

Leveraging an Information and Communication Technology (ICT) application to enhance Communication and Coordination within Nandi Avocado Farmers Cooperative Society



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Leveraging an Information and Communication Technology (ICT) application to enhance Communication and Coordination within Nandi Avocado Farmers Cooperative Society

A Research Thesis Submitted to Van Hall Larenstein University of Applied Sciences in Partial Fulfilment of the Requirements for Master of Agricultural Production Chain Management (APCM) – Horticulture Chains Degree

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DEDICATION

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ABBREVIATIONS

3R- Robustness, Reliability and Resilience AFA- Agriculture and Food Authority FAO- Food and Agriculture Organization FORQLAB- Food Waste Reduction and Food Quality Living Lab GAP- Good Agricultural Practices **GPS-Global Positioning System** HCD- Horticultural Crops Directorate ICT- Information and communication technologies KALRO- Kenya Agricultural and Livestock Research Organization KAMIS- Kenya Agricultural Market Information System KAOP-Kenya Agricultural Observatory Platform KEPHIS-Kenya Plant Health Inspectorate Service NARIGP- National Agriculture and Rural Inclusive Growth Project SMS-Short Message Service **TOTs- Training Of Trainers TVET-** Technical Vocational Education and Training

ABSTRACT

Avocados have been gaining market share worldwide. Kenya's avocado exports rose by 313% in export share from 25,002 tons in 2013 to 103,240 tons in 2022. Effective communication and coordination across chain actors are crucial for the Kenyan avocado cooperatives to sustain their market share in the diverse markets.

Cooperatives are valuable for strategically representing the interests of farmers; yet, effective communication remains a barrier. The four cooperatives in the FORQLAB project, dealing with the avocado value chain (Nandi, Mt. Kenya, Mt. Kenya East, and Abothoguchi) have formed a union. They do not, however, have needs that are compatible with one another. The lack of a well-organized framework and sufficient data management has led to issues including mismatches in supply and demand, challenges in accurately recording supply, and the cooperatives' inability to clearly state their goals and demands in terms of value addition. To improve communication practices within the cooperatives, there is a need to introduce an ICT application to facilitate communication and strengthen coordination.

The study aimed to identify the needs required to successfully implement an ICT application that would strengthen coordination and communication among the Nandi avocado farmers' cooperative. The study examined the needs of farmers and the cooperative for coordination and communication, as well as the short and long-term features that the application should have. It also examined the resources that developers would require to develop the application, as well as the timeframe and key steps that developers will take. A qualitative methodology was employed in the study design, utilizing data from both desk and field research. Data was acquired through focus group discussions with farmers and the cooperative, as well as interviews with the KALRO ICT officer, the eProd founder, the Pharox director, and the Amtech Easy pro software developer.

The results showed that the needs of farmers and cooperatives are among the five essential services of information analytics, market and financial accessibility, tracking and traceability, and information sharing. Information analytics was a long-term feature; market and finance accessibility, as well as information sharing, were short-term features. There were long-term aspects to tracking and traceability as well as short-term aspects. Financial resources, end-user needs, and a technical grasp of what the application should have are the resources that developers will need to create the application.

According to the findings, introducing an ICT application for the Nandi Cooperative was not feasible at the moment since they already have the Easy Pro program and the needs required can be integrated into it. The recommendations proposed were for the cooperative to streamline its operations by using the bulk SMS with the sender ID "Nandi Avocado Farmers' Cooperative", the Easy Pro program, creating its website, establish tactical alliances to secure funding for the Easy Pro program, and create awareness of the existing KALRO applications. Moreover, in case they were to develop and implement an ICT application in the future enhancing farmers' digital literacy skills and establishing tactical alliances for funding would be needed.

CHAPTER ONE: INTRODUCTION

The research aimed to strengthen communication and coordination within the Nandi Avocado Farmers Cooperative Society by developing an action plan for implementing an ICT application and recommending features to be included. This will enable the cooperatives to share information amongst themselves, to know the market needs and if they are met, and to communicate the information to farmers and exporters. The cooperatives will match the demand and supply, know which variety and when it is needed, and the Good Agricultural Practices to adhere to.

According to Kourgialas and Dokou (2021), avocados have become more widely produced and consumed in recent years, and their global market share has been steadily growing. This shows great potential in the avocado market and there is a need to take advantage of the diverse markets. As the market continues increasing, there is a need for proper communication and coordination amongst the chain actors. Literature has demonstrated that communication is essential to organizational governance (Peng, Hendrikse, and Deng, 2018). Information and communication technologies (ICTs) can change cooperative cultures by strengthening communication and collaboration and broadening their network of future networks. Information and communication technologies (ICTs) also improve cooperative management by enhancing data and operational management practices. The importance of communication and collaboration within an organization cannot be overstated.

1.1. Avocado Sector in Kenya

Kenya's agriculture sector, which employs 80% of the nation's workforce and contributes 29% of GDP, is the backbone of the country's economy (Horticultural Crops Directorate, 2017-2018).Fruits contributed Ksh13 billion (91 million euros) in value exports, representing 8% of all horticultural exports (Horticultural Crops Directorate, 2017-2018). Avocados accounted for Ksh11 billion (76 million euros) representing 84% of the total fruit value that was exported (Horticultural Crops Directorate, 2017-2018).

Furthermore, the avocado output increased by 175 percent between 2012 and 2022 (Food and Agriculture Organization, 2024), as depicted in Figure 1 below. Additionally, a 152% rise in the area of avocados harvested in hectares as shown (Food and Agriculture Organization, 2024). The production of avocados rises in tandem with the steady increase in the cultivated area.



FIGURE 1: AVOCADO PRODUCTION AND AREA HARVESTED

⁽SOURCE: FAO 2024)

As illustrated by Figure 2 below, avocado exports have increased from 25,002 tons in 2013 to 103,240 tons in 2022, a 313% rise in export share (Food and Agriculture Organization, 2024).

FIGURE 2: AVOCADO EXPORT IN KENYA



(SOURCE: FAO 2024)

In Kenya, various regions have different weather patterns, which causes farmers in some areas to produce more avocados than others. The percentage of avocado output in each of Kenya's regions is shown in Figure 3 below. The majority of avocados, roughly 70% of the total, are produced in the Central and Eastern areas (Ouma et al 2018).





(SOURCE: OUMA ET AL 2018)

According to Johnny et al (2019) Hass (20%), Fuerte (80%), and Jumbo (Kienyeji) avocados are the three most common types of avocados in Kenya. The Jumbo avocados consist of Puebla, Pinkerton, and Reed, among other local varieties. Hass is the most popular variety, with a higher oil content of 20% and a stronger resistance to diseases and pests compared to the other two types of avocados while Fuerte is the second most popular type, with an oil content of 16–18%.

Due to a shift in consumer preference for Hass avocados that are ready to eat in the Western European market, avocado growers are now switching from Fuerte to Hass avocados (Johnny et al., 2019). Most avocados planted and produced in Kenya are organic. Furthermore, the climate makes it possible for the fruit to grow year-round. Fruits are available all year round, albeit in lower amounts that are mostly marketed locally. However, in Kenya, the main avocado season runs from February until October. While Fuerte is accessible from February, Hass avocado is available from March (EU-EAC MARKUP II, 2021).

Avocados are a popular fruit in Kenya and Kenyans enjoy avocados and often eat them with bread, rice, githeri, ugali, or other vegetables. Some people make guacamole out of them, while others just eat them plain. Avocado is also an ingredient in flavour soups, ice cream, and milkshakes. In addition to being used as an ingredient in skin lotion and hair oil, avocado oil may be used in cooking. According to Bill et al (2014), avocado is highly nutritious, and it is rich in vitamins A, B, C, minerals, potassium, phosphorus, magnesium, iron, and antioxidants. The biggest challenge is that the fruit is highly susceptible to qualitative and quantitative postharvest losses.

1.2. ICT in Agriculture Development

The importance of communication cannot be overemphasized as it enables the exchange of knowledge and information seamlessly amongst actors in the agricultural value chain, and it facilitates product tracking and traceability. Information symmetry is the result of improved communication when every actor in the communication or transaction has equal access to all pertinent information. The use of information and communication technologies (ICTs) in the agricultural sector is growing due to their capacity to bring people together who are geographically separated for real-time communications and information exchange (Madukwe, 2012).

The use of ICT in a value chain is a key component of competitive advantage and a performance enabler. Through the facilitation of quick and inexpensive communication, it plays a part in lowering transaction costs and increasing sustainability by its ability to connect and provide venues for knowledge sharing amongst different stakeholders via online platforms and apps (Waqar, Gu and Nie, 2018).

Currently in Kenya, there are existing applications to inform farmers on weather patterns and market prices. There is the KALRO Selector app which guides farmers on the right variety of crops to plant or livestock to keep, KALRO KAOP which informs farmers on the weather patterns, and KAMIS which informs on the prices of different commodities in different counties. Furthermore, there are the KALRO Avocado seedling, KALRO Avocado variety, and KALRO GAPs apps which inform farmers about the type of seedlings available and the farming practices(Kenya Agricultural & Livestock Research Organization, 2024). Although all these apps exist independently, according to Verschuur and Bouma (2024), there is an urgent need for an application that facilitates horizontal and vertical communication among the cooperatives, farmers, and exporters in the Nandi avocado value chain.

The four cooperatives in the FORQLAB project, dealing with the avocado value chain (Nandi, Mt. Kenya, Mt. Kenya East, and Abothoguchi) have formed a union. However, their needs are different and not in line with each other. The research will assist in ascertaining their needs and show them what they need at each time so that they can have proper coordination amongst themselves.

1.3. The Food Waste Reduction and Food Quality Living Lab Project (FORQLAB)

This project involves various partners including universities (2 Kenyan, and 4 Dutch), the private sector, and organizations supporting actors in the dairy and avocado chains. The project began in Kenya in early June 2022 and ended in May 2024 with an extension to November 2024. The project goal is to contribute to the structural reduction of post-harvest and food losses and food quality improvement via the application of technical solutions and tools as well as improved chain governance.

Sustainability is important in all operations and in the avocado value chain, there is the achievement of sustainable development goals 2 (zero hunger), 8 (decent work and economic growth), and 12 (responsible consumption and production). For the avocado value chain to continue flourishing even after the FORQLAB project ends, there is a need for communication upgrading within the cooperatives through the use of innovations. The communication and governance amongst all actors in the chain can be challenging and thus the avocado value chain needs to be resilient and capitalize on the everchanging technological requirements by leveraging an ICT application. A junior researcher from the FORQLAB project has designed basic design features that the proposed application should have which the cooperatives might require. More features that the proposed app should have will be known during the research.

The research aims to improve the robustness of the chain by developing an application where there can be efficient information flow and transparency since all the cooperative members can access the site thus improving the trust among them. In addition, the research will be capitalizing on ICT innovations thus improving on the resilience aspect of the 3R.

