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Thesis for the Degree of Masters of Arts

**THE USE OF INFORMATION AND COMMUNICATION
TECHNOLOGIES IN SMALL-SCALE FARMING IN EAST AFRICA**

By

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Department of International and Area Studies,

The Graduate School,



Pukyong National University

February, 2025

**THE USE OF INFORMATION AND COMMUNICATION
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동부 아프리카 지역 농업의 정보통신기술 활용 사례 연구

Advisor: Prof Sae Won Chung

By

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ACRONYMS

ICT: Information and Communication technologies

CD-ROM: Compact Disc Rom

COMESA: Common Market for Eastern and Southern Africa

EAC: East African Community

SADC: Southern African Development Community

AfDB: African Development Bank

USAID: United States Agency for International Development

GDP: Gross Domestic Product

IFAD: International Fund for Agricultural Development

BPO: Business Process Outsourcing

ISP: Service Providers

MNO: Mobile Network Operators

GIS: Geographic Information System

GSM: Global System for Mobile communications

m-ARD: Mobile Agricultural and Rural Development

ATA: Agricultural Transformation Agency

CARP: Community Action Research Project

DOI: Diffusion of Innovation Theory

ECX: Ethiopian Commodity Exchange

FAO: Fund for Agriculture Organization

FVR: Farmer Voice Radio

GSMA: Global System for Mobile Association

IPMS: Improving Productivity and Market Success

IVR: Interactive Voice Response

KACE: Kenya Agricultural Commodity Exchange

LINKS: Livestock Information Network Knowledge System

MILS: Market Information and Linkage System

SME: Small and Medium size Enterprises

SMS: Short Message Services

SRA: Strategy for Revitalizing Agriculture

SUFACE: Strengthening University-Farming Community Engagement

TAM: Technology Acceptance Model



DECLARATION

I, **Stany RYUMEKO**, declare that

- (i) The research reported in this thesis, except where otherwise indicated, is my original work.
- (ii) This thesis has not been submitted for any degree or examination at any other university
- (iii) This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.



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ABSTRACT

Information and Communication Technology (ICT) can revolutionize the African farming sector and benefit all farmers, including small landholders. Traditional approaches to agriculture are being adopted, and numerous challenges exist in production, marketing, profit, etc. The challenges of traditional agriculture are addressed significantly by using Information and Communication Technologies (ICT), which play an important role in uplifting the livelihoods of rural small-landholder farmers. ICT helps address the growing demand for new approaches. It also helps empower the rural people by providing better access to natural resources, improved agricultural technologies, effective production strategies, markets, banking and financial services, and so on.

Based on the Diffusion of Innovation Theory, the Technology Acceptance Model and the Theory of the Firm, this study uses evidence from Kenya, Ethiopia, Tanzania and Uganda to typify the means of ICTs used in agriculture. It reveals that mobile phones and radios are the most used and plays a crucial role in the advancement of agricultural business for smallholder farmers. Constraints, including an unconducive policy environment, insufficient communication infrastructure, and inadequate farmer-level capacities to use available ICT, are pointed out in this study. Therefore, a call to public policy is made to address these challenges and constraints within the sphere of agricultural productivity leading to rural development. The review concludes that when mobile phones and radio are combined with other ICT platforms, such as mass media, the impact on agriculture will likely be very high.

Keywords: East Africa, ICT, Farming Industry, Rural Development, Innovation Policy

국문초록

정보통신기술(ICT)은 아프리카 농업 부문에 혁신을 일으키고 소규모 지주를 포함한 모든 농민에게 혜택을 줄 수 있다. 전통적인 농업 접근 방식이 채택됨에 따라 생산, 마케팅, 수익 등에서 많은 도전 과제를 안고 있다. 전통 농업의 도전 과제는 농촌 소규모 지주 농민의 생계를 향상시키는 데 중요한 역할을 하는 정보통신기술(ICT)을 활용하여 크게 해결된다. ICT는 새로운 접근 방식에 대한 증가하는 수요를 해결하는 데 도움이 되며, 또한 천연 자원에 대한 더 나은 접근성, 개선된 농업 기술, 효과적인 생산 전략, 시장, 은행 및 금융 서비스 등을 제공하여 농촌 주민들에게 힘을 실어준다.

이 연구는 혁신의 확산 이론, 기술 수용 모델 및 기업 이론을 바탕으로 케냐, 에티오피아, 탄자니아, 우간다의 증거를 사용하여 농업에 사용되는 ICT 수단을 유형화하는 것을 목표로 한다. 휴대폰과 라디오가 가장 많이 사용되며 소규모 농가의 농업 비즈니스 발전에 중요한 역할을 한다는 것을 밝혀냈다. 이 연구에서는 유해한 정책 환경, 불충분한 통신 인프라, 가용한 ICT를 사용할 수 있는 농가 수준의 역량 부족 등의 제약을 지적합니다. 따라서 농촌 개발로 이어지는 농업 생산성 영역 내에서 이러한 도전과 제약을 해결하기 위해 공공 정책에 대한 촉구가 필요하다. 검토 결과, 휴대폰과 라디오가 대중 매체와 같은 다른 ICT 플랫폼과 결합될 경우 농업에 미치는 영향이 매우 클 것으로 결론지었다.

키워드: 동부 아프리카, ICT, 농업, 농촌 개발, 혁신

Chapter I. INTRODUCTION

The agricultural sector is the cornerstone of the economies in Sub-Saharan African nations. It ensures food stability, creates job opportunities, generates foreign currency, and supplies raw materials for various industries (World Bank, 2014). Agriculture also serves as the main source of rural livelihoods and is a critical sector for national progress, helping to alleviate poverty, enhance household food security, and support rural development (Francisca C Mbagwu, 2018).

While agriculture plays a vital role in the livelihoods of rural populations in many African countries, the sector remains underdeveloped, leaving many communities vulnerable to food insecurity and reliant on food imports (Verdier-Chouchane, 2016). Conventional Agricultural Extension Services designed to assist small-scale farmers have yet to make a significant impact. As a result, agricultural productivity remains stagnant, and widespread hunger and food shortages continue to affect large sections of the population (Nisiima, 2015).

Agricultural Extension Services are essential in helping farmers achieve greater food security by creating links between farmers, researchers, and policymakers. However, these services are often limited by a lack of staff. For instance, in Uganda, a single extension officer is expected to serve up to 400 square kilometers, with around 4,000 farm families. Additionally, poor road infrastructure, which worsens during the rainy season, further hampers the effectiveness of these services (Jean M. Due, 1997).

Numerous factors contribute to agricultural advancement, particularly for smallholder farming households. These include access to financial resources, machinery, labor, markets, credit, institutional frameworks, and technological tools like Information and Communication Technologies (ICT). While all these elements are important, ICT plays a particularly pivotal role in overcoming agricultural challenges and improving the livelihoods of rural populations.

ICT offers farmers access to critical information, resources, and technologies that can boost productivity and ultimately enhance their quality of life.

Information and Communication Technologies (ICTs) is a broader term for Information Technology (IT), which refers to all communication technologies, including the Internet, wireless networks, cell phones, computers, software, middleware, videoconferencing, social networking, and other media applications and services that enable users to access, retrieve, store, transmit, and manipulate information in digital form. ICTs are also used to refer to the convergence of media technology, such as audio-visual and telephone networks, with computer networks, by means of a unified system of cabling (including signal distribution and management) or link system. However, there is no universally accepted definition of ICTs, considering that the concepts, methods and tools involved in ICTs are continuously evolving on an almost daily basis (FAO, 2024).

For ITU (2023), "ICTs are information-handling tools - a varied set of goods, applications and services that are used to produce, store, process, distribute and exchange information. They include the "old" ICTs of radio, television and telephone, and the "new" ICTs of computers, satellite and wireless technology and the Internet. ICTs can be defined as technological means of collecting (inputting/gathering), collating (processing/analyzing), and conveying (outputting/transferring) information via technologies (AJAYI, 2009).

ICTs represent the integration of telecommunication and computing technologies for acquiring, retrieving, and disseminating information. ICTs encompass various technologies currently utilized to facilitate communication and manage information across various economic sectors. These include computer hardware and software, CD-ROMs, radios, telephones, email, the internet, television, videos, and digital cameras. They also involve processing, storing,

transmitting, and presenting information in diverse formats such as text, images, audio, and data (Asenso-Okyere & Mekonnen, 2012).

These platforms support the acquisition, processing, storage, sharing, and dissemination of information among individuals and systems, both locally and globally. Timely and reliable information is crucial for improving agricultural outcomes. The importance of information access lies in its ability to reduce transaction costs resulting from information imbalances between market participants (Bageftoft, 2004). Similarly, providing market information through ICT improves farmers' ability to access market data, facilitating trade. At the micro level, exchanging information through ICT benefits farmers and households (Ratnadiwakara, 2008).

Moreover, ICT helps lower costs for finding and choosing trading partners (such as search and screening expenses), negotiating terms, and monitoring transactions. It also reduces the price difference in output markets (Aker, 2008). ICT can also reduce the costs of acquiring credit and agricultural inputs (e.g., seeds, fertilizers, and advisory services) by cutting down on search, screening, negotiation, and monitoring costs. This, in turn, increases profit margins and income, assuming the market prices for outputs remain stable.

By lowering input costs and enhancing profit margins, ICT encourages agricultural commercialization, drives sectorial growth, and improves household welfare. Furthermore, ICT can help mitigate the exclusion of economically disadvantaged households by boosting their income (Chigona, 2008).

Theoretically, for commodity-based markets, reducing business costs benefits traders by increasing the net price they earn, thus improving their margins. If price information is effectively conveyed to farmers, ICT access can help them secure better prices for their produce, contributing to household asset accumulation. Over time, this accumulation of capital can stimulate investment in agriculture, foster commercialization, and enhance overall household

well-being. For example, mobile phone-based market information enhanced the welfare of small-scale vegetable growers in Colombia by connecting them to higher-paying export markets and reducing losses from rejected or unsold produce (Chigona, 2008). Also, that better access to information improves price discovery by reducing search, negotiation, and enforcement costs, thereby increasing marketing efficiency and raising farmers' incomes (Aker, 2008).

Agriculture is the most vital sector in the economies of many countries, supporting the livelihoods of the majority of the rural population. Despite numerous extension efforts in the past, the sector's performance has not significantly improved to meet expectations. Currently, the sector's performance does not align with its potential, nor does it meet the food demands of the population. Consequently, the challenge lies in how to effectively adopt and implement technological innovations that can bring about meaningful changes in agriculture and ultimately improve farmers' living standards (Belay, 2003).

The agricultural sector serves as the primary source of income for a large portion of the 75% of Africa's rural population. Over the past four decades, however, Africa's agricultural sector has experienced a significant decline, even though food security remains crucial for the survival of individuals, households, and entire nations. Seventy-three percent of Africa's population lives in rural areas, surviving on less than a dollar per day, and many poor farmers continue to face persistent poverty (Schulte, 2016).

The low productivity of agriculture can be attributed to several factors: (1) the lack of appropriate technologies, (2) farmers' lack of awareness about the technologies suited to their specific areas, (3) the unavailability of necessary inputs and resources when required, and (4) policies that discourage the adoption of new technologies (Gessei, 2012).

Smallholder farmers may refrain from adopting new innovations due to a lack of resources, or the technology may not be cost-effectiveness at small-scale production, or even because the technologies do not meet their needs. In many cases, they may simply be unaware of these innovations. "Awareness" of available technologies is a key factor in whether farmers will accept or reject new practices. Large scale farmers tend to have more contact with Development Agents (DAs) and are better connected to various sources of information, compared to smaller farmers. The latter often receive delayed and indirect information through the trickle-down approach, which exacerbates the economic divide between them, leading to either windfall profits or losses (Robert, 1994).

Numerous studies on the role of ICT in agricultural development suggest that ICT can provide farmers with the vital knowledge, information, and technologies they need to enhance productivity and improve their livelihoods. One of the most affordable inputs for advancing rural agricultural development is access to knowledge and information, particularly on new agricultural technologies, early warning systems (such as for droughts, pests, and diseases), improved seedlings, fertilizers, credit, and market prices. He also argues that farmers would greatly benefit from global information if rural information centers were equipped with the necessary communication tools and technologies.

Therefore, providing farmers with timely and accurate information is critical for improving agricultural outcomes. While technologies like telecenters can act as significant drivers for information dissemination and development opportunities, their reach is often limited in remote areas due to a lack of infrastructure (Getachew, 2012).

The role of ICT in enhancing food security and supporting rural livelihoods is increasingly acknowledged and was officially recognized at the World Summit on the Information Society (WSIS). This includes using computers, the internet, geographic information systems (GIS),

mobile phones, and traditional media such as radio and television, which can facilitate broadcasting and audience participation. Despite being a relatively recent development, evidence supporting the positive impact of ICT on agricultural growth and poverty reduction is steadily growing. However, for rural farmers to benefit from these ICT services, they must first be made aware of them and learn how to use them. Farmers are likely to adopt ICT tools that provide useful agricultural information, as long as they find them accessible and economically beneficial (ITU, 2023).

This study, therefore, aims at the assessing the availability and utilization of ICT services by the farmers in east African region. It covered the impact of ICT in enhancing agricultural development as it was largely studied by different researchers and tackle the different constraints to the use of ICTs by farmers. It will also deal with identifying the most commonly used ICT tools in the target region, evaluating their effectiveness, and exploring the barriers preventing rural farmers from accessing the agricultural knowledge and information needed to improve crop productivity, marketing opportunities, and financial transactions.

The study limited its scope to the utilization of ICT means and services by smallholders in the study area and did not address large-scale farmers as they have different ways of dealing with their production and commercialization of their produce. It focused on selected countries such as Kenya, Ethiopia, Tanzania and Uganda. The region of East Africa has been chosen as an area of study because of linguistic interests. English has been used as an official language in many countries since the colonial period, except for Ethiopia. Although Ethiopia does not use English as an official language, it is commonly used in academic writings and publications. The study focused on four East African countries: Kenya, Ethiopia, Tanzania and Uganda. These countries have the highest GDP and Purchasing Power Parity in East Africa, meaning

that they are more economically advanced than others, thus offering higher chances of providing more data for the study (IMF, 2024)

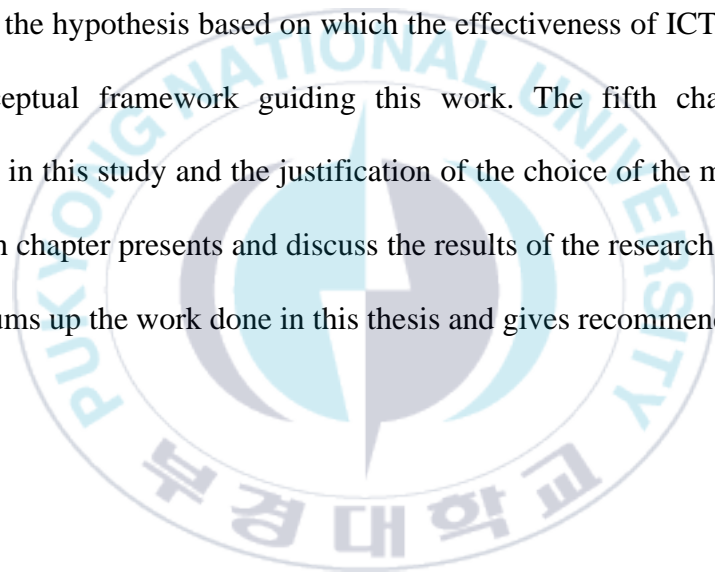
The overall objective of this study was to find out which ICT platforms and devices are used by smallholder farmers of the East African region with evidence of their effectiveness in matters of production, marketing finance and transaction accessibility. We also examine the challenges farmers face in the use of ICTs and suggest mitigating solutions. The specific objectives were to describe the economic characteristics of the East African region, describe the ICT platforms and devices used by farmers in the targeted region to provide evidence of their effectiveness, describe the challenges to the use of ICTs by farmers in the East African area, and provide a few possible recommendations for solutions to rectify the problem.

This study aims to enhance the understanding of ICT usage in the study region, evaluate the effectiveness of these services, and assess their availability and accessibility to farmers. It also explores why smallholder farmers in the area are not utilizing the ICT services currently available to them. Additionally, the findings of this study will be valuable for farmers, extension agents, subject matter experts, planners, researchers, policymakers, and relevant government bodies, NGOs, and private sector organizations. The results will help these stakeholders gain a deeper insight into rural conditions and enable them to design and deliver targeted, needs-based ICT solutions that cater to the diverse needs of farmers while addressing issues of equity within the framework of sustainable agricultural development. Finally, this study's findings will provide a valuable benchmark for future research in this field.

It is common that every researcher faces certain constraints while conducting research. Therefore, the major constraints faced by the researcher while conducting this study was associated to the shortage of up-to-date resources. Data collection had to be extended to more than 20 years in order to get a significant number of resources. Moreover, as this study is using

a qualitative method, we faced the issue of getting enough qualitative resources, because the great part of the available studies used quantitative methods.

This study of the use of ICTs in east African region carries in this thesis was made in 7 chapters. After the general introduction of study which serves as a call to the interest of the reader, the second chapter gives a contextual overview of the study, in which readers will get a glimpse of what the economic situation looks like in the study area, as well as its internet history. The third chapter deals with the literature review, which comes back on what other researchers have done in the domain of this study. The chapter four contains the theories and models which support this work, the hypothesis based on which the effectiveness of ICT can be justified, as well as the conceptual framework guiding this work. The fifth chapter describes the methodology used in this study and the justification of the choice of the method among other methods. The sixth chapter presents and discusses the results of the research and the discussion. The last chapter sums up the work done in this thesis and gives recommendations.



Chapter II. CONTEXTUAL OVERVIEW

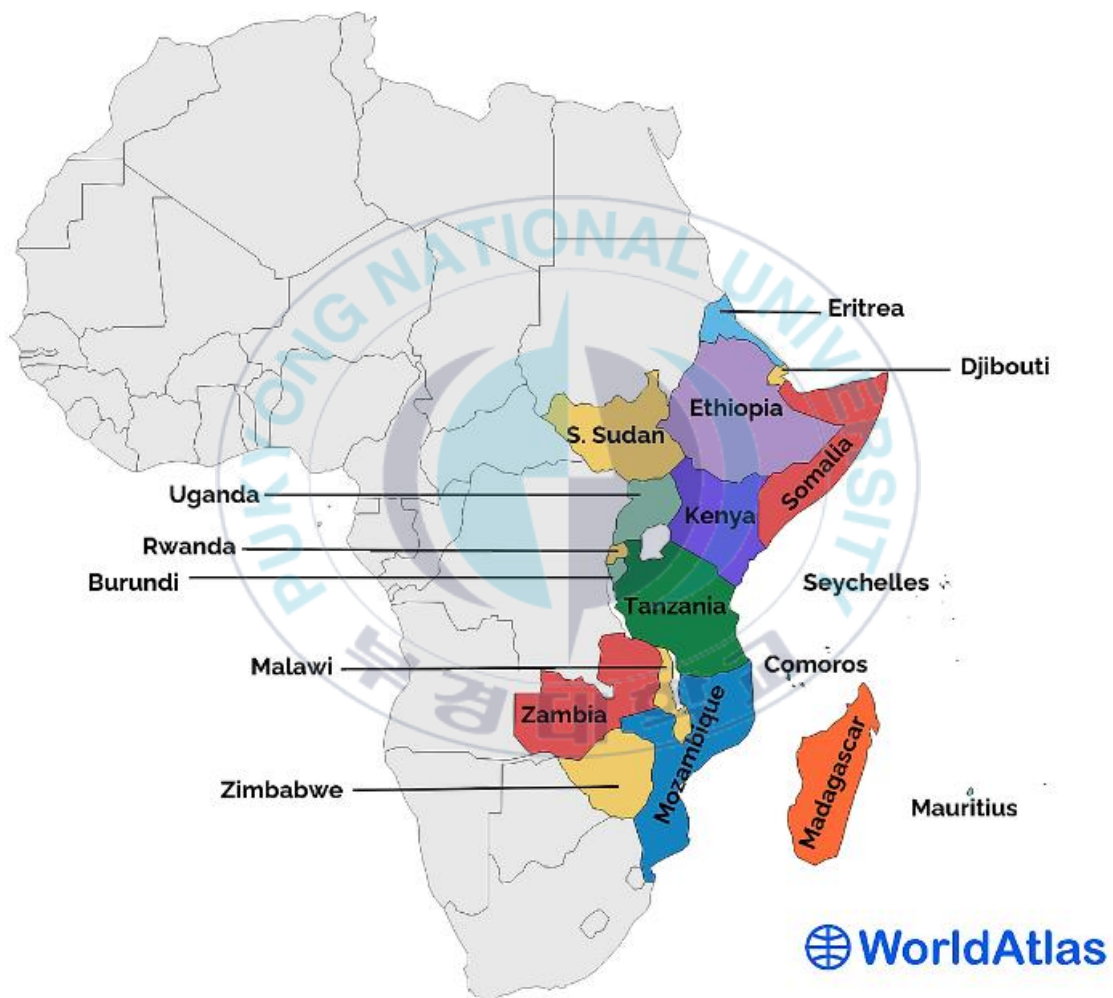
II. 1 East Africa Region Overview

The East Africa region comprises 13 countries that are members of four African Union-recognized regional economic communities: the Common Market for Eastern and Southern Africa (COMESA), the East African Community (EAC), the Intergovernmental Authority on Development (IGAD), and the Southern African Development Community (SADC). Some of these countries are part of other regional blocs, including the Indian Ocean Community, the economic Community of Great Lakes Countries, and the Central African States Economic Community. The 13 East African countries are Burundi, Comoros, Djibouti, Ethiopia, Eritrea, Kenya, Rwanda, Seychelles, Somalia, South Sudan, Sudan, Tanzania, and Uganda (AfDB, 2023).

World Atlas describes East Africa as a subregion of Africa as defined by the United Nations Geoscheme. The region encompasses 18 countries and two dependencies. It stretches from Eritrea in the north to Mozambique in the south, bordered by the Indian Ocean to the east. Middle Africa lies to the west of East Africa, and Southern Africa lies to the southwest. The boundary between East and North Africa is marked by the border separating Sudan from the East African countries of South Sudan, Ethiopia, and Eritrea (WorldAtlas, 2024). Three of East Africa's countries—Mauritius, Madagascar, and Seychelles—are island nations, along with the

French dependencies of Mayotte and Réunion. Additionally, seven of East Africa's countries are landlocked.

