Climate-smart agriculture. Se	kaggwaallan@gmail.com
87	Livestock Insurance	tirasrwoms@gmail.com
88	OWC National e-M&E System	cbitwayiki@yahoo.com
89	Weather Data Management System	petersamanya79@gmail.com
90	cloudstream	mckas2001@gmail.com
91	e-Wallet	batanda.kayondo@gmail.com
92	Kulimak	drkimbowageofrey@gmail.com
93	Kulimax a mobile application that helps farmers to calculate the amount of money needed	drkimbowageofrey@gmail.com
94	HIMS	mnuwayo@gmail.com
95	National Wealth Creation Information Management System	malvojohn@gmail.com
96	eLunda	fssozi@cs.uct.ac.za
97	Digital farms application	himugishahiram1997@gmail.com
98	STOCK MANAGEMENT SYSTEM	matsikoregan@outlook.com
99	Patasente	bakkarian@patasente.com
100	FARMERS APPLICATION	jacksoonmatsiko@gmail.com
101	Fund Manager	bbosamark@gmail.com
102	LivestockFarm-lite	jkisoro@billbrain.tech
103	Livestock Management System	speterlatigo@gmail.com
104	Farm Box UG	oscar@cactuswealth.com
105	WEACAST SOFTWARE	Bbosalj@gmail.com
106	FARMERS ASSISTANT APPLICATION	okyalimunsi12345@gmail.com
107	Buuza Agripoll	mahadizle@gmail.com
108	Mobile Phone Based Cattle Registration and Identification System for Smallholder Farmers in Uganda	smutaawe2k@gmail.com
109	FootMo Kit	mushushar@gmail.com

110	Our application development is focusing on cattle management, farm expenses and returns, payroll, br	nuwamanyaroberto@gmail.com
111	kokwech agro based youth project is a community based organization based is Bukedea district in kaba	kokwechagrobased@gmail.com
112	Hansu Mobile Innovations	nazirinisiraji@gmail.com
113	Agro Value Chain Manager Mobile App	info@agro-vcm.app
114	OWC Monitor	vmatsiko@gmail.com
115	Automated livestock tracking system	ocenambrose67@gmail.com
116	Omulunzi Information Management System	delyouth@gmail.com
117	A digital livestock tracking system for improved animal production in Uganda	katodrago@yahoo.com
118	Jaguza Livestock	katambaronald@gmail.com
119	Web Based application for Operation Wealth Creation Extension service monitoring and Tracking.	chelangatkapmelkutisaac@gmail.com
120	A robust distributed management system that will inter-connect Government, Cooperative Unions and Fa	olelesamuel@gmail.com
121	Akatale App	frank.bushuyu@gmail.com
122	DAIRY COOPERATIVE PAYMENTS AND RECORDS MANAGEMENT SYSTEM	niyibiizimust@gmail.com
123	Agro Machinary Hire App	viola@billbraintechnologies.com
124	LIVESTOCK MANAGEMENT SYSTEM	ochakolongesukaya1996@gmail.com
125	LIVESTOCK FOLLOWTHROUGH SYSTEM	osmugabi@xaecia.com
126	Smart Livestock Tracking and Management System using Internet of Things	jericho555@yahoo.com
127	Akellobanker	jonyait@akellobanker.com
128	AgricNetwork	amonxnye@gmail.com
129	Wetasse	emmanuelkakooza@gmail.com
130	A robust management system that will inter-connect Government, Cooperative Unions & Farmers by provi	d.afrisap@gmail.com
131	Kulimax a mobile application that helps farmers to calculate the amount of money needed for the d	drkimbowageofrey@gmail.com
132	Mkutano Market	emojeivan@gmail.com
133	LIMMA	muwanguzi.1d@gmail.com
134	Mechanized Farming	mukasa123456789@gmail.com
135	Akaboxi	kyokusiima@akaboxi.com
136	Efamu livestock management software.	brendabakesigaki@gmail.com
137	Farm Box Ug	oscar@screenaml.com
138	Ziimart Investment	vsnsereko@gmail.com
139	Operation Wealth Creation Monitoring Software	afrisaplimited@gmail.com
140	Vanguard	digitechconsults@gmail.com
141	FARM MANAGEMENT USING TECHNOLOGICAL ADVANCEMENT	geobasy2011@gmail.com
142	Omulunzi Owomutindo or Smart Livestock Manager or Mfugaji wa Kisasa	ismail@settendaenterprises.co.ug
143	TulimeCenter System	elyada@labconnectltd.com
144	A STORMWATER MANAGEMENT AND MONITORING SYSTEM FOR KAMPALA	imran_shaban@yahoo.com
145	TraVel Uganda Monitor	stephenopollo@gmail.com
146	UgandaLink Web platform - Agriculture	aogutu@bloomoninternational.com
147	Panda	medhi.matovu@gmail.com
148	Operation Wealth Creation Monitoring Software	simonlubangakene@gmail.com
149	BridgeFarm system	hoxbridgeit@gmail.com
150	OWC i App	abahodeo@gmail.com
151	Smart farming information system	Smartagriforum@gmail.com
152	Pamoja	malcolm.kastiro@mallan.biz
153	FOOD STORAGE	abelrugi5@gmail.com
154	CropPhenoApp: A cell phone App that delivers early warning services to farmers through mobile data	kabiri.marial@gmail.com
155	The project presented is a poultry support keeping application that keeps track of different poultry	muhwezigerald4@gmail.com
156	Let's Farm	nataanthoni@gmail.com
157	Mi-zoni App.	tdiphas@gmail.com
158	Building an Integrated National Weather Monitoring Network and Online Database	bwidenis@yahoo.com
159	BUDDE	bmukwayaj@gmail.com
160	MOBILE ADVISORY SERVICES	claire.bmct@gmail.com
161	WEATHER AND CLIMATE INFORMATION DISSEMINATION SYSTEM	displayweatherscreen@gmail.com
162	SUFACE	dpmirembe@gmail.com

163	Specialized Disbursement Solution (SDS)	peter@afrolynx.co.ug
164	Product Market Application -PMA	consultinfoservices@gmail.com
165	Constituency Farmers App	yaaug2001@gmail.com
166	DECISION ENHANCEMENT CREDIT FACILITATION STUDIO	faithmugisha80@gmail.com
167	Adsurv	emwebaze@gmail.com
168	GreenLeaf	cto@8technologies.net
169	Tickprome	cto@8technologies.net
170	Kudu	rkayondo@gmail.com
171	Market-led, User-owned ICT4Ag-enabled Information Service (MUIIS)	ckakooza@axiomzorn.com
172	ERIGNU	robert@8technologies.net
173	m-farmer	https://www.m-farmer.org/

7.2. Appendix II: Innovation and Incubation Centers in Uganda

1. The Innovation Village, Ntinda, www.innovationvillage.co.ug
2. Center for Innovation and Business Incubation, UTAMU, www.cibi.utamu.ac.ug
3. Center for Innovation and Professional Skills Development, CiPSD, Makerere University, www.cis.mak.ac.ug
4. RAN, Makerere, www.ranlab.org
5. Outbox, www.outbox.co.ug
6. TechBuzz hub https://techbuzztechz.wordpress.com/
7. The Design Hub Kampala,
8. HivColab, https://hivecolab.org/
9. WITU Lab, www.witug.org
10. ComTech, MUST, http://www.must.ac.ug/research-innovation/innovation-centres
11. CURAD, Kabanyoro
12. Gulu University, Department of Computer Science

Rural Communications Development Fund (RCDF)

UGANDA COMMUNICATIONS COMMISSION