Ten Master's theses on food loss and quality are among the anticipated outcomes of FORQLAB. Additional goals include enhancing cooperatives' capacity to enhance their operations and, ultimately, implementing this strategy in universities and TVETs. The FORQLAB project targets two areas in Kenya, a relatively well-developed chain in the central highlands and a less-developed chain in Western Kenya. This proposal will focus on the less developed chain in Western Kenya in Nandi (Regieorgaan SIA, 2024).

1.4. Nandi Avocado Farmers' Cooperative Society

The cooperative is in Kapsabet Nandi County, the home of the six sub-counties of Tinderet, Mosop, Aldai, Emgwen, Chesumei, and Nandi Hills. It began with 36 members in 2019 and increased to 1012 members in 2023, a notable increase (Niyonsenga et al., 2024). The Cooperative helps sell farmers' produce, train farmers on GAPs, and provide seeds to farmers.

To alleviate the post-harvest losses, the County government, development partners, and Nandi cooperative are also constructing a new collection, grading, and cooling center as well as an avocado processing plant. The FORQLAB project assists in linkage to the market and capacity building of the cooperative through the 'My Coop' training by Agriterra.

1.5. Commissioner of the Research

Peter Bouma commissioned the project on behalf of the Food Waste Reduction and Food Quality Living LAB (FORQLAB) Project. The problem owners are the farmers and the Nandi avocado farmers' cooperative society.

1.6. Problem Statement

Cooperatives play a strategic role in advocating for farmers' interests, however, there is the challenge of efficient communication which is centred on the fact that Nandi farmers' cooperatives still need improvement in efficient communication on production practices, market information, extension services, partnership with certified seedling suppliers, and assisting in farmers' certification. Studies have shown that the cooperatives lack a strategic agenda and key indicators for financial and operational management (Bouma, 2024). The absence of an organized structure and adequate data management has contributed to problems such as a mismatch between demand and supply, difficulty

recording supply, and the inability of the cooperatives to articulate the needs and objectives in terms of value addition. This is affirmed by Onyangore (2022), who reported on the inefficient analog data management system amongst the farmers.

To improve communication practices within the cooperatives, there is a need to introduce an ICT application to facilitate communication and strengthen coordination. This research will assess the farmers' cooperative communication and coordination needs, investigate the short- and long-term functionalities of the proposed application, and develop an action plan for the coming years within the Nandi avocado farmers cooperative society in Nandi County.

1.7. Research Objective

The research aims to develop an action plan for implementing an ICT application to strengthen communication and coordination within the Nandi avocado farmers cooperative in Nandi County, Kenya.

1.8. Research Questions

Main Research Question

What is needed to successfully implement an ICT application to strengthen communication and coordination within the Nandi avocado farmers' cooperatives in Kenya?

Sub-Research Questions

- 1. What are the farmers' and cooperatives' communication and coordination needs in Nandi County?
- 2. What short and long-term functionalities should the proposed ICT application have?
- 3. What resources are needed by developers to develop the proposed application?
- 4. What are the key steps and timeframe needed to develop the proposed application?

CHAPTER 2. LITERATURE REVIEW

2.1. Definition of Concepts

Action plan- It is a meticulously organized approach that identifies the precise key steps, assignments, and resources required to realize a goal. It also includes the people in charge of the assignments and the time frame of each assignment (Bridges, 2023).

Communication- It is the process of generating and disseminating concepts, knowledge, viewpoints, details, and emotions among individuals, groups, and locations (Toppr, 2023).

Coordination- is a well-planned set of actions that promotes teamwork in the pursuit of a common objective (Toppr, 2023).

Digital communication practices- It is sometimes referred to as data transmission or data communication and is the method of sending information or data across a point-to-point (P2P) channel using digital signals (European Institute of Technology, 2024).

ICT (Information and Communication Technology) - It is any form of hardware and software employed to facilitate the processing, storing, and analysis of data as well as the transport and communication of data via the Internet and other channels (Weber and Kauffman, 2011).

ICT adoption- It is when companies make technological investments to support their operations and when users start utilizing it and gain benefits from it (Weber and Kauffman, 2011).

ICT application- An information and communication technology (ICT) application is a user-focused program that works with computers, telecommunications, and information systems. It covers the creation and management of networks, databases, websites, and systems (Route ICR, 2024).

Information asymmetry- It is when one party has exclusive access to some information, and the other party makes decisions with limited available information (Wei et al., 2015).

Information symmetry- It is when all members of the supply chain have equal access to necessary information and are fully aware of one another's operations (Wei et al., 2015).

Leveraging ICT- It is the utilization of digital tools, platforms, and technology to advance sustainable development, boost production, and improve agricultural practices (Kausar et al., 2023).

Traditional communication practices- They refer to the channels of communication that are currently and were previously employed in rural areas. There is more verbal communication, and they use analog, face-to-face, or physical techniques (vtpass, 2017).

Value Chain- It has been promoted by Porter and is the series of actions that a company does to produce a worthwhile product for the market (Simatupang, Piboonrungroj and Williams, 2017).

Other concepts are explained within the chapter.

2.2. Chain Map

Figure 4 below depicts the various stakeholders involved in the Nandi avocado value chain.

FIGURE 4: NANDI COUNTY AVOCADO VALUE CHAIN MAP



(SOURCE: AUTHOR 2024)

2.3. Stakeholder Analysis

A. Chain Actors

- **Input Supply**: There are certified and non-certified nurseries where avocado farmers can buy seedlings from. However, the farmers are advised to buy from certified nurseries since these meet the market requirements.
- **Producers**: The smallholder farmers practice avocado farming as a means to diversify their income sources.
- **Collection**: The majority of the smallholder farmers are in the Nandi avocado farmers' cooperative and the cooperative collects the avocados from them. It also markets their avocados thus increasing their bargaining power due to higher volumes.
- Wholesale: This is done by the middlemen, some farmers sell to them since payment is direct, unlike the cooperative payment which delays. The middlemen sell the avocados to exporters, retailers, and oil processing companies.
- **Exporting**: The major avocado exporters are KEIIT and Sunripe. To ensure the avocado satisfies the requirements of the export market, they sort the avocados.
- **Processing**: The processing firms buy the avocados which do not meet the market requirements and also the middlemen sell some to them. They process the avocados into oil and also they make soaps and cosmetics.
- **Retail**: The avocados which do not meet the export market requirements are sold locally.

B. Chain Supporters

- **Ministry of Agriculture and Livestock Development** they play a supportive role by providing extension services.
- **FORQLAB** they lead the project and they use the living lab approach to assist the Nandi avocado value chain by reducing post-harvest food loss and waste in the avocado value chain.
- **Safaricom** a telecommunication provider that uses the Digifarm app to provide farmers with quality products, services, and markets. Additionally, the MPESA app offered by the telecommunications firm allows users to conduct financial operations including paying membership fees to the cooperative.
- **Financial Institutions** assist in access to finance by providing loans to any chain actor who needs the funds.
- **NARIGP** by the World Bank (National Agriculture and Rural Inclusive Growth Project) aid in offering technical and financial support.
- **KALRO** (Kenya Agricultural and Livestock Research Organization) provides extension services to farmers.
- **EOSTA** They are one of the main importers of avocados from Nandi County.
- **AIRFLO** They provide air transport for the avocados to the imported country.

C. Chain Enablers

• **KEPHIS** (Kenya Plant Health Inspectorate Service) and **HCDA** (Horticulture Development Authority)- oversee the regulation of the inputs and the produce.

2.4. ICT

Kau (2022) defines **ICT** as the infrastructure that supports modern computer operations and it is known as information and communication technology, or ICT. It consists of every device, components, applications, and systems that enable both individuals and organizations to connect and work together online. It's essential for individuals and institutions nowadays as it fosters economic growth and commercial expansion.

According to Marketlinks (2023), there are numerous opportunities to take advantage of and overcome hurdles to value chain growth and competitiveness, via information and communications technology (ICT). ICT can increase competitiveness in the following ways;

- barcoding helps expedite product delivery to markets minimizing the deterioration of perishable product shipments
- SMS text messaging can assist by giving farmers access to real-time market pricing information
- cell phones can increase vertical or horizontal links due to their ability to facilitate reliable rapid communication
- The Internet information on novel production methods and advances in technology can be found for the value chain actors to leverage and gain entry into new, higher-value markets.

Hardware- These are the visible components of a computer consisting of the input, output, storage device, and system unit (Afriyie, 2012).

Software- It is the unseen component that powers the computer and is made up of programs that instruct the hardware on how to perform operations (Afriyie, 2012).

Networks- An office or building's intranet is one example of an internal network, often known as a LAN (local area network), which links several hardware components together. External network is the communication that extends beyond an organization's internal network. One example of a Wide Area Network (WAN) in operation is the Internet, which is a massive network of networks(Afriyie, 2012).

2.4.1. ICT essential services

ICT-for-agriculture solutions offer the following five essential services (Agrilinks, 2018). Information analytics, tracking and traceability, market and financial accessibility, and information sharing to various actors across the chain as depicted by Annex 2.

- Information analytics- carries out data analysis and reports findings to partners or external clients, or uses the information for efficiency and internal reporting. It can be used in forecasting demand and optimizing production schedules.
- **Tracking and traceability** allows for the tracking of products as they move through a supply chain or the ability for consumers to determine the product's origin. It ensures transparency and quality control of the produce.
- Market accessibility- consists of enhanced internal supply chain or aggregator management systems; digital marketplaces for the purchase or sale of different inputs, produce, or services, and strengthened external market connections.
- **Financial accessibility** handles payments, extends loans, or oversees collateral; it can also give financial information to outside parties so they can supply farmers with these or other financial services.
- Information sharing- permits two or more actors to exchange information and knowledge through communication.

ICT functionalities refer to the specific features and capabilities that information and communication technology (ICT) offers to meet particular demands and tasks. The five essential services above make up the ICT functionalities, which can be long-term or short-term. To develop the proposed application, the app developers shared information on the steps they will take, the resources they will need, and the time it will take for them to develop the short-term and long-term functionalities.

2.4.2. Success Factors in ICT

An example of a successful application in Kenya is the M-pesa. The biggest cellular phone provider in Kenya, Safaricom, runs the M-Pesa money transfer service. With M-Pesa, users may send mobile money balance to other mobile phone users, convert mobile money balance back into cash, and trade cash for mobile money balance on their phones (Mbiti and Weil, 2015).

According to Campenhout (2021), since Mpesa was developed as a product for which there was a genuine need, it appears that initiatives like this are far more successful in having a broad influence. Information-gathering ICT applications frequently rely on subscription-based business models. At the farm level, however, there might not be much ability or inclination to pay for a non-rival product like information.

Applications of ICT for development that eliminate asymmetric information and resolve intricate coordination issues have the greatest potential. To create apps that use technology that the underprivileged can afford to tackle these intricate information problems; simple technologies (SMS, IVR, USSD) and human mediation in which members of the community or government representatives assist are needed in facilitating the interface between users and technologies (Campenhout 2021).