FIGURE 2.1 EAST AFRICAN COUNTRIES

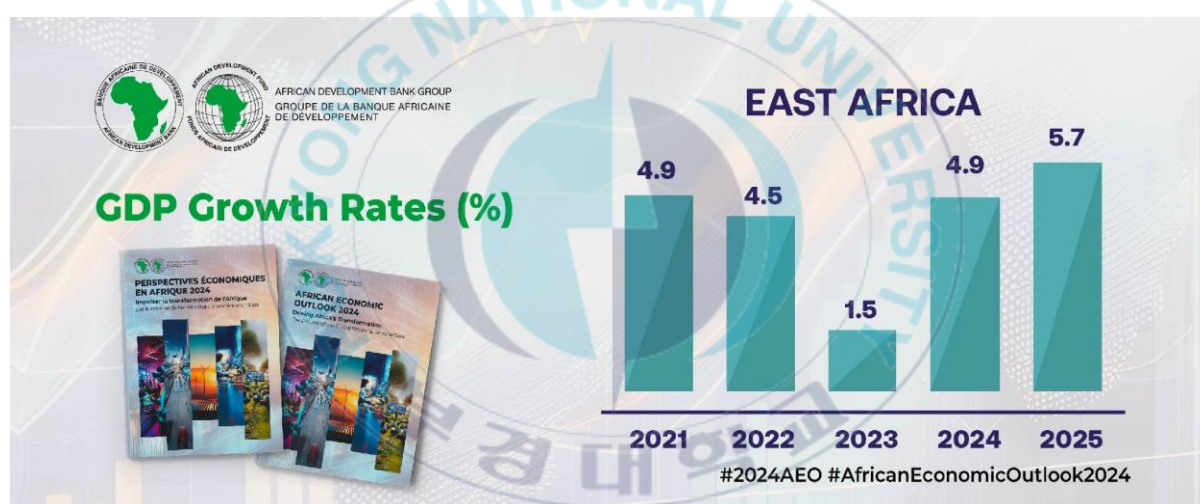


Source: WorldAtlas (2024)

II.2 East African Economy

East Africa has been the continent's fastest-growing region in recent years. It is home to several fastest-growing economies, including Ethiopia, Djibouti, Kenya, Rwanda, Tanzania, and Uganda. In 2020, Tanzania became the latest country in the region to graduate from low-income to middle-income status, joining three of its neighbors in the World Bank's lower middle-income category – Kenya, Comoros and Djibouti. One country, Seychelles, is classified as high-income, while the rest are low-income (AfDB, 2023).

FIGURE 2.2 EAST AFRICAN GDP GROWTH RATES



Source: AfDB (2023)

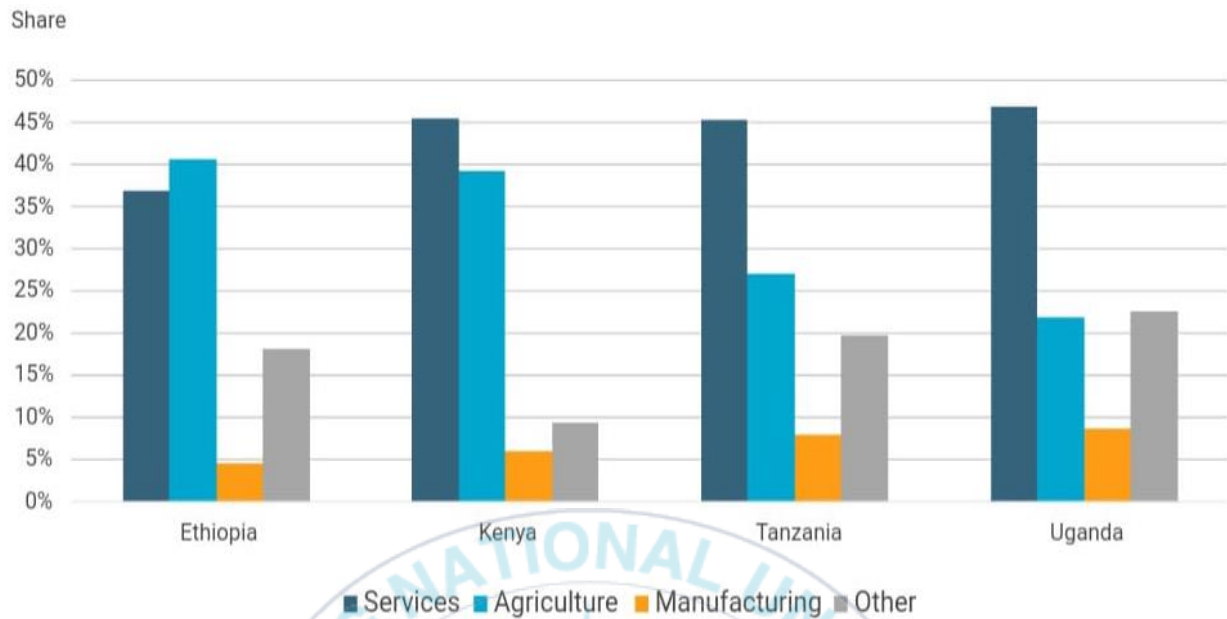
East Africa, the fastest-growing region, will see real GDP growth rising from an estimated 1.5% in 2023 to 4.9% in 2024 and 5.7% in 2025. The downward revision of 0.2 percentage points for 2024 compared with the forecast in January 2024 Africa's Macroeconomic Performance and Outlook (MEO) is due to larger-than-expected contractions in Sudan and South Sudan following the ongoing conflict. East Africa will continue to lead Africa's growth momentum,

projected to rise to 5.1% in 2024 and 5.7% in 2025, supported by strong strategic investments to improve internal connectivity and deepen intra-regional trade.

The growth rate of East Africa averaged 4.9% in 2018 and 5.3% in 2019, outperforming the broader African continent, which recorded growth rates of 3.3% and 3.4%, respectively. However, the Covid-19 pandemic caused a sharp decline in growth, with the region's rate dropping to just 0.7% in 2020. Despite this, East Africa's performance remained well above Africa's overall contraction of -2.1%, making it the only African region to avoid a recession during the pandemic. This resilience in 2020 was supported by positive growth in Ethiopia, Tanzania, Kenya, and Djibouti, driven by a more diversified service sector, ongoing public investments in large infrastructure projects, and a solid agricultural performance, despite challenges like desert locust infestations and other natural disasters such as droughts and floods. East Africa's GDP growth was expected to rebound to 3% in 2021, up from 0.7% in 2020, driven by the global economic recovery and ongoing reforms aimed at strengthening economic governance (AfDB, 2023).

The economic power in sub-Saharan Africa is shifting eastward. By 2040, East Africa is expected to contribute 29% of the region's GDP, up from 21% in 2022 and just 14% in 2000. This growth has been fueled in part by stronger bilateral ties with China, which has become a major source of foreign direct investment, particularly in infrastructure and non-service sectors. Between 2022 and 2040, East Africa is projected to experience faster economic growth than the broader sub-Saharan region and other rapidly industrializing Asian economies. However, as with other parts of sub-Saharan Africa, the region will face significant challenges, including high poverty levels and political instability (Euromonitor, 2022). Below are the four primary economic resources for selected countries, as suggested by Euromonitor International (Figure 2.4).

FIGURE 2.3 ECONOMIC RESOURCES FOR ETHIOPIA, KENYA, TANZANIA, AND UGANDA



Source: Euromonitor (2022)

Services played major role in the economy of the four countries, for the foreign direct investment (FDI) brought a big input in facilitating economic growth as it has been a source of capital for infrastructure. For example, in 2022, Ethiopia received USD3.7 billion in foreign direct investment inflows – the highest ever on record. Improving Sino-African relations in recent years has led to China laying claim to an increasing share of regional investment as part of its Belt and Road initiative. It has invested heavily in infrastructure megaprojects across East Africa, such as the construction of the Standard Gauge Railway and the Karimenu II Dam Water Supply Project in Kenya (Euromonitor, 2022).

II.3 Agriculture in East Africa

Africa has a broad array of agro-ecological regions, ranging from dense rainforest vegetation with twice-yearly rainfall to relatively sparse, dry, and arid landscapes with limited, single-season rainfall. This variety is a valuable asset but presents significant challenges for African

agricultural development. On the one hand, it opens the vast potential for a diverse range of agricultural products that can be cultivated and marketed both locally and internationally. However, the diversity also means that universal solutions to agricultural development issues are impractical across the continent. Therefore, planning and implementing initiatives in the sector must be customized to the specific conditions of each agro-ecological zone and the current socio-economic conditions of rural households within individual nations (AfDB, 2023).

In East Africa, unroasted coffee and tobacco had the highest export value among agricultural goods in 2020, each generating approximately 1.7 billion U.S. dollars in exports. By country, Zimbabwe was the top tobacco exporter in the region. Tea was a significant export from East Africa, with an export value of around 1.5 billion U.S. dollars. Palm oil was the primary agricultural import for East African nations in 2020, with imports exceeding 2.4 billion U.S. dollars. Wheat, milled rice, and refined sugar also ranked among the major agricultural imports (Statista, 2024)

The four East African economies studied – Uganda, Ethiopia, Kenya, and Tanzania – are all agriculture-focused, though the sector's contribution to GDP varies. In Ethiopia and Tanzania, agriculture remains the main contributor to GDP, at 47 percent and 43 percent, respectively. In Uganda and Kenya, however, the rapid growth of the service sector, at around 9.5 percent annually, has surpassed agriculture, contributing 45 percent and 60 percent of GDP, respectively, well above agriculture's share of 30 and 34 percent. Nevertheless, agriculture still employs about 75 percent of the workforce across these countries, highlighting its critical role in job creation and poverty alleviation (AfDB, 2023)

Over 75 percent of agricultural production in these four countries is generated by smallholder farmers, with average farm sizes around 2.5 hectares. These farmers primarily produce for household consumption, relying on traditional methods. Limited commercial and semi-

commercial production also occur. Furthermore, less than 4 percent of total land area is irrigated. Key crops in all these countries include grains, root crops, bananas, tea, pyrethrum, sisal, cut flowers, coffee, cotton, and tobacco. Coffee, cotton, horticultural products, and tea are the main exports. The livestock sector is dominated by cattle and poultry, with sheep, pigs, and goats also contributing. Forestry, horticulture, and fishing are vital economic activities in many of these nations. In particular, horticulture has become the largest sector in Kenya's economy, generating annual revenues of around USD 2 billion, with 240 large-scale producers, over 150,000 small-scale farmers, and employing 1.5 million workers (Adeleke Salami, 2010)

II.3.1 Kenyan Agriculture

Agriculture is a key driver of Kenya's economy, employing 40% of the total workforce (70% of the rural labor force) and representing about 25% of the annual labor market. Major agricultural exports include tea, coffee, cut flowers, and vegetables. Kenya's high-rainfall zones make up around 10% of its arable land but generate 70% of the nation's commercial agricultural output. Farmers in semi-arid areas contribute roughly 20% of the output, with arid regions accounting for the remaining 10%. Overall productivity remains fairly low across these regions due to weak incentives, inadequate infrastructure, and underdeveloped support systems.

Despite ongoing food supply shortages, Kenya leverages mechanisms under the COMESA and EAC agreements to limit food imports. These agreements include high tariffs on imports from non-member countries for sensitive goods, such as meat, dairy, poultry, maize, rice, wheat, and beans. Certain sectors, particularly in seed and fertilizer production, still benefit from subsidies (FAO, 2024).

II.3.2 Ugandan Agriculture

About one-quarter of rural residents in Uganda live below the poverty line, compared to slightly over one-tenth in urban areas. The agriculture sector comprises 24% of GDP and employs

around 70% of the workforce. For those lacking formal education, agriculture remains a crucial source of income. Over the last two decades, Uganda has experienced substantial economic growth and poverty reduction, with the economy expanding by over 5% in 2022 and the agriculture, forestry, and fishing sectors increasing nearly 5%. However, Uganda's rapid population growth and dependence on climate-sensitive sectors, such as agriculture and forestry, make it vulnerable to climate change and extreme weather events like droughts, floods, and landslides (IFAD, Uganda Investment Proposal, 2024).

II.3.3 Tanzanian Agriculture

Crop farming and livestock rearing occupy approximately half of Tanzania's land area. Unsurprisingly, agriculture forms the foundation of the nation's economy. In 2020, agricultural endeavors, forestry, and fishing accounted for nearly one-third of Tanzania's GDP. This represented around 14.3 billion U.S. dollars in value-added, an amount roughly 30 percent greater than that recorded in 2015. By the end of 2021, the sector achieved a quarterly growth rate of 4.2 percent at constant prices.

Grains, horticultural products, cashews, coffee, tea, cotton, tobacco, and cloves make up 20 percent of Tanzania's total exports. As of 2020, the nation generated over 1.2 billion U.S. dollars from exporting key agricultural goods. Despite variations, the overall value has increased in recent years. Revenue from grain exports, for instance, grew significantly, reaching nearly 403 million U.S. dollars in 2021. This growth was largely due to Tanzania's pivotal role in the cross-border trade of essential food items in East Africa, supplying neighboring countries such as Uganda and Kenya with rice and maize.

Agriculture is a cornerstone of sustenance for most Tanzanians. Around eight million households, primarily in rural areas, have been involved in farming activities. Additionally,

agriculture creates the majority of employment opportunities in Tanzania. The sector contributed to nearly 65 percent of total employment in 2020. However, this share has gradually declined. For comparison, in 2000, agricultural employment exceeded 80 percent of the total workforce. The decrease reflects a shift in employment distribution in Tanzania over the past decades, with more individuals joining the service industry each year, especially (Cowling, 2024) .

II.3.4 Ethiopian Agriculture

Ethiopia, with a population of 105 million, ranks among the world's most populous nations and is one of the best-performing economies in sub-Saharan Africa. Agriculture forms the backbone of the Ethiopian economy, with exports heavily reliant on agricultural goods such as coffee, seeds, pulses, and livestock. In recent years, Ethiopia has seen robust economic growth and notable improvements in social and human development; however, poverty remains a significant challenge.

Approximately 85% of Ethiopia's population lives in rural areas. The 2015/16 El Niño drought severely impacted agricultural production, leaving nearly 10 million people needing food aid. Nonetheless, favorable weather conditions and governmental actions to mitigate the drought's effects improved livestock production and productivity in 2016/17. Many rural areas have experienced years without adequate rainfall, leaving residents vulnerable to future crises.

Ethiopia's rapid population growth rate of 2.6% annually intensifies pressure on land resources, contributing to environmental degradation and raising concerns about food security. Challenges to agricultural productivity include land degradation, poor water management, low technology adoption, and an underdeveloped marketing infrastructure (IFAD, 2024).

II.4 Information and Communication Technologies in East Africa

II.4.1 Internet Background in East Africa

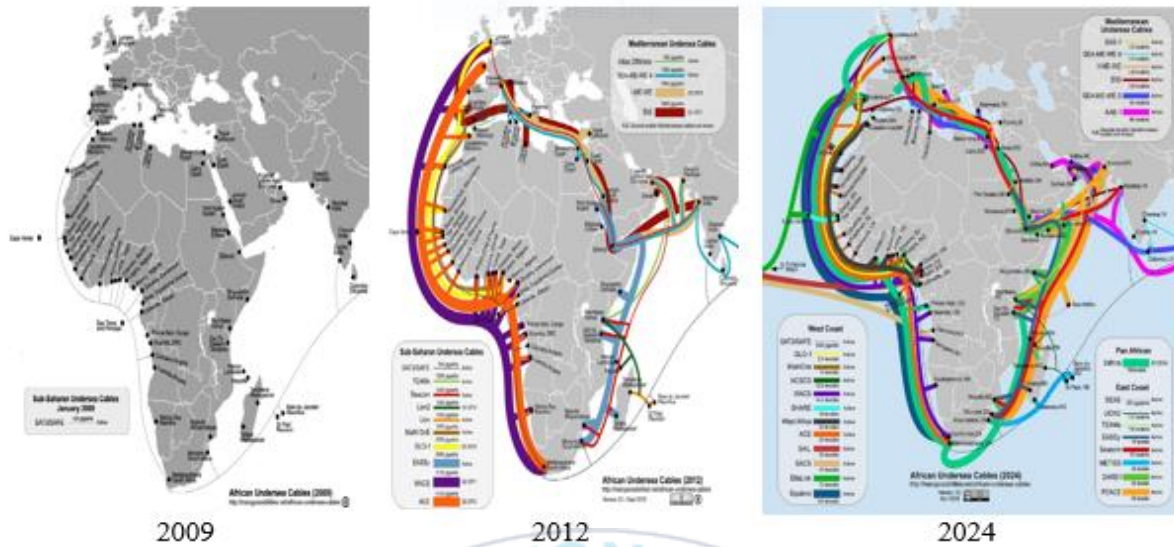
With the dawn of the twenty-first century and the rise of digital information, advanced technological solutions have become essential for regions to be considered well-connected. Access to fibre-optic cables allowed information and communications to be transmitted quickly and at low cost, making this infrastructure a near-essential component for regions seeking to participate in global economic activities, such as business process outsourcing (BPO)

However, East Africa was among the last major regions worldwide to be linked to the Internet via submarine fiber-optic cable. Less than a decade ago, the region still lacked an extensive cross-border terrestrial fiber-optic cable network. Internet transit relied on direct satellite Internet connections through individual Internet Service Providers (ISP) and Mobile Network Operators (MNO). This part of the world saw submarine fiber-optic cables making landfall in Mombasa, Kenya, and Dar es Salaam, Tanzania, in 2009 (Graham et al., 2015).

Before this, East Africa had notably low levels of ICT access and usage, along with some of the highest data costs globally due to a strong dependence on satellite connections (Moodley, 2002) This new connectivity was viewed by many as a profoundly transformative and groundbreaking development.

In 2009, the whole of Africa knew only one undersea cable company, covering the whole west, south and some parts of the east. The number had increased to ten in the Sub-Saharan region and four in the Mediterranean region by 2012. By 2024, the number of companies had increased to twelve in the west of Africa, six in the Mediterranean region, eight in east Africa, and one which contours the whole of Africa, as shown in the figure below (Song, 2024). The results are summarized in Figure 2.4.

FIGURE 2.4 AFRICAN UNDERSEA CABLES

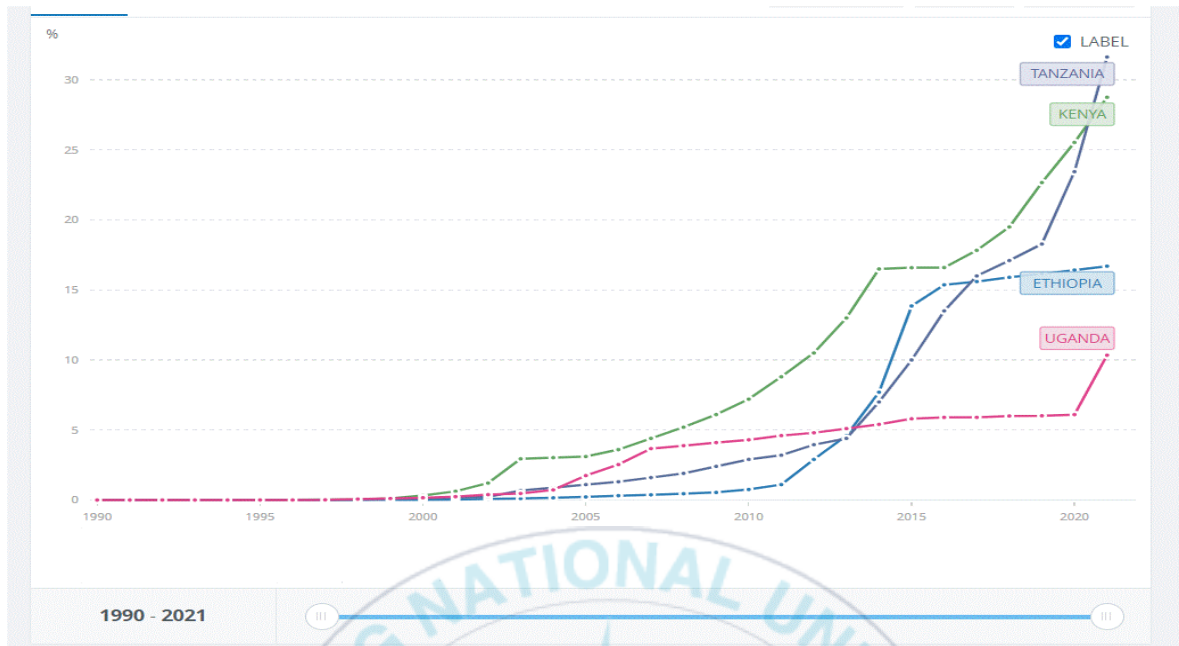


Source: manypossibilities.net (2024)

II.4.2 The rapid uptake of internet use in Africa

The use of the internet has evolved rapidly in Africa. The continent had around 570 million internet users in 2022, more than doubled compared to 2015. In recent years, improved telecommunication infrastructure and the rising adoption of mobile devices have boosted internet access in Africa. In turn, the growing internet accessibility has promoted digital activities and services, such as social media, online shopping, and mobile payments. Nevertheless, the continent has not yet achieved its full digital potential. Despite the rising number of users, the internet penetration rate stood at around 43 per cent in 2021, below a global average of 66 per cent.

Figure 2.5 Individual Internet Uptake (1990-2021) (% by population)



Source: World Bank (2024)

Mobile Internet broadband offers substantial potential, as cellular subscriptions have surged dramatically between 1990 and 2021 in Africa. In contrast, fixed broadband subscriptions remain very low in Sub-Saharan Africa, at only 0.3 per 100 people in 2013 (World Bank, 2024).

In the diagram above, we see that Tanzania and Kenya are the most advanced in individual internet uptake, compared to Uganda and Ethiopia. Tanzania experienced an uptake of more than 30%, and almost 30% for Kenya, from 2000 up to 2020. For the case of Ethiopia, the uptake was of less than 15% and almost 10% for Uganda, in the same time span of time. This difference can be explained by the fact that the undersea cable landed first in Tanzania and Kenya. The weak uptake for Uganda can be explained by its geographical condition: it is a landlocked country.

II.5 ICT Implementation for Agriculture

II.5.1 General ICT platforms used in African agriculture

A wide variety of ICT platforms is currently being utilized to deliver, share, and circulate various types of information and technologies to farmers and other stakeholders in agricultural research and development in East Africa. These include PC-based online platforms, internet websites, mobile phones, radio broadcasts, television, and Geographic Information Systems (GIS) tools, among others (May et al., 2007). Numerous websites and online portals serve as interaction hubs for agricultural research and development data. An example is the Africa Trial Sites (<http://africats.org/>), launched in response to the realization that the diverse agricultural conditions across Africa limited the widespread acceptance of high-yielding, stress-resistant crop varieties. This diversity also posed challenges in selecting suitable testing locations for these improved varieties and aligning them with compatible growing environments across the continent.

This platform enables both international and national research organizations to electronically consolidate their data on trial sites. It offers a range of ICT-based tools leveraging advancements in GIS, bioinformatics, and data management, which allow plant breeders, agronomists, and farmers to gather more actionable data from field trials through efficient field assessment of enhanced varieties. The platform hosts extensive data from field trials and research conducted over several decades, much of which was previously stored in institutional archives, making it challenging to assemble, analyze on a broad scale, and apply effectively.

Additionally, users can explore the site for trial locations and other data by country, design trials for cultivar assessment, access trial management and data analysis tools, view spatial analysis results, review data on an interactive Google map, and report outcomes online. Portal users can also rank varieties and provide feedback on their performance at specific sites.

Through the site, climate data for any point in Africa can be evaluated, and climate similarity between trial locations and other areas in Africa can be compared.

The platform also offers links to numerous resources, including the participating institutions' websites, where users can request seeds from gene bank curators and breeders. Integrating interactive data analysis tools and trial site data has facilitated broader access to critical information for agricultural research, development, and extension stakeholders. Although some results for improved varieties tested in Africa are available online, additional data from researchers could greatly expand knowledge on the adaptability of varieties to different environments, particularly those vulnerable to disease, pests, or environmental stressors. International agricultural research centres are now utilizing the trial sites within a climate adaptation research program that includes national partners, using Africats.org for standardized information from trial sites (WorldBank, 2011)

Mobile communications technology has also rapidly become one of the most prevalent means of transmitting voice, data, and related services across a variety of economic sectors in East Africa (Martiz, 2011). Given this significant shift, mobile applications (m-apps) offer great potential for advancing development, especially through mobile applications for agricultural and rural development (m-ARD apps). Most m-ARD apps aim to improve integration within the agricultural supply chain, offering a wide range of functions, such as delivering market information, facilitating market linkages, and enhancing access to extension services. Users of these apps vary widely and include produce buyers, farmers, input suppliers, cooperatives, content providers, and other key players in the agricultural sector (Nyaga, 2012).

II.5.2 ICT Platforms Usage in East Africa

The adoption of ICT-based agricultural market platforms is gradually increasing in East Africa. With access to markets and timely market information, farmers now can make informed decisions regarding marketing, which can lead to improved incomes through better bargaining power. Additionally, these platforms enable farmers to capitalize on market opportunities by adjusting their production plans and allocating resources more efficiently. In this regard, ICT-based market platforms are essential in providing relevant and timely information in a way that is easily digestible and actionable. The services offered by these platforms are typically simple to understand, subscribe to, and use, making them a valuable entry point for additional information services such as general agricultural education and long-term extension support (May et al., 2007). Below, we will explore some of the most significant ICT services platforms being used in Kenya, Ethiopia, Tanzania, and Uganda.

II.5.2.1 ICT-based service used in Kenya:

Kenya Agricultural Commodity Exchange (KACE): The Kenya Agricultural Commodity Exchange (KACE) offers ICT-based commodity exchange solutions, including bids and offers prominently displayed on blackboards, disseminated through SMS, and shared via the Internet. For example, KACE collects, updates, analyzes, and provides timely and dependable market insights and intelligence on various agricultural commodities. The platform primarily targets stakeholders in the commodity value chain, focusing on small-scale agribusinesses and smallholder farmers (KACE, 2011).

II.5.2.2 Mass Media Used in Kenya

Mali Shambani is a weekly, hour-long radio show produced by the Kenya Broadcasting Corporation (KBC). The program covers farming news, agricultural practices, market trends, weather forecasts, farming inputs, and financing opportunities. It also features an interactive

call-in segment where farmers can seek advice from experts via SMS or phone. An impact evaluation deemed the program highly effective in reaching farmers across Kenya (Nabutola, 2014). Shamba Shape Up is a weekly TV and radio show offering comprehensive information on agricultural technologies, including seed types and their sources. The program recently introduced *iShamba* (2024), a subscription-based SMS service that provides farmers expert advice on weather updates, pest and disease control, and market prices. The guidance is customized to specific crops, regional conditions, and seasonal cycles.

Seeds of Gold is a weekly insert in the *Daily Nation*, Kenya's most widely read newspaper, published by the Nation Media Group (NMG, 2024). It aims to enhance farmers' knowledge of best practices and introduce innovations and technologies from diverse sources. Content includes information on newly released crop varieties. Soko Hewani is a radio service featuring bid and offer announcements targeting farmers and small agricultural enterprises. Listeners, primarily smallholder farmers and SMEs, can call, email, or text to participate in bidding. The program's staff use mobile phones and SMS to match offers and bids, sometimes contacting individuals for further negotiations (Sokohewani, 2024)

II.5.2.3 Mobile Telephone Platforms Used in Kenya

Phone-based Voice Messages: The National Farmers' Information Service, through the Local Language Speech Technology Initiative, provides voice-based updates to farmers in remote regions. These updates cover crop production, market prices, weather forecasts, and disease outbreaks. The service converts text-based data into audio messages in English or Swahili, ensuring accessibility for farmers with limited literacy or internet access (Tucker RC, 2009). iKilimo is a mobile reference tool offering information on crop production, high-value crops, and marketing (iKilimo, 2024). Kendall Farmers Helpline is a profit-driven call centre offering real-time agricultural advice. Farmers can call to receive detailed support from agricultural

specialists on topics like planting, harvesting, negotiating prices, and marketing. This service (Kencall, 2024). Kilimo Salama is an innovative mobile-based insurance scheme allowing farmers to insure seeds and inputs against climate risks. Dealers sell inputs with a small insurance premium, and farmers receive SMS confirmations with policy details. If adverse weather conditions trigger payouts, compensation is transferred via M-PESA, a widely used mobile money platform. The system is linked to weather stations, ensuring data-driven compensation decisions (Kilimo Salama, 2024)

II.5.2.4 ICT-based Services Ethiopia

Ethiopian Commodity Exchange (ECX): In Ethiopia, the Ethiopian Commodity Exchange (ECX) utilizes an ICT-powered market platform that enables the instantaneous transmission of commodity price details to farmers. Market data is displayed on electronic boards at 31 locations across the country and accessible on the ECX website. Additionally, information is shared via SMS and automated voice messages in four regional languages. The service is highly popular, with approximately 20,000 daily toll-free calls made by users seeking price details (Kiambi, 2018)

Food Crop Market Information Sharing System (FCMIS): This system promotes transparent, precise, and comprehensive sharing of food crop market data between smallholder farmers and information providers. It supports stakeholders, including agricultural, trade, and communication offices, in managing market-related activities. Farmers collaborate with information distributors in centralized locations to discuss food crop markets. Integrating technological solutions enhances FCMIS by providing tools for seamless communication among farmers, traders, professionals, and consumers (Ambaye et al., 2021).

Agricultural Free Hotline Service (8028) is the Agricultural Transformation Agency (ATA), established by the Ethiopian government in 2011, introduced a free hotline service to deliver

agriculture-related information. Farmers can access interactive voice responses (IVR) or SMS content covering cereals, horticulture, pulses, oilseeds, and general agricultural practices. The service has transformed how smallholder farmers access timely information (Berhanu Daniso, 2020). Improving Productivity and Market Success (IPMS) aggregates data from local and global sources, offering information on technologies, market dynamics, and extension strategies for various crops, forestry products, and livestock. Livestock Information Network Knowledge System (LINKS): This platform gathers livestock pricing and trading volumes by interviewing merchants during peak market hours.

II.5.2.5 ICT-based Services Used in Tanzania

Farmer Voice Radio (FVR): The Farmer Voice Radio (FVR) initiative, in collaboration with the Sokoine University of Agriculture and the American Institutes of Research, has developed a radio-based agricultural extension model backed by ICT tools. FVR connects farmers and extension officers through interactive radio programs, with mobile phones facilitating feedback and desktop computers supporting program preparation and archiving. Farmers actively participate by selecting seasonal topics and hosting discussions, ensuring the content aligns with their immediate needs (FVRPRS, 2012).

Global System for Mobile Association (GSMA): Tanzania has incorporated ICT into its national development agenda since 2003. GSMA Mobile for Development supports six active projects to advance mobile-based solutions in agriculture. These initiatives use mobile technology to offer market intelligence, peer-to-peer learning, data collection, weather updates, and agricultural guidance. Two key GSMA mAgri tracker projects, Tigo Kilimo and Z-Kilimo, deliver actionable insights to farmers via SMS, IVR, and unstructured supplementary service data platforms. These services cover agronomic practices, market pricing, and weather

forecasts, ensuring information is accessible to farmers across multiple channels (GSMA, 2024).

Purchase for Progress (P4P): Launched in 2008 by the United Nations World Food Program, the P4P project connects small-scale farmers with reliable buyers, offering fair crop prices. This initiative utilizes web-based platforms, 3G networks, and wireless technologies across 20 pilot nations, including Tanzania (WFP, 2024). GeoPoll: This is a global mobile survey platform that empowers African farmers with essential farming insights, including market pricing and regulatory requirements (GeoPoll, 2024).

II.5.2.6 ICT-based Services Uganda

SUFACE: To transition from basic outreach initiatives to sustainable engagement with agricultural communities, Makerere University's School of Agricultural Sciences initiated the Community Action Research Project (CARP) titled *"Developing Outreach Framework for Strengthening University-Farming Community Engagement for Improved and Sustainable Livelihoods (SUFACE)"*. This study focused on developing an ICT-driven mechanism for farmers to access resources from a university information centre, referred to as the SUFACE-ICT platform (Ebanyate, 2016).

Ensibuuko is a digital platform that combines web and mobile applications to assist Savings and Credit Cooperative Societies (SACCOS) comprising small-scale farmers in Uganda. It facilitates savings mobilization and enables faster, easier loan disbursements and repayments using SMS and mobile money. Founded by two young Ugandans familiar with the challenges rural farmers face in securing financing, Ensibuuko has reached over 10,000 farmers through agricultural cooperatives and savings groups. Mobis (Ensibuuko App) is a mobile application developed by Ensibuuko to manage loans and credits for smallholder farmers and agricultural

cooperatives (Ensibuuko, 2024). Redcore Interactive specializes in facilitating international money transfers directly to mobile money accounts (Redcore Interactive, 2024). SmartMoney offers a cost-free, branchless mobile banking service tailored to underserved rural populations in Uganda and Tanzania (SmartMonney, 2024).YieldUganda is a platform which connects producers to local and export markets by sourcing high-quality, traceable food products in Uganda (Lohento, 2015).



Chapter III. LITERATURE REVIEW

III.1. Introduction

In the 21st century, agriculture has emerged as one of the most diverse sectors, significantly contributing to rural incomes and ensuring long-term economic stability. It generates various activities that impact farmers, stakeholders, consumers, and governmental entities. Information and Communication Technologies (ICTs) have played a transformative role in disseminating vital agricultural information across developing nations. These countries, including those in the East African region—the focus of this study—are now linked with developed nations, gaining access to the latest advancements in weather forecasting, natural resource management, and other critical agricultural information (Ogada et al., 2020). This section will explore the diverse definitions of ICTs and examine existing research on key topics such as the adoption of ICTs in the agricultural sector, the tools and facilities employed, and the effectiveness of ICTs in enhancing farmers' incomes.

III. 2 Adoption of ICTs in the Agriculture Sector

ICT innovations play a crucial role in Africa's agricultural sector, with numerous studies examining their adoption and impact over the years. Aleke et al. (2011) investigated the adoption of ICT solutions such as internet access, computers, and online portals among small agribusinesses in indigenous Nigerian communities. They discovered that social factors, including language and traditional life, significantly influence the adoption of ICT innovations. Hence, striking a balance between technological design and these social imperatives is essential for successful ICT adoption.

Lee et al. (2012) introduced the concept of *co-innovation*, a paradigm where diverse stakeholders collaboratively contribute to new solutions. Their findings emphasize the importance of government support and robust social networks for ICT adoption. They

examined ICT use in Kenya's dairy sector, finding that it improved market access and pricing negotiations for farmers. However, the high costs of these technologies posed a significant adoption barrier.

Addressing challenges like climate change, food security, and rural livelihoods has driven ICT innovation in developing countries. Zewge & Dittrich (2017) described initiatives such as the Great Green Wall, which used ICT solutions like remote sensing and databases for land use management, governance, and investment planning. He observed the growing role of ICT in rural development but noted a lack of substantial research on its application in agriculture despite its labour-intensive nature in Africa.

More researchers, such as Lwoga & Sangeda (2019) highlighted the limited evidence on ICT's long-term impact on livelihoods, underscoring the need for sustainable ICT adoption strategies. He emphasized integrating diverse frameworks to promote ICT-led sustainable development, providing baseline data for rural populations, noting the challenges in obtaining quality data for innovation studies.

The rapid growth of mobile technologies has also been a focus. Mujeyi et al. (2021) explored the role of mobile phones in providing weather and market information in Ghana, concluding that social networks and extension services significantly influence adoption. He also found that access to ICT tools like radios, TVs, and mobile phones positively impacted farmers' welfare and facilitated the adoption of climate-smart agriculture.

III. 3 Factors influencing use of ICT among smallholder agricultural enterprise

In agricultural enterprises, the utilization of information and communication technologies (ICT) is influenced by several diverse factors, including the type of agri-business, the inherent attributes of farmers, characteristics of the enterprise, objectives, and the surrounding cultural norms. These elements exhibit both direct and indirect interactions, impacting ICT usage either

favorably or unfavorably. Additionally, the adoption of ICT within an agricultural enterprise depends on its perceived usefulness (Alvarez, 2006)

Key factors affecting ICT adoption in the dairy sector include the expense of technology, insufficient training, lack of technological infrastructure, limited ICT proficiency, inadequate awareness of ICT benefits, complexity of use, trust in the ICT system, system integration challenges, and software availability. These barriers hinder the adoption of ICT by stakeholders in the dairy sector. (Ehud et al., 2012)

Oduwole et al (2009), through multiple regression analysis, examined variables influencing ICT adoption in Nigerian agricultural enterprises. They identified that computing knowledge, the type of ICT facilities utilized by respondents, operational knowledge of these facilities, search for business-related information, and the nature of business operation data sought significantly impacted ICT utilization. Perception factors that notably influenced ICT adoption included views on its effect on profitability, levels of ICT usage, internet skills, and the use of ICT for primary tasks like record processing. Thus, these factors are critical for ICT adoption among produce marketers.

Sabuhoro (2003) conducted a study in South Africa to identify factors influencing computer use among agricultural enterprise owners. Their findings revealed that larger household sizes were generally associated with increased ICT adoption compared to smaller households. Individuals with lower annual or monthly income typically had minimal access to ICT, while higher income levels corresponded with greater probabilities of ICT adoption. Education was positively correlated with technology adoption; farmers with post-secondary qualifications were more likely to utilize ICT.

Further, Sabuhoro investigated gender's influence on ICT adoption and found that male owners of agricultural enterprises were more inclined toward ICT usage than their female counterparts,

due to easier access and a greater willingness to adopt technology. Boadi et al. (2007), in their study on the role of mobile commerce in Ghana, identified significant factors affecting ICT adoption, such as perceived profitability impacts, levels of ICT usage, internet proficiency, and ICT utilization for primary functions like record processing. These factors were deemed crucial for ICT adoption among produce marketers.

Farmers with income sources outside farming were more likely to adopt ICT compared to full-time farmers. ICT adoption probabilities increased for those with off-farm employment. Conversely, barriers like insufficient training, high costs, limited technical expertise, and lack of education negatively influenced ICT adoption. Experienced farmers were generally more inclined to adopt ICT, although this also depended on factors like age, as some older, experienced farmers resisted change, favoring traditional farming methods. Additionally, agricultural enterprises located near development hubs had better access to ICT compared to those in remote areas. Finally, enterprise owners with positive attitudes toward ICT adoption were more likely to utilize it effectively, whereas negative attitudes hindered usage (Alvarez, 2006).

III. 4 Effect of ICT on the Performance of Agricultural Enterprises

Agricultural information services are essential for enabling agricultural entrepreneurs to make informed decisions about agricultural production and post-harvest practices (Mtega et al., 2016). ICT facilitates access to these services, serving as a channel to build local capacities, integrate modern and traditional knowledge, and enhance profitability in agricultural enterprises. Compared to other mediums of information dissemination, ICT can potentially increase both the speed and efficiency of information access. Certain ICT tools enable interactive communication, overcoming distance, volume, medium, or timing barriers.

Many agricultural enterprises benefit from ICT by accessing improved information flows, enabling timely access to necessary data, and ultimately improving agricultural practices and business performance. ICTs are particularly effective for sharing agricultural knowledge and providing multiple services simultaneously due to their interactive capabilities (Kilima et al., 2016). For example, mobile phones significantly enhance the performance of agricultural enterprises by supporting communication and facilitating financial services like mobile banking and money transfers.

In Kenya, mobile money services such as M-Pesa (Safaricom) and Airtel Money (Airtel) have revolutionized the financial landscape, with M-Pesa alone serving around 18 million users through 85,000 agents nationwide. Competition from providers like Equity Bank's Finserve and Mobile Pay's Tangaza and Zioncell has further advanced mobile banking services. Intense price competition among service providers has allowed agricultural enterprises to conduct transactions and access funds more affordably. For instance, in 2013, M-Pesa transactions accounted for 87% of Kenya's GDP (CBK, 2013). Similarly, Vodacom in Tanzania processed transactions worth 35 billion Tanzanian shillings daily by October 2012, underscoring the potential of mobile banking to drive investment in agricultural enterprises.

Mobile phones empower agribusiness stakeholders by enhancing bargaining power, increasing control over external factors, and expanding market opportunities (Nordström, 2008). The World Bank (2015) noted that ICT enables direct marketing, eliminating intermediaries, reducing transaction costs, and boosting profits. Farmers can directly communicate with international customers, improving service delivery, lowering risks, and enhancing operational efficiency in sectors like the wine industry.

III.5 Tools and facilities

Agriculture serves as the primary livelihood source for most families in East Africa. Addressing agricultural challenges to prevent famine and improve rural livelihoods is vital. Access to agricultural information has been identified as a crucial factor in enhancing small-scale farm production (G Masuki et al., 2010). Information and Communication Technologies (ICTs) are pivotal tools for providing such information, aiding farmers in boosting productivity and adapting to environmental challenges such as climate change (Heeks, 2019)

III.5.1 Mobile Phones

One of the most accessible ICT tools in developing countries is the mobile phone (Esselaar et al., 2011). Mobile phones are valued for their affordability, wide coverage, and ease of use. They enhance efficiency across agricultural supply chains (Amir et al., 2016). However, studies on mobile telephony's developmental contributions often fail to consider the dynamic interactions within the agricultural value chain. Instead, they typically adopt a linear approach, overlooking the interdependencies and feedback loops throughout the farming life cycle.

For example, in Cross River State, Nigeria, Ogbeide (2015) explored mobile phone use among farmers. They found that younger farmers use mobile phones more than older ones, with a focus on seeking marketing information over other agricultural activities. Similarly, Ogunniyi and Ojebuyi (2016) studied mobile phone use among farmers in Southwest Nigeria. They reported that while the radio feature is frequently used, voice calls are the most common service. Mobile phones increased productivity, income, and reduced costs, but infrastructural challenges, especially unreliable electricity, hindered broader adoption.

In Ghana and Uganda, Niemi et al., (2015) found that while many farmers owned mobile phones, they were not widely used for accessing market information. They concluded that better marketing information via mobile phones could efficiently link buyers and sellers,

leading to better prices for farmers. Tadesse (2017) made similar observations in rural Ethiopia, noting limited use of mobile phones for information searches due to the lack of relevant content. He observed that farmers who used ICT obtained better prices and sold more than those relying on traditional channels. This trend was particularly true for farmers producing large volumes or high-demand crops.

Other studies identified factors influencing ICT adoption. Kante et al., (2017) used structural equation modeling to show that perception, information simplicity, and quality are key determinants of ICT use by farmers. He highlighted how mobile phones in Ghana improved connectivity for fishermen, providing security at sea, reducing intermediaries, and lowering costs.

A common limitation of these studies is their focus on isolated components of the farming lifecycle. For instance, none explored the potential of mobile phone video functionality for enhancing quick learning of production and post-harvest practices. The use of low-cost participatory videos for documenting and sharing farmer-led innovations remains underexplored.

Participatory video offers a promising avenue for capturing and disseminating personal, meaningful farmer innovations, which are often overlooked by traditional extension networks. While mobile phones are a key enabler of agricultural information sharing in marginalized areas, their potential for participatory video usage should be further investigated to unlock their full potential. This approach could transform information dissemination, fostering faster adoption of effective practices in agriculture.

III.5.2 Internet

Berman (2008) highlighted the transformative role of new ICT methods in driving development in emerging countries. Notable advancements in ICT usage in remote areas have been observed

in India and Sri Lanka. In India, initiatives like the Proletarian Organization, funded by the government and United Nations agencies, adopted a participatory, bottom-up approach to enhance development projects. These efforts included establishing Virtual Knowledge Centers (VKCs) equipped with computers, internet access, and communication systems. These centers played a pivotal role in empowering farmers through capacity-building initiatives, including the use of loudspeakers for disseminating vital agricultural information.

Kiomi & Assumpção (2007) emphasized the value of community internet access centers, which offer significant benefits to rural farmers. These centers serve as examples of successful local government initiatives, often supported by international experiences. They illustrate the potential of collaborative efforts between federal and local governments and civil society organizations in creating digital opportunities in rural areas. Such technologies not only benefit farmers and fishermen but also extend advantages to broader communities.

Furuholt and Matotay (2010) explored the intermediary role of the internet in agricultural development. For example, Bangladesh's DNet project enabled farmers to access information through intermediaries. Farmers sent inquiries via mobile phones to the Pallitathya Kendra Rural Information Centre (KRIC), where operators accessed the internet and provided tailored responses, including advice on pesticide use. In India, similar initiatives used megaphones to relay weather forecasts and agricultural updates from the internet. Rao (2020) described the Information Village Research Project in India, where computer centers in fishing villages connected farmers and fishermen to real-time weather reports from the Indian Meteorological Office. These updates, broadcast via loudspeakers and VHF radios, improved safety and productivity by informing fishermen of sea conditions and assisting farmers with pesticide application.

III.5.3 Television

Television has played a crucial role in agricultural development by connecting rural communities and disseminating knowledge. Murty et al. (2012) argue that television broadcasts of agricultural programs provide farmers with access to scientific knowledge and expert advice. In countries like India and Ethiopia, television has proven vital for sharing agricultural information, offering an accessible medium for farmers to learn innovative techniques. Salleh (2010) emphasized that the effectiveness of agriculture-related television programs depends on community engagement and mobilization. Nazari and Hasbullah (2011) observed that television is a preferred medium for agricultural communication in South Asian countries such as India, Pakistan, Bangladesh, and Sri Lanka due to low literacy rates. Farmers can quickly access valuable insights on pesticide use and modern farming techniques. Television producers and directors have been encouraged to prioritize agricultural content for sustainable development.

III.5.4 Radio

Radio remains an effective tool for disseminating agricultural information, especially in rural areas. A study in the Bhawalpur district of Punjab, Pakistan, revealed that radio was instrumental in educating farmers about agroforestry and agri-business news. Similarly, in Nigeria, radio programs provided valuable information on livestock and fisheries, proving to be a prominent communication channel among farmers (Autónoma D et al., 2004) . He highlighted the positive impact of radio broadcasts, noting that farmers actively listen to agricultural programs. Radio's multidimensional capability makes it a powerful medium for spreading agricultural, scientific, and technical information in developing countries.

Radio has also been instrumental in areas with limited access to electricity, serving as an essential source of education, health updates, agricultural news, and weather forecasts. Murty

and Albino (2012) underscored that the success of agricultural development programs often hinges on effective use of mass media like radio. For illiterate farmers, radio provides a reliable channel for staying informed about advancements in agriculture, research findings, and innovative farming techniques. They concluded that radio remains a vital medium for agricultural development in regions with low literacy rates, such as East Africa. Radio broadcasts new ideas and scientific information, helping farmers improve productivity and adopt modern techniques. It has brought transformative changes in agriculture by enabling access to critical knowledge in remote areas, fostering socio-economic growth.