Another example of successful ICT usage in cooperatives is India. According to Patel (2019) in India, Airtel's "Green Card" SIM cards are promoted by IFFCO Kisan Sanchar Limited (IKSL), a trilateral venture between Airtel, Star Global Resources Limited, and the Indian Farmers' Fertilizer Cooperative Ltd (IFFCO). Every day, users receive free recorded voice messages about government programs, disease alerts, yield increase advice, crop calendar activities, localized weather forecasts, and answers to any farming-related questions from specialists in the field.

2.4.3. Challenges in ICT Adoption

Annex 2 depicts the type of challenges (lack of market knowledge, lack of information on quality and farmer experience, lack of access to credit) experienced by the chain actors and from it the type of information required arises. It also shows the type of essential services required by an actor. The input suppliers and farmers require information on risks, markets, agronomic advice, digital marketplaces, digital payments, and transport logistics while the other chain actors (middlemen, processors, wholesalers, exporters, importers, retailers, and consumers) require these services and in addition, quality assurance control, product provenance and the value chain management.

According to the Innovation Platform Agribusiness Portal (2017), the various apps currently in Kenya are under these five essential services mentioned above. The weather, GAPS, and input variety apps are under information sharing services, market prices platform is under market accessibility.

Warwimbo (2017), notes that despite the advancements in ICT services, several challenges remain. Digital literacy is a significant barrier, as many smallholder farmers lack the necessary skills to effectively use digital tools. Additionally, infrastructural deficits, such as unreliable electricity and limited internet connectivity, hinder the widespread adoption of ICT solutions in rural areas. The high costs associated with purchasing and maintaining digital devices also pose a financial burden for many farmers.

2.5. Communication channels

Effective communication and information channels are crucial for optimizing agricultural value chains. Across the value chain, there is vertical and horizontal communication. Vertical communication is between different actors performing different functions like the producer and collector while horizontal communication is amongst actors on the same function level like the farmers (Marketlinks, 2023). One effective strategy to reduce information asymmetry is to use ICTs' ability to gather, process, and distribute information in nearly real-time. When the actors are willing to share information they

contribute to the value chain competitiveness since there is information symmetry and trust among them (Cragg and McNamara, 2018).

Halewood & Surya (2012) state that digital technologies have revolutionized these channels, significantly improving the flow of information among various stakeholders. ICT tools such as mobile phones, internet services, and digital platforms are essential for providing farmers with timely and relevant information. Mobile-based applications and SMS services, for instance, offer real-time data on market prices, weather forecasts, and agricultural practices, which are critical for informed decision-making and productivity enhancements.

According to Krone (2017), ICT's role in bridging information gaps is significant. Traditionally, smallholder farmers faced considerable challenges in accessing essential information due to geographical and infrastructural barriers. However, the widespread use of mobile phones and digital platforms has alleviated these challenges, allowing farmers to access and share vital information more effectively.

Moreover, integrating multi-stakeholder communication networks has improved the efficiency and coordination of agricultural value chains. These networks, involving farmers, wholesalers, processors, retailers, and consumers, enhance communication, reduce transaction costs, and improve overall value chain performance.

Various firms in Kenya as shown in Annex 1, offer agriculture ICT services on supply chain management, financial management, market information and linkages, and farm advisory and information (UNEP 2021). For example, Wefarm, a United Kingdom company in various countries in Africa, is a peer-topeer social network enabling smallholder farmers to share expertise. Through the network, members exchange advice and ask questions about business and agriculture by SMS or online. This makes it possible for farmers in remote places without internet access to share information. It fosters a collaborative environment that promotes learning and the adoption of new techniques.

eProd Solutions, a Dutch company in African and North American countries, improves supply chain management and traceability for small and medium enterprises and may offer great insights into the Nandi avocado value chain in the value chain management and in coordinating the logistics.

In addition, the KALRO applications offer more insights to farmers on inputs, GAPs, and weather practices (Innovation Platform Agribusiness Portal, 2017).

2.6. Cooperatives

According to Ingale and Sayed (2022), a **cooperative** is an autonomous group of people who have come together voluntarily to address their shared needs and goals in the areas of economics, society, and culture through a collectively owned and democratically run business. In addition to providing short- and medium-term loans, cooperative societies assist small and marginal farmers in converting agriculture into an agribusiness venture by combining resources to create economies of scale.

Gunga (2013), states that the establishment, administration, and operations of cooperatives should be guided by the following seven principles, according to the International Cooperative Alliance:

- Open and voluntary membership
- Democratic member governance
- Economic involvement of members
- Autonomy and independence
- Information, education, and training
- Cooperative relationships among cooperatives
- Community concern

Following the aforementioned guidelines has the following advantages for cooperatives: they can invest in more advanced stages of the value chain, such as product and service processing, distribution, marketing, and storage, and they can obtain economies of scale and bargaining leverage.

Gunga (2013) also stated the goal of the Kenyan cooperative movement's policies is to promote sustainable economic growth by emphasizing the attainment of desired results via the movement's strengthening, enhanced corporate governance, improved cooperative extension service delivery, market accessibility, and more effective marketing. Kenyan cooperatives are divided into producer and service cooperatives. The goals of producer cooperatives are to advance contemporary technology use and support national growth utilizing production. The purchasing, marketing, and expansion services, loan disbursement, consumer goods sales, and member education are under the purview of the service cooperatives.

2.6.1. ICT and cooperatives

As stated by Ingale and Sayed (2022), ICTs have several benefits for cooperatives. By leveraging ICTs to their fullest potential, cooperatives can expand their customer base online, open up new markets, stay abreast of technological advancements, and obtain remote training. By enhancing management procedures, financial data and reporting, records management, and online presence, ICTs can transform cooperative management. These upgrades contribute to reduced operating costs and greater efficiency.

The main obstacles facing Kenya's cooperative movement as stated by Gunga (2013), include inadequate capital bases, insufficient governance, a lack of openness in cooperative management, a lack of management expertise, and deficiencies in market research and intelligence. Gunga stated that in rural areas, there are additional issues such as low infrastructure, high deployment and maintenance costs, insufficient funding or the use of "high-margin low volume" finance models, a lack of awareness, and "disposable" income for ICTs. By using an administrative strategy that takes advantage of the potential for public-private partnerships (PPP) in ICT and management information system environments, all of these difficulties can be readily resolved.

In addition, Ingale and Sayed (2022) stated that numerous problems, including a lack of professionalism, corporate governance, ageing and unenthusiastic staff, political affiliation, bureaucratization, and low member engagement, plague the cooperative system. Nonetheless, cooperatives are distinct since they are democratically run by their members, who also serve as the institution's consumers and owners.

2.7. Chain Governance

The power dynamics within a production network are referred to as **chain governance** (Havice and Campling, 2017). It can regulate what transpires in a value chain, including the rules that govern how chain activities are carried out and the collaboration between various stakeholders.

The governance of the avocado chain is defined by the principles of robustness, resiliency, and reliability (3R). These 3R principles focus on chain relations, institutional governance and innovation, and technical expertise.

According to Matui et al. (2016), efficient and trusted interactions among chain participants that lower transaction costs and the risks associated with improving product quality, and safety and bolstering sustainability are referred to as **robustness**. Co-innovation, public-private cooperation, and a framework for public economic policy that encourages private investment and expands prospects for (inter)national trade are all components of **reliable institutional governance**. The dynamic adaptive capacities that allow systems and actors (research, extension, and projects) to react appropriately to changing conditions is **resilience**.

According to Kessler et al. (2020), to improve the Robustness aspect of the 3R on chain relations, trust, and transparency; partnership models between producers and other value chain participants are required, with the primary objective being fair pricing. It is also necessary to investigate various forms of cooperation among chain participants and whether or not all actors gain from them. Furthermore, on the Reliability aspect, the implementation of the policies is weak thus capacity building is required of the policies already in place. In addition, Patel (2019) stated that the cooperatives must be enhanced by creating an enabling environment, which includes a legal, policy, business, and participative framework that supports the formation and growth of organizations, to facilitate or offer access to ICTs for them. While on the Resilience of the innovation support system, the chain actors can capitalize by promoting and co-designing (e-)traceability systems that they can easily adopt.

2.8. Conceptual Framework

The conceptual framework (Figure 5) presents a summary of the key concept, dimensions, aspects, and output that is intended to be achieved by the research.



FIGURE 5: CONCEPTUAL FRAMEWORK

(SOURCE: AUTHOR, 2024)

CHAPTER 3: RESEARCH METHODOLOGY

The methodology that was used for the study is presented in this chapter. It includes details about the area description, target research population, sample size, data collection methods, data analysis techniques, and ethical considerations.

3.1. Area Description

The study was conducted in Nandi County which is located in the North Rift region of Kenya. It borders Kericho and Kisumu Counties to the South; Vihiga and Kakamega Counties to the West; and Uasin Gishu County to the East and North. The constituencies of Nandi County are Tinderet, Aldai, Nandi Hills, Chesumei, Emgwen, and Mosop as shown in Figure 6. Kapsabet Town serves as Nandi headquarters. Tea plantations abound in Nandi County, which boasts a picturesque topography.

According to Mark and Ryse (2021), Nandi County covers an area of roughly 2900 km2. It is elevated between 1000 and 2000 meters above sea level and lies between longitude 35°08'60.00" E and latitude 0°10'0.00" N. The average annual rainfall in the area is between 1000 and 1500 mm, and the average temperature is around 20 °C (Marete et al., 2020).



FIGURE 6: LOCATION OF NANDI COUNTY

(SOURCE: MAPHILL 2013 AND ADOBE STOCK, 2024)

3.2. Target Population

The target population for the study was mainly the avocado farmers and the Nandi Avocado Farmers' Cooperative Society. Furthermore, key informants from different organizations had more information on agriculture ICT apps.

3.3. Data Collection

The research utilized qualitative data collection tools, semi-structured interviews as shown in Annex 3, and focus group discussions to gather opinions from different stakeholders.

Aspers and Corte (2021) defined qualitative research as an iterative process whereby new significant distinctions resulting from closer examination of the phenomenon under study are made to achieve improved understanding to the scientific community. Monke (2007) states that expert interviews offer unique expertise insights and an in-depth approach to learning more and the respondent is considered a reliable source of factual information.

Secondary data on ICT, cooperatives, communication practices, chain governance, short and long-term functionalities, and coordination needs were collected by reviewing existing literature through desk studies using search engines such as Greeni, and Google Scholar.

Respondents for the interviews were selected based on their expert knowledge of ICT applications and development) and focus group discussion participants were selected through purposive sampling.

According to Laws et al. (2013), purposive sampling is a non-probability sampling technique where participants are selected according to the purpose of the study to obtain pertinent information.

- The farmers chosen were from the six sub-counties of Nandi with equal gender representation.
- The extension officer chose farmers who could converse well in English and Swahili and could provide in-depth farming information. The management of the cooperative had much information about the cooperative.
- The interviewees included EProd, the founder, Pharox, the director, Amtech Easypro software developer, a junior researcher from FORQLAB, and an ICT officer from KALRO.

The two Focus group discussions involved 6 people each, one consisted of farmers, and the other one consisted of the management of the Nandi cooperative team, while the semi-structured interviews comprised six stakeholders as shown in Table 1 below.

eProd solutions may be supporters of the avocado value chain in the future since they have applications on supply chains in place that may be integrated into the Nandi avocado value chain thus why their input is of importance.

KALRO has much information on app development since they have already developed other applications. Pharox may also be a supporter in the future since it is great at logistics planning and tracking and traceability of products.

Amtech software developer was chosen since the cooperative has just begun using the Easy Pro program.

TABLE 1: RESEARCH PARTICIPANTS

Research questions	Respondents	Sampling	Collection Tools
What are the farmers' and cooperative communication and coordination needs in Nandi County?	FarmersNandi Cooperative	Purposive sampling	Focus Group Discussion Desk study
What short and long-term functionalities should the proposed ICT application have?	 Farmers Nandi Cooperative FORQLAB Junior Researcher KALRO eProd Solutions 	Purposive sampling	Focus Group Discussion Semi-structured Interviews Desk study
What resources are needed by developers to develop the proposed application?	 eProd Solutions KALRO FORQLAB Junior Researcher Pharox Amtech EasyPro software developer 	Purposive sampling	Semi-structured Interviews
What are the key steps and timeframe needed to develop the proposed application?	 eProd Solutions KALRO FORQLAB Junior Researcher Pharox Amtech EasyPro software developer 	Purposive sampling	Semi-structured Interviews

(SOURCE: AUTHOR, 2024)

3.4. Data Analysis

The qualitative data obtained was analysed based on themes regarding the research questions. The themes are the communication needs of farmers and the cooperative, short and long-term app functionalities, resources needed by developers, stages for the app implementation, and proposed recommendation steps for implementation in the coming years. Triangulating the results from different responses assisted in validating the findings. The data was presented in narrative form and using SWOT analysis for the communication and coordination in the Nandi avocado value chain.

3.5. Ethical Considerations

According to Laws et al. (2013), protecting the rights, interests, and privacy of people during research, as well as their physical, social, and psychological well-being, is a researcher's top priority. The following are some ethical issues this study addressed:

- Seeking permission before filming interviews and taking pictures.
- Obtaining informed consent from interviewees before their involvement in the interviews by ensuring the respondents receive a clear explanation of the research's goal.
- The researcher guaranteed the respondents' anonymity and confidentiality.

CHAPTER 4: FINDINGS

This chapter presents the findings from the focus group discussions and interviews conducted. The results are categorized based on the research questions.

4.1. Farmers' and cooperative communication and coordination needs in Nandi County

The focus group discussion with the cooperative revealed that the Nandi Avocado Cooperative Society's management team comprises the Chairman, Manager, Secretary, Treasurer, Marketing Officer, and Extensionist. There are 1012 farmers within the cooperative, with about 20% female members. Farmers join the cooperative by paying a membership fee of Ksh.500 (3.5 euros) and purchasing a minimum of 20 shares each at Ksh.100 (0.7 euros) totaling Ksh.2000 (14 euros). Marketing their produce and providing training on GAPs (planting avocados, spacing between trees, pruning, plant diseases, and the application of chemicals) are the main advantages that their members receive. However, the Cooperative has not yet established itself online, it still lacks a website.

The Nandi Avocado Cooperative has been making great strides in ensuring the quality of their produce and the chairman commented how they had made their first direct shipment to Belgium and the Netherlands. They had received their export license from the Horticultural Crops Directorate. To reach a wider market, farmers will now need to receive training on the Global GAP standards. The extensionist stated that the cooperative also sources certified seedlings to farmers from Ustawi Limited.

The farmers' focus group discussion revealed various challenges the farmers still experience. One farmer mentioned how he suffered great losses because he neglected to prune his trees. Some farmers still need to know which pesticides to use for their trees and they need insurance from hailstones that damage their avocado trees. The farmers and the cooperative commented how there are exporters who dupe the farmers that they are working with the cooperative yet the cooperative stopped working with them. The farmers stated that, 20% of women within the cooperative farm avocados, thus 80% of the men within the cooperative practice avocado farming. This was attributed to the fact that women possess smaller plots of land than men do. The tasks (tree pruning, clearing land, and applying agrochemicals) also need a lot of physical effort and are usually carried out by men. Nonetheless, the farmers also mentioned that most women prefer to rear chickens and livestock.

4.1.1. Communication and Coordination

Communication

The cooperative commented that currently, they use bundled SMS and WhatsApp to interact with farmers in their cooperative. However not all farmers own Android phones, and not all farmers periodically check their phones for the bundled SMS. Furthermore, only a specific percentage of farmers are accommodated by the bundled SMS. Thus there is a need for bulk SMS going to all farmers with the the sender ID "Nandi Avocado Farmers' Cooperative" to pique their curiosity and prompt a response. Additionally, the farmers stated that they use barazas (community gatherings in public places to discuss and disseminate information) to interact with each other.

The cooperative communicates with exporters through phone calls. The Cooperative extensionist uses the KALRO apps like the KALRO avocado variety to learn more about Good agricultural practices. He sends SMS invitations for training to the farmers, and when he visits their farms during harvest, he disseminates the information. Furthermore, he attends training on GAPs, and AFA KS1758 which the County, Agriterra, and AFA organise. The farmers from the focus group discussion use online tools like Digifarm to learn more about farming; they prefer it because the tool has a chatbot that allows them to ask questions and get answers. They also use other KALRO apps for their other crops and livestock because they provide the best farming information and are effective. The farmers in the focus group discussion commented that some farmers are either unaware of or uninterested in the apps that are now available. The chairman is in charge of communicating with other avocado cooperatives and disseminating information to the other board members. Their primary areas of communication include global market issues, such as avocado pricing.

The cooperative has been storing farmers' information (the production quantity, grade, and amount paid) on hard copies. However, they have just now begun using Amtech's EasyPro program. The World Bank enabled EasyPro via the NARIGP project, and this year the expense of using the website has been covered. Only board members have access to the website. All of the cooperative members, the amount of produce they have contributed, the amount they have been paid, and the amount the farmers are owed are listed in the database. The Cooperative has been using a laptop for the Amtech Easypro, but they were in the process of installing WIFI and buying an office computer they already have a printer. Furthermore, the manager of the cooperative mentioned that they would like to incorporate produce tracking and traceability in the future by gathering data on the quantity produced by a particular farm, the location of the farm, and the grade of avocados harvested. Figure 7 below shows the management team of the Nandi Avocado Cooperative Society.

FIGURE 7: NANDI AVOCADO COOPERATIVE SOCIETY MANAGEMENT TEAM



(SOURCE: AUTHOR 2024)

Coordination

Currently, there is uncoordination during transportation by cooperatives due to the unworthy road network and the rains also hinder proper transport. As a result, the farmers' trust in the cooperative is eroded when the avocados are collected from them later than expected, resulting in losses. Moreover, there is a need for an aggregation center and schedule indicating the wards and the day to collect produce from them. To help with farmer training and harvest coordination, the cooperative has started deploying Training of Trainers (TOTs) in the wards and it is being facilitated by Agriterra. They have stationed 25 TOTs in 25 wards (one per ward) which are the main avocado growing areas.

4.1.2. Farmers Needs on the ICT Application

These are the needs that the farmers addressed in the focus group discussion:

- Free soil testing services
- Certified seed supplier information
- Marketing prices for Hass and Fuerte with weekly updates
- Information on GAPs
- A chat platform
- Weather data
- Knowledge of applying chemicals to avocados

- Hailstone insurance
- Avocado collection scheduling
- Financial statements showing the cooperative's performance
- Financial details on loan eligibility

Since 70% of cooperative farmers have access to smartphones and English is a language that is simpler to understand compared to Kiswahili and Kalenjin, they suggested that the app should be available in English. Furthermore, awareness and training of the app is required and free access to the proposed app are all necessary.

4.1.3. Nandi Avocado Cooperative Society Needs on the ICT Application

These are the needs that the Cooperative management team highlighted in the focus group discussion:

- Unlimited SMS and the "Nandi Avocado Farmers' Cooperative" heading must be included in the Sender ID
- Marketing information with national and global prices
- Tracking and traceability of the produce and the GPS coordinates of the farmers
- A chatbot or chat platform
- Weather data
- Information on GAPs
- Certified seed supplier information
- Agro-store information to know what the store has
- Guidelines for purchasing items from the agro store (inputs like fertilizers, fruitfly, and false codling moth traps),
- Applying for cooperative shares
- Production schedules
- A digital weighing scale that is integrated with the app
- Uploading and downloading documents (cooperative newsletter, latest GAP training information, trends in production)
- The cooperative's financial information
- Loan accessibility
- Avocado dispatch details
- Contact details with photos of the cooperative board members so that farmers can identify them.

Moreover, the management of the cooperative recommended that the application should not only be accessible through the phone but also through computers and laptops.

FIGURE 8: FREQUENCY OF THE FARMERS' AND THE COOPERATIVE NEEDS



(Source: Author 2024)

Desk research showed that according to Mucemi, Kristen, and Francois (2009), farmers need basic information about market prices, weather forecasts, available transportation, and details about storage facilities. Farmers also require information about fertilizers, diseases of cattle and crops, and other related issues that can be found through a question-and-answer service.

Meera, Jhamtani, and Rao, 2004 stated that Information and communication technologies (ICT) initiatives offer a range of information services, including but not limited to facilitating access to land records, question and answer services, providing information on rural development programs, weather forecasting, marketing information, best agricultural practices, crop insurance, input prices and availability, early warning systems for pest and disease management, and soil testing and sampling.

Furthermore, Etela and Onoja (2017) suggest that e-agriculture may help farmers by providing accurate instructions on how to apply fertilizer, insecticides, and herbicides; teaching them about highyielding varieties and where they can purchase them; and offering guidance on when and how to sow, among other suggestions that will enhance productivity. It provides farmers with relevant and reliable market information so they can make a profit. Etela and Onoja also state that farmers are particularly affected by global warming, therefore they must be aware of the best places to plant to prevent floods from carrying their crops away.

4.2. Short and long-term functionalities the proposed ICT application should have

The farmers from the focus group discussion proposed that the short-term functionalities to be included in the application from the beginning should include details on certified seeds, soil testing, weather patterns, avocado variety prices, avocado collection schedules, financial information on where to source loans, chemicals to use on avocados and hailstone insurance. While information on the financial performance of the cooperative can come later since the cooperative is still relatively new also the live video engagement and discussion forums can come later.

The management of the cooperative commented that the short-term functionalities should be the SMS messages with the sender ID "Nandi Avocado Farmers' Cooperative", the chatbot, market information with both national and global prices, weather data, tracking and traceability of the produce with GPS of farmers, financial information such as loan availability, certified suppliers, harvesting schedules,

agro store items and guidelines on how to purchase them, shares, and registration. The information on the cooperative's financial performance, live video engagement, and discussion forums can come later.