III.6 Contribution to the Literature

This work is going to extend the existing knowledge by providing information concerning the ICT tools and means that are primarily used in the target in the targeted area. This information will be helpful because it will guide the decision makers and stakeholders in knowing where to focus their energy on what is necessary for farmers.

The work will also compile some empirical evidence of the effectiveness of ICT tools and means in production, marketing, and finance access and transactions. It will also tackle the different hindrances to farmers' adoption and use of ICT tools and means and suggest adequate solutions for optimizing their use of ICTs.

In short, the research was conducted to answer the following questions:

1. What are the economic characteristics of the countries in the study area?
2. What are the devices and platforms available for farmers in the study area?
3. Do ICTs helpful in the influence in increasing production
4. Do ICTs play any significant role in market access for farm produce?
5. Do ICTs present advantages in accessing and managing finances and transactions?

6. What challenges do farmers encounter in the use of ICTs?
7. What are the possible solutions to those challenges in East Africa?



Chapter IV. THEORETICAL AND CONCEPTUAL FRAMEWORKS

IV.1 Introduction

A theory is a systematic explanation or abstract generalization that describes relationships among phenomena, aiming to explain, predict, and control these phenomena. Within research, theory serves as a foundational element, helping to identify the starting point of a research problem and shaping the direction toward which the investigation is oriented.

Theories act as conceptual tools, offering researchers different "lenses" through which to examine complex problems and social issues. These lenses focus attention on specific aspects of the data, allowing researchers to prioritize certain elements while providing a structured framework for analysis (Reeves et al., 2008) . This structured approach enhances the clarity and depth of research, guiding the interpretation of findings and their implications.

IV.2 Theories/Model

Several theoretical frameworks can be applied to the study of Information and Communication Technologies (ICTs) in agriculture in the context of this research. Among the most relevant are the Diffusion of Innovation Theory (DOI), the Technology Acceptance Model (TAM), and the Theory of the Firm.

IV.2.1 The Diffusion of Innovation Theory (DOI)

Rogers (2005) introduced the diffusion of Innovation Theory (DOI), which explains how an innovation or new idea spreads within a social system over time. The process of diffusion involves the communication of innovations through various channels, influencing the adoption rates among individuals or groups, particularly smallholder farmers, in the case of agricultural innovations.

Rogers' Diffusion of Innovation Theory has been foundational in extension theory and practice, and it is central to understanding how agricultural technologies or ideas are adopted by farmers

This theory is especially useful in agricultural development as it helps identify factors that influence the adoption of new technologies. Diffusion of Innovation theory classifies individuals into different adopter categories based on their readiness to adopt new technology. These categories include the innovators who are the first to adopt and experiment with new technology. There are also the early adopters who are leaders within the community who influence others. Then comes the early majority who adopts after the technology has been proven. They will be followed by late majority who adopts when the innovation becomes widely accepted, then the laggards: this is the resistant to change and slow to adopt new technology (Rogers, 1995). This categorization is particularly relevant in agriculture, where farmers' willingness to adopt innovations can vary significantly.

The characteristics of the innovation itself are critical to its adoption. Rogers identified several attributes that influence adoption. He mentions the Relative Advantage, which has to do with the perceived benefit or improvement over existing practices such as higher yields, cost savings, or environmental benefits. For instance, a new drought-resistant crop variety might have clear benefits in arid regions.

With compatibility, he wants to show how well the innovation fits with existing practices and values. For example, organic fertilizers might face resistance in conventional farming systems. About complexity, he refers to the ease or difficulty of understanding and using the innovation can be a hindrance to adoption of innovation in agriculture. For instance, precision farming technologies may appear too complex for smallholder farmers without proper training.

When it comes to trialability, he describes it as the ability to test the innovation on a small scale before full adoption. Farmers may experiment with a small plot of land before committing to a new seed variety. Observability implies the extent to which the benefits of the innovation are visible to others. Neighbors observing a farmer's increased yield from improved irrigation

systems can encourage adoption. These attributes determine the perceived value of the innovation and influence its rate of adoption.

Communication channels are essential for the diffusion process. These can include the Extension Services through which the Agricultural advisors and experts providing information to farmers. There are also Farmer Cooperatives and Agricultural Associations where peer networks can facilitate the spread of knowledge. Sometimes there are Community Networks which playing the role of channels of informal communication among farmers, which can significantly impact their decision to adopt innovations (Oresanya & Olajide, 2023). Diffusion occurs over time, and the time it takes for an innovation to spread influences its adoption rate. The complexity of the innovation also affects how long it takes for farmers to adopt it. Simpler innovations are more likely to be adopted quickly, while complex innovations may take longer to gain acceptance as farmers adjust their beliefs and practices to incorporate the new technology.

By understanding these factors, policymakers and extension workers can design more effective programs to promote the adoption of ICTs and other agricultural innovations. The Diffusion of Innovation Theory provides valuable insights into how different agricultural technologies can be introduced to farming communities and how they can be successfully adopted and integrated into existing farming practices.

IV.2.2 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is a widely accepted framework in the field of information systems that aims to understand and predict the acceptance and use of technology by individuals or organizations. Davis developed TAM in 1989 and posits that two key factors—Perceived Usefulness (PU) and Perceived Ease of Use (PEOU)—are the main predictors of an individual's intention to use technology. The PU is the extent to which a person

believes that using a particular technology will enhance their performance or make tasks easier, while the PEOU is the degree to which a person believes that using the technology will be free of effort.

In the context of agriculture, TAM has been used to explore how farmers and agricultural stakeholders adopt and use various Information and Communication Technologies (ICTs) to improve farming practices (Sekhon et al., 2010). In TAM, perceived usefulness refers to how much a person believes that using a particular technology will enhance their job performance. For farmers, this could mean believing that using an ICT tool, such as a farm management app or precision agriculture technology, will result in increased productivity, better decision-making, or improved farm management.

For the case of perceived ease of use in agriculture, this component assesses how easy it is to use a technology. In agriculture, this could relate to the user-friendliness of ICT solutions. If the technology has a simple interface, clear instructions, and is easy to navigate, farmers are more likely to perceive it as easy to use (Legris et al., 2003)

According to TAM, an individual's attitude toward technology is influenced by both perceived usefulness and perceived ease of use. In agriculture, if farmers believe that an ICT tool will help them and is easy to use, they are more likely to develop a positive attitude toward adopting it, which will increase the likelihood of its use. TAM suggests that a person's intention to use a technology is a strong predictor of whether they will actually adopt it. For farmers, their intention to use a specific ICT tool—based on its perceived usefulness and ease of use—will determine whether they incorporate it into their farming practices (Tornatzky & Klein, 1982).

While intention is important, TAM acknowledges that actual use may not always follow intention. Factors such as availability, accessibility, training, and support systems also play a crucial role in determining whether farmers will adopt and use the technology in practice.

External factors, such as social influence, government initiatives, or extension services, also impact technology adoption. In agriculture, peer influence, support from local agricultural institutions, and initiatives from governments or NGOs can significantly affect farmers' decisions to adopt ICT solutions.

By applying TAM to agriculture, researchers can understand the factors influencing farmers' decisions to adopt and use ICTs. The Technology Acceptance Model provides a structured way to analyze and address the barriers to ICT adoption in agriculture. By focusing on perceived usefulness and ease of use, stakeholders can design ICT solutions that resonate with farmers' needs, improving their adoption and impact. Additionally, addressing external variables like trust, infrastructure, and cultural factors can enhance the effectiveness of ICT interventions in agriculture.

IV.2.3 The Theory of the Firm

The Theory of the Firm is a foundational concept in economics that focuses on the determination of goods, outputs, and income distributions in markets through supply and demand. It explains how firms make decisions to maximize profits by optimizing their inputs and outputs. According to the Theory of the Firm, firms exist to close the gap between revenue and costs (Murphy et al., 2022).

In the Theory of the Firm, technology is considered a key input in the production process, along with labor, capital, and raw materials. ICTs are increasingly seen as an essential input for firms, enabling enhanced efficiency, communication, automation, and better management of operations (Ahmad et al., 2023). The Theory of the Firm examines how businesses operate, make decisions, and interact with markets to achieve objectives such as profit maximization, efficiency, or growth. When applied to ICT in agriculture, this theory helps to analyze how agricultural enterprises (including individual farms, cooperatives, and agribusinesses) adopt

and use ICTs to improve decision-making, reduce costs, and increase productivity. Here is how the Theory of the Firm relates to ICT and agriculture:

The Theory of the Firm emphasizes how firms allocate resources efficiently under constraints such as cost, labor, and technology. ICTs in agriculture enable better decision-making by providing real-time data (weather forecasts, soil health monitoring, and crop disease alerts help firms optimize input use), market information (ICT platforms providing real-time price updates allow firms to decide where and when to sell their produce for maximum profit), and risk management tools (Information on pest outbreaks or climate risks can guide firms in taking proactive measures. For example, a farmer deciding whether to invest in fertilizer or pesticide can use ICT tools (e.g., crop advisory apps) to predict the likely returns from these inputs based on current conditions (Tirole, 1988).

The Theory of the Firm posits that firms aim to minimize production costs for a given level of output. ICTs in agriculture can significantly reduce costs by improving resource allocation, reducing transaction costs, labor-saving technologies. For example, using a drone for pest control minimizes the cost of pesticides by targeting affected areas instead of spraying entire fields, and reduces labor work (Hall & Hitch, 1939).

According to the Theory of the Firm, firms seek to maximize output for a given set of inputs. ICTs enhance agricultural productivity by enhancing precision (GPS-enabled machinery ensures precise planting, fertilizing, and harvesting, maximizing yields), knowledge transfer (Internet extension services and mobile advisory apps provide farmers with timely advice, improving farming techniques), and monitoring and evaluation (ICT systems like remote sensing or satellite imagery help track crop health, allowing corrective action). For example,

smart farming tools provide continuous feedback on soil conditions, ensuring optimal planting strategies, (Ahmad et al., 2023)

The Theory of the Firm also focuses on firms' responses to market forces. ICTs in agriculture improve market access and profit opportunities through the following elements: 1. Price discovery: ICT platforms like mobile apps or online marketplaces offer farmers real-time price information, enabling better negotiation. 2. Market access: digital platforms connect farmers to buyers, expanding market reach. 3. Value addition: ICT tools like traceability systems help firms meet market demands for transparency, boosting competitiveness. A farmer using an e-marketplace app can compare prices in multiple markets and choose the most profitable option

The Transaction Cost Economics component of the Theory of the Firm highlights how ICTs can lower transaction costs in agriculture. Transaction costs can be reduced by supply chain integration: ICT tools like blockchain reduce information asymmetry by providing transparency in transactions between farmers, processors, and retailers. They can also be reduced by coordination efficiencies: ICT platforms allow real-time coordination among stakeholders, minimizing delays and misunderstandings. A digital platform enables seamless communication between a farmer, transporter, and buyer, reducing post-harvest losses (Hall & Hitch, n.d.).

In short, the Theory of the Firm offers a valuable lens for understanding how agricultural enterprises—whether smallholder farmers or large agribusinesses—adopt ICTs to enhance efficiency, reduce costs, and maximize profits. By addressing challenges such as accessibility, affordability, and digital literacy, stakeholders can leverage ICTs to transform agriculture and align with the principles of the Theory of the Firm

IV 3. Hypothesis.

This research will be based on the following hypothesis:

H1: The use of ICTs for agricultural services improves farmers' knowledge and skills, leading to increased incomes.

H2: ICT adoption among farmers positively influences agricultural productivity.

IV.4 Conceptual Framework

This study is guided by the modified Ospina and Heeks (2019) conceptual framework, which emphasizes the transformative role of Information and Communication Technologies (ICTs) in agricultural production and poverty reduction. The framework is focused on enhancing access to agricultural information services, which can significantly impact farmers' decisions regarding agricultural practices and post-harvest activities. Key Elements of the Conceptual Framework are the role of ICTs in agricultural transformation, the factors influencing ICT usage in agriculture, and the benefits of ICTs in agriculture.

IV.4. 1. Role of ICTs in Agricultural Transformation

The modified Ospina and Heeks framework illustrates how ICTs can act as catalysts for change in the agricultural sector. By providing farmers with access to vital agricultural information, ICTs enable farmers to make informed decisions that improve their productivity and income. This access helps in addressing challenges such as inefficient farming practices, market uncertainties, and post-harvest losses.

IV.4. 2. Factors Influencing ICT Usage in Agriculture

For ICTs to be effective tools in agricultural transformation, several factors must be in place. First and foremost, infrastructures facilitating internet connectivity, electricity distribution need to be reliable, and devices have to be accessible in order to insure the effective use of

ICTs by farmers. Then the tariffs have to be affordable: this includes the costs of data, devices, and services. High costs can limit farmers' ability to access and use these technologies. Also, farmers need appropriate skills to utilize ICT tools effectively. This requires training and capacity-building efforts that empower farmers with the technical know-how to engage with ICT solutions. Last but not the least, agricultural information must be provided at relevant times for ICTs to be effective. Programs that deliver agricultural advice through mass media or digital platforms must be timed to coincide with key decision-making periods in farming.

IV.4. 3. Benefits of ICTs in Agriculture

When implemented and used correctly, ICTs offer several benefits that enhance agricultural productivity and livelihoods. First of all, access to real-time agricultural data enables farmers to make better-informed decisions related to planting, harvesting, and marketing helps the farmers to make improved decisions. Then the ICT tools support precision agriculture practices, lead to higher yields and more efficient use of resources, and all this lead to increasing the productivity. The ICTs play an important role in enhancing market access, that is, they enable farmers to access information about market prices, which can help them make better decisions about when and where to sell their produce, thus increasing profits.

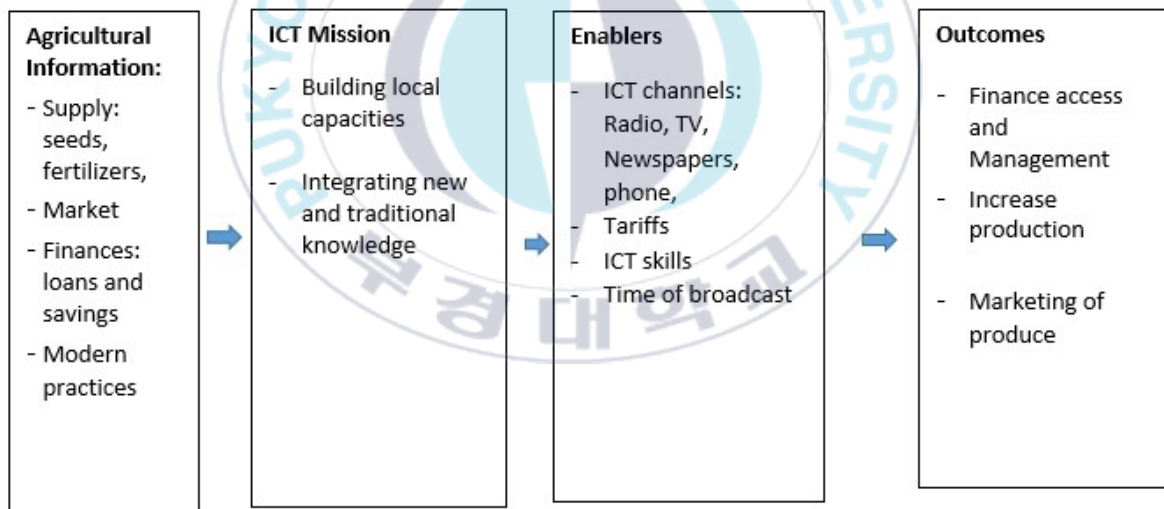
ICTs also bridge the gap between traditional farming knowledge and modern agricultural practices, allowing for the integration of both types of knowledge to improve farming outcomes. Moreover, ICTs are essential for building local agricultural capabilities: by facilitating access to information, ICTs enable farmers to integrate new agricultural knowledge with traditional farming practices, which can help improve sustainability and productivity in the long term. All in all, the ultimate goal of using ICTs in agriculture, according to the framework, is to improve the livelihoods of farmers and other actors in the agricultural sector. When farmers adopt and

integrate ICTs into their farming practices, they can see improvements in their productivity, income, and overall well-being, contributing to poverty reduction in rural areas.

FIGURE 4.1: MODIFIED OSPINA AND HEEKS’ CONCEPTUAL FRAMEWORK

The modified Heeks & Ospina conceptual framework offers a comprehensive guide for understanding the role of ICTs in agriculture. It highlights the importance of infrastructure, affordability, skills, and the timely provision of information in ensuring the effectiveness of ICTs in transforming agricultural practices. The framework also underscores the broader impact of ICTs in improving agricultural productivity, enhancing livelihoods, and fostering rural development.

FIGURE 4.1 OSPINA AND HEEKS CONCEPTUAL FRAMEWORK



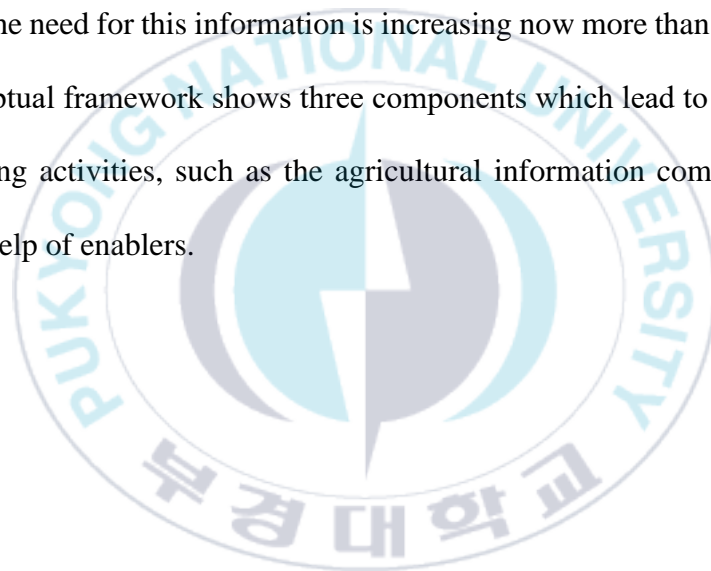
Source: Ospina and Heeks (2012)

IV.5 Conclusion

This study is based on two theories and one model, which altogether provide a suitable framework within which to conduct the analysis. The Diffusion of Innovations Theory will

help policymakers, extension services, and agricultural advisors better to understand the dynamics of technology adoption within farming communities. The Theory of the firm shows how firms operate and competitively make decisions in the modern, and ICT plays a role of paramount importance in resource allocation and the organizational structure of the firm. All of these frameworks give a strong point to adopting ICTs in the agricultural sector, which will enhance productivity.

Like with other economic sectors, effective agricultural development requires access to information on all aspects of agricultural production, processing marketing, and selling, and it seems likely that the need for this information is increasing now more than ever before. Ospina and Heeks' conceptual framework shows three components which lead to the effectiveness of the ICTs in farming activities, such as the agricultural information combined with the ICT mission with the help of enablers.



Chapter V. METHODOLOGY

V .1. Introduction

This study will use qualitative content analysis methodology using Nvivo, a software used in qualitative analysis (Nvivo, 2024). A directed content analysis will be used as approach to this study to shed light on the importance of ICTs for the profitability of farming activities. According to Zhang & Wildemuth (2022), research using qualitative content analysis focuses on the characteristics of language as communication with attention to the content or contextual meaning of the text. In this section we will define our methodology and justify our choice. We will also present the advantages and disadvantages compared to other methodologies, and then we will present our data profile.

V. 2. Definition and Purpose

Qualitative content analysis is a research method used to subjectively interpret the content of text data by systematically classifying it, coding it, and identifying themes or patterns within the data. It is a process that helps researchers gain insight into the meaning behind text, moving beyond simple word counting to focus on the underlying themes and messages conveyed. Qualitative content analysis involves the subjective interpretation of text data through classification and coding to identify significant themes or patterns. It seeks to understand the phenomenon under study by examining language carefully and categorizing text in a meaningful way.

Zhang & Wildemuth (2022) emphasize that qualitative content analysis is empirical, controlled, and context-based, which distinguishes it from other methods that may be more quantitative in nature. Unlike traditional content analysis, which may focus on counting words or occurrences, qualitative content analysis focusses the identification of deeper meanings. The method examines the language in detail and categorizes large amounts of text into a

manageable number of themes or categories that share similar meanings. These categories may represent either explicit or inferred communication, contributing to a more nuanced understanding of the text.

The primary goal of qualitative content analysis is to derive knowledge and understanding from the data. The method's aim is not simply to quantify text but to interpret it in a way that highlights patterns and key insights related to the phenomenon being studied. One of the strengths of qualitative content analysis is its flexibility, making it suitable for a wide range of research contexts. Cavanagh (1997) notes that content analysis can be applied across various disciplines and is adaptable depending on the research objectives. It ranges from more impressionistic, intuitive, and interpretive analyses to more systematic and structured approaches.

The type of content analysis approach selected depends on the theoretical framework and specific research questions being addressed. Researchers may choose a more structured or more flexible method depending on the nature of their study and the data available. However, this flexibility can also lead to ambiguity, as the method lacks a single, universally accepted definition or procedure can limit its application.

In summary, qualitative content analysis is a dynamic and adaptable method for analyzing textual data. It is primarily concerned with identifying patterns, themes, and underlying meanings, helping researchers understand the deeper significance of textual content. Despite its flexibility, the lack of a standardized procedure can sometimes pose challenges in ensuring consistency across studies. However, when applied appropriately, it can provide valuable insights into complex phenomena.

V.3 Advantages and disadvantages

Qualitative content analysis is one of several research methods used to examine text data. Other methods include ethnography, grounded theory, phenomenology, and historical research. Ethnography, often referred to as cultural anthropology or naturalistic inquiry, is one of the main approaches in qualitative research, with its origins in anthropology. However, it is not suitable for our study as it focuses on discovering and describing the culture of a group. The core theme of ethnographic research is centered on cultural exploration (Lata Sharma & Sarkar, 2019)

Grounded theory is a widely recognized methodology used in many studies, combining both qualitative and quantitative data collection methods. This approach aims to develop or construct a theory based on data systematically collected and analyzed through comparative analysis. However, the primary challenge with this approach lies in its goal of constructing theory directly from the data, which can be complex and time-consuming. Phenomenology, on the other hand, is an approach focused on describing the essence of a phenomenon by exploring it from the perspective of those who have experienced it. The objective of phenomenology is to capture the meaning of an experience in terms of both its content and the way it was experienced (Teherani et al., 2015). However, this approach is not suitable for our study.

Historical research, which involves using primary and secondary sources to investigate past events, is also not appropriate for this study. Historians use their scientific knowledge, experience, and intuition to formulate research questions (such as "who was involved in an event?" or "when did it happen?") and then search for relevant information in their sources (Priest et al., 2002) . This approach is not applicable to our research needs.

Qualitative content analysis has several advantages in research. It allows for a direct examination of communication through text, provides valuable historical and cultural insights,

allows for a close examination of data, and enables the statistical analysis of coded text. When performed properly, content analysis is considered a precise research method that is widely understood and cost-effective. However, there are also some drawbacks to content analysis. It can be time-consuming and prone to error, particularly when using relational analysis for deeper interpretation. Additionally, it can be reductive when dealing with complex texts and is often limited to word counts. It is also challenging to automate or computerize (Elo et al., 2014).

Content analysis is commonly used in qualitative research, with three main approaches: conventional, directed, and summative. All three methods aim to interpret the meaning of text data, adhering to the naturalistic paradigm. The primary differences among the approaches lie in the coding schemes, origins of the codes, and challenges related to trustworthiness. In conventional content analysis, coding categories are derived directly from the text data. In the directed approach, the analysis is guided by a theory or existing research findings that inform the initial coding process (Hsieh & Shannon, 2005).

In this study, we have chosen the directed approach, as we aim to provide supporting or non-supporting evidence for an existing theory. The directed approach has the advantage of enabling researchers to confirm or extend existing theories. Moreover, as research in a particular area evolves, a directed approach acknowledges that researchers are unlikely to start from a completely naïve perspective, which is often associated with naturalistic approaches. However, using theory does present challenges to the naturalistic paradigm, as it introduces some bias. Researchers may be more inclined to find evidence that supports the theory, rather than evidence that contradicts it.

V.4 Procedure plan

To address the research questions guiding this study, several steps have been undertaken to collect data that will help achieve the study's objectives. An extensive literature search was

conducted across a variety of reliable and relevant platforms, including the Food and Agriculture Organization (FAO), Google Scholar, government websites, academic journals, and other related publications. The goal was to locate and review the most current literature on the role of ICTs in agriculture, specifically in relation to smallholder farmers.

During the search, the researchers utilized a complex query that combined the following keywords, using Boolean operators ("AND" and "OR") and parentheses for more efficient results: ICT, smart farming, e-agriculture, digital farming, smallholder farmers, small-scale farmers, impact, profit, and sustainable agriculture.

Data processing for this study will be conducted through frequency analysis, using NVivo, a professional software tool designed for qualitative data analysis. NVivo has the capacity to handle large volumes of data, generating word frequencies and identifying themes and codes within the text. A word cloud will be employed to visually represent the dominant themes found in each processed dataset.

Additionally, NVivo will be used to calculate the frequency of specific terms in the data, displaying both the count and the percentage of each term's occurrence. In this study, particular attention will be paid to terms related to ICTs in the context of agricultural production, marketing, and transactions, in order to identify which ICT-related terms are most commonly used in these areas.

V.5. Data Profile.

The data used for this study were collected from four countries, namely Kenya, Ethiopia, Tanzania and Uganda. After the presentation of the data profile, data from each country will be processed and analyzed in order to find out which ICT means are used in the respective countries, and from the impact these ICTs means make on farming activities, we will find out

how important they are for the agricultural development of the farmers who adopted them. The resources we used are made of published articles as well as other official publications.

TABLE 5.1 SUMMARY OF RESOURCES BY COUNTRY AND BY CATEGORY

Country	Published Articles	Gray Literature	Total
Kenya	40	16	56
Tanzania	40	13	53
Ethiopia	41	15	56
Uganda	30	17	47

Source: Author's Compilation by NVivo

During the research, each article was considered alleageable for this study after having a look at its abstract to determine whether it is within the range of what we need. A certain number of resources were rejected either because of their content or because they were duplicated. Then, we remain with **212** resources to process.

Because of the lack of publications in this domain, especially in qualitative research, our research has been extended to the period from 2010 up to date. The data have to be collected from online open resources, and only English publications were considered. The data used for this study had to cover only four countries, such as Kenya, Tanzania, Uganda and Ethiopia. They were considered be because they give more chance to access English publications, and a little more advanced in matters of ICTs use and internet penetration, thus offering a wider range of publications in matters of ICTs and agriculture.

V.6 Conclusion

The qualitative content analysis methodology and the directed analysis approach have been chosen among other options for studying the use of ICTs among small-scale farmers in East

Africa. Regarding their advantages, they are expected to lead us to a good analysis of the collected data. The frequency analysis and the word cloud generated by Nvivo will facilitate the process and analysis of the data and help us determine which tools are mostly used in the selected countries as ICT means suitable for small-scale farmers. Now that we have the data collected, we will proceed with data processing and present our results and discussions.



Chapter VI. RESULTS AND DISCUSSIONS

VI.1 Introduction.

In this digital age, Information and Communication Technologies (ICTs) are central to the development of political, economic and social aspects of human life. In the same way, Smallholder farmers can potentially achieve sustainable agriculture through Information and Communication Technologies (ICTs). They can significantly reduce poverty vulnerability by increasing their incomes and ability to make more informed decisions on various agricultural practices and other matters related to agribusiness Zhang & Wildemuth (2022).

In this section, we will use the from data collected from Kenya, Ethiopia, Tanzania and Uganda to discuss what are the ICT means mostly used by farmers and their impact in the process of production, the sales, and their importance in the finances and transactions, which in overall lead to a positive impact in the rural agriculture productivity and improvement of rural farmers' life of ICTs users.

VI.2 Results from Kenyan Data

VI.2.1 Findings

The word cloud for the data form Kenya shows that information, mobile (associated with phone), and ICT are among the most outstanding themes.

phones	6	1248	0.26
technology	10	991	0.20
technologies	12	867	0.18
communication	13	818	0.17
radio	5	596	0.12
digital	7	472	0.10
telephone	9	239	0.05
electronic	10	180	0.04
computer	8	174	0.04
messages	8	162	0.03
voice	5	161	0.03
call	4	135	0.03
web	3	82	0.02
cell	4	79	0.02
Online library	13	79	0.02
smartphones	11	79	0.02

Source: Author's Compilation by NVivo

The word frequency shows that phones (including phones, mobile, cell, telephone, smartphones, voice, call, and message) come on top as ICT means mostly used in Kenya. They cover a total of 4.01 % of the words of Kenyan data. The internet follows with coverage of 0.15%, radio covers 0.12%, and computers: 0.04. It is obvious that other means, such as the web and online libraries, are used, but at a very low level.

VI.2.2 Evidence of Impacts of ICTs

The use of these ICT means has a positive impact on the livelihood small holder Kenyans farmers. We will consider some evidence in production, marketing and transactions.

VI.3.1 Impact on production

In a study by Casaburi et al., (2015) investigating the impacts of SMS on cultivation practices and harvest losses, a program was implemented where sugarcane farmers in Kenya received SMS messages advising them on field tasks. The intervention took place in two rounds: the first from 2011-2013, and the second from 2012-2014. In the first round, the SMS program resulted in a yield increase of approximately 3.3 tons per hectare, which represented an 8% improvement compared to the control group average. With a 65% sign-up rate for the SMS program in the treatment group, the treatment-on-treated effect was around 11.5%. These improvements were particularly evident among farmers with no prior agronomy training or little interaction with company field staff. However, in the second round, the impact on yields was negligible, although confidence intervals suggested the possibility of large effects.

In terms of financial outcomes, the increase in yield in the first round led to an estimated profit boost of \$43 for the company and \$54 for the farmers, with the program's cost per farmer being about \$0.30. Another example is the M-Farm platform, launched in Kenya in October 2010 by a small start-up. M-Farm aims to improve smallholder farmers' bargaining power and connect them to buyers. The platform provides price information for 47 crops in five markets six days a week via SMS and its website. It also enables farmers to sell collectively to larger buyers through contracts. While M-Farm has encouraged farmers to expand their cultivation of certain crops, it has not necessarily led to the introduction of new crops. For instance, 89% of farmers in Rachuonyo and 62% in Migori reported increasing production of existing crops. However,

only a small percentage of farmers introduced new crops, such as passion fruit in Migori, motivated more by contracts than price information.

VI.2 3.2 Impact on Sales and Marketing

M-Farm's introduction has significantly transformed the way farmers access price information. Before M-Farm, 50% of farmers relied on middlemen for price information, but this dropped to 23% after M-Farm's launch. Nearly all surveyed farmers indicated that M-Farm helped them secure better prices for their produce, and 85% agreed that the service had boosted their income. In terms of sales practices, around 90% of farmers changed the way they sold their produce, with 45% of farmers in Migori selling to collection centers, compared to only 9% in Rachuonyo.

VI.2.3.3 Impact on Finances and Transactions

A study by Kikulwe et al., (2014) in Kenya's banana sector revealed that mobile money use significantly impacted market transactions and profits. Mobile money users were 19% more likely to sell more of their banana harvest in the market compared to non-users. Moreover, mobile money users earned 30.1 thousand Ksh (about \$365) more per acre, representing a 35% increase in banana profits.

Mobile money services, such as M-Pesa in Kenya, have also been shown to improve household resilience to economic shocks. Research by Aker & Mbiti (2010) found that households using mobile money were better able to manage unexpected hardships like job loss or crop failure. Furthermore, mobile money is being integrated into insurance, credit, and savings systems for smallholder farmers. For example, Kilimo Salama, a microinsurance program using M-Pesa, provided payouts to farmers whose crops failed. By 2011, 12,000 farmers were insured, with

10% receiving payouts covering up to 50% of their insured crops, further supporting agricultural growth and improving livelihoods.

The Kikulwe et al.(2014) study also indicated that mobile money use was linked to higher income. For mobile money users, the estimated income boost was 61.5 thousand Ksh (about \$745), a 40% increase relative to non-users' mean income. Furthermore, mobile money users experienced a 66% increase in remittances compared to non-users, with an estimated treatment effect of 12.7 thousand Ksh (about \$154) annually.

VI. 3 Results from Ethiopian Data

VI. 3. 1 Findings

The findings for Ethiopia will help identify which ICT means are mostly used by farmers. Then, we will discuss their impacts on production, sales, and transactions. The frequency cloud for the data from Ethiopia shows that information, ICT, and mobile (phone) are among the most outstanding themes. Radio, Television, and media are also mentioned as minor themes that may play a role in the lives of farmers in Ethiopia.

icts	4	1155	0.22
phones	6	932	0.17
media	5	252	0.05
television	10	177	0.03
telephone	9	174	0.03

Source: Author's Compilation by NVivo

The word mobile, associated to phone, phones, and telephone counts for the most frequent in the date, covering in total 1.13% of the words. We then have radio which covers 0.22%, media 0.05%, and Television 0.03%.

VI.3.2 Evidence of Impacts of ICTs

VI. 3.2.1 Impact on production

According to a report by Lulseged Tamene (2022) on Digital Agriculture, a meta-analysis of six studies revealed that transmitting agricultural information through mobile technologies has led to a 4.7% increase in crop production and a 3.3% rise in animal farming and hunting. In 2022, total grain production reached 335.2 million quintals, with cereals accounting for 88.5% of the total and pulses and oil seeds making up 11.5%.

In Suluta District, a study conducted by Samuel Leta Degefa (2023) involving 296 smallholder farmers showed a strong positive relationship between access to information and household income, with a significant effect at less than 1% significance level. For each unit increase in annual income, the probability of information access under a low category decreased by 4.9%, while access in medium and higher categories increased by 4.2% and 2.7%, respectively, when other factors were held constant.

Tirkaso & Hess (2015) also studied the role of ICT expenditure for cash crop production and income generation in southern Ethiopia. The findings showed a statistically significant relationship between income levels and the use of telephones, with coefficients of 0.81 and 0.99, respectively. This suggests that a 1% increase in household crop income leads to a corresponding 0.81% increase in ICT spending.

VI.3.3.3 Impact on Marketing and Sales

In Tirkaso's above mentioned study, respondents utilize various ICT devices to access product and input-related information. Radio remains a key device for obtaining information (owned by 76% of respondents), but mobile phones have become increasingly important, with 48% of respondents using SMS services for price-related information from the product market and 26% from the input market. Moreover, 92% of respondents believed that using these technologies offers a great opportunity for accessing knowledge and receiving up-to-date information from various sources.

VI.3.3.4 Impact on Finances and Transactions

Households in the same study exhibited varied perceptions regarding the benefits of effective ICT application. For example, 57% viewed using ICTs as a sign of socio-economic development, while 74% believed it would benefit farming and related activities. Furthermore, 88% of respondents thought that ICTs could help minimize transaction costs associated with marketing activities, indicating the importance of ICTs in reducing costs and improving efficiency.

TABLE 6.3: WORD FREQUENCY FOR UGANDAN DATA

Word	Length	Count	Weighted Percentage (%)
information	11	6667	1.06
ict	3	3971	0.63
mobile	6	2153	0.34
technology	10	1708	0.27
icts	4	1678	0.27
phone	5	1036	0.17
technologies	12	1025	0.16
radio	5	801	0.13
computer	8	470	0.07
software	8	421	0.07
media	5	267	0.04
radios	6	149	0.02

Source: Author's Compilation by NVivo

From Table 6.4, we see that the word mobile, related to the phone, represents the most ICT tool used in Uganda. They cover 0.41% of the words in the data. Radio/s is used at a ratio of 0.15, computer is used at a ratio of 0.07%, software represents 0.07%, and media represents 0.04%.

VI.4.2 Evidence of Impacts of ICTs

VI.4.2.1 Impact on Production

In a study conducted by Baumüller (2014) on the impact of information dissemination among farmers in Uganda, it was concluded that price information transmitted through the radio helped Ugandan farmers negotiate 15% higher prices. However, another evaluation of the Ugandan market information service found that while 76% of farmers used the service to learn about prices, only 40% actually used the information to negotiate better prices. He also found that Ugandan farmers who had access to price information via the radio were able to secure 15% higher prices than those without access to a radio, attributing these price increases to improved bargaining skills.

Martin et al., (2011) conducted a study in Kamuli District, Uganda, on the use of mobile phones in agricultural activities. Half of the respondents (49%) reported that mobile phones had a positive impact on their productivity. The use of mobile phones allowed farmers to access agricultural advice and inputs such as labor, seeds, plant cuttings, livestock, and loans from VEDCO or NAADS. Additionally, respondents reported that continual consultations with veterinarians and agricultural experts led to improvements in the health and productivity of their livestock and crops. The mobile phones also facilitated coordination during agricultural emergencies, with nearly 22% of respondents indicating that they were able to manage crises more effectively due to mobile phone usage.

VI.4.2.2 Impact on Marketing and Sales

According to (Martin et al., 2011), mobile phones were also used to negotiate market prices and coordinate with buyers, enabling farmers to save on travel costs and avoid the uncertainty of finding buyers at markets. For example, one male respondent shared that he used to spend

5,000 shillings to travel to larger towns to market his crops but now spends only 500 shillings to call a buyer who comes to him. Approximately 49% of respondents reported saving transportation costs through increased coordination with buyers.

VI.4.2.3 Impact on Finances and Transactions

A study by Munyegera & Matsumoto, (2018) examined the impact of mobile money adoption and found strong evidence that it increases real household per capita consumption. This was largely due to the facilitation of remittances among family members and friends. Households with at least one mobile money subscriber were found to be 20 percentage points more likely to receive remittances from relatives in towns, and the total annual value of remittances was 33% higher for mobile money users compared to non-users.

VI.5 Results from Tanzanian Data

VI.5.1 Findings

The collected and processed for the Tanzanian case will help identify what Tanzanian farmers are normally using as ICT means to enhance their productivity. We will discuss how these means help to improve farmers' earnings.

The frequency cloud for the data from Tanzania shows that information, ICT are among the most outstanding themes. Phone and Mobile are also mentioned as themes which may play an important role in the life of farmers in Tanzania.

Figure 6.4 Word cloud for Tanzanian data



Source: Author’s Compilation by NVivo

In the table below, we have frequency of words generated by Nvivo, from which we will be able to know which ICT means are present in Tanzanian data, and the percentage to which they are represented.

TABLE 6.4 WORD FREQUENCY FOR TANZANIAN DATA

Word	Length	Count	Weighted Percentage (%)
information	11	7595	1.54
ict	3	2532	0.51
mobile	6	2391	0.48
icts	4	2012	0.41
phones	6	1432	0.29
technology	10	1414	0.29

radio	5	1229	0.25
phone	5	971	0.20
technologies	12	968	0.20
internet	8	917	0.19
digital	7	809	0.16
library	7	394	0.08
online library	13	237	0.05
calls	5	112	0.02
cell	4	87	0.02
telephone	9	87	0.02

Source: Author's Compilation by NVivo

Mobile, linked to phone/s, calls, cell and telephone, comes on the top of the most present tools in the data, representing a ration 1.07 %. The radio comes next with 0.25% of representation. We also have the internet which is represented at 0.16%, and libraries represented at 0.13%.

VI.5.2 Evidence of Impact of ICTs

VI.5.2.1 Impact on Production

Empirical research from Tanzania has highlighted the transformative role of ICTs, particularly radio programs and mobile phones, in enhancing the livelihoods of smallholder farmers and improving agricultural productivity. A studies by Pius Mtega & Ronald, (2013) indicates that these technologies are helping smallholder farmers produce more food and cash crops. For instance, Quandt et al. (2020) conducted a study in four rural Tanzanian communities and found a strong correlation between mobile phone use and increased agricultural productivity.

In their study, 67% of respondents reported that mobile phone use increased agricultural profits, while 50% and 47% mentioned that it reduced expenses and time commitments, respectively.

Sife et al. (2010) found that ICTs, particularly mobile phones and radios, have significantly reduced the travel costs for smallholder farmers in rural areas. These farmers no longer need to travel long distances to seek agricultural information, enabling them to allocate more time and resources toward improving agricultural productivity.

VI.5.2.2 Impact on Marketing and Sales

Baumüller (2012) argued that better access to information, such as market prices, improves farmers' bargaining positions by reducing information asymmetries. The ability to access market prices via mobile phones helps farmers compare different markets or buyers, leading to better negotiation outcomes. In a study conducted in Mologoro, Tanzania, (Kilima et al., 2016) found that 58.9% of respondents believed that mobile phones had significantly improved their ability to access market information. Furthermore, farmers reported using mobile phones to directly negotiate prices with buyers and crosscheck prices, bypassing the traditional reliance on middlemen. This shift helped farmers secure better prices for their produce, mitigating the issue of exploitation by middlemen who often conceal market prices.

VI.5.2.3 Impact on Transactions and Finances

In the same study in Mologoro, 70% of respondents indicated that mobile phones had a positive impact on travel and transportation, helping them reduce the need for travel and simplifying transport arrangements, thereby saving both time and money. For example, a one-way bus fare from Rubeho village to Morogoro town cost about 5000 Tanzanian shillings (approximately US\$5), which was equivalent to 10 minutes of airtime. This amount allowed rural phone users

to make several phone calls, further enhancing their access to information and improving their financial transactions.

VI.6 Summary of the findings

It has been observed that the phone is the most frequently talked about when it comes to the means of ICTs used in in the region of East Africa, especially in Kenya, Ethiopia, Tanzania and Uganda. Internet and radio also appear to be of a great importance as ICT means used by farmers. Computer/software, library, media and television also appear to be part of what is being used, but at a very low level. The following tables summarizes the findings form the data from the four countries.

TABLE 5.6 SUMMARY OF THE FINDINGS FOR FOUR COUNTRIES

	Phone	Radio	Internet	library	PC/software	media	TV
Kenya	4.01	0.12	0.15		0.4	-	-
Ethiopia	1.13	0.22	-	-	-	0.05	0.03
Uganda	0.41	0.15			0.14	0.4	-
Tanzania	1.07	0.25	0.16	0.13	-	-	-

Source: Author's Compilation by NVivo

Something in common for all the countries is that phone (mobile) and radio are the most used ICT means. Two main reasons can explain this situation.

First, we saw in the background that there is a high penetration and adoption of mobile phone in the east African region in the past 20 years. The rural people, mostly ICT illiterate, can

enjoy the full potential use of the very basic phone, which is used just for call and text message. Moreover, this same basic phone, with the progress of the soft technology, can fully efficiently used for financial transactions, due to an efficient collaboration between banks and telecommunication companies.

Second, rural people have been relying on radio for any kind of information. Owning a radio is cost effective for rural dwellers, seen its low maintenance and availability of towers for networking (even in remote areas, everyone can listen to a radio).

The rest of the means found in our data are less represented not because they are not necessary or useful. They are instead very important in the communication and dissemination of information, but are submitted to different constraints in the rural areas.

Why the choice of the mobile phone over the radio which has been on the ground for long time? The availability of mobile phone has been made very possible the Chinese companies, which can provide very low quality handsets, affordable for many users. The cost of communication has also been cut down with the use of communication applications such as whatsapp, messenger, and so on.

VI.7 Constraints

The application of ICTs in African agriculture is growing, especially the expansion of mobile telephones usage, though they have mainly been used to provide marketing information. However, this information alone may not necessarily lead to innovations and the desired increased productivity of smallholder agriculture if ICTs are not supported with such extension services as advice on improved agricultural practices, availability of agricultural technologies including seeds and other inputs as well as farmer education. The use of ICTs has several constraints compared to human-based extension service, which requires deployment of a large number of extension workers. These constraints can be summarized into three broad categories

in the rural setting: the policy environment, infrastructure and capacity constraints and the nature of local communities including their inability to use the technology to access information for various agricultural activities.

VI.7.1 Telecommunications Sector Constraints

Despite the dynamic telecommunications sectors in countries like Ghana, Kenya, Nigeria, and Senegal, the broader African continent continues to lag in ICT development. A study by (Calandro & Wang, 2010.) in 17 Sub-Saharan African countries indicates that the high cost of ICT services is a significant barrier to achieving affordable and universal access. The research points out that poor policies, weak institutional frameworks, and regressive taxes on ICT usage exacerbate these challenges. Effective regulation is needed to promote competition and open access regimes, which could help reduce service costs and stimulate market growth. In countries like Cote d'Ivoire and Uganda, high service costs and poor spectrum allocation have hindered ICT growth, even in open markets with multiple operators.

VI.7.2 Rural Infrastructure and Capacity Constraints

Rural areas in Africa face unique challenges that hinder the provision and uptake of ICT services. Many rural areas are sparsely populated, making it difficult to deploy services like electricity, modern ICTs, and infrastructure. Private firms, which are the primary providers of ICT services, typically invest where there is potential for high returns. This leaves rural areas underserved, as the lack of infrastructure (such as electricity and good GSM networks) and lower income levels make investment less attractive (Nakasone et al., 2014) As a result, rural areas are often excluded from the digital opportunities that urban centers enjoy, contributing to a significant digital divide (Asenso-Okyere & Mekonnen, 2012)

VI.7.3 Social and Educational Barriers to ICT Use

The adoption and use of ICTs are also influenced by factors such as education, income, and social and cultural constraints. According to a study by Moyo (2013), individuals with lower education levels and income are less likely to possess the e-skills necessary to effectively use technology. He found that mobile phone ownership in Uganda was directly related to the assets and education levels of household members. Furthermore, Munyua (2007) highlighted that ICT initiatives in Africa often suffer from low adoption rates and are scattered across uncoordinated efforts, with challenges such as high technology costs, low ICT literacy, poor infrastructure, and inadequate credit systems.