The eProd Solutions manager suggested that a one-way and two-way SMS could help communication and collaboration within the cooperative in both the short and long terms. He added that farmer and field registration and polygon mapping will assist in knowing the perimeter and area of the farm thus assisting with traceability, field inspections, avocado collections, contracts, payment (mobile, bank) based on quality, certification, reporting, soil sampling, loan cycle management (with and without banks), and digital ID/biometrics are the activities within the cooperative that would benefit most from an ICT application.

The KALRO ICT officer commented that while automated features like farmers' GPS require a longer time to integrate into the applications, general advisory features like weather information and GAPs are among the short-term features. The officer added that since the application is for the cooperative, information on credit and saving would be essential. Other aspects that should be included are weather forecasts, market data on prices, and information on the avocado value chain.

The junior researcher at Forqlab suggested that a chat feature in the application would let the farmers and the cooperative communicate and collaborate. Furthermore, the data being recorded by either the farmers or the cooperative must be correctly entered and updated. No significant improvement in collaboration will result from incorrect data entry. He added that the use of an ICT application will boost the efficiency between farmers and exporters. Improved communication additionally ensures that farmers' knowledge is increased, which raises the quantity and quality of avocados and allows for timely avocado harvesting. The basic functional design features that had been designed included information on;

Farmers- Their personal information, farm size, number of trees, avocado grades with kilograms, harvest time, revenue generated, and orders they have.

Cooperative- Their personal information, incoming and outgoing orders specifying which farmer the yield is from.

Exporters- Their personal information, current and upcoming stock type, information of when to expect the next batch, and which farmer the yield is from.

Importers- Their personal information, incoming batches, and batches in stock.

Different sections for log-in for farmers, cooperatives, and importers, chatroom, and the map dashboard.

The Pharox manager stated that having a chat feature with visuals will be essential in the short term since it will speed up communication and allow for feedback.

Literature reveals that according to Sørensen et al., (2011), farm management information systems (FMIS) must meet the following criteria to be considered effective: they must be designed with farmers' needs in mind; they must have a clear user interface; automated and user-friendly data processing techniques; they must have a user-controlled interface that grants access to processing and analysis functions; they must integrate user preferences and expert knowledge; they must improve the integration of standard computer systems; they must improve interoperability and integration; scalability; interchangeability between applications; and be of low cost.

The summary of the information collected from the research shows that information sharing, market accessibility, financial accessibility, tracking and traceability, and information analytics are the five important services that meet the needs of farmers and cooperatives. Information analytics is one of the features that would require some time to integrate into the proposed application while

information sharing, market accessibility, and financial accessibility would be added in the short term. Similarly, for tracking and traceability, some features could be added right away like the size of the farm, quantity, and grade of avocadoes produced while more complex data like GPS and produce monitoring with quality checks would need to be added later. It is desired by exporters and certified suppliers alike that all information required by them can be included in the proposed application, making it inclusive of all actors within the value chain. Furthermore, the chat feature will be essential to facilitate communication between the farmers and the cooperative.

4.3. Resources needed by developers to develop the proposed application

The eProd solutions manager stated that some resources are necessary to develop the suggested application. Hardware like laptops and mobile phones, as well as a dependable internet connection, SMS registration since it will be bulk SMS, and credit to send the SMS, are required by developers. Extra resources like printers and Bluetooth scales may also be helpful. In addition, third-party apps like the Agrocares soil testing kit and license fee payment are needed by the project. The manager added that the cooperative should provide the funds for these resources or it can get partners to fund it.

According to the KALRO ICT officer, to develop their applications, they usually need a technical team made up of experts in weather, post-harvest, scientists, programmers, audiovisual, communication, and tech. Since their apps are free for farmers to use, they also need funding to pay for licenses from the Google Play Store and to the telecommunications company to use their SMS service. Moreover, funding for their diverse applications have been funded by development partners according to their areas of interest. Their weather application was funded by the Bill and Melinda Gates Foundation.

The junior researcher at Forqlab suggested that possessing the necessary information is crucial when creating an application of this kind. Furthermore, the information can be gotten from the users that the software is intended for and knowing the functionalities they need the most. Since they are the application's users, it is crucial to understand their needs.

The Pharox manager said that in addition to meeting with end users to hear their opinions, funding is required for development and it can be sought from the government and stakeholders who will benefit from the application.

According to Amtech EasyPro software developer, developers require specialized software and tools to write and test code, such as development environments and testing tools to verify their work. Additionally, they rely on libraries and frameworks—basically, pre-written code—to assist them in developing the software's front end, which is what customers see, and the back end, which is what goes on behind the scenes. They also adhere to rules and specifications to guarantee that everything is completed appropriately. Lastly, they collaborate and monitor their projects using GitHub and other collaboration and project management platforms.

The summary of the findings collected from the research reveals that for developers to create an application, they must first understand the needs of the application's user, then assemble a technical team capable of meeting those needs, and finally obtain finance for the application. The government or development partners that may be interested in the application can provide funds for the application. Hardware infrastructure is also necessary, including phones, laptops, printers, and an internet connection.

4.4. Key steps and timeframe needed to develop the proposed application

The eProd solutions manager stated that the required timeline for complete deployment and ongoing back-office support is two to three months. Additionally, for the application to be user-friendly, the user interface must be created with the demands of the user in mind, providing the users with a real solution. The quarterly data health checks, which examine current performance and offer recommendations for enhancements, usually serve as the monitoring tools for tracking the application's effectiveness. The cooperatives will be requested by eProd to sign an end-user license

agreement and a service-level agreement that addresses problems with data ownership, and they will have specific mechanisms in place to protect against data breaches if eProd develops the application. The estimated budget for the development of the application in Nandi Cooperative with individualized training, with a maximum of 1000 farmers and excluding value-added tax would be Ksh. 562,685 (3,935 euros). The application subscription fee would be Ksh. 154,000 (1,100 euros) per year per farmer.

The KALRO ICT officer stated that while creating their applications, they usually already have the content since they have done their research so they incorporate it into the framework. The developers first develop the wireframe then after agreement with all teams involved coding is done. They conduct two tests on the application. First testing is internal and it is done by the developers and the value chain experts. The second phase of testing, known as the validation stage, occurs when the application is made publicly accessible via KALRO's IP address, though it has not yet been released on the Google Play Store. During this stage, the application is tested by the ward agriculture officer, farmers, agrodealers, and experts at the county level.

Moreover, KALRO develops several apps concurrently rather than just one, and if there is no break, they usually take three months to complete. To make their programs more user-friendly, they also translate them into the major ethnic community languages and utilize simple language. They can track where and by whom their apps have been downloaded, as well as how long they are utilized, by using Google Analytics to monitor their apps. Additionally, there is a data protection regulation that prohibits data breaches and prohibits the sharing of personal information on applications. The estimated budget for the development of their applications is usually Ksh. 600,000 (4,196 euros). Furthermore, the KALRO apps are usually free and farmers pay no subscription fee.

The junior researcher at FORQLAB suggested that the amount of knowledge accessible will also determine how long it will take to develop and execute an ICT application for the cooperative. Databases, the app's design, and user-friendliness must all be considered, but this should be possible in six months. Moreover, the program should be user-friendly ensuring that only the essential components (data entry, chat functionality, individual pages for each participant, and the ability to view data) are included. It is possible to avoid misinterpreting the program by keeping everything simple and adding only the most essential components.

The Pharox manager states that to develop applications, they must map out and evaluate the needs of the users, plan and understand the cost indicators, design the application, gather user input, and hold meetings with the users. Generally, they can construct the application in no more than six months. Additionally, developers make the program more user-friendly for the users by using iconography, vibrant displays, and field research to get to know the application's users.

Amtech software developer commented that while developing applications they:

- Plan and analyse (describing the objectives, goals, and scope of the application)
- Design (creating the user interface)
- Develop (front and back end)
- Test (unit and user acceptance testing)
- Deployment (setting up the production environment, including servers and databases)
- Launch
- Perform continuous improvement (performance optimization) on the application.

The length of time it takes to develop a system also relies on a variety of factors, such as the size of the system being developed; however, a medium-sized system can be completed in three months. The developer commented how their app subscription fees vary from one organization to another due to the varying modules in different organizations but the minimum subscription fee is Ksh.72,000 (504 euros) per year.

The summary of the collected information from the study shows that the timeframe for developing an app is three to six months. The main steps in developing an app are as follows:

- Plan and determine whether they have the necessary content for the application
- Design of the app
- Develop the wireframe (blueprint or visual guide that outlines the basic structure of the application) and then coding of the wireframe begins
- Testing of the application, it is done by the developers and a few users to ensure that it functions as intended then it is deployed (moving app from developing environment to server) and launched (officially introduced to users).

After it is launched the developers can monitor and see who is downloading the apps and check whether it is properly utilized. To satisfy customers' expectations, the application must also be user-friendly and undergo performance enhancements.

4.5. SWOT Analysis of the Avocado Value Chain in Nandi County

The Nandi avocado value chain's internal and external environments are analysed using the SWOT method as shown in Table 2 below.

Strengths	Weaknesses
 The cooperative has an in-house extensionist. Farmers use organic production methods. Use of other phone applications by farmers like Digi-farm and the KALRO applications. Partnership by World Bank with cooperative on the Easypro program. Presence of TOTs in wards. Acquisition of Export license by cooperative. Certified seedling suppliers (Ustawi Limited). 	 Cooperative lacks aggregation centres. Cooperative lacks product traceability. There is poor coordination during the collection of harvest.
Opportunities	Threats
 Building of a packhouse Availability of supporting partners like Agriterra Training farmers on Global GAP standards Market accessibility in Belgium 	 The hailstones damage the avocado trees There are poor roads

TABLE 2: SWOT FOR NANDI AVOCADO VALUE CHAIN

(Source: Focus group discussion with cooperative and farmers 2024)

CHAPTER 5: DISCUSSION

This chapter primarily compares and contrasts the information gathered from the literature review with the findings drawn from the interviews and focus group discussions and the researcher's knowledge and grasp of the topics researched.

5.1. Farmers' and cooperative communication and coordination needs in Nandi County

According to the study, a question and answer section, a schedule for collecting avocados, certified seed suppliers, weather patterns, market prices, GAPs, financial information on how to source loans, and financial services like insurance were among the suggestions made by both the cooperative and the farmers for the proposed application.

Some needs are unique to cooperatives (agro store information, guidelines for purchasing cooperative shares, produce tracking and traceability, farmer GPS), and some are specific to farmers (financial statements outlining the cooperative's performance, financial services such as insurance and soil testing services) as shown in figure 9 below.

The Focus group discussion for farmers and the cooperative had six members each and the avocado collection schedule, chat platform, and marketing prices for Hass and Fuerte were the most mentioned needs.