VI.7.4 Gender Disparities in ICT Access

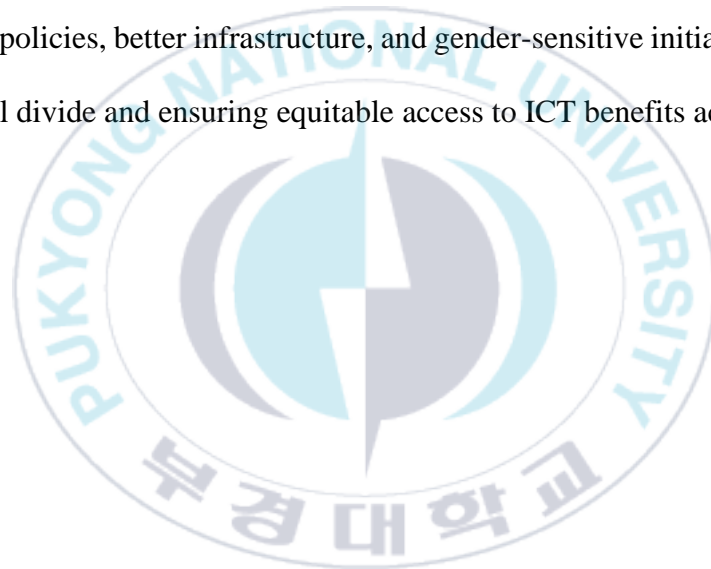
Gender plays a significant role in ICT access and usage, with women in low-income countries often facing more obstacles than men. A study by GSMA (2010) found that women are 21% less likely to own a mobile phone than men in low- and middle-income countries, despite the fact that women are key players in agriculture. This gender gap in ICT access is concerning for agricultural development, as women require access to ICTs to improve productivity and profitability in farming. Studies by Odame & Hafkin (2007) and Hafkin & Taggart (2001) identified several factors that hinder women's use of telecenters and ICT facilities. These include the multiple roles women play, limited time due to heavy workloads, societal attitudes towards women's use of technology, and lower levels of education compared to men.

VI.7.5 Impact of Social and Economic Factors on ICT Access

The diffusion of ICTs in Africa has been highly uneven, with urban areas generally having better access to mobile phones, radio, internet, and television, while rural areas remain underserved. A study by Moyo (2013) found that income is a significant constraint on ICT

access and usage, and as technologies become more complex, literacy and education become even more critical. Additionally, gender differences in ICT access are more pronounced when men and women have differing educational and socio-economic backgrounds, with women generally having less access to ICTs due to lower income and educational levels.

In summary, the challenges to ICT adoption in Africa are deeply interconnected with socio-economic, infrastructural, and policy-related factors. While mobile phones and radios are more widely accessible, the high cost of services, inadequate infrastructure, and gender disparities continue to limit the effectiveness of ICTs, especially in rural areas. Addressing these barriers through improved policies, better infrastructure, and gender-sensitive initiatives is essential for bridging the digital divide and ensuring equitable access to ICT benefits across the continent.



Chapter VII. DISCUSSION AND CONCLUSION

VII.1 DISCUSSION

It is important to note that the penetration of the Internet in the East African region has significantly increased since 2009. This penetration, together with the progress of electronic technology worldwide, will help improve the use of ICTs in this part of the world that was lagging behind others in matters of ICT use.

This study focused on finding out how ICTs are used by small-scale farmers in the East African region and how they affect their production, marketing, finances, and transactions. A qualitative study using data collected from different publications from 2010 to the present helped us get a glimpse of how farmers in this study area use ICTs.

The Diffusion of Innovation Theory, the Technology of Acceptance Model, and the Theory of the Firm were applied, and they are the basis of our assumption that the use of ICTs significantly improves agriculture outcomes in the study area. Ospina and Heeks's conceptual framework for ICT use in agriculture guided the structure of our study, proving that ICTs contribute to transforming agricultural productivity by enhancing access to information services.

A frequency analysis of the data using Nvivo revealed that the telephone and radio are the first devices used by farmers in their activities. From the articles collected from the study countries, that is, Kenya, Ethiopia, Tanzania, and Uganda, the scenario looks the same. Telephone comes first, then radio, and then the rest of the ICT means can differ for the rest of the options like computers, internet and so on.

The mission of this work was to answer to a couple of questions that guided our study. Concerning the economic characteristics of the study area, we have seen the agriculture is the backbone of east African economy, even though in some countries like Kenya, services

contribute much to the GDP because of heavy infrastructure investments. Concerning the platforms and devices used by farmers in east Africa, the mobile phone is taking the lead, because of its affordability and ease of use, as well as the cheap communication tariffs due to the use of communication applications.

We have demonstrated that the use of ICTs has a positive impact on the production, marketing and transaction cost and finance accessibility, which was the main focus of the study. This positive impact proves both of our hypothesis, in the sense that ICTs helps the rural farmers to acquire required knowledge and skills for being successful in the whole process of agricultural entrepreneurship. The more ICTs are adopted, the more the production increases.

Despite the high speed of penetration of the internet, and the evolution of technology, farmers in the rural area are not enjoying this opportunity because of different constraints such as the policy environment, which does not act in favor of the rural area in terms of affordability, the rural setting itself which does not favor the infrastructure availability, and the communities themselves which are intellectually and skillfully not fit for the use of the modern ICT means.

This work is calling the readers to get their minds open to learning and exploring the various ways ICTs can revolutionize farming. This could include advancements in precision farming, data analytics, mobile apps, or information technologies that improve efficiency and productivity. Consider both the benefits and challenges of implementing ICTs in agriculture. For example, while ICTs can increase yields and optimize resources, issues like cost, accessibility, and digital literacy must also be acknowledged.

Readers should recognize and appreciate how technology is transforming traditional practices in agriculture, making them more sustainable and scalable. Understanding that ICT adoption may vary significantly between regions and socio-economic groups, readers should be aware of the need for policies and initiatives that ensure smallholder farmers and marginalized

communities are not left behind. Farmers who read this works should be optimistic about the potential for ICTs to address challenges like food security and climate change, while remaining realistic about the steps needed to implement these technologies effectively. If inspired, the reader might feel motivated to support or advocate for the integration of ICTs in agriculture, whether through policy-making, investments, education, or research.

VII.2 Recommendations

There is no doubt that the development of ICT facilitated the dissemination of knowledge and information and it is revolutionizing the use of technology in agricultural research, development and marketing. The wide range of ICT platforms has a great potential for increased use in disseminating agricultural information, which would inevitably cause an increase in revenues for rural farmers. Seen the challenges in the hands of rural farmers to enjoy the full potential of ICTs, a couple of recommendations can be pointed out to the deciders to address them in favour of small-scale farmers who need them for the increase of their incomes.

First, it is worth noting that in East Africa, the acquisition and usage of mobile phones has increased tremendously. When they are combined with other ICT platforms, such as mass media, the impact on agriculture is likely to be very high. The expansion of access to these platforms could be increased through the reduction of costs of the devices and connectivity charges. A key strategy for reducing costs would be greater cooperation among African countries in rolling out ICT platforms, particularly equipment and content.

Second, it is also evident that rural incomes have increased with the use of ICTs to access knowledge and information. However, a large number of rural people engaged in agriculture still face challenges in accessing ICTs and related platforms. These challenges and constraints need to be addressed through public policy within the context of rural development in general and agricultural productivity in particular.

Third, there is an excellent need for ICT literacy for the farmers and the entire population, as the results illustrate the evolution of technology and the rapid digitalization of world business and affairs. This study suggests that basic ICT classes should be made possible for rural areas from primary school so that soon, every farmer may be able to enjoy the full potential of basic ICT services, such as video and photo editing and displaying, using a different search engine, exploring basic websites and using them. This would be possible if the second recommendation is considered because this entails the availability of electricity in schools in rural areas, computers and trained trainers.

Last, there is a need for integrating information between the ICT service providers and the agricultural research and development sector so that all the needed information can easily be displayed to farmers. For further research, this thesis can be a good step stone for exploring many more facets of the relationship between ICT and farming; based on the work accomplished in this thesis, subjects like the effectiveness of video in farmers' training should be given attention.

References

- Adeleke Salami, A. B. (2010). Smallholder Agriculture in East Africa: Trends, Constraints and Opportunities. *African Development Bank* (105), 31. Retrieved from https://www.afdb.org/sites/default/files/documents/publications/working_105_pdf_d.pdf
- AfDB. (2023). *East Africa Regional Economic Outlook 2023: Mid-term growth for East Africa region projected highest on the continent for 2023-4*. Retrieved from AFRICAN TRANSFORMATION INDEX: <https://www.afdb.org/en/news-and-events/press-releases/east-africa-regional-economic-outlook-2023-mid-term-growth>
- Ahmad, A., Sanga, C., Mapunda, K., Mwaseba, D., & Haug, R. (2023). Strengthening Extension and Advisory Services Delivery through Village Knowledge Centre in Rungwe District, Tanzania: Lessons Learned from InnovAfrica Project. In *International Journal of Education and Development using Information and Communication Technology (IJEDICT)* (Vol. 19, Issue 2). <https://cordis.europa.eu/project/id/727201/results>
- AJAYI, O. (2009). E-learning: A Shorter, Safer, and Surer Route to Reaching the Education For All Destination. *Journal of Science and Technical Education (JSTE)*, 1(1), 138-145.
- Aker, J. C. (2008). *Does Digital Divide or Provide? The Impact of Mobile Phones on Grain Markets in Niger*. BREAD Working Paper 177.
- Aker, J. C., & Mbiti, I. M. (2010). Mobile phones and economic development in Africa. *Journal of Economic Perspectives*, 24(3), 207–232. <https://doi.org/10.1257/jep.24.3.207>
- Aleke B, O. U. (2011). ICT adoption in developing countries: perspectives from small-scale agribusinesses. *Journal of Enterprise Information Management*, 79. doi:DOI: 10.1108/17410391111097438
- Alvarez, J. a. (2006). Adoption of computer based information systems. The case of dairy farmers in Canterbury, NZ and Florida, Uruguay. *Computers and Electronics in Agriculture*, 50(2), 48-60.
- Ambaye, T. K., Siyoum Tsehay, A., & Hailu, A. G. (2021). Analysis of the status and determinants of rural households' access to agricultural extension services: the case of Jimma Geneti Woreda, Oromia regional state, Ethiopia. *International Journal of Agricultural Extension and Rural Development Studies*, 8(1), 52–99. <https://ssrn.com/abstract=3820302>
- Amir, M., Peter, N., & Muluken, W. (2016). *The role of mobile phones in accessing agricultural information by smallholder farmers in Ethiopia*. 17–21. <http://repository.ruforum.org>
- Asenso-Okyere, K., & Mekonnen, D. A. (n.d.). *The Importance of ICTs in the Provision of Information for Improving Agricultural Productivity and Rural Incomes in Africa*.

- Autónoma De Yucatán, U., Bolorunduro, M., Adesehinwa, P. I. ; De, Adopción, Bolorunduro, P. I., & Adesehinwa, A. O. K. (2004). Tropical and Subtropical Agroecosystems Adoption status of disseminated technologies on the artisanal fisheries of Niger state, Nigeria. *México Tropical and Subtropical Agroecosystems*, 4(1), 1–5. <http://www.redalyc.org/articulo.oa?id=93940101>
- Bagetoft, P. &. (2004). *The Design of Production Contracts*. Copenhagen, Denmark: Copenhagen Business School Press. P45
- Baumüller, H. (n.d.). *Enhancing smallholder market participation through mobile phone-enabled services: The case of M-Farm in Kenya*.
- Belay, K. (2003). Agricultural Extension in Ethiopia: The Case of Participatory Demonstration and Training Extension System. *Journal of Social Development in Africa*, 49-83. doi:10.4314/jsda.v18i1.23819
- Berhanu Daniso, M. M. (2020). Assessment of rural households' mobile phone usage status for rural innovation services in Gomma Woreda, Southwest Ethiopia 6:1, 1728083. *Cogent Food & Agriculture*, 6.
- Berman, S. D. (2008). Technical Evaluation Report 62. The Return of Educational Radio? *International Review of Research in Open and Distance Learning*, 9(2).
- Calandro, E., & Wang, R. (2012.). Predictors of mobile internet usage in 10 African countries, 19th Biennial Conference of the International Telecommunications Society (ITS): "Moving Forward with Future Technologies: Opening a Platform for All", Bangkok, Thailand, 18th-21th November 2012, International Telecommunications Society (ITS), Calgary
- Casaburi, L., Kremer, M., Mullainathan, S., & Ramrattan, R. (n.d.). *Harnessing ICT to Increase Agricultural Production: Evidence From Kenya*. <https://api.semanticscholar.org/CorpusID:3828015>}
- Cavanagh, S. (1997) *Content Analysis: Concepts, Methods and Applications*, Nurse Research 1, 4 (3), 5-16, doi: 10.7748/nr.4.3.5.s2.
- CBK. (2013). Social Statistics in Kenya. Retrieved from [http// www.cbk.org.ke](http://www.cbk.org.ke)
- Chigona, W. (2008). The uses and gratifications of mobile internet among the South African students. *SA Journal of Information Management*, Vol.10(3) 2197 – 2207.

- Cowling, N. (2024, May 31). Agriculture in Tanzania - statistics & facts. Johannesburg , SJOhanesbourg, South Africa. Retrieved from <https://www.statista.com/topics/9058/agriculture-in-tanzania/#topicOverview>
- Ebanyate, P. (2016). Developing and piloting a multi-channel ICT-enabled model to enhance University engagement with smallholder farming communities in Uganda. *African Journal of Rural Development* , vol. 1(1)13 - 21. DOI: 10.22004/ag.econ.263572
- Ehud, G., Taragola, N., & Gelb, E. (n.d.). *Information and Communication Technology (ICT) Adoption in Horticulture: A Comparison to the EFITA Baseline-Information and Communication Technology (ICT) Adoption in Horticulture: A Comparison to the EFITA Baseline*. <https://www.researchgate.net/publication/283212569>
- Elo, S., Kääriäinen, M., Kanste, O., Pölkki, T., Utriainen, K., & Kyngäs, H. (2014). Qualitative Content Analysis. *SAGE Open*, 4(1), 215824401452263. <https://doi.org/10.1177/2158244014522633>
- Esselaar, S., Qiang, C. Z., Chew Kuek, S., & Dymond, A. (2011). *Mobil Applications for Agriculture and Rural Development Mobile Applications for Agriculture and Rural Development*. <https://www.researchgate.net/publication/268420568>
- Euromonitor. (2022). *East Africa - The Rising Economic Jewel of Sub-Saharan Africa*. . Retrieved from <https://www.euromonitor.com/article/east-africa---the-rising-economic-jewel-of-sub-saharan-africa>
- FAO. (2024). Kenya at a glance. Nairobi, Nairobi, Kenya: FAO. Retrieved from FAO in Kenya: <https://www.fao.org/kenya/fao-in-kenya/kenya-at-a-glance/en/>
- FAO. (2024). The agriculture sector in Kenya. Nairobi, Nairobi, Kenya. Retrieved from <https://www.fao.org/kenya/fao-in-kenya/kenya-at-a-glance/en/>
- FAO. (2024, 12 22). *Information and Communication Technologies (ICT)*. Retrieved from e-Agriculture.
- Francisca C Mbagwu, O. V. (2018). *Challenges of meeting information needs of rural farmers through internet-based services: experiences from developing countries in Africa*. . <https://library.ifla.org/id/eprint/2195/1/166-mbagwu>.
- FVRPRS. (2012). Transforming the lives of millions of farmers and rural communities through the power of radio. Retrieved from <https://www.farmersvoiceradio.org/>
- G Masuki, K. F., Kamugisha, R., Mogoi, J., & O, A. E. (2010). *Mobile Phones for Information Delivery in Agriculture] 1 ICT and Development-Research Voices from Africa. International Federation for Information Processing (IFIP), Technical Commission 9-Relationship Between Computers and Society*. <https://www.researchgate.net/publication/260402865>
- Gessei, M. M. (2012). *Towards improving smallholder agriculture: Role of climate information services in Ethiopia*. Lund University. P28-40

- Getachew, A. (2012). *Accessibility of Agricultural Knowledge and Communication /ICT/ services to small farm households and level of utilization for agricultural development: the case of dugda woreda of east showa zone, oromia region, Ethiopia*. A thesis. Addis Ababa, Ethiopia.
- Graham, M., De Sabbata, S., & Zook, M. A. (2015). Towards a study of information geographies: (im)mutable augmentations and a mapping of the geographies of information. *Geo: Geography and Environment*, 2(1), 88–105. <https://doi.org/10.1002/geo2.8>
- GSMA. (2024). The Reduction of Mobile Money Levy in Tanzania. Retrieved from <https://www.gsma.com/about-us/regions/sub-saharan-africa/the-reduction-of-mobile-money-levy-in-tanzania/>
- Hafkin, N., & Taggart, N. (2001). *Gender, Information Technology, and Developing Countries: An Analytic Study*. <https://www.researchgate.net/publication/237479049>
- Hall, R. L., & Hitch, C. J. (1939). Price theory and business behaviour. *Oxford Economic Papers*, Volume 2, Issue 1.
- Heeks, R., & Ospina, A. V. (2019). Conceptualising the link between information systems and resilience: A developing country field study. *Information Systems Journal*, 29(1), 70–96. <https://doi.org/10.1111/isj.12177>
- Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, 15(9), 1277–1288. <https://doi.org/10.1177/1049732305276687>
- IFAD. (2024). The context. Retrieved from <https://www.ifad.org/en/w/countries/ethiopia>
- IFAD. (2024). Uganda Investment Proposal. Kampala, Kampala, Uganda. Retrieved from <https://www.fao.org/hand-in-hand/hih-IF-2024/uganda/en>
- IMF. (2024, 12 22). *GDP, current prices*. Retrieved from International Monetary Fund: https://www.imf.org/external/datamapper/PPPGDP@WEO/OEMDC/ADVEC/WEO_WORLD
- ITU, .. P. (2023). *Tools for Development: Using Information and Communications Technology to Achieve the Millennium Development Goals Working*. Paper United Nations ICT Task Force. Retrieved from <https://www.itu.int/net/wsis/stocktaking/docs/activities/1103056110/ICTMDGFina>
- ITU. (2023). *Tools for Development: Using Information and Communications Technology to Achieve the Millennium Development Goals*. Washington DC: Working Paper United Nations ICT Task Force. Retrieved from <https://www.itu.int/net/wsis/stocktaking/docs/activities/1103056110/ICTMDGFina>
- Jean M. Due, F. M. (1997). Gender again--views of female agricultural extension officers by smallholder farmers in Tanzania. *World Development*, vol. 25, 713-725.
- Kabura Nyaga, E. (2012). Give to AgEcon Search Is ICT in Agricultural Extension Feasible in Enhancing Marketing of Agricultural Produce in Kenya: A Case of Kiambu

- District. In *Quarterly Journal of International Agriculture* (Vol. 51, Issue 3). DLG-Verlag Frankfurt/M. <http://ageconsearch.umn.edu>
- Kabura Nyaga, E. (2012). Give to AgEcon Search Is ICT in Agricultural Extension Feasible in Enhancing Marketing of Agricultural Produce in Kenya: A Case of Kiambu District. In *Quarterly Journal of International Agriculture* (Vol. 51, Issue 3). DLG-Verlag Frankfurt/M. <http://ageconsearch.umn.edu>
- KACE. (2011). (KACE) (2011). KACE Services: The KACE Market Information and Linkage System. <http://www.kacekenya.co.ke/section.asp?ID=64>. Retrieved from <http://www.kacekenya.co.ke/section.asp?ID=64>
- Kante, M., Oboko, R., & Chepken, C. (2017). Influence of perception and quality of ICT-based agricultural input information on use of ICTs by farmers in developing countries: Case of Sikasso in Mali. *Electronic Journal of Information Systems in Developing Countries*, 83(1). <https://doi.org/10.1002/j.1681-4835.2017.tb00617.x>
- Kante, M., Oboko, R., & Chepken, C. (2017). Influence of perception and quality of ICT-based agricultural input information on use of ICTs by farmers in developing countries: Case of Sikasso in Mali. *Electronic Journal of Information Systems in Developing Countries*, 83(1). <https://doi.org/10.1002/j.1681-4835.2017.tb00617.x>
- Kiambi, D. (2018). The use of information communication and technology in advancement of African agriculture. *Afr J Agric Res*, 2025–36. Retrieved from <https://doi.org/10.5897/AJAR2018.13300>.
- Kikulwe, E. M., Fischer, E., & Qaim, M. (2014). Mobile money, smallholder farmers, and household welfare in Kenya. *PLoS ONE*, 9(10). <https://doi.org/10.1371/journal.pone.0109804>
- Kikulwe, E. M., Fischer, E., & Qaim, M. (2014). Mobile money, smallholder farmers, and household welfare in Kenya. *PLoS ONE*, 9(10). <https://doi.org/10.1371/journal.pone.0109804>
- Kilima, F., Sife, A., & Sanga, C. A. (2016). Factors Underlying the Choice of Information and Communication Technologies among Small holder Farmers in Tanzania. In *International Journal of Computing and ICT Research* (Vol. 10, Issue 2). <https://www.researchgate.net/publication/313469855>
- Kilima, F., Sife, A., & Sanga, C. A. (2016). Factors Underlying the Choice of Information and Communication Technologies among Small holder Farmers in Tanzania. In *International Journal of Computing and ICT Research* (Vol. 10, Issue 2). <https://www.researchgate.net/publication/313469855>
- Kiomi Mori, C., & Ortiz Assumpção, R. (2007). Brazilian Digital Inclusion Public Policy: achievements and challenges. *The Journal of Community Informatics* 3(3) p10-25. DOI:[10.15353/joci.v3i3.2369](https://doi.org/10.15353/joci.v3i3.2369)
- Lata Sharma, H., & Sarkar, C. (2019). Ethnography Research: An Overvie. *International Journal of Advance and Innovative Research*. Volume 6, Issue 2 (VIII). P75 <https://www.researchgate.net/publication/333701617>

- Lee SM, O. D. (2012). Co-innovation: convergenomics, collaboration, and co-creation for organizational values. *ManagDecis*, 50(5), 817–31. Retrieved from <https://doi.org/10.1108/00251741211227528>.
- Legris, P., Ingham, J., & Colletette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information and Management*, 40(3), 191–204. [https://doi.org/10.1016/S0378-7206\(01\)00143-4](https://doi.org/10.1016/S0378-7206(01)00143-4)
- Leta, S (2023). Smallholder Wheat Producers' Access to Agricultural Information and its Influencing factors in Sululta District, Oromia Regional state in Ethiopia. A Thesis. *Haramaya University*, Haramaya, Ethiopia
- Lohento, K. (2015). *ICT and Youth in Agriculture*. <https://www.researchgate.net/publication/308968253>
- Lwoga, E. T., & Sangeda, R. Z. (2019). ICTs and development in developing countries: A systematic review of reviews. *Electronic Journal of Information Systems in Developing Countries*, 85(1). <https://doi.org/10.1002/isd2.12060>
- Martin, B. L., Candidate, P., & Abbott, E. (2011). *Mobile Phones and Rural Livelihoods: Diffusion, Uses, and Perceived Impacts Among Farmers in Rural Uganda*.
- Martiz, J. (2011). How mobile phones are transforming African Agriculture. *Agri4Africa*. Retrieved from <http://www.howwemadeitinafrica.com/howmobile-phones-are-transforming-african-griculture/8704/>.
- May, J., Karugia, J., & Ndokweni, M. (2007). Information And Communication Technologies And Agricultural Development In Sub-Saharan Africa: Transformation And Employment Generation. Final Framework Paper prepared for the African Economic Research Consortium. University of Kwazulu Natal.
- Moodley, S. (2002). Competing in the Digital Economy?: The Dynamics and Impacts of B2B E-commerce on the South African Manufacturing Sector," WIDER Working Paper Series DP2002-79, World Institute for Development Economic Research (UNU-WIDER).
- Moyo, M. (2013). *Understanding what is happening in ICT in South Africa. Evidence for ICT Policy Action*. <https://doi.org/10.13140/RG.2.1.3535.9769>
- Mtega, W. P., Ngoepe, M., & Dube, L. (2016). Factors influencing access to agricultural knowledge: The case of smallholder rice farmers in the Kilombero district of Tanzania. *SA Journal of Information Management*, 18(1). <https://doi.org/10.4102/sajim.v18i1.679>
- Mujeyi A, M. M. (2021). The impact of climate smart agriculture on household welfare in smallholder integrated crop–livestock farming systems: evidence from Zimbabwe. *Agric Food Secur*. Retrieved from <https://doi.org/10.1186/s40066-020-00277-3>.
- Munyegera, G. K., & Matsumoto, T. (2018). ICT for financial access: Mobile money and the financial behavior of rural households in Uganda. *Review of Development Economics*, 22(1), 45–66. <https://doi.org/10.1111/rode.12327>