FIGURE 9: FARMERS' AND COOPERATIVE COMMUNICATION AND COORDINATION NEEDS

(Source: Author 2024)

Mucemi, Kristen, and Francois (2009) and Etela and Onoja (2017) confirmed that the requirements mentioned in this research are important for chain coordination and communication. They added details about storage, transportation, and land location in case of flooding. Meera, Jhamtani, and Rao, 2004 also confirmed that Information and communication technologies (ICT) initiatives offer a range of information services, including but not limited to facilitating access to land records, question and answer services, providing information on rural development programs, weather forecasting, marketing information, best agricultural practices, crop insurance, input prices and availability, early warning systems for pest and disease management, and soil testing and sampling.

The farmers and cooperative needs collected from this research validate the five necessary services as per Agrilinks (2018): information analytics, tracking and traceability, market and financial accessibility, and information sharing because the various needs belong to these five essential services as shown in

Table 3 below. Information sharing is an important essential service since it will enable farmers to get their needs met. Farmers' needs are satisfied by giving them access to timely, accurate, and pertinent information so that they may make informed choices. This greatly increases their agricultural production and revenue.

Essential services	Cooperative and farmers' needs				
Market accessibility	Weekly updated global market prices				
Financial accessibility	Loans, hailstone insurance, cooperative financia statements				
Tracking and traceability	Quantity of avocado produced by the specific farm, the region of the farm, the grade of avocados, and the type of avocados				
Information Sharing	Weather, GAPs, certified seedlings suppliers, schedule of avocado harvest collection, soil testing, and agro store information				
Information analytics	Cooperative performance statements, the predictive quantity of harvest, predictive timing of harvest, and market prediction models (prices, demand, supply, and weather).				

TABLE 3: THE FIVE ESSENTIAL SERVICES

(Source: Author 2024)

Coordination and communication problems cause losses in the Nandi avocado value chain. Due to the lack of an aggregation center, poor transport network, and lack of harvesting schedules, there arises significant post-harvest losses. Currently, the farmers' most urgent need is information sharing on the harvesting schedules. This information can be sent to them via SMS using the exclusive "Nandi Avocado Farmers' Cooperative" sender ID, this will capture the farmers' attention and thus they will check the message through this coordination can be enhanced within the cooperative.

5.2. Short and long-term functionalities the proposed ICT application should have

The most frequently suggested feature for the short-term was the chat feature which would promote communication between the farmers and the cooperative; the application might eventually include forums and videos. Additionally, the KALRO ICT officer explained that while more automated elements (such as information analytics, tracking, and traceability) can be included in the long run, general aspects (such as market accessibility, financial accessibility, and information sharing) are usually included in the short term. Information sharing (GAPs, weather, certified suppliers, harvesting schedules), finance accessibility (how much they have paid or are owed, availability of loans), and market accessibility (avocado prices) should all be included in the short-term functions, according to the cooperative and the farmers.

The cooperative's management made the following remarks regarding tracking and traceability: in the short term, basic produce traceability information (the size of the farm, quantity, and grade of avocadoes produced) can be incorporated; later on, more sophisticated product monitoring with quality checks can be introduced given it is feasible to add more features in the application.

Among the urgent needs needed is the chat platform and the cooperative can set up toll-free lines for communication with farmers additionally they can create their website and have a chatbot in it where farmers can ask and receive questions from the cooperative.

5.3. Resources needed by developers to develop the proposed application

The results of the interviews demonstrated that the following resources are required by developers when creating ICT applications: financial resources, end-user needs (weather updates, GAPs, chat platform, certified seedling suppliers, information from agro stores, avocado harvest collection schedules, soil testing, loan information, market prices), and technical understanding of what the application should contain. In addition, infrastructure resources like the Internet and computers are required. This is confirmed by Ryu, Kim, and Kim (2014). They stated that developers in the mobile platform industry have to determine priorities for their limited resources, which include time, money, and human resources. Furthermore, Salz and Moranz (2013) also commented that creating apps requires financial investment, time commitment, and access to all technical knowledge.

Although the usage of Amtech Easypro has only been paid for this year by the World Bank, there appears to be a duplication of information between the information that the proposed application would contain and what the Amtech Easypro contains (all of the cooperative members, the amount of produce they have contributed, the amount they have been paid, and the amount the farmers are owed are listed in the database). Thus the cooperative can add more features to the Easy Pro program, integrate it with the bulk SMS, and send farmers the required information.

To develop an application that will be utilized to its full potential and be accepted by users, developers must be aware of the needs of the end user which are weather updates, GAPs, chat platform, certified seedling suppliers, information from agro stores, avocado harvest collection schedules, soil testing, loan information, market prices and incorporate them. Technical expertise is also necessary to ensure that the content of the application is correct and pertinent. Additionally, the programmers need to ensure that the application conforms to data protection laws.

5.4. Key steps and timeframe needed to develop the proposed application

The key steps taken during application development are first including the knowledge needs of the users like weather updates, GAPs, chat platform, certified seedling suppliers, information from agro stores, avocado harvest collection schedules, soil testing, loan information, and market prices. Furthermore, cost and time estimation, designing the application whereby they develop the wireframe do the coding, then test the application, and if successful deploy and launch it. Moreover, the study revealed that the timeframe taken to develop the application differed amongst the developers, some developers needed six months while the majority needed three months.

Potnis, Regenstreif-Harms & Cortez (2016) confirm that the key steps taken during the development of mobile applications and mobile websites are generally:

- The planning phase (forming and managing a team, making strategic choices, requirements gathering, managing scope, and selecting an appropriate software development method)
- Analysis phase (requirements analysis, or liaising with stakeholders)
- Design phase (prototyping, selecting hardware and programming languages and platforms, designing user interfaces of the mobile application)
- Implementation phase (programming for application, testing the application, training patrons, and data management)
- Maintenance phase (documentation and version control of software)

Monitoring the application is important to confirm whether it is meeting its objective. The application also needs to be refined based on users' feedback since users have evolving needs so that it remains relevant and competitive. The application needs to be user-friendly to farmers with easy-to-understand words making it comprehensible. Moreover, such an application will win more farmers to join the cooperative thus it should be able to accommodate them and continue functioning smoothly.

According to Samadder & Rao (2023), for the sustainability of the ICT application farmers, extension agents, and other stakeholders should be involved in the management and ownership of ICT projects

for agricultural extension. This can guarantee that the project will be viable and responsive to local requirements in the long term. Furthermore, there will be a need to monitor and evaluate to determine their effectiveness and pinpoint areas for development. Therefore ICT projects for agricultural extension should be routinely monitored and assessed. This can assist in making sure the project is accomplishing its goals and that any necessary modifications can be made.

5.5. Feasibility of Implementing the Application

Currently, Nandi Cooperative has the Amtech Easy Pro and thus they already need to organize their data and ensure that their internal information can be traced and reviewed for transparency. This will help eliminate the mismatch between demand and supply. However, it was only paid till December, hence there is a need for the funding sustainability of the program.

Moreover, the identified needs of farmers can be added to the program rather than developing a new application. In the Easy Pro program, the cooperative can include its agro store information, and track and traceability of produce.

The cooperative can use the toll-free lines and also set up their website. The cooperative can approach the telecommunication services either Safaricom or Airtel and be guided on the toll-free line. Through this farmers who have any questions can call the cooperative through the toll-free line at no cost and get advice. The cooperative can approach an ICT personnel to aid in setting up their website. On their website, they can put a chatbot where the farmers can also ask questions to them through this communication will be enhanced between the farmers and the cooperative. Information on certified supplier seed information, financial details on loan eligibility, and cooperative financial information can also be put on the website.

Furthermore, the cooperative also mentioned how they had previously worked with exporters and ended contracts with them yet they still pretended to be in contract with the cooperative and purchased avocados from farmers. If the cooperative could publish newsletters on their website informing farmers of the exporters they are collaborating with, this may be prevented.

Some of the farmers are already utilizing other apps, such as Digifarm and KALRO apps. These have added value regarding the GAPs however, increased awareness of the benefit of these applications for nonusers is necessary. The low adoption rate of the existing applications makes the introduction of a new application (especially a paid one), non-feasible at the moment. The farmers need to be informed of the existing applications so that they can maximize them. They can use the KALRO GAP application to learn more about proper avocado care practices from the application. They can learn the importance of pruning, how they are required to prune, and the type of pesticides to apply on their avocado. The KALRO KAOP can be used to inform the farmers about the weather patterns. The cooperative can partner up with Agrocare for soil testing services.

Khidir (2020) stated that agricultural and rural development stakeholders should design policies and programs aimed at raising the degree of awareness and usage of mobile applications. Twenty-five TOTs have been stationed in the 25 wards, one in each ward which are primarily avocado growing areas. They are to help with the harvest of avocados and with training the farmers on GAPs. Agriterra is facilitating the TOTs. The TOTs can help create awareness and training of the KALRO and Digifarm applications to farmers so that the applications can be utilized well.

The estimated budget for the development of the application by eProd for the Nandi Cooperative, including individualized training for up to 1,000 farmers (excluding VAT), is Ksh. 562,685 (3,935 euros). Additionally, the annual subscription fee for the application would be Ksh. 154,000 (1,100 euros) per farmer. In comparison, the estimated budget for developing KALRO applications is approximately Ksh. 600,000 (4,196 euros).

Conversations with the cooperative and farmers highlighted that this initiative would require a significant financial commitment, for which external support would be essential. Moreover, since the farmers are expected to cover the subscription cost, this poses a potential barrier to adoption.

It would not be possible to launch a new, paid application at this time because the existing free applications are not being fully utilized. Rather, the emphasis ought to be on making farmers aware of current applications and promoting their use through training and focused awareness efforts. This strategy would increase the utilization of the applications that are currently accessible without adding to the farmers' expenses. Lokeswari (2016) confirms that many of these farmers, nevertheless, are not making the most of the ICT to its fullest extent. A multitude of obstacles impede the use of the applications, such as the inability to visit farmers, the absence of program promotion, and farmer training.

Although the Nandi cooperative has the Easy Pro program, in the future there might be a need for an application that strengthens communication and coordination among the four FORQLAB avocado cooperatives (Mt. Kenya, Abothoguchi, Mt. Kenya East, and Nandi). This application would enable the cooperatives to communicate effectively and share their experiences. In the long term, if such an application is developed and implemented, it could enhance collaboration, knowledge-sharing, and decision-making across the cooperatives, ultimately improving their collective efficiency within the avocado value chain.

5.6. Reflection on the Research Process

The research scope was initially unclear, so another meeting was needed with the commissioner to refine the initial objectives to SMART objective.

The interview and focus group discussions yielded detailed information, demonstrating the efficacy of the qualitative approach to data collection and analysis.

Despite some difficulties at first because the interviewees had already started their summer vacation, it was still possible to conduct interviews with them. Additionally, there were protests in the study country, but the focus group discussion still occurred according to plan. Similar checklists were used for the same interviewee groups to ensure the validity and reliability of the information gathered. However, quantitative research assisted in knowing the percentage of farmers using applications and their willingness to adopt the proposed application.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

The goal of this study was to determine what would be needed for an ICT application to be successfully implemented within the Nandi avocado farmers' cooperative. This chapter provides answers to the main research question and sub-questions based on the study findings and discussion.

Farmers' and cooperative communication and coordination needs in Nandi County

According to the study, the cooperative's current communication channels are SMS and WhatsApp. However, only 70% of farmers have access to Android phones, so sending an SMS with the sender ID "Nandi Avocado Farmers' Cooperative" will capture farmers' interests and keep them informed of the harvesting schedules. Since not all the farmers are already utilizing existing apps from Digifarm and KALRO, awareness of these apps is still required.

The farmer and cooperative needs are among the five essential services of communication: information sharing, information analytics, tracking and traceability, market and financial accessibility.

Information sharing is necessary for the farmers and cooperative to be informed about weather updates, GAPs, certified seedling suppliers, information from agro stores, avocado harvest collection schedules, and soil testing. A chat platform is required where farmers can ask questions and share their farming experiences. Farmers need financial accessibility to learn about sourcing loans, cooperative financial statements, and financial services like hailstone insurance. Market accessibility is necessary to learn about prices on the international market. In addition, the amount and grade of avocados, the size of the farm, the produce tracking, and the GPS coordinates of the farmers are all necessary for the cooperative for tracking and traceability. Long-term market forecasting and the estimation of harvest amount and market prediction models of prices, demand, supply, and weather timing would be aided by information analytics.

Short and long-term functionalities the proposed ICT application should have

Since information transmission is essential to meeting farmers' needs, the chat feature is the top functionality highlighted by the farmers and cooperatives. Additional short-term features were accessibility to finance and the market.

Findings revealed that while certain aspects of tracking and traceability are short-term, some are longterm, and information analytics is a long-term feature. In tracking and traceability, the short-term aspects proposed are basic produce traceability like the size of the farm, quantity, and grade of avocadoes produced while the long-term aspects proposed are produce monitoring with quality checks and farmers' GPS. Also, live video engagements and discussion forums are long-term features.

Resources needed by developers to develop the proposed application

The study also showed that the users' needs being (weather updates, GAPs, certified seedling suppliers, information from agro stores, avocado harvest collection schedules, soil testing, loan information, and market prices), a multidisciplinary technical team, financial needs, and ICT infrastructure are the resources needed for developing the applications.

The estimated budget for the development of the application by eProd in Nandi Cooperative with individualized training, with a maximum of 1000 farmers and excluding value-added tax would be Ksh. 562,685 (3,935 euros). The application subscription fee would be Ksh. 154,000 (1,100 euros) per year per farmer. The estimated budget for the development of the KALRO applications is usually Ksh. 600,000 (4,196 euros). Based on conversations with the cooperative and farmers, it was clear that this would need a significant financial commitment, for which they would require support. The study revealed that getting funding from applications is usually from the government, developing partners, investors, and stakeholders within the value chain. Currently, farmers can download free versions of

KALRO applications, but adoption rates are still low. If there was a usage fee, farmers might be even less inclined to use the application.

Key steps and time frame needed to develop the proposed application

The developmental stage of an application begins with needs assessment i.e. ensuring the user needs (weather updates, GAPs, certified seedling suppliers, information from agro stores, avocado harvest collection schedules, soil testing, loan information, market prices) are known and employing a skilled technical team. Then, the design of the application or wire framing, is followed by the development or coding, testing, and deployment or launch. Before the program is deployed and made available to users, it is tested by both the developers and the users. Additionally, developers monitor how users are using the application and ensure the application is user-friendly.

The proposed application would take a maximum of three to six months to be developed.

What is needed to successfully implement an ICT application to strengthen communication and coordination within the Nandi avocado farmers' cooperatives in Kenya?

The research showed that implementing an ICT application in the Nandi cooperative is currently not feasible since they already have the Easy Pro program and the farmers and cooperative needs can be integrated into it. There are also the KALRO applications which can offer information on weather patterns and GAPs. The study revealed how the Cooperative can make use of bulk SMS with their sender ID to improve communication and coordination between the farmers and the cooperative. The cooperative can also create its own website and use the toll-free lines.

In case the new ICT application is to be developed and implemented at a later stage then the following is to be taken into account the users' needs (weather updates, GAPs, certified seedling suppliers, information from agro stores, avocado harvest collection schedules, soil testing, loan information, market prices) for coordination and communication must be understood by the developer. It is also necessary to check the current available infrastructure like computers, printers, and WiFi. Through knowing farmers' needs, the developers with the funders can prioritize needs in the short or long term.

It is important to:

- a. Consult with the developers to find out the resources needed, the steps taken, and the timeframe for developing the application.
- b. Monitor the application to ascertain it is meeting the user's needs and put it to effective use.
- c. Ascertain the financial resources required to develop the application, and where to source the money from.
- d. Know where the subscription costs will come from for the application's sustainability.

6.2. Recommendations

The recommendations given below are based on the findings, discussion, and conclusions. Since the development and implementation of a new ICT application is not feasible in the short term. It is recommended to start with the following actions:

• Streamlining cooperative operations

Within the next three months prioritizing the registration of the bulk SMS heading as "Nandi Avocado Farmers' Cooperative" will help the cooperative effectively notify farmers about harvest collection schedules. The cooperative needs to consult the telecommunication services (Safaricom or Airtel) so that they can set up the Sender ID. Additionally, they can consult on the toll-free line for the cooperative. The FORQLAB project can assist in financial support.

Moreover, for proper data management and supply and demand alignment, the Cooperative needs to meet up with the Amtech software developer and consult how new features can be integrated into the Amtech Easy Pro within three months. Doing so will assist in eliminating mismatches and enhance overall coordination.

The cooperative can also meet up with ICT personnel who will help develop the website of the cooperative. The cooperative can pay for the website funding and the ICT personnel cost. The website will assist the cooperative to post about its dealings and they can also include a chatbot. This will improve communication between the farmers and the cooperative.

• Establishing tactical alliances

The study revealed that the Easy Pro program had only been paid till the end of the year thus there is a need for the cooperative to build partnerships with private funders within the next six months to secure financial support. Moreover, the cooperative can seek extended funding from the World Bank.

• Creating awareness of existing applications, the TOTs currently deployed in the 25 wards can assist in creating awareness of the KALRO applications and Digifarm, they can also train farmers on how to maximize the usage of the applications.

Long term recommendations

In case the new ICT application is to be developed and implemented in the long term then the following are recommended:

• Enhancing digital literacy

The farmers need to be sensitized and trained on how to use applications effectively. The cooperative management team, the application developer, and TOTs can assist in training the farmers on how to use applications. The developers will also know the farmers' literacy levels and develop an appropriate application that they can fully maximize.

• Establishing tactical alliances

The study revealed that the initial cost of the application would be high thus there is a need to build partnerships with development partners, government, actors, and supporters within the avocado value chain for funding. Moreover, to ascertain the sustainability payment of the application it is recommended that the cooperative pays for the subscription fee.

6.2.1. Theory of Change

Table 4 below shows the theory of change for the proposed interventions.

TABLE 4: THEORY OF CHANGE

Intervention	Activities	Input	Output	Outcome
Streamlining cooperative operations	Cooperatives using their sender ID in bulk SMS More use of Amtech Easy Pro	Cooperative management team Telecommunication services Amtech software developer	Farmers know the specific days their harvest is being collected Data management within the cooperative	Reduction in post- harvest losses and proper coordination between the farmers and the cooperative
	Cooperative creating its website	ICT personnel	The members and partners access key information	Market itself to investors, and win new members thus promoting cooperative growth
Establishing tactical alliances	Securing funding for the Easy Pro program	Importers, exporters World Bank, and development partners contribute to the funding	The program cost paid and the program is running smoothly.	Improved data management, proper coordination, and communication between farmers and cooperative
Awareness creation	Creating awareness of the existing applications	ToTs Cooperative management team	Over 1000 farmers are aware and are trained on how to use the existing application.	Farmers have quality produce
Enhancing digital literacy	Farmers are trained on digital skills	Cooperative management team The application developer TOTs	Over 1000 farmers are equipped with digital literacy skills	Increased access to applications by farmers

(Source: Author 2024)

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ANNEXES

Annex 1: Selected firms and projects providing agriculture ICT services in Kenya

FIRM OR PROJECT (YEAR)	TYPE OF SERVICE SUPPLIED	VALUE PROPOSITION AND SERVICE SUPPLIED	TYPE OF TECHNOLOGY	NO. OF USERS	NO. OF USERS
Mezzanine (2012)	Supply chain management Financial management Market information and linkages Farm advisory and information	Delivers mobile, IoT and dig- ital solutions for the areas of agriculture, health and social innovation, education, asset management and finance. Has co-developed DigiFarm with Safaricom.	Mobile apps used by both farmers and vendors.	See Safaricom	South Africa, Ghana, Nigeria, Mozam- bique, Zambia, Kenya and Tanzania.
MTela (NA)	Supply chain management Financial management Market information and linkages	Shop management app for agricultural input retail- ers, including sales and inventory management and simple input usage instructions for farmers. This is a mobile solution with 7 different features.	Mobile app	NA	Kenya
Twiga Foods (2014)	Financial management Market information and linkages	Business-to-business agricultural supply chain management and fin-tech solutions, which	Mobile app	+4000 suppliers, 35,000 + vendors	Kenya
Wazinsure (2016)	Financial management	Insurtech services for provi- sion of micro insurances via data driven platform apps.	Mobile app	NA	Kenya
Weatherimpact (2014)	Farm advisory and information	WeatherImpact provides farmers with easy access to reliable weather and climate information with the goal to support and optimize food production while reducing the impact of climate change through mobile app services.	Mobile app	206,942 farmers across multiple countries.	Angola, Burundi, Ethiopia, Ghana, Kenya, Myanmar, South Africa, Nether- lands
Wefarm platform (2015)	Market information and linkages Farm advisory and information	Farmer-to-farmer infor- mation exchange via SMS services for feature phones. The service should help farmers increase yields, gain pricing insights, tackle effects of climate change, source the best quality seeds, fertiliser etc.	SMS service and app service	2.4 million farmers have connected to each other. Farmers share *40,000 questions a day.	Kenya, Tanzania, Uganda, United Kingdom
DigiCow (Farmingtech Solutions) (2014; started operation in) 2016)	Farm advisory and information	Delivers veterinary advice on meat and dairy produc- tion. The app gives farmers peer-to-peer engagement through chatrooms, dig- ital records and analysed reports, digital training rooms, expert consultancy through private chatrooms, and notifications on important gestation dates.	Mobile app, SMS services, IVR (interactive voice response) system	NA	Kenya
Yielder (NA)	Farm advisory and information	Information sharing app between farmers to help improve their agricultural production	Mobile app	NA	Kenyaz
FutureWater (ThirdEye Project) (NA)	Farm advisory and information	This project supports farmers with flying sensors to enable them to improve decision making on limited resources such as seeds, water, fertilizers and labour.	Drones and mobile phone	NA	Several African and European countries