- Munyua, H. (2007). *Final Report ICTs and small-scale agriculture in Africa: a scoping study*. <http://hdl.handle.net/10625/50998>
- Murty, S., Robert Russell, R., & Levkoff, S. B. (2012). On modeling pollution-generating technologies. *Journal of Environmental Economics and Management*, 64(1), 117–135. <https://doi.org/10.1016/j.jeem.2012.02.005>
- Nabutola, T. (2014). *The impact of radio agricultural programmes on small scale farmers: the case of “Mali Shambani” program on KBC Radio Taifa*. Masters Thesis,. Nairobi, Kenya: Nairobi University.
- Nakasone, E., Torero, M., & Minten, B. (2014). The power of information: The ICT revolution in agricultural development. *Annual Review of Resource Economics*, 6(1), 533–550. <https://doi.org/10.1146/annurev-resource-100913-012714>
- Nazari, M. R., Bin, S., & Hassan, H. (2011). The role of television in the enhancement of farmers’ agricultural knowledge. *African Journal of Agricultural Research*, 6(4), 931–936. <https://doi.org/10.5897/AJAR10.1154>
- Niemi, J. K., Minot, N., & Sell, M. (2015). Marketing of Agricultural Products and the Use of Mobile Phones among Farm-Households in Ghana and Uganda: A Survey. *Sustainable Rural and Territorial Development* 468. <https://cabidigitallibrary.org>
- Nisiima, D. (2015). *Factors affecting adoption of an information communications technology system for agriculture in Uganda*. Michigan : Michigan State University, Master of Arts. . Retrieved from <https://d.lib.msu.edu/etd/3397>
- Nisiima, D. (2015). *Factors affecting adoption of an information communications technology system for agriculture in Uganda*. Michigan : Michigan State University, Master of Arts. . Retrieved from <https://d.lib.msu.edu/etd/3397>
- Odame, H. H., & Hafkin, N. J. (2007). *Gender, ICTs and agriculture. A situation analysis for the 5th Consultative Expert Meeting of CTA’s ICT Observatory meeting on gender and agriculture in the information society*. <https://www.researchgate.net/publication/259258410>
- Olorunnishola E; ZWALMAM, Singya Zhimwang; and SUBERU, Saka Bamidele, "Challenges in Accessing Agricultural Information Sources and Services by Farmers in Edu Local Government Area of Kwara State" (2021). *Library Philosophy and Practice (e-journal)*. 6192. P52-70. <https://digitalcommons.unl.edu/libphilprac/6192>
- Ogada, M. J., Radeny, M., Recha, J. W., & Solomon, D. (2020). Climate-smart agriculture, household income and asset accumulation among smallholder farmers in the Nyando basin of Kenya. *World Development Perspectives*, 18. <https://doi.org/10.1016/j.wdp.2020.100203>
- Ogbeide, O. A. (2015). Smallholder Farmers and Mobile Phone Technology in Sub-Sahara Agriculture. *Mayfair Journal of Information and Technology Management in Agriculture* 1(1), 1-19.

- Ogunniyi, M. D., & Ojebuyi, B. R. (2016). Mobile phone use for agribusiness by farmers in Southwest Nigeria. *Journal of Agricultural Extension*, 20(2), 172–187. <https://doi.org/10.4314/jae.v20i2.13>
- Oresanya, A. J., & Olajide, B. R. (2023). Farmers' propensity to use reality television shows for information on climate-smart agriculture strategies in southwestern Nigeria. *Agricultura Tropica et Subtropica*, 56(1), 65–73. <https://doi.org/10.2478/ats-2023-0008>
- Ratnadiwakara, H. d. (2008). *Using ICT to reduce transaction costs in agriculture through better communication: A case-study from Sri Lanka*. Sri Lanka . Retrieved from <https://lirneasia.net/>
- Reeves, S., Albert, M., Kuper, A., & Hodges, B. D. (2008). Qualitative research: Why use theories in qualitative research? In *BMJ* (Vol. 337, Issue 7670, pp. 631–634). <https://doi.org/10.1136/bmj.a949>
- Robert, T. (1994). Research with farmers: Lessons from Ethiopia . (S. F. Houten, Ed.) *CAB International*, 1992. 303.
- Rogers, E. M. (1995). Diffusion of Innovations. *The Free Press*. P6
- Schulte, P. W. (2016). ICT and the Demand for Energy: Evidence from OECD Countries. *Environ Resource Econ* 63, 119–146. Retrieved from <https://doi.org/10.1007/s>
- Sekhon, M. K., Mahal, A. K., Kaur, M., & Sidhu, M. S. (2010). Give to AgEcon Search Technical Efficiency in Crop Production: A Region-wise Analysis §. In *Agricultural Economics Research Review* (Vol. 23). <http://ageconsearch.umn.edu>
- Sife, A. S., Kiondo, E., & Lyimo-Macha, J. G. (2010). Contribution of Mobile Phones to Rural Livelihoods and Poverty Reduction in Morogoro Region, Tanzania. *Electronic Journal of Information Systems in Developing Countries*, 42(1), 1–15. <https://doi.org/10.1002/j.1681-4835.2010.tb00299.x>
- Song, S. (2024). African Undersea Cables. Retrieved from <https://manypossibilities.net/african-undersea-cables/>
- Statista. (2024). *Statistics about Agriculture in Africa*. Retrieved from <https://www.statista.com/map/africa/branch/agriculture>
- Tadesse, M. (2017). Factors Influencing the Use of Mobile Phone by Smallholder Farmers in Vegetable Marketing: The Case of Fogera District of South Gondar Zone, Amhara Regional State, Ethiopia. A Thesis. Haramaya Univerity, Haramaya, Ethiopia
- Teherani, A., Martimianakis, T., Stenfors-Hayes, T., Wadhwa, A., & Varpio, L. (2015). Choosing a Qualitative Research Approach. *Journal of Graduate Medical Education*, 7(4), 669–670. <https://doi.org/10.4300/JGME-D-15-00414.1>
- Tirkaso, W. T., & Hess, S. (2015). The role of ICT expenditure for cash crop production and income generation in southern Ethiopia. *Electronic Journal of Information Systems in Developing Countries*, 71(1), 1–14. <https://doi.org/10.1002/j.1681-4835.2015.tb00511.x>

- Tornatzky, L. G., & Klein, K. J. (1982). Innovation Characteristics and Innovation Adoption Implementation: A MetaAnalysis of Findings. In *IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT* (Vol. 29, Issue 1).
- Tucker RC, G. M. (2009). Experience with developing and deploying an agricultural information system using spoken language technology in Kenya. . *IEEE*.
- Verdier-Chouchane, A. &. (2016). *Moving towards a green productive agriculture in Africa: the role of ICTs*. Africa Economic Brief, 7 (7), 1-12.
- World Bank : (2010). *World Development Report 2010: Development and Climate Change*. Washington DC: Climate Action . Retrieved from <https://siteresources.worldbank.org/INTWDR2010/Resources/5287678-1226014527953/WDR10-Full-Text.pdf>
- World Bank. (2014). *Financial Inclusion Data: Kenya country dashboard*. . <https://microdata.worldbank.org/index.php/catalog/2442> .
- World Bank. (2024). *Individuals using internet*. Retrieved from World Bank: <https://databank.worldbank.org/source/world-development-indicators/Series/IT.NET.USER.ZS>
- WorldAtlas. (2024). *East African Countries*. Retrieved from <https://www.worldatlas.com/geography/east-african-countries.html>
- WorldBank. (2011). *ICT in agriculture: Connecting Smallholders to Knowledge, Networks and Institutions*. . Washington DC, USA.: The International Bank for Reconstruction and Development / The World Bank. <http://documents.worldbank.org/cu>
- Zewge, A., & Dittrich, Y. (2017). Systematic mapping study of information technology for development in agriculture (the case of developing countries). *Electronic Journal of Information Systems in Developing Countries*, 82(1). <https://doi.org/10.1002/j.1681-4835.2017.tb00602.x>
- Zhang, Y., & Wildemuth, B. M. (2005). Qualitative Analysis of Content. *Human Brain Mapping* 30 (7):2197-2206.

Appendix

Appendix 1. Data Sources for Qualitative Content Analysis by NVivo, Kenya

	Title	Author	Publisher	year
1	Role of ICT in the dissemination and access of agricultural information by smallholder farmers in south eastern Kenya	Ireria D, et al.	Acta Informatica Malaysia	2021
2	Impact of Information and Communication Technology-Based Market Use and Productivity: The Case of Kenya Information Services on Smallholder Farm Input	OCHIENG S, et al.	Science Direct	2021
3	Connected cows and cyber chickens? Stocktaking and case studies of digital livestock tools in Kenya and India	Daum T, et al.	Science Direct	2022
4	Household-specific targeting of agricultural advice via mobile phones: Feasibility of a minimum data approach for smallholder context	Steinke J, et al.	Science Direct	2019
5	Differential Impacts of Conservation Agriculture Technology Options on Household Income in Sub-Saharan Africa	Justice A, et al.	science Direct	2018
6	Use of mobile financial services among farmers in Africa: Insights from Kenya	Martin C. et al.	Science Direct	2022
7	Climate-smart agriculture, household income and asset accumulation among smallholder farmers in the Nyando basin of Kenya	Ogada J, et al.	Science Direct	2020
8	Impact of ICT-based pest information services on tomato pest management practices in the Central Highlands of Kenya	Mwenda E, et al.	Science Direct	2023
9	The Potential and Limitations of Mobile-learning and other services in the Agriculture Sector of Kenya Using Phone Applications	Henze, J. and Ulrichs, C.	Humboldt-Universität zu Berlin	
10	Is ICT in Agricultural Extension Feasible in Enhancing Marketing of Agricultural Produce in Kenya: A Case of Kiambu District	Elizabeth Kabura Nyaga	AgEcon Search	2012

11	Telephone farmers and an emerging ecosystem are unlocking the hidden middle of agricultural value chains in Kenya through innovation	Dijk P, et al.	Journal of Agribusiness in Developing and Emerging Economies	2021
12	Towards a Sustainable Horticultural Value Chain among Smallholder farmers in Kenya: Unlocking the Potential of Mobile Telephony	Musau G. Enock	African Journal of Education, Science and Technology	2021
13	Enhancing smallholder market participation through mobile phone-enabled services: The case of M-Farm in Kenya	Heike Baumüller	University of Bonn	2013
14	Towards Improving Agricultural Marketing Information Systems for Smallholder Farmers: A Tharaka Nithi Case	Amer N, et al.	Journal of Agriculture and Sustainability	2018
15	Factors influencing the intensity of use of ICT tools by youth along agricultural value chains: Evidence from Busia County, Kenya	Katunyo P et al,	AgEcon Search	2018
16	E-agriculture Framework for Improving Agricultural Productivity among the Smallholder Farmers in Rural Kenya	Mbucu D, e al.	School of Information Science and Technology, Kisii University	2021
17	Exploring the Opportunities and Challenges of ICTs for Women Farmers in Kenya	Tania Braimok	Swedish University of Agricultural Science	2017
18	ICTs and Agricultural Marketing in Africa: A Review	Yohannes Girma, Abebaw Abebe	Raya University Ethiopia	2019
19	Evaluation of information and communication technologies utilization by smallholder banana farmers in Gatanga District, Kenya	Simon O. L. Mwombe	University of Nairobi	2011
20	Adoption of ICT innovations in the agriculture sector in Africa: a review of the literature	Ayim C,	Ayim et al. Agriculture & Food Security	2022
21	Factors Influencing the Use of Mobile Phone-Enabled Services in Accessing Agricultural Information by Smallholder Farmers in Bungoma County, Kenya	Mary L, at al.	African Journal of Empirical Research	2023
22	Application of ICT in Agriculture: Opportunities and Challenges in Developing Countries	Abdulrahman A, et al ,	International Journal of Computer Science and Mathematical Theory	2017
23	Horticulture in the Mt. Kenya Region – Dynamics and challenges in the context of globalization	Krone M, et al	Geographisches Institut, Humboldt-Universität zu Berlin	2016

24	Availability, Use and Challenges of Information and Communication Technology Gadgets in Sustainable Small Scale Dairy Farmers Livelihoods in Nandi County, Kenya	M. K. Beru, G. Cheserek and M. Kiptui	Africa Environmental Review journal	2018
25	The use of Information Communication and Technology in advancement of African agriculture	Dionysious Kiambi	African Journal of Agricultural Research	2018
26	Access and use of ICT and its contribution to poverty reduction in Kenya	Timothy M. Waema and Obadia Okinda Miroro	Research Gate	2014
27	Electronic Marketplaces as an Agricultural Value Chain Development Stimulus in Low Income Countries	Evans Tenge, Katherine Wambaya	Journal of Emerging Trends in Computing and Information Sciences	2014
28	Assessing the role of mobile phones in offering price information and market linkages: the case of m-farm in kenya	Heike Baumüller	The Electronic Journal of Information Systems in Developing Countries	2015
29	Systematic mapping study of information technology for development in agriculture (the case of developing countries)	Amanuel Zewge, Yvonne Dittrich	The Electronic Journal of Information Systems in Developing Countries	2017
30	ICTs and Development in Developing Countries: A systematic Review of Reviews	Edda Tandi Lwoga, Raphael Zozimus Sangeda	Wiley Online Library	2018
31	Systematic mapping study of information technology for development in agriculture (the case of developing countries)	Amanuel Zewge, Yvonne Dittrich	The Electronic Journal of Information Systems in Developing Countries	2017
32	Are mobile phone-based information services making a positive difference to the livelihoods of kenyan smallholder farmers?	Emma Eтчells	University of London	2019
33	Factors that determine farmers' access and utilization of the information and communication technology provided by the department of agriculture in bahati division, nakuru north district, kenya	James Waciuri Wanjohi	EGERTON UNIVERSITY	2015
34	Mobile Money, Smallholder Farmers, and Household Welfare in Kenya	Enoch M, et al.	University of Goettingen, Germany	2014

35	Use of information communication technologies in conservation agriculture knowledge pathways among smallholder farmers in Machakos and Laikipia counties, Kenya.	Janet cox achora	MAKERERE UNIVERSITY	2019
36	Harnessing ICT to Increase Agricultural Production: Evidence From Kenya	Casaburi L, et al.	Government of UK Journal	2019
37	Impact of ICT Based Extension Services on Dairy Production and Household Welfare: The Case of iCow Service in Kenya	Mwita E, et al. r	Canadian Center of Science and Education	2020
38	Impact of mobile phone-based money transfer services in agriculture: evidence from Kenya	Oliver K, et al.	University of Nairobi	2012
39	Participation in ICT-based market information projects, smallholder farmers' commercialisation, and agricultural income effects: findings from Kenya	Okello j , et al	Taylor and Francis Group	2020
40	Information Communication Technologies And Marketing Decisions Among Small Scale Farmers In Kenya: Review Of Evidence	Rosebella J, et al.	International Journal of Economics, Commerce and Management	2016
41	Determinants of Information Communication Technologies Usage in Agriculture value Chains bu Rural Youth in Busia County, Kenya	Pauline Ndindi Katunyo	University of Nairobi	2015
42	Information And Communication Technology In Small- Scale Business Based Agricultural Value Chains In Sub-Saharan Africa: Examples from Kenyan and Tanzanian Horticulture	Madlen Krone	Universität zu Köln	2018
43	The use of modern information and communication technologies in smallholder agriculture: Examples from Kenya and Tanzania	Krone M, et al.	Research Gate	2015
44	The use of Information Communication and Technology in advancement of African agriculture	Dionysious Kiambi	African Journal of Agricultural Research	2018
45	Mobile Based Agriculture and Climate Services Impact on Farming Households in Rural Kenya	Lilian Muasa & Hirotaka Matsuda	Journal of Sustainable Development	2019

46	The Power of Information: The ICT Revolution in Agricultural Development	Nakasone E, et al.	International Food Policy Research Institute	2014
47	Impact of Collective Action on the smallholder agricultural commercialization and incomes: Experiences from Kenya	Oliver K. Kirui and Georgina W. Njiraini	AgEcon Search	2013
48	Smallholder farmers' perception of climate change and adoption of climate smart agriculture practices in Masaba South Sub-county, Kisii, Kenya	Jared O, et al.	Science Direct	2021
49	Smallholder farmers' use of mobile phone services in central Kenya	Krell T, et al	Taylor and Francis Group	2020
50	Towards a Revolutionized Agricultural Extension System for the Sustainability of Smallholder Livestock Production in Developing Countries: The Potential Role of ICTs	Mapiye O et al.	Research Gate	2021
51	Impact of Information and Communication Technology-based Market Information Services on Smallholder Farm Input Use and Productivity: The Case of Kenya	Ochieng O et al.	AgEcon Search	2013
52	Adoption of ICT-in-Agriculture Innovations by Smallholder Farmers in Kenya	Awuor F, et al.	Science Research Publishing	2022
53	The use of Information Communication and Technology in advancement of African agriculture	Dionysious Kiambi	African Journal of Agricultural Research	2018
54	Smallholder Agriculture in East Africa: Trends, Constraints and Opportunities	Adeleke S.	AFRICAN DEVELOPMENT BANK GROUP	2010
55	Determinants of Awareness and Use of ICT-based Market Information Services in Developing-Country Agriculture: The Case of Smallholder Farmers in Kenya	Julius J. Okello and Oliver K. Kirui	AgEcon Search	2014
56	Factors Influencing the Use of Mobile Phone-Enabled Services in Accessing Agricultural Information by Smallholder Farmers in Bungoma County, Kenya	Lusike M, et al.	African Journal of Empirical Research	2023

Appendix 2. Data Sources for Qualitative Content Analysis by NVivo, Ethiopia

	Title	Author	Publisher	year
1	The role of ICT in collective management of public bads: The case of potato late blight in Ethiopia	Katarzyna C, et al.	Science Direct	2021
2	Accelerating technical change through ICT: Evidence from a video-mediated extension experiment in Ethiopia	Gashaw T, et al.	Science Direct	2023
3	Access to information, price expectations and welfare: The role of mobile phone adoption in Ethiopia☆	Mekbib G, et al.	Science Direct	2019
4	Digital tools and agricultural market transformation in Africa: Why are they not at scale yet, and what will it take to get there?	Gashaw T, et al.	Science Direct	2023
5	Using radio and interactive ICTs to improve food security among smallholder farmers in Sub-Saharan Africa	Heather E, et al.	Science Direct	2017
6	Credit access and agricultural technology adoption nexus in Ethiopia: A systematic review and meta-analysis	Yohannes Girma	Science Direct	2022
7	Determinants of agricultural knowledge and information usage to achieve SDGs: Misrak Badawacho district, Southern Ethiopia	Maldayo E, et al.	Science Direct	2024
8	Challenges of smallholder farmers in accessing agricultural information in Southern Ethiopia	G.R. Megerssa, B.G. Gemedede, A.W. Jarsa	Trakia University, Bulgaria	2020
9	The Role Of Ict Expenditure For Cash Crop Production and Income Generation In Southern Ethiopia	W Tafesse Tirkaso, Sebastian Hess	Research Gate	2015
10	Trends and Challenges in Improved Agricultural Inputs Use by Smallholder Farmers in Ethiopia: A Review	Mideksa Fufa Jilito, Desalegn Yadeta Wedajo	Turkish Journal of Agriculture - Food Science and Technology	2020
11	Review on Impact of ICTs on Improving Agricultural Productivity and Rural Incomes in Ethiopia	Lelisa Daba Chibsa	The International Institute for Science, Technology and Education	2020
12	Determinants of Smallholder Farmers' Income Diversification in Sodo Zuria District, Southern Ethiopia	Atalelech W/kidan and Alula Tafesse	The International Institute for Science, Technology and Education	2023
13	The Role of Information and Communication Technologies for	Abebaw Abebe	The International Institute for Science,	2020

	Agricultural Development in Developing Countries		Technology and Education	
14	Does commercialisation drive technical efficiency improvements in Ethiopian subsistence agriculture?	Wondmagegn Tirkaso, Sebastian Hess	African Journal of Agricultural and Resource Economics	2018
15	Will digital technologies transform agriculture in developing countries?	Deichmanna U, et al.	World Bank	2016
16	A text message away: ICTs as a tool to improve food security	Eduardo Nakasonea, Maximo Torerob	World Bank	2016
17	Agricultural Knowledge Centers: Opportunities and challenges for ICT-enabled knowledge management in Ethiopia	Mamusha Lemma and Beamlak Tesfaye	Research Gate	2016
18	Familiarization and Application of ICTs in Agricultural Advisory Services to Farmers: The Case of Two Rural Districts of Ethiopia	Zegeye F, et al	African Journals Online	2017
19	Commercialization of Coffee Production in Coffee Based Farming Systems in Ethiopia	Erko D, et al.	African Journals Online	2022
20	The role of mobile phones in accessing agricultural information by smallholder farmers in Ethiopia	Amir M, et al.	Research Gate	2016
21	Effect of Mobile Phone Ownership on Agricultural Productivity in Benin: The Case of Maize Farmers	Fawaz A, et al.	Journal of Economics and Development Studies	2018
22	Accessibility Of Agricultural Knowledge And Communication /ICT/ Services To Small Farm Households And Level Of Utilization For Agricultural Development: The Case Of Dugda Woreda Of East Showa Zone, Oromia Region, Ethiopia	ASRESAHEGN GETACHEW	St Mary University	2012
23	Sources of information and information seeking behavior of smallholder farmers of Tanqa Abergelle Wereda, central zone of Tigray, Ethiopia	Brhane G, et al.	Journal of Agricultural Extension and Rural Development	2017
24	The Effects of Training, Innovation and New Technology on African Smallholder Farmers' Economic Outcomes and Food Security: A Systematic Review	Stewart R, et al.	Campbell Systematic Reviews	2015

25	Challenges and Opportunities of Information And Communication Technologies for Dissemination of Agricultural Information in Ethiopia	Abebaw A. Getahun	International Journal Of Agricultural Extension	2020
26	Contributions And Challenges In Research And Extension Linkage For Agricultural Transformation In Ethiopia: A Review	Debele T, et al.	International Journal Of Agricultural Extension	2019
27	The contribution of information and communication technologies to the Ethiopian agricultural extension system: a review of literature on agriculture knowledge management	Dereje Derso and Ekuogbe Ejiro	African Journal of Agricultural Science and Technology	2015
28	Analysis of the Use of Information and Communication Technologies among Farmers in Tole District, South West Shewa Zone, Oromia Regional State, Ethiopia	Derso D, et al.	International Journal of ICT Research and Development in Africa	2012
29	The Use of Mobile Phones In Agricultural Extension In Southern Ethiopia	DERIBE KASKEKACHARO	Sokoine University Of Agriculture. Morogoro, Tanzania.	2016
30	Determinants of smallholder commercialization of livestock: A case study from Tigray, Ethiopia	Gebrekiros H, at al.	Taylor and Francis Group	2021
31	Developing Android Based Application Model for Provision of Real Time Marketing and Agricultural Information for Small Holder's Farmers in North Shoa Zone, Ethiopia	Tesfaye G, et al.	Journal of Computer Engineering	2019
32	Smallholder Agricultural Commercialization for Income Growth and Poverty Alleviation: A Review from Ethiopian Context	Debebe Cheber	The International Institute for Science, Technology and Education	2018
33	Public agriculture extension and Information and Communication Technologies: A case study in South Wollo, Ethiopia	Prof. Dr. Andrea Knierim	University of Hohonheim	2020
34	The Role Of Ict Expenditure For Cash Crop Production And Income Generation In Southern Ethiopia	W Tafesse Tirkaso and Sebastian Hess	The Electronic Journal of Information Systems in Developing Countries	2015
35	Factors affecting farmers' decision to participate in various agricultural related information sources in Ethiopia	Berhanu Daniso	Taylor and Francis Group	2022

36	Harnessing ICT for agricultural extension	Mangnus E, et al.	Sustainable Economic Development and Gender	2016
37	ICTs and Agricultural Marketing in Africa: A Review	Yohannes Girma, Abebaw Abebe	The Electronic Journal of Information Systems in Developing Countries	2019
38	The role of ICTs in agricultural production in Africa	Hopestone Kayisha Chavula	Journal of Development and Agricultural Economics	2014
39	Capacity for knowledge-based smallholder agriculture in Ethiopia Linking graduate programs to market-oriented agricultural development: Challenges, opportunities and IPMS experience	Tefera L, et al.	Livestock Research Institute (ILRI), Addis Ababa, Ethiopia	2012
40	Review on Roles and Challenges of Agricultural Extension System on Growth of Agricultural Production in Ethiopia	Waktole Bayisa Debelo	Journal of Plant Sciences	2020
41	M-Learning For Promoting Advancements In Agriculture: An Innovative Educational Model For Ethiopian Farmers	Vikrant S, et Al.	Adv Math Sci Journal	2020
42	Accelerating technical change through ICT: Evidence from a video-mediated extension experiment in Ethiopia	Gashaw T, at al.	Science Direct	2023
43	Factors Affecting the Use Of Mobile Phone By Smallholder Farmers in Vegetable Marketing: The Case of Fogera District Of South Gondar Zone, Amhara Regional State, Ethiopia	Molla Tadesse	Haramaya University, Ethiopia	2017
44	Measuring the poverty reduction effects of adopting agricultural technologies in rural Ethiopia: findings from an endogenous switching regression approach	Mesel B, et al.	Science Direct	2022
45	Piloting an ICT-based App for providing weather forecasts, agroadvisory and market information to smallholder farmers in Ethiopia	Fikreyesus D, et al.	Research Gate	2020
46	Review on Information Communication Technology Based Agricultural Extension Service in Ethiopia	Berhanu Daniso	Research Gate	2019

47	Smallholder wheat producers' access to agricultural information and its influencing factors in sululta district, oromia regional state in ethiopia	Samuel Leta Degefa	Haramaya University, Ethiopia	2023
48	Analysis of the status and determinants of rural households' access to agricultural extension services: the case ff jimma geneti woreda, oromia regional state, ethiopia	Kassa A, et al.	International Journal of Agricultural Extension and Rural Development Studies	2021
49	Radio and mobile phone utilization among smallholder farmers for food crop market information: the case of damboya district, kembata tembaro zone, central ethiopia	Tariku Gemedo	Haramaya University, Ethiopia	2023
50	The Importance of ICTs in the Provision of Information for Improving Agricultural Productivity and Rural Incomes in Africa	Asenso-Okyere and Daniel Ayalew Mekonnen	United Nations Development Programme	2012
51	The Role of ICT for Good Governance and Agricultural Development in Ethiopia: Local Evidence from Southern Ethiopia	Mohammed Yimer	International Journal of Political Science and Development	2015
52	The Role of Information Communication Technology for Agricultural Extension Service In Ethiopia	Berhanu Daniso	Research Gate	2017
53	Information Communication Technologies and Poverty Reduction in Rural Ethiopia Challenges and Prospects: Household Level Analysis	Wondmagegn Tafesse Tirkaso	Swedish University of Agricultural Sciences	2011
54	The Role of Agricultural Commercialization for Smallholders Productivity and Food Security	Wondmagegn Tafesse Tirkaso	Swedish University of Agricultural Sciences	2013
55	The Use Of Mobile Phone In Beef Cattle Marketing Among Smallholder Farmers: The Case of Girar Jarso District Of North Shoa Zone, Oromia Region, Ethiopia	Yohannes Girma	Haramaya University, Ethiopia	

Appendix 3. Data Sources for Qualitative Content Analysis by NVivo, Tanzania

	Title	Author	Publisher	year
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1	Household-specific targeting of agricultural advice via mobile phones: Feasibility of a minimum data approach for smallholder context	Steinke J, et al.	Science Direct	2019
2	Using radio and interactive ICTs to improve food security among smallholder farmers in Sub-Saharan Africa☆	Hudson e. et al.	Science Direct	2017
3	Differential Impacts of Conservation Agriculture Technology Options on Household Income in Sub-Saharan Africa	Justice A. Tamboa, Jonathan Mockshell	Science Direct	2018
4	An overview of approaches and methodologies for supporting smallholders: ICT tools, blockchain, business models, sustainability	Francesco Longo	Science Direct	2023
5	Use of Icts In Sharing Agricultural Information Among Fish Farmers In The Southern Highlands In Tanzania	Ronald Benard	Sokoine University of Agriculture, Tanzania	2018
6	Role of ICTS in Accessing and disseminating Information for Improved Urban Livestock Keeping in Tanzania. A Review of Related Literature.	Consolata Angello	Library Philosophy and Practice (e-journal), University of Nebraska	2017
7	The impact of mobile phones on knowledge access and transfer of small-scale horticultural farmers in Tanzania	Krone M, at al.	Journal of the Geographical Society of Berlin	2014
8	Delivery mechanisms of agricultural information and knowledge to smallholder farmers in Tanzania: A meta-analysis study	Tumpe Ndimbwa T, et al	University of Dar es Salaam Library Journal	2019
9	Access to and Use of Agricultural Information for Smallholder Farmers' Adaptation to Climate Change in Iringa Rural District, Tanzani	Jackson R. Sawe	University of Dar es Salaam Library Journal	2022
10	Access and Use of Information Communication Technologies by Agricultural Extension Agents in Tanzania	R. Martin and J. S. Kahamba	Sokoine University of Agriculture, Tanzania	2017
11	Socio Economic Characteristics Enhancing Farmers' Use of Mobile Phones to Access Agricultural Information in Tanzania	Siwel Yohakim Nyamba	International Journal of Agricultural Science, Research and Technology in Extension and Education Systems	2021

12	Building an agricultural extension services system supported by ICTs in Tanzania: Progress made, Challenges remain	Sanga C, et al.	International Journal of Education and Development using Information and Communication Technology	2013
13	Assessment of information needs of rice farmers in Tanzania; A case study of Kilombero District, Morogoro	Ronald Benard	International Journal of Education and Development using Information and Communication Technology	2013
14	Bridging Gender Gaps in Provision of Agricultural Extension Service Using ICT: Experiences from Sokoine University of Agriculture (SUA) Farmer Voice Radio (FVR) Project in Tanzania	Sanga C, et al.	International Journal of ICT Research and Development in Africa	2014
15	Data management system for sustainable agriculture among smallholder farmers in Tanzania: research-in-progress	Mushi G, et al.	Taylor and Francis Group	2023
16	Information And Communication Technology In Small- Scale Business Based Agricultural Value Chains In Sub-Saharan Africa	Madlen Krone	Berlin University	2017
17	The State of Rural Information and Communication Services in Tanzania: A Meta-Analysis	Wulystan Pius Mtega, Benard Ronald	International Journal of Information and Communication Technology Research	2013
18	The Use Of Participatory Approaches In Developing Ict-Based Systems for Disseminating Agricultural Knowledge and Information For Farmers In Developing Countries: The Case Of Tanzania	Barakabitze A, Kadegehe G. Fue	The Electronic Journal of Information Systems in Developing Countries	2017
19	Bridging The Agricultural Knowledge And Information Divide: The Case Of Selected Telecenters and Rural Radio In Tanzania	Edda Tandi Lwoga	The Electronic Journal of Information Systems in Developing Countries	2017
20	Technology For Small Scale Farmers In Tanzania: A Design Science Research Approach	Misaki E, et al.	The Electronic Journal of Information Systems in Developing Countries	2016
21	ICTs and development in developing countries: A systematic review of reviews	Lwoga E, et al.	The Electronic Journal of Information Systems	2018

			in Developing Countries	
22	Effect of ICT tools attributes in accessing technical, market and financial information among youth dairy agripreneurs in Tanzania	Otieno Okello D, et al.	Taylor and Francis Group	2020
23	Exploring the use of ICTs in learning and disseminating livestock husbandry knowledge to urban and peri-urban communities in Tanzania	Consolata Angello	Library Philosophy and Practice (e-journal), University of Nebraska	2015
24	Strengthening Extension and Advisory Services Delivery through Village Knowledge Centre in Rungwe District, Tanzania: Lessons Learned from InnovAfrica Project	Athman A, et al	International Journal of Education and Development using Information and Communication Technology	2023
25	Farmers' Access and Use of Mobile Phones for Improving the Coverage of Agricultural Extension Service: A Case of Kilosa District, Tanzania	Boaz Stanslaus Kiberiti	International Journal of ICT Research in Africa and the Middle East	2016
26	Mobile phone use is associated with higher smallholder agricultural productivity in Tanzania, East Africa	Quandt A, et al.	Research Gate	2020
27	Movements, Determinants And Effect of Agriculture Commercialization Among Smallholder Farmers In Tanzania	Franco John Mbegallo	AgEcon Search	2016
28	Urban Agriculture and the Use of ICTS in Accessing and Disseminating Livestock Husbandry Information in Urban Areas of Tanzania. A Review of Related Literature.	Consolata Angello	Library Philosophy and Practice (e-journal), University of Nebraska	2017
29	Bridging The Agricultural Knowledge And Information Divide: The Case Of Selected Telecenters and Rural Radio In Tanzania	Edda Tandi Lwoga	The Electronic Journal on Information Systems in Developing Countries	2013
30	Ict ss A Tool For Improving Information Flow Among Livestock Stakeholders. A Case Study Of Tanzania.	Gladness Mwanga George	International Journal of Computer Science and Information Security	2014
31	The Influence of ICT Usage in Sharing Information on Fish Farming Productivity in the Southern Highlands of Tanzania	Ronald B. et al.	The International Journal Of Science & Technoledge	2018
32	ICTs, smallholder agriculture and farmers' livelihood improvement in	Gabriel Kanuti Ndimbo	Sage Journals	2023

	developing countries: Evidence from Tanzania			
33	Factors Underlying the Choice of Information and Communication Technologies among Small holder Farmers in Tanzania	Timothy F, et al.	Reseach Gate	2016
34	The Little we Know: An Exploratory Literature Review on The Utility Of Mobile Phoneenabled Services For Smallholder Farmers	HEIKE BAUMÜLLER	Journal of International Development	2018
35	E-Ng'ombe: A Mobile Phone ICT to Tackle the Pitfall of Information Asymmetry in the Value Chain of Indigenous Beef Cattle in Mwanza Region, Tanzania	Ibrahim L, et al.	Journal of Agriculture Economics and Rural Development	2013
36	Information and Communication Technologies as Enablers for Effective Functioning of Agricultural Innovation Systems in Tanzania: Experiences of Young Farmers	Jotta S, et al	ASRIC JOURNAL ON AGRICULTURAL SCIENCES	2022
37	The use of modern information and communication technologies in smallholder agriculture: Examples from Kenya and Tanzania	Krone M, et al.	Reseach Gate	2015
38	Effectiveness of information and communication technologies in dissemination of agricultural information to smallholder farmers in Kilosa District, Tanzania	Levi, C., Kyazze, B. F. & Sseguya, H.	FAO	2014
39	ICT Adoption and Access Among Small-Scale Tea Growers in Rungwe, Tanzania	Madembwe P, et al.	MUST Journal of Research and Development	2023
40	Making ICTs work for Agro-pastoral Livelihood: Using the Telecentre as Learning Tool for Agro-pastoralists Communities in Tanzania	Ngowi, E, et al.	Journal of Sustainable Development	2015
41	Minding the Gaps: Information and Communication Technology (ICTs) and Sustainable Agriculture Development in Rural Areas of Tanzania	Ngowi E.Edwin	University od Dodoma	2020
42	Contribution of Mobile Phones To Rural Livelihoods and Poverty Reduction In Morogoro Region, Tanzania	Sife s, et al.	The Electronic Journal on Information Systems in Developing Countries	2010

43	Factors influencing access to agricultural knowledge: The case of smallholder rice farmers in the Kilombero district of Tanzania	Wulystan P, et al.	South African Journal of Information Management	2016
44	A framework for enhancing sustainable access and use of agricultural market information by small-scale farmers in Tanzania	Magesa, Mawazo Mwita	The Nelson Mandela African Institution of Science and Technology	2018
45	Using Information and Communication Technologies to Enhance Information Sharing For Improved Fish Farming Productivity In Tanzania	Ronald Benard	Sokoine University Of Agriculture, Morogoro, Tanzania	2019
46	What happens after technology adoption? Gendered aspects of smallscale irrigation technologies in Ethiopia, Ghana, and Tanzania	Theis T, et al.	Agriculture and Human Values	2018
47	System Design and ICT Adoption in Agricultural Extension Services Delivery in Tanzania	Sanga A, et kal.	Reseach Gate	2013
48	Sources of agricultural information for women farmers in Tanzania	Elizabeth L, et al.	Reseach Gate	2018
49	Towards a Revolutionized Agricultural Extension System for the Sustainability of Smallholder Livestock Production in Developing Countries: The Potential Role of ICTs	Mapiye O, et al.	Multidisciplinary Digital Publishing Institute	2021
50	Digital Technology and Services for Sustainable Agriculture in Tanzania: A Literature Review	Mushi e et al.	Multidisciplinary Digital Publishing Institute	2022
51	Digital Literacy of Smallholder Farmers in Tanzania	Magesa M, et al.	Multidisciplinary Digital Publishing Institute	2023
52	Mobile Technology for Enhancing the Flow of Agricultural Information between SmallScale Farmers and Other Crop Farming Stakeholders in Chamwino, Tanzania	EZRA MISAKI	University of Eastern Finland	2021

Appendix 4: Data Sources for Qualitative Content Analysis by NVivo, Uganda

	Title	Author	Publisher	year
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1	Agricultural Technology, Crop Income, and Poverty Alleviation in Uganda	KASSIE M, et al	Elsevier Ltd	2011
2	ICT-based market information and adoption of agricultural seed technologies: Insights from Uganda	Barnabas Kiiza & Glenn Pederson	Elsevier Ltd	2012
3	Using radio and interactive ICTs to improve food security among smallholder farmers in Sub-Saharan Africa	Hudson E, et al.	Elsevier Ltd	2017
4	Building digital bridges in African value chains: Exploring linkages between ICT use and social capital in agricultural marketing	Baumüller H, et al.	Elsevier Ltd	2023
5	The benefits and challenges of using ICTs to strengthen university-farming community engagement in Uganda	Opolot H, et al.	AgEcon serarch	2016
6	Challenges of meeting information needs of rural farmers through internet-based services: experiences from developing countries in Africa	Chinyeaka F, et al.	IFLA WLIC	2016
7	Mobile Phones and Rural Livelihoods: Diffusion, Uses, and Perceived Impacts Among Farmers in Rural Uganda	Brandie Lee Martin & Eric Abbott	USC Annenberg School for Communication & Journalism	2011
8	Adopting and Practicing ICT led Agriculture by young Farmers: A Success Story in Luwero District, Uganda	Herbert Lwanga	CTA	2015
9	Marketing of Agricultural Products And The Use Of Mobile Phones Among Farm-Households in Ghana And Uganda: A Survey	Niem K et al,	Nordic View To Sustainable Rural Development	2015
10	Digitalisation for Agriculture The Case Of Muiis Uganda.	CTA	CTA	2019
11	Making ICTs relevant to rural farmers in Uganda: A Case of Kamuli District	Winy Nekesa Akullo & Onan Mulumba	RBPD	2016
12	Women's Empowerment, Agricultural Extension, and Digitalization.	Lecoutere E, et al	IFPRI	2016
13	A Mobile-Based Communication Adoption Model for agricultural market information dissemination in Uganda	Engotoit B, et al.	Global Journal of Computers & Technology	2016
14	A text message away: ICTs as a tool to improve food security	Eduardo Nakasone & Maximo Torero	Agricultural Economics	2016

15	The Role of Information and Interaction Processes in the Adoption of Agriculture Inputs in Uganda	Kathlee Freeman & Hua Qin	Agronomy	2019
16	Performance Incentives and Information Communication Technologies in Ugandan Agricultural Extension Service Delivery	Festus Amadu	African Journal of Food, Agriculture, Nutrition and Development	2019
17	Agricultural Extension And Technology Adoption For Food Security: Evidence From Uganda*	PAN Y, et al.	American Journal of Agriculture	2018
18	Information and Communication Technologies to Provide Agricultural Advice To Smallholder Farmers: Experimental Evidence From Uganda	VAN B, et al.	American Journal of Agriculture	2014
19	Application of ICT in Agriculture: Opportunities and Challenges in Developing Countries	Saidu A, et al.	International Journal of Computer Science and Mathematical Theory	2017
20	Agricultural Technology Adoption and Nonfarm Earnings In Uganda: A Semiparametric Analysis	Gracious M. Diiro & Abdoul G. Sam	The Ohio State University	2016
21	Awareness of ICT-Based Projects and the Intensity of Use of Mobile Phones Among Smallholder Farmers in Uganda: The Case of Mayuge and Apac District	Lwasa S, et al	IGI Global	2013
22	Extent, Levels and Suitability of ICT Usage for Agricultural Information Dissemination in Uganda: A Case of Rubanda, Mayuge Districts, and Mbarara City	Willbroad B, et al.	Global Journal of Science Frontier Research: D Agriculture and Veterinary	2023
23	Challenges Facing Smallholder Farmers' ICT-Based Market Information Service (Mis) Projects: The Case Of Brosdi And Wougnet In Uganda	Narathius Asingwire	international Journal of Research	2011
24	Determinants for Adoption of ICT-based Market Information Services by Smallholder Farmers and Traders in Mayuge District, Uganda	Haruna Sekabira	AgEcon serarch	2012
25	ICT and Youth in Agriculture	Ken Lohento & Oluwabunmi D. Ajilore	Research Gate	2015

26	Perceptions of the role of ICT on quality of life in rural communities in Uganda	Kivunike F, et al.	Taylor and Francis Group	2011
27	Influence of performance expectancy on commercial farmers' intention to use mobile-based communication technologies for agricultural market information dissemination in Uganda	Engotoit B, et al	Research Gate	2016
28	Crop Production, Gender Roles and the Use of Mobile Phones and Radios for Agricultural Information by Farmers in Apac District, Northern Uganda	Mugambe D, et al	Open Journal of Social Sciences	2019
29	The role of ICT adoption in promoting livelihoods in Eastern Africa: Evidence from Uganda.	Subramanian K, et al.	Research Gate	2022
30	Mobile phone technology for increasing banana productivity among smallholder farmers in Uganda	Tinzaara W, et al.	Journal of Agricultural Extension and Rural Development	2021
31	Factors Affecting Adoption of An Information Communications Technology System For Agriculture In Uganda	Daniel Ninsiima	Mishigan State University	2015
32	The Effects of Agricultural Extension Service on Farm Productivity: Evidence from Mbale District in Uganda	Lee Y, et al	Creative Commons	2017
33	Re-Conceptualisation of Agriculture Information System for Uganda	Oyo B, et al.	Research Gate	2014
34	Effects of Agricultural Extension Services on Farm Productivity in Ugand	Richard Sebaggala & Fred Matovu	A FRICAN ECONOMIC RESEARCH CONSORTIUM	2020
35	ICT for financial access: Mobile money and the financial behavior of rural households in Uganda	Ggombe Kasim Munyegera & Tomoya Matsumoto	John Wiley & Sons Ltd	2017
36	Role of mobile phones in improving communication and information delivery for agricultural development: Lessons from South Western Uganda	Masuki K, et al.	Research Gate	2010
37	Adoption of ICT innovations in the agriculture sector in Africa: a review of the literature	Ayim C, et al.	Agriculture & Food Security	2022

38	ICT and agricultural sector performance: empirical evidence from sub-Saharan Africa	Oyelami O, et al.	Agriculture & Food Security	2022
39	Revolutionalizing Agriculture Extension Delivery Through Mobile Telephony: The Experience Of Village Enterprise Agent Model In Greater Masaka Area, Uganda	MUGABI N, et al.	WIT Transactions on Ecology and the Environmen	2019
40	Mobile Phones, Gender, and Nutrition among Smallholder Farm Households in Uganda	Sekabira H, et al.	Research Gate	2016
41	The Importance of ICTs in the Provision of Information for Improving Agricultural Productivity and Rural Incomes in Africa	Kwadwo Asenso-Okyere and Daniel Ayalew Mekonnen	UNDP	2012
42	The use of Information Communication and Technology in advancement of African agriculture	Dionysious Kiambi	African Journal of Agricultural Research	2018
43	There is an app for that? The impact of community knowledge workers in Uganda	Bjorn Van Campenhout	Taylor and Francis Group	2017
44	The Role of Market Information in Adoption of Agricultural Seed Technology in Rural Uganda	Kiiza B B, et al.	IGI Global	2013
45	Using ICTs to disseminate Agricultural Marketing Information to Small Scale Rural Farmers in Western Uganda	Miwanda A, et al.	International Journal of Innovative and Applied Research	2014
46	Determinants for Adoption of ICT-Based Market Information Services by Smallholder Farmers and Traders in Mayuge District, Uganda	Sekabira A, et al	AgEcon search	2012
47	Efficiency Effects of Access to Information on Small Scale Agriculture: Empirical Evidence from Uganda	Yakubu Abdul-Salam & Euan Phimister	AgEcon search	2010