FIRM OR PROJECT (YEAR)	TYPE OF SERVICE SUPPLIED	VALUE PROPOSITION AND SERVICE SUPPLIED	TYPE OF TECHNOLOGY	NO. OF USERS	NO. OF USERS
Safaricom (DigiFarm technol- ogy) (NA)	Supply chain management Financial management Market information and linkages Farm advisory and information	Agricultural and fin-tech mobile solutions (SMS and app services) for farmers. Increases access to knowl- edge, finance for inputs and access to markets within particular value chains.	SMS services and app.	1.3 million farmers	Kenya
eProd Solutions (2004)	Supply chain management Financial management Market information and linkages	Agricultural and fin-tech solutions (SMS and email services) to improve supply chain management for both farmers and suppliers	Supply chain management software	250,000 farmers across 12 countries	Guatemala, Kenya, Guinea, Ghana, Mali, Burkina, Nigeria, Rwanda, Tanzania, Malawi, Ethiopia
M-Advisory Africa (NA)	Farm advisory and information Financial management	Provides a call service advisory platform where farmers can get informa- tion on crop and livestock management as well as help with financial literacy. It is a multi-language ser- vice that delivers real-time answers to various queries.	Call service, tele conference	NA	Kenya
Agrics (2012)	Financial management Farm advisory and information	Builds sustainable businesses by providing smallholder farmers access to farm inputs, capital, innovation, knowledge and markets.	NA	35,000 farmers across Kenya and Tanzania.	Kenya, Tanzania
Dodore Kenya (Agri-wallet tech- nology) (NA)	Financial management	Provides a fin-tech solution that ensures financial flow between the farmers, markets, agrovets/dealer and suppliers. Agri-wallet also offers loans and saving options for farmers.	Mobile wallet	NA	Kenya, Rwanda
Esoko (2008)	Supply chain management Financial management Market information and linkages Farm advisory and information	Connects farmers via mobile phone to informa- tion such as agronomic advice, weather forecasts, market linkages and insur- ance coverage over a range of channels including SMS, voice SMS and call centre.	Text and voice messages, bulk text messages (for organisa- tions), videos, online market place, data col- lection tools.	S0,000 farmers. Agri- businesses and projects buy sub- scription on behalf of the farmers.	Ghana and 8 other African countries
FarmDrive (NA)	Financial management	FarmDrive is an agricultural data analytics company that provides credit for farmers and helps financial institutions to increase loan portfolios in a sustainable way. Uses phone technol- ogy, alternative credit scor- ing, and machine learning	Mobile app	NA	Kenya
Geodata for Agriculture and Water project (G4AW) (NA)	Farm advisory and information	Government project. Makes tailor-made advice on fertilizer advice, market information, and general farm management support for individual farmers. The information is spread via a mobile platform and SMS system.	SMS service and mobile app	NA	Kenya, Tanzania

FIRM OR PROJECT (YEAR)	TYPE OF SERVICE SUPPLIED	VALUE PROPOSITION AND SERVICE SUPPLIED	TYPE OF TECHNOLOGY	NO. OF USERS	NO. OF USERS
Tahmo (NA)	Farm advisory and information	Large project that builds weather stations Africa. Weather data is freely available and can enhance crop modelling and crop insurance.	Weather sta- tions	The aim is to develop a dense network of 20,000 weather sta- tions across Africa.	Multiple countries
ifarm360 (2020)	Market information and linkages Financial management	Wholesale market service connecting fresh-produce farmers to buyers through storage and distribution hub enabled by WhatsApp or web store. Crowd- funding platform for farm investment. Farmer wallet- payment and savings.	Mobile app and ICT ecosystem. Web store. Logistics.	+300 farmers	Kenya
VanderSat (NA)	Farm advisory and information	Uses satellite technology to deliver daily data on soil moisture, temperature and vegetation to power different applications	Satellite tech- nology (passive microwave sensing).	NA	Based in The Nether- lands and South Africa.

(Source: UNEP, 2021)

Annex 2: ICT essential agriculture services

		Pre-Production	Production	Aggregation	Marketing	Consumption
	Challenges	 Lack of information on famer credit, insurance and investment risks, input needs, current practices 	 Unimproved farm management practices Lack market knowledge Lack access to credit & savings Low quality inputs Vulnerable to shocks 	 Lack of information on quality & farmer practices Incomplete and/or cumbersome accounting and tracking systems 	 Lack of information on product origin & farmer practices Poor processing & handling techniques May have underutilized capacity 	 Lack of information on product origin, farmer practices & environmental impact May demand certified/premium products
	Product Flow	Input suppliers Financial institutions	Farmers	Traders Co-ops	Processors Manufacturers Buyers (Domestic & Exporters)	Retailers Consumers
, _ → [l] ₁ ,1 ₁ ,1	Sharing	Risk information	Risk information Market information Farm management / agronomic advice	Market information	Market information	 Market information
	Analytics	 Farmer / farm profiles Credit / transaction history 	 Tailored input packages & agronomic advice Internal management system 	 Internal management system Farmer / farm profile Credit / transaction history 	Internal management system Farmer/farm profiles Credit / transaction history	 Farmer / farm profiles.
	Access to Markets	 Digital marketplaces 	Digital marketplaces Transport logistics Market transparency Professionalization	Facilitating payments Formalizing market linkages Transport logistics	Digital marketplaces Facilitating payments Formalizing market linkages	 Digital marketplaces Facilitating payments Formalizing market linkages
T	Access to Finance	 Digital payments (828, 82C) Farmer credit / transaction history In-house finance 	 Digital payments (B2B, B2C) Farmer credit / transaction history In-house finance Facilitated savings Insurance services 	 Digital payments (B2B, B2C) 	Digital payments (828, 82C)	 Digital payments (B2B, B2C)
	Traceability			 Supply chain management / transparency Quality assurance & Control 	Supply chain management / transparency Quality assurance & control Product provenance	 Supply chain management / transparency Quality assurance & control Product provenance

(Source: Agrilinks 2018)

Annex 3. Interview questions checklist

Farmers and Cooperatives Focus Group Discussion

• Can you describe the current challenges you face in communication within your farmer cooperative?

- Does your cooperative currently have access to digital devices?
- What information needs to be shared better?

• How do you share information on updates about market prices, crop yields, and best practices with other cooperative members? Are there any difficulties with this approach?

• Are there any existing applications or tools you currently use that address some of these needs? If so, what functionalities do you find helpful or lacking?

• Have you encountered any situations where better communication or coordination could have improved your cooperative's success? Can you elaborate?

• Are there any difficulties in coordinating logistics like transportation or storage for your cooperative?

• How do you think an ICT application could help address these communication and coordination challenges?

What are your biggest concerns or reservations about using a new ICT application?

• In your opinion, what functionalities would be most helpful in an ICT application to address these communication and coordination needs within the cooperative?

• What information would be most helpful for you to have readily available through an ICT application? (e.g., market prices, weather forecasts, agricultural advice)

• What features would be most beneficial for communication within the cooperative? (e.g., messaging platform, discussion forum)?

• Is there anything else you would like to see included in an ICT application designed for farmer cooperatives?

• What specific tasks or activities within the cooperative would benefit most from an ICT application?

• Are there any technical skills or training needs that would be necessary for your cooperative members to use the application effectively?

• Are there any technical skills or resources readily available within the cooperative that could be utilized for developing the application?

• What kind of training or support would be most helpful for cooperative members to effectively utilize the ICT application?

• How would you like to be involved in the development process of the application? (e.g., providing feedback on functionalities, testing prototypes)

eProd Solutions

• In your opinion, what features would be most beneficial for communication within the cooperative? (e.g., messaging platform, discussion forum)?

• What specific tasks or activities within the cooperative would benefit most from an ICT application?

• Do you envision any features in an ICT application that would facilitate communication and collaboration within the cooperative both short and long term?

• In your experience, what makes an application user-friendly or accessible? What is needed?

• From your perspective, what is a realistic timeframe for developing and implementing an ICT application for the cooperative?

• Apart from a financial standpoint, what other resources are needed for the development of an application?

- How do the developers operate with farmers and cooperatives?
- What is the estimated budget for the development of the application?

- Where does the funding usually come from?
- Are there any licensing fees?
- Is the app subscription fee affordable for the cooperative?
- How will the budget be allocated across different phases of the project?
- What monitoring tools will be used to track the application's performance?
- Are there specific protocols or measures to protect against data breaches or unauthorised access? Confidentiality?

FORQLAB Junior Researcher

• In your opinion, what specific tasks or activities within the cooperative would benefit most from an ICT application?

• Can you envision any features in an ICT application that would facilitate communication and collaboration between members?

• What in your experience makes an application user-friendly or accessible? What is needed?

• From your perspective, what is a realistic timeframe for developing and implementing an ICT application for the cooperative?

• Apart from financials, what other resources are needed for the development of an application?

• What was the thought of the cooperatives about your presentation on the functional ideas?

KALRO

• Can you envision any features in an ICT application that would facilitate communication and collaboration between members?

• What in your experience makes an application user-friendly or accessible? What is needed?

• From your perspective, what is a realistic timeframe for developing and implementing an ICT application for the cooperative?

• How would you like to be involved in the development process of an application? (e.g., development, providing feedback on functionalities, testing prototypes)

• Apart from financials, what other resources are needed for the development of an application?

- How do your developers operate with farmers and cooperatives?
- What is the estimated budget for the development of the application?
- Where does the funding usually come from?
- Are there any licensing fees?
- Is the app subscription fee affordable for the cooperative?
- How will the budget be allocated across different phases of the project?
- What monitoring tools will be used to track application performance?

• Are there specific protocols or measures to protect against data breaches or unauthorized access? Confidentiality?

Pharox Logistics Intelligence

- What information do the exporters need from the cooperatives?
- What in your experience makes an application user-friendly or accessible? What is needed?

• From your perspective, what is a realistic timeframe for developing and implementing an ICT application for the cooperative?

- Apart from financials, what other resources are needed for the development of an application?
- How do the developers operate with farmers and cooperatives?
- What is the estimated budget for the development of the application?
- Where does the funding usually come from?
- Are there any licensing fees?
- Is the app subscription fee affordable for the cooperative?
- How will the budget be allocated across different phases of the project?

Amtech EasyPro Software developer

• What in your experience makes an application user-friendly or accessible? What is needed?

• From your perspective, what is a realistic timeframe for developing and implementing an ICT application for the cooperative?

• Apart from financials, what other resources are needed for the development of an application?

- How do the developers operate with farmers and cooperatives?
- What is the estimated budget for the development of the application?
- Where does the funding usually come from?
- Are there any licensing fees?
- Is the app subscription fee affordable for the cooperative?
- How will the budget be allocated across different phases of the project?
- What are the key steps needed to develop such an application?